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Journal of Indian Academy of Forensic Medicine

Volume 43 Number 2 April - June 2021

Contents

Review Article

Case Reports

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EDITORIAL

COVID-19 and forensic research avenues

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The world is witnessing a global pandemic in form of Coronavirus disease (COVID-19) caused by SARS-CoV-2 virus. The exponential spread of COVID-19 has already resulted in enormous morbidity and mortality. In these trying times, healthcare providers and researchers have left no stone unturned to save human lives by providing prompt healthcare services and devising newer ways to combat the crisis.[1] In view of the considerable mortality, role of forensic practitioners has become paramount specially in view of the dignified management of the dead.

The proverb "*Necessity is the mother of invention*" aptly fits in the current scenario where researchers and scientists have come together to find ways to negate the effect of COVID-19. Be it the understanding of the pathophysiology of the disease, or the development of better infection control strategies and vaccines, etc. Forensic scientists, practitioners and researchers have a tremendous role to play in this regard. The core areas where the forensic medicine experts can contribute to counter the SARS-CoV-2 virus and its effects are shown in Figure 1.

Figure 1: Four core areas of Forensic research during COVID-19 pandemic

Understanding the pathophysiology of COVID-19: Autopsy is gold standard to study the morphological features of COVID-19 infection, its pathophysiology and causes of death. Forensic autopsies have proven to be a useful source of providing information in this regard.[2] In view of the highly infectious nature of the virus, and limited autopsies being allowed in COVID-19 deaths, forensic practitioners have resorted to minimally invasive autopsies and postmortem imaging, and have shared the autopsy observations for better understanding of the pathophysiology of COVID-19.[3,4]

Infection control practices: The COVID-19 pandemic has seen researchers devise newer techniques and protective gears to safeguard the health care providers as well as the lay public. Mortuary set ups require a sophisticated approach in protecting its staff from the severe infection that they are likely to be exposed to during conduction of autopsies as well as while handling the COVID-19 dead bodies.[5,6] Thus, besides upgradation of mortuaries, and developing forensic radiology services,[7-9] research on infection control practices remain an important area to be explored.

COVID-19 dead body management: Various guidelines and SOPs were laid down and gradually revised for better management of COVID-19 dead bodies. This was possible only by virtue of sharing of the various practices being followed in different parts of the world and by amalgamating the best ones. Forensic practitioners have played an important role in ensuring the standardization of ongoing practices by publishing their experiences in this regard.[10,11]

Mortality data related research: Mortality data has always been a useful source of information when it comes to understanding the effect of any disease. During COVID-19, mortality data can be a useful source of epidemiological information. Furthermore, the mortality data can help establish association of COVID-19 and co-morbidities, and even the effect and safety of vaccines by analyzing the post-vaccination mortalities. Thus, this becomes another vital research avenue for the forensic practitioners.

It is amply clear that Forensic research has a key role in developing a better understanding of the pathophysiology of COVID-19 which is vital in developing the effective treatment strategies and vaccines. Experiences shared by the forensic professionals across the globe can prove to be significant in upgradation of mortuaries, gradual shift to virtopsy/ minimally invasive autopsies, and recommendations for infection control and safety measures. Mortality data with the forensic experts can also provide useful information on role and weight of comorbidities to the mechanism of death in COVID-19. Its high time that Forensic practitioners venture into collaborative research and contribute in combating the menace of SARS-CoV-2.

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ORIGINAL ARTICLE

Forensic age estimation from secondary ossification centres of elbow joint: A digital radiographic study on South Indian metropolitan population in a tertiary care hospital

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Abstract

Age of an individual involving in crime or civil disputes takes immense significance in jurisprudence. In Medical field, a single criteria or technique is neither exhaustive nor reliable for age estimation across ages; hence we resort to multiple modes of determining age scientifically and conclude the achieved results. Most widely utilized technique in early years of life is radiographic assessment of long bones. This technique has been accepted scientifically because of its accuracy in +/- 06 months to 01 year which is very much needed in settling cases.

Keywords

Forensic anthropology; Age estimation; Elbow joint

Introduction

Age estimation is an important parameter of forensic human identification. Considerable research has been done on age estimation using epiphyseal fusion of the long bones. Conventional radiography is considered to the gold standard for age estimation studies. Sizeable amount of tests focuses on age estimation from X-rays. The technique of age assessment from X-rays, having been accepted by Courts, Medical doctors witnessing in Courts of law are often questioned upon the physiological variables, environmental influences and inconsistencies of the biological changes that would determine age of ossification in human bodies.

This study is an attempt to elicit the ages of ossification of long bone epiphyseal ends around elbow and the extent of its inconsistencies among young individuals of Chennai.

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Materials and Methods

Plain X-rays [1] of both elbow joints with antero-posterior and lateral views[2] of individuals with known age were studied for status of secondary ossification centres of lower end of Humerus and upper ends of Radius and Ulna. Radiological data was collected and the clinical records were back traced. A total of 50 samples were analysed in this cross-sectional study. The inclusion criteria was individuals of both sexes with definite date of birth (0-18 years of age). The exclusion criteria was cases with evidence of recent fractures, fracture in healing stage around the elbow joint including suspected epiphyseal injury, skeletal deformities on either side, preterm delivered new-borns, individuals with nutritional deficiencies or chronic illnesses. Age of appearance and fusion of the ossification centres around elbow viz. – capitulum, radial head, medial epicondyle, trochlea, olecranon, lateral epicondyle and status of conjoined epiphyses were recorded. Observations were entered into excel sheet and results derived. Results were then compared with Indian & foreign standards of age of ossification.

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Results

Of the samples collected, 21 were female and 29 were male. Age wise distribution of sample is given in the Table 1.

X ray appearance of secondary ossification centre for capitulum is observed as early as 1.5 years in female, 2 years in male, appearance is complete by 2 years in both sexes, and, non-appearance of capitulum is absent beyond 2 years of life. X ray appearance of secondary ossification centre for trochlea is observed as early as 8 years (7-8 years age group) in both males and females. Appearance is complete at 13-14 years in male. 50% of females in 11-12 years showed appearance. We observed that all cases in 17-18 years group show complete ossification centres (Tables 2).

X ray appearance of secondary ossification centre for lateral epicondyle is observed as early as 8 years (7-8 years age group) in females and 14 years (13-14 years age group) in males, appearance is complete by 17 years (17-18 years age group) in females and 14 years (13-14 years age group) in males (Tables 5). In females, percentage of appearance is 50 % at 11-12 years, but there is a lacuna of representation in 13-14- and 15-16-years group. For available sample data, appearance is complete in 17-

18 years group.

Ossification centres for capitulum, trochlea and lateral epicondyle fuse together to form conjoined epiphysis or composite epiphysis of lower end of Humerus as early as 11 years (11-12 years age group) in females and 14 years (13-14 years age group) in males and the formation is complete by 15-16-years in males, 17 18 years in females. Fusion (of conjoined epiphysis) with shaft is observed as early as 15-16 years in males, 17-18 years in females. Fusion process is complete at 19 years in males, but only 75% females show complete fusion at 17-18 years and 25 % show open conjoined epiphysis, after which no representation is available (Table 6).

