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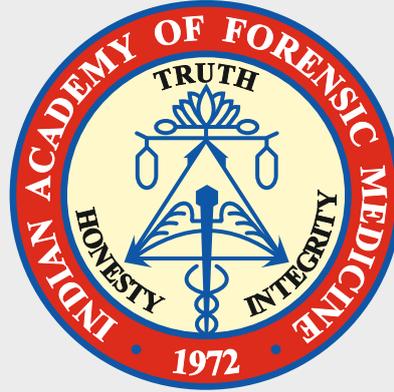
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Predatory publishing – A cautionary for researchers

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Predatory publishing usually refers to publication of substandard journals or books etc. with the sole motive of minting money from, or at the cost of unsuspecting researchers. Thus, the idea of predatory publishing is to seek financial gains, and there are hardly any academic interests involved. The outcome is very obvious; release of journals and books with poor scientific content. The significant contrast between predatory and non-predatory publishing is based on the level of editorial and publishing efforts taken to check the quality of the content. It takes a lot of serious efforts on the part of the editorial and publishing team to ensure that quality articles with reliable and useful information only are passed on in the academic circles. It has been emphasized time and again to make researchers aware of the problems associated with predatory journals so as to safeguard their interests.¹

Predatory journals are mostly open-access and charge varying amounts of publication fees. This however, does not mean that all open access journals are predatory, or that all the journals charging article processing fee are predatory. Thus, the researchers are often left with a very valid and difficult question; how to identify if a journal is predatory or not? Beall's list for long was known to provide the researchers with requisite information on predatory journals in consideration of certain criteria set by him. The list however, has been withdrawn a couple of years back. Though there are other websites such as Cabell's list which provide information similar to Beall's list, one can never totally rely on any information that lacks definitive standards. The issue is further complicated owing to the fact that globally new journals are being launched almost weekly and no list can be taken as perfect and exhaustive. That means researchers have to be aware of this menace, and wise enough to protect their research interests.

Predatory journals sometimes sound very similar to some reputed journal or these may boast of a self-created fictitious impact factors to befool and attract the attention of unsuspecting

researchers, prompting them to submit their hard work to these journals. While there are researchers who unsuspectingly submit their hard work to the predatory journals, there are researchers who intentionally get their often substandard work published in predatory journals, mostly in order to strengthen their CVs or get the required number of publications for promotion etc. in quick time. Little do they know that more often than not, such publications are not considered in reputed job positions in national and international circuits. Even the legitimate work published in predatory journals loses its value or the place it deserves. The study observations and author credentials are often doubted, and such research is hardly ever cited in good journals. Concerned about the threat posed by predatory publications, and in order to discourage researchers from publishing in predatory journals in India, the UGC released an approved list of journals that are duly recommended for promotions of teachers in higher educational institutes/colleges.²

Problem of predatory publishing is multiplying each passing day. In absence of suitable and timely interventions, more and more researchers are likely to be preyed upon by these predators. Researchers and authors should be discouraged from engaging in predatory publishing. They should be made aware that such journals are not well recognized by academia, and hence, their hard work stands wasted. It is suggested that authors and researchers for their high quality work, prefer journals of known reputation, journals of various scientific societies, those with journal impact factor (JIF), or the journals abstracted, indexed and included in the leading indexing agencies.

References

1. Tandon A, Kanchan T, Krishan K. Predatory publishing: send the alarms ringing. *Curr Sci* 2016;7:1133.
2. UGC Approved List of Journals. Available at: <https://www.ugc.ac.in/journallist>

Artificial finger with dental alginate impression material can fool the sensor of various finger print systems

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Abstract

Most of the offices, institutes and banking sectors currently use finger print biometrics in order to validate a person's identity. The current biometric system employs the uniqueness of the individual's fingerprints for daily attendance register, bank transactions & security measures for opening personal computers and mobiles. So it is a potential threat to security and banking, if biometric machines are deceived by an artificial finger. Twenty fingerprints from different individuals were first registered in various types of fingerprint scanners having optical and capacitive sensors. Then, twenty counterfeit artificial fingers containing the artificial fingerprints of the individuals were prepared using alginate. The potential of these artificial fingers to deceive the biometric devices was compared with the sample fingers taking quality of image, matching score and time taken for matching as comparison parameters. Results showed that artificial fingers with alginate material were successfully accepted by both optical and capacitive fingerprint devices. To conclude, finger print device can be easily deceived by artificial alginate finger. So, adjunctive identification methods should be developed to secure personal data.

Key words

Artificial alginate finger; Biometric spoofing; Fingerprint; Scanner

Introduction

The *biometric traits* are used to authenticate personal identification through physiological or behavioral characteristics. The word "biometric" in Greek means *bios* (life) and *metrikos* (measure). In order to validate a person's identity, the current biometric system employs the uniqueness of the individual's body parts. In the recent technological era, in a covet to make life simpler, the biometric systems which do not require an identity card or memorizing of a Personal Identification Number have been invented.¹

Reliability of these biometric systems would be questionable if biometric data are abused by duplication of personal physiological characters by artificial means. This is called as "Biometric spoofing".² The flaw in these systems can be exploited by the persons where biometric analysis is used as an authorized entry system or as attendance records. This can also be misused by criminals by incognizant ways or forcefully procuring fingerprint impressions.

In fingerprint systems, the fingerprint data from an enrollee is extracted by a sensing device which records them as a template. During verification, when the same features correspond or super

impose with previously stored data in the template, it is accepted by the system.³

Capacitive and optical sensors are most commonly used fingerprint systems.⁴⁻⁷ Optical sensors are based on reflection where as the capacitive systems are based on variable capacitance of ridge and valley of the finger. The other fingerprint systems used are thermal and ultrasound systems.⁸⁻¹⁰ Optical fingerprint scanners are the oldest technique. It captures two dimensional (2D) pictures which can be easily deluded by artificial means.⁹ Capacitive scanners have proven to be more reliable than optical scanners.⁹

In this study, we compared the reliability of various biometric sensors and its potential to deceive the current fingerprint biometric systems.

Materials and Methods

Twenty fingerprints were registered in the various fingerprint analysis devices. The aims, objective and methodology of the study and the risks and benefits of participation was explained the participants. Written consent was obtained. The persons willing to participate were included in the study. The persons with burns, injury or scar on fingers were excluded.

In this study, we have used optical and capacitive sensors devices. Capacitive sensors devices used for recording fingerprints were Vivo V5 (Vivo, India) and Apple iphone 6S model (Apple inc, California),¹¹ called device 1 and 2 respectively. Startek FM fingerprint scanner was used to test optical fingerprint sensor (Figure 1).

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The artificial replica of fingerprint was done by making an artificial alginate finger using Dental alginate material (Zelganplus, Densply) and light body addition silicon impression material (Aquasil LV, Densply). Rubber bowl, spatula, wax knife were the other armamentariums used (Figure 1). Small portion of equal amount of catalyst paste and base paste

Figure 1: Armamentarium used for the study.



of addition silicon impression material were taken on a thick paper. Both pastes were mixed using a wax knife and spread thinly over the paper and allowed to set for 10-15 minutes. Equal amount of both the pastes were again mixed and placed over the previously set impression material. Finger was pressed over it with moderate pressure such that lower convexity of finger flattens. Finger is kept stable without movement for 10-15 minutes. The purpose of prior layer of material was to allow lower part of fingertip to come in contact with preset silicon material instead of direct contact with the paper. The finger was then

Figure 2: Step by step procedures for making artificial alginate finger



removed and a thin mixture of alginate was poured. It was pressed lightly and allowed to set. Once hardened, the alginate finger was removed from the mould (Figure 2).

For capacitive fingerprint sensor analysis, each sample finger was first registered in mobile and then the unlocking of the cellular telephone screen was tested by the sample fingers and its corresponding artificial alginate fingers for hundred times each (Figure 3) (Table 1). While pressing alginate finger over the sensor of scanner, water content of alginate finger is very high and water squeezes to the surface in each time while pressing. Therefore, precaution was taken to remove water from

Figure 3: a: Unlocking of mobile using alginate finger. b: Scanned image derived from optical sensor device showing higher intensity of the fingerprint by alginate finger than the sample finger of the same person.



surface of the alginate finger by using a dry and clean cotton cloth followed by slowly air drying through a chip blower. Optical sensor surface should be cleaned repeatedly by dry and clean cloth to remove moisture.

Driver of Startek FM fingerprint scanner was installed by following FM220U User Guide.¹² After installation of "FM220 Demo Program", enrollment of clear fingerprints of the twenty sample fingers was done. To check the fingerprints quality and match the sample to its respective artificial prints, the software displayed four parameters. The quality of image ranged from 1 to 5. The matching scores ranged from 0 to 100000. A matching score less than 1500 suggested a failure in matching and a score of 1500 or more suggested a successful matching. The time taken for matching was also recorded. Matching of the same enrolled finger was done for hundred times. Matching record for these parameters is summarized in Table 2. Precaution of drying the alginate finger by dry and clean cloth and blowing air by a chip blower was done in between each matching.

Results

In capacitive fingerprint sensors, successful acceptance rate by artificial alginate finger ranges from 95.2% to 98.2% depending on type of devices (Table 1, Figure 3a). In optical sensor devices, the scanned images of the artificial alginate finger when compared with respective sample fingers were similar and of higher intensity (Figure. 3b). The acceptance rates, matching

scores, time taken by optical sensors was compared between the twenty sample fingers and their respective alginate fingers. The average acceptance rate of alginate fingers was 97.3% whereas the acceptance rate of the sample fingers was 98.4%. Average matching score of alginate fingers was much lower than the sample fingers which were 18874 and 50555 respectively. Average time taken by an optical fingerprint scanner to match alginate finger and sample finger was 4.1 seconds and 10 seconds respectively. This suggests that the optical scanner

Table 1: Successful acceptance rate of the capacitive sensor devices by counterfeit artificial alginate fingers of the sample fingers

Finger number	Frequency of successful unlocking with alginate fingers	
	Device 1	Device 2
1	100	96
2	98	95
3	99	97
4	100	94
5	99	93
6	97	95
7	98	96
8	97	94
9	100	97
10	96	92
11	98	95
12	99	94
13	100	96
14	97	94
15	96	93
16	98	95
17	100	95
18	95	94
19	99	91
20	98	94
Mean	98.2	95.2

senses the alginate fingers faster than sample fingers (Table 2).

Discussion

Technology has its own boon and bane. Biometric sensors are one such technology which has been widely used in the recent era for security identification and authentication. Such devices automatically verify the identity of a living person based on a physiological or behavioral characteristic such as fingerprints, facial images, iris and voice recognition.¹³ Fingerprint systems are currently globally used to establish better and accessible records of the employee's work hours, banking systems and even handheld and personal devices. "Biometric spoofing" is a method of fooling a biometric identification management system, where a counterfeit mold mimics the biometric traits of an individual so as to deceive the system between the artificial

and the real biological target and gain access to sensitive data/materials. This can pose a potential threat to the society. Thus, this study was designed to compare the reliability of various commonly used biometric sensors and its potential to deceive the current fingerprint biometric systems.¹⁴

We have tried to emulate the unique features of the fingerprint in an artificial finger made of alginate material. This was then used in comparison to the sample genuine finger in the various fingerprint sensing devices. We found that the acceptance rate of the artificial alginate finger by different capacitive sensor device ranges 95.2% to 98.2% depending on type of devices (Table.1). This is equivalent to the accuracy produced by the genuine finger. The intensity of the scanned computer images of the artificial alginate fingers was higher than the image of the respective sample fingers in the optical sensor device (Figure. 3). This may be attributed to the variation in texture of the artificial finger and the pressure applied. Moreover, the images obtained were very similar.

The acceptance rate, matching score, time taken by optical sensors was compared between the twenty sample fingers and their counterfeit alginate fingers. The average acceptance rate of alginate fingers was 97.3% whereas the acceptance rate of the fingers was 98.4%. This data is much higher than artificial gummy fingers made of gelatin in a study by T. Matsumoto et al.³ where they found the acceptance rate to be 67%. Average matching score of alginate finger was 18874 and sample finger was 50555 which suggest that matching score of alginate finger is lower than live finger. This matching score is insignificant since a matching score more than 1500 gives a successful acceptance by the finger print device.

Average time taken by an optical finger print scanner to match alginate finger was found to be 4.1 seconds whereas for sample finger the average time taken was 10 seconds which suggests that optical scanner senses alginate finger much faster than the genuine finger.

The alginate fingers best work on same day of preparation. Once devoid of moisture, it could not be sensed by finger print device. However, keeping its moisture intact by wrapping it in a wet cotton cloth, it can be used up to 3-4 days. On application of repeated pressure over the alginate the chances of wear and tear of the material increases. Studies have found addition silicon artificial finger failed to mislead the capacitive sensors but was accepted at a low rate by optical sensors.¹⁵⁻¹⁷

The limitation of the current research is small sample size and limited biometric devices used. Hence, the findings may not be generalized to other device working on other principles. Other limitations are that very few studies are done in this field which limits our study to compare among various systems of biometric sensors. Further studies can be done to procure extended data which can be utilized by the biometric sensor preparation units to remove the flaws in the identification devices.

Table 2: Comparison of acceptance rates, matching scores, time taken by optical sensors to match between the sample fingers and respective artificial alginate fingers

Finger Number	Matching with enrolled finger for 100 times				Matching with alginate finger for 100 times			
	Frequency of successful matching	Range of matching score	Average matching score	Average matching time (seconds)	Frequency of successful matching	Range of matching score	Average matching score	Average matching time (seconds)
1	98	650-100000	65678	8sec	96	400-42550	23006	5 sec
2	97	200-100000	54326	9sec	99	880-38008	18654	6 sec
3	100	2200-100000	53834	11 sec	95	236-45238	21834	3 sec
4	98	896-100000	48565	13 sec	99	923-36542	18485	3 sec
5	96	380-100000	54000	7 sec	100	2267-43675	26867	4 sec
6	98	1100-100000	76445	11 sec	100	1786-36745	16745	3 sec
7	98	650-99000	52000	9 sec	96	134-56000	23546	4 sec
8	99	698-92008	47590	10 sec	97	1132-48387	26341	5 sec
9	100	1900-98582	43297	12 sec	96	432-34575	8435	3 sec
10	97	853-100000	56421	9 sec	98	1145-56234	14387	4 sec
11	99	765-97654	52459	8 sec	97	834-36540	17956	4 sec
12	100	4300-99560	43250	16 sec	99	56-46230	14380	3 sec
13	97	843-100000	45629	9 sec	98	578-34769	21745	6 sec
14	98	1124-100000	39650	11 sec	96	756-34563	15438	7 sec
15	97	653-99650	41256	12 sec	95	953-43278	18590	6 sec
16	99	1123-100000	54219	9 sec	95	832-48256	22867	3 sec
17	100	1650-99540	46000	8 sec	99	960-42648	21734	4 sec
18	98	589-100000	45870	9 sec	97	450-50234	15239	3 sec
19	99	890-100000	41670	11 sec	98	670-36380	16348	3 sec
20	100	2400-98345	48950	9 sec	97	123-51649	14890	4 sec
Average	98.4	200-100000	50555.45	10 sec	97.3	56-56000	18874.35	4.1 sec

Conclusion

The extensive usage of the fingerprint sensing biometric devices is in vain if the artificial replica of the fingerprints can delude these devices. This can be misused for illegal and unethical purposes. This can not only pose a potential threat to the society and also mislead the crime investigations. Recently, Government of India has planned Aadhaar linked banking transaction through fingerprint biometry as an alternative to debit card and credit cards to encourage cashless transactions so that common people can use it in day-to-day dealings without memorizing PIN number and passwords. This can be a potential risk to the security of banking systems if such artificial finger misguides fingerprint scanner. This can also be a threat to data security on personal computer or mobile and mislead identification terrorist and criminals.

In our study we conclude that, the finger print devices can be deceived by artificial alginate finger made of up dental alginate material. The Alginate finger was successfully accepted by various finger print device. Therefore, extra security measure should be taken. This uncertainty revolving around the system should encourage more research towards development of biometric devices with adjunctive identification methods. Continuing the reliance of traditional password-based methods can also be an aid to secure personal information. The concerned authorities, general people and police should be aware of this and take necessary measures.

Declaration: This study is not meant to criticize any fingerprint manufacturing company. As it was self-financing study, we conducted the study with material/ device that was available with us in limited resources and not to criticize any company in particular.

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References

- O'Gorman L, Fingerprint Verification. In: Jain AK, Bolle R, Pankanti S, editors. Biometrics: personal identification in networked society. Springer Science & Business Media; 2006.p. 43-63.
- Available from: <http://www.m2sys.com/blog/scanning-and-efficiency/liveness-detection-fight-biometric-spoofing/>. Accessed on: 21/06/19
- Matsumoto T, Matsumoto H, Yamada K, Hoshino S. Impact of artificial "gummy" fingers on fingerprint systems. Available from: <https://www.spiedigitallibrary.org/conference-proceedings-of-spie/4677/1/Impact-of-artificial-gummy-fingers-on-fingerprint-systems/10.1117/12.462719.short>. Accessed on :24/06/2018
- Bahuguna RD, Corboline T. Technical Note Prism fingerprint sensor that uses a holographic optical element. *Applied optics*.1996;35(26):5242-5.
- Igaki S, Eguchi S, Yamagishi F, Ikeda H, Inagaki T. Real-time fingerprint sensor using a hologram. *Applied Optics*. 1992;31(11):1794-802.
- Jung S, Thewes R, Scheiter T, Goser KF, Weber W. A low-power and high-performance CMOS fingerprint sensing and encoding architecture. *IEEE Journal of Solid-State Circuits*.1999;34(7):978-84.
- Heyrman B, Painsavoine M, Schmit R, Letellier L, Collette T. Smart camera design for intensive embedded computing. *Real-Time Imaging*. 2005;11(4):282-9.
- Collins CG. *Fingerprint Science: How to Roll, Classify, File and Use Fingerprints*. 1sted. Copperhouse Publishing Company; 1998
- Available from: <http://www.androidauthority.com/how-fingerprint-scanners-work-670934/> Accessed on :24/02/2018
- Mainguet JF, Pégulu M, Harris JB. Fingerprint recognition based on silicon chips. *Future Generation Computer Systems*. 2000;16(4):403-15.
- Available from: <http://www.gadgetsnow.com/compare-mobile-phones/Apple-iPhone-6-64GB-vs-Vivo-V5>. Accessed on :24/02/2018
- Available from: <http://www.startek-eng.com/technology.aspx>. Accessed on: 24/06/2018
- Wayman J, Jain A, Maltonie D, Maio D. *An Introduction to Biometric Authentication Systems*. 1sted. Boston, MA: Springer London; 2005
- Reddy PV, Kumar A, Rahman S, Mundra TS. A new antispoofing approach for biometric devices. *IEEE Trans Biomed Circuits Syst*. 2008;2(4):328-37.
- Available from: http://biometrics.cse.msu.edu/Publications/Fingerprint/JainFpMatching_IEEEComp10.pdf. Accessed on: 24/02/2018
- Yamada K. Can We Make Artificial Fingers That Fool Fingerprint Systems? In *Technical Report of IEICE*. 2000(68):159-66
- Ngo DCL, Teoh ABJ, Hu J. *Biometric Security*. 1sted. Cambridge Scholars Publishing: UK; 2015

Sexual dimorphism based on various measurements of corpus callosum in South Indian population

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Abstract

Identification of an individual is of utmost importance in cases of mass disasters. In such cases determination of sex reduces the field of search to 50% of the population as it eliminates one gender from the said population. Many Parameters are used for sex determination. In this regard various body structural measurements are used for sexual dimorphism. We attempted to find out sexual differences in various measurements of Carpus callosum of brain. The right half of the brain dissected during autopsy was preserved in 10% formalin. The following measurements were recorded using a digital sliding caliper before and after fixation of brain did not reveal any significant differences: Frontal pole to occipital pole [FO], Length of corpus callosum [GS], Frontal pole of brain to the corpus callosum [FG], Occipital pole to corpus callosum [OS], Genu of corpus callosum to the column of the fornix [GC], Splenium of corpus callosum to superior colliculus [SSc]. Data was analyzed using the Statistical Package for Social Sciences (SPSS), version 16.0. Statistically significant difference was observed between the mean values of all the parameters of corpus callosum between the males and females. Hence, the dimensions of carpus callosum can be used to determine sex whenever necessary along with other parameters of sex determination

Key words

Identification; Sex determination; Fixation of brain; Carpus callosum

Introduction

Identification is the determination of the individuality of a person based on certain physical characteristics, also known as exact fixation of personality¹.

The question of identity of an individual is of utmost importance in cases of mass disasters like floods, tsunamis, earthquakes, shipwrecks, plane crashes, riots, wars etc. Among the various parameters used for identification, sex is considered as one of the primary characteristics, since determination of sex reduces the field of search to 50% of the population as it eliminates one gender from the said population².

In forensics field, sex determination is required for the following reasons:

- 1) For simple identification in a living or a dead individual.
- 2) In civil cases where certain rights are restricted to one sex only.
- 3) For questions related to legitimacy, paternity, affiliation, divorce etc. and some criminal cases².

In case of mutilated or charred bodies relying completely on the external characters to determine sex proves futile. Therefore, some additional points should be taken into consideration to determine sex so as to affix the identity of an individual.

It is well known that human brain exhibits sexual dimorphism

with respect to hypothalamus, amygdala, hippocampus etc. Differences in the midsagittal area of the corpus callosum (MSACC) have been associated with a number of cognitive and behavioral phenotypes, including obsessive-compulsive disorders, psychopathy, suicidal tendencies, bipolar disorder, schizophrenia, autism, and attention deficit hyperactivity disorder³.

So if it is a well-established fact that behavioural changes do exist between individuals of either genders, there has to occur structural differences between the largest white matter structure of the brain, i.e. the corpus callosum. Whether corpus callosum also exhibits such dimorphism is always a topic of debate.

Various studies have been carried out in the past to look for sexual dimorphism in the corpus callosum of humans as well as animals (Capuchin monkeys, rats).⁴ But results of most of those studies have been rejected on the basis of sample size, methodology, the parameters taken into consideration etc. The present study aims to find out statistically significant differences in the measurements of corpus callosum with regards to gender in the South Indian population and to compare the results with other studies.

Material and Methods

This was a prospective study of 80 autopsies conducted in the Department of Forensic Medicine and Toxicology in a Medical school in South India. Anticipating 80% accuracy in differentiating the gender based on the measurements of corpus callosum with the precision of 10% for 95% confidence level and with a prevalence of 25% cases of the total number of autopsy cases, a sample size of 40 brains of each gender was collected.

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During autopsy after opening the cranial cavity the brain was removed as a whole. The brain specimens with gross structural abnormality due to blunt force trauma, intracranial lesions or any recorded brain pathology were excluded from our study. This brains included in the study were sectioned mid-sagittally through the septum pellucidum into right and the left halves (Fig 1a). The right half consisting of right cerebrum and the cerebellum was then preserved in 10% formalin. It was kept immersed in formalin with the medial surface facing downwards. The measurements done before and after fixation did not reveal any significant differences. After three weeks of fixation, the brain was removed and the following six measurements in relation to the corpus callosum described by authors^{5,6} (Fig 1b) were noted:

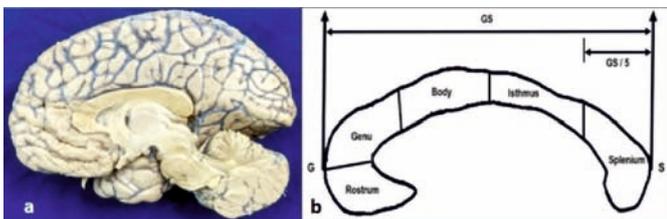


Fig 1: Right half of the sagittally sectioned brain (a) and schematic diagram showing Divisions of the corpus callosum (b)

(i) Frontal pole to occipital pole [FO] = Distance between the frontal pole (F) to the occipital pole (O) of brain. This is measured by a perpendicular drawn at the anterior most and posterior most convexities of the frontal and occipital lobes respectively and measuring the straight distance between them as shown in Fig 2a.

(ii) Length of corpus callosum [GS] = Distance between the genu of corpus callosum (G) to the splenium (S) of corpus callosum. This is measured by a perpendicular drawn at the anterior most convexity of the genu of the corpus callosum and a perpendicular drawn at the posterior most convexities of the splenium of the corpus callosum and measuring the straight distance between them as shown in Fig 2b.

(iii) Frontal pole of brain to the corpus callosum [FG] = Distance between the frontal pole (F) to the genu of corpus callosum (G). This is measured by a perpendicular drawn at the anterior most convexity of the frontal pole of the brain and a perpendicular drawn at the anterior most convexity of the genu of the corpus callosum and measuring the straight distance between them as shown in Fig 2c.

(iv) Occipital pole to corpus callosum [OS] = Distance between the occipital pole (O) to the splenium (S) of corpus callosum. This is measured by a perpendicular drawn to the posterior most convexity of the splenium and a perpendicular drawn to the posterior most convexity of the occipital pole of brain and measuring the straight distance between them as shown in Fig 3a.

(v) Genu of corpus callosum to the column of the fornix [GC] = Distance between the genu of corpus callosum (G) to column of fornix ©. This is measured by a perpendicular drawn at the anterior most convexity of the genu of the corpus callosum and a

perpendicular drawn at the anterior most convexity of the columns of the fornix and measuring the straight distance between them as shown in Fig 3b.

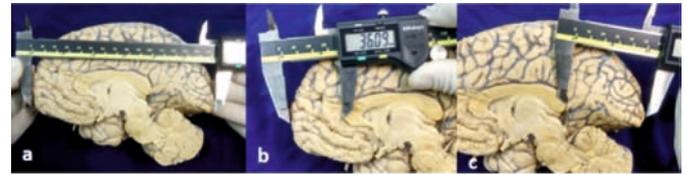


Fig 2: Measurement of frontal pole to the occipital pole of brain [FO] (a); frontal pole to the genu of the corpus callosum [FG] (b) and occipital pole to the splenium of the corpus callosum [OS] (c)

(vi) Splenium of corpus callosum to superior colliculus [SSc] = Distance between the anterior edge of splenium (S) to the superior most point of superior colliculus (Sc). For this measurement, first the anterior edge of the splenium has to be determined. The anterior edge of splenium is determined by measuring 1/5th distance of the length of corpus callosum [GS/5] from the posterior most point of the convexity of splenium (S) of corpus callosum. Once the anterior edge of the splenium is ascertained straight line measurement from the lower most point of the anterior edge of the splenium to the superior most point of the superior colliculus is measured. (Fig 1b, 3c and 3d).

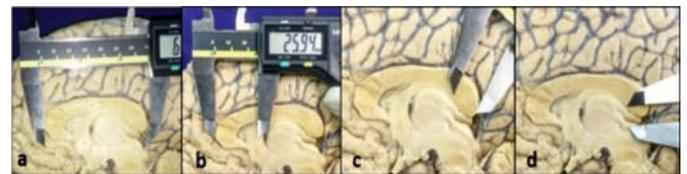


Fig 3: Measurement of length of the corpus callosum [GS] (a); length of genu of the corpus callosum to the column of fornix [GC] (b); length of fifth of the length of corpus callosum from the splenium [GS/5] (c) and splenium to the superior colliculus [SSc] (d)

The above measurements were recorded using a digital sliding caliper (Mitutoyo, Japan) capable of measuring to the nearest 0.01 mm. The measurements were recorded by the same person to minimize the errors in measurements. All the measurements were repeated thrice and the mean was taken for further analysis. To assure the repeatability of the measurements two authors recorded the measurements independently at different times. Data was analyzed using the Statistical Package for Social Sciences (SPSS), version 16.0. Student t-test for independent variables was used to analyse the data. Results were expressed as mean \pm Standard Deviation. p value < 0.05 was considered statistically significant.

Results

The study population comprised of 40 males and 40 females. The range of the age for the study population was 12 – 82 yrs. Mean age of both the population was 41.82 ± 18.65 for males and 33.05 ± 17.45 for females.

The age-wise distribution of study cases is shown in table no. 1:

Table 1: Age wise distribution of cases

Age groups	Cases
11 – 20	12
21 – 30	27
31 – 40	12
41 – 50	11
51 – 60	6
61 – 70	7
71 – 80	3
Total	80

The distribution of study population according to the cause of death was as shown in table no 2:

Table 2: Distribution of cause of death in the study population

Cause of death	No. of cases	
	Males	Females
Burns	3	15
Drowning	1	4
Electrocution	1	-
Hanging	9	1
Myocardial infarction	2	-
Poisoning	23	18
Post-partum haemorrhage	-	1
Road traffic accident	1	1
Total	40	40

The results of the various parameters of the corpus callosum according to the gender are shown in Table. Statistically significant (P value < 0.05) differences were observed between the mean values of all the parameters recorded. Mean of all the parameters were greater in males as compared to females. Student t-test for independent variables was used for comparison of the mean values for both the genders and the p values were obtained. The P values for the six measurements between both the genders were statistically significant as shown in table 3.

Table 3: Mean \pm standard deviation for the six parameters in males and females

Parameter	Male (cm)	Female (cm)	P value
FO	16.37 \pm 0.59	15.79 \pm 0.54	0.0001
GS	7.46 \pm 0.58	7.08 \pm 0.54	0.004
FG	4.02 \pm 0.81	3.72 \pm 0.31	0.033
OS	5.47 \pm 0.61	5.22 \pm 0.38	0.032
GC	2.64 \pm 0.28	2.49 \pm 0.29	0.022
SSc	1.45 \pm 0.17	1.34 \pm 0.20	0.011

Discussion

Determination of sex of an individual is one of the major components in affixing an identity of an individual. In the past many studies have been carried out to ascertain sex of an

individual for e.g. sex from bones. It is well established that human brain displays sexual dimorphism, for e.g. the brain size, the hypothalamus, amygdala, corpus callosum and other commissural systems etc. The results obtained from various studies for the sexual dimorphism of corpus callosum were always in controversy and a topic for debate.

The major problem pointed out in various studies with regards to morphology or gender related differences in corpus callosum is the relative size of corpus callosum not taken into consideration. During development of the human brain the mature size of the brain is achieved by the age of six years. But the volumes of cerebrum, lateral ventricles, caudate nucleus, putamen, temporal lobe, hippocampal gyrus and mid-sagittal area of the corpus callosum are known to exert gender differences. Size of the corpus callosum is also known to be influenced by environmental factors but the study to see environmental influences were only done in rats. In our study the first parameter [FO] which corresponds to the antero-posterior length of the corpus callosum helps to take care of the relative brain size. Also the second [FG] and third [OS] parameters, which correspond to the distance of frontal pole to the genu and occipital pole to the splenium helps to incorporate relative size of corpus callosum in our study.

The brain weight was not taken in to consideration in our study. Normal weight of brain in males is 1400 – 1450 g, whereas in females it is 1250 – 1350 g. Ralph L. Holloway argues for the need of brain weight to be having any relation to the study involving morphology of corpus callosum. He stated that brain weight can be considered in a post-mortem study but in a MRI or diffusion imaging study the same is neglected.⁷

The sample size of this study population was 40 brains for either gender. The sample size was decided by consulting statistician for 80% accuracy and 95% confidence interval. Results of the studies done in the past were rejected mainly because of inadequate sample size. In many studies even if the data was presented, it wasn't statistically significant. In present study all the six parameters of measurements have shown differences which are statistically significant with p values below 0.05.

Many studies have pointed out the larger corpus callosum area in females as compared to males. This may be attributed to the larger and bulbous splenium in females. The number of interhemispheric fibres correlates inversely with the lateralization of function of the cerebrum. So if this is to be taken into consideration in case of more bulbous splenium of females then female splenium should carry more number of fibres, which indirectly implies female brains are less lateralized as compared to male brains. More over the area has no correlation with the length of corpus callosum.

Of the various methods available to study the morphology of the corpus callosum this study adopted the straight line method to demarcate the area of corpus callosum. The method is easy and feasible as compared to the other methods which include the curved line method, the bent line method and the radial gravity method. The easier method makes the study more reliable by minimizing the observer error.⁸

Different studies have tried to correlate age and age related changes with the morphology of corpus callosum. Human brain is enclosed in a cranial cavity which is fixed and there is no room for even less amount of changes in the contents of cranial cavity. Human brain attains its adult size by the age of six years. The myelination of different fibres is completed around puberty. There is not much scope of change with age in the morphology of corpus callosum. It is also believed that with increasing age the corpus callosum undergoes atrophy. The age range in our study population ranged from 12 – 82 years. This range roughly corresponds to the age of puberty to the old age where we can expect the years of normalcy in corpus callosum.

Animal studies on Capuchin monkey by Phillips et al, have tried to correlate handedness with the variation in corpus callosum morphology stating that left handed monkeys had a larger corpus callosum. The parameter of handedness was not included in our study.⁴

Suganthi et al, in their study gender and age related differences in the morphology of the corpus callosum, found that the corpus callosum was longer in males and that the gender could be determined with an accuracy of 66%. The length of the corpus callosum, the width of the genu, trunk, and splenium, the area of the splenium, the total area of the corpus callosum and the length of the brain also taken into consideration.⁹

Giedd et al in their MRI based review study titled magnetic resonance imaging of male/ female differences in human adolescent brain anatomy found that across all ages total brain size is consistently reported to be about 10% larger in males.¹⁰

Padmini et al studied corpus callosum from 50 fetuses, 25 from each sex and concluded that in female fetuses the width of the splenium was greater as compared to that of males and that the average length of the corpus callosum of male fetuses was more than the females. So it is clear that this gender based morphologic difference in the corpus callosum is established since the period of gestation. Also this finding rules out the influence of cultural background in the variability of corpus callosum.¹¹

Study done by John et al raises the question of psychiatric illnesses having influence over the corpus callosal morphology. Many neuropsychiatric illnesses e.g. schizophrenia, autism are known to cause changes in the size of corpus callosum.¹²

Highley et al in their post-mortem study on schizophrenic patients stated that the density of axons decreased in schizophrenic males. The history of any neuropsychiatric illness was not sought in our study population.¹³

In a MRI based study titled Characterization of sexual dimorphism in the human corpus callosum, done by Dubb et al, the results were in agreement with the other studies that females possess larger splenium as compared to males. However, in addition the authors also mentioned that males possess larger genu as compared to females. Also the results demonstrated significant morphologic differences in the corpus callosum between genders and a possible sex difference in the neuro-developmental cycle.¹⁴

Out of most of the neural structures like amygdaloid nucleus, cerebellum, hippocampus and thalamus, the sexual dimorphism for human corpus callosum is most varied. The absolute sizes of these structures were significantly larger in males when brain size not taken in to consideration. Only corpus callosum was a structure to show larger set of relative measures in females.¹⁵

The basic criteria for any research study requires it to be cost effective. Even though newer and advanced techniques like Magnetic resonance imaging, diffusion imaging techniques, Dynamic recursive partitioning, voxel based morphometry etc. promise reliable and accurate results but at the same time are costly. Present study requires fixation of the study samples in 10% formalin which is easily available in any mortuary and can be re-used for other samples for fixation.

This study concluded that males have a larger brain size and overall corpus callosal size as compared to females. Corpus callosum being the major structural commissure connecting both the hemispheres is likely to be affected by physiological and pathological changes in the cortical and sub-cortical regions of the brain. The reason for this is that the major fibre systems that connect corresponding hemispheres pass through specific regions in the corpus callosum. These structural differences can be a basis for gender related changes in certain cognitive functions of the brain. Also precise knowledge about the morphology of corpus callosum can provide a base line data for diagnosis and assessment of progression of a disease.

A limitation of the study could be that other imaging techniques like the MRI were not taken into consideration. Findings from different imaging techniques along with autopsy data could be of great help in improving the study and can be used for comparative analysis of data. Hence, further studies with larger sample size and considering factors like weight of the brain, area of the corpus callosum etc. can be undertaken. Studies can be done in association with imaging studies like Magnetic resonance and results from both can be compared for more reliable results.

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References

1. Reddy KSN. Identification. In: The Essentials of Forensic Medicine and Toxicology. 30th ed. Hyderabad: K Suguna Devi; 2012: 51.
2. Vij K. Identification. In: Textbook of Forensic Medicine and Toxicology Principles & Practice; 5th ed. New Delhi, India: Elsevier; 2011: 35 – 51.
3. Newbury AJ, Rosen GD. Genetic, morphometric, and behavioral factors linked to the midsagittal area of the corpus callosum. *Frontiers in Genetics*. 2012; 3(Article 91): 1-12.
4. Phillips KA, Sherwood CC, Lilak AL. Corpus Callosum Morphology in Capuchin Monkeys Is Influenced by Sex and Handedness. *PLoS one*. 2007; 792(8): 1-7.
5. Ilayperuma I, Nanayakkara G, Palahepitiya N. Gross anatomical

- study on the gender differences in the corpus callosum. *Galle Medical Journal*. 2009; 14(1): 22-25.
6. Kathleen Baynes. *Encyclopedia of the Human Brain*. Vol 2. University of California, Davis. Elsevier Science (USA); 2002; 51-64.
 7. Holloway RL. Relative Size of the Human Corpus Callosum Redux: Statistical Smoke and Mirrors? *Behavioral and Brain Sciences*. 1998; 21(3): 311-352.
 8. Bishop KM, Wahlsten D. Sex Differences in the Human Corpus Callosum: Myth or Reality? *Neuroscience and Biobehavioral Review*. 1997; 21 (5): 581–601.
 9. Suganthy J, Raghuram L, Antonisamy B, Vettivel S, Madhavi C, Rachel Koshi. Gender- and Age-Related Differences in the Morphology of the Corpus Callosum. *Clinical Anatomy*. 2003; 16: 396-403.
 10. Jay N Giedd, Armin Raznahan, Kathryn L Mills, Rhoshel K Lenroot. Review: Magnetic resonance imaging of male/female differences in human adolescent brain anatomy. *Biology of sex differences*. 2012; 3(19): 1-19.
 11. Pramila Padmini M, Rao NB. Sexual Dimorphism of Corpus Callosum Occurs in Human Foetuses. 2012; 5(1):15-18.
 12. John PJ, Mohammad SK, Jain S. Corpus Callosal Area Differences and Gender Dimorphism in Neuroleptic-Naive, Recent-Onset Schizophrenia and Healthy Control Subjects. *Schizophr Res*. 2008; 103 (1-3): 11-21.
 13. Highley JR, Esiri MM, McDonald B, Borja MC, Herron BM, Crow TJ. The size and fibre composition of the corpus callosum with respect to gender and schizophrenia: a post-mortem study. *Brain*. 1999; 122: 99-110.
 14. Dubb A, Gur R, Avants B, Gee J. Characterization of sexual dimorphism in the human corpus callosum. *Neuroimage*. 2003; 20(1): 512–519
 15. Holloway RL. Sexual dimorphism in the human corpus callosum: Its evolutionary and clinical implications. *From Apes to Angels: Essays in Anthropology in Honor of Phillip V. Tobias*. 1990: 221-228.

Medico-legal profile of cases referred for age determination to a Government tertiary care hospital in Mumbai, Maharashtra: A three-year retrospective study

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Abstract

Estimation of age of living individual is of great importance and is necessary for the purpose of administration of justice. Age estimation is important in both civil and criminal cases. Determination of age is playing a key role in cases where exact age is not known or proof of birth is not available, because many births take place at home or in a rural area where lack of maternity hospital is the issue and documentation of such births are not up to date. In medico-legal cases, the age of an individual is determined by a forensic practitioner on requisition from a police officer or magistrate or session's judge or juvenile justice board. Age of individual is determined by radiological assessment, dental and physical examination. Total of 305 cases of age determination were studied. Out of which 211(69.18%) were females and 94(30.82%) were males. Female victim cases were 210(68.85%) and male accused cases were 81(26.65%). Most cases i.e. 162(53.12%) belongs to the age group between 15 years to 18 years. 281(92.13%) cases belong to the urban area and 248(81.31%) cases were unmarried. Cases of victims registered under 376 IPC were 80, 363, 366 IPC were 87, 294 IPC were 7, POCSO act were 90, 377 IPC were 8, 354 IPC were 16 and under PITA act were 58. Cases of accused registered under 376 IPC were 30, POCSO act were 43, 377 IPC were 12, 354 IPC were 9, 363,366 IPC were 21, 302 IPC were 8 and under 379 IPC were 6. Most of the female victims belong to the age group 15 to 18 years. Epiphyseal fusion around the elbow joint, wrist joint & pelvis found to be earlier in females than males.

Key words

Age determination; Radiological assessment; Victim; Accused; IPC; PITA; POCSO Act.

Introduction

Age is an imperative component for medico-legal cases. So that determination of age is mandatory in criminal cases for the administration of justice. Age determination is done in civil as well as in criminal cases. In civil cases like marriage, employment, competency for giving evidence, identification, impotency, retirement and insurance benefits, for playing sports. In criminal cases, as per amendments made in the juvenile justice act, the term juvenile is replaced with term child in conflict with law if the age of an offender is between 16 to 18 years. If such a child commits any heinous crime like rape, murder etc. then such criminal offenders shall be tried as adults. The opinion as to the age is given after the combination of physical, dental and radiological examination. Age of individual varies with racial, geographic, climate and various other factors.¹⁻³ The main objective of study is to analyse the age of offenders and victims in relation to the different crime committed especially cases registered under POCSO Act. In addition to this study also aims at understanding the demographic profile of the accused and victims in analysing the relevant socio-culture and epidemiological factors associated

with the crime committed. The present study was undertaken retrospectively to study the profile of medico-legal cases of age estimation in victims and accused in various crime committed such as sexual assault, kidnapping, trafficking, POCSO Act etc. coming to the forensic medicine and toxicology department for age determination. An aims and objectives of this present study are to study the incidence of age estimation cases with respect to sex, estimated age, locality, religion, occupation, marital status, socio-economic status; to analyse the age cases booked under various IPC sections with regards to sexual assault, abduction, trafficking, POCSO Act, juvenile justice Act, murder, robbery, PITA Act, child labour etc; to determine the approximate age of an individual by means of physical, dental and radiological examination and to assess the date of birth, stated age and determined age in study group for accuracy.

Materials and Methods

In this study total 305 cases (female = 211; male = 94) of victims and accused of sexual assault, abduction, kidnapping, trafficking, child labour, POCSO Act, murder, robbery etc. were studied for age determination retrospectively for period of three year from 2014 to 2017 in Dept. of Forensic Medicine and Toxicology, Grant Govt. Medical College, Mumbai. Details regarding the demographic profile, various IPC sections and Acts under which cases had been registered and approximate age of individual concluded with the help of various examinations. Only medico-legal age cases brought to the Forensic Medicine Department. examined during the tenure of

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study. For age determination, to see the epiphyseal union at the wrist, elbow and pelvis joint the radiological assessment was studied along with dental status and physical examination of an individual. Age of the individual had also been confirmed with their birth date where proof for birth date was available.

Staging of the Degree of Fusion⁴ was described as; Non fusion: complete gap or space between the epiphyses and shaft of the bone. Incomplete fusion: Incomplete closure of gap or space. Recent fusion: Closure of the gap or space but a thin line visible at the epiphyseo-diaphyseal junction. Fusion: Epiphyseal space is bony in architecture and indistinguishable from either epiphyses or diaphyses.

Results

In the present study we observed that most of the age cases brought to the hospital for age determination were female's i.e.211 (69.18%) as compared to the males i.e.94 (30.82%). In female cases almost all were victims i.e.210 (99.52%), and; in male cases of accused being 81 (86.17%); and cases of victim being 13 (13.83%). In the entire three-year retrospective study

Table 1: Distribution of cases according to sex and age groups.