X ray appearance of secondary ossification centre for medial epicondyle is observed as early as 4 years (3-4 years group) in females and 7 years in (7-8 years group) males, and appearance is complete after 7 years (7 to 8 years group) in females and after 8 years (9 to 10 years) in males. Centre of medial epicondyle fuses with Humerus shaft as early as (11-12 years group) in females and 16 years (15-16 years group) in males. Open medial epicondyle is observed up to 17 years in females and 18 years in males. Fusion is 100% complete at 19 years in males, whereas fusion is 75 % complete at 17-18 years group in females (Table 7).

X ray appearance of secondary ossification centre for olecranon is observed as early as 8 years (7-8 years group) in females and 10 years (9-10 years group) in males, appearance is complete by 8 years (7-8 years group) in females and 11 years (11-12 years group) in males. Centre of olecranon process of Ulna epicondyle fuses with Ulna shaft as early as 17 years (17-18 years group) in females and 16 years (15-16 years group) in males.

Figure 1: Secondary ossification centre for capitulum (appeared, open / not fused)

Figure 2: Secondary ossification centres for capitulum, medial epicondyle, radial head (appeared, open / not fused)

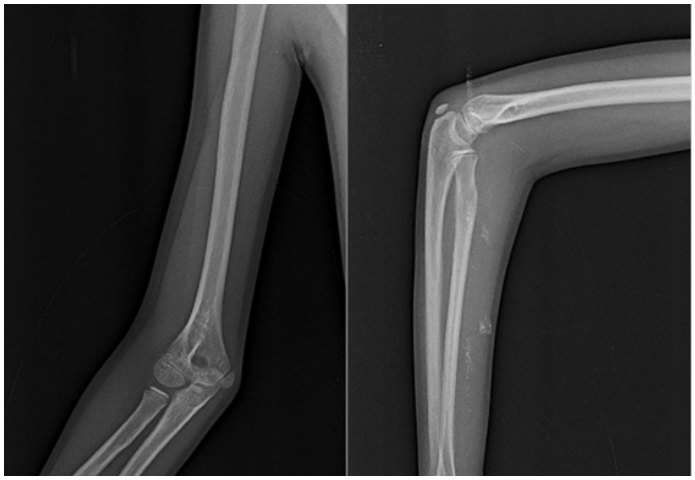

Figure 3: Secondary ossification centres for capitulum, trochlea, medial epicondyle & olecranon process (appeared, open / not fused)

Figure 4: Secondary ossification centre for olecranon (appeared, open / not fused)

Figure 5: All secondary ossification centres around elbow joint (fused)

Table 1: Age wise distribution of the study population

Age group	n	%
0 to 2 years	3	06 %
3 to 4 years	11	26 %
5 to 6 years	4	06 %
7 to 8 years	7	12 %
9 to 10 years	5	12 %
11 to 12 years	5	08 %
13 to 14 years	3	06 %
15 to 16 years	3	06 %
to 18 years	7	14 %
19 years	2	04 %

Table 2: Age of ossification for trochlea

Age group	Sex	n	Appearance	Fused
0 to 2 years	Male	NA	NA	NA
	Female	3	0	0
3 to 4 years	Male	6	0	0
	Female	5	0	0
5 to 6 years	Male	2	0	0
	Female	2	0	0
7 to 8 years	Male	5	1	0
	Female	2	1	0
9 to 10 years	Male	3	1	0
	Female	2	2	0
11 to 12 years	Male	3	0	0
	Female	2	1	0
13 to 14 years	Male	3	3	0
	Female	NA	NA	NA
15 to 16 years	Male	3	3	3
	Female	NA	NA	NA
17 to 18 years	Male	3	3	2
	Female	4	4	3
19 years	Male	2	2	2
	Female	NA	NA	NA

Open olecranon process is observed up to 17 years in females and 16 years in males. Fusion is complete after 16 years (15-16 years group) in males and fusion process is completed in only 75 % of cases in 17-18 years group (Table 8).

X ray appearance of secondary ossification centre for radial head is observed as early as 3 years (3-4 years group) in females and 5 years (5-6 years group) in males, appearance is complete by 7 years (7-8 years group) in females and 6 years (5-6 years group) in males. Centre of radial head fuses with radial shaft as early as 17 years (17-18 years group) in females and 16 years (15-16 years group) in males. An open radial head is observed up to 17 years (17-18 years group) in females and 14 years (13-14 years group) in males. Fusion is complete after 16 years (15-16 years group) in males and fusion process is completed in only 75 % of cases for 17-18 years group in females (Table 9). Figures 1-5 represent the various stages in the fusion process.

Table 3: Age of ossification for lateral epicondyle

Age group	Sex	n	Appearance	Fused
0 to 2 years	Male	NA	NA	NA
	Female	3	0	0
3 to 4 years	Male	6	0	0
	Female	5	0	0
5 to 6 years	Male	2	0	0
	Female	2	0	0
7 to 8 years	Male	5	0	0
	Female	1	1	0
9 to 10 years	Male	3	0	0
	Female	2	0	0
11 to 12 years	Male	3	0	0
	Female	2	1	1
13 to 14 years	Male	3	3	0
	Female	NA	NA	NA
15 to 16 years	Male	3	3	3
	Female	NA	NA	NA
17 to 18 years	Male	3	2	2
	Female	4	4	3
19 years	Male	2	2	2
	Female	NA	NA	NA

Table 4: Age of ossification for conjoined epiphysis

Age group	Sex	n	Appearance	Fused
0 to 2 years	Male	NA	NA	NA
	Female	3	0	0
3 to 4 years	Male	6	0	0
	Female	5	0	0
5 to 6 years	Male	2	0	0
	Female	2	0	0
7 to 8 years	Male	5	0	0
	Female	1	0	0
9 to 10 years	Male	3	0	0
	Female	2	0	0
11 to 12 years	Male	3	0	0
	Female	2	1	0
13 to 14 years	Male	3	1	0
	Female	NA	NA	NA
15 to 16 years	Male	3	3	3
	Female	NA	NA	NA
17 to 18 years	Male	3	2	2
	Female	4	4	3
19 years	Male	2	2	2
	Female	NA	NA	NA

Table 5: Age of ossification for medial epicondyle

Age group	Sex	Total No. of cases	N	Fused
0 to 2 years	Male	NA	NA	NA
	Female	3	0	0
3 to 4 years	Male	6	0	0
	Female	5	1	0
5 to 6 years	Male	2	0	0
	Female	2	1	0
7 to 8 years	Male	5	4	0
	Female	1	1	0
9 to 10 years	Male	3	3	0
	Female	2	2	0
11 to 12 years	Male	3	3	0
	Female	2	2	1
13 to 14 years	Male	3	3	0
	Female	NA	NA	NA
15 to 16 years	Male	3	3	2
	Female	NA	NA	NA
17 to 18 years	Male	3	3	1
	Female	4	4	3
19 years	Male	2	2	2
	Female	NA	NA	NA

Table 6: Age of ossification for olecranon

Age group	Sex	Total No. of cases	N	Fused
0 to 2 years	Male	NA	NA	NA
	Female	3	0	0
3 to 4 years	Male	6	0	0
	Female	5	0	0
5 to 6 years	Male	2	0	0
	Female	2	0	0
7 to 8 years	Male	5	0	0
	Female	1	1	0
9 to 10 years	Male	3	1	0
	Female	2	1	0
11 to 12 years	Male	3	2	0
	Female	2	2	0
13 to 14 years	Male	3	2	0
	Female	NA	NA	NA
15 to 16 years	Male	3	3	2
	Female	NA	NA	NA
17 to 18 years	Male	3	2	2
	Female	4	4	3
19 years	Male	2	2	2
	Female	NA	NA	NA

Table 7: Age of ossification for radial head

Age group	Sex	Total No. of cases	N	Fused
0 to 2 years	Male	NA	NA	NA
	Female	3	0	0
3 to 4 years	Male	6	0	0
	Female	5	2	0
5 to 6 years	Male	2	2	0
	Female	2	1	0
7 to 8 years	Male	5	5	0
	Female	1	1	0
9 to 10 years	Male	3	3	0
	Female	2	2	0
11 to 12 years	Male	3	2	0
	Female	2	2	0
13 to 14 years	Male	3	3	0
	Female	NA	NA	NA
15 to 16 years	Male	3	3	3
	Female	NA	NA	NA
17 to 18 years	Male	3	3	3
	Female	4	4	3
19 years	Male	2	2	2
	Female	NA	NA	NA

Discussion

Secondary ossification centres follow an approximate biological time scale. Their radiological appearance, simply referred as to 'appearance' of centre and its fusion with body of the bone, simply referred as 'fusion' of centre is used to assess biological age with a range of +/- 1 to 2 years. This technique is useful from birth till 21 to 22 years. By that time the last secondary ossification centre fuses in clavicle. Bone growth is influenced by sex hormones, nutrition, environmental factors like temperature, life style of the individual etc. Crowder[3], Koc[4], Loder[5] conducted independent studies on ossification patterns and age assessment from it. These three investigators in recent times insisted on having separate age standard scale of ossification for separate regions. Koc[4] and Loder[5] went one step ahead and insisted on reviewing the existing age standard scales from time to time. A Cross sectional sample attending Govt. Medical College Hospital, Omandurar Govt. Estate, Chennai between February 2018 and December 2018 were selected for the study. With due Institutional Ethics Committee approval, the study was initiated. Apparent healthy individuals comprised the study population. Even with the advent of computed tomography and sonographic views of articular surfaces, plain radiograph is still a gold standard technique to visualise ossification centres. [1] Antero-posterior (AP) and lateral views of both elbows were X-rayed. For antero-posterior view the elbow should be fully extended with the forearm supinated allowing optimal visualization of the medial and lateral epicondyles, [2] for lateral view the elbow should be in 90°flexion and the forearm in neutral (thumb up) position to visualize olecranon and radial head. Both sides were separately studied. Male and female participants were separately studied. After due analysis, both right and left sides of an individual showed same ossification status, hence further analysis and discussion were limited to right side X ray films.

Radiologically visible ossification centre was marked as 'Appeared'; when there was no radiolucent space between shaft and epiphyseal centre making a continuous periosteum on epiphyses and diaphysis, it is regarded as 'Fused'. If radiolucent space is visible between the ossification centre and its corresponding shaft of fusion, it is regarded as 'Open' / 'Non-Fused.' For practical purposes, signs of recent union is considered as 'Fused' and presence of a notch at the periphery of epiphysis is considered to be 'Open' / 'Non-Fused'. When the capitulum ossification centre was visible on X-ray, appearance was observed as early as 1.5 years in females, 2 years in males, appearance is 100 % complete by 2 years in both sexes, and, non-appearance of capitulum is absent after 2 years of age. These findings are in accordance with the accepted standards since there is only negligible difference in documented age of ossification with respect to capitulum.

X-ray appearance of secondary ossification centres for trochlea is completed by 13-14 years in males. 50% of females in the 11-12 years age group showed appearance of fusion centres and 100 % of females in 17-18 years showed appearance. Appearance age is contrary to the results by Miyazaki wherein the documented age is 5-11 years.[6] Nandy reported an age of 9-10 years in females and 10-11 years in males[7], 11 years was the documented age by Parikh[8] and Umadethan[9], Biswas noted an age of 9-10years[10], Rao reported an age of 9-11 years[11], Vij recorded the age as 9-11 years[12], Reddy as 9-11 year[13], and Aggrawal as 10 years.[14] X-ray appearance of secondary ossification centre for lateral epicondyle is completed by 17-18 years of age in females and 13-14 years of age in males. These results are closer to the studies by Miyazaki who reported an age of 8-13 years[6], Nandy who obtained an age of 10-12 years in female and 11-13 years in male in his study[7], Umadethan with 13 years as the documented appearance age[9], Biswas with 10-11 years[10], Rao observed appearance at 11 years[11], Vij[12], Reddy[13] and Aggarwal[14] at 11 years. Ossification centres for capitulum, trochlea and lateral epicondyle develop individually and unite to form conjoined epiphysis or composite conjoined epiphysis. Formation of conjoined epiphysis was observed first at 11-12 years in females, 13-14 years in males and fusion with shaft is completed in 100 % sample by the age of 17-18 years in females and before 19 years male. The results for fusion age is in agreement with the studies by Gupta[15], Singh[16] and Paterson.[17] Fusion age is contrary to results of the studies by Basu and Basu[18], Pillay[19], Hepworth[20], Gaulstaun[21], Lal and Townsend[22], Lal and Nat[23], Sangma[24], Jnanesh[25], Bhise[26], Nemade et al.[27], Gaddewar and Meshram[28], Sidhom and Derry[29], Barrett[30], Ledger and Wasson[31], Frazer[32] and Gray.[33]

X ray appearance of secondary ossification centre for Medial Epicondyle is complete after 7-8 years in females and after 9-10 years in male. Centre of medial epicondyle fuses with Humerus shaft as early as 11-12 years in females and 15-16 years in males and open medial epicondyle is observed up to 17 years in females and 18 years in males. Fusion was completed in 100% of the sample at 19 years in males, whereas fusion is 75% complete by 17-18 years in females. Appearance age is contrary to the results by Miyazaki[6], Nandy[7], Parikh[8], Galstaun[21], Umadethan[9], Biswas[10], Rao[11], Vij[12], Reddy[13], Aggrawal.[14] Fusion age is along the results of studies by Gupta[15], Singh[16], Jnanesh[25], Gaddewar and Meshram[28], Paterson[17], Sidhom and Derry[29], Gray.[33] Fusion age is contrary to results of the studies by Gaulstaun[21], Aggrawal and Pathak[34], Sangma[24], Sahni and Jit[35], Pillay[19], Bhise[26], Nemade et al.[27], Ledger and Wasson[31], Frazer[32], Barrett.[30]

X ray appearance of secondary ossification centre for Olecranon is complete by 7-8 years group in females and 11-12 years in males. Centre of olecranon process of Ulna epicondyle fuses with shaft of ulna by 15-16 years in males and fusion process is completed in only 75% of cases by 17-18 years age group.