Age groups	Female	Male	Total
0-10yrs	4(1.31%)	1(0.33%)	5(1.64%)
10-12yrs	2(0.66%)	1(0.33%)	3(0.98%)
12-14yrs	6(1.97%)	12(3.93%)	18(5.90%)
14-15yrs	11(3.61%)	0(0.0%)	11(3.61%)
15-16yrs	29(9.51%)	10(3.28%)	39(12.79%)
16-17yrs	64(20.98%)	12(3.93%)	76(24.92%)
17-18yrs	32(10.49%)	15(4.92%)	47(15.41%)
18-19yrs	19(6.23%)	15(4.92%)	34(11.15%)
19-20yrs	13(4.26%)	10(3.28%)	23(7.54%)
20-21yrs	16(5.25%)	16(5.25%)	32(10.49%)
> 21yrs	15(4.92%)	2(0.66%)	17(5.57%)

total cases of victims were 223 (73.11%) and total cases of accused were 82 (26.89%). The cases of victims outnumbered the cases of accused in the present study. The cases belonging to urban area were 281 (92.13%); and cases belonging to rural area were 24 (7.87%). 248 (81.31%) cases were unmarried and 57 (18.69%) cases were married. Out of 305 cases studied; 188

(60.98%) cases belong to the Hindu community; 118 (38.69%) cases belong to the Muslim community; one case belongs to the Christian community. Occupations of the victim and accused were student, housewives, worker, profession, waitress, bar dancer, brothel house worker, driver, labourer, self-employed etc.

In this study it was observed that total number of female victim cases belonging to 15 to 18 years of age group were 125 (59.52%); and 23 (10.95%) female victim cases belong to 4 to

Table 2: Distribution of victims and accused cases according to IPC sections and relevant acts.

Various sections of IPC and Acts	Victim	Accused	Total
IPC sections involving human body-victim only (370(1),371,372,294,394IPC)	54	0	54
IPC sections involving human body-accused only (302,306,307,379,392IPC)	0	16	16
IPC sections involving human body-victim and accused both (376,377,354,363,366IPC)	191	72	163
POCSO Act	90	43	133
PITA Act	58	0	58
NDPS Act	0	3	3
Juvenile Justice Act	5	0	5
Child labour Prevention & Regulation act	7	0	7
Others-Maharashtra police act, State excise act, Railway act etc.	6	1	7

15 years of age group; and 63 (30%) female victim cases belong to age group above 18 years. Out of 94 cases of male, male victim cases belonging to 4 to 14 years of age group were 13 (13.82%). Out of 81 cases of male accused, the male accused cases belonging to 15 to 18 years of age group were 37 (45.67%) and above 18 years of age group were 43 (53.08%). (Table 1)

In the present study the cases of female victim registered under section 376 IPC were 80 (38.09%); and male accused cases were 30 (37.03%). The cases of female victim registered under section 377 IPC were 8 (3.80%), and; male accused cases were 12 (14.81%). The cases of female victim registered under section 354 IPC were 16 (7.61%), and; male accused cases were 9 (11.11%). The cases of female victim under section 363 IPC & 366 IPC were 87 (41.42%), and; male accused cases were 21 (25.92%). Female victim cases registered under 370 IPC, 371 IPC & 372 IPC were 45 (21.42%); female victim cases registered under 294 IPC and 394 IPC were 7 (3.33%) & 2 (0.95%) respectively. The cases of male accused registered

Table 3: Age and Sex wise case distribution of epiphyseal fusion of lower end of radius and ulna.

Age group	Fusion		Recent fusion		Incomplete fusion		Non fusion	
	male	female	male	Female	Male	female	male	female
11-12yrs	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	1(100%)	1(100%)
12-13yrs	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	2(100%)	6(100%)
13-14yrs	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	1(25%)	6(100%)	3(75%)
14-15yrs	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	11(100%)
15-16yrs	1(10%)	0(0.0%)	0(0.0%)	2(6.90%)	2(20%)	1(3.45%)	7(70%)	26(89.66%)
16-17yrs	1(7.69%)	2(3.08%)	2(15.38%)	16(24.62%)	1(7.69%)	16(24.62%)	9(69.23%)	31(47.69%)
17-18yrs	0(0.0%)	9(27.27%)	4(28.57%)	15(45.45%)	4(28.57%)	3(9.09%)	6(42.86%)	6(18.18%)
18-19yrs	8(50%)	12(66.67%)	3(18.75%)	5(27.78%)	3(18.75%)	0(0.0%)	2(12.50%)	1(5.56%)
19-20yrs	7(87.50%)	11(100%)	1(12.50%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)
20-21yrs	19(100%)	32(100%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)

Table 4: Age and Sex wise case distribution of epiphyseal fusion around elbow joint.

Age group	Fusion		Recent fusion		Incomplete fusion		Non fusion	
	Male	female	male	female	male	female	male	female
11 - 12yrs	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	1(100%)	1(100%)
12 - 13yrs	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	2(100%)	6(100%)
13 - 14yrs	0(0.0%)	1(25%)	0(0.0%)	1(25%)	1(16.67%)	0(0.0%)	5(83.33%)	2(50%)
14- * 15yrs	0(0.0%)	5(45.45%)	0(0.0%)	3(27.27%)	0(0.0%)	0(0.0%)	0(0.0%)	3(27.27%)
15 - 16yrs	6(60%)	22(75.86%)	1(10%)	5(17.24%)	2(20%)	1(3.45%)	1(10%)	1(3.45%)
16 - 17yrs	11(84.62%)	64(98.46%)	1(7.69%)	1(1.54%)	0(0.0%)	0(0.0%)	1(7.69%)	0(0.0%)
17 - 18yrs	14(100%)	33(100%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)

Table 5: Age and Sex wise case distribution of epiphyseal fusion in Ischial tuberosity.

Age group	Fusion		Recent fusion		Incomplete fusion		Non fusion	
	male	female	male	Female	male	female	male	female
16 - 17 yrs	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	1(1.54%)	13(100%)	64(98.46%)
17 - 18yrs	0(0.0%)	2(6.06%)	0(0.0%)	0(0.0%)	0(0.0%)	6(18.18%)	14(100%)	25(75.76%)
18 - 19yrs	3(18.75%)	2(11.11%)	3(18.75%)	1(5.56%)	4(25%)	7(38.89%)	6(37.50%)	8(44.44%)
19 - 20yrs	1(12.50%)	4(36.36%)	4(50%)	3(27.27%)	2(25%)	2(18.18%)	1(12.50%)	2(18.18%)
20 - 21yrs	17(89.47%)	29(90.63%)	0(0.0%)	0(0.0%)	0(0.0%)	2(6.25%)	2(10.53%)	1(3.13%)

Table 6: Age and Sex wise case distribution of ossification of tri-radiate cartilage.

Age group	Fusion		Recent fusion		Incomplete fusion		Non fusion	
	male	female	male	Female	male	female	male	female
13 - 14yrs	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	4(100%)	4(100%)
14 - 15yrs	0(0.0%)	10(90.91%)	0(0.0%)	0(0.0%)	0(0.0%)	1(9.09%)	0(0.0%)	0(0.0%)
15 - 16yrs	10(100%)	28(96.55%)	0(0.0%)	1(3.45%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)
16 - 17yrs	13(100%)	65(100%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)

under section 379 IPC and 392 IPC were 6 (7.40%) & 5 (6.17%) respectively. The cases of male accused under section 302 IPC were 8 (9.87%). The cases of female victim registered under POCSO Act were 90 (42.85%), and; male accused cases were 43 (53.08%). The female victim cases registered under PITA Act were 58 (27.61%). The male victim cases registered under child labour prevention and regulation Act were 7 (7.44%) and male accused cases registered under NDPS Act were 3 (3.70%). And some cases were detained under Juvenile Justice Act referred by child welfare committee for age determination. (Table 2)

Out of 80 cases of female victim registered under 376 IPC of which 10 (12.5%) cases were found to be pregnant at the time of examination. During study it was noticed that age of menarche in females at 13 years of age were 57 (27.01%) cases, at 14 years of age 48 (22.74%) cases, at 12 years of age 45 (21.32%) cases, at 11 years of age 14 (6.63%) cases as per the history given by each female victim during physical examination. In 40 cases female victim did not remember the definite age of menarche.

During the study, it was observed that on radiological assessment the complete epiphyseal union at wrist joint seen in 58.82% cases at the age group of 18 to 19 years and in 86.96% cases at the age group of 19 to 20 years. (Table 3) The complete epiphyseal union at elbow joint seen in 71.79% cases at the age group of 15 to 16 years and 96.05% cases at the age group of 16 to 17 years. (Table 4) The complete epiphyseal union of ischial tuberosity seen in 17.65% cases at the age group of 18 to 19 years and 26.09% cases at the age group of 19 to 20 years and

84.38% cases at the age group of 20 to 21 years. (Table 5) Fusion of tri-radiate cartilage seen in 90.91% cases at the age group 14 to 15 years and 97.44% cases at the age group 15 to 16 years. (Table 6) On dental examination it was noticed that earliest age of complete eruptions of lower left and right mandibular third molars were 17 to 18 years of age group in 38.30% cases, third molar erupted in 41.18% cases at 18 to 19 years, 52.17% cases at 19 to 20 years and 68.75% cases at the age group of 20 to 21 years.

In this study out of 305 cases, in 116 cases subject knew the date of birth and out of that in 74 cases calculated age was approximately equal to the age as per date of birth, but in remaining 42 cases calculated age is either less or more than the age as per date of birth.

Discussion

Age determination is important evidence in medico-legal cases. As per the various acts, laws and criminal law amendments, the definite age of an accused and victims are necessary to give justice and judgements. As per the criminal law amendment 2013, the age for having consensual sexual intercourse has been increased to the 18 years. As per the amended juvenile justice Act if age of accused is between 16 to 18 years and he committed heinous crime like rape, murder etc. then such child in conflict with the law can be treated as an adult in trial court and accordingly the punishment is awarded. Many times accused with age less than 18 years deliberately contented to be

age more than 18 years for the purpose to get some benefits of laws and avoid maximum punishments. So in such circumstances definite age determination is important.

In present study it was observed that the cases of females brought for age estimation (69.18%) outnumbered the male (30.82%). Majority of the female victims were found to be in the age group 15 to 18 years, with 125 cases (59.52%), followed by 63 cases (30%) in the above 18 years age group and 23 cases (10.95%) in the 4 to 15 years of age group. It has been observed that love affairs of girls led to abduction, sexual assault on girls on the pretext of marriage, female indulged in bar dancing for their livelihood and trafficking of girls account for more number of female victim's cases. In some cases it is observed that girls left their home and found working in the places like dance bar where they have been subjected to sexual harassment. The most of the subjects were unmarried as they were below 18 years of age. The present study has been conducted at urban area so that majority of cases belong to urban region.

The cases of victims registered under 376 IPC, 363 IPC & 366 IPC were 167, and majority of them were below 18 years. Owing to that such few cases were registered under POCSO Act with its sections 4, 6, 8 & 12. These cases were 90 in numbers. It has been observed that POCSO Act was invoked in such cases on account of victim's age less than 18 years. In present study it has also been noticed that in majority of the cases of victims had love affair with accused and had history of consensual sex. Also most of the victims were left the home after disapproval for legal marriage from their parents and also on the false promises made by accused to them. Most of the victims were students or stayed at home. Five cases of incest and one case of mentally retarded victim of sexual assault has been observed during study. Two cases of gang rape have been noticed during study. In 16 cases, victims were either stalked, accosted on road for sexual favour and sexual advances made by accused. The cases of the victims registered under PITA act were 58. Most of the victims rescued from the hotels where they were found dancing, singing, allegedly making obscene gesture or indulging in the prostitution and accordingly cases were registered under different IPC sections and acts. The most of these victims were trafficked from other states or from other country for the purpose of immoral practices.

The cases of accused registered under heinous crime like sexual assault, murder etc. were referred for age by juvenile justice board, session's judge or prison authority. Most of the accused were found to be child in conflict with the law and so meticulous assessment as to age determination done in such cases. Three cases of accused were registered under NDPS act, in which they were found to be in possession of narcotics drugs and were drug peddlers. Seven cases of male victim were registered under child labour prevention & regulation act and their age were found to be less than 14 years.

During this study while determining the age of individual as per radiological assessment as to what time of age epiphyseal union occurs at different joints, it has been observed that epiphyseal fusion at all joints occur earlier in females than males. An

earliest fusion seen in the females at age group 14 to 15 years in 45.45% cases, but no fusion seen in males by that time. Our findings are consistent with the works of Bhise and Nanandkar⁵. The epiphyseal fusion around elbow joint in the females were seen in 22 cases (75.86%) at the age group 15 to 16 years, while in the males 6 cases (60%) at the same age group.

The epiphyseal fusion around elbow joint in the females were seen in 64 cases (98.46%) at the age group 16 to 17 years, while in the males were seen in 11 cases (84.62%) at the same age group. This observation is similar to the other studies⁵ and observations described in various textbooks.¹⁻³ The epiphyseal fusion around wrist joint in the females were seen in 12 cases (66.67%) at the age group 18 to 19 years, while in the males at same age group epiphyseal fusion seen in 8 cases (50%). By 19 to 20 years of the age group in females 100% fusion seen around wrist joint while in the males at same age group fusion were seen in 87.50% cases. These findings are similar to the observations reported in earlier studies.⁶⁻¹⁶ The ossification of ischial tuberosity was found to have occurred in 90.63% cases in the females at the age group 20 to 21 years and in males 89.47% cases at same age group. Our findings were close to other studies¹⁷⁻²⁰ at the age group 15 to 16 years, the fusion of tri-radiate cartilage seen in 100% cases in the males and 96.55% cases in the females in present study.

Third molar has been erupted at the group 17 to 18 years in 38.30% cases both in male and female and this findings are consistent with observations described in Modi's textbook.²⁰ Mandibular third molar erupts earlier than maxillary third molar in present study which is similar observation found in other studies. From this present study conclusions can be made are most of the female victims belong to age group 15 to 18 year; in 50% cases, the accused contending to be child conflict with the law, on radiological assessment found to be more than 18 years, so the information furnished about birth date and supportive documents were found to be unreliable; in the majority of cases of sexual assault, the history of consensual sex has been established out of love affair; epiphyseal fusion around elbow joint, wrist joint & pelvis found to be earlier in females than males and Radiological analysis of lower end of radius and ulna, elbow joint, ischial tuberosity and tri-radiate cartilage can be used for estimation of age.

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References

1. Reddy KSN. The Essential of Forensic Medicine and Toxicology. 33rd Ed. New Delhi, Health Sciences Publishers; 2014: 72-82.
2. Mathiharan K, Patnaik AK. Modi's Medical Jurisprudence and Toxicology. 23rd Ed. New Delhi, India: Butterworths; 2005: 645-55.

3. Nandy A. Principles of Forensic Medicine: Including Toxicology. 3rd Revised Ed. New Delhi, New Central Book Agency (P) Ltd; 2010: 107-38.
4. Flecker H: Time of appearance and fusion of ossification centres as observed by Roentginographic methods. American Journal of Roentgenology. 1942; (47): 97-159.
5. Bhise SS, Nanandkar SD. Age determination from radiological study of epiphyseal appearance and fusion around elbow joint. Journal of Forensic Medicine, science and Law. 2011; 20(1): 24-32.
6. Bhise SS, Chikhalkar BG, Nanandkar SD, Chavan GS. Age Determination from Radiological Study of Epiphyseal Appearance and Union around Wrist Joint and Hand. J Indian Acad Forensic Med. 2011; 33(4): 292-95.
7. Wankhade P, Tirpude BH, Khandekar IL, Hussaini N, Wankhade SP. A roentgenographic study of wrist joint ossification for age estimation in the male population of central India. Journal of Forensic Medicine, Science and Law. 2013; 22(1): 10-19.
8. Sharma Y. Thesis for MD Forensic Medicine titled a Roentgenologic prospective study of epiphyseal union around elbow and wrist joint and pelvis in boys and girls of Mewar region of Rajasthan. Submitted to the University of Rajasthan, 1994; Jaipur.
9. Lall R, Nat B S. Ages of Epiphyseal union at the Elbow and Wrist joints amongst Indians, Indian J Med Res. 1934; XXI: (4): 683-687.
10. Loomba S D. Age of Epiphyseal union at the wrist joint in U.P. J Indian Med Assoc. 1958; 30 (12): 389-395.
11. Vaishnawa NK, Jugtawat J, Shrivastava A, Vyas PC Epiphyseal union at lower end of radius and ulna in the age group of 16-20 years in Jodhpur Region of Rajasthan. J Indian Acad Forensic Med 2015; 37 (2): 135-139.
12. Nemade KS, Kamdi NY, Parchand MP. Ages of epiphyseal union around wrist joint- a radiological study. J Anat Soc India 2010; 59(2): 201-10.
13. Gaddewar R , Meshram MM. Assessment of skeletal maturity by radiological study around wrist joint in vidarbha region. J Indian Acad Forensic Med 2017; 39(1): 46-50.
14. Banerjee KK, Agrawal BBL. Estimation of age from epiphyseal union at the wrist and ankle joints in the capital city of India. Forensic Sci Int 1998; 98(1): 31-19.
15. Sangama WB, Marak FK, Singh MS, Kharrubon B: Age determination in girls of North-Eastern region of India. J Indian Acad Forensic Med. 2007; 29(4): 102-8.
16. Patel DS, Agarwal H, Shah JV. Epiphyseal fusion at lower end of radius and ulna valuable tool for age determination. J Indian Acad Forensic Med. 2011; 33(2): 125-9.
17. Galstaun G A. A study of ossification as observed in Indian subjects. Indian J Med Res..1937; (25): 267-327.
18. Parikh CK. Personal identity, Parikh's Textbook of Medical Jurisprudence and Toxicology. C.B.S. (edi.) 5th; 1990; pg. 39-50.
19. Vij K. Identification, Textbook of Forensic Medicine, Principle and Practice B.I. Churchill Livingston, (ed), 1st 2001; pg. 74-82.
20. Modi JP: Personal identity. Modi's Medical Jurisprudence and Toxicology. 22nd Ed. New Delhi: Lexis Nexis Butterworth's publication; 1988; 35-42.

Linear and multiple logistic regression analysis of hand measurements of adolescent boys and girls of Ladakh (Jammu and Kashmir) for sex determination: A forensic-anthropological study

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Abstract

To establish biological profile of an unknown person is important to narrow down the possibility of identification in forensic anthropological contexts in absence of any other concrete evidence. Present study was designed to collect baseline anthropometric data and established models for sex determination among Ladakh adolescents. Different hands parameters were recorded on 229 adolescents (129) boys and (77) girls age between 14-19 years using standard techniques and instruments. All the subjects were right-handed. Different hands parameters were measured by using sliding callipers. Statistically significant differences were observed between all hand measurements of boys and girls ($p < 0.001$). Male hand dimensions were found larger than the girls. Left hand breadth was found the highest sex predictor variable in linear logistic regression analysis to accurately determine sex of (90%) boy's subjects to their biological sex category whereas right hand breadth accurately predicted sex of (76.2%) girls. Left hand breadth and left hand breadth accurately determines (90.7%) boys and (79.2%) girls, respectively by multiple logistic regression. This study is population specific and useful for forensic and medico-legal experts in formulating biological profile of unknown person.

Key words

Forensic anthropology; Sexual dimorphism; Hand measurements; Ladakh adolescents; Population specific

Introduction

Various techniques have been applied by the biological anthropologist to identify the individuals (living as well as dead) from various body parts.¹⁻³ Anthropometry is the best known method of identification an individual and it is also known as Bertillon system of identification.⁴ Sexual dimorphic differences in human body dimensions and features are also reflected in their skeleton. Males have larger body physique and are taller than the females due to certain genetic, nutrition and environmental factors.^{5,6} Conducted a research on the corpses of two sexes for the first time who reported that there exists a significant correlation between various body dimensions and sex and stature of an individual. Determination of sex is the classification of individuals as either male or female. A number of studies have been reported in the literature which used body dimensions or osteometrics to estimate sex and stature of an individual in different population groups. Population specific standards (discriminant scores or regression equations) have been proposed to estimate sex of a person from anthropometric measurements.⁷⁻⁹ Sex estimation is an important component of biological identity of an individual as it just halves the task of a forensic anthropologist. Due to certain natural or man-made

disasters like traffic accidents, floods, earthquakes, war-like conflicts etc., a number of body parts are found scattered at the site. Identity establishment of deceased is important from certain ethical, legal, moral and sometimes political perspectives. Though certain population-specific standards are available, these standards cannot be applied as such to other populations or secular changes might have occurred in already stated standards.^{10,11} Later found these standard cannot be use to predict the whole population as the earlier standards acquired for the prediction of sex and stature have lost their values due to secular changes in modern population Therefore it becomes necessary to develop renewed standards method for achieve precision and accuracy in sex estimations for a particular population.

It is important for forensic anthropologist to establish biological profile of the deceased from available body parts like hand or foot in case of mass-disasters, traffic accidents, war or war-like conflicts etc. Anthropometry of hand has been found an important tool to predict correlation between body measurements and sexual dimorphism in an individual.¹²⁻¹⁴ Biological profile consists of age, stature; sex, ethnicity and traumatic conditions of an individual to narrow down the possibility of identification in medico-legal or forensic anthropological contexts.^{14,15} Once the basic information i.e. the biological profile of an unknown individual is established by forensic anthropologist, the other techniques like DNA profiling, biometrics like fingerprints, facial reconstruction etc., can be used accordingly to provide positive identification of the individual¹⁶. The present study was conducted to:

- To collect base line anthropometric measurements from

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adolescent boys and girls of (Ladakh) J&K.

- To determine sexual dimorphism in hand measurements like length and breadth of hand, length of index and ring fingers.
- To established regression models for sex determination and to determine sexing accuracy of hand variables to estimate sex accurately of an unknown person from Ladakh region of J & K.

Material and Methods

The present study was conducted on 229 adolescents (129) boys and (77) girls, aged between 14-19 years Subjects having any abnormality in their hands were discarded for inclusion in this study. The data was collected from students studying at the higher secondary schools of Kargil, Ladakh. Data obtained are height of the subject, the hand length, hand breadth, index finger length and ring finger length from both sides of hand with the help of sliding calliper (in cm) to the nearest millimetre after taking permission from the respective school authorities and consent of each subject prior to taking their hand measurements. The standard methods were followed to take the said measurements on hand suggested in literature.^{16,17} Data obtained were entered in the excel spread-sheets and transferred to the SPSS software (version 16.0) for further statistical analyses. Logistic regression was used to determine sex on this data because regressions fit well with various types of distribution of data sheets. The correct sex estimation accuracies were estimated for each measurement in univariate analysis and all measurements in multivariate regression analysis and regression equations were suggested for determination of sex of an unknown individual belonging to Ladakh region of Jammu and Kashmir. T-test was applied to test the significance of differences between hand measurements of male and females. Technical error of measurements and absolute technical error of measurements were calculated on each parameter as subjected to some degree of measurements error by using TEM formula. $TEM = \sqrt{\Sigma D^2 / 2N}$ where, D is the difference in measurements, N is number of individual measured as given in Table 1.

Table 1: Technical error of measurements and absolute technical error of the measurements

Variables	TEM	ATEM %
Height	1.67	1.02
Right Hand Length (RHL)	0.17	0.99
Right Hand Breadth (RHB)	0.12	1.57
Right Index Finger Length (RIFL)	0.13	2.11
Right Ring Finger Length (RRFL)	0.11	1.73
Left Hand Length (RHL)	0.12	0.71
Left Hand Breadth (RHB)	0.12	1.51
Left Index Finger Length (RIFL)	0.14	2.18
Left Ring Finger Length (RRFL)	0.15	2.26

Results

Height of the participants varied from 140.5 cm to 167.2 cm with an average 155.43±4.80 cm in girls and from 147cm to 185cm with an average height of 166.72±6.06 in boys. Table 2 shows the mean values of height and hands measurements among adolescent boys and girls included in the study. The height and all the hand and finger measurements included in the study were significantly larger in boys than girls (P<0.001). Different linear regression equations established from hand measurements of both left and right hands are shown in (Table 2).

Table 2: Descriptive statistics of hand variables in adolescent boys and girls of Ladakh

Variables	Adolescent Girls	Adolescent Boys	Independent t-test	
	Mean ±S.D	Mean±S.D	t-value	p-value
Height	155.43±4.80	166.72 ±6.06	13.94	<0.001
RHL	16.36 ±.82	17.63±.82	10.78	<0.001
RHB	7.36 ±.39	8.12±.38	13.78	<0.001
RIFL	6.29 ±.39	6.69±.39	7.05	<0.001
RRFL	6.38±.41	6.88±.41	8.44	<0.001
LHL	16.37±.85	17.60±1.18	8.03	<0.001
LHB	7.30 ±.37	8.05±0.377	14.15	<0.001
LIFL	6.38±.42	6.76±0.40	6.52	<0.001
LRFL	6.38 ±.41	6.01±0.44	8.21	<0.001

Hand variables showed different accuracy rate for sex prediction also among Ladakhi adolescent. Right hand length accurately determines (87.6%) boys and (67.5%) girls respectively and (80.1%) collectively. Left hand length accurately determines (89.9%) boys and (61.0%) girls respectively and accurately (79.1%) combined in both boys and girls. Right hand breadth accurately determines (89.9%) boys and (76.6%) girls which combinedly determines (85.5%) sex. Left hand breadth shows higher accurately determine (90.7%)

Table 3: Linear logistic regression models for sex determination and their predictive accuracy (PA) from different hand variables among the adolescent boys and girls of Ladakh

Regression models	PA (Boys)	PA (Girls)	PA (Combined)
29.852 -1.785 (RHL)*	87.6%	67.5%	80.1%
22.007 -1.321(LHL)*	89.9%	61.0%	79.1%
35.916 -4.698 (RHB)*	89.9%	76.6%	85.0%
40.472 -5.33 5 (LHB)*	90.7%	75.3%	85.0%
18.997 -2.941(RRFL)*	84.5%	55.8%	73.8%
17.394 -2.700(LRFL)*	86.8%	58.4%	76.2%
16.278 -2.586(RIFL)*	84.5%	44.2%	69.4%
14.144 -2.230(LIFL)*	85.3%	48.1%	71.4%

*P<0.01

boys and (75.3%) girls with overall (85.5%) accuracy. Ring finger length of left and right hand accurately determines (73.8%) boys and (76.2%) girls accurately. Index finger length of left and right hand accurately determines (84.55%) and

(85.3%) boys, (44.2%) and (48.1%) with overall accuracy of (69.45%); (71.4%) boys and girls combined. Among all the variables Left hand breadth showed highest accuracy with (90.7%) and index finger length showed lowest accuracy with (44.2%) as given in (Table 3).

Multiple logistic regressions determined accurately (89.9%) boys and (80.5%) girls from hand length and hand breadth of right hand respectively and combinedly determines (86.4%). Left hand breadth and left hand breadth accurately determines (90.7%) boys and (79.2%) girls and 86.4% combinedly. Right Ring and index finger length accurately determines (85.3%) boys and (55.8%) girls and combined (74.3%) sex can be determined. Left ring and index finger length can accurately

Table 4: Multiple logistic regression models for sex determination and their predictive accuracy (PA) from hand variables of adolescent boys and girls of Ladakh

Regression models	PA (Boys)	PA (Girls)	PA (Combined)
40.595 - 3.847 (RHB)*- 0.661 (RHL)	89.9%	80.5%	86.4%
43.790 - 4.989 (LHB)*- 0.350 (LHL)	90.7%	79.2%	86.4%
19.879 - 2.540 (RRFL)*- 0.546 (RIFL)	85.3%	55.8%	74.3%
17.623 - 2.579 (LRFL)* - 0.158 (LIFL)	86.8%	58.4%	76.2%

*P<0.01

determine (86.8%) boys and (58.4%) girls and (76.2%) combinedly as shown in (Table 4). Highest accuracy was shown by hand length and breadth of left hand.

Discussion

Establishing identity of humans from the remains is a challenging task for forensic anthropologist in medico-legal contexts. Many studies have conducted for sex determination from hand dimensions such as hand length, hand breadth, ring finger length, index finger length, metacarpals and proximal phalanges.⁹ No anthropometric study was accessible to the authors in the literature for sex determination from hand measurements of subjects of Ladakh. During adolescent period many changes take place physically, mentally and socially. Height and other bodily dimensions increase at much higher rate during adolescent. Height among Ladakhi adolescent boys and girls are lower than average height for Indian children as per Indian Academy of Paediatrics,¹⁸ probably due to due to certain environmental, genetical and economic factors. Ladakh is a high altitude area situated about more than 3000 meters above sea level. Climate of Ladakh is severely harsh cold in winters with very short summers, and the economic conditions are not well off which leads to poor nutritional conditions and hence retarded physical growth of individuals in the region.¹⁹ Hand breadth shows the best predictor for sex determination among Udaipur Rajasthani population same result has found in the present study too hand breadth can accurately determine (85%) boys and girls. The accuracy rate for sex determination in the present study is 84.5% boys and 86.5% girls from right ring length finger. They found significant sexual dimorphism in the

hand dimensions between males and females. In the present study also found males have larger hand length with +1.27 cm and hand breadth with +0.76 cm as compared with their female counterparts.

Sexual dimorphism in the hand dimensions of adolescent boys and girls may be all because of the high intense and rapid adolescent growth spurt in males in which the hormones androgen- dependent bone growth faster and last for longer period than in female counterparts, which result in taller extremities such, arms, legs, hand and foot. In Egyptian population, sexes were accurately determined to (90.4%) males 85.6%) females from right and left ring finger.²⁶ Conducted sex estimation from index finger length and ring finger length were found significantly longer in males than females and the sex estimation accuracy rate was (70-75%) in Rajbanshi and 60-66% in Karbi populations of eastern India.⁸ In the present study too, ring finger index finger lengths were longer in males by +0.4cm and 0.5cm in right hands and accuracy for sex determination found to be greater i.e. (73.8%) and (76.2%) in present study than in eastern population.²⁰ Conducted digit ratio study on different ethnics group of Berbers, Uygurs, Hans and Jamaicans. They found the males have lower 2D:4D ratios than the females and had significant differences in 2D:4D ratios in entire ethnics group. Digit ratio is ration of length of different digits or fingers which is measured from the midpoint of bottom crease to tip of finger. 2D:4D ration is considered for index finger and ring finger ration.²¹ It has been found by many researchers that there exist a correlation between age, sex and stature with every different part of our body. Sex estimation can be determined not only from hand variables but with others parts of our body such as foot variables, cephalometry, palatal rugae and long bones.²²⁻²⁴ Divaker *et al.*,²⁴ found that reliability of sex determination is 100% from the lateral cephalometric based on his study on the Croogs population of Karnataka. Average hand length and breadth among the adolescent of Ladakhi are smaller than the others North Indian population, South Indian, Rajasthani and Egyptians population studied by Wankhede *et al.*,²², Kanchan and Rastogi²⁵ and Aboul-Hagag *et al*²⁶, though were found almost equal to the Mauritius subjects.⁹ The shorter hand variables of present study might be due to the different socio-economic status, age differences and the genetic features when compared with other studies. The present population belongs to Mongoloid ethnic groups. It has been found that higher socioeconomic status may have ensured good nutrition; sound growth and earlier maturation that took place earlier than the individuals belonging to lower socioeconomic profile. Present study results may not provide accurate accuracy for forensic anthropological identification of Ladakh subjects but it can be a valuable adjunct to other forensic identification methods.

Conclusion

Present study is useful for the forensic anthropologist and medico-legal experts for establishing biological profile of a

dead person, whose death is caused by fire or tragic accidents such as by bombing or jet crash, where only body parts have been recovered. Significant sexual differences have been noticed between various hands measurements considered here. The study revealed that left hand breadth was found the highest sex predictor variable in linear logistic regression analysis to accurately determine sex of (90%) boy's subjects to their biological sex category whereas right hand breadth accurately predicted sex of (76.2%) girls. Left hand breadth and left hand breadth accurately determines (90.7%) boys and (79.2%) girls, respectively by multiple logistic regression. These findings are population specific and can only be useful for sex estimation among the Ladakhi adolescent. More data and research should be carried on different populations groups for more reliability and accuracy for sex determination.

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References

- Burns KR. Forensic Anthropology Training Manual. New Jersey: Prentice Hall Publishing; 2007
- Kanchan T, Krishan K. Personal identification in forensic examinations. *Anthropol* 2013; 2(1):114
- Ali M, Sehrawat JS. Stature reconstruction from cephalo-facial measurements of Brokpa Tribals of Kargil (India): A forensic anthropological investigation. *Int J Med Toxicol Leg Med* 2017; 20(3-4):22-28
- Bertillon A. Identification Anthropometrique. *Melun*. 1885; 65-73
- Nancy E, Sciulli PW. Anthropological analysis of the lower extremity. In: Rich J, Dean DE, Powers RH (eds.); *Forensic Medicine of the Lower Extremity: Human Identification and Trauma Analysis of the Thigh, Leg and Foot*. Switzerland; Humana Press, 2005; 69-98
- Rollet, E. De la mensuration des os longs des membres dans ses rapports avec l'anthropologie. *La Clin et la Med. Judi*, Lyon. 1889.
- Pickering RR, Bachman DC. *The Use of Forensic Anthropology*. New York: CRC Press-Taylor and Francis Group, 2009.
- Sen J, Kanchan T, Ghosh A, Monadl N, Krishan K. Estimation of sex from index and ring finger lengths in an indigenous population of Eastern India. *J Clin Diag Res* 2015; (9): HC01-HC0
- Agnihotri A, Purwar B, Jeebun N, Agnihotri S. Determination of sex by hand dimensions. *Internet J Forensic Sci* 2005; 1(2):1-3.
- Eveleth PB, Tanner JM. *Worldwide variation in human growth*. Cambridge, U.K: Cambridge University Press; 1976
- Ulijaszek SJ, Masci-Taylor CJN. *Anthropometry: The individual and the population Cambridge studies in biological anthropology*. Cambridge, UK: Cambridge University Press; 1994.
- Case DT, Ross RH. Sex determination from hand and foot bones lengths. *J Forensic Sci* 2007 (52): 264-270
- Iscan MY. Forensic anthropology of sex and body size. *Forensic Sci. Int* 2005 (147): 107- 112
- El-Najjar MY, McWilliams KR. *Forensic anthropology: the structure, morphology and variation bone dentition*. Springfield, IL: Charles C. Thomas; 1978.
- Krogman MW, Iscan MY. *The Human Skeleton in Forensic Medicine*. 2nd eds. Springfield, IL: Charles C. Thomas; 1986
- Singh IP, Bhasin MK. *Anthropometry*. Delhi: Kamla-Raj Enterprises; 1989.
- Vallois HV. Anthropometric techniques. *Current Anthropol* 1965 (6):127-44.
- Khadilkar V, Yadav S, Agarwal KK, Tamboli SS, Banerjee M, Cherian A, et al. Revised IAP growth chart for height, weight and BMI for 5 to 18 yrs old Indian children. *Ind Pediatr* 2015; (52):47-55
- Dey S, Kapoor AK. Sex determination from hand dimensions for forensic identification. *Int J Res Med Sci* 2015; 3(6):1466-1472.
- Manning JT, Stewart A, Bundred PE, Trivers RL. Sex and ethnic differences in 2nd to 4th digit ratio of children. *Early Human Develop* 2004; 80 (2):161-168.
- Mayhew TM, Gillam L, McDonald R, Ebling FJP. Human 2D (index) and 4D (ring) digit length: their variation and relationships during the menstrual cycle. *J Anat* 2007; 211(5): 630-638
- Wankhede KP, Bardale RV, Chaudhari GR, Kamdi NY. Determination of sex by discriminant function analysis of mandibles from a Central Indian population. *J Forensic Dent Sci* 2015;7(1):37-43
- Bharath ST, Kumar GV, Dhanapal R, Saraswathi. Sex determination by discriminant function analysis of palatal rugae from population of coastal Andhra. *J Forensic Dent Sci* 2011; 2(3): 58-62
- Divakar DD, John J, Kheraif AA, Manviapalla S, Ramkrishnaiah VS, Hashem MI, et al. Sex determination using discriminant function analysis in indigenous (Kurubas) children and adolescent of Croog, Karnataka, India: A lateral cephalometry study. *Saudi J Bio Sci* 2016; 23(6):782-788.
- Kanchan T, Rastogi P. Sex determination from hand dimensions of North and South Indians. *J Forensic Sci* 2009; 54(3):546-50.
- Aboul-Hagag K, Mohamed SA, Hilal MA, Mohamed EA. Determination of sex from hand dimensions and index/ring finger length ratio in Upper Egyptians. *Egypt J Forensic Sci* 2011; 1(2):80-86.

Profile of deaths due to thermal injuries in a coastal township in South India

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Abstract

Morbidity and mortality related to thermal injuries are a serious health concern worldwide. Burns and scalds are known to be responsible for a significant fraction of deaths in South India every year. The aim of this retrospective study is to give an overview of the trends in burn epidemiology in Manipal, during the years 2011 to 2015. The 5 years retrospective research was conducted in the mortuary attached to the tertiary care teaching hospital in the study area. All cases of deaths due to thermal injuries between 2011 and 2015 were included in this study. Relevant information was collected from post mortem records and analysed for descriptive statistics using Statistical Package for Social Sciences (SPSS) 21. Deaths due to thermal injuries constituted 14% of the total unnatural deaths that occurred during the study period. 68% of the victims were female. The victims were aged between 1 and 80 years. The percentage of burnt body surface area varied in the range of 22% and 100%. The time interval between the occurrence of the incident and death of the victim ranged between 1 day and 3 months. The highest number of cases occurred in the months of April, May and June. The causes of death included complications such as hypovolemia, septicaemia, pulmonary edema and renal failure. The findings of this study give us an insight into the pattern and magnitude of deaths due to thermal injuries so that preventative measures can be suggested and taken up accordingly.

Key words

Thermal Injuries; Body surface area burnt; Preventive measures

Introduction

Hot beverages ease a sore throat; fires cook food; give warmth and light

Electricity powers appliances; all essential... but also a source of fright

Burns, scars, scalds and shocks are all caused by these necessary evils

We must, therefore, be wary...for they can wound or even kill!

Thermal injuries comprising burns, scalds and electrocution are commonplace in the developing world and are associated with significant morbidity and mortality. The effects of overpopulation, illiteracy, poor standards of safety at home and in the industry further add to the overwhelming rise in the burn incidents¹. They constitute a major health problem and lie next only to road traffic accidents as a major cause of death in India². Such deaths can be attributed to household accidents, accidents at the workplace, suicide and dowry deaths.

An analysis of the epidemiological factors associated with thermal injuries and comparing the findings with other national and international studies will assist in both the clinical and social fields to prevent and manage thermal injuries.

Material and Methods

The 5-years retrospective research was conducted in the mortuary attached to the tertiary care teaching hospital in the study area after obtaining approval from the Institutional Ethics Committee. All cases of deaths due to thermal injuries under Sections 174 and 176 Criminal Procedure Code that took place between 2011 and 2015 were included in this study. The post mortem records of the victims were retrieved and perused. Relevant information was collected and analysed for descriptive statistics using Statistical Package for Social Sciences (SPSS) 21.

Results

Eight hundred sixty-one unnatural deaths (under sections 174 and 176 Cr Pc) were reported during the study period, of which 14% (121) were due to thermal injuries. Burn injuries constituted 77% of the total cases, scalds constituted 14%, and electrocution constituted 5%. Of the 121 victims, 68% were female and 32% were males. No age group was spared from thermal injuries. The highest incidence was in the age groups of 21-30 years (26%), followed by 31-40 years (21%). Least percentage of cases was noted in the age groups of >80 years (0.8%) and 0-10 years (6%). (Fig 1)

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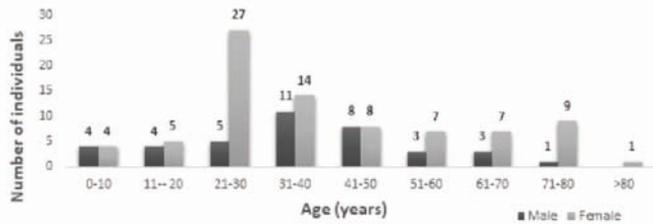
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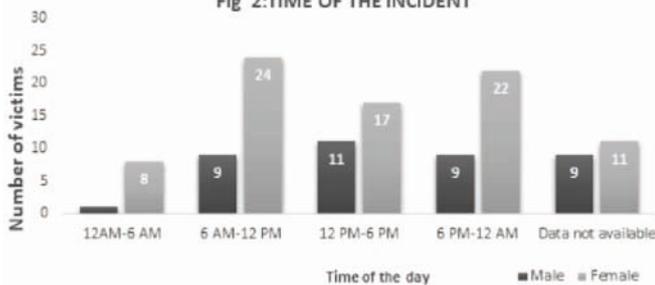
50.4% of thermal injuries were sustained during the daytime (between 6 AM and 6 PM) as against 33% of victims who sustained burns in the night time. Majority of the cases in males were reported to have taken place between 12 PM, and 6 PM (28.2% of males; 9% of total) and the least percentage of cases

Fig 1: AGEWISE DISTRIBUTION OF CASES



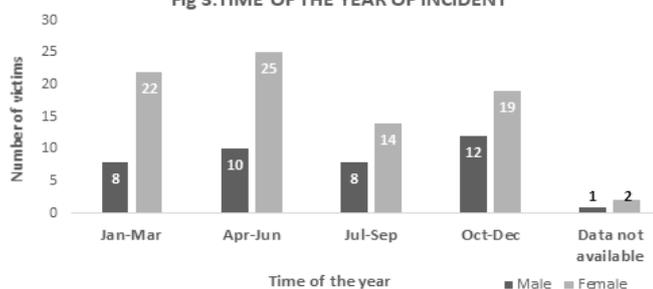
were reported to have taken place between 12 AM and 6 AM (2.5% of males; 0.8% of total). Maximum incidence of thermal injuries in females was noted between 6 AM and 12 PM (29.3% of females; 19.8% of total), and minimum incidence was noted between 12 AM and 6 AM (9.8% of females; 6.6% of total). (Fig 2)

Fig 2: TIME OF THE INCIDENT



The maximum percentage of cases took place during April, May and June (28.9%). Least percentage of cases occurred during July, August and September (18.2%). In males, the maximum percentage of cases were reported during October, November and December (30.8% of males; 10% of total). In Females, the maximum percentages of cases were reported during April, May and June (30.5% of females; 20.7% of total) as shown in Fig 3.

Fig 3: TIME OF THE YEAR OF INCIDENT



The time interval between the incident and death of the victim (Fig 4) ranged between 1 day and one week in the majority of the victims, i.e 44%. Only 1.6% of the victims survived for longer than a month after the occurrence of the incident. 6.6% died within 24 hours of sustaining the injuries. The maximum percentage of victims (17.4%) had 91-100% involved body surface area. Only

6.6% of the victims had <30% of body surface area involved. In males, the majority of victims (17.9% of males; 5.8% of total) had 51-60% of burnt body surface area. In females, the maximum percentage of victims (18.3% of females; 12.4% of total) of victims had 91-100 % of involved body surface area as shown in Fig 5.

Fig 4: TIME INTERVAL BETWEEN INCEDENCE AND DEATH

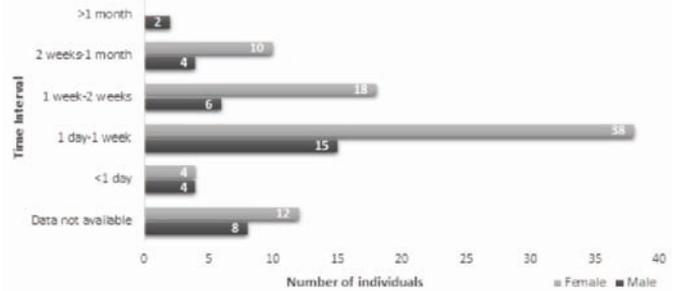
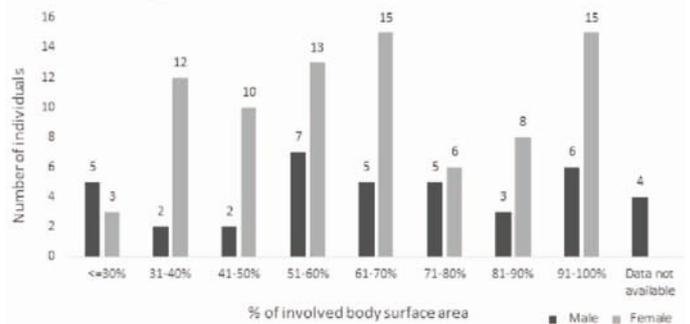


Fig. 5: PERCENTAGE OF BODY SURFACE AREA INVOLVED



Discussion

A strong female preponderance was noted in our study. 68% of victims were females and 32% were males which is in agreement with the studies conducted by Chawla et al.¹ who observed 64% cases belonging to females and 36% males and Aggarwal and Chandra study³ showing 67% females and 33% males. Doshi⁴ observed 157 females and 143 males in his study of 300 cases with male to female ratio of 1:1.17. Ganguli⁵ observed 58.34% of cases belonged to the female category as compared to 41.66% males. The reason for this preponderance is that females are more likely to be the victims of domestic accidents such as stove burst and gas leakage. Also, adornment of loose clothing makes them vulnerable to catch fire. Dowry deaths also contribute to a significant fraction of deaths due to burns in females.

The highest incidence of thermal injuries was noted in the age group of 21-40 years, i.e 47%; out of which 34% were females and 13% were males. These findings are similar to studies conducted by Subramanyam⁶, Namedeora⁷ and Chawla et al¹¹. This can be explained by the fact that females are more involved in kitchen chores; making them prone to accidental burns. Also, dowry disputes and marital disharmony often lead to suicidal and homicidal episodes. Higher incidence of burns among males in this age group can be attributed to their exposure to causative factors such as generators, high power electricity

lines, furnaces and boilers both at home and the workplace.

50.4% of cases were reported to have taken place between 6 AM and 6 PM (during the daytime) as against 33% of victims who sustained burns during the night time. This is consistent with the studies conducted by Kumar et al⁸ and Yoshioka et al⁹. Most household chores are done during the daytime. Hence, the risk of sustaining burn injuries during these hours is high. Working individuals are more likely to sustain thermal injuries due to accidents at the workplace during the day time as their working hours generally lie within this time interval.

The maximum number of cases were reported during April, May and June, i.e 28.9%. Other national and international studies such as those conducted by Kumar et al⁸, Mostafa Hemada et al¹⁰ and Analacti et al¹¹ observed that maximum number of cases took place during the winter, the probable reason being the need to stay warm and the use of hot water for bathing. The present study, however, has findings that are dissimilar to ones stated above, for which the probable reason is multifactorial: 1) April, May and June are the months of the year where the temperature in the study area is at its peak. Hence, the likelihood of inflammable substances catching fire is greatly increased. 2) The extensive usage of kerosene stoves that lack safety measures. 3) Dowry deaths, domestic accidents and accidents at the workplace cannot be ruled out.

The time interval between the incident and the cause of death ranged between 1 day and 1 week in 44% and between 1 week and one month in 31.4% of the victims. 6.6% of the victims died within 24 hours of sustaining the injuries. Williams et al.¹² observed post burn survival of patients to be 29 + 50 days. Early causes of death include neurogenic shock, suffocation, hypovolemic shock and pulmonary edema. Delayed causes of death are sepsis, renal failure, pulmonary complications such as pneumonia and rarely, duodenal ulcers termed "curling's ulcer".¹³

The maximum percentage (17.4%) of the victims had > 90% involved body surface area .51-60% and 61-70% of body surface area was involved in 16.5% and 16.5% of the victims respectively (Fig 5). The lowest percentage of the victims (6.8%) had <30% involved body surface area. Similar observations were seen in the studies conducted by Sukhai et al¹⁴ and Betz et al¹⁵. Regarding with the above mentioned findings and figures 4 and 5, it can be inferred that it is the percentage of body surface area involved that decides mortality due to burns. More the percentage of body surface area burnt, less is the post burn survival period.

The findings of this study give us an insight to the pattern and magnitude of deaths due to thermal injuries in the region (which in turn reflects the prevailing social set up and mental health status), so that preventative measures such as: usage of safe stoves and lamps, careful handling of thermal instruments, regulation of water heater temperature, close adult supervision of children; and management strategies such as: first aid, fluid replacement and burn wound care can be suggested and taken up accordingly.

Ethical Clearance: Obtained from Institutional Ethics Committee (No.830/2016)

Conflict of interest: None

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References

- 1 Chawla R, Chanana A, Rai H, Aggarwal AD, Singh H, Sharma G. A Two-year Burns Fatality Study. *J Indian Acad Forensic Med*, 32(4): 292-297
- 2 Gupta JL, Makhija LK, Bajaj SP. National programme for prevention of burn injuries. *Indian J Plast Surg* 2010;43:S6-10.
- 3 Aggarwal BBL, Chandra J. A Study of Fatal Cases of Burns in South Zone Delhi. *Punjab Med J* 1970; 20(12): 451.
- 4 Doshi AJ. Aetiology of Burns. *Curr Med Pract* 1976; 20: 316-320.
- 5 Ganguli AC. Burns. *J Ind Med Assoc* 1976; 67: 150-152.
- 6 Subramanyam M. Epidemiology of burns in a district hospital in western India. *Burns* 1996;22(6):1-3.
- 7 Ambde VN, Godbole HV. Study of burn deaths in Nagpur, Central India. *Burns* 2006;32: 902-908.
- 8 Kumar P, Sharma M, Chanda A. Epidemiological Determinants of Burns in Pediatric and Adolescent Patients from A Centre in Western India. *Burns* 1994; 20:236-240.
- 9 Yoshioka T, Ohashi Y, Sugimoto H, Sawada Y, Kobayashi H, Sugimoto T. Epidemiological Analysis of Deaths Caused by Burns in Osaka, Japan. *Burns Incl Therm Inj*. 1982 Jul; 8(6):414-23.
- 10 Hemada M, Mahar A, Mabrouk A. Epidemiology of burns admitted to Ain Shams University Burns unit, Cairo, Egypt. *Burns* 2003; 29(4):353-358.
- 11 Anlatıcı R, Ozerdem OR, Dalay C, Kesiktaş E, Acartürk S, Saydaoğlu G. A Retrospective analysis of 1083 Turkish patients with serious burns. *Burns* 2002; 28(3):231-237.
- 12 Williams FN, Herndon DN, Hawkins HK, Lee JO, Cox RA, Kulp GA, Finnerty CC, Chinkes DL, Jeschke MG. The leading causes of death after burn injury in a single pediatric burn center. *Critical Care* 2009; 13: R183.
- 13 Pillay VV. Injuries due to Heat, Lightning, Electrocutation and Radiation. *The Essentials of Forensic Medicine and Toxicology*; 17th Ed. Hyderabad: Divyesh Arvind Kothari, 2016; p 262-263.
- 14 Sukhai A, Harris C, Moorad RG, Dada MA. Suicide by self-immolation in Durban South Africa; A fine year retrospective review. *Am J Forensic Med Pathol*. 2002; 23(3): 295-298.
- 15 Betz P, Roeder G, Meyer LV, Drasch G, Eisenmenger W. Carboxyhemoglobin Blood Concentrations in Suicides by Fire. *J British Acad Forensic Sci*. 1996; 36: 313-316.

Pattern of homicidal deaths in Khammam district, Telangana

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Abstract

The homicide cases are often intriguing and challenging to the investigative agencies. They often have local or regional characteristics, as well as various intricacies, which require through analysis and understanding for the administration of justice and to deter such incidences from recurring. The present retrospective study, analyses the data of 108 cases, from Jan 2017 to Dec 2017 for a period of one year in the Department of Forensic Medicine, Mamata Medical College, Khammam. Our study, revealed that the victims were mostly males of 21 - 30 years, married, Hindu, belonged to low socioeconomic status, from rural areas, literates and occupationally working as laborers. We observed, that the majority of the incidents had taken place at night 86 (79.63%), and most cases were reported during summer months (46.29%). Most of the homicides took place at victim 's residence; indoor incidents were commoner (45.37%) than outdoor incidents (27.77%). According to the day of incident, homicide deaths were more prevalent on weekends Sundays and Saturdays. Acquaintances were involved in the majority (69.44%) of the cases. In 12.25 % of cases, police did not suspect homicide prior to autopsy. The main motive was revenge in 40.74% cases. Sharp weapon injuries (45.37%) were the most commonly reported followed by blunt weapon injuries (30.55%). 90.74% of the victims died on the spot. Hemorrhage and shock was the most common cause of death. Previous enmity and family disharmony were the two common causes behind such heinous crime. Most victims had injuries over multiple body parts. Blood alcohol was found positive in 30.23% of victims. The study intends to identify the potential risk factors and susceptible victims and propose preventive measures.

Key words

Homicidal Death; Motive; Acquaintance; Family Disharmony; Victim

Introduction

Homicide is defined as, killing of one human being by another human being and is one of the leading causes of unnatural deaths.¹ Killing of an individual is the highest level of aggression found in all the cultures. Since ages the very reason or motive for these killings has remained the same v.i.z. lust for money, women and land. The methods employed by criminals are many, and the pattern and circumstances of crimes may have some regional characteristics. Criminals often try to hoodwink investigative agencies to avoid penalty, and therefore naturally it becomes challenging to for law enforcement agencies and the crime investigators to understand the pattern of crimes committed from time to time as well as region-specific patterns. To commit murder, two elements (Mens-rea which means preplanning or aforethought and Actus-reus which means the actual execution) should work together to constitute the crime.² The various patterns of homicidal deaths include assault by sharp weapon, blunt weapon, firearms, strangulation, homicidal hanging, smothering, drowning, burns, poisoning etc. The incidence of homicide is increasing worldwide and the pattern is

also changing because of population explosion, changing life style, modern needs of the man and easy availability of various type of weapons.³

More often than not, homicide is well planned; hence not usually adequately witnessed. In this context, it becomes difficult to elucidate the truth which mostly relies on linking the act of crime to the criminal, basing on scientific/circumstantial evidences. This creates a challengeable task for the investigating agencies to explore the mystery. As the investigation to a case of homicide will be incomplete without thorough analysis and scientific interpretation of autopsy findings, the responsibility of forensic medicine specialist is of immense importance to recognize the medico legal injuries in their right perspective, and help the investigating authorities and the judiciary for their legal conclusions.⁴

As per National Crime Record Bureau, violent crimes reported in India were 3.0% of the total Indian Penal Code crimes. The total number of murders recorded all over India in 2016 is 33,981 and in our state, Telangana it is 1308 which is still increasing every year.⁵ The incidence of homicide is increasing world wise and the pattern is also changing because of population explosion, changing life style, modern needs of man and easily availability of various type of weapons.

The present study was carried out to establish the prevalence of homicide in relation to various the epidemiological ,environmental and social factors, motive, explore different aspects of crime in relation to victims, acquaintances were involved, common methods used ,causes behind crime, pattern

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of homicide, type of weapons used for crime, time, place of occurrence of crime, seasonal variation, period of survival of victims, the causes for death, contributing factors, previous enmity, defence wounds, associated cognizable offence, sites of injuries are concerned, drug abuse, potential risk factors and initiate preventive measures. The findings will help in investigating a case of homicide which will further help in the deliverance of justice.

Material and Methods

A retrospective study was conducted in the department of Forensic Medicine, Mamata Medical College Khammam, during the period of one-year from Jan 2017 to Dec 2017. All the cases brought to the department for medico legal autopsy with alleged history of homicide and cases which were later registered as homicide were studied. All fatal homicidal cases included in the study were either hospitalized following trauma and subsequently succumbed to the injuries or were found dead with or without injuries. All putrefied or skeletonized bodies and those where nature of injuries was undetermined, were excluded from the study.

A detailed history regarding the case, age, sex, religion, area wise, marital status, educational status, socioeconomic status, occupation, time, and place of occurrence, day wise, season wise, causes of death, type of weapon used, relationship between victim and offender, motive behind death, circumstances of crime etc. were obtained from relevant sources, the police, victim's relatives and friends, post mortem reports and were recorded in a pre-designed proforma. Visits to the scene of occurrence or deduced by the photographs of the scene of occurrence. Post mortem examination of the case was carried out as per the standards. Master chart was then prepared which included the detailed description of all cases of homicide and the chart was systematically analyzed. Prior permission was taken from the institutional Ethics Committee for this study.

Results

During the study period, a total of 1294 postmortem examinations were conducted in Mamata General Hospital attached with Mamata Medical College, Khammam, of which 108 were fatal homicide. The most commonly affected age group was 21-30 years (39.81%) followed by 31-40 years (23.14%) and 41 -50 years (12.03%). Males (N=86; 79.62%) predominated females (N=22; 20.37%). Male to female ratio of the victims was 3:9. The present study also revealed that 63 victims were married (58.33%) and 38 were unmarried (35.33%). In this study most of the victims were followers of Hindu (N=89) belief followed by Islam (N=15) and Christianity (N=4). In our study, 60 deaths (55.55%) from rural areas are more than those reported in urban (N=48; 44.44%) areas. The majority of the victims had studied up to secondary education. Most of the victims belonged to low socioeconomic group as depicted in Table 1. We observed that most of the victims were

Table 1: Socio-demographic and time wise distribution of cases

Trait		N (%)
Education	Illiterate	10 (9.25)
	Primary	11(10.18)
	Secondary	51(47.22)
	Intermediate	20 (18.51)
	Degree	12 (11.11)
	Post Graduate	04 (3.7)
Socioeconomic status	Low	58 (53.7)
	Middle	32 (29.62)
	High	18 (16.66)
Time	Day	22 (20.37)
	Night	86 (79.62)
Seasonal variation	Winter (Nov-Feb)	30 (22.77)
	Summer (March-June)	50 (46.29)
	Rainy (July - Oct)	28 (25.92)
Day of the week	Monday	11(10.18%)
	Tuesday	10(9.25%)
	Wednesday	12(11.11%)
	Thursday	11(10.18%)
	Friday	14(12.96%)
	Saturday	23(21.29%)
	Sunday	27(25.00%)

Table 2: Occupation of the victims

Occupation	N (%)
Laborers	33 (30.55)
Farmers	13 (12.03)
House wife	12 (11.11)
Student	11 (10.18)
Employed	09 (08.33)
Unemployed	20 (18.51)
Business	10 (09.25)
Total	108 (100.00)

laborers (35.18%) followed by farmers (18.51%) among males and housewives (11.11%) among females as depicted in Table 2. The majority of homicides (45.37%) were committed at the house of victim followed by street (27.77%) and those in shared residence (12.03%) as depicted in Table 3. In the present study, 79.63% homicides took place in night and 20.37% took place in the day as depicted in Table 1. Regarding the monthly variations, 25.92% cases were reported in the month of May

Table 3: Place of Occurrence

Place of Occurrence	N (%)
Victim's House	49 (45.37)
Assailant's House	06 (05.55)
Victim's & Assailant's Shared Residency	13 (12.03)
Work Place	05 (04.62)
Street	30 (27.77)
Remote Place	03 (02.77)
Play Ground	02 (01.85)
Total	108 (100.0)

Table 4: Survival Period

Survival Period	N (%)
Spot Death (<1/2 hr).	98 (90.74)
½ hr.-1 day	08 (07.40)
1 to 7 days	02 (01.85)
Total	108 (100.0)

Table 5: Pattern of Homicide

Homicide caused by	N (%)
Sharp Weapon Injuries	49(45.37)
Blunt Weapon Injuries	33(30.55)
Sharp & Blunt Weapon Injuries	17(15.74)
Asphyxiation (1 each from drowning, hanging, strangulation, throttling, and smothering)	05(4.62)
Asphyxiation & Sharp Weapon Injuries	01(0.92)
Burns / Vitriolage	01(0.92)
Firearm Injuries	01(0.92)
Poisoning	01(0.92)
Total	108(100)

followed by 20.37% cases in the month of December. Regarding seasonal variation, maximum number of cases were reported in summer (46.29%) followed by winter months (27.77%) as shown in Table 1. According to the day of incident, homicidal deaths were more prevalent on weekend as depicted in Table 1.

Maximum number of cases (75.5%) were registered as homicides at the time of autopsy. Police did not suspect homicide prior to autopsy 1.85% of the cases. In 15 cases (13.88%) the dead body was moved from the scene of the crime. The body was disposed to a different spot in 14.7% of cases. Maximum number of offenders 98 (90.74%) were identified prior to autopsy and in 10 cases offenders were identified after the autopsy. In most of the homicides offenders were acquaintance of the victim. In majority of homicides committed by acquaintance, 75(69.44%) includes

relative, friend, neighbor, employee and enemy etc. In all most all spousal homicides the offender was the male. In only 7.40% of cases, homicides were committed by strangers for the monetary gain or argument.

For the pattern of homicides, use of sharp weapons for homicide (53.70%) was more common than use of blunt weapons (37.03%). Similarly, sudden aggression can be assumed in 9.25% of cases who were murdered by ligature or manual strangulation and thermal deaths. Most of the sharp weapon injuries (53.70%) were pre-meditated and mostly involved mob conflict whereas most of the blunt weapon injuries were unpremeditated (37.035) as depicted in Table.5. In my study 90.74% of the victims (N=98) did not have any past history of criminal activities and no history of association of any other cognizable offence whereas 9.25% of cases had history of previous association with other cognizable offences. Most of the victims (82.5%) died on the spot. Almost all homicides (90.74%) occurred on the spot followed by 1/2hr -1 day (7.40%) cases and the least 2 cases were deceased within a week as depicted in Table 4.

Table 6: Motive of Homicide

Motive of Homicide	N (%)
Revenge / Enmity	44(40.74)
Financial Conflicts	30(27.77)
Property Gain	03(2.77)
Previous Property Dispute	05(4.62)
Family Disharmony	06(5.55)
Argument	02(1.85)
Love Affair	02(1.85)
Dowry	04(3.70)
Robbery	01(0.92)
Criminal Rivalry	02(1.85)
Gang War	02(1.85)
Sudden Emotional Outburst	03(2.77)
Rape & Murder	02(1.85)
Mental Illness of Offender	01(0.92)
Unknown	01(0.92)
Total	108 (100)

It is revealed robbery, theft and organized crimes in 10 cases. Direct provocation of accused by the victim was seen in 20.34% of cases. In present study, the provocation could have been misinterpreted in 38 cases due to the insufficient history given by relatives, acquaintances or police. In our study 30.23% of homicides were alcohol related. It was observed in our study that the majority of injuries were at multiple sites (72.22%) followed by injury to head & neck (27.77%). Our study revealed that defense wounds were present in 12.07% of the cases. The main motive behind homicide was found to be revenge (40.74%) followed by financial conflicts (27.77%) and marital

disharmony (5.55%) as depicted in Table 6. Most common cause of death was hemorrhagic shock (79.62%) followed by craniocerebral injuries (18.51%).

Discussion

Incidence of homicides was 8.90% of all medico legal autopsies.⁶ The trends of homicides in India over the years increased this could be due to increase in population, economic factors, matrimonial quarrels, migration, poverty and enmity. The most commonly affected age group was 21-30 years followed by 31-40 years. These age groups were more vulnerable to homicides due to revenge, marital disputes, infidelity, dowry, gang rivalry, unemployment, arguments etc. Similar findings were observed in the other studies.^{4,7} Males predominates females, which might be due to the aggressive nature of males, more exposed to the outside environment and violent activities. Similar observations were made by other authors.^{5,7} In our study the majority of the victims were followers of Hinduism followed by Islam and Christianity. This is due to predomination of Hindu population in the region, and is consistent with other studies.^{8,9} A larger proportion of the victims were married. Similar findings were observed by studies conducted by others.^{8,10} High incidence in married individuals may be due to marital disharmony, early marriage, family responsibilities, dowry, domestic quarrels, misunderstanding, poverty, and alcohol.

In our study, deaths from rural areas were more common than urban areas. Similar observations were made by other studies.^{9,11} The rural predominance could be due to poverty, unemployment, illiteracy, early marriage and availability of alcohol. We observed that most of the victims were laborers followed by farmers among males and housewives among females. This was consistent with other research workers.^{12,13} The majority of the homicides were committed at the house of victim followed by the street and those in shared residence. This strongly suggests that these homicides were mostly intentional as the attackers were aware of the victim's whereabouts. Motives include financial dispute, murder for gain, gang rivalry, revenge murders and arguments arising under the influence of alcohol. These results are similar to studies conducted by others.^{6,12,14} In our study, most of the homicides took place in night, which is very similar to other studies.¹¹⁻¹⁴ This could be attributed to less risk of identification in the darkness and abuse of alcohol at night.

When the homicidal deaths were analyzed according to the day of incident, homicide deaths were more prevalent on weekends. This pattern is similar to other studies too.¹¹⁻¹⁴ Regarding month wise distribution, most of the cases were reported in May followed by of December. Regarding seasonal variation, almost half of the cases were reported in summers. Studies conducted by others observed similar incidence in summer.^{15,17} Due to erratic seasonal variation with extended summer season and unpredictability of rainy season affecting this area, farmers and agricultural laborers belonging to lower strata of society are

practically jobless, and poverty, may lead to extreme situations resulting homicide.

In our study, more than 3/4th of the cases were registered as homicides at the time of autopsy. Two cases were registered as accidental deaths as the victims were found by road side or railway track with injuries and two cases had a history of natural disease and absence of external injuries lead the police to register it as natural death. In two cases the police suspected foul play based on the alleged history by the deceased relatives or the injuries present on the body. Police did not suspect homicide prior to autopsy in 1.85% of the cases. Similar findings were noted by study conducted by others¹⁵⁻¹⁷ In 15 cases, the dead body was moved from the scene of the crime and attempts were made by the assailants to obliterate the identity as well as the evidence of crime. The presence or absence of blood stains, signs of struggle/disturbance at the spot of recovery of body was considered for the above inference by visiting the scene. The body was disposed to a different spot in 14.7% of the cases. Similar results have been reported by others.^{4,14-17} Maximum number of offenders were identified prior to autopsy and in 10 cases, offenders were identified after the autopsy. In most of the homicides, offenders were acquaintances. This was similar to other studies.¹²⁻¹⁶ In 75(69.44%) cases, acquaintances were relative, friend, neighbor, employee, enemy etc. In all most all spousal homicides, the offender was the male. Only 8(7.40%) homicides were committed by strangers for the monetary gain or argument. This is similar to observations made by other studies.¹²⁻¹⁶

Most of the victims died on the spot. This could be attributed to the lethality of weapon used by the assailant to kill the victim. Similar findings were noted by others.¹⁵⁻¹⁹ It also depends on the determination on the part of assailant to kill the victim, since most of these cases were premeditated. Sharp weapons were used in more than half of the cases followed by blunt weapons which is similar to other studies.¹⁶⁻¹⁸ Sharp weapon injury was the most common cause of death and accounted for 50% of the homicides, which can be attributed to the easy availability of various sharp weapons. In one case the assailant used sharp weapon to cause fatal injury and made it sure by strangulating his wife. In another case the pattern could not be made out as the body was almost charred (post mortem burns) and was found in a gunny bag. Similarly, sudden aggression can be assumed in 9.25% of the cases. It mostly involved murder by ligature or manual strangulation and thermal deaths. Most of the sharp weapon injuries were pre-meditated and mostly involved mob conflict whereas most of the blunt weapon injuries were unpremeditated and assailants used the blunt weapon available at the scene of occurrence. Similar finding noted by studies by others.¹⁶⁻¹⁸

More than 90% of the victims were without any past history of criminal activities whereas in 9.25% of the cases, there was some history of previous association of other cognizable offence. Which are consistent with observation of other researchers.^{11,15-19}

Robbery, theft and organized crimes were the reason in 10 cases.

The reasons for homicidal deaths in this area include illiteracy and disdainful attitude towards legal procedures. Direct provocation of accused by the victim was seen in 20.34% of the cases. This is consistent with studies by others.¹⁶⁻¹⁹ Provocation could have been misinterpreted in more than 1/3rd of the cases due to the insufficient history given by relatives, acquaintances or police. Less provocation may point to the planning beforehand and hatred among the offenders start with simple quarrel. These were consistent with other studies.^{18,20} In the present study, 30.23% of the homicides were alcohol related. The victims were addicted to tobacco and alcohol due to socio-cultural practices. This decreases the threshold of inhibition and potentially provokes the victims to be aggressive and quarrelsome leading to violence.¹⁸⁻²⁰

We observed that in a vast frequency of cases, injuries were at multiple sites followed by injury to head & neck in 30(27.77%) cases. Similar results have been reported in other studies.¹⁸⁻²⁰ Male victims of homicide exhibited multiple injuries over their body due to stronger effort to resist or fighting whereas female victims usually surrender with few injuries. Our study revealed the presence of defense wounds in 12.07% of the cases. Similar results have been reported in literature.^{17,20,21} Raising of hands to prevent the attack or by grasping the weapon were considered as defense wounds while their absence was due to involvement of multiple assailants, assault during sleep or intoxication and unexpected attack. On subsequent evaluation, we observed hemorrhagic shock as the most common cause of death followed by craniocerebral injuries. Similar findings were observed by studies carried out by other authors.^{11,15,18-22} The reason for this might be the type of weapons used, pattern and distribution of injuries. The main motive behind homicide was found to be revenge due to previous enmity followed by financial conflicts and marital disharmony. Similar observations were made by other studies.⁹⁻¹² Other causes included real estate enmity, gang rivalry, business contracts, financial conflicts and poverty, sexual jealousy, disruptive activity and infidelity.

Conclusion

Homicide is one of the worst forms of crime. Trends of homicide differ from country to country, region to region and from time to time. The social and cultural values along with demographic variables affect the crime. At the same time illiteracy, poverty and mistrust worsen the scenario. Socioeconomic wellbeing, removal of poverty and enhanced employment opportunities will also help to check it. Along with the socioeconomic improvement, the crime investigating agencies including medico legal experts and judiciary system is to be strengthened so that the laws can be enforced stringently. Education and providing better job opportunities, prohibition or restricted sale of alcohol, safe guarding their interests. Up to date knowledge of the prevailing trends of homicide may help the law makers in preventing homicides.

Assessing the burden of the issue on the socioeconomical, cultural and multidirectional after effects, I feel that continuous

research in this field is the need of the hour, to divulge various factors and implement strategies to prevent loss of innocent lives. In the Indian scenario the investigating officer, the forensic pathologist and the judiciary system work independently and not in tandem as in the western countries where the homicide unit is constituted who share their knowledge in solving a crime. Hence investigating officers should co-ordinate with the forensic pathologists in solving homicides. Strict measures should be taken to monitor and control the possession of illegal fire arms /dangerous weapons. Well illuminated street lights and better quality CCTV camera with good night vision at sensitive areas.

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References

1. Reddy KSN, Murthy OP. The Essentials of Forensic Medicine and Toxicology. 34th Ed., New Delhi: Jaypee Brothers Publishers (P) Ltd; 2017: p290.
2. Parikh CK. Parikh's Medical jurisprudence and Toxicology for Classrooms and Courtrooms, CBC Publishers and Distributors, New Delhi, 6th Ed.1990:2.1pp,3.51pp,4.23pp.
3. Scott KMW. Homicide Patterns in the West Midland. Med, Sci and Law.1990; 30(3): 234-8.
4. Mohanty MK, Kumar TS, Mohan ram A et al. Victims of Homicidal Deaths – An Analysis of Variable. J Clin Forensic Med. 2005; 12(6): 302-4.
5. NCRB Records (2016) <http://ncrb.gov.com>
6. Vougiouklakis T, Tsiligianni K. Forensic and Criminologic Aspects of Murder in North-West (Epirus) Greece. J Clin Forensic Med.2006; 13: 316-320.
7. Gupta A, Rani M, Mittal AK, Dikshit PC. A study of homicidal deaths in Delhi. Med Sci Law 2004;44 (2):127-32
8. Shivakumar BC, Vishwanath D, Srivastava PC. Trends of homicidal deaths at a tertiary care centre Bengaluru. J Indian Acad Forensic Med. 2011 Apr; 33(2):120-4.
9. Mohanty S, Mohanty SK, Patnaik KK. Homicide in southern India- A five-year retrospective study. J Forensic Med and Anat Res. 2013 Apr 18; 1(2):18. 8
10. Buchade D, Mohite S. Pattern of injuries in homicidal cases in greater Mumbai. J Indian Acad Forensic Med 2011; 33(1):46-9.
11. Bhupinder S, Kumara TK, Syed AM. Pattern of homicidal deaths autopsied at Penang Hospital, Malaysia, 2007-2009: A preliminary study. Malays J of Pathol.2015; 32(1); 81-86.
12. Mohanty MK, Mohanty S, Acharya S. Circumstances of crime in homicidal deaths. Med Sci Law.2004; 44(2), 160-64.
13. Kumar V, Mae Li AK, Zaniah AZ, Lee, DA, Salleh SA. A study of Homicidal deaths in medicolegal autopsies at UMMC, Kuala Lumpur. J Clin. Forensic Med.2005; 12, 254-257.

14. Kominato Y, Shimda L, Hata N et al. Homicide Patterns in the Toyoma Prefecture, Japan. *Med Sci Law*. 1997; 37(4): 316-20.
15. Padmaraj RY, Tandon RN. Pattern of homicides at mortuary of civic hospital Ahmedabad. *J Ind Forensic Med*. 2010; 27(2): 51-55.
16. Wahlsten. P. Koiranen V, Saukko P. Survey of Medico-legal Investigation of Homicides in the City of Turku, Finland. *J Forensic Leg Med* 2007; 14 (5): 243-52.
17. Gadge S, Batra AK, Kuchewar SV, Meshram RD, Dhawane SG. Medico-legal study of homicide in and around GMC Aurangabad. *Medico-Legal Up-date*. 2011; 1: 56-58.
18. Gupta S, Prajapati P. Homicide trends at Surat region of Gujarat, India. *Indian J Forensic Med Toxicol*. 2009; 26(1): 45-48.
19. Eze UO, Akang EEU, Odesanmi WO. Pattern of homicide coroner's autopsies at university college hospital, Ibadan, Nigeria: 1997-2006. *Med Sci Law*. 2011; 51: 43-48.
20. Vij A, Menon A, Menezes RG, Kanchan T, Rastogi P. A retrospective review of homicides in Mangalore, South India. *J Forensic Leg Med* 2010; 17(6):312-5.
21. Ghangale AL, Dhawane S G, Mukherjee AA. Study of homicidal deaths at Indira Gandhi Medical College, Nagpur. *IJFMT* .2003; 20[1]:47-51.
22. Henderson J P, Morgan SE, Patel F et al. Patterns of non-firearm homicide. *J Clin Forensic Med*. 2005; 12(3):128-32.

Autopsy based analysis of unidentified dead bodies in a tertiary care hospital of South India

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Abstract

Increasing number of the unknown dead body is also described as the silent mass disaster. The identification of cadavers is a key issue in autopsy and equally important for ethical, criminal and civil reasons. This prospective study was conducted during the period from January 2016 to December 2016 at Coimbatore Medical College Hospital. Over 152 cases of unidentified dead bodies, brought for postmortem examination were included in this study. The study observed seasonal variation in the unidentified corpse brought for autopsy, with a male sex predilection. Most of the victims were in the age group of 50 to 60 years with the majority of the cases being reported as road traffic accidents. The cause of death in unidentified dead bodies was highly variable. The most commonly applied method for identification of dead bodies in India is visual and other customary means of identification. Identifying the dead body is the essential criteria in the process of medico-legal autopsy and we are supporting the investigating officers in identifying the deceased by various techniques like fingerprints, superimposition, blood grouping and DNA fingerprinting. Even though the modern and more accurate techniques are available for identification, the usage is limited than the expected outcome because of the limited availability of data for comparison. By improving and increasing the availability of data by means of Aadhar linking or data bank we could ensure that the suffering of a family comes to an end, and for dignified disposal of corpses.

Key words

Unidentified corpse; Road Traffic Accident; DNA fingerprint; Identification.

Introduction

The intention of postmortem examination in the medico-legal case is to ascertain the identity of the individual and cause of death. In unnatural deaths, this is highly important and has legal implications. According to the National Crime Records Bureau & Ministry of Home Affairs statistics, a total number of missing untraced persons at the end of 2016 including previous years all over India was 3,19,627 persons. The recovery percentage is 59.2%. In Tamil Nadu, out of 28797 reported missing cases, 10769 persons remain untraced.¹ This indicates the necessity of improvement in identification techniques in India.

The dead body becomes unidentifiable because of many reasons including intentional mutilation. Non-identification of dead body may be possible due to decomposition changes, or the incidences which occurred at the time of death such as natural calamities (earthquakes), air crash, fire, building collapse, railway accidents or mass firing or manmade incidences like bomb blasts etc.² The deliberate mutilation of a corpse by the offenders in order to hide the crime is not unusual. The responsibility of the autopsy surgeon becomes more challenging when bodies are completely skeletonized. However, meticulous and scientific autopsy

examination with scientific comparison helps to find out the identity and cause of death.

The present retrospective research is an autopsy based analysis of unidentified dead bodies in a tertiary care hospital of South India.

Material and Methods

The present study was conducted at Department of Forensic Medicine, Coimbatore Medical College Hospital, Coimbatore from January 2016 to December 2016. In our hospital, we are receiving various types of dead bodies for medico-legal autopsy investigation. These cases embrace unknown bodies including exhumed bodies, burnt bodies, skeletonized human remains, mutilated bodies, and decomposed bodies. Identification of the victim is needed in criminal cases to file charges against the alleged culprit, within the process of life assurance claims and in delivering the remains to relatives. In the absence of established identity, the death certificate isn't issued with the name of the individual. This, in turn, might produce inadequacy to fulfil legal formalities in civil and criminal cases. When receiving the corpse to the mortuary, the details provided by investigation authorities are reviewed, which is followed by detailed postmortem examination, relevant viscera is preserved both for chemical analysis as well as for identification purposes.

During the study period, a total of 152 unidentified dead bodies that underwent postmortem examination, were analysed for their demographic profile, cause and manner of death etc. The cases were analyzed on the premise of case records and inquest reports. Most of the cases were reported from Coimbatore city (N=120), followed by Tiruppur city (N=31) and Nilgiri district (N=1).

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Results

A total of 3,676 autopsies were conducted in our department during the study period. Nearly 4.1% (152 cases) of the above cases were unidentified at the time of postmortem examination.

Table 1: Age wise distribution of cases

Age in years	N
Fetus	2
New born	5
<1	1
1 to 10	0
11 to 20	1
21 to 30	13
31 to 40	36
41 to 50	32
51 to 60	41
>60	21
Total	152

Males (N=121) outnumbered females (N=31). The most common age group of the deceased was 50-60 years. (Table 1). Overall, the maximum number of cases was encountered in winter (56 cases) while the least number of cases was reported in autumn (18 cases) Season wise distribution of cases is shown in Table 2.

Table 2: Season wise distribution of cases

Season	N
Autumn	18
Monsoon	35
Summer	43
Winter	56
Total	152

The majority of the opinions regarding the cause of death in these cases was given as 'cranio-cerebral damage' due to Road Traffic Accident (46 cases), followed by natural cause of death in 39 cases and train accidents in 26 cases (Table 3). Opinion regarding the cause of death was given at the time of autopsy in 112 cases while the rest needed additional investigations. Viscera for chemical analysis were sent in 26% cases, histopathology in 39 cases and for both chemical analysis and histopathology, in 25% cases. The manner of death in the majority of the deaths were accidental (N=87) followed by Natural disease (N=39). The distribution of cases as per the manner of death are shown in Table 4.

Investigation procedure including photograph and publication of notice in dailies in all the cases was carried out by the police personnel. Autopsy surgeons, on the other hand, preserved

Table 3: Distribution of cases according to the circumstances of death

Type of case	N
Road Traffic Accident	46
Natural death	39
Train Accident	26
Fall from height	11
Hanging	09
Murder	08
Drowning	06
Accidental fall	03
Dead born	02
Burns	01
Poison	01
Total	152

Table 4: Manner of Death

Manner	N
Accidental	87
Suicidal	16
Homicidal	08
Natural	39
Dead born	02
Total	152

bones for DNA analysis in all the cases (N=152), noted the marks of identification/ deformities/tattoos in 55% cases, fingerprints were taken in 40% cases, skull preserved for superimposition in 30% of cases and blood for cross matching in 7% cases.

Discussion

The identity of the dead is an essential part of post-mortem examination, for various reasons. These include: the ethical and humanitarian need to know which individual has died, especially for the information of surviving relatives, to establish the fact of death in respect of that individual, for official, statistical and legal purposes, to record the identity for administrative and ceremonial purposes in respect of burial or cremation, to discharge legal claims and obligations in relation to property, estate and debts, to prove claims for life insurance contracts, survivor's pensions, and other financial matters and to allow legal investigations, inquests and other tribunals, such as those held by coroners, procurators fiscal, medical examiners, judges and accident enquiries to proceed with a firm knowledge

of the identity of the decedent to facilitate police enquiries into overtly criminal or suspicious deaths, as the identity of the deceased person is a vital factor in initiating investigations.³ Thousands of people whose bodies were found on railway track across Southern Railway remain unidentified. The victims, including hundreds of women, were suspected of having either committed suicide or had an accidental fall, though police do not rule out other possibilities.⁴ Increasing number of the unknown dead body is also described as the silent mass disaster. The identification of cadavers is a key issue in autopsy and equally important for ethical, criminal and civil reasons.⁵

We consider the following reason for dead bodies remaining unclaimed (or) unidentified in our region: a) Coimbatore being an emerging metropolitan city, has a huge native population along with members of people migrating into the city from various other cities, districts and states in search of work or for tourism. b) Elderly citizens of the age group 50-60 years are emotionally sensitive and are vulnerable to abuse, harassment and hence are detached from their families and friends wandering around alone. Sometimes such elderly citizens are abandoned by their own family also. They also have a tendency to commit suicide. c) Elderly citizens are also commonly affected by natural diseases like myocardial infarction, tuberculosis, cerebro vascular accident, diabetes mellitus etc. d) Hearing, speech and visually challenged persons are also vulnerable to be deserted by family members to become victims of accidents and starvation. Men often travel alone making them vulnerable to become unclaimed in case of their untoward demise. Alcoholism among men also contributes to this factor. e) The dead bodies reported for postmortem examination constitute a very essential and significant role in every forensic surgeon's carrier. These cases absolutely test the proficiency and expertise of the specialist and the investigating officers. Traditional postmortem identification is based on fingerprint, dental or skeletal evidence. f) However, deaths as a result of fires, explosions, aeroplane crashes, and other traumatic events, as well as old remains are difficult to identify via traditional methods³. In these cases, only possible means of identification is by DNA Fingerprinting. However, due to the lack of availability of DNA data bank or any other modes of DNA for comparison makes the utility of this method to be limited.

Identification is a procedure that involves one or more of the following means: i) Visual and other customary means of identification. This usually involves relatives or acquaintances of the missing person(s) viewing the remains. ii) Systematic comparison of ante-mortem and post-mortem data. iii) Scientific/objective means which would involve matching of: iv) Post-mortem and ante-mortem dental radiographs; v) Post-mortem and ante-mortem fingerprints; vi) DNA samples from the human remain with reference samples; vii) Other unique identifiers, such as unique physical or medical traits, including skeletal radiographs, viii) Numbered surgical implants/prostheses.⁶ Among these technologies, the gold standard is DNA fingerprinting next to this identification by fingerprints but the most commonly applied method in India is Visual and other

customary means of identification. This usually involves relatives or acquaintances of the missing person(s) viewing the remains.

Visual and other customary means of identification is the commonly applied method in India. However, it has the following disadvantages. i) Not all the unknown dead bodies will present without disfigurement. ii) Based on clothes we cannot conclude because each dress is produced at a rate of million times in the garment industry. iii) This method of identification also produces mental trauma to the relatives and family members i.e. in order to identify their loved ones they have to look at many unknown human remains. This will definitely be a nightmare. iv) There are also cases reported that people fake their death in order to escape from their crimes or for the gain of insurance money. Circumstantial evidence need not be always true likewise it could be misleading as well. There are criminal cases which are pending till date because of the lack of identity.

Fingerprints are routinely taken from unknown dead bodies for the purpose of identification. In order to match fingerprints, the reference sample from the same individual is essential. Even though the fingerprints are unique for each individual and not even the monozygotic twins have similar fingerprints, this system remains as a failure due to the lack of availability of data. In this 21st century, technology is evolving like an Everest Aadhar card even the door lockers, security lockers and mobile phones are designed with a fingerprint identification system. So if we can combine this fingerprint identification system with the police portal or create a fingerprint databank, we could make use of this readily available and feasible technology.

A thorough search of the literature did not yield much information regarding the identification of the unidentified dead in the Indian context. Mostly, the available literature is on individual body identification or identification of victims of mass disasters.⁷⁻⁹ With the advent of forensic DNA testing and its eventual routine implementation, forensic science has been revolutionized over the past three-plus decades. From the early days when DNA testing first allowed for 'individualization' of persons^{10,11} and polymerase chain reaction (PCR) was developed,¹² the technologies has continued to make great progress, such as the ability to perform rapid, multiplex PCR using fluorescently labeled primers for identification purposes.¹³ The DNA fingerprinting requires a comparative sample to arrive at a conclusion the problem faced is either no family member seeking the dead person or he doesn't have one. So we suggest that if a system could be introduced in such a way that each individual could be a comparative sample for himself, the identification of dead /live by the scientific method will reduce the burden for society and also enhance the utilization of the available technologies.

As for the dental data, it will not be available unless the person had done odontogram for some dental diseases or the ante-mortem photographs with a significant unique feature. For most of the cases, this system will not be applicable even if it's going

to be applied it goes inconclusive. As for the skeletal survey and other radiological data in life carries the risk of radiation exposure as well. Surgical implants and prosthesis can act as a supportive evidence of identification still the cases identified by the utilization of this method are less.

Conclusion

Complete and meticulous postmortem examination, including investigation of personal belongings, external and internal examination and supported by necessary analytical investigations are helpful to determine identity and cause of death. History of the incident is equally important to the cause of death in highly decomposed and or skeletonized bodies. However, confirming the identity by a scientifically proven technology like DNA fingerprinting, fingerprints etc. is the only way out for the identity of the unknown and proper direction for criminal investigation. This will also prevent the harm caused by the visual and customary means of identification to the family members who have already been in a nightmare by the missing person. Chemical analysis of the samples may prove to be helpful in some cases. A multifactorial approach is necessary to establish the identity and cause of death. Identification of unclaimed dead bodies is essential to ensure that the suffering of a family comes to an end and for dignified disposal of corpses. Improving the utilization of available and feasible standard scientific techniques can restore the identity of untraced citizens and also aid in the criminal investigation.

Suggestions

Linking Aadhar with Tamil Nadu Police citizen portal for missing persons for the purpose of identification of unknown dead bodies / missing persons would be useful since the tool of forensic identification involves fingerprinting. In addition, linking information about DNA fingerprinting with Aadhar card would be much more useful in the identification of unknown dead bodies / missing persons especially in cases where retrieval of fingerprints is not possible. Creating a DNA data bank for all the citizens of India will provide able assistance in criminal's identification and identification of unknown dead bodies and missing persons.

Ethical clearance: Approval was obtained from the Institutional Ethical Committee.

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References

1. National Crime Records Bureau (Ministry of Home Affairs). Crime in India - 2016. Statistics, Available at: <http://ncrb.gov.in/StatPublications/CII/CII2016/cii2016.html>. Accessed on 26th April 2018.
2. Waghmare PB, Chikhalkar BG, Nanandkar SD. Establishing Identity and Cause of Death in Mutilated and Un Identifiable Corpses: A Challenging Task for Medico Legal Expert. *J Forensic Biomed* 2015;4:120.
3. Saukko P, Knight B. Knight's forensic pathology. 3rd ed. Edward Arnold.; London, 2004.
4. Kumar SV, Kumar SV. Thousands of bodies found on railway track unidentified. *The Hindu*. 2013 Oct 7; Available at: <http://www.thehindu.com/todays-paper/tp-national/tp-Tamilnadu/thousands-of-bodies-found-on-railway-track-unidentified/article5208789.ece>. Accessed on 5th October 2017.
5. Wankhede MN, Parchake MB, Pathak H, Hosmani A. Study of demographic profile of unidentified dead bodies in central Mumbai region. *Sch. J. App. Med. Sci.*, 2017; 5(1A):57-61.
6. ICRC (International Committee of the Red Cross). 2009. Missing People, DNA Analysis and Identification of Human Remains. A Guide to Best Practice in Armed Conflicts and Other Situations of Armed Violence. 2nd ed. Geneva: ICRC.
7. Job C. Determination of cause of death in decomposed bodies – a regional study. *J Indian Acad Forensic Med* 2009;31(1):11-17.
8. Kahana T, Hiss J. Personal identification based on radiographic vertebral features. *Am J Forensic Med Pathol* 2002;28(1):36-41.
9. Ludes B, Tracqui A, Pfitzner H, Kintz P, Levy P, Disteldorf M, et al. Medico-legal investigations of the Airbus A 320 crash upon Mount Ste-Odile, France. *JFS* 1994;39(5):1147-1152.
10. Jeffreys AJ, Wilson V, Thein SL. Hypervariable "minisatellite" regions in human DNA. *Nature* 1985; 314: 67-73.
11. Jeffreys AJ, Wilson V, Thein SL. Individual-specific "fingerprints" of human DNA. *Nature* 1985; 316: 76-79.
12. Mullis KB, Faloona FA. Specific synthesis of DNA in vitro via a polymerase-catalyzed chain reaction. *Methods Enzymol* 1987; 155: 335-350.
13. Romsos EL, Vallone PM. Rapid PCR of STR markers: applications to human identification. *Forensic Sci Int Genet* 2015; 18: 90-99.