Appearance age is along the studies by Parikh[8], Miyazaki[6], Umadethan[9], Biswas[10], Rao[11], Vij[12], Reddy [13], Aggrawal[14], Galstaun.[21]

X-ray appearance of secondary ossification centre for radial head is complete by 7-8 years in females and 5-6 years in males. Centre of Radial head fuses with Radial shaft by 15-16 years in males and fusion process is completed in only 75% of cases by 17-18 years in females. Appearance age is along the studies by Miyazaki[6], Nandy[7], Umadethan[9], Biswas[10], Rao[11], Vij[12], Reddy[13], Aggrawal[14], but contrary to Gaulstan.[21]

Fusion is complete by 15-16 years in males, but only in 75% cases by 17-18 years in females. Fusion age is along results of the studies by Hepworth[20], Gupta[15], Galstaun[21], Bhise[26], Singh.[16] This is in contrast to the results by Basu and Basu[18], Lal and Townsend[22], Sangma[24], Lal and Nat[23], Sahni and Jit[35], Pillay[19], Paterson[17], Sidhom and Derry[29], Barrett[30], Ledger and Wasson[31], Frazer[32] and Gray.[33]

There was an incidental finding of Harris lines or lines of arrested growth is seen in a one year boy. The case was excluded from the study. Though the study is region specific, equal distribution of sample in all age groups was not done. Equal representation of both males and females in all groups with more sample size would be required to generalise the study result.

Conclusion

In biology, variation is the rule and consistency is often variable. To find the extent of inconsistencies further studies are being undertaken at our institution at present. On increasing the sample size and arriving at radiological skeletal age in varied districts of a state / nation, age estimation from X-rays could be updated for recent times and thus scientifically more useful for solving crimes and at instances in determining type of treatment.

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ORIGINAL ARTICLE

Morphometric sex estimation using mastoid triangle: A prospective study

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Abstract

In the evaluation of unidentified skeletal remains one important step is to estimate the sex of the remains. The morphometric analysis of the mastoid triangle for sex estimation in and around Mangaluru District was the objective of the study. The present study was conducted on 50 male and 50 female bodies subjected to medico-legal autopsy at Justice K. S. Hegde Charitable Hospital. The quantitative variables, and the area were expressed in terms of mean and standard deviation along with the utility of measurements which was evaluated for sensitivity and specificity of using ROC curve. The study confirms the low accuracy of the mastoid triangle with respect to sex estimation.

Keywords

Anthropology; Craniometry; Mastoid Triangle; Morphometric sex estimation.

Introduction

Establishing identity, is an imperative aspect in any investigating procedure. The estimation of the identity of the person based on certain physical characteristics amounts to identification and is of utmost importance in the medico-legal field as it holds many social, economic and legal corollaries.[1,2] Out of the innumerable data to be established, a few important aspects include; positive determination of sex, age, anthropometric measurements like stature, built, dental morphology, foot prints, iris scan, dactylography, lip prints and DNA profiling etc; wherein sex estimation is an important part in forensic investigations and is a decisive feature of identification.[3] It is most often the first component of the biological profile to be assessed because other components like stature, age and race are dependent on sex estimation.[3] Once the sex of the skeleton or bone fragment is determined, it reduces the search for identity by half. Out of the numerous available parameters for sex estimation, following are the few noteworthy methods that are followed routinely[4]-physical morphology, radiographs, microscopic study of sex chromatin-gonadal biopsy, DNA profiling, gonadal biopsies.

Among these, morphological study is the most simple, dependable, economical and non-invasive method. Numerous researches have been piloted across the world on sex estimation based on various human bones mainly focusing on long bones[5,6], skull[7,8,9], pelvis[10,11,12], clavicle[13], sternum[14-17] etc.

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When it is about the estimation of sex, as per Krogman and Iscan skull and pelvis provide the most precise results in estimation of sex.[18] Various isolated regions on the skull such as teeth[19,20], frontal bone[21], nasal bone[22], palate[23,24] and foramen magnum[25] have been subjected to various studies to differentiate sex

Due to its compact structure and anatomical position the mastoid region along with the mastoid process, is highly resilient to physical damage, remains unharmed even in the ancient and damaged skulls.[22-26] Few researchers[19-21] recently have shown that the mastoid triangle formed by joining the three osteological landmarks namely Porion, Asterion and Mastoidale have legitimately aided in determining the sex of the given skull. Pioneers Paiva and Segre conducted the study by using the three landmarks in the population of Sao Paulo, Brazil.[27]

The growth of Forensic anthropology in general has been wide-reaching with major research and publications stirring all over the world. More than a few scientific papers and researches have been published on morphometric measurements of the mastoid triangle, a few on dry skulls and few on X-rays, for sex estimation all over the world including India and it as well established that results vary from region to region.[22-26]

Studies have not been undertaken on morphometric analysis of the mastoid triangle for sex estimation in this region of our country and hence the study was aimed at using this to gauge sex differences.

Materials and Methods

The required data for the study was collected, analysed and studied, for the cases above 18 years of age, subjected to medico-legal autopsy at Justice K. S. Hegde Charitable Hospital. 50 male and 50 female bodies were included in the study. Bodies with skull fractures, deformities, wormian bones

and below the age group of 18 years of age were excluded. The study was conducted from Sept 15, 2015 to Sept 16, 2017. Following the dissection and reflection of the scalp, the related anatomical structures were dissected to expose the skull, the following bony landmarks, which constitute the mastoid triangle were identified.

Porion: Uppermost lateral point of the external auditory meatus

Asterion: Meeting point of the lambdoid, occipitomastoid and parietomastoid sutures.

Mastoidale: The lowest point of the mastoid process.

An imaginary triangle is drawn by joining the above three anatomical landmarks; and the following measurements were taken using digital vernier calipers with 0.00 mm precision.