Analysis of cooling curves obtained from the human corpses where time since death is known

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Abstract

A physical change that may occur in a corpse after death would be heat exchange from the body to the surrounding environment. An attempt has been made by the investigators to analyse the cooling curves obtained from the human corpses where time since death is known. A total of 100 human corpses selected for the study. The study was conducted in typical winter season from October to December of the year 2013. During the process of recording, ambient temperature remains almost same on every day of the study period and it was 27°C-28°C. On an average, it took 18-20 hours for the thin built bodies to reach the ambient temperature, whereas 20-22 hours for moderately built bodies and for thick built bodies 22-24 hours. The cooling curves obtained by applying observed data, is of more or less double exponential sigmoid one. It is observed that the process of cooling retarded in its earlier stages, represented by a flat portion in its upper most part, signifying the occurrence of a lag period in the earlier stages of cooling, known as "temperature plateau". Followed by a plateau, the investigators observed that a steeper portion of the cooling curve having two different components of variable lengths on the curve, representing different phases of cooling during the process of reaching the equilibrium with the ambient temperature. The initial rate of cooling in most of the cases is to be 0.5°C/hour rising to 1°C/hour during the period of maximum cooling. The average rate of cooling/hour has been estimated as 0.5°C.

Key words

Core Temperature; Conduction; Convection; Radiation; Temperature plateau.

Introduction

A remarkable physical change that may occur in a corpse after death would be heat exchange from the body to the surrounding environment provided there might have been temperature gradient existed between the body and the environment. The cooling of the body after death is a complex process, which does not occur at the same rate throughout the body¹. Cooling occurs from the surface of the body to the surroundings due to temperature difference between the body and surroundings¹. Basically there are four types of heat exchange mechanisms through which heat will be lost from the body namely conduction, convection, radiation and evaporation². During life, heat is constantly transferred from one body part to other by conduction as well as convection². After death, this occurs only through conduction. Heat loss from the body parts which are in direct contact with the supporting surface occurs through conduction; whereas the body parts which are not in direct contact with the surface lose heat through convection². Radiation is the physical process through which all bodies radiate heat. Radiation is fastest during the initial few hours,

when the body is hot after death, then after body loses heat mainly by conduction². Only a small fraction of heat is lost by evaporation of fluids from the body, the effect of which is incalculable². A temperature gradient is formed soon after death between the surface to the core of the body with core being warmer. Core temperature is the temperature of the viscera which is higher than the surface temperature².

The cooling pattern of human corpse does not obey the Newton's law of cooling which was thought by earlier investigators, which states that the rate of heat loss from the object is directly proportional to the temperature gradient existed between the object & surroundings. The cooling curve pattern is adequately described by a double exponential formula and the shape of the curve is a sigmoid one. The uppermost part of the cooling curve in all observed cases was flattened for variable length, which was physically determined, signifying the phenomenon of "Post mortem Temperature plateau". The calculated temperature plateau in all observed cases varies from 2-4 hours, depending on the original body temperature at the time of death. The body temperature at the time of death largely influenced by Mode & Cause of death. It is observed that in all violent, unnatural deaths the body temperature recorded is considerably high and remained constant for a significant time period. Following the plateau, a steeper portion of the cooling curve noted having two different components of variable length i.e. the sloping part and the linear part. These two phases of cooling mainly depend on the original body temperature at the time of death.

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Materials and Methods

In this study a total of 100 human corpses were taken to analyse the cooling curves obtained from them where time since death is known. Of the 100 cases, 50 were males and another 50 were females. The study was conducted for a period of 3 months in the winter season from October to December of the year 2013. The winter season is ideal for studying the cooling pattern of the human corpse because ambient temperature is always less than body temperature which is unlike in summer where ambient temperatures recorded are always far high than the body temperature^{3,4}. All these cases are collected from the Acute Medical Care unit of the Osmania General Hospital who were admitted and undergone treatment as Medico Legal Cases and sent to the mortuary for autopsy. The corpses are categorically divided into Thin, Moderate and Thick depending on their Body Size and their Body Mass Index^{3,4}. (Table1) The investigators

Table 1: Body size among males and females in different age groups

Age group (years)	Male (N=50)			Female (N=50)		
	Thin	Moderate	Thick	Thin	Moderate	Thick
20-29 (N=20)	3	3	4	5	4	1
30-39 (N=20)	4	3	3	2	5	3
40-49 (N=20)	5	3	2	2	4	4
50-59 (N=20)	5	4	1	1	3	6
60-69 (N=20)	6	2	2	4	4	2
Total (N=100)	23	15	12	14	20	16

personally attended the Acute Medical Care unit of the Osmania General Hospital and recorded the temperature of the Acute Medical Care unit (ambient temperature) of the hospital and rectal temperatures of the corpses, at the moment of death, before declaring death by the duty doctor to the patient attenders. From then the monitoring of the corpse was supervised by the investigators in the process of shifting from the ward to the mortuary, in order to avoid much delay in shifting the corpse by the ward attenders so that corpse may not be laid down in two different room temperatures (i.e. ward and mortuary)^{3,4}.

After admission to the mortuary, the name, sex, age, height & built, weight, Medico Legal Case Number & In patient Number, date and time of death, cause of death were recorded. Then the bodies were stripped, made naked, placed over the mortuary table in prone position with both upper limbs lying side by the body. Thermometer (chemical), graduated from 0° to 50°C was inserted into the rectum of the corpse by keeping the buttocks wide apart, such that at least 10cms of it from its tip should be there in the rectum^{3,4}.

The chemical thermometer, as such kept there undisturbed, and readings are taken after 5mts interval, the time being required for its stabilization^{3,4}. From then serial recording of the rectal temperature readings at an hourly interval made by the

investigator without disturbing the corpse and thermometer^{3,4}. The initial time of recording the ambient and rectal temperatures were noted and tabulated^{3,4}. Likewise, serial recording at an hourly interval of rectal and ambient temperatures taken and tabulated. Informed consent was taken from the deceased's attenders for the same. Institutional ethics committee gave no objection certificate for the project.

Results

In total 100 cases were studied (50 males and 50 females). Cases included in the study were; Road Traffic Accidents (n=60), Burns (n=10), Asphyxial deaths (n=10), Poisoning (n=10) and Natural deaths (n=10).

The shape of the cooling curve observed is more (or) less double exponential sigmoid one. (Fig1 & 2) Human corpse did not

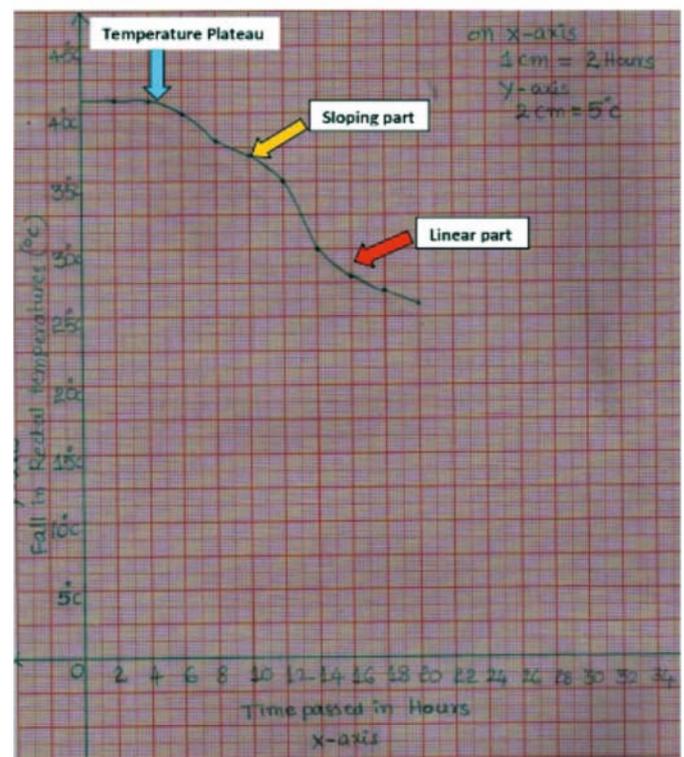


Fig 1: Cooling curve showing different components

follow the “Newtonian principle” of cooling to reach the ambient temperature. The uppermost part of the cooling curve showed flat portion in all cooling curves signifying the occurrence of “Temperature plateau”. “Post-mortem temperature plateau” is of variable period, ranging from 2-4 hours in all observed cases, which is proportional to the body temperature at the time of death which in turn depends on the cause of death (Fig 3). Following the plateau, a steeper portion of the cooling curve noted having two different components of variable length i.e., the sloping part and the linear part. The duration of the sloping part on the curve is proportional to the original body temperature at the time of death (Fig 4). The

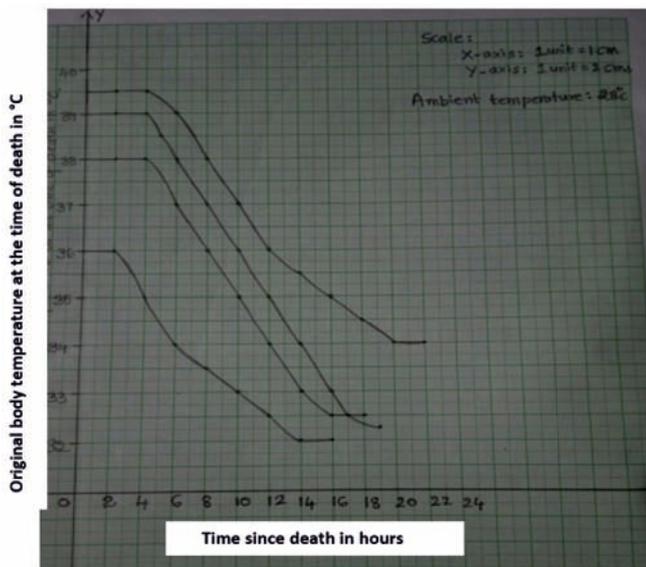


Fig 2: Cooling curves obtained at different body temperatures at the time of death

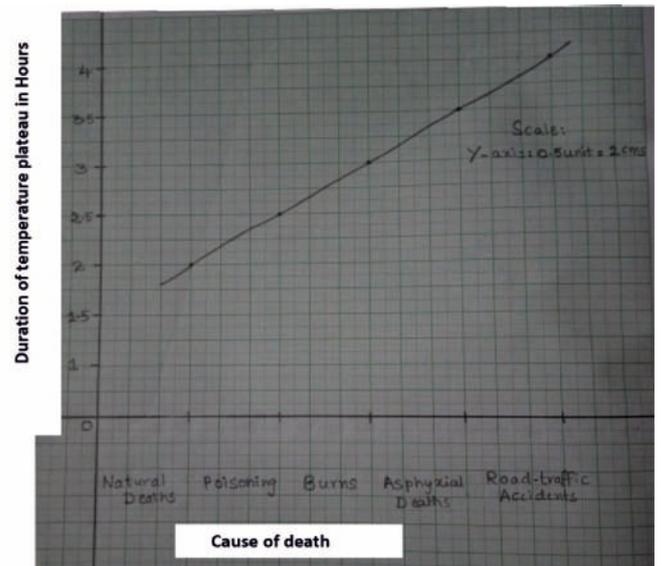


Fig 3: Effect of Cause of death on duration of temperature plateau cooling curve

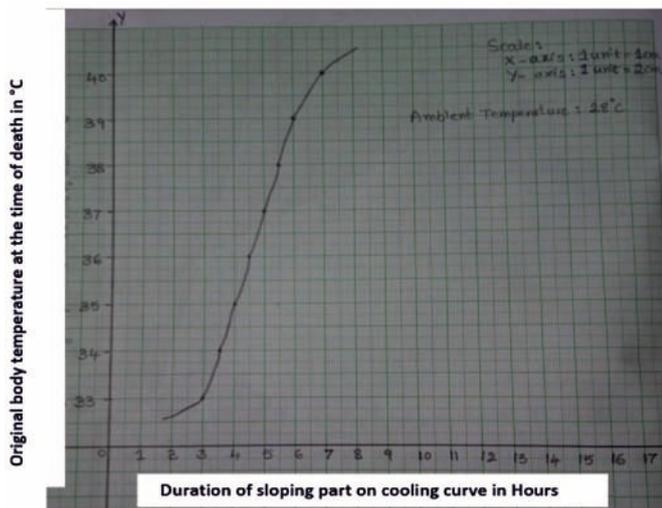


Fig 4: Effect of original body temperature on the sloping part of the cooling curve

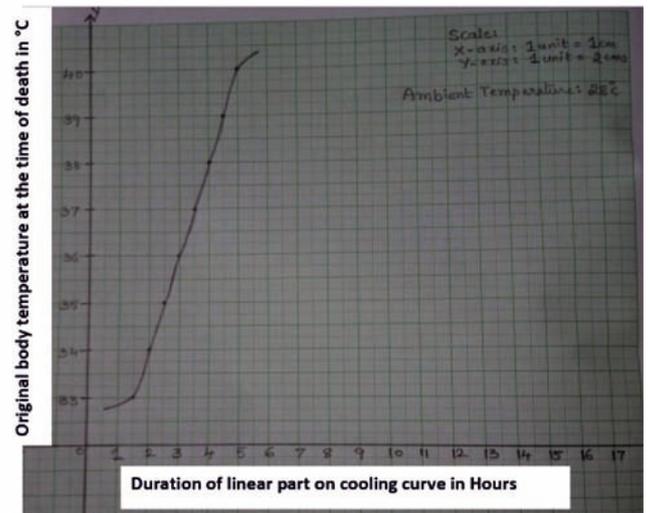


Fig 5: Effect of original body temperature on the linear part of the cooling curve

duration of the linear part on the curve is proportional to the original body temperature at the time of death (Fig 5). It is observed that rate of cooling per hour varied from 0.3 – 0.6°C, the average being 0.5°C (Fig 1).

Discussion

To study the cooling patterns of the human corpses, it is ideal to choose winter season of the year, where the body temperature is always significantly high than the ambient temperature. During the process of recording rectal temperatures, the ambient temperature was almost remained more or same for the entire 3 months of study period and it was 27°C-28°C. The rectal temperatures recorded from the selected human corpses varied from 36°C-39°C. All the cases selected had died due to unnatural deaths of varied etiology showing significant rise in

body temperature at the time of death. The elevated body temperature recorded from all the corpses signifying the occurrence of post-mortem caloricity probably due to violence & exertion they faced at the time of death. On average, it took 18-20 hours for the thin built bodies to reach the ambient temperature, whereas 20-22 hours for moderately built bodies and for thick built bodies 22-24 hours.

The shape of the cooling curve of a human corpse is of great importance as it is inevitably the basis on which all post mortem temperature investigations were made. The human body cools in a manner adequately described mathematically by the double exponential formula. The cooling curve obtained from the observed data of the investigators show more or less double exponential one. It is observed that the process of cooling is retarded in its earlier stages represented by a flat portion in upper most part of the cooling curve in all observed cases,

signifying the occurrence of a lag period in the earlier stages of cooling, known as “temperature plateau”, determined physically by the variable period of 2-4 hours in all cases^{5,6}. The duration of plateau largely depends on the original body temperature at the time of death which is considerably high in violent unnatural deaths^{5,6}.

The phenomenon of temperature plateau was due to delay in establishment of temperature gradients and the continuation of metabolic processes that do not cease at the moment of death but continue for a short period after clinical death, responsible for production of heat at cellular level, which maintains the plateau^{5,6}. Followed by a plateau, the cooling curve shows a steeper part, having two different components of variable lengths i.e., the upper sloping part of variable length and the lower linear part of variable length. The upper sloping part of the cooling curve represents the period of quickest cooling; whereas the lower linear part corresponds to period of slowest cooling⁷. The part of the cooling curve that is of forensic use is the sloping one, which represents the period of fast cooling⁷.

The cooling of a human corpse does not follow the Newton's law of cooling and it is adequately described by a double exponential formula, and the shape of the curve is a sigmoid one⁷. The initial stages of cooling reported a “lag period”, known as temperature plateau for a variable length on the cooling curve; the calculated period of plateau on the curve is 2-4 hours in all observed cases. The steeper part of the cooling curve shows two different components of variable length i.e., the upper sloping and lowers more (or) less linear part⁷. The duration of the sloping part on the curve is proportional to the original body temperature at the time of death⁷. The duration of the linear part on the curve is proportional to the original body temperature at the time of death⁷. The initial rate of cooling to be 0.5°C/hour and reaches the 1°C/hour during the period of maximum cooling. The rate of cooling varied from 0.3–0.6°C/

hour the average being 0.5°C/hour. With such a small rate of fall in temperature, it is not advisable to estimate the time since death, based on the cooling process of the body⁸⁻¹⁰. The average rate of fall in temperature thus obtained is during winter season, hence the applicability of this data to the temperature based – time estimation methods are restricted to winter season only.⁸⁻¹⁰

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References

1. Reddy KSN. The essentials of Forensic Medicine and Toxicology. 31st Ed. Suguna Devi K, Hyderabad. p141-2.
2. Aggrawal A. Essentials of Forensic Medicine and Toxicology. 1st ed. Avichal Publishing Company, Delhi. 118: 1-6.
3. Knight B. The evolution of methods for estimating the time of death from body temperature. *Forensic Sci. Int.* 1988; 36: 47-55.
4. Lundquist F. Physical and chemical methods for the estimation of the time of death. *Acta Med. Leg Soc* 1956; 9: 205-13.
5. Nokes L, Hicks B, Knight B. The post-mortem temperature plateau – fact or fiction. *Med. Sci. Law* 1985; 25: 263-4.
6. Hutchins G. Body Temperature is elevated in the early post mortem period. *Hum. Pathol.* 1985; 16: 560-1.
7. Marshall T, Hoare F. Estimating the time of death - the rectal cooling after death and its mathematical representation. *Forensic Sci.* 1962; 7: 56-81.
8. James W, Knight B. Errors in estimating time since death. *Med. Sci. Law* 1965; 5: 111-16.
9. Joseph A, Schiekele A. A General method for assessing factors controlling post mortem cooling. *J Forensic Sci* 1970; 15: 364 - 91.
10. Lyle H, Cleveland F. Determination of the time since death by heat loss. *J. Forensic Sci.* 1956, 1: 11-24.

Study of sagittal suture closure at autopsy: A three-year prospective study

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Abstract

The skeleton is a principle source of information in age estimation. It is difficult to estimate age after 25 years. Changes in the pubic symphysis, transparency of root and root length measurement have been considered as good parameters to estimate age beyond 25 years. The reliability of skull suture closure alone in age estimation still remains doubtful. Sagittal suture is considered to be the most accurate among the other vault sutures. Hence this study was conducted to check for its reliability in age estimation. It was observed that, sagittal suture closure starts earlier on the endocranial surface than on the ectocranial surface. Ectocranially females showed earlier fusion than males, but endocranial suture closure was earlier in males. Ectocranial fusion started between 20-29 years, with maximum closure occurring by 60 years. Endocranial fusion also started between 20-29 years and achieved maximum closure by 55 years.

Key words

Skeleton; Forensic anthropology; Sagittal suture; Cranial suture; Age estimation; Autopsy.

Introduction

As an indicator of skeletal age at death, cranial suture closure has had a curious history. Despite being used since 16th century it is currently regarded by many as a criterion of the last resort. Some researchers rejected suture closure as an ageing method, while some concluded it to be unreliable and erratic in onset and progress. The period during which suture closure was effectively abandoned appears to have been a phase in skeletal biology during which it was hoped that one or two highly reliable age indicators would be isolated and perfected, allowing those of lesser accuracy to be required only in special cases.¹ Accurate estimation of age at death is a prerequisite for forensic identification and paleoanthropological studies. However, the aims and constraints of palaeoanthropology and forensic anthropology are different, although both fields apply the same methods. For past populations, estimation of age at death in skeletal material enables development of a demographic profile to discuss biology of past peoples and their burial practices. In forensic investigation, age assessment is a part of establishing the biological profile of unidentified human remains. The value of this estimation is particular. Identification is essential for police or justice, as unidentified human remains arouse suspicion. Identification of a deceased person is also very important to the next of kin for economic and financial reasons (life insurance premium and salary payments of the deceased); for administrative reasons (funerals, inheritance,

remarriage); and last, but not least, for psychological reasons.²

In adults there are macroscopic and microscopic methods of age estimation. The principal macroscopic changes include, pubic symphysis changes, closure of cranial sutures, lipping vertebral bodies and joints. The vault bones have a very specialized structure: they have two layers, an inner (tabula interna) and an outer (tabula externa), separated by a vascular spongy bone space (the diploe). And just as epiphyseo-diaphyseal union most frequently begins centrally and proceeds peripherally, so does suture closure begin endocranially and proceed ectocranially. The sagittal suture is said to be the most reliable and accurate among the other vault sutures in age estimation. It is said to be the first to start closing endocranially at about 25 years at its back portion – pars lambdica, close to the parietal foramina. The fusion becomes completed both endo and ectocranially by 35-40 years – the last part to unite is pars bregmatica – the portion near bregma; pars vertica and pars obelica – the 2nd and 3rd part of sagittal suture unite in between endocranially on either end of sagittal sutures, some pits or depressions become more marked with age.³ The use of cranial sutures for age estimation has always been a matter of considerable debate and its reliability within the parameter has not been demonstrated conclusively by various researchers.⁴ Hence we undertook a study on sagittal suture closure at autopsy to check for its reliability in age estimation.

Materials and Methods

A three year selective, descriptive and prospective autopsy study on sagittal suture closure was conducted on cases coming for medico- legal post-mortem examinations to the department of Forensic Medicine, Kempegowda Institute of Medical Sciences & Hospital, Bangalore, between June 2011 and June 2014, after obtaining necessary approval from the institutional ethical committee. Only cases of known age confirmed by

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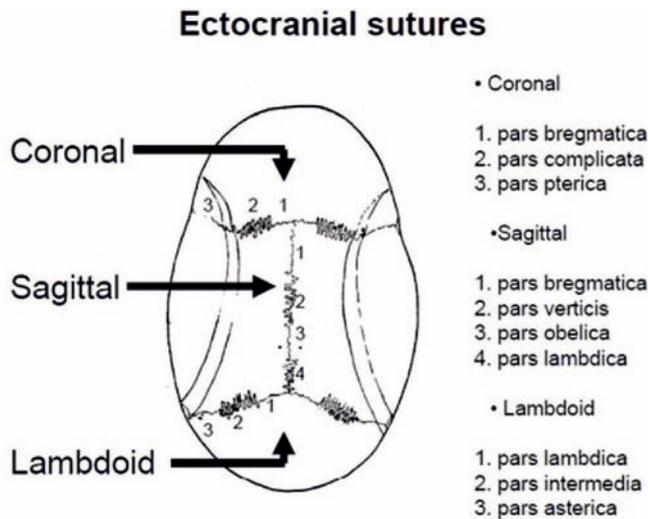
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documentary evidences like birth certificate, identification cards, ration card etc. and deceased persons of age group between 20 years to 60 years were included based on purposive sampling. Unknown, unclaimed bodies where exact age cannot

the character of the sutures (ie. based on serrations in the suture). Endocranially the sutures do not show this characteristic markedly. Hence, the endocranial sutures were divided in sections of equal length.

The scoring was done based on the Acsadi- Nemeskeri scale, both ectocranially and endocranially (Figure 2). Acsadi-Nemeskeri Scale for closure is described as; 0 = open (there is still little space left between edges of adjoining bones), 1 = incipient closure (suture is clearly visible as a continuous zigzag line), 2 = closure in process (suture line thinner, less zigzags, interrupted by complete closure), 3 = advanced closure (only pits indicate where the suture is located) and 4 = closed (even location of suture cannot be recognized). After examination the calvarium was replaced back on the skull and scalp sutured.

Fig 1: Cranial vault sutures division by parts

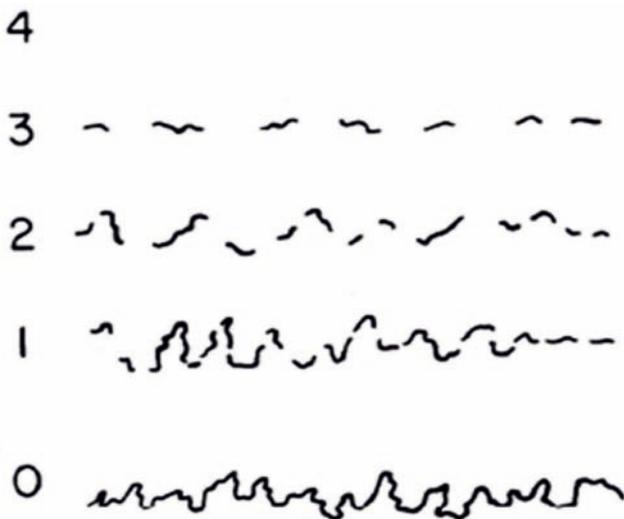


be confirmed and cases showing deformed or diseased or fractured skull, which may hamper the study of suture closure were excluded. The sample size was 100 cases. Age groups were divided into 20-29, 30-39, 40-49, 50-59 and at 60 years. A

Fig 3: Suture closure grading in some of the cases included in the study



Fig 2: Acsadi-Nemeskeri grading based on serrations, diagrammatic representation



Transverse incision over the scalp was made from one mastoid to other mastoid and reflected sufficiently to expose the sagittal suture. Calvarium was removed using autopsy saw taking due care to include complete sagittal suture. The calvarium was cleaned of soft tissues by immersing the calvarium in hot water and 5 % glacial acetic acid [dilution (20:5)] for one hour which made the suture more prominent. The sagittal suture was divided into 4 parts (Figure 1). Ectocranially the different sections of the suture were distinguished by the differences in

Mean ectocranial and endocranial closure stages were calculated for the sagittal suture. Detailed predesigned proforma was completed for every case studied. To estimate the possible relation between suture closure and age at death, appropriate statistical tools and software were used (Microsoft excel 2007, IBMTM SPSS v20).

Results

During the three-year study period, 100 cases were selected based on purposive sampling. Of the 100 cases studied 76 % were males and 24% were females. The male to female ratio being 3.16:1. Maximum number of cases were observed in the 20-29 years' age group and least at 60 years. The mean age was 38 years. Age distribution of study sample is shown in Table 1. Ectocranial suture closure was compared with endocranial suture closure and Pearson coefficients were calculated. In males ectocranial and endocranial suture closure was found to be correlating with all age groups except at 60 years. Whereas in females ectocranial and endocranial suture closure was found to

be correlating in other age groups excepting 50-59 yrs and at 60 yrs (Table 2). In both males and females ectocranial closure was found to be age related. Comparison showed that ectocranially closure occurred early in males in the 20-29 yrs and 30-39 yrs

Table 1: Age wise distribution of cases

Age groups	Frequency	Percent
20 - 29	30	30.0
30 - 39	26	26.0
40 - 49	22	22.0
50 - 59	17	17.0
At 60	5	5.0
Total	100	100.0

age group. Females showed earlier closure in rest all other age groups. The mean ectocranial closure showed that overall closure was earlier in females. However, mean endocranial

Table 2: Suture closure correlation (R) with age in males & females

Age groups	Males (N)	R (p-value)	Females (N)	R (p-value)
20-29	19	.663 (p<0.001)	11	.328 (p=0.030)
30-39	22	.715 (p<0.001)	04	.221 (p=0.411)
40-49	17	.339 (p=0.005)	05	.469 (p=0.037)
50-59	15	.638 (p<0.001)	02	--
At 60	03	--	02	--

closure showed that overall closure occurred earlier in males. Suture closure for each part is shown in Table 3.

S 1 [Pars Bregmatica] – Observable Ectocranial S1 closure started at 40 years and mean value was found to be 1.72 in 40-49 years age group. Further it was seen that the closure progressed very slowly reaching a mean closure of 2.6 at 60 years. Endocranial closure of S1 began in the early twenties (23 Years) with a mean value of 1.03 in 20-29 years age group and progressed steadily and rapidly reaching obliteration by 60 years (mean value of 4 at 60).

Table 3: Mean scores for ectocranial and endocranial suture closure for its each part

Age (years)	Ectocranial closure				Endocranial closure			
	S1	S2	S3	S4	S1	S2	S3	S4
20-29	0.13	0.13	0.4	0.4	1.03	1.1	1.1	1.1
30-39	0.76	0.80	1.00	1.23	2.15	2.19	2.15	2.15
40-49	1.72	1.81	2.22	2.5	3.13	3.22	3.54	3.54
50-59	2.41	2.41	2.88	2.82	3.47	3.47	3.58	3.58
At 60	2.6	2.6	2.6	3.4	0.0	0.0	0.0	0.0

S 2 [Pars Verticis] – Observable Ectocranial S2 closure started at 40 years and mean value was found to be 1.81 in 40-49 years age group. Further it was observed that closure progressed very

slowly reaching a mean closure of 2.6 at 60 years. Endocranial closure of S 2 began in the early twenties with a mean value of 1.1 in 20-29 years age group and progressed steadily and rapidly reaching obliteration by 60 years (mean value of 4 at 60 years).

S 3 [Pars Obelica] - Observable Ectocranial S3 closure started at 33 years and mean value was found to be 1.00 in 30-39 years age group. Further it was observed that closure progressed erratically reaching a mean closure of 2.8 in 50-59 years age group and 2.6 at 60 years. Endocranial closure of S3 began in the early twenties with a mean value of 1.1 in 20-29 years age group and progressed steadily and rapidly reaching obliteration by 60 years (mean value of 4 at 60 years).

S 4 [Pars Lambdica] – Observable ectocranial S4 closure started at 33 years and mean value was found to be 1.23 in 30-39 years age group. Further it was observed that that closure progressed slowly reaching a mean closure of 3.4 at 60 years. Endocranial closure of S4 began in the early twenties with a mean value of 1.1 in 20-29 years age group and progressed steadily and rapidly reaching obliteration by 60 years (mean value of 4 at 60 years).

The closure pattern observed both in ectocranial and endocranial closure was S4 closed early than S3, S2 and S1 in a descending order (S4> S3> S2> S1). Suture closure as observed in some of the cases included in the study are shown in Figure 3.

Discussion

In the present study, ectocranial fusion of sagittal suture started at the age of 28 years (stage 1) and closure was never complete (stage 4). Endocranial fusion of sagittal suture started at the age of 22 years (stage 1) and completion was observed at 55 years (stage 4). This observation confirms with that reported by Todd and Lyon⁵, while it is not in contrast to the observation made by Pomerol & Topinard⁶, who observed endocranial commencement of sagittal suture at a much later age at about 40 years. The ectocranial fusion of sagittal suture was observed to progress somewhat steadily from the age of 31 -45 years and later again from 55 - 60 years, but never fused completely. Based on this observation, we deduced that; when a closure of stage 1 is attained in the ectocranial sagittal suture, the probable age of the person is between 30 -35 years, Stage 2 represents 36-45 years, and stage 3 was observed during 55- 60 years. However, the period between 46 - 54 years showed closure stages between 1 and 2, thereby being inconclusive for estimating age at death.

The endocranial fusion of sagittal suture was observed to progress steadily and rapidly from the age of 24 - 55 years, reaching completion at 55 years. Based on this observation, we deduced that; when a closure stage of 1 is attained in the endocranial sagittal suture, the probable age of the person is between 24 -30 years, stage 2 represents 31- 38 years, stage 3 for 39- 54 years, and stage 4 for 55 - 60 years. Lapsed union was more pronounced in the ectocranial sagittal suture. Ectocranially, closure began in the 4th part of sagittal suture followed by the 3rd part. The final stage of closure was found in the 2nd and then the 1st part. This is partially in accordance with the observation made by McKern and Stewart

who noted that closure begins in the 1st and 4th parts of sagittal, final stage of closure tends to be in the 1st and 2nd parts of the sagittal suture.⁷ Endocranially closure tends to begin in the 4th, 3rd and 2nd part and a little later in the 1st part. The final stage of closure was found to occur first in the 4th and 3rd parts, followed by 2nd and 1st part of the suture.

We observed that suture closure began first endocranially, which is in accordance with researchers like Dwight T, Parsons and Box, Todd and Lyon, Daisy Sahni et.al and Vijay Kumar A.G *et.al.*⁵⁻⁹ However, it is in contrast with Nandy's observation in 1995, who stated that suture closure usually starts at the ectocranial surface.¹⁰ Suture closure was found to occur earlier in males than in female's endocranially. This observation is in accordance with the research conducted by Dwight T, Hershkowitz et.al¹¹, Chowdury D, Apurba Nandy, Daisy Sahni et.al and Vijay Kumar A.G et.al.⁶⁻¹¹ However, ectocranial suture closure was found to occur marginally early in females than in males.

To conclude, suture closure starts earlier on the endocranial surface than on the ectocranial surface. Females showed earlier fusion than males in ectocranial suture closure, whereas males showed earlier fusion endocranially. Ectocranially and endocranially within the sagittal suture segments close in order of, S4> S3 >S2> S1. Ectocranial fusion starts in the 20-29 years age group but its progression is very erratic and complete closure never occurred. Maximum closure occurred in the 60 years age group. Endocranial fusion starts in the 20-29 years age group and progresses uniformly and rapidly. Complete closure occurred by 55 years. Endocranial suture closure is more reliable than ectocranial suture closure for estimating age at death. However due to its rapid progression and closure occurring by 60 years, makes it difficult to estimate skeletal age at death above 60 years. Age can be estimated only in range of decades. It is thus concluded that sagittal suture is "Not reliable as a single parameter for age estimation".

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References

1. Meindl RS, Lovejoy CO. Ectocranial suture closure, a revised method for the determination of skeletal age at death based on the lateral anterior sutures. *Am J Phys Anthropol.* 1985; 68: 57-66.
2. Ritz-Timme S, Cattaneo C, Collins M.J, et al. Age estimation: the state of the art in relation to the specific demand of forensic practice. *Int. J. Legal. Med.* 2000; 113: 129-136.
3. Mukherjee J.B. *Textbook of Forensic Medicine and Toxicology.* 4th ed. Academic publishers (P) Ltd.; 2011.
4. Baccino E, Schmitt A. *Forensic Anthropology and Medicine: Complementary Sciences from Recovery to Cause of Death.* *Int. J. Osteoarchaeol.* 2007; 17:434-436.
5. Todd TW, Lyon DW. Endocranial suture closure, Its progress and age relationship part 1. *Am J Phys Anthropol.* 1924; 7:325-384.
6. Shetty, U. Macroscopic study of cranial suture closure at autopsy for estimation of age. *Anil Aggrawal's Internet Journal of Forensic Medicine and Toxicology.* 2009; 10:7-8.
7. McKern TW, Stewart TD. Skeletal age changes in young American males. Environmental Protection Research Division, Technical Report, Headquarters Quartermaster Research and Development Command, Natick, MA. 1957; 45:26-28.
8. Sahni D, Jit I, Sanjeev N. Time of closure of cranial sutures in northwestern Indian adults. *Forensic Sci Int* 2005; 148:199-205.
9. Vijay Kumar AG, Agarwal SS, Bastia, et al. Fusion of skull vault sutures in relation to age. A cross sectional post-mortem study done in 3rd, 4th and 5th decades of life. *J Forensic Res* 2012; 3:173.
10. Nandy A. *Principles of Forensic Medicine.* 1st Ed. New central book agency (P) Ltd.; 1995.
11. Hershkowitz I, Latimer B, Dutour O, Jellema L M, Wish-Bartaz S, Rothschild C, et al. Why do we fail in aging the skull from the sagittal suture? *Am J Phys Anthropol.* 1997; 103:393-399.

Dental practitioners - Are they real patrons of forensic odontology?

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Abstract

Forensic odontology nowadays became a developing science and is of fantastic importance to society. It's necessary that dental practitioners must have knowledge of forensics. The aim of study was to evaluate the present status of consciousness of forensics among the dental practitioners of Rohtak city and surrounding areas. Study was conducted among 100 randomly selected dentists practicing in Rohtak and the surrounding areas. Data was collected in a custom fashion by way of a questionnaire comprising 21 questions regarding knowledge of forensic dentistry. 36.5% of the dental practitioners don't have a notion that DNA analysis can be performed from tooth pulp, about 85% dental practitioners were not aware that they might testify as a professional witness at the court of law enforcement. Ninety six percent practitioners haven't managed any forensic case during their practice. The number of dentists having an instruction for the collection, preservation and presentation of dental evidence in court is even less than 1 percent. It had been concluded from the analysis that dental practitioners from the Rohtak along with other surrounding areas don't possess the adequate knowledge of forensic odontology.

Key words

Dental practitioners; Forensic odontology; Forensic dentistry; Rohtak

Introduction

Forensic Science is a boon to tackle the present rate of crime. In the course of recent years, forensic dentistry has turned into a vital part of forensic science and plays an extremely important and valuable part in the identification of bodies uniquely in instances of mass disasters and characteristic catastrophes.¹ In medico-legal cases, it has slowly settled itself as a vital science since the late nineteenth century. Among all the sub-orders of dental science, it is one of the quickest developing branch.²

Forensic dentistry can be defined as "a branch of dentistry, which deals with the proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings in the interest of the justice."³ Dental practitioners assume a noteworthy position in forensic dentistry as the teeth are the main essential structures accessible in a completely decayed, consumed and ravaged body. This might be because of the reason that serious mutilation or consuming of bodies may occur in mass catastrophes and teeth will turn into the only proof to be used for the purpose of identification. Teeth are a standout amongst the strongest parts of our body which can withstand a larger number of attacks than some other piece of the body. The four foremost areas of interest of forensic dentistry are: dental identification, bite marks investigation, cheiloscropy (the study of lip prints) and rugoscopy (the study of palatal rugae patterns)⁴

The duty of a dentist in gathering evidence is crucial, which has to be presented in the interest of justice. The present study was

done with the aim to check the current status of awareness of forensic dentistry amongst the dental practitioners of Rohtak city and surroundings.

Material and Methods

A questionnaire survey was conducted to assess the awareness regarding forensic odontology amongst dental practitioners of Rohtak and the surrounding areas. The Questionnaire was divided into total four parts having 21 questions apart from the demographic details of the dental practitioner. Part A consists of questions regarding the experience and maintenance of dental records by the dentist. Part B and Part C comprise questions related to check their knowledge regarding forensic odontology. And the last part D consists of questions related to the application of their forensics odontology knowledge. The questionnaire was customized based on previously published studies.⁵⁻⁷ Questionnaire was audited through the internal and external validation processes. A pilot assessment was done on 10 dental practitioners to ensure the precision and appropriateness of the questions. Most of the contributors found the questionnaire to be uncomplicated and satisfactory.

Only dental practitioners were included in the study. Data for the present study was collected through the personal visit to the dental clinics or hospitals. The questionnaires were personally given to the study participants and the duly filled questionnaires were collected back from them the next day so that they get sufficient time to fill the same. The participants who did not respond and were not available on the day of the visit were excluded. A total of 110 dentists present during the study were given the questionnaire and 100 of them reported with the completely filled questionnaire. The obtained responses from the questionnaire were plotted on Microsoft Excel Spreadsheet. The percentage for each response was calculated and conclusions were drawn from the responses in the form of pie charts, bar diagrams etc.

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Results

Results of present study suggested that One hundred percent of the participants were aware of the branch in dentistry called forensic odontology and all the participants had forensic odontology as part of their curriculum. Part A consists of questions regarding the experience and maintenance of dental records. Only 7% dentists were reported having experience of 14-21 years. 54%, 14% and 7% dentists found to be having experience of 0-7 years, more than 21% and 14-21 years respectively. 70% of dental practitioners agreed to the question that maintenance of dental records during the practice of dentistry is critically important. More than 60% participants know the importance of maintenance of dental records during the practice of dentistry. Results of present study showed that 39% of dental practitioners are maintaining the dental records for approximately five years. 45.3% participants are maintaining dental records for 1-5 years. Radiograph / Photographs / Study cast were kept as a record by 58.5% of participants. More than 60% participants do not compile records for studying trends/ making deductions / conducting research (Table1). Part B and Part C comprised of questions regarding knowledge of forensic odontology. Only a few dentists know the significance of age estimation, gender determination and DNA analysis (Table1).

Part D contains questions regarding application of forensics odontology knowledge in clinical practice. 40% of participants agreed positively for the role of forensic dentistry for mass disasters. 80 % of participants are providing therapeutic

Table 1: Responses to the questionnaire administered to the practitioners

Q - Information maintained by dental practitioners in records	Reason of visit 26 (26%)	Family & Dental History 27 (27%)	OPGs/ Casts/ Photographs 21 (21%)	Diagnosis/ Treatment 26 (26%)
Q - Part of oral cavity that is best used for age estimation is	Pulp 35 (35%)	Dentine 4 (4%)	Enamel 38 (38%)	Saliva 23 (23%)
Q - Part of oral cavity that is best used for sex determination is	Pulp 35 (35%)	Dentine 14 (14%)	Enamel 6 (6%)	Don't know 45 (45%)
Q - Best sample for DNA analysis in humans is	Pulp 30 (30%)	Dentine 20 (20%)	Enamel 13 (13%)	Don't know 37 (37%)
Q - Dental parameters preferably used for identification purposes is	Bite marks 10 (10%)	Lip marks 10 (10%)	Dental features 35 (35%)	Don't know 45 (45%)
Q - Human tissue least susceptible to decomposition and degradation is	Muscles 16 (16%)	Bones 34 (34%)	Soft tissues 15 (15%)	Dental tissues 35 (35%)

treatment to the victims of physical abuse. Only 5% of them responded that they will inform the authority. 96% of dentist do you extend an opinion and testify as expert opinion in court.

Discussion

Forensic dentistry is an imperative branch of the investigation of dentistry that would help in solving cases of deaths and abuses.⁸ In India, forensic dentistry came into the spotlight in

1193, when Jai Chand, the Raja of Kanauj, was killed by Muhammad Ghori at the Battle of Chandawar and was later distinguished by his false teeth subsequent to being found among the killed. Other significant cases in India, such as the death of former Prime Minister Mr. Rajiv Gandhi in 1991 was likewise later distinguished from his dentition and all the more as of late, Dr. Ashith B Acharya, the forensic odontologists, helped in understanding the sixteenth December 2012 Delhi pack assault case with the assistance of bite marks examination.

The loss of life in India because of the tidal wave in 2004 was more than 15,000, yet it is an inquiry left unanswered, regardless of whether all casualties were distinguished. This could have been made conceivable if there were satisfactory forensic odontologists for recognizable proof of the casualties⁹. Today forensic odontology is thought to be a specific and solid strategy for identification of the expired, especially in various casualty episodes. Systematic reviews would help us to better understand the condition of forensic dentistry in India. However, due to the scarcity of studies on the present topic, very few systematic reviews have been conducted.¹⁰

Gupta *et al.* found a genuinely terrible condition of dental record maintenance with just 22% of the dental specialists keeping up some sort of record of the investigation performed by them. It was seen that even written consent which in medico-legal cases can go about as a guardian angel for a dentist was acquired by just 15% of the dental specialists. Shockingly, just 13% specialists affirmed that they had satisfactory learning with respect to the strategies and methods of forensic odontology.¹¹ Shockingly in Srinagar, Kashmir presumably because of the absence of appropriate awareness, neither the legislature nor the qualified dental specialists have totally understood the role that can be played by them that's why forensic odontology is still in outset like in different conditions of India.¹²

There is a need to start the specialty training in forensic dentistry. A huge number of graduate doctors would definitely pursue the carrier as forensic odontologists who in turn will improve the services to Indian judicial as the well educational system.¹³ Forensic odontology is very much important for criminal identification and identification of deceased so it is high time that professional expertise has to be generated in their field. Harchandani *et al.* study indicates unmistakably that there is a general absence of the routine practice of forensics among dental specialists in India. There are no completely prepared labs for forensic odontology in India yet nowadays there are numerous establishments offering formal preparing in forensic dentistry like in Mumbai, Karnataka, and Delhi.¹⁴

The present study was conducted on 100 dentists practicing in Rohtak city and surrounding areas by questionnaire method. The result of study concludes the dentists practicing in the study areas does not have adequate knowledge of forensic dentistry which is in accordance with the studies conducted by Preethi *et al.* (Chennai); Wadhvani *et al.* (Mangalore); Sarode *et al.* (Pune) and Astekar *et al.* (Rajasthan).^{15,16,17,18} Similarly, Rathod *et al.* performed a cross-sectional study among 100 dental practitioners in Bhilai-Durg They also come to the conclusion

that specified areas dentists do not know regarding the role of dentistry in forensics.⁸

In contrast to results of our study, Waleed *et al.* observed that students in college maintain proper dental records than private practitioners in the study conducted by them.¹⁹ It is a lawful commitment for each dental specialist to keep some sort of documentation for each patient they treat. However, the experience among dental specialists with respect to forensic sciences is as yet deficient in India.²⁰ Obviously, the present study likewise conveys to our notice a general lack of awareness regarding forensic dentistry among dental practitioners. The reason may be the number of organizations providing the training program for forensic odontology. In this way, the accomplishment of forensic dentistry can be achieved absolutely if the dental authority and the dental foundations keep up antemortem records of their own patients.

Conclusion

The findings of the present study suggest lack or inadequate awareness regarding forensic odontology in dentists practicing in Rohtak and surrounding areas. Many dentists are still not maintaining dental records properly. This sends an alarm for increasing the awareness among the dentists on the importance of maintaining dental records containing all the relevant details. Thus, a new format for recording the findings must be prepared to maintain the uniformity in records. Along with this, the appointment of a statutory body to conduct a regular check on maintenance of proper dental records by the practicing dentists is necessary. Every dental expert has a duty to comprehend the forensic implications related to the act of his/her calling and hence he should work earnestly enough so to guarantee his commitment in the field of forensic dentistry.

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References

1. Debnath N, Gupta R, Nongthomban RS, Chandran P. Forensic odontology. *J Med Sci* 2016;30:20-23.
2. Keiser-Nielsen S. Forensic odontology. *Int Dent J* 1968;18:668-83.
3. Jurel SK. Role of dentist in forensic investigations. *J Forensic Res* 2012;3:148
4. Nagarajappa R, Mehta M, Shukla N, Tuteja JS, Bhalla A. Awareness of Forensic Odontology among Dental Practitioners in Kanpur City, India: A Kap Study. *J Dent Res Updates* 2014 Dec;1(1):6-12.
5. Sahni A, Rehani S, Mathias Y, Kardam P, Nagpal R, Kumari R. A questionnaire survey on forensic odontology: Are we really aware? *J Forensic Dent Sci* 2016;8:113.
6. Preethi S, Einstein A, Sivapathasundharam B. Awareness of forensic odontology among dental practitioners in Chennai: A knowledge, attitude, practice study. *J Forensic Dent Sci* 2011;3:63-6.
7. Hannah R, Ramani P, Natesan A, Sherlin HJ, Gheena S, Ramasubramanian A, et al. Evaluation of knowledge, attitude and practice of forensic odontology among undergraduate dental students. *Int J Orofac Biol* 2017;1:16-20.
8. Rathod V, Desai V, Pundir S, Dixit S, Chandraker R. Role of forensic dentistry for dental practitioners: A comprehensive study. *J Forensic Dent Sci* 2017;9:108-9.
9. Rai B, Anand SC. Role of forensic odontology in tsunami disasters. *The Internet Journal of Forensic Science* 2006;2: 11-15. Doi: 10.5580/1c28.s
10. Gambhir RS, Singh G, Talwar PS, Gambhir J, Munjal V. Knowledge and awareness of forensic odontology among dentists in India: A systematic review. *J Forensic Dent Sci* 2016;8:2-6.
11. Gupta A, Mishra G, Bhutani H, Hoshing C, Bhalla A. Forensic revolution need maintenance of dental records of patients by the dentists: A descriptive study. *J Int Soc Prevent Communit Dent* 2016;6:316-20
12. Sengupta S. Forensic odontology as a victim identification tool in mass disasters: A feasibility study in the Indian scenario. *Journal of Forensic Dental Sciences* 2014;6(1):58-61
13. Zeeshan M, Khalid B, Siddiqi M, Jabeen N, Israr M, Ehsan MT, Rahman F. Awareness and compliance about forensic dentistry among dental professionals of twin cities of Rawalpindi-Islamabad: a questionnaire based study. *Pak Oral Dent J* 2014;34(2):277-80.
14. Harchandani N, Marathe S, Hebbale M, Nisa S U, Hiremutt D: Awareness of Forensic Odontology among General Dental Practitioners in Pune - A Cross-sectional Study. *Journal of Advanced Medical and Dental Sciences Research*. 2014; 2 (3):148-53.
15. Sarode GS, Sarode SC, Choudhary S, Patil S, Anand R, Vyas H. Dental records of forensic odontological importance: Maintenance pattern among dental practitioners of Pune city. *J Forensic Dent Sci* 2017;9:48-52
16. Preethi, S, Einstein A, Sivapathasundharam B. Awareness of forensic odontology among dental practitioners in Chennai: A knowledge, attitude, practice study. *J Forensic Dent Sci* 2011;3:63-6.
17. Wadhvani S, Shetty P, Sreelatha SV. Maintenance of antemortem dental records in private dental clinics: Knowledge, attitude, and practice among the practitioners of Mangalore and surrounding areas. *J Forensic Dent Sci* 2017;9:78-82.
18. Astekar M, Saawarn S, Ramesh G, Saawarn N. Maintaining dental records: Are we ready for forensic needs? *J Forensic dent sci* 2011;3:52-7.
19. Waleed P, Baba F, Alsulami S, Tarakji B. Importance of dental records in forensic dental identification. *Acta Inform Med* 2015;23:49-52.
20. Shanbhag VL. Significance of Dental Records in Personal Identification in Forensic Sciences. *J Forensic Sci Med* 2016; 2:39-43.

Ethical climate and its effect in teaching hospital: A vision from 3rd eye

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Abstract

Ethics are the basic things to be followed everywhere and more importantly at work place. In the same way, ethical climate plays a key role in deciding the working environment of a teaching hospital and medical college. The present study aimed to investigate the correlation between ethical climate and its effects in teaching hospital on the basis of perception of the nurses employed in a teaching hospital regarding the ethical climate in their work environment. It was a descriptive, cross-sectional study, which was conducted on 200 nurses working at Parul Sevashram Hospital and Medical College, Vadodara, Gujarat, India. For data analysis, descriptive and inferential statistics were used. Olson's Hospital Ethical Climate Survey (HECS), a self-administered standard questionnaire, was used to assess the nurses' perceptions of the hospital ethical climate. Mean ethical climate scores of nurses for colleagues, patients, managers, hospital and physicians' factors were 4.49 ± 0.491 , 4.25 ± 0.489 , 4.70 ± 0.353 , 4.38 ± 0.402 , and 4.53 ± 0.454 , respectively. The total mean score of ethical climate was 4.49 ± 0.288 . The comparison among the mentioned factors indicated that managers ($P=0.000$) factor acquired the highest score. In addition, organizational ethical climate did not show any significant association with age, sex, marital status, education status and work experience. The highest score of ethical climate belonged to managers' factor, while the minimum score was related to patients. Regarding the role of ethical climate in the improvement of nurses' performance, planning for enhancing the ethical climate seems to be mandatory.

Key words

Ethical climate; HECS; Teaching Hospital; Nurses.

Introduction

Ethical values vary from one region to another region, one culture to another culture and from time to time. Climate is the surrounding environment, in which particular group of persons working and that climate affects the behaviour of each and every person directly or indirectly which in turn affect work output. Ethical climate is a part of the overall organizational climate and refers to "shared perceptions of what ethically correct behaviour is and how ethical issues should be handled"¹. Olson describes ethical climate as the "individual perceptions of the organization that influences attitudes and behaviour and serves as a reference for employee behavior".

Ethical climate is hinged upon organizational culture, rules, policies and principles made by them. Nurses' perceptions of this concept vary according to the ward they are working in, persons in their surrounding they are dealing with on daily routine basis and the new guidelines of the system. This can exert adverse impact on their care method and performance. So it is very important to maintain and keep improving the ethical

climate of the work place as a topmost priority to improve the efficiency of employees. Principles alone do not lead to ethical decisions; decisions without principles are ethically empty². The first known documents dealing with ethics are Egyptian papyri dated 16th century B.C. Malpractice occurs if and only if professional standards of care are not met³.

Perception of ethical climate is an important aspect of organizational culture⁴. For optimum performance and to oblige observance of rules and regulations, organizations need ethical principles to help with implementation of ethical behaviours and management practices^{5,6}. In fact, the structure of organizational climate plays an important role in the organizational perceptions and behaviours, such as ethical climate⁷. Attention to the perception of organization's ethical climate increases sensitivity of managers to the improvement of staff compliance with ethical standards^{5,6}. Ethical climate is one of the important factors in the formation of inter-organizational relationships^{8,9} and the consistency of the already-made decisions with ethical principles^{5,10}, which influence the productivity and efficiency of the organization's performance⁸ at multiple levels.

The attitudes and perceptions of nurses and their perceptions of the governing climate affect their performance and their job satisfaction or stress in organizational affairs which ultimately affects the patient care and core system of the teaching hospital. Nurses play a pivot role in health care system of a hospital and medical college as they are more connected in comparison to all other person like management (manager and hospital),

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physicians, patients and they spend maximum time in patient care which makes their role very crucial in health care system. That's why terminology of vision from 3rd eye of the teaching hospital is very much suitable for them.

Former studies showed that unsuitable ethical climate in the organization can play a critical role in creating moral distress, job dissatisfaction and consequently resignation from the nursing profession¹¹⁻¹⁴. Several factors such as age, type of hospital, human resources, management approach, organizational philosophy and values affect nurses' perceptions of ethical climate,^{9, 15-17}. Indeed, promotion of ethical climate leads to increased quality of care¹⁸ and coping up of nurses with other causes of dissatisfaction in the work environment¹¹.

Therefore, ethical climate, having shared values in organization, is considered as a hallmark of a healthy work environment¹⁹ and has been associated with various aspects of clinical practice and nurses' jobs. These aspects include nurses' job satisfaction^{16,20} turnover intentions,^{12,21,22} retention¹⁹, moral distress,²³⁻²⁵ organizational commitment²⁶ and well-being in genera.²⁷

Materials and Methods

Present study was undertaken after obtaining the necessary permission from the ethical approval committee of the Parul University (concerned teaching hospital and medical college), Vadodara, Gujarat, India. Before the distribution of the questionnaires, the researchers provided the necessary explanations for the nurses and received their verbal consent for participation for the study. Moreover, the nurses were assured of the confidentiality of the data. After doing all formal workout the questionnaire was distributed among the nursing staff of Parul Sevashram Hospital and Medical College, Vadodara, Gujarat.

This was a descriptive, cross-sectional study in which 200 nurses were studied using a demographic form and Hospital Ethical Climate Scale (HECS). This form was designed by Oslon30 in 1998 to measure nurses' perceptions of ethical climate dominant over their workplace or hospital based on Victor and Cullen's questionnaire which was used after obtaining permission. This was divided in 5 categories which are as follows: colleagues, patients, managers, hospital and physicians.

1. Colleagues (total 4 questions - 1, 10, 18, 23),
2. Patients (total 4 questions - 2, 6, 11, 19),
3. Managers (total 6 questions - 3, 7, 12, 15, 20, 24),
4. Hospital (total 6 questions - 4, 8, 13, 16, 21, 25) and
5. Physicians (total 6 questions - 5, 9, 14, 17, 22, 26)

The HECS items were translated into Gujarati language by two of the researchers fluent in concerned languages. The draft was then reviewed by another member of the research group. Based on their comments and suggestions, the questionnaire was revised further to increase its accuracy. After which the HECS was tested on twenty nurses who had not been included in the study group and their opinions were used to prepare the final

version of the HECS. The resulting questionnaire was then translated back into English by an independent and competent translator in order to compare and contrast the back translation with the original questionnaire which was prepared earlier. By this way questionnaire was finalised.

The questionnaire was rated by using a 5-point Likert scale ranging from - almost never true (1 point), seldom (2 points), sometimes (3 points), often (4 points), and almost always true (5 points). Scores 1 and 5 indicate the lowest and highest agreement with the expression, respectively. The minimum and maximum scores for each item were 1 and 5, respectively. The total score of the scale was obtained from calculating the sum of the all items. To analyze the data, descriptive (frequency, percentage, mean and standard deviation), inferential statistics, that is, independent t-test and One-way ANOVA for the relationship of ethical climate with demographics and other factors were used in SPSS, version 24.0. The reliability of the original instrument, that is, the internal consistency, Cronbach's α was used.

Results

The higher the score denotes the more positive ethical climate. In addition, mean value of 3.5 considered the cut-off point to make a better comparison. Indeed, any score above the cut-off point indicates the positive opinion of the working staff regarding the ethical climate and indicates good and favourable climate^{28,29}. In the present study, a total mean score of 4.49 was obtained, indicating a positive ethical climate. Mean age of the subjects was 23.73 ± 3.414 years (age range: 18 to 40 years). Mean duration of work experience was 2.81 ± 2.509 years (range: 1 to 20 years). Khalesi, et al. reported the Cronbach's alpha reliability coefficient of 0.94 for the same scale²⁸. The reliability of the original instrument, that is, the internal consistency, Cronbach's α was 0.92 for the overall scale in our study. Cronbach's α for the subscales: colleagues, patients, managers, hospital and physicians were 0.81, 0.80, 0.89, 0.91 and 0.83, respectively³⁰. (Table 1 and 2)

In addition, the mean score of the nurses' perception of the ethical climate governing the hospital was 4.49 ± 0.288 . The

Table 1: Demographic characteristics of the nurses (n=200).

Variable		N	%
Age	Above 25	34	17
	Below 25	166	83
Sex	Male	36	18
	Female	164	82
Marital status	Married	60	30
	Unmarried	140	70
Education	Post graduate and above	178	89
	Undergraduate and below	22	11
Work experience	3 yrs or more	72	36
	Less than 3 yrs	128	64

highest mean score obtained for the manager factor followed by physicians, colleagues, hospital and patients respectively (Table 2).

Table 2: Statistics of HECS sub-scales, Cronbach's alpha and Pearson's Correlation

Category (no. of items)	Mean \pm SD	Cronbach's alpha coefficient	Cronbach's alpha Coefficient (Olson's study)	Pearson's Correlation (r)
Colleagues (4)	4.49 \pm 0.491	0.81	0.73	0.695*
Patients (4)	4.25 \pm 0.489	0.80	0.68	0.532*
Managers (6)	4.70 \pm 0.353	0.89	0.81	0.663*
Hospital (6)	4.38 \pm 0.402	0.91	0.92	0.757*
Physicians (6)	4.53 \pm 0.454	0.83	0.77	0.681*
Total (26)	4.49 \pm 0.288	0.92	0.91	

HECS: Hospital Ethical Climate Survey; SD: standard deviation Pearson's Product Moment Correlation between sub-scale and HECS total * P-value < 0.01

Table 3: Mean score of nurses' responses to hospital ethical climate survey items

Factor	Questions	Mean \pm SD
Colleagues	1. My colleagues listen to my concerns about patient care	4.40 \pm 0.816
	10. My colleagues help me with difficult patient care issues	4.56 \pm 0.641
	18. I work with competent colleagues	4.44 \pm 0.880
	23. Safe patient care is provided in my unit	4.56 \pm 0.715
Patients	2. Patients know what to expect from their care givers	3.42 \pm 0.273
	6. Nurses have access to the information necessary to solve a patient care problem	4.49 \pm 0.798
	11. Nurses use the information necessary to solve a patient care issue/problem	4.57 \pm 0.590
	19. The patient's wishes are respected	4.53 \pm 0.674
Managers	3. When I am unable to decide what is right or wrong in a patient care situation, my manager helps me	4.72 \pm 0.514
	7. My manager supports me in my decisions about patient care	4.66 \pm 0.536
	12. My manager listens to me about patient care issues	4.72 \pm 0.621
	15. My manager is someone I can trust	4.71 \pm 0.608
	20. When my colleagues are unable to decide what is right or wrong in a patient care situation, I have observed that my manager helps them	4.61 \pm 0.530
	24. My manager is someone I can respect	4.75 \pm 0.479
Hospital	4. Hospital policies help me with difficult patient care issues	4.42 \pm 0.794
	8. A clear sense of the hospital's mission is shared among nurses	3.82 \pm 0.158
	13. The feelings and values of all parties involved in a patient care issue/problem are taken into account when choosing a course of action	4.51 \pm 0.559
	16. Conflict is openly dealt with, not avoided	4.47 \pm 0.717
	21. There is a sense of questioning, learning, and seeking creative responses to patient care problems	4.62 \pm 0.565
	25. I am able to practice nursing in my unit as I believe it should be practiced	4.45 \pm 0.783
Physicians	5. Nurses and physicians trust one another	4.54 \pm 0.642
	9. Physicians ask nurses for their opinions about treatment decisions	4.54 \pm 0.758
	14. I participate in treatment decisions for my patients	4.47 \pm 0.731
	17. Nurses and physicians respect each other's opinions	4.67 \pm 0.514
	22. Nurses and physicians respect one another	4.71 \pm 0.537
	26. Nurses are supported and respected in this hospital	4.26 \pm 0.981

Comparison of the ranks among the factors, managers and patients were at the highest and lowest ranks, respectively. The comparison of the mean of nurses' responses showed that the highest score for the item "My manager is someone I can respect" obtained from the manager factor. The lowest score obtained for the item "Patients know what to expect from their care givers" from the patient factor (Table 3).

Shapiro-Wilk test was used to compute the normality of the data and it was found that it rejects the null hypothesis which means that data were not normally distributed ($P < 0.001$). Kruskal Wallis one-way ANOVA post hoc test showed that organizational ethical climate was significantly correlated with age ($P = 0.031$). However, it was not significantly correlated with sex ($P = 0.868$), marital status ($P = 0.640$), education status ($P = 0.956$) and work experience ($P = 0.231$).

Moreover, independent t-test did not reveal any statistically significant difference between ethical climate with age, with sex, with marital status, with education status and with work experiences. Pearson's product-moment correlation reflected that ethical climate is not significant and negatively correlated with age ($P = 0.061$, $r = -0.188$), sex ($P = 0.226$, $r = -0.112$), marital status ($P = 0.360$, $r = -0.093$) and work experience ($P = 0.484$, $r = -0.071$) but it was found to be not significant and positively correlated with education status ($P = 0.587$, $r = 0.071$).

Discussion

The relationship with colleagues is concern with support and the possibility to rely on your colleagues in difficult decision making situations. The patient-nurse relation encompasses the providing of information and do care for the patients. The relationship with the managers not only included respect and confidence but also support as an additional count. The relationship with the hospital relates to support via hospital's vision as well as the available protocols and policies. At the end, the relationship with physicians included respect for each other and confidence in the physicians.

Our sample was also restricted to one institution, so that a generalization of the results should be made with caution. The results of this study indicated that from the perspective of the nurses, the mean of the majority of the HECS items was equalled to 4.5 out of 5. When other studies were compared from different geographical regions results were found as per Table 4.

It seems that the regional culture of each demographic part affects the ethical climate of its working place along with that, the staff in different hospital wards had different ethical climate. In terms of ICU nurses' perceptions of ethical climate, a study found support for the negative relationship of moral distress and work pressure with ethical climate, such that ICU nurses expressed a better perception of ethical climate as a result of reduced work pressure³¹.

It should be considered that the individuals' perceptions and experiences of ethical climate are affected by organizational policies and procedures that vary due to the differences in

individual circumstances and working systems. To improve the quality of the nursing profession one should be dealt with as it might lead to the loss of confidence in self and others along with respect and ultimately, the quality of health care system will decline very fast.

It is noteworthy that the term “managers” here refers to the higher authorities who are directly responsible for the Department of Nursing, such as matrons, supervisors, and head nurses rather than hospital administrators. From among the 26 items of the HECS, the item “My manager is someone I respect”

Table 4: Comparison with other studies.

Place of study	Min. Score	Max. score
Fogel et al. ³¹	Hospital	Colleagues
Jalali et al. ⁵	Hospital	Colleagues
Pauly et al. ¹⁸	Hospital	Colleagues
Mobasher et al. ⁶	Hospital	Manager
Shafipour et al. ³²	Physicians	Manager
Han et al. ³³	Physician	Colleagues
Present study	Patients	Managers

received the highest mean score, while the item “Patients know what to expect from their care givers” acquired the lowest mean score. Thus, it seems that cultural and management differences can influence some inter-firm relationships between nurses and their colleagues and/or authorities. Nurses whose responses on the HECS indicated a perceived higher ethical climate were also more likely to report higher intentions to stay at their organisation. In this study, three factors in the HECS (colleagues, managers and physicians) were found to be significantly correlated with turnover intention of the staff. Therefore, the work environment should enable nurses to receive support from their managers and hospital and make them to actively participate in decision-making for patient care with physicians and to find out what patients require when physicians are not around.

Conclusion

The ethical climate of hospitals is typical of the organizational environment which includes relationship between the health care personnel as well as their relationships with patients and their families. Given the importance of ethical climate in hospitals for the development of a good atmosphere for higher performance of each and every employee and the type of nursing care provided for patients, managers are recommended to boost the spirit of cooperation and interaction among treatment groups by making the necessary positively directed strategies and policies. It has to be kept in mind that, negative ethical climate can lead to depression, lack of morality, job

dissatisfaction, lack of performance, and some time resignation from the organisation. In these cases, the authorities should take the necessary steps regarding nurses' perceptions and vision to improve workplace environment. The limitations of this study include the lack of control of economic, social, and cultural variables.

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References

- Elçi M, Alpkan L. The impact of perceived organizational ethical climate on work satisfaction. *J Bus Ethics*, 2009; 84(3): 297-311.
- Hassan KZ. Islam and the four Principles, "a Pakistani view" In *Principles of Health care Ethics*. Gillon R. (edi) John Wiley and sons; 1994.
- Beauchamp TL, Childress JF. *Principles of Biomedical ethics*. 4th edition, Oxford University Press, 1994.
- Joolae S, Jalili H, Rafiee F, Haggani H. The relationship between nurses' perception of moral distress and ethical environment in Tehran University of Medical Sciences. *J Med Ethics Hist Med.*, 2011; 4(4): 56-66.
- Jalali T, Kalantari S, Hekmat Afshar M, M jouybari L. The nurse's perception from the hospital ethical. *Jentashapir.*, 2013; 4(1): 65-72.
- Mobasher M, Nkhaee N, Garoosi S. Assessing the ethical climate of Kerman teaching hospitals. *ijme*. 2008; 1(1): 45-52.
- Borhani F, Jalali T, Abbaszadeh A, Haghdoost AA, Amiresmaili M. Nurses' perception of ethical climate and job satisfaction. *J Med Ethics Hist Med.*, 2012; 5(6): 1-6.
- Cullen JB, Parboteeah KP, Vtictor B. The effects of ethical climates on organizational commitment: A two-study analysis. *J Bus Ethics*, 2003; 46(2): 127-41.
- Borhani F, Jalali T, Dehestani M, Abbaszadeh A, Torabi J, Esmailpour H. Ethical climate in social security and private hospitals in Kerman in 2012. *Journal of Bioethics*, 2013; 4(14): 67-81.
- Montakab Yegane M, Arshadi N, Baharlo M, Changi Ahmadi S. The relationship between organizational climate and moral, leader-member exchange And perceived external prestige on organizational commitment. *Journal of Social Psychology*, 2013; 8(29): 61-73.
- Joolae S, Jalili HR, Rafii F, Hajibabae F, Haghani H. The relationship between ethical climate at work and job satisfaction among nurses in Tehran. *Indian J Med Ethics*, 2013; 10(4): 238-42.
- Hart SE. Hospital ethical climates and registered nurses' turnover intentions. *Image J Nurs Scholarsh*, 2005; 37: 173-77.
- Borhani F, Hoseini SH, Abbaszadeh A, Abbasi M, Fazljoo E. Nurses' perception of ethical climate governing the teaching

- hospital affiliated with the the university of Medical Sciences Shahid Sadughi Yazd. *J Med Ethics*, 2014; 8(29): 41-65.
14. Hwang JI, Park HA. Nurses' perception of ethical climate, medical error experience and intent-to-leave. *Nurs Ethics*, 2014; 21(1): 28-42.
 15. Barnett T, Vaicys Ch. The moderating effect of individuals' perceptions of ethical work climate on ethical judgments and behavioral intentions. *Journal of Business Ethics*, 2000; 27(4): 351-362.
 16. Goldman A, Tabak N. Perception of ethical climate and its relationship to nurses' demographic characteristics and job satisfaction. *Nurs Ethics*, 2010; 17(2): 233-46.
 17. García IG, Castillo RF, Santa-Bárbara ES. Nursing organizational climates in public and private hospitals. *Nurs Ethics*, 2013; 21(4): 437-446.
 18. Pauly B, Varcoe C, Storch J, Newton L. Registered nurses' perceptions of moral distress and ethical climate. *Nurs Ethics*, 2009; 16(5): 561-73.
 19. Robichaux C and Parsons ML. An ethical framework for developing and sustaining a healthy workplace. *Crit Care Nurs Q*, 2009; 32: 199-207.
 20. Joseph J and Deshpande SP. The impact of ethical climate on job satisfaction of nurses. *Health Care Manage Rev.*, 1997; 22(1): 76-81.
 21. Ulrich C, O'Donnell P, Taylor C, et al. Ethical climate, ethics stress, and the job satisfaction of nurses and social workers in the United States. *Soc Sci Med.*, 2007; 65: 1708-1719.
 22. Filipova AA. Relationships among ethical climates, perceived organizational support, and intent-to-leave for licensed nurses in skilled nursing facilities. *J Appl Gerontol.*, 2011; 30: 44-66.
 23. Sile'n M, Svantesson M, Kjellström S, et al. Moral distress and ethical climate in a Swedish nursing context: perceptions and instrument usability. *J Clin Nurs.*, 2011; 20: 3483-3493.
 24. Lützné K1, Blom T, Ewalds-Kvist B, Winch S. Moral stress, moral climate and moral sensitivity among psychiatric professionals. *Nurs Ethics* 2010; 17(2): 213-24.
 25. Corley MC, Minick P, Elswick RK, Jacobs M. Nurse moral distress and ethical work environment. *Nurs Ethics*, 2005; 12(4): 381-90.
 26. Huang CC, You CS and Tsai MT. A multidimensional analysis of ethical climate, job satisfaction, organizational commitment, and organizational citizenship behaviors. *Nurs Ethics*, 2012; 19: 513-529.
 27. Storch J, Rodney P, Pauly B, et al. Enhancing ethical climates in nursing work environments. *Can Nurse*, 2009; 105(3): 20-25.
 28. Khalesi N, Arabloo J, Khosravizadeh O, Taghizadeh S, Heyrani A, Ebrahimian A. Psychometric properties of the Persian version of the "Hospital Ethical Climate Survey". *J Med Ethics Hist Med*, 2014; 7(15): 1-7.
 29. Suhonen R, Stolt M, Gustafsson ML, Katajisto J, Charalambous A. The associations among the ethical climate, the professional practice environment and individualized care in care settings for older people. *J Adv Nurs.*, 2014; 70(6): 1356-68.
 30. Olson L.L. Hospital nurses' perceptions of the ethical climate of their work setting. *Image. J Nurs Scholarship*, 1998; 30: 345-349.
 31. Fogel, KM. The relationship of moral distress, ethical climate, and intent to turnover among critical care nurse, Ph.D Dissertation in philosophy, University of Chicago, 2007.
 32. Shafipour V, Yaghobian M, Shafipour L, Heidari MR. Nurses' perception of the ethical climate in the Iranian hospital environment. *J Nurs Midwifery Sci*, 2016; 3(4): 37-43.
 33. Han S. Ethical climate and Turnover Intention of Nurses in the South Korea. *Advanced Science and Technology Letters (Healthcare and Nursing)* 2014; 47: 295-299.

An epidemiological study of poisoning trends in eastern region of Nepal

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Abstract

Poisoning is a common problem worldwide in which, insecticide poisoning is a major problem in developing countries. Numbers of cases are reported in agricultural rich countries. Insecticide poisoning is an important cause of morbidity and mortality in many countries in the world. Majority of the farmers are unaware of insecticide types, level of poisoning, safety precautions and potential hazards on health and environment.

In present study 2533 patients in which 1441 females and 1092 males with severe poisoning were admitted in the emergency ward of tertiary care hospital at eastern region of Nepal from January 2009 to December 2011 were studied for detail epidemiological and medico legal analysis. Cases of toxic effect of insecticides, other noxious substances eaten as food and toxic effect of contact with venomous animals were reported. The prone age group was 27 years in most of the cases. Most of the admitted cases were of suicidal as well as accidental in nature and female were the main victim in incidence of such poisoning. It is also increasing because of free access and easy availability. Toxic and environmentally persistent chemicals are being used as Insecticides. It is therefore essential that manufacture, use, storage, transport and disposal of chemical insecticides be strictly regulated.

Key words

Poisoning trend; Retrospective study; Insecticide poisoning; Eastern Nepal

Introduction

Organophosphorus (OP), Organochlorines (OC), Carbamates and Pyrethroids compounds are used as pesticides, herbicides, and chemical warfare agents in the form of nerve gases^{1,2}. Acute poisoning by these agents is a major global problem with thousands of deaths occurring every year³. Most of the insecticides poisoning and subsequent death occur in developing countries following a deliberate self-ingestion particularly in young, productive age group as highly toxic insecticides are readily available at the moment of stress due to family constraint and personal issues⁴. Poisoning has been a common cause of medical admissions and deaths in Nepalese hospitals⁵⁻¹².

Accidental and occupational exposures were estimated to cause 1 million cases with 200,000 deaths. Many studies have shown the deliberate self-poisoning has for higher mortality than accidental poisoning. Various isolated hospital-based studies also clearly demonstrate that OP compounds occupy the greatest burden of poisoning related morbidity and mortality in Nepal².

Aim of the study: The objective of the study was to describe the profile of poisoning cases and to know the trends of poisoning in eastern region of Nepal.

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Material and Methods

In the present study 2533 patients with severe poisoning admitted in the emergency ward of tertiary care hospital at eastern region of Nepal from January 2009 to December 2011 were studied for detail epidemiological and medico legal analysis. Cases of toxic effect of insecticide, other noxious substances eaten as food and toxic effect of contact with venomous animals were reported. This cohort study includes 1092 males (M) and 1441 females (F) consecutive patient history of route of administration (inhalation, ingestion and injection), availability of bottles, clinical symptoms and signs help to diagnose the poisoning. The present study is an important and useful study of poisoning trends in eastern Nepal.

Results

A total of 2533 patients (1441 females and 1092 males) with severe poisoning were admitted in the emergency ward of tertiary care hospital at eastern region of Nepal from January 2009 to December 2011. The reported cases included those from toxic effect of insecticides, other noxious substances along with venomous animals (Table 1). It is very apparent that insecticides were involved in the majority of the cases. This trend was from positive results of toxicology cases in hospital which was represented in Table 1. In the present study the number of cases of insecticide poisoning reported in the 2010 was higher than 2009 and 2011. Surprisingly, for reasons unknown, no cases due to other type of poisoning was reported in the year 2010.

Female victims suffered poisoning more commonly than male victims (Table 2). Numbers of female victims were probably more because female face financial as well as family constraints

more than male. Table 3 shows the outcome of total cases which reported at tertiary care hospital, and suggest that the patients' health improved in most cases. Death occurred in rural area patients as well as in those patients in which administration of poison or drugs took place in more than lethal doses.

Table 1: Distribution of cases on the basis of poison consumed

Poisons	2009	2010	2011	Total
Insecticides	542	841	208	1591
Drugs	165	-	-	175
Chemical substances	59	-	-	59
Noxious substances (eaten as food)	-	-	193	193
Venomous animals	-	-	192	192
Metals	25	-	-	25
Unspecified substances	-	-	308	308
Total	791	841	901	2533

Source: B.P.Koirala Institute of Health Sciences, Dharan, Nepal.

Table 2: Sex distribution during the study period

Year	Female	Male	Total
2009	439	352	791
2010	472	369	841
2011	530	371	901
Total	1441	1092	2533

Table 3: Outcome of the patients admitted to the hospital

Outcome	2009	2010	2011	Total
Absconded without Case sheet	4	4	10	18
Cured	10	11	10	31
Patient died in more than 48 hours	22	19	14	55
Patient died within 48 hours	42	24	17	83
Improved	660	714	771	2145
Left against medical advice	31	41	64	136
Others	6	9	6	21
Recovered	14	16	7	37
Referred	1	2	1	4
Unchanged	1	1	1	3
Total	791	841	901	2533

Discussion

Birincioglu et al. found that insecticide was the second most common toxic agent category (17%)¹³. Their data showed that insecticides were the most common poisons used for suicidal purposes (61.2%). Similar data have been reported by other researchers; 43% by Elif *et al.*¹⁴, 52.9% by Soltaninejad *et al.*¹⁵, 64.3% by Vougiouklakis *et al.*¹⁶, and 71.9% by Fedakar *et al.*¹⁷. The number of fatal insecticide poisoning cases was higher in summer than in other seasons. The present study showed that insecticides were the most important cause of mortality.

Insecticides were the primary agent in poisonings in Tehran¹⁵, Sri Lanka¹⁸, Jordan¹⁹, and Taiwan²⁰. Insecticide application without adequate protection, illiteracy, economic problems, difficult living conditions, and various psychological problems seems to correlate with high rates of insecticide poisoning, both intentional and unintentional.

The second toxic agent in our study was medications and drugs, and the most common cause of medication-related deaths was intake of medications without prescription. According to the studies from the developed countries, analgesics, particularly acetaminophen, is the most common agent in deliberate poisonings in adults²¹. In some other studies, psychoactive drugs have been reported as the most common agent in deliberate self-poisonings²². In Denmark, Norway, and Sweden, heroin and morphine were the most frequently encountered drugs²³. In the present study, medication poisonings were primarily with antidepressants and benzodiazepines. Cases who utilized these drugs for intentional suicide had easy access to them, because either they themselves or their relatives used such medicines. The abuse of heroin and cocaine in the area is low because of the low socioeconomic status of the population. This can account for the low number of deaths caused by poisonings with heroin and cocaine.

Conclusion

Unconventional use of insecticides for agricultural purposes were harm not only our agriculture production but it's directly and indirectly affected to common people, due to easy availability in Nepal. It does not use only in agricultural practices but use as homicidal and suicidal purposes. Improper medications are also harmful and its cause suicidal and accidental deaths. With the increasing stress in life, suicide among adolescents and young adults is a common problem. Females are the main working mass in the Nepalese society and face more stress during daily activities in compare to male. They use insecticides as suicidal purposes because it is available in common household. Patient with intentional poisoning must undergo psychiatric consultation during their stay in the hospital for the prevention and treatment from suicidal and accidental poisoning. This will minimize the risk of next attempt of self-harm. As Nepal is country of natural resources and field of cultivation most people are below poverty line. Farmers have been risked group by occupation, they have use insecticides during cultivation and there is no restriction on its use. Hence strict rules must be followed regarding sale of insecticides mainly in adolescent. The insecticides and psychoactive drugs must be sold in the presence of a witness who should be known to the client. Many accidental insecticide poisoning cases occurs due unawareness of proper use of these chemical substances. So, proper guidelines and precautions are necessary to handle these chemical substances.

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References

- Bowls BJ, Freeman JM, Luna JA, Meggs WJ. Oral treatment of organophosphate poisoning in mice. *Acad Emerg Med.* 2003; 10:286-288.
- Mishra A, Shukla SK, Yadav MK, Gupta AK. Epidemiological Study of Medicolegal Organophosphorus Poisoning in Central Region of Nepal. *J Forensic Res.* 2012; 3:167.
- Eddleston M, Buckley NA, Checketts H, Senarathna L, Mohamed F, Sheriff MH, et al. Speed of initial atropinisation in significant organophosphorus pesticide poisoning--a systematic comparison of recommended regimens. *J Toxicol Clin Toxicol.* 2004;42: 865-875.
- Karalliedde L, Eddleston M, Murray V. The global picture of organophosphate poisoning. *Organophosphates and health.* Imperial press London. 2001;432-471.
- Paudyal BP. Poisoning: pattern and profile of admitted cases in a hospital in central Nepal. *J Nepal Med Assoc.* 2005;44: 92-96.
- Kafle KK, Gyawali KK. Organophosphorus-Commonest Poisoning Agent. *J Inst Med.* 1992;14: 228-233.
- Prasad PN, Karki P. Poisoning cases of TUTH emergency; a one-year review. *J Inst Med.* 1997;19: 18-24.
- Ghimire RH, Sharma SP, Pandey KR. A Retrospective Study of the Changing Trends of Poisoning Cases at Tribhuvan University Teaching Hospital, Nepal Between 1990-1992 and 2000-2002. *J NHRC.* 1990.
- Subedi BK. A Retrospective Study of Poisoning Cases at Bir Hospital, Nepal. *J Inst Med.* 1990;12: 296-302.
- Pokhrel N, Gurung CK. A Study of Poison Cases Recorded in Bir Hospital Over four Years. *J Inst Med.* 1987;29-34.
- Rauniyar GP, Das BP, Naga Rani MA, Gupta MP, Karki BMS. Retrospective Analysis of Profile of Acute Poisoning Cases in a Tertiary Care Hospital in Eastern Nepal: A Four-Year Database from 1994 to 1997. *J Nep Med Assoc.* 1999;38: 23-28.
- Pathak UN, Chhetri PK, Dhungel S, Chokhani R, Devkota KC, Shrestha BO. Retrospective Study of Poisoning cases admitted in Nepal Medical College Teaching Hospital. *Nep Med Col J.* 2001; 3:101-105.
- Birincioglu H, Karadeniz HYT. Fatal poisonings in Trabzon (Turkey). *J. Forensic Sci.* 2011;56, pp. 660-663.
- Elif D, Akgur SA, Ozturk P, Sen F. Fatal poisonings in the Aegean region of Turkey. *Vet Hum Toxicol.* 2003; 45:106-8.
- Soltaninejad K, Faryadi M, Sardari F. Acute Pesticide poisoning related deaths in Tehran during the period 2003-2004. *J Forensic Leg Med.* 2007;4(6):352-4.
- Vougiouklakis T, Boumba VA, Mitselou A. Fatal poisoning in the region of Epirus, Greece, during the period 1998-2004. *J Clin Forensic Med* 2006; 13:321-5.
- Fedakar R, Turkmen N. Fatal poisonings in the south Marmara region of Turkey, 1996-2003. *Eur J Gen Med.* 2008;5(1):1-8.
- De Alwis LB, Salgado MS. Agrochemical poisoning in Sri Lanka. *Forensic Sci. Int.* 1988; 36:81-9.
- Abu al-Ragheb SY, Salhab AS. Pesticide mortality. A Jordanian experience. *Am J Forensic Med Pathol.* 1989;10: 221-5.
- Sheu JJ, Wang JD, Wu YK. Determinants of lethality from suicidal Pesticide poisoning in metropolitan Hsin Chu. *Vet Hum Toxicol.* 1998;40: 332-6.
- Lau FL. Emergency Management of Poisoning in Hong Kong. *Hong Kong Med J.* 2000; 6:288-92.
- Viertel A, Weidmann E, Brodt HR. Cases of Acute poisoning admitted to a Medical intensive care unit. *Dtsch Med Wochenschr.* 2001;126: 1159-63.
- Steenftoft Q, Teige B, Holmgren P, Vuori E, Kristinsson J, Kaa E, et al. Fatal poisonings in young Drug addicts in the Nordic countries: A comparison between 1984-1985 and 1991. *Forensic Sci. Int.* 1996;78: 29-37.

Medico-legal Audit: An essential yet ignored aspect of healthcare in India

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Abstract

Clinical audits have become an indispensable and mandatory tool in ascertaining quality assurance in the context of health care services. The significance of these audits is laid by regulatory bodies which prescribe the procedural format and logistics to conduct these audits. Conventionally, medico-legal audits are often mentioned in relation to the medico-legal reports and documents such as insurance records etc. The available literature further describes that medico-legal audits deal particularly with the formal scrutiny of forensic case work. Medico-legal audits are an integral part of hospital/clinical audits that involves examination of all the hospital records. The clinical audits aim towards quality improvement measures and hence are limited to the scrutiny of patient's clinical records. On the contrary, a medico-legal audit aims at the prevention of foreseeable litigations on the hospital and thus includes the perusal of all the hospital records. Medico-legal audits are significant whenever there is an interaction between the working of the hospital and the law. The present article discusses the various aspects of conducting audits, their significance, aims and objectives, limitations, variants, procedural layouts, etc.

Key words

Audit; Law; Medico-legal; India

Introduction

The term 'audit' is derived from the Latin word "audire" which means to hear. It is an evaluation of an organization, system, project, process or product. Auditing includes an examination of records, whether financial or nonfinancial, maintained by the institute and to express an opinion based on these records, whether they are within specific law and regulations applicable to that entity or institute. The audit is performed to determine the validity and reliability of the information. The principles of the system of the audit have been applied to the medical field also, especially in a context of the patient health care services where a meticulous examination of the health records is conducted in a systematic manner. The overall objective of conducting audits in a health care system is assuring improvement in the present patient care services.¹

The term auditing has to be distinguished from the investigation. While auditing is a general assessment of the functioning of the system, investigations are undertaken for special purposes such as determining the extent of fraud etc.

Types of audit in medical practice

1. **Clinical audit:** Clinical audit has been defined as "a quality improvement process that seeks to improve patient care and outcome through systemic review of care against explicit criteria and the implementation of change".² The clinical

audit is used as a method to review the patient care protocols that are being followed in the institution. In other words, it is a review of the current clinical practice. It helps in improving the patient care services that are being offered by suggesting the necessary changes that are required.

2. **Epidemiological audit:** Epidemiological audit was first done by Florence Nightingale about sanitation in soldiers wounded in the war during Crimean war (1853-55). An epidemiological audit involves collecting epidemiological data and using it to investigate the potential health hazards in the community. The information gathered by these audits is used to develop protocols and interventions that can be used for improving public health.

How is the audit done?

1. **Material audit:** It is an audit of available space, instruments, equipment, medicines etc. those are required for optimum patient care. It tells whether the institute is well equipped to deal with all kinds of situations or not and whether there is lack of infrastructure in any form that can hamper the proper and optimum functioning of the institute.
2. **Patient care audit:** It involves preparing Standard Operative Procedures (SOPs), reviewing patient care being given. Patient care audit aims to improve the quality of patient care and clinical outcomes and implementing change where necessary. It assesses the best patient care practice.
3. **Death audit:** It is also known as death review or mortality review. All deaths which take place in the hospital are subjected to review. Various treatment related records are reviewed to establish whether the best possible care was provided or whether things might have been done differently to avoid or minimize such deaths.³

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Current status of medico-legal audit

Interestingly, one may assume that medico-legal audits and forensic audits are same. The general belief is that a forensic audit involves the process of reviewing financial matters of a firm. Better known by the mention of a related term 'forensic accounting', a forensic audit will invariably involve experts like an accountant and a criminologist. Their role is to uncover financial frauds and alleged cases of corruptions. However, the present perception about the medico-legal audit is only partly correct. This is because a medico-legal audit involves much more than mere evaluation of financial records, the details of which are presented later.

The thin line between a clinical and a medico-legal audit

Clinical audit is a quality improvement process that helps to measure the ongoing patient care practices with regard to the agreed standards of best practices that are prevalent at that time. Its aim is to provide the clinicians the channel to find and rectify any deficiency that may be present in the existing patient care delivery system, and the possible suggestions of how to rectify it and convert it into the best practice. Clinical audit is usually a multi-disciplinary activity. It may involve various aspects and pillars of health care, like health and social services, primary and acute care providers, medical education departments and so on.

The medico-legal audit, on the other hand, takes care of the health of the doctor and the institution and is designed to prevent them from future litigations. This type of audit is associated with examining all records, ensuring that all the legal formalities are complete in all aspects, any potential legal complication is detected and rectified, and all the staff of the institute is trained in working for the above mentioned goals and ensuring that they follow them. It also involves periodic checks and updates so that the staff is well versed with any changes that may occur in the law, either from the legislature or from the judiciary.