The readings were carefully noted for both right and the left side and were carefully tabulated. The area of each triangle i.e., triangle on the right side and on the left side is calculated using the Heron's formula[5]:

$$\textbf{Area} = \sqrt{s(s-a)(s-b)(s-c)} \text{ where } s \text{ is } (a+b+c) \div 2$$

After which, areas of both sides are added. Quantitative variables such as age, measurements of the sides of the triangle on right and left (porion to asterion, porion to mastoidale and asterion to mastoidale) was expressed in terms of mean and standard deviation after ascertaining normality distribution using Shapiro–Wilk test. Quantitative variables of age group and gender were expressed in terms of percentages and proportions. Utility of the measurements to identify the sex of the skulls in terms of sensitivity and specificity of the measured variables was determined using Receiver Operator Characteristic (ROC) curve.[7,8] Statistical significance was assumed at <0.05. Data was entered into MS Excel 2010 and analyzed using SPSS version 16.0

Results

In the present study; about 30(60%) of males and 25 (50%) of females were in the age group of 18- 40 years, followed by 13(26%) males and 16 (32%) females were in the age group of 41-60 years and 7 (14%) males and 9 (18%) females were in the age group of 61%.

The values of right porion to asterion and the left porion to asterion of both males and females are presented in Table 2. Mean differences in porion to asterion on right side between males and females i.e. 43.14 ± 3.97 and 39.15± 3.90 respectively, was found to be statistically significant (p<0.05%). Mean differences in porion to asterion on left side between males and females i.e. 43.24± 3.62 and 38.63± 4.09 respectively was found to be statistically significant (p<0.05%).

The values of right porion to mastoidale and left porion to mastoidale of both males and females are presented in Table 3. Mean values of male skulls were found to be 35.46± 4.67 and 33.20± 3.79 and mean values of female skulls were found to be 31.32± 3.75 and 30.44± 2.85, respectively. The mean differences between the measurements on both sides in both males and females was found to differ significantly.

The mean values of right asterion to mastoidale and left asterion to mastoidale of both males and females are presented in Table 4. Mean values of male skulls i.e. 43.00± 3.44 was significantly higher when compared to the female sex i.e. 41.19± 5.04 in left asterion to mastoidale measurements. However, in the right asterion to mastoidale the mean value in females 43.81± 5.17 was found to be higher compared to males 43.28± 4.38 and these differences were not significant statistically. The values of right, left and total area of both males and females are presented in Table 5.

The mean area of the mastoid triangle on the right side in males was found to be 699.06± 125.61 and 581.60± 81.36 in females. The mean are of the mastoid triangle on the left side in males (656.2±85.99) and in females (552.62± 69.95) was also found to differ significantly.

Total mean area of the mastoid triangle on right and left side was 1346.2±195.0 in males and 1132.4±140.6 in females. This too was found to differ significantly between males and females.

Figure 1: Distance between Porion and Asterion

Figure 2: Distance-between-Porion-and-Mastoidale

Figure 3: Distance-between-Asterion-and-Mastoidale

Figure 4 shows the ROC7,8 (Receiver Operating Characteristic Curve for the various parameters used for the determination of the sex on both right and left side. The cut off for all the values in terms of area under the curve, along with 95% confidence interval is shown in the Table 6.

The table shows the area of the left triangle (83.4%), area of the right triangle (80.9%), total area of both left and right triangle (81.2%), and the distance between the left porion to asterion (81.1%) had moderate discriminatory ability based on the area under the curve cut off to distinguish between male and female skulls.

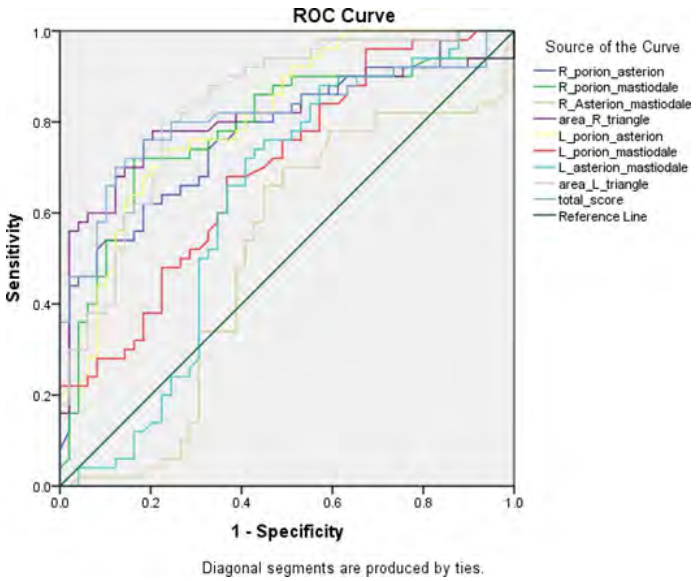

Figure 4: ROC for various parameters of mastoid triangles on both sides

The test result variable(s): R_porion_asterion, R_porion_mastiodale, R_Asterion_mastiodale, area_R_triangle, L_porion_asterion, L_porion_mastiodale, L_asterion_mastiodale, area_L_triangle, total_score has at least one tie between the positive actual state group and the negative actual state group. Intra observer error was addressed by taking mean of measurements three times consecutively and averaging the readings.

Table 1: Sex distribution of the study population

Age in years	Male n (%)	Female n (%)
<40	30 (60)	25 (50)
41-60	13 (26)	16 (32)
>61	7 (14)	9 (18)
Total	50 (100)	50 (100)

Table 2: Measurements of porion to asterion (right and left) between males and females

Dimensions	Males (mm)		Females (mm)		t value
	Range	Mean±SD	Range	Mean±SD	
Right porion to asterion	34.00-49.00	43.14±3.97	30.89-47.13	39.15±3.90	5.07
Left porion to asterion	36.00-50.00	43.24±3.62	31.00-46.69	38.63±4.09	5.97

$p<0.05$

Table 3: Measurements of porion to mastoidale (right and left) between males and females

Dimensions	Males (mm)		Females (mm)		t value
	Range	Mean±SD	Range	Mean±SD	
Right porion to mastoidale	20.00-42.00	35.46±4.67	23.00-41.00	31.32± 3.75	4.88
Left porion to mastoidale	28.00-44.00	33.20±3.79	23.00-35.83	30.44± 2.85	4.11

SD = standard deviation; p<0.05

Table 4: Measurements of asterion to mastoidale (right and left) between males and females

Dimensions	Males (mm)		Females (mm)		t value
	Range	Mean±SD	Range	Mean±SD	
Right porion to mastoidale	34.00-49.00	43.28±4.38	34.53-53.96	43.81±5.17	-0.56
Left porion to mastoidale	35.00-49.00	43.00±3.44	31.26-50.79	41.19±5.04	2.099

SD = standard deviation; p<0.05

Table 5: Measurements of area (right and left) between males and females

Dimensions	Male (mm^2)		Female (mm^2)		t value
	Range	Mean±SD	Range	Mean±SD	
Right area	332.0-884.0	699.06±125.61	429.18-796.75	581.60±81.36	5.55
Left area	478.0-866.0	656.2±85.99	419.86-727.94	552.62±69.95	6.61
Total area	1215.7-1455.9	1346.2±195.0	1021.8-1215.5	1132.4±140.6	6.27