Role of medico-legal audit in medical practice

A medico-legal audit involves auditing the hospital records from a legal angle. All the records are examined keeping in mind the statutory requirements of the law of the land. In India, more than one hundred laws govern the functioning of a hospital/medical institute. It is very difficult to keep a check on all the happenings of the hospital at all times, especially if it's a self-managed small set up of the doctor. The doctor has to spend a lot of time arranging for the administrative tasks, the time which he would like to devote to patient care. In a large set up, although there is no shortage of manpower, the problem remains the same, how to ensure that the records, especially medico-legal records are kept properly. In such situations, it's the medico-legal audit that ensures the compliance of the hospital with respect to all the relevant laws. As mentioned before, while the clinical audit is to improve the patient's health, the medico-legal audit is to improve the doctor's health. Its importance can be judged from the fact that a well performed medico-legal audit

will always raise the red flag before the establishment can be penalized for any act which is not conforming to the law.

- The performance of the hospital is reviewed (or audited) to ensure that what should be done is being done effectively.
- It helps health care providers to identify their lacunae and deficiencies so that they can improve the services.
- To ensure the safety of the patient and avoid inappropriate services.
- To assess health program and service efficiency for better results.
- Compliance with appropriate central, state and local governmental laws and regulations, as well as applicable legal opinions and interpretations.
- To check the internal control of the Hospital.

The genesis of medico-legal audit

A medico-legal audit comprises of multiple interlinked procedures that are used to ensure that all is well with the health of the institution. The laws that govern an establishment vary, and many times, it is not possible for a single person to be well versed with all of them. Consequently, it is always advisable to have a team of people, each being an expert in the relevant field to perform this audit. Though it is up to the individual hospital to decide how many different types of auditors they feel are necessary to perform a complete medico-legal audit, for an easy understanding, we have described the types of laws that govern the establishment into three types.

1. **General laws:** These are applicable on the general working of the hospital and not specifically related to patient care e.g. labour laws, environmental laws, biomedical waste disposal laws, building bylaws, fire safety norms etc.

The role of auditor: General laws are mainly the domain of administration. These laws are applicable to everyone who is working in an institute including the doctors. In these cases, the auditor has to ensure that all the relevant documents are maintained properly. He has to ensure that the requisite permissions have been sought, and the hospital administration has got the renewals done in time. Any potential irregularity if found has to be brought to the notice of the hospital administration so that the same can be rectified in time.

2. **Medico legal cases:** These are related to various provisions of Indian Penal codes (IPC), Criminal Procedure Codes (CrPC) etc. The primary responsibility of the doctor is to treat the patient. In medico-legal cases, a medical practitioner has to be very vigilant as the matter will go to the court and his documents will be subjected to strict judicial scrutiny. Even a minor mistake can affect the judicial process and can be potentially damaging to the doctor.

The role of auditor: In these cases, the auditor has to be extra careful since these matters are related to patient care records. He must have at least working knowledge of both medicine as well as the law. Thus, a person trained in both medicine and the law

would be an ideal person for this job. Here, the auditor has to ensure that the patient care records, when they are prepared by the doctor, are prepared in such a manner that when they go to the court, there is no procedural or other such deficiency that can adversely affect the justice delivery system. To ensure this, the following needs to be done:

- a. Check all records
- b. All records should be proper and updated
- c. Identify any existing and potential mistakes in the records
- d. Suggest measures for correction of such mistakes
- e. Suggest measures to prevent the occurrence of such mistakes in future

3. Different provisions of the special acts: The Medical Termination of Pregnancy (MTP) Act, Preconception and Prenatal Diagnostics Test (PCPNDT) Act, Transplantation of Human Organs Act and Consumer Protection Act etc.

The role of auditor: The aforementioned laws are specific to India. It is both the social as well as the legal duty of every individual to follow the provisions of these acts, since any lacunae in following the provisions of these acts are not only legally damaging, but also socially very damaging, both for the institute as well as for the society as a whole. The provisions of these act/laws are strict and the punishment even stricter. Therefore, the auditor has to be extra vigilant while reviewing these documents and has to observe the following:

- a. Maintenance of registers. It is one of the most important provisions of these acts and the auditor has to make sure that all the registers are in proper order, and all the relevant information is present in them
- b. Information to the authorities where required. Various information's needs to be provided to the relevant authorities at specific times and it has to be ensured that it is done properly and efficiently
- c. Application for licenses etc. where required has to be adhered to
- d. Ensure that the various provisions of the acts like putting up of various display boards at the proper places are being followed

Benefits of medico-legal audit

Only a stress free mind can work optimally. The most important benefit of a medico-legal audit is that it removes or minimizes the stress of any potential litigation on the health care provider. Today, a doctor has to be more concerned about his personal safety than that of the patient as it is never known when he may be manhandled at the work place or may be taken to the court at the slightest of pretext. A medico-legal audit relieves him of this stress as a well performed audit will ensure that everything is in order and there are no legal lacunae present in the workplace for which the doctor may be held responsible. It may not only reduce the number of litigations but also ensure that the chances of the doctor winning any court battle are much more when compared to those not engaging in such audits.

In addition, there are many other benefits that are attached to a medico-legal audit. These can be Satisfaction of the institute, prevention of future errors and litigations, record verification, quality check, moral check for the staff, reputation building, proper valuation of assets, government acceptance, suggestions for improvement, evidence in a court of law.

Limitations of audit

The audit is a time consuming process that higher cost. The major inadequacies for audits are on the part of the commitment, participation, and seriousness. Audits in Indian perspective are still more or less considered as an obligation and are done only to fulfil the requirement of various accreditation rather than for the improvement of hospital processes and quality of service in actual.

The audit has some inherent limitation with it. Auditing process involves the exercise of judgment, for example, deciding the duration of audit and in assessing the reasonableness of the judgment and estimates made by the management. The evidence available to the auditor can allow him to draw only reasonable conclusions. This evidence is generally persuasive in nature rather than conclusive in nature. Because of this, the auditor can only express an opinion. That's why absolute certainty in auditing is difficult to attain. There are also chances that some irregularities resulting from fraud or error if either exists may not be detected in the audit process.

The entire audit process is usually based on the existence of an effective system of internal control. Further, it is also important to remember some risk of failing internal control system. Any conflict between employee and management can lead to the ineffectiveness of internal control system.

The outcome of the medico-legal audit

A well performed medico-legal audit will help the hospital administration in making adequate changes to the functioning of the hospital. The various suggestions that can be provided by an audit are as follows:

- a. Designing SOPs for healthcare workers with respect to medico-legal work
- b. Regular checking/rechecking of all patient related records
- c. Provide a good working environment, and motivate healthcare workers
- d. Improvement in the healthcare services and maintenance of documents based on the review of audit and patient feedback

International scenario

In the United States, auditing standards for financial and legal matters are given by the American Institute of Certified Public Accountants (AICPA), Government Auditing Standards issued by the Comptroller General of the United States, and other applicable AICPA pronouncements and Statements of Positions

(SOPs). Auditing is done by the third party.⁴ According to its guidelines, it is required to prepare a response when deficiencies in internal control, fraud, illegal acts, and violations of a provision of contracts or grant agreements or abuse are reported. This should also include the responsible officials' view on the reported findings, conclusions, and recommendations, as well as management's planned corrective actions. In African region Agency for cooperation and research in Development (ACORD) is implementing the guidelines for legal audits related to hospitals. It is a pan African agency working for social justice and development in Africa. ACORD started audit process in Uganda in 2009.⁵ In the United Kingdom, after graduation doctors are asked to conduct clinical audits. This process is based on the National Health Service (NHS) or National Institute for Health and Care Excellence (NICE) guidelines in United Kingdom/England.¹

Conclusion

Audits are targeted toward quality improvement plans, but these plans should be time limited to clear objectives and concrete recommendations. To implement such tasks, instructions should be clearly given to the staff that carries the necessary authority to effect such change. Sometimes, quality improvement plans and associated actions are beyond the scope or limit of individuals. The support from hospital administration is very much important in such cases for the successful outcome of an audit.

While clinical audits aim towards taking care of the health care services rendered to the patients, it is prudent to state explicitly that the medico-legal audits provide a preventive safeguard to

the hospital services against future litigations. Although, it may be an easy exercise to mention that medico-legal audit has its genesis in 'defensive medicine', but in the era of patient's awareness and judicial litigations, we propose its integration in the functioning of the health care systems.

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References

1. Benjamin A. Audit: How to Do It in Practice. *BMJ*. 2008;336(7655):1241-5.
2. Dupont C, Deneux-Tharoux C, Touzet S, Colin C, Bouvier-Colle MH, Lansac J, Thevenet S et al. Clinical audit: useful tool for reducing severe postpartum haemorrhages? *Int J Qual Health Care*. 2011;23(5):583-9.
3. Sayinzoga F, Bijlmakers L, van Dillen J, Mivumbi V, Ngabo F and van der Velden K, "Maternal Death Audit in Rwanda 2009-2013: A Nationwide Facility-Based Retrospective Cohort Study." *BMJ Open*. 2016;6(1):e009734.
4. Jones RL. (2014) Hospital audit guide. [online] Examiners.state.al.us. Available at: http://www.examiners.state.al.us/documents/formpub/Hosp_Audit_Guide.pdf [Accessed 31 Mar. 2018].
5. Acordinternational.org. (2010). Uganda: An audit of legal practice on sexual violence. [online] Available at: <http://www.acordinternational.org/silo/files/uganda-an-audit-of-legal-practice-on-sexual-violence.pdf> [Accessed 31 Mar. 2018].

Forensic odontology and rapid prototyping: Adding 3rd dimension for investigation

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Abstract

Forensic odontology has evolved in multiple aspects ranging from anthropology, personal identification, crime scene investigations, mass disaster evaluation etc. Radiographs and photographs are helpful in various studies/investigations related to forensic Dental Science. Forensic Odontologist's report has been accepted in court of law to solve many medicolegal cases. Forensic radiology is particularly important in skeletal survey, antemortem and post-mortem imaging. In recent times Rapid Prototyping (3D Printing) has taken over the previous digital techniques in various fields of Medicine and Dentistry. In Forensic Odontology, 3D printing can become one of the important tools in investigation and also can overcome various shortcomings of many pervious imaging techniques.

Key words

Forensic Odontology; Forensic Radiology; Rapid Prototyping; 3D Printing; Radiographs

Introduction

Use of dental evidence in court of law has been ever since a case solved at Scotland in 1814.¹ Since then the role of Forensic Odontology has evolved and crossed various milestones in recognizing the identity of a person through uniqueness of oral structures and determining probable age of an individual utilizing hard tissues of the oral cavity. This is usually accomplished by simple old dental records, soft tissue patterns and by using radiographs.

Forensic Radiology has evolved from plain film radiography to digital radiographs, Cone Beam Computed Tomography (CBCT) being the most recent. When dental identification becomes an issue, usually high resolution radiographs such as Computed Tomography (CT) is used in various parts of world as a part of post-mortem identification.² In recent times rapid prototyping has taken over the previous digital techniques in various fields of Medicine and Dentistry.

Rapid prototyping in other words called as 3D printing involves complex technology. But, lack of trained professionals has restricted its use presently in crime investigation. Research related to 3D printing usage in Forensic Odontology is gaining its importance in present years. Rapid Prototyping allows for the creation of full-scale models which will depict exact anatomy, hence will be of very good use in Forensic Medicine and Forensic Odontology.³⁻⁶ This paper briefly reviews various aspects of 3D printing and its possible role in Forensic Odontology which can be accepted as evidence in court of law.

History

Brain behind this Rapid Prototyping is Mr. Chuck Hull who is considered as the Father of 3D printing. He developed 1st 3D printer in the year 1984. Since then there has been significant growth in the field of 3D printing. Traditionally this was used in the field of engineering, later its use was in many areas such as defence, medical and dental science⁶⁻⁸

Technology

3D models are created based on the digital images. Different imaging modalities can be used to obtain the raw image like CT, CBCT and Magnetic Resonance Imaging (MRI). Digital Imaging and Communications in Medicine (DICOM) radiographic images are exported to Standard Triangular Language (STL) format for its use in rapid prototyping. 3D digitizing systems uses different scanners such as laser scanners, structured light scanners, photogrammetry, and similar technologies. Materials like ceramics, certain powders, liquid resins, metals, and various others are used to create layer by layer model for generating 3 dimensional objects utilizing the 2 dimensional image data.^{5,8-13}

Types

Basically 3 methods of rapid prototyping techniques are present, namely liquid-based, solid-based and powder-based. Stereolithography (SLA) is liquid –based prototyping, Fused Deposition Modeling (FDM) and Laminated Object Manufacturing (LOM) are solid-based prototyping. Selective Laser Sintering (SLS) and Direct Metal Laser Sintering (DMLS) are Powder-Based rapid prototyping methods.^{10,13,14}

Applications of Rapid prototyping in forensic odontology

In Forensic Odontology, 3D printing can be used in various areas like bite marks analysis, recording, documenting &

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analysing lip prints, analysing palatal rugae pattern, facial reconstructions, post mortem recreation of the skull and other bones, for identification of pattern of fracture, identification and reconstruction of weapons used during crime, etc.¹⁵⁻²⁰

Discussion

Photographs and radiographs may not serve as appropriate data or information in certain situations, especially during evaluation of human remains. Presently the court of law relies on photographs and radiographs of human remains as it is difficult to transport the evidence from the investigation site.²¹ But, these images may serve to develop 3D replica of the specimen, which will be more appropriate method of investigation and presenting evidence. As 3D model easily demonstrates the various anatomic abnormalities, jury members can understand the evidence better as compared to cross-sectional imaging. Facial reconstruction by 3D printing has solved a case in Florida.²² In a case of blunt force head injury, 3D printing has been successfully used for weapon identification and construction.²³ Researchers have told facial reconstruction by 3D printing is effective for fracture analysis.²⁴ Bite mark analysis is done by various methods and more recently the digital analysis of the same has gained its popularity. Rapid prototyping can be useful in analysis of same by creating the 3D replica of bite mark and comparing it with the suspect.¹⁷ In fingerprint analysis 3D printing is being used and in similar ways it can be utilized for lip print analysis and for study of palatal rugae pattern.²⁵ In forensic odontology gender determination is usually done using dental models. Measurements of inter-canine distances, intermolar distances, arch size/length and tooth sizes are used. The dental models created using 3D printing has shown to be accurate for measurements.^{26,27} Using 3D printing, a new X-Ray equipment has been designed by researches to overcome the difficulty of aligning the equipment with the area of interest in forensic dental studies. However, still further studies are required for obtaining accurate dental X-Ray machine for forensic use.²⁸

Conclusion

Forensic medicine experts, forensic odontologists, forensic pathologists and anthropologists use photograph and radiograph images for solving mysteries. Addition of rapid prototyping will add the 3rd dimension to their investigation and help in solving the cases more accurately. More research studies are required in forensic odontology section for use of 3D printing, so it can be accepted in court of law.

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References

- Balachander N, Babu N, Jimson S, Priyadharsini C, Masthan K. Evolution of Forensic Odontology: An Overview. *J Pharm Bioallied Sci.* 2015; 7: S176–80.
- Kumar R, Athota A, Rastogi T, Karumuri S. Forensic Radiology: An Emerging Tool in Identification. *J Indian Acad Oral Med Radiol.* 2015;27:416-22.
- Cesarani F, Martina MC, Grilletto R, Boano R. Facial reconstruction of a wrapped Egyptian mummy using MDCT. *Am J Roentgenol.* 2004;183: 755-758.
- Galantucci LM, Percoco G, Angelelli G, Lopez C, Introna F, Liuzzi C, De Donno A. Reverse engineering techniques applied to a human skull, for CAD 3D reconstruction and physical replication by rapid prototyping. *J Med Eng Technol.* 2006;30(2):102-11.
- Andonovic V, Vrtanoski G. Growing Rapid Prototyping as a Technology in Dental Medicine. *Mech Eng Sci J.* 2010; 29: 31–9.
- Ramya A. and Vanapalli S. 3D Printing Technologies in Various Applications. 2016:1-14.
- The Guardian. Chuck Hull: the father of 3D printing who shaped technology; Available from: <https://www.theguardian.com/business/2014/jun/22/chuck-hull-father-3d-printing-shaped-technology>.
- Azari A, Nikzad S. The Evolution of Rapid Prototyping in Dentistry: A Review. *Rapid Prototyping J.* 2009; 15: 216-25.
- Khanna S, Dhaimade P. Exploring the 3rd Dimension: Application of 3D Printing In Forensic Odontology. *J Forensic Sci Criminal Inves.* 2017;3:001-3.
- Dawood A, Marti B, Jackson V, Darwood A. 3D Printing in Dentistry. *Br Dental J.* 2015; 219:521-29.
- Chua C, Leong K, Lim C. *Rapid Prototyping: Principles and Applications.* 3rd Edition, World Scientific. 2003.
- Ebert L, Thali M, Ross S. Getting in touch—3D printing in Forensic Imaging. *Forensic Sci Int* 2011; 211:e1–6.
- Engineering special topic leaving certificate. Basic principles of operation and applications of rapid prototyping processes; Available from: <http://2016engineeringstoptopic.weebly.com/overview-of-rp.html>
- Peltola S, Melchels F, Grijpma D, Kellomaki M. A review of Rapid prototyping techniques for tissue engineering purposes. *Ann Med.* 2008; 40: 268-80.
- Chaudhary RK, Doggalli N, Chandrakant HV, Patil K. Current and evolving applications of three-dimensional printing in forensic odontology: A review. *Int J Forensic Odontol* 2018;3:59-65.
- Dedhia JP, Pawar AM. 3D Scanning and Printing in Forensic Odontology- Revolutionizing Forensics. *Int J Curr Med Pharmaceutical Res.* 2017; 3(8): 2190-2192.
- Thali MJ, Braun M, Markwalder TH, Brueschweiler W, Zollinger U, Malik NJ, Yen K, Dirnhofer R. Bite mark documentation and analysis: The forensic 3D/CAD supported photogrammetry approach. *Forensic Sci Int.* 2003; 135(2): 115-121.
- Elifritz J, Nolte K, Hatch G, N Adolphi, C Gerrard, Forensic Radiology. *Pathobiology of Human Disease: A Dynamic Encyclopedia of Disease Mechanisms.* 2014;3448-58.
- Esses SJ, Berman P, Bloom AI, Sosna J. Clinical Applications of

Elder abuse: Ground realities in India

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Abstract

Elder abuse is an issue one often refrains from talking about or acknowledging its existence in the society because of the various socio-cultural factors involved. According to the Population Census 2011, there are nearly 104 million elderly persons (aged 60 years or above) in India and the number is increasing. The number of abused persons is also disproportionately mounting. Unfortunately, most of the abused, never report it. Indian legislations have lots of sanctions against the act of elderly abuse. Abuse of elders can result not only in civil claims, but criminal charges as well, and the perpetrators may be prosecuted under existing criminal laws. Legal obligations of children for maintenance of their parents are mentioned in Hindu, Muslim and the Christian laws. Neglected elderly persons can also seek maintenance under Section 125 of the Code of Criminal Procedure (Cr PC). The elderly persons are given lots of constitutional and civil safeguard and benefits. Basic human rights of elderly citizen are mentioned, besides their legal protection.

In this review paper, different ethical and legal issues are discussed so as to draw the attention of all concerned for a multi-disciplinary legal and holistic approach as a need of the hour to this grave problem.

Key words

Legal Provisions; Elderly Privileges; Welfare of Elders

Introduction

Rights of the elderly are considered as one of the fundamental rights in India which include Right to Equality, Right to Freedom, Right to Freedom of Religion, Cultural and Education Rights, Right against Exploitation, Right to Constitutional Remedies, etc.¹ The 'International Day' of older persons is celebrated annually on 1st October, for raising awareness about issues affecting the elderly.

Day by day population of older people is increasing in the society and creates new challenges in multiple social dimension including politics, economics, and health care.² The ground reality of the ageing scenario in India is becoming to raise to 177 million in another 25 years. With life expectancy having increased from 40 years in 1951 to 64 years today; a person today has 20 years more to live than he would have 50 years back.³ Globally, the percentage of the elder population (60+) was 8.1%, in 1950, this percentage is projected to rise to 22%, which means one of five people in the world is expected to be older than 60 years of age.⁴

This phenomenon of population ageing has resulted in various challenges on family and the society. Individualistic attitude and craving for personal achievements lead to intergenerational tension and elder abuse within the family.⁵ The impact of abuse on physical and psychological health of the victims as well as

quality of life is enormous as it can worsen chronic and disabling condition of older person and make the person more dependent, vulnerable, and marginalized.⁶

Elder abuse can be defined as 'a single or repeated act of, or lack of appropriate action, occurring within any relationship, where there is an expectation of trust, which causes harm or distress to an older person'.⁷

This review paper aims at identifying the different ethical and legal issues involving abuse of elderly so as to find out some remedial measures.

Indian Scenario

In a survey it was found that 9% of the elderly abused were physically battered, while 13% said that they were denied basic needs; another 13% quoted mental torture and 20% elders cited restrictions on their social life. Misbehaviour and ill treatment were cited by 37% while 8% cited other forms of harassment.⁸

There are over 100 million senior citizens over the age of 60 in India. A 2014 survey conducted by HelpAge India found that 50% of the elderly surveyed, including 48% men and 52% women, reported suffering abuse.⁹

Abuse, as a problem in all developing countries, including India, has been felt by 73% of the population surveyed. Majority (83%) perceive that identifying elder abuse in the neighbourhood is not a difficult task. The youth's experience of coming across 'Instances of elder abuse' is as high as 32.5% among relatives, and 21% among friends and 20% among neighbours.¹⁰

In a study though link of "Elder abuse" with violence was not acknowledged by the respondent, they however did acknowledge the existence of "maltreatment", "neglect", and

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“disrespect” within their society and community.¹¹

Indian data are limited. Lack of well-validated screening tool may be one reason for poor documentation¹² and whatever the prevalence of elder abuse may be, it is just a tip of the iceberg only.

Factors Responsible

Factors contributing to elder abuse are varied case to case. One of the important causes of elderly abuse is the “Property and inheritance disputes” that constitute for 53.2%. However, 35.7% feel that 'Attitude and relationship issues' to be an important cause. Some of the important contributing factors are shown in table 1.¹⁰

Women were most affected and is due to issues like sex discrimination, longer life span of women, lengthier widowhood. Women usually has less or no source of income in comparison to men is another reason of abuse and also their illiteracy are some important cause of high incidence of women abuse. Social norms and high level of patience and tolerance of women also make them vulnerable for abuse.⁸

Table 1 Factors contributing to elder abuse¹³

Factors	Percentage (%)
Personal mental problems of the abusers	3.4
Demanding attitude of the elders	4.7
Personal financial problems of the abusers	15.5
Poor physical health of the elders	20.8
Lack of understanding of youth concerns by elders	22.7
Changing value systems within the society	25.9
Completely busy life of the abuser and the family.	32.6
Need to financially support the elders	34.6
Lack of patience among the younger generation	35.3
Excessive stress that urban lifestyle brings	38.1
Greed and desire to inherit property	49.2

Struggles faced by the elderly

Multiple morbidities and consequent disabilities make elderly dependant on their children or family members for their day to day activities. In absence of adequate community and social support system, care of elderly becomes a huge issue. Access to employment opportunities, transportation, housing and income also comes to play.¹¹

The change of societal and family values leads to poor social interaction and networking in the family as well as society. Traditional values in Indian society where elders are considered as an asset and treasure have declined and elder's neglect seems to be the social custom which elderly feel to be a matter of embarrassment to discuss. Losing the will to live from a lack of social support is another issue. Educational access and opportunities, the potential for leisure pursuits, consumer protections and having access to information are also the key concerns.

Table 2 Types of abuse¹⁶

Types of abuse	Characteristics	Examples
Physical abuse	The infliction of pain or injury	Hitting, punching, slapping, burning, pushing, kicking, restraining, false imprisonment or confinement, or giving excessive or improper medication as well as withholding treatment and medication
Psychological or emotional abuse	Infliction of mental anguish	Verbal aggression or threat, threats of institutionalization, social isolation, humiliating statements
Elder financial abuse	The illegal or improper exploitation and/or use of funds or resources	Theft of cheques or money, coercion to deprive the older person of his or her assets, such as forcible transfer of property
Sexual abuse	Non-consensual contact of any kind with an older person	Suggestive talk, forced sexual activity, touching, fondling with a non-consenting competent or incompetent person
Neglect	Intentional or unintentional refusal or failure of designated caregiver to meet needs required for older person's well-being	Failure to provide adequate food, clothing, shelter, medical care, hygiene, or social stimulation
Societal abuse	Ageism, lack of appropriate pensions, discrimination	

Table 3 Alternative Classification

Neglect	Isolation, abandonment and social exclusion
Violation of	Human, legal and medical rights
Deprivation of	Choices, decisions, status finances and respect

Types of elderly abuse: The frequently encountered types^{14,15} are shown in Tables 2 & 3.

Welfares Schemes:

Senior citizens are not aware of the schemes which are in place. Government of India has earmarked special benefits and concessions for senior citizens of India as follows:

- 1. Court cases involving senior citizens:** The Chief Justice of India has advised the Chief Justices of all High Courts to accord priority to cases involving older persons and ensure their expeditious disposal.^{17,18}
- 2. RTI Act:** Second appeals filed by senior citizens and differently abled persons under the RTI Act are to be taken on a high priority basis, according to a directive of the Central Information Commission (CIC).¹⁷
- 3. Health Care:17**
 - a. There is provision for separate queues for senior citizens at hospitals and health care centres.
 - b. Assistance like wheelchairs/trolleys is also provided for senior citizens in OPDs, where they are attended on a priority basis.
 - c. The Delhi Government runs special clinics for senior citizens in most of its hospitals in Delhi.

d. There are geriatric OPDs in many of the government hospital.

To improve the health of elderly, the Govt. of India launched '**The National Programme for Health Care of Elderly**' (NPHCE), which is an articulation of international and national commitments of the governments as envisaged under the '**UN convention on the Rights of Persons with Disabilities**' (UNCRPD), 'National Policy on Older Persons'(NPOP) adopted by Govt. of India in 1999 and Section 20 of '**The Maintenance and Welfare of Parents and Senior Citizens Act 2007**' dealing with the provisions of medical care of elderly. The range of services include promotive, preventive, diagnosis and management of geriatric medical problems, day care services, rehabilitative services and home-based care as needed.¹⁸

Although, the NPHCE addresses most of the health problems in an institutional health-care system, but it completely neglects the home-based care of an elderly person in families. It would have been better to focus on awareness among families and make them prepare for possible eventualities rather than treating when it happened.¹⁹ The programme is not addressing the issue of care giver support which may be responsible for care giver stress and finally landed in elder abuse.

4. **Finance Taxation:** Senior Citizens Benefit of Sec. 80c of 'Income Tax Act 1961' has been extended to the investments made less than 5 years post office deposits account and senior citizens saving schemes. Threshold income when start paying tax stands at Rs. 2.25 lakh per annum for senior citizens. The exemption is further increased to Rs. 5 Lakh for very senior citizens who have attained the age of 80 and above. Any payment made by a senior citizen towards health insurance premium gets tax exemption under section 80D of Income Tax Act 1961.¹⁷

5. **Banking:** Govt. also gives a higher rate of interest on certain savings schemes which it runs through its large network of Post Offices (Senior Citizens Saving Schemes) and public sector banks.¹⁷

6. **Telecommunications:** Telecommunications department has separate priority category for the seniors. MTNL (Delhi) gives 25% discount in rentals and installation to senior citizens who are 65 years or above in age.¹⁷

7. **Travel:** Indian railways extend certain facilities to senior citizens aged 60 years and above, while women aged 58 years or above are entitled to 50% concessions in fare men gets 40%,²⁰ besides inclusion of specially designed coaches and toilets in it. Air India gives 50% concessions to senior citizens aged 60 years and above on basic fare for economy class tickets in domestic flights with the facilities of wheel chairs and are allowed to board the plan first. Provision of seat reservation and concession in fare is also available under State Road Transport Department.

Maintenance and welfare of elderly

Abuse of elders can result not only in civil claims, but criminal charges as well and may be prosecuted under existing criminal laws. Legal obligations of children for maintenance their parents are mentioned in Hindu, Muslim and Christian laws.

Neglected elderly persons can seek maintenance under Section 125 of the CrPC.

More concerning is that very little are aware of that which protects senior citizens from abuse and abandonment, i.e., the '**Maintenance and Welfare of Parents and Senior Citizen Act, 2007**'.²¹ The Act was enacted 'to provide for more effective provisions for the maintenance and welfare of parents and senior citizens, guaranteed and recognized under the Constitution and for matters connected therewith or incidental thereto.' This Act states that parents and grandparents who are unable to maintain themselves from their own earning can seek maintenance from their children. Under this Act, childless senior citizens can also demand maintenance from a "relative" who is the legal heir of the former and is in possession or will inherit their property after their death.

Constitutional provision¹⁴

Constitutional protection is also given to elderly. There is provision of age pension, social security, social insurance, economic and social planning, and relief to the disabled and the unemployed in the item 9 of the State list and items 20, 23 and 24 of the concurrent List.

The Article 41 of the directive principles of the state Policy expresses "the state shall make effective provision for securing the right to work, to education and to public assistance in case of unemployment, old age, sickness and disablement, and in other cases undeserved wants, within its limits of economic development and capacity". Article 47 of the Indian Constitution points out the raising of the level of nutrition and the standard of living of its people and improvement of public health is an issue of state responsibilities.

Legislative measures¹⁴

Indian legislation is providing the elderly citizen a basic human rights, legal protection, and social security. The retirement benefits, viz., GPF, PPF, etc., are provided, who has served the Government and public undertakings. The Employees Provident Funds and Miscellaneous Provisions Act, 1952 (amended in 1996) provide for economic security to persons or their families in the event of retirement or even death before retirement. The National Social Assistance Programme (1995) and one of its programs 'National Old Age Pension Scheme' is implemented through the Panchayats and municipalities. Presently, all State Governments and Union Territories are implementing the Old Age Pension Scheme under the State sector.

Conclusion

'World Elder Abuse Awareness day' is celebrated on 15th June to make aware all concern. More concerning is that very little are awareness among the common people about those facts and benefits, etc. Media coverage on elder abuse in different avenues is very much needed to generate awareness amongst

public for needs of the elderly, to sensitize the youth about geriatric care and wellbeing. Government must create awareness about rights of older persons, advocacy of old age issues at all level of governance and ensure implementation of policies pertaining to protection of interests of older persons. About the attitude and behavior towards elderly should be taught in all the levels of schooling. Strict legal and holistic approach to this grave problem could make some changes in the current situation.

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References

1. Iloveindia.com. Indian constitution: fundamental rights [online]. [cited 2019 June 15]; Available from: URL:<http://www.iloveindia.com/constitution-of-india/fundamental-rights.html>
2. Bloom DE, Canning D, Fink G. Implications of population ageing for economic growth. *Oxford Review of Economic Policy* 2010;26:583-612.
3. Mishra JP, Ahad N. Elder abuse and social work intervention methods: a cross-sectional study in Bilaspur district of Chhattisgarh. *J of Social Work Education and Practice* 2017;2(2):17-25.
4. Popli UK, Panday R. Caregivers Burden of Hospitalized Elderly. *J Gerontol Geriatr Res* 2018;7(5):483.
5. Joy GS, Rehman N. Elderly abuse in India: special reference to age old women widows. In: K Jaishankar, Natti Ronel, editors. *Second international conference of the south Asian society of criminology and victimology (SASCV)*. Tamil Nadu, India: SASCV and Dept. of Criminology and Criminal Justice; 2013 Jan 11-13. p. 47.
6. Gupta R, Chaudhuri A. Elder abuse in a cross-cultural context: assessment, policy and practice. *Indian J Gerontol* 2008;22:373-93.
7. Krug EG, Dahlberg LL, Mercy JA, Zwi AB, Lozano R, editors. *World report on violence and health*. Geneva: WHO; 2002. p. 123-45. [cited on 2013 Feb]; Available from: URL: https://apps.who.int/iris/bitstream/handle/10665/42495/9241545615_eng.pdf;sequence=1
8. Agewell foundation. Most elderly persons are subject to abuse in old age: study. *Times of India* 2016 June [online]. [cited 2019 June 20]; Available from: URL: <https://timesofindia.indiatimes.com/city/delhi/Most-elderly-persons-are-subject-to-abuse-in-old-age-Study/articleshow/52741509.cms>
9. Das Monalisa. Abused, abandoned, neglected: a law protects senior citizens in India, but not many know of it: elder abuse. *The news minute* 2017 March 23 [online]. [cited 2018 March 14]; Available from: URL:<https://www.thenewsminute.com/article/abused-abandoned-neglected-law-protects-senior-citizens-india-not-many-know-it-59099>
10. MaRS Monitoring and Research Systems Private Limited. National Survey a youth perspective on elder abuse. *HelpAge India Research Report*. 2015. p. 7.
11. Soneja Shubha. Elder abuse in India. Country Report for World Health Organization. New Delhi: HelpAge India; p. 15. [online]. [cited on 2019 June 20]; Available from: URL:https://www.who.int/ageing/projects/elder_abuse/alc_ea_ind.pdf
12. Saikia AM, Mahanta N, Mahanta A, Das AJ, Kakati A. Prevalence and risk factors of abuse among community dwelling elderly of Guwahati city, Assam. *Indian J of Community Med* 2015;40(4):279:281.
13. MaRS Monitoring and Research Systems Private Limited. National Survey a youth perspective on elder abuse. *HelpAge India Research Report*. 2015. p. 21.
14. Department of Health and Human Service. What is elder abuse? Administration on ageing [online]. 2009 Aug 10 [cited 2018 March 14]; Available from: URL:https://web.archive.org/web/20121220071251/http://www.aoa.gov/AoA_programs/Elder_Rights/EA_Prevention/whatIsEA.aspx
15. Comfort Home Care. 6 Types of Elder Abuse: Senior News [online]. 2014 August 30 [cited 2019 June 15]; Available from: URL: <https://www.choosecomforthome.com/6-types-of-elder-abuse-senior-news/>
16. Robinson L, Saisan J, Segal J. Elder abuse and neglect. *Help Guide* [online]. 2019 May [cited 2012 Dec 15]; Available from: URL:<https://www.helpguide.org/articles/abuse/elder-abuse-and-neglect.htm>
17. Goswami Vedant. Protection of elderly people against crime and society. *Intl J of Legal Developments and Allied Issues* 2018;4(2):504-14.
18. Goel P. Benefits, concessions and schemes for senior citizens in India. *Voice4india.org* [online]. 2008 April 8 [cited 2019 15]; Available from: URL:<http://voice4india.org/benefits-concessions-schemes-senior-citizens-india/66/>
19. NHP CC DC. National Programme for Health Care of the Elderly (NPHCE). MENU [online]. 2015 April 06 [cited 2018 March 14]; Available from: https://nhp.gov.in/national-program-of-health-care-for-the-elderly-n_pg
20. Dubbudu R. Railways now change the rules for availing the Senior Citizen Concession and Quota. *FACTLY* [online]. 2016 Jan 10 [cited 2011 October]; Available from: URL: <https://factly.in/senior-citizen-concession-in-indian-railways-rules/>
21. Team-bhp.com. Important government circulars/ orders / om's / notifications. [cited 2018 March 14]. Available from: URL:<http://www.team-bhp.com/forum/shifting-gears/104096-important-government-circulars-orders-oms-notifications-4.html>

Techniques in Forensic Cytology: The road ahead

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Abstract

Cytology evolved as a branch of biology which later became integrated into many of the fields such as botany and health sciences including forensic case work. In the vast majority of the forensic cases, tissue samples are retained for histology to make a scientific inquiry into the cause of death. Additional questions that need to be treated include vitality, timing, and causes of injuries and their differentiation from post-mortem changes. In the strictest sense, the cytological examination done on tissues rather than a cell or a group of cells is not a cytological diagnosis but a histological one. With the advent of new techniques, cytology has become a significant contributor in solving crimes but has remained an orphan speciality in the developing nations. Traditionally the cytological examination has always been correlated with crime investigations in sexual assaults, but in the present era, cytology can be of robust help in a myriad of cases of amniotic fluid embolism, fat embolism, wound ballistics, sex determination, etc. The present paper gives a brief review of the current practices in Forensic Cytology and discusses the recent advances. It also provides an insight into the possible future implications of these techniques for the crime investigation.

Key words

Forensic cytology; Flow cytometry; Laser-capture microdissection; Sexual assault; Condom residues

Introduction

In the practice of Forensic Medicine, all the disciplines of biological sciences are employed, whether it is the anatomical or clinical pathology. The role of cytology has remained pivotal in the solution of medico-legal questions and cases, as has been described earlier.^{1,2} Applications of the principles of cytology to crime investigation were initially observed in cases of sexual assaults where the study of the morphology of male gametes and presence of vaginal cells on the assailant's penis were found to be relevant in proving an offence.^{3,4} The importance of cytological examination in Forensic gynaecology has been emphasised, as early as the 1950s.⁵ In the 1980s, with the introduction of luminescent microscopes, various authors started utilising it for the examination of cells.⁶ It may sound to be a straightforward analysis of the cells, but in practice, it involves locating and identifying the cells, delegating the cells to a particular organ, as well as isolating the cells for further molecular examinations. The practice of cytological examination can be combined with appropriate immunohistochemistry techniques for crime investigations.⁷ In a series of general and forensic autopsies conducted by Gibson et al., where authors were studying C cell nodules, they utilised immune-peroxidase stain for demonstrating calcitonin positive C cells in the thyroid.⁸ The utilisation of cytological techniques has been central in the determination of sex of an individual when required for civil/criminal purposes.⁹ Even the

cytological examination of foreign bodies, like Lycopodium spores from the condoms, has been utilised in the investigation of sexual assaults.¹⁰ It was in 1988 that while working in Institute of Economic Botany of New York, Balick & Beitel got an industrial inquiry from a supplier of herbal products, for which they utilised electron microscopy and found the presence of Lycopodium spores in condoms and latex gloves.¹¹ Although in the 1980s, the primary concern of the clinicians was to deal with uprising diseases like AIDS and formation of granulomatous mass due to the presence of spores, the discovery has been utilised in forensic practice in sexual crimes.

Processing of the cells

The samples for the cytological examination can be retrieved from the living as well as during autopsy. Commonly smears are collected from the place where the tissues or cells are suspected. Additionally, in advanced studies, FNAC can be performed. The cells can be obtained from the suspected materials too, like from the biological material on firearms and projectiles, the diatoms from the clothes and spermatozoa from the undergarments.¹²⁻¹⁵

Once the specimen is retrieved, it should undergo a microscopic screening. Accordingly, the cells can be assigned to one of the following categories:

- a) Keratinized and nucleated epithelial cells: from skin
- b) Non-keratinized epithelial cells: from the mucosa of mouth, vagina or anus
- c) Spermatozoa: intact or with the head only
- d) Cells belonging to the blood
- e) Cells that can be assigned to a particular tissue or organ

It is pertinent to state that flow cytometry has been used by various researchers in crime investigations.¹⁶ The utility of flow

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cytometry in forensics is not only limited to sorting the cells from each other, but it has been applied for the estimation of time since death, which is a critical task for the forensic pathologist.¹⁷ Cina proposed in 1994 that degeneration of DNA occurs in a relatively predictable manner in the post-mortem and this was utilised by him to submit that flow cytometric analysis of sample harvested from the splenic tissue of the cadaver can be used in estimating time since death.¹⁸ The technique has been used by various researchers in cases of sexual violence where the separation of vaginal cells from sperms is of paramount importance for DNA analysis. It has further been proposed that flow cytometry yields better results than conventional techniques like preferential lysis.^{19,20}

Extraction of cells

Preferential lysis has been used traditionally for the extraction of desired cells from a pool of tiny sample. The process necessarily involves the treatment of the whole sample with detergents and proteases so that cells other than sperms get lysed.²¹ It can be attributed to the fact that the head of the mammalian sperm contains disulfide bonds in its condensed chromatin, making it relatively resistant to proteases.²² This technique was developed by Gill et al., in 1985, when they proposed that a sample consisting of vaginal cells and sperms can be subjected to this technique for extracting DNA samples from sperms.²³ This method continues to be used at many centres until today with certain modifications but has proved to be inefficient in cases where samples are inadequate.^{24,25}

Laser Capture Microdissection (LCM) is a relatively new technique that can be used to isolate single cells from complex tissue samples mounted on light microscope slides. The basic principle is to use a laser beam to target a cell with the aid of a microscope.²⁶ For sorting out the subpopulation of cells of various origins, LCM can either use Infrared or ultraviolet systems, both of which have been utilised by various authors.^{27,28}

This technique is especially useful in cases where a sperm needs to be isolated from microscopic slides containing sperms and vaginal cells.²⁹ Sanders et al. (2006) have provided a method for separation of a subpopulation of cells by using membrane-coated slides at the base of the cells and using ultraviolet rays to cut the membrane around the particular cells.³⁰ However, this method had a significant disadvantage since most of the slides of forensic importance are glass slides and is archived. Additionally, the membrane-coated slides are expensive and cannot be subject to regular staining methods.³¹ Trace evidence which is notoriously found in small amounts like dandruff can be submitted to LCM.

Selection of cells can be a challenge in cases of mixed traces. In such situations, it has been suggested to examine at least ten cells using molecular genetics techniques.³² Fluorescent in situ hybridisation (FISH) and its related cell differentiation modalities have been utilised in the biological samples for investigation purposes.²⁸ Sexual dimorphism in human cells has been demonstrated in human cells using probes unique to Y

chromosomes. Newer methods like Suspension-FISH (S-FISH), offers an additional advantage over the conventional method in which tissue samples were fixed on glass slides. In this, cells are in suspension, which allows them to be easily separated when subjected to LCM.³³ This technique has also been applied for separation of epithelial cells using locked nucleic acid probes³⁴

Prominent applications of cytology

1. Sexual Offences

In sexual offences, the primary goal lies in the detection of sperms and condom residues. Problematic situations can arise when the offender has azoospermia or when the examiner cannot differentiate whether the squamous cells are of penile or vaginal origin.

a) Detection of sperms

Although chemical tests and immunological tests have a significant role in crimes related to sexual violence, the demonstration of either live sperm or its identifiable remnants remains a cornerstone to prove the allegation. The microscopic detection of sperm is carried out using smear samples. Staining is performed after air-drying, according to Stiasny-H&E, Baecchi, or Papanicolaou methods. Table 1 summarises the conclusive findings of the microscopic detection of sperms³⁵

Table 1: Findings of the microscopic detection of sperm

Staining or detection	Findings
Stiasny-H&E staining	Blue spermatozoa
Native sample	Motile spermatozoa for 5–8 h
Regular detection	Up to 12 h
Longest detection	24–48 h, only occasional spermatozoa or sperm heads (possibly much longer on the corpse)
Additional findings	Vaginal epithelial cells with the blue nucleolus, signs of inflammation (granulocytes), basophilic bacterial colonies (likely cocci), potentially foreign material
Condom use	Detection of starch granules, possibly Lycopodium spores

The morphology of tail is often studied to estimate the age of sperm, but this it is highly influenced by the storage conditions.³⁶ The selection of histological technique has been found to have an impact on the chances of recovery of DNA and quality of cells. The choice of staining methods can be detrimental to the recovery of DNA samples from the only available histological slide smears.³⁷

Although preferential cell lysis can theoretically isolate the male gametes from the vaginal epithelial cells, it cannot help when there are sperms from multiple donors in a single pool of sample. In the practice of forensics, it is common to

encounter a crime of sexual violence in which there are multiple perpetrators; like in a 'gang rape' case. In such circumstances, the central requirement is to obtain the DNA profile of all the donors. Technologies like LCM and low-volume PCR (lv-PCR) have been utilised in such cases and offer promising results.^{38,39}

b) Detection of vaginal epithelial cells

Traditionally, the vaginal epithelial cells are stained using the Lugol's solution or Papanicolaou method. This is based on the fact that the vaginal epithelial cells have a high concentration of glycogen. Interestingly, the male efferent urinary tract (fossa navicularis) also contains glycogen-containing cells, and thus, Lugol's method should not be employed for Forensic samples.⁴⁰ For an experienced cytologist, it might be an easier task to differentiate between various cells of different origins, but at times it can be a difficult task to differentiate between cells of buccal, vaginal and penile origin.⁴¹ It has been recently demonstrated that there is a difference in diameter of the vaginal epithelial cells and the epithelial cells of penile origin. If the sample is sufficient in amount, the morphometrically measured diameters determined by stereomicroscope can differentiate these two kinds of cells. Usually, the vaginal cells have a diameter of more than 60µm.³⁶ In 2006, Paterson et al. proposed utilising Immunohistochemical techniques for identifying vaginal cells.⁴² Till today no specific or unique biomarker of vaginal epithelial cells has been found, but recent studies have shown that loricrin and stratifin are expressed more in vaginal epithelial cells as compared to the cells of buccal mucosa.⁴³ Such findings can be beneficial in forensic casework.

c) Detection of condom residues

Offenders are changing the nature of sexual assault investigations by wearing condoms. Many sexual crimes can be associated with the use of Barrier contraceptives like condoms, and it may pose as the biggest challenge in the Forensic investigation. Interestingly, many condom manufacturers apply certain substances over the surface of condoms, which prevent them from rolling up. These materials may include starch granules, cornstarch, silica, talc or *Lycopodium clavatum* spores. The detection of starch granules is of lesser evidentiary value as they are also found in various foodstuffs and cosmetics. *Lycopodium* spores require a special mention as their retrieval and identification from the vaginal swabs can be conclusive evidence of sexual intercourse and penetration.⁴⁴ *Lycopodium* spores have a diameter of 25–40 µm, a characteristic tetrahedral form, and a reticular surface. Owing to their high oil concentrations, they stain yellow with Sudan III and can be differentiated from starch granules which stain blue with Lugol's solution.

The condom residues may also include lubricants like dimethicone and polydimethylsiloxane, which have been successfully detected in sexual crimes with the aid of

techniques like 'desorption chemical ionisation mass spectrometry'.¹⁰ The detection of spermicides like nonoxynol-9 and related amphiphilic compounds is often a challenging task due to their complex chemical properties and demands a detailed mass spectral profile by employing GC-MS (Gas Chromatography-Mass Spectrometry).⁴⁵

2. Amniotic fluid embolism

Studies have suggested that during pregnancy, the overall incidence of amniotic fluid embolism is approximately 1/50,000. Unfortunately, it has a mortality rate in more than 80% cases.⁴⁶ At autopsy, the signs of disseminated intravascular coagulation usually suggest an amniotic fluid embolism. Additionally, post-mortem blood samples may show elevated acute phase proteins as embolism is expected the cascade of an inflammatory response in the body.⁴⁷ Attempts should be made for meticulous histology of lung tissues, using special stains and determining the serum tryptase levels. Amniotic fluid contains squamous epithelial cells from the fetal skin, mucin derived from meconium that is excreted by the fetal intestine, fat derived from the vernix caseosa, and hair. These constituents can be correctly identified by using immunohistochemical markers for cytokeratin AE1/AE3, Alcian blue or mucicarmine staining, oil red O staining, and polarised light, respectively.^{48,49}

3. Pulmonary fat embolism

Fat embolism syndrome (FES) is explicitly a clinical diagnosis characterised by the onset of respiratory distress along with haematological, neurological and cutaneous manifestations, after a significant traumatic injury (not necessarily). Traditionally, the diagnosis of fat embolism is made by demonstration of fat globules by staining the sections of lungs. The concept is based on the 'mechanical theory' of causation of FES, which states that tissue of adipose origin either from a fracture site or an extraosseous site gets lodged into damaged microvasculature.⁵⁰ Examination of microscopic slides stained with hematoxylin and eosin (H & E) reveals only clear spaces. Samples like blood and urine can be subjected to cytological examination in which either free fat globules or fat globules with macrophages can be found.⁵¹ Postfixation of formalin-fixed tissue with osmium tetroxide may demonstrate fat.⁵² In this respect, the pulmonary microvascular cytological examination is an interesting technique. A study has suggested that in certain suspected cases, samples should be collected from a pulmonary catheter and subjected for cytological studies then after. The samples are expected to contain cellular debris and cells of diagnostic interest. Other than diagnosing pulmonary fat embolism, this technique can be also be used in the diagnosis of amniotic fluid embolism and malignant cells.⁵³ Recently immunohistochemistry has been used for autopsy diagnosis of a clinically confirmed case of FES. This case study showed positive results for anti-CD61 and anti-fibrinogen antibodies.⁵⁴

4. *Wound ballistics*

The credit of applying knowledge of cytology to ballistics goes to Knudsen (1993), who proposed that particulate matter on bullets may be used to decide which target they have passed through.¹³ For this, he had used full jacketed metal bullets which were fired on anaesthetised pigs. Tissue samples taken from the recovered bullets were subjected to cytological examination. He concluded that this could not only be used to say if the bullet has passed a tissue or not, but it can be used to predict that which particular tissue damaged by the bullet. Further advancements took place when it was studied that immunocytochemical investigations can aid in matching a particular injury to the path of the bullet. In cases where expanding bullets have been used, and a projectile has stricken the heart or liver, it can be shown that the cells remaining on the bullet stem from those particular organs.⁵⁵

5. *Forensic palynology and limnology*

Study of spores, pollens and other microscopic bodies comes under the ambit of palynology. Limnology is a sub-speciality which deals with the study of diatoms. Forensic experts have utilised both for crime investigation.^{56,57} Pollen and spores can be obtained from an incredibly wide range of items, including dead bodies. These microscopic entities of botanical origin can give a clue to the source of their origin and geographical distribution.⁵⁸ Forensic palynology finds a special implication in those cases of violent assaults which take place in an open area. There have been instances when the principles of forensic palynology have been applied to cases involving vehicular accidents and archaeological research.^{59,60} They are eukaryotic planktons of class Bacillariophyceae and are ubiquitous organisms found in both sea water and fresh water bodies. The role of diatoms is widely described in the legal and forensic literature in connection with deaths associated with immersion.^{61,62} Indeed, it requires an expert plant botanist to make interpretations for the cytological examination, which not only includes assessment of their forensically significant number in the sample but also their species identification. The fact that their structure consists of an outer covering of silica (frustule), acid digestion technique has been used traditionally for their retrieval from the samples using hydrochloric acid, along with nitric acid. The other methods for extraction of diatoms include using proteinase K, hydrogen peroxide, and Soluene-350. Individual studies recommend the use of proteinase K, stating that it distorts the cellular morphology to the least extent.⁶³ Another recent study has suggested that the hydrogen peroxide digestion technique is better than the traditional acid digestion procedure.⁶⁴ It is based on observations that the peroxide technique yields better qualitative results, and the chemical agent is less hazardous to the operator. The results of the diatom test should be made with precautions. The concept of 'dry drowning' is a known entity in forensics, where the person dies due to laryngospasm and not due to fluid

overload. Additionally, diatoms are present in food, pipeline water, air and clothes and this fact can complicate the situation.⁶⁵ The so-called diatom test cannot be used for estimation of postmortem interval.

Other than using the conventional light microscope, a better examination of diatoms can be done by both scanning and transmission electron microscopes. This allows better examination of the details and allows taxonomic identification. Recent advances in electron microscopy have added certain modifications. For forensic purposes, techniques like microwave digestion-vacuum filtration-automated scanning electron microscopy method (MD-VF-Auto SEM) and microwave digestion-membrane filtration-light microscopy (MD-MF-LM) have been proposed to be superior technique than the conventional methods.^{66,67}

6. *Transfusion reactions*

Erroneous transfusion of ABO-incompatible blood can potentially cause fatal acute haemolytic anaemia and complement-induced shock, resulting in death in about 10% of cases. A forensic investigation into such deaths would require immunocytochemical techniques to identify the foreign erythrocytes and resulting decomposition products. This identification is highly influenced by the period of survival of the subject. Following a survival time of more than 24 h, intravascular foreign erythrocytes can typically no longer be determined.⁶⁸

7. *Age and sex determination*

The determination of sex is an indispensable task in many forensic investigations, especially in cases of sexual abuse, paternity disputes, the inheritance of property, divorce, etc.^{69,70} Interestingly, the presence of Barr bodies has been related to criminal tendencies.⁷¹ As described earlier, demonstration of chromatin body in the somatic cells has remained an important field, and it has found a particular reference in the forensic dentistry literature where it has been extensively researched.² Research in Forensic odontology has shown promising results for the estimation of age by employing the techniques of exfoliative cytology.⁷² In a recent study, the cytological techniques have integrated methods like G-banded Karyotyping and FISH for determination of sex in a case with mosaic chromosomes.⁷³

The introduction of Morphometric analysis of cells has been a breakthrough in the medical field. The technique has been mostly utilized in tumour research. Software dedicated to the Morphometric analysis of cells was introduced in the early 80s.⁷⁴ The process makes an assessment of the surface area of the cell, the volume of the cell and ratios amongst these two. The researchers and academicians can gain access to either proprietary or open source software. In a study done on 100 healthy individuals, where a morphometric software assessed buccal smears it was found that there is a gradual decrease in the size of cells with progressing age and this difference is significant after achieving the age of 60.⁷⁵

It will be justified to mention here that the introduction of Confocal laser scanning microscopy (CLSM) has added new dimensions for the microscopic examination of tissue samples. Confocal microscopes were introduced in the 80s and use a beam of the laser to illuminate the object of interest to give a far better optical resolution as compared to traditional methods. The greatest advantage of this technique is that since the laser beam can be focused at varying depths of the object, it aids in the three-dimensional volumetric assessment. Other than cytological analysis, it finds a special mention in forensic ballistics investigations.⁷⁶

8. Post-mortem cytology

Multiple cytodagnostic techniques can be used during the autopsy, providing rapid microscopic confirmation of macroscopic findings and facilitating more comprehensive provisional reporting. Additionally, research has also found that it is a helpful tool for teaching residents and is a better method to give preliminary autopsy diagnosis.⁷⁷ The work done by Schnadig et al. provides a comfortable and attractive guide for interested readers.^{77,78} The utility of cytology and allied modality in interpretation of results of samples collected from dead bodies have been used in conditions of medico-legal importance like sudden infant disease syndrome (SIDS), myocardial infarction, formation of coma blisters, sudden unexpected deaths of neurological origin/ sudden neurological deaths (SND) etc.⁷⁹⁻⁸²

Additionally, the technique can be used for other purposes like an estimation of time since death from RNA profiling and utilize relevant molecular techniques.^{2,83,84} These cytodagnostic methods can utilize FNAC, or scrape sampling, or touch preparation. For solid organs, scrape sampling is better, but for cystic lesions, soft areas in the brain and alike tissues FNAC is expected to yield better results. These samples can later be subjected to centrifugation or may be forwarded for microbiological examination, depending on the requirement. Fluid sampling with the cytological examination is another quick and inexpensive technique.⁸⁵

The cytologist and the forensic case work

Whether the sample is from the hospital asking the cytologist/pathologist to give the clinical diagnosis, or from the police/forensic practitioner, the final diagnosis is based on scientific methods and interpretations. The specimens of forensic relevance are often the archived ones, and there are remote chances that a lost sample can be made available again. Additionally, such samples are in small amounts and often contaminated. The process of handling pathology samples includes its identification, labelling, sorting and subjecting it to screening/ancillary procedures. 'Chain of custody' is an important aspect in the court of law any breach or mishandling in the chain may have unpleasant, often embarrassing consequences.⁸⁶ Thus, due precautions need to be taken by the forensic practitioners in this regard. It has to be taken into

account that most of the forensic practitioners in developing countries like India do not have any formal training in histopathology and its allied fields, which further complicates the scenario. This issue can be addressed by efficient communication between the two fraternities and creating awareness about the recent advances in cytology amongst the forensic practitioners. Certainly, in an era of 'patient awareness' and 'judicial reforms', a medical professional should be aware of the law of the land. Inadvertent and unintentional mistakes may happen in pathology and allied specialities. Besides, there may be an 'Error of Judgement' while making interpretations, which may further be attributed to the error in the technical modality used for assessment of a sample. In all such cases, the best practice is not to conceal such events but to document such occupational mishaps.

Conclusion

Cytology has an indispensable role in crime investigation. As a diagnostic tool, various cytological methods such as Immunohistochemistry, FISH, LCM and morphometric analysis, etc. hold great promise in crime investigations. Though the use of forensic cytology in forensic case work is unquestioned, surprisingly its utility is yet to be explored to the full potential. This not only warrants initiatives by forensic practitioners to learn the recent advances in cytology but also prompts the education system to integrate formal training courses in the curriculum.

Further advancements of cytological techniques can be utilized in forensic investigations to strengthen the system and bring about justice. The role of cytological examination in Forensic practice in many developing nations is ignored. It is important for the cytologist and Forensic practitioner to be well acquainted with the recent advances to aid in Forensic Casework.

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References

1. Murphy GK. Applications of cytology to forensic pathology. *Acta Cytol.* 1981;25(2):153-6.
2. Mittal T, Saralaya KM, Kuruvilla A, Achary C. Sex determination from buccal mucosa scrapes. *Int J Legal Med.* 2009;123(5):437-40.
3. Sharpe N. The significance of spermatozoa in victims of sexual offences. *Can Med Assoc J.* 1963;89:513-4.
4. Dahlke MB, Cooke C, Cunnane M, Chawla J, Lau P. Identification of semen in 500 patients seen because of rape. *Am J Clin Pathol.* 1977;68(6):740-6.
5. Vinci M. Vaginal cytology in forensic gynecology. *Folia medica (Naples, Italy).* 1953;36(6):472-82.
6. Zagriadskaia AP, Fedorovtsev AL, Koroleva EI. Use of

- luminescent microscopy in forensic cytology studies. *Sud Med Ekspert.* 1982;25(1):35-7.
7. Duraiyan J, Govindarajan R, Kaliyappan K, Palanisamy M. Applications of immunohistochemistry. *J Pharm Bioallied Sci.* 4(Suppl 2):S307-S9.
 8. Gibson WC, Peng TC, Croker BP. C-cell nodules in adult human thyroid. A common autopsy finding. *Am J Clin Pathol.* 1981;75(3):347-50.
 9. Priyadharsini RA, Sabarinath TR. Barr bodies in sex determination. *J Forensic Dent Sci.* 2013;5(1):64-7.
 10. Blackledge RD, Vincenti M. Identification of polydimethylsiloxane lubricant traces from latex condoms in cases of sexual assault. *J Forensic Sci Soc.* 1994; 34(4):245-56.
 11. Balick MJ, Beitel JM. Lycopodium spores found in condom dusting agent. *Nature.* 1988;14;332(6165):591.
 12. Karger B, Meyer E, Knudsen PJ, Brinkmann B. DNA typing of cellular material on perforating bullets. *Int J Legal Med.* 1996;108(4):177-9.
 13. Knudsen PJ. Cytology in ballistics. An experimental investigation of tissue fragments on full metal jacketed bullets using routine cytological techniques. *Int J Legal Med.* 1993;106(1):15-8.
 14. Uitdehaag S, Dragutinovic A, Kuiper I. Extraction of diatoms from (cotton) clothing for forensic comparisons. *Forensic Sci Int.* 2010; 200(1-3):112-6.
 15. Ingemann-Hansen O, Charles AV. Forensic medical examination of adolescent and adult victims of sexual violence. *Best Pract Res Clin Obstet Gynaecol.* 2013;27(1):91-102.
 16. Van Oorschot RA, Ballantyne KN, Mitchell RJ. R.A. Forensic trace DNA: a review. *Investig Genet.* 2010; 1: 14.
 17. Ibrahim SF, van den Engh G. High-speed cell sorting: fundamentals and recent advances. *Curr Opin Biotechnol.* 2003;14(1):5-12.
 18. Cina SJ. Flow cytometric evaluation of DNA degradation: a predictor of postmortem interval? *Am J Forensic Med Pathol.* 1994;15(4):300-2.
 19. Di Nunno N, Melato M, Vimercati A, Di Nunno C, Costantinides F, Vecchiotti C, et al. DNA identification of sperm cells collected and sorted by flow cytometry. *Am J Forensic Med Pathol.* 2003;24(3):254-70.
 20. Schoell WM, Klintschar M, Mirhashemi R, Pertl B. Separation of sperm and vaginal cells with flow cytometry for DNA typing after sexual assault. *Obstet Gynecol.* 1999;94(4):623-7.
 21. Garvin AM, Fischer A, Schnee-Griese J, Jelinski A, Bottinelli M, Soldati G, et al. Isolating DNA from sexual assault cases: a comparison of standard methods with a nuclease-based approach. *Investig Genet.* 2012;3(1):25
 22. Barrera C, Mazzolli AB, Pelling C, Stockert JC. Metachromatic staining of human sperm nuclei after reduction of disulphide bonds. *Acta Histochem.* 1993;94(2):141-9.
 23. Gill P, Jeffreys AJ, Werrett DJ. Forensic application of DNA 'fingerprints'. *Nature.* 1985;318(6046):577-9.
 24. Nori DV, McCord BR. The application of alkaline lysis and pressure cycling technology in the differential extraction of DNA from sperm and epithelial cells recovered from cotton swabs. *Anal Bioanal Chem.* 2015;407(23):6975-84.
 25. Nemes E, Kagina BM, Smit E, Africa H, Steyn M, Hanekom WA, et al. Differential leukocyte counting and immunophenotyping in cryopreserved ex vivo whole blood. *Cytometry A.* 2015;87(2):157-65.
 26. Espina V, Wulfkuhle JD, Calvert VS, VanMeter A, Zhou W, Coukos G, et al. Laser-capture microdissection. *Nat Protoc.* 2006;1(2):586-603.
 27. Gallagher RI, Blakely SR, Liotta LA, Espina V. Laser capture microdissection: Arcturus(XT) infrared capture and UV cutting methods. *Methods Mol Biol.* 2012;823:157-78.
 28. Vandewoestyne M, Goossens K, Burvenich C, Van Soom A, Peelman L, Deforce D. Laser capture microdissection: should an ultraviolet or infrared laser be used? *Anal Biochem.* 2013;439(2):88-98.
 29. Elliott K, Hill DS, Lambert C, Burroughes TR, Gill P. Use of laser microdissection greatly improves the recovery of DNA from sperm on microscope slides. *Forensic Sci Int.* 2003;137(1):28-36.
 30. Sanders CT, Sanchez N, Ballantyne J, Peterson DA. Laser microdissection separation of pure spermatozoa from epithelial cells for short tandem repeat analysis. *J Forensic Sci.* 2006;51(4):748-57.
 31. Vandewoestyne M, Deforce D. Laser capture microdissection in forensic research: a review. *Int J Legal Med.* 124(6):513-21.
 32. Seidl S, Burgemeister R, Hausmann R, Betz P, Lederer T. Contact-free isolation of sperm and epithelial cells by laser microdissection and pressure catapulting. *Forensic Sci Med Pathol.* 2005;1(2):153-7.
 33. Vandewoestyne M, Van Hoofstat D, Van Nieuwerburgh F, Deforce D. Suspension fluorescence in situ hybridization (S-FISH) combined with automatic detection and laser microdissection for STR profiling of male cells in male/female mixtures. *Int J Legal Med.* 2009;123(5):441-7.
 34. Williams E, Lin MH, Harbison S, Fleming R. The development of a method of suspension RNA-FISH for forensically relevant epithelial cells using LNA probes. *Forensic Sci Int Genet.* 2016;9:85-92.
 35. Dettmeyer RB. *Forensic Cytology. Forensic Histopathology: Fundamentals and Perspectives.* Berlin, Heidelberg: Springer Berlin Heidelberg; 2011. p. 391-9.
 36. Smith DA, Webb LG, Fennell AI, Nathan EA, Bassindale CA, Phillips MA. Early evidence kits in sexual assault: an observational study of spermatozoa detection in urine and other forensic specimens. *Forensic Sci Med Pathol.* 2014;10(3):336-43.
 37. Simons JL, Vintiner SK. Effects of histological staining on the analysis of human DNA from archived slides. *J Forensic Sci.* 2011;56 Suppl 1:S223-8.
 38. Feng L, Xu C, Zeng X, Zhang H, Yang F, Li W, et al. Y-chromosomal haplotyping of single sperm cells isolated from semen mixtures - a successful identification of three perpetrators in a multi-suspect sexual assault case. *Croat Med J.* 2014;55(5):537-41.
 39. Han JP, Yang F, Xu C, Wei YL, Zhao XC, Hu L, et al. A new strategy for sperm isolation and STR typing from multi-donor sperm mixtures. *Forensic Sci Int Genet.* 2014;13:239-46.
 40. Hausmann R, Schellmann B. Forensic value of the Lugol's staining method: further studies on glycogenated epithelium in the male urinary tract. *Int J Legal Med.* 1994;107(3):147-51.
 41. Jones EL, Jr., Leon JA. Lugol's test reexamined again: buccal cells. *J Forensic Sci.* 2004;49(1):64-7.
 42. Paterson SK, Jensen CG, Vintiner SK, McGlashan SR.

- Immunohistochemical staining as a potential method for the identification of vaginal epithelial cells in forensic casework. *J Forensic Sci.* 2006;51(5):1138-43.
43. Simons JL, Vintiner SK. Efficacy of several candidate protein biomarkers in the differentiation of vaginal from buccal epithelial cells. *J Forensic Sci.* 2012;57(6):1585-90.
 44. Berkefeld K. A possibility for verifying condom use in sex offenses. *Archiv fur Kriminologie.* 1993;192(1-2):37-42.
 45. Musah RA, Vuong AL, Henck C, Shepard JR. Detection of the spermicide nonoxynol-9 via GC-MS. *J Am Soc Mass Spectrom.* 2012;23(5):996-9.
 46. Marcus BJ, Collins KA, Harley RA. Ancillary studies in amniotic fluid embolism: a case report and review of the literature. *Am J Forensic Med Pathol.* 2005;26(1):92-5.
 47. Jain S, Gautam V, Naseem S. Acute-phase proteins: As diagnostic tool. *J Pharm Bioallied Sci.* 2011;3(1):118-27.
 48. Sisodia SM, Bendale KA, Khan WA. Amniotic fluid embolism: a cause of sudden maternal death and police inquest. *Am J Forensic Med Pathol.* 2012;33(4):330-4.
 49. Conde-Agudelo A, Romero R. Amniotic fluid embolism: an evidence-based review. *Am J Obstet Gynecol.* 2009;201(5):445.e1-13.
 50. Kwiatt ME, Seamon MJ. Fat embolism syndrome. *Int J Crit Illn Inj Sci.* 2013;3(1):64-8.
 51. Gupta A, Reilly CS. Fat embolism. *Cont Edu Anaesth Crit Care & Pain* 2007;7:148-51.
 52. Abramowsky CR, Pickett JP, Goodfellow BC, Bradford WD. Comparative demonstration of pulmonary fat emboli by "en bloc" osmium tetroxide and oil red o methods. *Hum Pathol.* 1981;12(8):753-5.
 53. Castella X, Valles J, Cabezuelo MA, Fernandez R, Artigas A. Fat embolism syndrome and pulmonary microvascular cytology. *Chest.* 1992;101(6):1710-1.
 54. Neri M, Riezzo I, Dambrosio M, Pomara C, Turillazzi E, Fineschi V. CD61 and fibrinogen immunohistochemical study to improve the post-mortem diagnosis in a fat embolism syndrome clinically demonstrated by transesophageal echocardiography. *Forensic Sci Int.* 2010;202(1-3):18.
 55. Wehner F, Moos NRM, Wehner H-D, Martin D, Schulz MM. Immunocytochemical examinations of biological traces on expanding bullets (QD-PEP). *Forensic Sci Int.* 182(1):66-70.
 56. Walsh KA, Horrocks M. Palynology: its position in the field of forensic science. *J Forensic Sci.* 2008;53(5):1053-60
 57. Lancia M, Conforti F, Aleffi M, Caccianiga M, Bacci M, Rossi R. The use of *Leptodictium riparium* (Hedw.) Warnst in the estimation of minimum postmortem interval. *J Forensic Sci.* 2013; 58 Suppl 1:S239-42.
 58. Mildenhall DC, Wiltshire PE, Bryant VM. Forensic palynology: why do it and how it works. *Forensic Sci Int.* 2006; 163(3):163-72.
 59. Morgan RM, Flynn J, Sena V, Bull PA. Experimental forensic studies of the preservation of pollen in vehicle fires. *Sci Justice.* 1016;54(2):141-5.
 60. Arguelles P, Reinhard K, Shin DH. Forensic palynological analysis of intestinal contents of a Korean mummy. *Anat Rec.* 2015;298(6):1182-90.
 61. Peabody AJ. Diatoms in Forensic Science. *J Forensic Sci Soc.* 1977;17(2):81-7.
 62. Fukui Y, Hata M, Takahashi S, Matsubara K. A new method for detecting diatoms in human organs. *Forensic Sci Int.* 1980;16(1):67-74.
 63. Ming M, Meng X, Wang E. Evaluation of four digestive methods for extracting diatoms. *Forensic Sci Int.* 2007;170(1):29-34.
 64. Fucci N, Pascali VL, Puccinelli C, Marcheggiani S, Mancini L, Marchetti D. Evaluation of two methods for the use of diatoms in drowning cases. *Forensic Sci Med Pathol.* 2015;11(4):601-5.
 65. Spitz WU, Schneider V. The Significance of diatoms in the diagnosis of death by drowning. *J Forensic Sci.* 1964;9(1):11-8.
 66. Wang Y, Zhao J, Li P, Hu S, Wang H, Wang H, et al. [Evaluation of three methods for forensic diatom test]. *Nan fang yi ke da xue xue bao = Journal of Southern Medical University.* 2015;35(3):427-31.
 67. Zhao J, Wang Y, Wang G, Ma Y, Shi H, Wen J, Li X, Hu S, Chen F, Liu C. Application of the microwave digestion-vacuum filtration-automated scanning electron microscopy method for diatom detection in the diagnosis of drowning. *J Forensic Leg Med.* 2015; 33:125-8
 68. Padosch SA, Schmidt PH, Pedal I, Franchy C, Hoch J, Madea B. Medicolegal assessment of blood transfusion errors-an interdisciplinary challenge. *Forensic Sci Int.* 2007;172(1):40-8.
 69. Marwah V. Gender bending, gender testing: reflections on the Pinki Pramanik case. *Indian J Med Ethics.* 10(1):45-8.
 70. Albrecht K, Schultheiss D. Proof of paternity: historical reflections on an andrological-forensic challenge. *Andrologia.* 2004;36(1):31-7.
 71. Kulkarni MK, Somannavar PD, Kotrashetti V, Nayak R, Hosmani J, Babji D. Do the presence of Barr bodies in male jail inmates indicates criminality: A pilot study. *J Oral Maxillofac Pathol.* 20(1):11-5.
 72. Ramakrishnan K, Sharma S, Sreeja C, Pratima DB, Aesha I, Vijayabanu B. Sex determination in forensic odontology: A review. *J Pharm Bioallied Sci.* 2015 Aug;7(Suppl 2):S398-402.
 73. Tu X, Zeng J, Cong X, Zhang X, Yan A. Cytogenetic and molecular genetic analysis of a case with mosaic marker chromosomes. *Zhonghua Yi Xue Yi Chuan Xue Za Zhi.* 2016; 33(1):76-80.
 74. Poole MC, Costoff A. A computer program for the morphometric analysis of cell profiles. *Comput Programs Biomed.* 1979;10(2):143-50.
 75. Shetty DC, Wadhwan V, Khanna KS, Jain A, Gupta A. Exfoliative cytology: A possible tool in age estimation in forensic odontology. *J Forensic Dent Sci.* 2015;7(1):63-6.
 76. Turillazzi E, Karch SB, Neri M, Pomara C, Riezzo I, Fineschi V. Confocal laser scanning microscopy. Using new technology to answer old questions in forensic investigations. *Int J Legal Med.* 2008;122(2):173-7.
 77. Schnadig VJ, Molina CP, Aronson JF. Cytodiagnosis in the autopsy suite: a tool for improving autopsy quality and resident education. *Arch Pathol Lab Med.* 2007;131(7):1056-62.
 78. Schnadig VJ. Cytology as a diagnostic tool in the autopsy suite. *Cancer Cytopathol.* 2016;124(11):773-775.
 79. Scadding GK, Brock C, Chouiali F, Hamid Q. Laryngeal inflammation in the sudden infant death syndrome. *Curr Pediatr Rev.* 2014;10(4):309-13.
 80. Morita S, Furukawa S, Nishi K. Classification of contraction bands using immunohistochemistry. *Am J Forensic Med Pathol.* 2015;36(1):23-6.

81. Kashiwagi M, Ishigami A, Hara K, Matsusue A, Waters B, Takayama M, et al. Immunohistochemical investigation of the coma blister and its pathogenesis. *J Med Invest.* 2013;60(3-4):256-61.
82. Riezzo I, Zamparese R, Neri M, De Stefano F, Parente R, Pomara C, et al. Sudden, unexpected death due to glioblastoma: report of three fatal cases and review of the literature. *Diagn Pathol.* 2013;8(73):1746-596.
83. Sampaio-Silva F, Magalhaes T, Carvalho F, Dinis-Oliveira RJ, Silvestre R. Profiling of RNA degradation for estimation of post mortem interval. *PLoS One.* 2013;8(2):20.
84. Tester DJ, Ackerman MJ. The molecular autopsy: should the evaluation continue after the funeral? *Pediatr Cardiol.* 2012;33(3):461-70.
85. Dada MA, Ansari NA. Post-mortem cytology: a reappraisal of a little used technique. *Cytopathology.* 1997;8(6):417-20.
86. Gregory G, Davis M, editor. *Pathology and Law.* New York: Springer; 2004.

CASE REPORT

Critical analysis of Aadhar dactylography – A case report and review of literature

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Abstract

Ever since its inception Aadhar biometric enrolment created a volley of controversies in India ranging from rights issues, data privacy, security, fears of exclusion etc. to name a few. Aadhar has gained sanctity in our public life in the recent past. In today's Indian scenario it would not be wrong to say that an individual without an Aadhar card has attained a civil death. Through this case report, we are limiting to the discussion of difficulties in recording fingerprints during enrolment, congenital absence of fingerprints and alteration of finger prints. This case report also emphasizes upon emerging and re-emerging situations where opinion is sought from forensic physicians. The technology failures, cryptography, privacy, security, network glitches etc. leading to failure of Aadhar authentication are not a part of this write-up.

Key words

Aadhar Fingerprints; Biometrics; Identification; Adermatoglyphia; NFJS syndrome; Immigration Delay Disease; Hyperhidrosis

Introduction

The Aadhar project initiated by UNIQUE IDENTIFICATION AUTHORITY OF INDIA created many problems for the less privileged sections like elderly, manual labourers, persons with amputated fingers during the digital recording of fingerprints. There were also situations where finger prints were recorded successfully but the beneficiaries could not authenticate them at a later date due to alteration. The UIDAI slowly understood these problems after years of initiating the project and provided concessions of fusion mode alternative authentication like iris scan and facial recognition. The fundamental point in discussing all these matters is it is a failure on the part of UIDAI not to take Forensic Physicians on board while doling out the project. There are many glitches on the technical side of the project as well which were discussed candidly in a study by scholars from IIT Delhi.¹

Case Summary

A 22-year-old girl, Ms X, pursuing Pharm D course in a private college was referred to Clinical Forensic Medicine Unit, Osmania General Hospital from Dermatology OPD. She attended the skin clinic with a complaint of the absence of fingerprints requiring further evaluation. On examination, the dermatologist noted that the skin over the fingers is smooth and there were no associated pigmentation or disorders. Systemic disease and dermopathology causing loss of finger prints were ruled out by the dermatologist. The case was referred to us in view of issuing a medical certificate towards the same.

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The case was registered for issuing an expert opinion on the matter in our department. Upon enquiry, the girl narrated that her fingerprints were not digitally recordable in Aadhar enrolment centres and failure to procure Aadhar card was preventing her in getting a scholarship. This has led the girl to run from pillar to post. She made a representation to the minority welfare officer about her condition who ordered her to obtain a medical certificate for the same from a tertiary care teaching hospital. Occupational factors leading to alteration of prints or loss of prints and intentional alteration were ruled out carefully. In a strong commitment to helping her, the case was taken up and after recording and examining her fingerprints she was referred to Fingerprint Bureau, CID, Telanganastate for an expert opinion on the same. The finger print expert gave an opinion that because of the excessive sweating her finger prints were not recordable digitally and manual recording of only right thumb print was possible. It was suggested to use the same for authentication for processing her scholarship.

Discussion

We came to know that her mother and aunts had the same issue and only some of her mother's fingerprints were digitally recordable. Certain congenital disease was suspected initially but was subsequently ruled out. It was clear that they did not suffer from any of the Ectodermal Dysplasia Syndrome namely NFJS (Naegeli-Franceschetti-Jadassohn syndrome), Dermopathia Pigmentosa Reticularis etc. where there is a complete absence of fingerprints. Literally, such prints in these syndromes are black smudges. On examination, the girl had a clear pattern of completely horizontally placed ridges without any deltas and the pattern is nonconfirming to any of the existing recognizably classified primary patterns like the loop, whorl, arch and composite. The girl was suffering from hyperhidrosis which led to difficulty in the recording of finger prints in this case.

On further probing the girl revealed there are quite a considerable number of people within the limits of their public

distribution system fair shop who face frequent hassles to get their ration. As rationing is linked to Aadhar fingerprints authentication, the fair price shops are denying ration to people with electronically unrecognizable or not recordable fingerprints. In spite of multiple attempts by these people to update their fingerprints electronically, they were unsuccessful.

There was a litany of arguments by disability rights activists that people suffering from cerebral palsy, involuntary movements, locomotor disability, bed ridden adults and children who couldn't cope up with the procedure were excluded in the enrolment process². Interestingly and unexplainably authentication failure of affluent urban Indians is being reported³. Adermatoglyphia is a rare condition, that only a few affected families have been identified worldwide to be suffering from. People with adermatoglyphia do not have epidermal ridges and so they cannot be identified by their fingerprints. Adermatoglyphia has been called the "immigration delay disease" because affected individuals have had difficulty entering countries that require fingerprinting for identification. Adermatoglyphia is inherited in an autosomal dominant pattern, which means one copy of the altered SMARCD1 gene in each cell is sufficient to cause the condition. In many cases, an affected person has one parent with the condition.⁴

There are three possibilities for things to go wrong in any case of Aadhar Dactylography; firstly, the software recording prints digitally cannot recognize any pattern other than the primary pattern i.e. unrecognizable prints, secondly, excessive sweating leading to recording difficulties i.e. not recordable fingerprints, and thirdly and rarely they might be suffering from congenital Autosomal Dominant ectodermal dysplasia syndromes leading to the absence of fingerprints? Common causes for difficulty in digital recording of finger prints in otherwise normal individuals may be putting too much or too little pressure, excessive moisture or drying, or missing central region.⁵

Some of the reasons for alteration of fingerprints are described in literature as acromegaly, infantile paralysis, rickets, celiac disease dermatitis, leprosy, Acanthosis Nigricans, eczema, scleroderma, skin atrophy (age-related changes), burns electrical injury, radiation exposure, intentional abrading, exposure to corrosives, cauterisation, transmogrification, and in manual labourers working with cement, gravel, lime and sand etc.⁶ Alteration of fingerprints after they are recorded digitally can lead to authentication failure at a later date. Aadhar authentication failure in MNREGA workers across the country is general and Telangana, in particular, was frequently discussed in the press.⁷ Though current UIDAI guidelines prescribe fusion methods of authentication like using OTP (one-time password) and face recognition or iris and OTP etc, they are rarely practically enforceable by the needy⁸.

Conclusion

Aadhar while successfully attempting to empower citizens is also disempowering a few people of this kind. It is suggested that an alternative biometric authentication like iris scan, facial recognition etc. should be included and made readily available for preventing instances of denial of benefits. All the existing biometric data viz. fingerprints, iris scan data, facial recognition etc. should be verified while authentications are being carried out so as to not make a citizen suffer the clear failure of state for want of infrastructure. A state failing in such a responsibility amounts to a blatant denial of citizen rights. Due care should be taken while enrolment, issue of Aadhar number and authentication for people with special needs.

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References

1. Agrawal S, Benerjoe S, Sharma S. Privacy and Security of Aadhar- A Computer Science Perspective A Report, Computer Science Engineering Department, IIT Delhi. Available at: <http://www.cse.iitd.ernet.in/~suban/reports/aadhaar.pdf>
2. Krishna G. Fixing bugs of Aadhar: Putting a finger on the biometric problem, Business Standard, New Delhi, January 16 2018, Available at: http://www.business-standard.com/article/economy-policy/fixing-bugs-of-aadhaar-putting-a-finger-on-the-biometric-problem-118011501030_1.html. Last accessed on 20/05/2018
3. Deep A. Now, even the fingerprints of urban Indians are failing during the Aadhar authentication. November 15 2017 Available at: <https://scroll.in/article/857274/now-even-the-fingerprints-of-urban-indians-are-failing-during-aadhaar-authentication> Last accessed on 15/06/2019.
4. Editor, Adermatoglyphia, U.S National Library of Medicine, Genetics Home Reference. Available at: <https://ghr.nlm.nih.gov/condition/adermatoglyphia>. Last accessed on 19/05/2018
5. Editor, Biometric Data Capture Guidelines, UIDAI. Available at: <https://uidai.gov.in/298-faqs/enrolment-update/enrolment-partners-ecosystem-partners/2016-what-are-the-uidai-guidelines-for-biometric-data-capture.html>. Last accessed on 15/06/2019
6. Aggrawal A (ed), Identification. In: Textbook of Forensic Medicine and Toxicology, 1st Edition. Avichal Publishing Company, New Delhi.
7. Kapoor P, Nair R, Roche E. Aadhar fails MGNREGS test in Telangana. Live Mint 07 April 2017. Available at: <https://www.livemint.com/Politics/Uf5B33ZB2sYKpmLqWMke8O/Aadhaar-fails-MGNREGS-test-in-Telangana.html>. Last accessed on 20/05/2018.
8. Special Correspondent, Face Recognition for Aadhar Validation, The Hindu, New Delhi, January 16 2018. Available at: <http://www.thehindu.com/todays-paper/aadhaar-validation-with-face-recognition-from-july-1/article22445834.ece>. Last accessed on 19/05/2018

CASE REPORT

Amlodipine overdose - A case report

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Abstract

An autopsy surgeon encounters different types of toxicological deaths in practice which include suicidal consumption of poisons, accidental consumption of poisons and homicidal administration of poisons. Kenneth Barlow insulin murder case is a classic case of homicidal poisoning reported in history. A recent incident in 1990 involving death of 84 Nigerian children after being given "My Pikin", teething syrup contaminated with diethylene glycol is one of the fatal episodes of accidental toxicological deaths. Suicide by poisoning forms a part of our routine practice in India. However, suicide by therapeutic drug abuse is a rather uncommon phenomenon. The commonly encountered therapeutic drug abuse cases involve NSAIDs, purgatives, steroids, etc. We report a case of amlodipine toxicity causing death with due emphasis towards autopsy findings, toxicokinetics, drug interactions, analytical toxicology considerations and differential diagnosis of capillary leak syndrome.

Key words

Amlodipine Toxicity; Cumulative drug overdose; Pharmaceutical Toxicology; Therapeutic drug abuse; Capillary leak syndrome

Introduction

Calcium channel blockers form an important cluster of cardiovascular drug overdose and are attributed to about 48% of deaths due to Cardiovascular System (CVS) drug exposure.¹ In all cases of drug deaths, postmortem samples are to be screened for volatiles, therapeutic drugs and recreational drugs. Prescription drug abuse is an uncommon phenomenon except in psychiatric medical practice. Compared to other instances of poisoning by medicines, less number of cases of amlodipine toxicity has been reported in the literature.²⁻⁴ Few cases of combinational drug overdose with amlodipine as a constituent was documented.^{5,6}

We present a case of amlodipine toxicity causing death with due emphasis towards autopsy findings, toxicokinetics, drug interactions, analytical toxicology considerations and differential diagnosis of capillary leak syndrome.

Case History

A 45-year old male was referred to Osmania General Hospital with an alleged history of consuming five tablets of Amlodipine 5 Mg per day for the past 15 days. Upon verification of hospital records, it was found that he developed a severe chest pain 1 hour after taking anti-hypertensive medication on the unfortunate day. The patient attended a nearby clinic from where he was immediately referred to our tertiary care center. The patient reported alive to the emergency and died on the way to Acute Medical Care Unit. The body was preserved in cold chamber.

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An autopsy was requested by the police U/S 174 CrPC. At autopsy, cold stiffening was present. Post Mortem lividity was present on the back of the body. Rectal temperature was equal to the external temperature at the time of autopsy. Pedal edema was present. There were no external or internal ante-mortem injuries present on the body. On Internal examination, Brain was edematous and congested. 315 ml of straw color fluid was present in left pleural cavity, and the left lung was partially collapsed, doughy, heavy and weighed 450 g. 275 ml of straw color fluid was present in the right pleural cavity, and right lung was doughy, heavy and weighed 600g. Both lungs on cut section exuded fluid. A 1 x 1 cm white patch (old infarct) was present on the lower part of anterior wall of the left ventricle. Heart valves, myocardium and origin of great vessels showed no abnormality except for atheromatous plaques at the root of the aorta. 1.7 litres of straw color fluid was present in the peritoneal cavity. 200cc of brownish fluid was present in the stomach, mucosa was pale, no specific smell was noticed. Small intestine shows collapsed hose appearance with intermittent narrowing of the lumen. Large bowel was unremarkable. Bilateral adrenal hemorrhages were present. Both kidneys weighed 240g. with poor cortico-medullary differentiation on cut section. Routine viscera were preserved for chemical analysis at the RFLS.

Discussion

Calcium channel blockers selectively block voltage sensitive L Type channels in smooth muscles and other excitable cells. Amlodipine, a Dihydropyridine class of drug, bind to their specific binding site on alpha-1 subunit of long lasting current voltage sensitive calcium channel. The early vasodilator effects like palpitation, flushing, headache, postural dizziness which are common with other dihydropyridines are less frequently seen with amlodipine considering its properties-60-65% bioavailability, volume of distribution 21.0L/kg, clearance of 0.42L/hr/Kg, elimination half-life of 35-45 hours and 93%

protein bound.⁷ Amlodipine has very low metabolic clearance rate with the advantage of using it as an OD dose. The same property of this drug turns fatal as it accumulates in the blood. It has a very long elimination half-life of almost 45 hours after repeated doses. Amlodipine can worsen angina and can cause more harm to patients with nephropathy.⁸

Interactions with other drugs⁸

Hypotension, bradycardia and conduction blocks were reported when beta blockers and calcium channel blockers were used together at therapeutic doses. Complete AV block and QT prolongation has been associated with concurrent administration of Cisapride and Diltiazem. Concomitant administration of Verapamil, Erythromycin with amlodipine causes pharmacokinetic drug interactions as the former two are potent CYP3A4 and P-Glycoprotein inhibitors. Azoles, Sildenafil and Cyclosporine also show pharmacokinetic interactions.

The classical clinical features in amlodipine toxicity with calcium channel blockers are refractory hypotension, tissue hypoperfusion and target organ damage, non-cardiogenic pulmonary edema and acute renal failure. Amlodipine overdose can result in severe hypotension and shock. Management protocols include maintenance of ABC (Airway, Breathing, and Circulation), calcium supplementation to aid in competitive blockade of drug, glucagon to exert chronotropic and inotropic effects, anti arrhythmics, inamrinone, aminopyridine, insulin plus glucose, administration of intralipid, anti-epileptics and VA ECMO. All these modalities have been tried with variable degrees of success and failure⁸. Jang *et al.* suggested the use of methyl blue in the management of refractory shock due to amlodipine overdose⁹. However, clinical toxicology of amlodipine overdose is beyond the scope of this report.

The symptomatology in amlodipine toxicity manifests as capillary leak syndrome. In the absence of toxicological analysis or undetectability of the drug in autopsy samples and when the history is inconsistent, a lengthy differential diagnosis of capillary leak syndrome should be borne in mind¹⁰. It includes sepsis, idiopathic systemic capillary leak syndrome/Clarkson's disease, engraftment syndrome, differentiation syndrome, ovarian hyperstimulation syndrome, haemophagocytic lymphohistiocytosis viral hemorrhagic fevers, autoimmune disease, snake bite/loxooscelism, ricin poisoning, interleukins used for treatment, monoclonal antibodies and gemcitabine overdose.