Table 6: Area under the curve for various parameters

Area Under the Curve					
Test Result Variable(s)	Area	SE	p-value	Asymptotic 95% Confidence Interval	
				Lower bound	Upper bound
R_porion_asterion	0.778	0.047	<0.001	0.687	0.869
R_porion_mastiodale	0.783	0.048	<0.001	0.688	0.877
R_Asterion_mastiodale	0.507	0.061	0.911	0.387	0.626
area_R_triangle	0.809	0.047	<0.001	0.718	0.900
L_porion_asterion	0.811	0.043	<0.001	0.728	0.895
L_porion_mastiodale	0.694	0.052	0.001	0.592	0.797
L_asterion_mastiodale	0.621	0.059	0.038	0.506	0.737
area_L_triangle	0.834	0.041	<0.001	0.754	0.914
total_score	0.812	0.045	<0.001	0.723	0.901

SE = standard error

Discussion

Identification is the basis of the individuality of a person.[23] Skeleton is an important part of the body which resists all environment insults for maximum time and thus can be a valuable tool in identification.[24] In the field of Forensic medicine as well as anthropology, skull has a distinctive role in differentiating the sex of the skeletal remains. As discussed previously in the review of the literature, morphological methods and morphometric methods are the two primary ways of differentiating sex of a human skeleton.[18]

At all times, mastoid region has drawn the interest of investigators for its effectiveness in sex estimation. Size of the mastoid being one of Krogmans trait is significant in distinguishing male from female skulls both morphologically and morphometrically.[27]

In this study, an attempt was made to determine the efficacy of the distance between the three craniometric parameters and the calculated areas of the triangles, compare the data with existing literature and to establish the standards for the local population. The lack of study in reference to sex estimation from dimensions and mastoid triangle area in this region underlines the importance of the present study.

The three dimensions (porion to asterion, asterion to mastoidale and porion to mastoidale) of the mastoid triangle were measured for both, left and right sides and the areas of each mastoid triangle was calculated by substituting the above measurements in Heron's formula.

In present study, all the three dimensions and the area of the mastoid triangle on both right and left sides were found to be larger in males when compared to the females which is in accordance with the studies done by Kemke et al.[22], Galdames et al.[24], Manoonpol et al.[25], Madadin et al.[26], Bhagya et al.[28], Kanchan et al.[29], Blessing et al.[31], Singh et al.[33] This is probably due to the larger size of male skulls when compared to the female skulls as well as it is in response to the stronger muscle actions, thereby resulting in greater development of the mastoid process in males.

In the present study, statistically significant values ($p < 0.05$) were detected for the distance between porion to asterion and porion to mastoidale on right and the left mastoid triangles and it was in agreement with the studies done by Kemke et al.[22], Galdames et al.[24], Manoonpol et al.[25], Madadin et al.26, Bhagya et al.[28], Kanchan et al.[29], Blessing et al.[31], Singh et al.[33]

In our prospective study, the distance between the asterion to mastoidale was the longest of the other two mastoid dimensions (porion to asterion and porion to mastoidale), which is agreed upon the similar studies done by Galdames et al.[24], Manoonpol et al.[25], Madadin et al.[26], Singh et al.[33] However, no statistically significant difference was observed for asterion to mastoidale on both left and right mastoid triangles which is supported by the studies conducted by Kemke et al.[22] and Kanchan et al.[29] The confounder for this, could be the anatomical relationship of the asterion with other cranial structures as well as the position of the asterion which differs with the advance of the age in a population specific manner.[21,29]

The results of the current study specify that there exist a statistically significant difference in the areas of the mastoid triangle between males and females and thus agree with the

observations made by Kemke et al.[22], Manoonpol et al.[25], Madadin et al.[26], Paiva and Segre[27], Bhagya et al.[28], Kanchan et al.[29], Blessing et al.[31], and Singh et al.[33]

When the area of the mastoid triangle calculated in our prospective study was compared (Table 8) with other similar studies done by foreign researchers like Kemke et al.[22], Manoonpal et al.[25], Madadin et al.[26], Paiva and Segre[27], Blessing et al.[31], it was observed that the mastoid triangle area in our study was comparatively lesser. As a matter of fact; the mean mastoid triangle area amid males in our study was by far less than the mean area of mastoid triangle in females just as in the studies of foreign researchers.[25,26,27] The discrepancies in the observations of aforementioned studies[25,26,27], thus prove the existence of population specific dissimilarities exhibited in the skull. This can be a result of the nutritional, environmental effects, sociocultural practices and racial differences as well as the inconsistency in the location of the landmarks of the skull in various populations.

Likewise, when our study was compared with other Indian studies done by Saini et al.[21], Bhagya et al.[28], Kanchan et al.[29], Singh et al.[33]; it was noted the incongruities still existed between the regions. These variations could be due to the fact that India is a diversified country where substantial population and ethnic diversity exists leading to intermixing of populations.

In the present study, the sexing aptitude of the mastoid triangle dimensions was low, when it was subjected to Receiver Operating Characteristic Curve analysis (ROC).[32] And it was similar to the study done by Kanchan et al.[29] Our observations that are indicative of a lower accuracy level of mastoid triangle dimensions are similar to those stated by Kemke et al.[22] and Kanchan et al.[29]

It is a well known fact that the criterions established on the skulls for one population should not be used on another population owing to the population variations.[22,29] In the modern world due to the intermixing of populations and due to the migration of population, it may not be virtually possible to consign a population reference when a skull is brought for the examination, thereby plummeting the applicability of the mastoid triangle in the estimation of sex from an unknown skull.

Conclusion

All the dimensions (porion to asterion, porion to mastoidale and asterion to mastoidale) of the mastoid triangles were higher in males than the females. All the dimensions (porion to asterion, and porion to mastoidale) were statistically significant except the distance between the asterion to mastoidale. The AUC (area under the curve) had a moderate sensitivity of (above 80%) for area of the left triangle(0.834), area of the right triangle (0. 809), total area of both left and right triangle (0.812) and distance between porion to asterion on the left side (0.811). It can be established from the study as well as from the comparative analysis with other studies that, the mastoid triangle is a poor indicator of sex and of limited significance in the absence of population reference. The AUC (area under the curve) had a moderate sensitivity (above 80%)- 0.834, 0. 809, 0.812 and 0.811 for area of the left triangle, area of the right triangle, total area of both left and right triangle and distance between porion to asterion on the left side, respectively. However; a cut-off point to distinguish between male and female skulls could not be arrived without significant compromise in the specificity. The study sample was insufficient to derive standards for the population.