Analytical Toxicology Concerns

Amlodipine levels can be measured by liquid chromatography, atmospheric pressure photoionisation-mass spectrometry or even gas chromatography. HPLC, GC MS methods can be used to separate and analyze complex mixtures easily. Hence they can be of great help in case of concomitant drug abuse. Because dihydropyridine calcium channel blockers decompose rapidly on exposure to light, only fresh sample should be used, and the infusion bottle should be covered with opaque wrapping. The therapeutic range in plasma for amlodipine is 0.003-0.015 Mg/L, and the mean value of the fatal concentration detected postmortem is 0.1 mg/L¹¹.

Conclusion

Pharmaceutical Toxicology is gaining very much relevance in

clinical and autopsy practice. With emerging novel methods in all manner of deaths, it is high time the forensic personnel should be well aware of the toxicokinetics of few common drug overdoses, appropriate methods for detecting them and interpretation of results on scientific basis especially if there is a concomitant drug overdose/ synergistic combination of drugs.

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References

1. DeWitt CR, Walksman JC. Pharmacology, pathophysiology and management of calcium channel blocker and β -blocker toxicity. *Toxicol Rev* 2004;23:223-38.
2. Ghosh S, Sircar M. Calcium channel blocker overdose: Experience with amlodipine. *Indian J Crit Care Med* 2008;12(4):190-193.
3. El Houari T, Haddiya I, El Ouafi N, Bazid Z, A Survival Case in a Severe Amlodipine Intoxication, [HYPERLINK "https://www.ncbi.nlm.nih.gov/pubmed/?term=3.%09T.+El+Hourai%2C+I.+Haddiya%2C+N.+El+Ouafi%2C+and+Z.+Bazid%2C+A+Survival+Case+in+a+Severe+Amlodipine+Intoxication%2C+Case+Reports+in+Cardiology%2C+vol.+2013%2C+Article+ID+842606%2C+2+pages%2C+2013.+https%3A%2F%2Fdoi.org%2F10.1155%2F2013%2F842606"](https://www.ncbi.nlm.nih.gov/pubmed/?term=3.%09T.+El+Hourai%2C+I.+Haddiya%2C+N.+El+Ouafi%2C+and+Z.+Bazid%2C+A+Survival+Case+in+a+Severe+Amlodipine+Intoxication%2C+Case+Reports+in+Cardiology%2C+vol.+2013%2C+Article+ID+842606%2C+2+pages%2C+2013.+https%3A%2F%2Fdoi.org%2F10.1155%2F2013%2F842606). *Case Rep Cardiol*. 2013; 2013:842606.
4. Upreti V, Ratheesh VR, Dhull P, Handa A. Shock due to amlodipine overdose. *Indian J Crit Care Med* 2013;17(6):375-7.
5. [HYPERLINK "https://www.ncbi.nlm.nih.gov/pubmed/?term=Brunette-Lawrey%20E%5BAuthor%5D&cauthor=true&cauthor_uid=27355173"](https://www.ncbi.nlm.nih.gov/pubmed/?term=Brunette-Lawrey%20E%5BAuthor%5D&cauthor=true&cauthor_uid=27355173) Brunette-Lawrey E, [HYPERLINK "https://www.ncbi.nlm.nih.gov/pubmed/?term=Croft%20F%5BAuthor%5D&cauthor=true&cauthor_uid=27355173"](https://www.ncbi.nlm.nih.gov/pubmed/?term=Croft%20F%5BAuthor%5D&cauthor=true&cauthor_uid=27355173) Croft F, Losartan and amlodipine overdose: case report of a patient with anuric renal failure prior to the onset of hypotension. [HYPERLINK "https://www.ncbi.nlm.nih.gov/pubmed/27355173"](https://www.ncbi.nlm.nih.gov/pubmed/27355173) *N Z Med J* 2016;129(1435):84-6.
6. Sandeep P, Ram R, Sowgandhi N, Reddy SA, Katyarmal DT, Kumar BS, Kumar VS. Atenolol and amlodipine combination overdose managed with continuous venovenous hemodiafiltration: A case report. *Indian J Nephrol* 2014;24:327-9
7. Tripathi KD. *Essentials of Medical Pharmacology* 7th Ed, Jaypee Publishers, 2013
8. Pillay VV. *Comprehensive Medical Toxicology*, 3rd Ed, Paras Medical Publishers, 2018
9. Jang DH, Nelson LS, Hoffman RS. Methylene blue in the treatment of refractory shock from an amlodipine overdose. *Ann Emerg Med*. 2011; 58:565-7.
10. Siddall E, Khatri M, Radhakrishnan J. Capillary leak syndrome: etiologies, pathophysiology, and management, [HYPERLINK "https://www.ncbi.nlm.nih.gov/pubmed/28318633"](https://www.ncbi.nlm.nih.gov/pubmed/28318633) *Kidney Int*. 2017;92(1):37-46.
11. Saukko P, Knight B. *Poisoning by Medicines, Concentration distribution in postmortem femoral blood and proportion of fatal poisoning for 129 drugs, Knight's Forensic Pathology*, CRC Press, 4th Ed, 2015.p.602-607.

CASE REPORT

Cardiac tamponade and complete aortic rupture following blunt trauma chest: A case report and review of literature

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Abstract

Cardiac tamponade may be due to a traumatic or non-traumatic rupture of heart or root of great vessels. Traumatic rupture of the heart and aorta, due to its high fatality and narrow window period are rarely diagnosed. These are usually detected only during autopsy. An unusual case of cardiac tamponade and aortic rupture following blunt trauma chest sustained due to a collision between a motorcycle and a tractor. Autopsy showed cardiac rupture involving left auricle, left atrium, both ventricles along with interventricular septum. It also showed complete rupture of aorta. Shovelling effect, combination of water-hammer effect and shearing stress could be the possible mechanisms for the unique pattern of a cardiac and aortic rupture.

Key words

Cardiac tamponade; Cardiac rupture; Aortic rupture; Blunt trauma chest

Introduction

Cardiac tamponade is defined as a collection of blood in pericardial sac. It is classified as a traumatic or non-traumatic origin. In traumatic origin, cardiac tamponade is caused by either penetrating trauma or blunt trauma chest (BTC) which leads to cardiac chamber rupture. Among these BTC is the least common cause when compared with penetrating trauma to chest.¹ BTC is commonly associated with vehicular accidents, fall from height and following crush injuries.² Heart is the most common organ injured in BTC.³ Early diagnosis of cardiac tamponade is necessary to save the life of patient. Cardiac tamponade can be diagnosed clinically by hypotension, muffled heart sounds, and engorged neck veins. Cardiac markers like creatine kinase-myoglobin and electrocardiogram are also helpful.⁴ But in case of severe cardiac injury patient's survival time is very short due to its high fatality. Which diminishes the window period available for diagnosis.⁵ Cardiac injuries can be more evidently detected only during the autopsy.⁶

Cardiac injury and aortic ruptures depend on the magnitude of force applied to the chest. The force may be low or high velocity. The low velocity force will produce soft tissue injuries like contusions. High velocity forces as seen in road traffic accidents may produce variety of external and internal injuries like abrasion, contusion, laceration and rupture of visceral organs.⁷ In BTC, there is severe anterior compression of heart that leads to crush between the sternum and vertebral column which causes entrapment of heart between the sternum and vertebral column termed as a shovelling effect.⁸ The diaphragm is twisted

due to sudden compression of the chest which results in occlusion of the blood flow in the aorta at the level where it passes through the diaphragm. It results in the rise in aortic blood pressure, which is known as 'water-hammer' effect.⁹ Heart is suspended like a pendulum by root of great vessels in thoracic cage.¹⁰ The rupture of aorta is constantly associated with deceleration of thorax. Shearing stress may be caused by the rapid deceleration; root of great vessel can be jerked away from the posterior chest wall and severe traction occurs between arch of aorta and descending aorta due to their attachments. Arch of aorta being attached to the pulmonary trunk by ligamentum arteriosum and descending aorta attached to vertebral column by anterior longitudinal ligament. Shearing stress results in rupture of aorta most commonly at the junction between the arch of aorta and descending aorta.¹¹

We report a unique case of cardiac tamponade following cardiac rupture involving multiple surfaces and chambers of the heart. Aorta was ruptured without any external injury over the chest. There is a possibility of multiple mechanisms involved in causation of reported injuries, that are discussed in the article.

Case report

A forty-two-year-old male motorcycle rider was hit from behind by a tractor. He was declared dead on arrival to a tertiary health care center after sustaining the BTC. After inquest and requisition, autopsy conducted on the deceased. On external examination, multiple abrasions were noted over left elbow prominence (Fig. 1a) and right forearm (Fig. 1b). Contusion was noticed on the back of left shoulder (Fig. 1c). Superficial burns were seen on the lower one third of right leg. It was 2 cm above the medial malleolus due to contact with exhaust pipe of the motorcycle which was relatively hot (Fig. 1d). Lacerated wound was seen over the right side of chin (Fig. 1e). No injuries were noted over the chest (Fig. 1f).

On internal examination, brain and vertebral column showed no

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Fig 1: (a) Abrasion noted over the left elbow prominence. (b) Grazed abrasion noted over the right forearm. (c) Contusion seen on the back of left shoulder. (d) Second degree burns seen on the lower one third of right leg. (e) Lacerated wound seen on the right side of chin. (f) No injuries noted over the chest.

evidence of injuries. Thoracic cage showed fractures of 2nd to 5th ribs seen along the right anterior axillary line and 4th to 9th ribs along the right paravertebral line. Contusions were seen on both diaphragm and left lateral aspect of trachea. Both primary bronchi showed lacerations and hilar surface of both lungs were

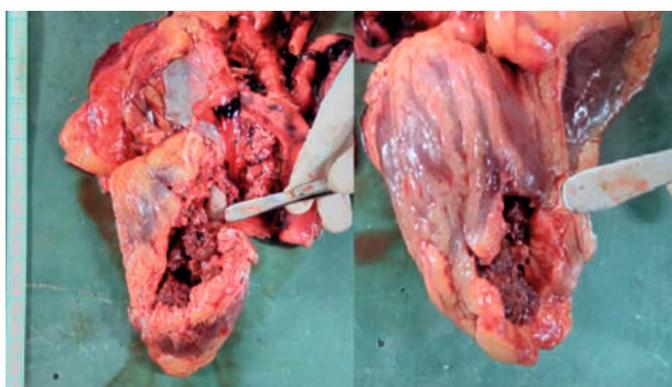


Fig 2: (a) Complete rupture of left atrium extends along the anterior surface involving anterior interventricular groove ending at right border of heart measuring (9 cm x 5 cm x full thickness) and it also showed rupture of both ventricles along with interventricular septum rupture. (b) Rupture noted over the inferior surface of heart of measuring 5 cm x 3 cm x full thickness

contused. Posterior surface of esophagus showed contusion. Bilateral hemothorax (total 1500 ml) were noted. Pericardium was intact and contained around 150 ml of fluid blood. Heart examination revealed complete rupture of left auricle, left atrium extending along with the anterior surface involving anterior interventricular groove ending at right border of heart, measuring 9 cm x 5 cm x full thickness. It also showed rupture of both ventricles along with interventricular septum rupture (Fig. 2a). Another rupture was noted on the inferior surface of heart measuring 5 cm x 3 cm x full thickness (Fig. 2b). Complete

rupture of aorta was noticed at the junction of arch of aorta and descending aorta (Fig. 3). All other organs were intact and pale. Cause of death was opined as hemorrhagic shock as result of aortic rupture and cardiac tamponade due to BTC.

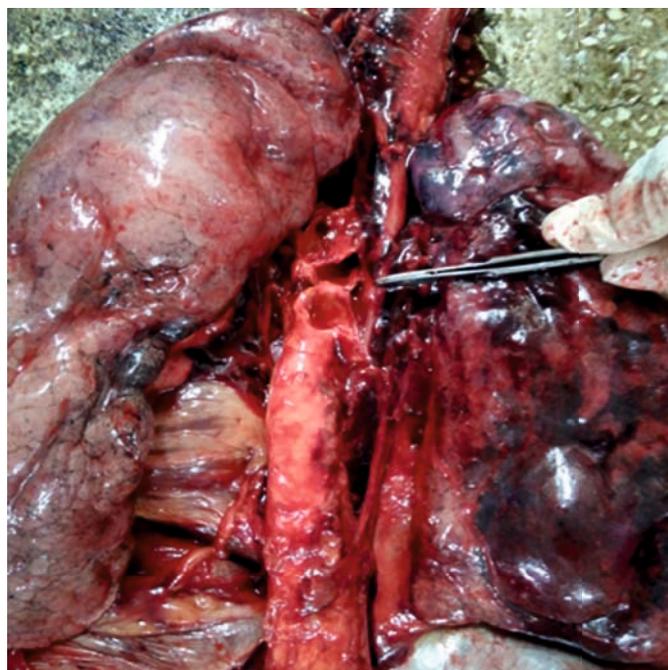


Fig 3: Complete rupture of aorta at the junction of arch of aorta and ascending aorta

Discussion

Cardiac tamponade is difficult to diagnose when it occurs due to cardiac chamber rupture following BTC. It has high fatality rate. The incidence rate of cardiac injuries due to BTC is 2.6% - 4.5%.¹² Cardiac rupture is rarely encountered following blunt cardiac injury. Teixeira et al. conducted a study of BTC which revealed 366 cases (0.045%) out of 8,11,531 blunt trauma patients had a cardiac rupture. The most common cause was motor vehicle collision (73%), followed by pedestrian struck by auto (16%), and fall from height (8%).¹³ Pretre and Chilcott observed that cardiac damage in BTC was 15%.¹⁴ BTC can damage either chest wall or organs like heart, lung and diaphragm corresponding to their relationship with the external landmark. Among the visceral organs, injury to heart is more fatal. BTC may cause the rupture and contusion of heart.¹⁰ Heart was ruptured in present case. Injury to the lungs and diaphragm were also noticed due to the broken ribs being displaced inwards and the jagged tip injuring the visceral and parietal pleura, resulting in laceration of lungs and hemothorax.

Brathwaite et al. observed right atrial rupture was 40%.¹⁵ Parnley et al. studied that heart rupture most commonly occur in the right auricle followed by right ventricle, left ventricle, left auricle, ventricular septum and valves.¹⁶ Bright and Beck observed that all the four chambers of the heart were susceptible to rupture in non-penetrating trauma and Ventricular ruptures were more common.¹⁷ Waele *et al.* observed that blunt cardiac injury was

common after sternal trauma and the severity of the fracture was an indicator of possible myocardial or pericardial damage.¹⁸ Meera *et al.* observed 35 cases of BTC, among these lacerations were seen in the right atrium (11.42%), both atria (11.42%), right ventricle (40%), right atrium and right ventricle (17.4%), both atrium and ventricle (8.57%), both ventricles (5.7%), left atrium and left ventricle contusion (2.86%). Laceration of right atrium on the anterior surface of heart without any external injury of the chest (2.86%).¹⁹ Ebert *et al.* reported, a left ventricle rupture and pericardial hemorrhage following horse kick. Postmortem CT and MRI was more helpful for detecting the rupture and it was confirmed with autopsy.²⁰

Feczko *et al.* conducted the autopsy study on blunt injury to the aorta. It was reported that 72% blunt aorta injuries resulting from motor vehicle crashes, of which 58% were associated with head-on collisions and 42% broadside collisions.²¹ Diaphragm injuries due to violent compressive force over the anterior chest causes the twisting of diaphragm leaflet resulting in hemorrhagic edges. Further there is fracture of 1st to 3rd ribs which is always associated with damage of aorta, vena cava, trachea and esophagus.⁷ The transverse tears usually present on posterior aspect of thoracic aorta and associated with spine fracture and dislocation.²² Kim and Busuttil studied 276 cases of road traffic accident and fall from height. They found that 66 cases were having traumatic rupture of aorta. Out of 66 cases, 36 cases were caused due to automobile collision, 15 were pedestrian struck, 3 were motorcycle rider, 1 was pillion rider and 11 were fall from height. They concluded that, traumatic rupture of aorta was most commonly occurred in driver followed by pedestrian and person involved in a fall from height.²³ Kotopoulos *et al.* observed a case of rupture of thoracic aorta in severe kyphoscoliosis. They found out the traumatic rupture of thoracic aorta was due to acute angulation of thoracic spine.²⁴ In present case, complete rupture was observed at junction of arch of aorta and descending aorta and spine was intact.

In the reported case, the deceased fell down on chest wall, heart was compressed between sternum and vertebral column. Particular pattern of cardiac rupture was seen and these could be attributed to a shovelling effect. In this case two mechanism was responsible for aortic rupture. The rider was thrown away from motorcycle after being struck from behind by a tractor. It resulted in production of sudden rapid acceleration followed by deceleration force. This will lead to severe stretching of aorta occur at the junction between the arch of aorta and descending aorta (shearing stress). Severe impact on the chest leads to compression of the diaphragm and chest wall leading to rapid rise of aortic pressure (water hammer effect). The combination of shearing stress and water hammer effect had caused the complete rupture at the junction between the arch of aorta and descending aorta.

Cardiac tamponade and aortic ruptures are the most catastrophic event following BTC. Due to the short survival period in cases of BTC with cardiac and aortic injuries, the doctors might miss the diagnosis due to its uncommon presentation, rapid clinical deterioration and high fatality rate. The forensic pathologist must possess knowledge about the commonest sites,

mechanism like shoveling effect, water hammer effect, and shearing stress involved. He should also look for the degree of injuries sustained to the deceased. This will help the forensic pathologist to perform a meticulous postmortem examination in cases of BTC.

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References

- Callahan M. Pericardiocentesis in traumatic and nontraumatic cardiac tamponade. *Ann Emerg Med.* 1984; 13(10):924-945.
- Fulda G, Brathwaite CE, Rodriguez A, Turney SZ, Dunham CM, Cowley RA. Blunt traumatic rupture of the heart and pericardium: a ten-year experience (1979-1989). *J Trauma.* 1991; 31(2):167-172.
- Huguet M, Tobon-Gomez C, Bijnens BH, Frangi AF, Petit M. Cardiac injuries in blunt chest trauma. *J Cardiovasc Magn Reson.* 2009; 11: 35.
- Sybrandy KC, Cramer MJ, Burgersdijk C. Diagnosing cardiac contusion: old wisdom and new insights. *Heart.* 2003; 89(5):485-499.
- Healey MA, Brown R, Fleiszer D. Blunt cardiac injury: is this diagnosis necessary? *J Trauma.* 1990; 30:137-146.
- Wang Q, Yang L, Zhang Y, Yao Y, He H, Wang Z. Forensic-Pathological Analysis of Blunt Cardiac Rupture Involving the Relationship between Injury and Disease: 2 Cases Report and Review of the Literature. *Forensic Med Anat Res* 2016; 4(2):23.
- Vincent J Dimaio, Dominick Dimaio. In: Blunt Trauma Injuries of the Trunk and Extremities. Forensic pathology. 2nd ed. Washington: CRC press; 2001. p.119.
- Orliaguet G, Ferjani M, Riou B. The heart in blunt trauma. *Anesthesiology.* 2001; 95(2):544-548.
- Gotzen L, Flory PJ, Otte D. Biomechanics of aortic rupture at classical location in traffic accidents. *Thorac Cardiovasc Surg.* 1980; 28:64-68.
- Saukko P, Knight B. In: Chest and Abdominal Injuries. Knight's forensic pathology. 4th ed. London: CRC press; 2016. p.215.
- Ben-Menachem Y, Handel SF. The mechanism of injury. *Angiography in trauma. A work atlas.* London: W.B Saunders, 1981.
- Maenza RL, Seaberg D, D'Amico F, A meta-analysis of blunt cardiac trauma; ending myocardial contusion. *Am J Emerg Med* 1996; 14:237-241.
- Teixeira PG, Inaba K, Oncel D, DuBose J, Chan L, Rhee P, Salim A, Browder T, Brown C, Demetriades D. Blunt cardiac rupture: a 5-year NTDB analysis. *J Trauma Acute Care Surg.* 2009; 67(4):788-791.
- Prete R, Chilcott M. Blunt trauma to the heart and great vessels. *N Engl J Med.* 1997; 336(9):626-632.
- Brathwaite CE, Rodriguez AU, Turney SZ, Dunham CM, Cowley RA. Blunt traumatic cardiac rupture. A 5-year experience. *Ann Surg.* 1990; 212(6):701.
- Parmley LF, Mattingly TW, Manion WC, Jahnke EJ. Nonpenetrating traumatic injury of the aorta. *Circulation.* 1958; 17(6):1086-1101.
- Bright EF, Beck CS. Nonpenetrating wounds of the heart: a clinical

- and experimental study. *Am Heart J.* 1935; 10(3):293-321.
18. Waele JJD, Calle PAA, Blondeel L, and Vermassen FEG. Blunt cardiac injury in patients with isolated sternal fractures: the importance of fracture grading. *Eur J Trauma Emerg Surg.* 2002; 28(3):178-182.
19. Meera T H, Nabachandra H. A Postmortem study of blunt cardiac injuries. *J Indian Acad Forensic Med.* 2005; 27(2):0971-0973.
20. Ebert LC, Schön CA, Ruder TD, Thali MJ, Hatch GM. Fatal left ventricular rupture and pericardial tamponade following a horse kick to the chest. *Am J Forensic Med Pathol.* 2012; 33(2):167-169.
21. Feczko JD, Lynch L, Pless JE, Clark MA, McClain J, Hawley DA. An autopsy case review of 142 nonpenetrating (blunt) injuries of the aorta. *J Trauma.* 1992; 33(6):846-9.
22. Sevitt S. The mechanisms of traumatic rupture of the thoracic aorta. *Br J Surg.* 1977; 64:166-173.
23. Kim J, Busuttill A. Traumatic rupture of the aorta. *J Clin Forensic Med.* 1996; 3(3):123-127.
24. Kotopoulos C, Karakasi MV, Kapetanakis S, Pavlidis P. Can Severe Kyphoscoliosis Lead to Aorta Rupture? *Am J Forensic Med Pathol.* 2016; 37(3):205-207.

CASE REPORT

A rare case of sudden death due to cardiac myxoma

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Abstract

Sudden death is known to occur in patients with primary cardiac tumours; however, it is rare and is estimated to constitute a very small percentage of all sudden deaths. We present here a case diagnosed with post-mortem of a left atrial myxoma which had subtle ante-mortem manifestations and yet turned out to be the cause of sudden death that occurred in a patient with Non-Hodgkin's Lymphoma (NHL). We also present a brief review of available literature on this subject. This paper should alert the clinician with regard to the need to be aware of the rather obscure clinical presentation which may accompany this potentially fatal but treatable condition.

Key words

Cardiac myxoma; Non-Hodgkin's lymphoma; Sudden Death.

Introduction

Death is said to be sudden or unexpected when a person not known to have been suffering from any dangerous disease, injury or poisoning is found dead or dies within 24 hours after the onset of terminal illness (World Health Organization)¹. On the other hand, sudden cardiac death (SCD) is defined as natural death from cardiac causes, heralded by abrupt loss of consciousness within 1 hour of the onset of an acute change in cardiovascular status.²

Although sudden death is known to occur in patients with primary cardiac tumour, it is rare and is estimated to constitute 0.01 to 0.005% of all sudden death.³ Association between sudden death and cardiac myxoma has been reported as early as 1953 by Madonia et al.⁴

Case report

One afternoon, in the later part of July 2017, the Jailor of a jail in a northeastern town of India reported to the police that one female Under Trial Prisoner (foreigner or illegal immigrant), remanded by Chief Judicial Magistrate died in the local hospital.

The patient was brought to the hospital in the afternoon of the previous day with complaints of shortness of breath, generalized weakness and altered sensorium. As per the hospital records, the following findings were observed on clinical examination; the deceased was semiconscious; BP 70/50mmHg; Pulse rate was 110/min and SpO₂ 74%. Despite the treatments, she could not be saved. The post-mortem

examination was done in our morgue and the following findings were observed; the body was emaciated with no external injuries. Internally, neck lymph nodes were enlarged and hardened on both sides. Lungs were congested and edematous. Stomach contained 70ml of watery fluid with no characteristic odour. The heart weighed 250gm and a firm irregular pedunculated mass, greyish brown in colour, was identified at the left atrium attached near the junction with the pulmonary veins (3X2X1.5cm) having a smooth glistening surface (Fig 1). Coronaries and aorta were patent throughout.

On HPE; sections from the mass in the left atrium showed benign myxoma cells mostly of fusiform and few stellate cells in a myxomatous background (Fig 2a & 2b). Focal areas of



Fig 1. Showing a firm irregular pedunculated mass, greyish brown in colour in the left atrium (myxoma)

calcification were also noted. Sections from the left ventricular wall, right ventricular wall, interventricular septum, right and left coronary arteries were histologically unremarkable. Sections from the lungs showed pulmonary edema. Sections studied from the multiple pieces of lymph node showed features of lymphoma.

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Discussion

An atrial myxoma is a noncancerous primary cardiac tumor in the left or right atria of the heart often on the atrial septum with

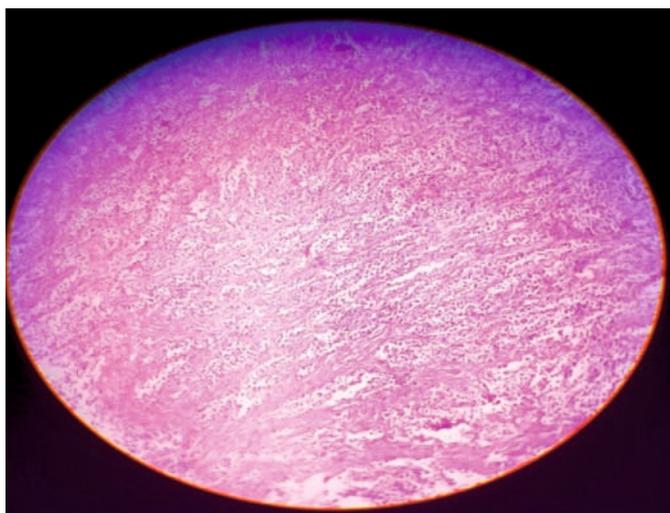


Fig 2.(a) Myxoma cells mostly of fusiform and few stellate cells in a myxomatous background

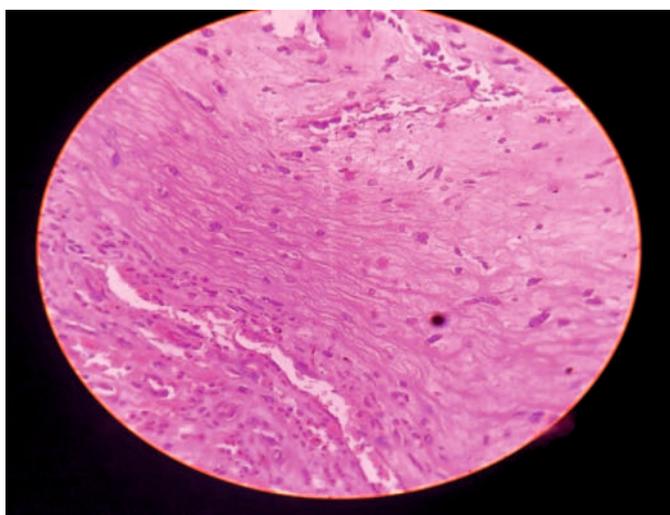


Fig 2. (b) Myxoma cells mostly of fusiform and few stellate cells in a myxomatous background

75% occurring in the left atrium. The rest are in the right atrium and myxomas are more common in women.² The complications of myxoma may include: arrhythmias, pulmonary edema, peripheral emboli, spread (metastasis) of the tumor, blockage of the mitral heart valve, etc.⁵ Death is typically caused by coronary or systemic embolization or by obstruction of blood flow at the mitral or tricuspid valve in such cases. Sudden death may occur in 15% patients with atrial myxoma and constitute 0.01 to 0.005% of all sudden deaths.³ A review of the literature on this subject between 1950 to 2008 revealed 17 cases of sudden death were attributed to cardiac myxoma in adults.⁶⁻¹⁰ The size of the tumour did not influence clinical presentation and in some reports of sudden cardiac death, the tumour was as small as 1.5 cm and without previous symptoms.¹¹ In the present case, the tumour was comparatively large i.e. 3cm X 2cm X 1.5cm. Sudden death in myxoma is attributed to either severe acute disturbance in cardiac haemodynamics from cardiac obstruction (ball-valve syndrome) or to coronary embolization

from the tumour. The latter is probably responsible for sudden death in patients with very small tumours.

On the other hand, non-Hodgkin's lymphoma (NHL) is cancer that originates in the lymphatic system. In non-Hodgkin's lymphoma, tumors develop from lymphocytes. Advances in diagnosis and treatment of non-Hodgkin's lymphoma have helped improve the prognosis for people with this disease. The stages of non-Hodgkin's lymphoma include: 1. Stage I. The cancer is limited to one lymph node region or a group of nearby nodes. 2. Stage II. The cancer is in two lymph node regions, or the cancer has invaded one organ and the nearby lymph nodes. But the cancer is still limited to a section of the body either above or below the diaphragm. 3. Stage III. The cancer moves to lymph nodes both above and below the diaphragm. Cancer may also be found in the lymph nodes above the diaphragm and in the spleen. 4. Stage IV. This is the most advanced stage of non-Hodgkin's lymphoma. Cancer cells are in several portions of one or more organs and tissues.¹²

In the present case lymphoma was detected only in the cervical lymph nodes i.e. Stage-I. Further, the causes of death and postmortem findings in patients treated for non-Hodgkin's lymphoma at a single institution over a 13-year period were reviewed. The most frequent extranodal sites of involvement were the respiratory tract, bone marrow, liver, kidney, and gastrointestinal tract in that order, and the most common cause of death was infection (33% of cases). Other causes of death included hemorrhage and respiratory failure secondary to lymphomatous infiltration of the lung.¹³ In the present case, NHL was in Stage I and was far from danger. The presenting clinical symptoms and the large size of the atrial myxoma confirmed the cause of death as due to the myxoma.

Sudden death of a person under custody often leads to suspicion of foul play. In the present case, all attention was diverted to the NHL and there was no suspicion about the atrial myxoma which was diagnosed only on autopsy. Though the patient was suffering from Non Hodgkin's Lymphoma, it was still in Stage-I and far from danger. The purpose of this paper is to highlight the possibility of the existence of this rare condition which can potentially cause sudden death but is treatable.

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References

1. Reddy KSN, Murty OP. Death and its causes. The essentials of Forensic Medicine and toxicology. 34th ed. New Delhi: The Health Sciences Publisher;2017.p.128-43.
2. Lenihan DJ, Yusuf SW. Tumors affecting the cardiovascular system. In: Bonow RO, Mann DL, Zipes DP, Libby P, Braunwald E, eds. Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine. 10th ed. Philadelphia, PA: Elsevier Saunders; 2015.p.1863-75.
3. Cina SJ, Smialek JE, Burke AP, et al . Primary cardiac tumors causing sudden death: a review of the literature. American

- Journal of Forensic Medicine & Pathology. 1996; 17(4):271-81.
4. Madonia, PF, Boggiano R, Gubner, R, Ball Valve Syndrome caused by primary cardiac tumor. NY State J Med. 1953; 53:3043-4.
 5. McKenna WJ, Elliott P. Diseases of the myocardium and endocardium. In: Goldman L, Schafer AI, eds. Goldman's Cecil Medicine. 25th ed. Philadelphia, PA: Elsevier Saunders; 2016.p.320-38.
 6. Turkmen N. Eren B. Fedakar R. Comunoglu N. An unusual cause of sudden death: cardiac myxoma. Advances in Therapy. 2007; 24(3):529-32.
 7. Maruyama T. Chino C. Kobayashi T. Ohta K. Kono T. Nakano H. A survivor of near sudden death caused by giant left atrial myxoma. Journal of Emergency Medicine. 1999; 17(6):1003-6.
 8. Vassiliadis N. Vassiliadis K. Karkavelas G. Sudden death due to cardiac myxoma. Medicine, Science & the Law. 1997; 37(1):76-8.
 9. Puff M. Taff ML. Spitz WU. Eckert WG. Syncope and sudden death caused by mitral valve myxomas. American Journal of Forensic Medicine & Pathology. 1986; 7(1):84-6.
 10. McAllister HA, Fenoglio JJ. Tumors of the Cardiovascular System, second series, 1978; Fascicle 15: 5-20.
 11. Casazza AR, Duvall CP, Carbone PP. Infection in lymphoma. JAMA 1966; 197:710-6.
 12. Kumar V, Abbas AK, Aster JC. The Heart. In: Robbins & Cotran Pathologic Basis of Disease (Robbins Pathology) 9th Ed. Philadelphia, PA: Elsevier; 2015.p.575-6.
 13. Ostrow, S, Diggs, CH, Sutherland, J, and Wiernik, PH. Causes of death in patients with non-Hodgkins lymphoma. Cancer. 1981; 48: 779–82.

CASE REPORT

Sudden death during flight due to strangulated hernia – A rare case report

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Abstract

Sudden death according to WHO is when death occurs within 24 hours of onset of symptoms, not otherwise explained. Hernia though a benign condition may result in sudden death if it becomes strangulated. The changes in pressure and volume during flight may result in increased incidence of complication especially in irreducible hernia. This case highlights that family physicians should be sensitized to the possibility of hernia strangulating during flight. Individuals with irreducible hernia should be advised against taking flight as a means of transport.

Key words

Strangulated hernia; Flight; Sudden death

Introduction

Sudden death according to WHO is when death occurs within 24 hours of onset of symptoms, not otherwise explained.¹ Cardiac causes are the most important cause of sudden death.² But sometimes other diseases and pathologies also cause sudden death that is rarely reported in the medical literature. Hernia is otherwise a benign treatable condition, however, a delay in seeking treatment or neglecting symptoms can result in complications and even sudden death. Mechanical bowel obstruction is one of the commonest surgical emergencies in the tropics and strangulated external hernias remain the main cause of mechanical bowel obstruction.^{3,4} Ihedioha et al in their study found that hernias are the most common cause of strangulation in patients presenting with small bowel obstruction.⁵ Although strangulation of femoral hernias is more common, inguinal hernia strangulation is also a frequent occurrence.^{4,6,7} The authors report an unusual case of death of a young individual during a flight due to strangulated inguinal hernia.

Case report

A 24 years old male was found dead in toilet of a flight while travelling flight from Doha to Delhi. Since it was sudden unexpected, unattended death, the body was brought to the Department of Forensic Medicine, Safdarjung hospital for post mortem examination. Past history was unremarkable and no treatment records were available. On examination of the deceased, the right side scrotal wall was reddened and there was

non-reducible scrotal swelling present. (Figure-1) On dissection of the body there was perforation present in ileal loop which was strangulated in the hernia pouch along with necrotic



Fig 1: Reddened scrotal wall with swelling

region around the perforated loop. (Figure-2) Pus was present in intestinal loops with intestinal adhesions. Both lungs were adherent to the chest wall and consolidation with occasional pus



Fig 2: Perforated intestinal loop (content of hernia sac)

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pockets were present in all the lobes. In abdomen, the peritoneal lining was inflamed with about 750 ml of pus mixed fluid present in peritoneum. The cause of death was concluded as shock as a result of perforation peritonitis due to strangulated inguinal hernia.

Discussion

A hernia is a protrusion of a viscus or a part of viscus through an abnormal opening in the walls of its containing cavity.⁸ There are different types of hernia like direct inguinal (does not enter inguinal canal), indirect inguinal (enters inguinal canal), femoral, incisional, umbilical, spigilean, epigastric, ventral and hiatal. Based on complexity hernia can be occult (detectable clinically, may cause severe pain), reducible (a swelling which appears and disappears), irreducible/ incarcerated (a swelling which cannot be replaced in the abdomen, high risk of complications), strangulated (painful swelling with vascular compromise, required urgent surgery), infarcted (when contents of the hernia have become gangrenous, high mortality).⁸ Most frequent type of hernia is inguinal hernia, present in 75% population.⁸ Men are eight times more prone to develop inguinal hernia than females.⁹ Incidence is about 2% in men of United States.¹⁰ There is no separate data regarding the incidence of hernia and associated deaths in India.

Strangulation is the most significant complication in hernia. In this the hernia contents become ischemic and non-viable. Clinically the hernia would be tense, very tender and the overlying skin may be discoloured with a reddish or bluish tinge. There are no bowel sounds present within the hernia itself. The patient commonly has a leukocytosis with a left shift, and is toxic, dehydrated and febrile. Arterial blood gas analysis may reveal metabolic acidosis. Treatment is done by rapid infusion of intravenous fluids, electrolyte replacement, antibiotics, nasogastric suction followed by urgent surgery.¹¹ The rate of incarceration and strangulation of hernia is difficult to determine and the generally quoted life time risk of 4-6 % strangulation is more of speculation rather than fact.¹¹

According to Rai, age (older age group), duration of hernia (short duration), type of hernia (femoral more than inguinal) and coexisting medical illness are risk factors useful in anticipating complications in an adult patient with groin hernia. In children, the risk factors were age (very young), gender (male), short duration of hernia and side (right side).^{6,11} According to literature, high intraabdominal pressure is not a major factor in causing hernia.⁸ However the changes in pressure and volume during flight may result in increased incidence of complication especially in irreducible hernia. During ascent the volume of gas would have expanded by 30%.¹² It is possible that at this time the gases may cause distension of the loops of intestine resulting in ischemic changes to the contents of hernial sac causing strangulation.

In the present case the deceased was a young male suffering

from right side indirect inguinal hernia with contents being loops of small intestine who had not sought treatment. No urgent care could have been provided during flight. In all probability the pressure changes happening in the cabin during flight resulted in distension of hernia sac causing strangulation of contents of hernia sac eventually causing death.

This case highlights that hernia may be a cause of sudden death. The prevalence of Hernia is not well documented because of which the incidence and complications are under reported. The family physicians should be sensitized to the possibility of hernia strangulating during flight. Individuals with irreducible hernia should be advised against taking flight as a means of transport.

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References

1. WHO International Classification of Diseases and related health problems 10th revision (ICD 10) version for 2010. Available online. who.int/classifications/icd10/browse/2010/en#R96 [Last accessed on 2018 Sep 10].
2. Pandian JR, Laishram RS, Kumar LD, Phuritsabam P, Debnath K. Autopsy review of sudden deaths in a tertiary hospital of northeastern India. *Journal of Medical Society.* 2014;28 (3):145-8.
3. Madziga AG, Nuhu AI. Causes and treatment outcome of mechanical bowel obstruction in north eastern Nigeria. *West Afr J Med.* 2008;27(2):101-5.
4. Wysocki A, Krzywoń J. Causes of intestinal obstruction. *Przegl Lek.* 2001;58(6):507-8.
5. Ihedioha U, Alani A, Modak P, Chong P, O'Dwyer PJ. Hernia. 2006;10(4):338-40. Epub 2006 Jun 8.
6. Rai S, Chandra SS, Smile SR. A study of the risk of strangulation and obstruction in groin hernias. *Aust N Z J Surg.* 1998;68(9):650-4.
7. Moon SK, Lee GS, Lee ES, Kang HM, Lee JH, Kim JS, Kim SC, Kwak SS. A case of intestinal obstruction caused by strangulated femoral hernia accompanying soft tissue necrosis. *Korean J Gastroenterol.* 2007;50(5):340-3.
8. Hill J, Abdominal wall, hernia and umbilicus. In: Williams NS, Bulstrode CJK, O'Connell PR. Boca Raton FL. *Bailey and Love's Short Practice of Surgery*; 26th edition. CRC Press, 2013.
9. Mayo clinic. Inguinal hernia. Retrieved from <https://www.mayoclinic.org/diseases-conditions/inguinal-hernia/symptoms-causes/syc-20351547>. [last accessed on 12/9/2018]
10. Balentine JR. Hernia FAQ. Retrieved from https://www.emedicinehealth.com/hernia_faqs/article_em.htm. [last accessed on 12/9/2018]
11. Sherman V, Macho JR, Brunnicardi FC, Inguinal hernia. In: Schwartz SI, Brunnicardi FC, (editors). *Schwartz's principles of surgery*; 10th edition. New York, N.Y.: McGraw Hill Medical 2015.
12. Dowdall N, Evans T, Carter D. The impact of flying on passenger health: a guide for healthcare professionals. *BMA*; 2004.

LETTER TO THE EDITOR

Need of revamping Forensic Science in India

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Dear Editor,

Forensic science though sounds to be a glamorous and exciting scientific discipline providing numerous interesting awarding careers; the picture in real world is totally different. Its growth is static, rather stunted in India. Every year more than 400 students are getting bachelor's, masters and doctorate degrees in the subject of 'Forensic Science' from various government/private universities and institutes. However, the job prospects are limited, despite of the fact that almost all the universities which are providing forensic courses are A or A+ as accredited by NAAC¹.

Scope for Forensics is limited and shady in our country. It sounds to be a fascinating profession, but in reality, forensic science is a dying profession in India. However, its Scope can be widened. Forensic Science subject is always considered as an additional subject with other subjects (botany, zoology, biotechnology, chemistry etc.) in the recruitment for the scientific posts in Forensic Science laboratories.² Forensic Science is not an elementary subject. It takes lot of rigorous scientific efforts/training. The recruitment rules of the Forensic Science Laboratories should be reformed. Either the subject of Forensic Science should be made only optional or people applying with basic sciences must have diploma in forensic sciences.

Because of the exponential increase in crime, the state and central laboratories are burdened with large number of cases. The establishment of Regional laboratories and mobile laboratories throughout India will lower down the burden and will help in solving the majority of the cases in short span of time. The banks often deal with forged cheques and counterfeit currencies. The questioned document examination is one of the integral parts of Forensic Science. Recruitment of questioned document examiner in the banks and insurance companies should be made. There should be a regional office for collective banks where the forged documents are examined. The bank employees must be given regular short term training about the procedure of the analysis of forged documents.

In certain states, viz. Rajasthan public service commission and West Bengal service commission the subject of Forensic Science was not included as an eligibility criterion in the recruitment processes. The subject forensic science must be made a mandatory inclusion in the recruitment rules of every

state and union public service commission. In India, the police appearing at the scene of crime is usually neither aware of the need to maintain crime scene integrity for the forensic purposes nor are they well equipped to collect the crime scene evidence. That's why there should be special reservations for forensic students in investigative agencies (Police department and other investigative agencies). Forensic Science subject must be added as an additional subject in the core syllabus of professional (BDS, LLB, LLM etc.) courses. At least Forensic diploma should be there in the core syllabus of professional courses in academic institutions.

The linkages among forensic laboratories, academic institutions and research bodies which are so essential for any field to grow is totally lacking. Establishment of Forensic council at central level to link all these together at the same platform with the responsibility of establishing and maintaining high standards of forensic education and recognition of forensic qualifications in India. It registers forensic scientist to practice in courts in India, in order to protect and promote the legal and safety of the public by ensuring proper standards in the practice of forensic. There should be National Academy of Forensic Sciences (NAFS) to identify the needs of the forensic Science Community. Forensic sciences are a vast field of study that has many sub-disciplines in its scope and application. Forensic Universities should be established in every state similar to the one established recently in Gujarat.

It's a high time Ministry of Home Affairs, the Government of India and the Directorate of Forensic Science Services should take steps to fortify the discipline of forensic science. The government should try to bring forensic science in the main stream of science and technology. Forensic science has never been given the freedom to innovate, resulting in stagnation. If given freedom, encouragement and infrastructure, forensic science can develop equally well like other branches of science - space, computer, atomic energy, medicine and pharmaceuticals.

References

1. List of institutions with valid accreditation. Available at: <http://www.naac.gov.in/19-quick-links/32-accreditation-status> (Accessed on 22nd Jan. 2018)
2. Information for candidates. For the posts of Senior Scientific Officer (Biology) (unreserved) Group-B, for Forensic Science Laboratories in Haryana. Advt. No. : 4 (4). Page no. 12-13. Available at : http://hpsc.gov.in/Instructions/2016/Inst_Advt.%20No.%2004%20of%202016_6%20Posts.pdf (Accessed on: 22nd Jan. 2018)

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