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ORIGINAL ARTICLE

Sex estimation from mandible using lateral cephalogram: A short study

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Abstract
The mandible is seen as an important tool for radiological identification because of several growth parameters that can be exploited using cephalometric analysis, ease of imaging, and no overlying bony structures. These parameters can be handy in sex estimation in extreme situations like mass disasters, remains of dead, exhumed and murderous mutilations, missing or severely burnt individuals, etc. The study was conducted on randomized 80 lateral cephalograms obtained from the Department of Oral Medicine and Radiology. The three linear measurements of mandibular growth were mandibular body length, mandibular length and mandibular height. Gonial angle was measured as the angle formed by the ramus line (RL) and mandibular line (ML). The values obtained were statistically analyzed by Student's t-test using SPSS version 24.0. After obtaining all the measurements, unpaired 't-test' was performed. The gonial angle, height of ramus, mandibular length showed statistically significant sex difference. Whereas mandibular body length were statistically non-significant in gender determination. The linear and angular parameters used in the study, when combined together, might prove to be of importance in studying the growth pattern of mandible in males and females for sex estimation.

Keywords
Mandible; Linear measurements; Sexual dimorphism; Lateral cephalogram.

Introduction

Recognition of gender is an important aspect of identification of an individual and is an important part of the medicolegal practice where forensic odontology has an important role.[1] Apart from the pelvis, mandible exhibits great amount of sexual dimorphism in the human body. The mandible is used as an important tool for radiological identification due to several growth parameters that can be recorded by using cephalometric analysis, ease of imaging, and no overlying bony structures. These parameters can be used in sex estimation in extreme conditions like mass disasters, remains of dead, exhumed and murderous mutilations, missing or severely burnt individuals, etc.[2] The equipment required for lateral cephalometry is readily available and the technique is cost effective, easy to perform offers quick results. So the lateral cephalogram is a reliable tool which can be routinely used for forensic and anthropological purposes.[3] With this background the present study was focused towards the identification of sex by gonial angle and measuring three linear measurements of mandibular growth.

Materials and Methods

The aims and objectives were to assess the mandibular growth parameters such as total mandibular body length, mandibular length, mandibular height and gonial angle using lateral cephalogram in the study population for determination of sex of an individual. Radiographs with Class 1 skelatal base are included and radiographs with skeletal class II or III skeletal base were excluded (because of exaggerated growth). Patients with missing teeth or with syndromes, cleft lip or palate, or other craniofacial pathology, were also excluded.

The study was conducted on randomized 80 lateral cephalograms obtained from the Department of Oral Medicine and Radiology data base. The study used the following cephalometric landmarks; condylon (Co), gonion (Go), and gnathion (Gn). Three linear measurements of mandibular growth were; mandibular body length (distance between Go and Gn Figure 1) mandibular length (distance between Co and Gn Figure 2) and mandibular height (distance between Co and Go Figure 3) as per the study conducted by Rai et al.[4] These measurements were done using a mouse driven cursor. Gonial angle was measured as the angle formed by the ramus line (RL) and mandibular line (ML), where RL is a tangent to the posterior border of mandible and ML is the lower border of the mandible through the Gn as per the study conducted by Upadhyay et al.[5] (Figure 4) All the measurements were done on a computer monitor using a mouse driven cursor and mathematical protractor. The values obtained were statistically analyzed by Student's *t*-test using IBM SPSS version 24.0.

Results

The study constituted of 80 participants out of which 40 were females and 40 were males. The age range was 10–35 years. Table 1 describes the distribution of samples and mean values of various linear measurements and gonial angle among males

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and females. In males, the mean values for mandibular body length, mandibular length, and the mandibular height, and the gonial angle were observed to be 76.01 mm, 108.7 mm, 51.35 mm, and 122^0, respectively. In females, the mean values for mandibular body length, mandibular length, and the mandibular height, and the gonial angle were observed to be 73.76 mm, 105.22 mm, 48.49 mm, and 125.13^0 respectively.

Table 2 shows the sex differences in the different mandibular measurements studied. Statistically significant sex differences were observed for the mandibular length, the mandibular height, and the age of the study participants ($p < 0.05$).

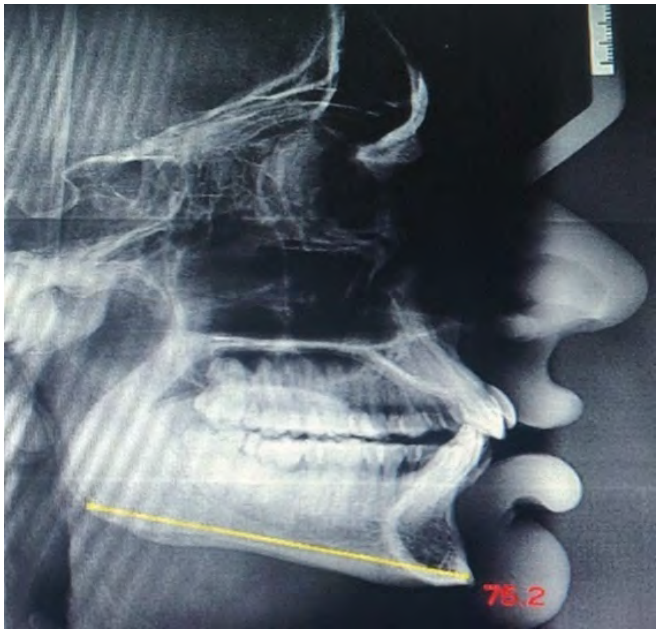

Figure 1: Mandibular body length

Figure 2: Mandibular length

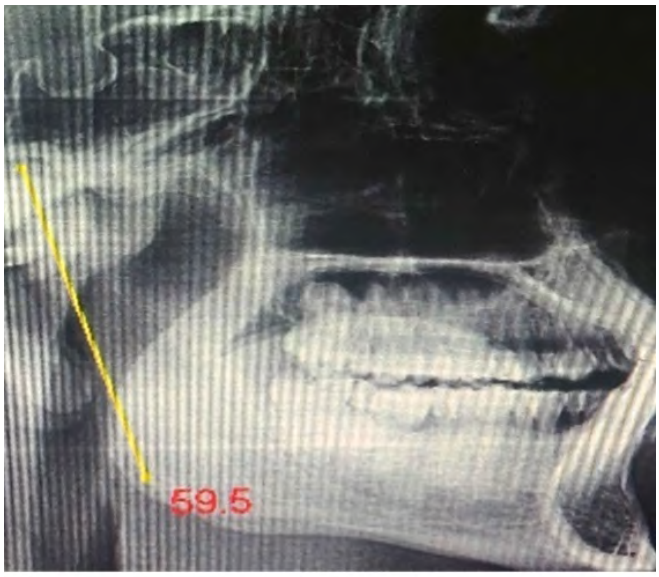

Figure 3: Mandibular height

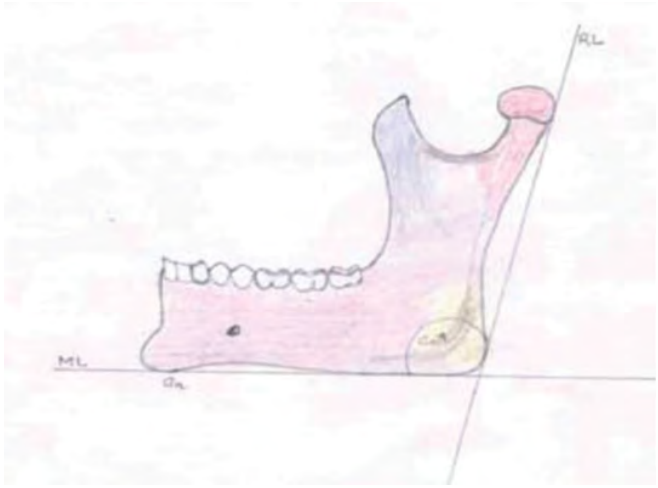

Figure 4: Measurement of gonial angle

Table 1: Group Statistics

Parameter	Gender	N	Mean	SD	SEM
Mandibular Body Length (MBL)	Male	40	76.0125	6.46181	1.02170
	Female	40	73.7625	5.09739	.80597
Mandibular Length (ML)	Male	40	108.6975	7.55671	1.19482
	Female	40	105.2150	5.02504	.79453
Mandibular Height (MH)	Male	40	51.3500	7.42784	1.17444
	Female	40	48.4925	3.97204	.62804
Gonial Angle (GA)	Male	40	122.0000	7.07107	1.11803
	Female	40	125.1250	6.68403	1.05684

SD = Standard deviation; SEM = Standard error of the mean

Table 2: Sex differences in the different mandibular measurements investigated in the present study

Measurement	t-score	p-value
Age	1.009	0.033
MBL	1.729	0.115
ML	2.427	0.001
MH	2.146	<0.001
GA	2.031	0.785

MBL = mandibular body length; ML = mandibular length; MH = mandibular height; GA = gonial angle

Discussion

In the present study, linear and angular parameters of mandibular growth were analyzed on cephalometric radiographs and were used to study the mandibular growth rate between male and female groups and the linear and angular measurements were compared between males and females. It has been observed that the mandible grows in a posterior superior direction resulting in an anteriorinferior displacement and that mandibular sagittal growth is due to anterior resorption in the ramus.

In the present study the mean value of the height of ramus of mandible was found to be 51.3 mm in males and 48.49 mm in females. The standard deviation for height of ramus in males was 7.42784 and in females was 3.97204. The values in the female mandibles was lesser compared to that obtained in males. Study conducted by Rai et al.[6] showed mean mandibular ramus height was greater in males (53.9 cm) than in females (51.8 mm) and there was a statistically significant correlation in the height of ramus between the male and female mandibles. Study conducted by Al-Shamout et al.[7] concluded that males have higher values of the height of ramus compared to female counterparts and statistically significant gender differences were recorded in the height of ramus. In accordance with studies done by Rai et al.[6] and Al-Shamout et al.[7] our study showed statistically significant differences between male and female mandible height with a p value of 0.036.

In the present study the mean value of gonial angle was found to be 122 ˚ in males and 125.2 ˚ in females. The standard deviation in males was 7 ˚ and females was 6 ˚. The values of female mandibles were higher than that of males. Study conducted by Vinay et al.[8] found that mandibular angle of male mandible varies from 111° – 136° with an average of 121° ± 6° and that of female mandible varies from 97° – 137° with an average of 122° ± 7°. The gender differences in mean values of mandibular angle of males and females is not statistically significant for mandible. Jayakaran et al.[9] in their series of 207 mandible found that the mean of mandibular angle for male mandible was 121.43 ˚ and for female 124.19 ˚. Standard deviation was 6.99 in males and 6.90 in females. Ranganath et al.[10] found that the mean for mandibular angle in males was 110.68 ˚ and for females mean was 114.53 ˚. Standard deviation for males was 15.50 and for female 6.95. Ayoub et al.[11] observed no significant difference in mandibular angle in sex determination in the young Lebanese population (83 young individuals- 40 males and 43 females) aged between 17 and 26 years. In present study there was a statistically significant difference between male and female mandible with a p value of .046.

In the present study the mean value of the mandibular length was found to be 108.6 mm in males and 105.2 mm in females. Standard deviation for mandibular angle in males was 7.5 and in females was 5.02. Jayakaran et al.[9] in their series of 207 mandible found that the mean of mandibular length for male mandible was 7.44 cm and for females was 7.06 cm. Standard deviation was 0.41 in males and 0.47 in females. Ranganath et al.[10] in their study on 111 mandibles showed that the mean of mandibular angle in males was 6.78 cm and for females 6.63 cm. Standard deviation for male was 0.94 and for female was 0.76. Study by Ongkana et al.[12] on 102 mandibles showed that the mean value of mandibular length for male mandible was 8.94 cm and for females was 8.53 cm. Standard deviation for male was 0.60 and for females was 0.55. Vinay et al.[8] in their study found the mean value of the mandibular length to be 7.54 cm in males and 7.25 cm in females. Standard deviation for mandibular angle in male was 0.43 and in female was 0.51. The demarking point of mandibular length for males was 8.81 and for females was 6.22. Limiting point for mandibular length was 7.36, by which 66.02% of male and 53.01% of female were correctly sexed. The t-value of mandibular length was 4.83. The sex differences in mean values of mandibular length of males and females was statistically significant ($p<0.0001$) for mandible bone.In accordance with studies done Vinay et al.[8], Jayakaran F et al.[9], Ranganath et al.[10] and Ongkana et al.[12] our study showed statistical significant difference between male and female mandible length with a p value of 0.018.

In the present study the mean value of the mandibular body length was found to be 76.1 mm in males and 73.3mm in females. Standard deviation for mandibular body length in males 6.4 and in females was 5.0 which does not show statistically significant differences.

Conclusion

Human skeletal examination plays an important role in anthropology and medicolegal work to identify the individual. Sometimes if a part of bone is also available, sex and age can be determined based upon different morphological and metrical parameters. The present study utilizes the 4 different metrical parameters like gonial angle, height of mandible, mandibular length and mandibular body length. The application of these parameters along with morphological features could be a useful

tool for sex determination of mandibles. This is the first time where 4 different linear measurements have been used for sex estimation and out of those measurements all the other parameters showed significant sex differences except mandibular body length.

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ORIGINAL ARTICLE

Correlation of cadaveric stature with posterior curve length of sternum in Mewat Region of Haryana: A comparative analysis of SPSS with machine learning

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Abstract

The aim of the present study was to develop a population specific regression formula for estimating cadaveric length from posterior curve length of fresh sternum and compare the linear regression results of SPSS and machine learning. Cadaveric length and posterior curve length (PCL) of the sternum were measured from 74 dead bodies (39 males and 35 females) aged between 18 and 95 years from known corpses during medico-legal autopsies. Cadaveric stature and PCL was greater in males as compared to females ($p<0.001$). Regression equations and correlation coefficients were derived for PCL by SPSS and machine learning, which were Y=122.79+2.504(PCL) and Y= 122.98+2.49(PCL), respectively, with correlation coefficients of 0.609 and 0.606, respectively. Individual regression equations were also formulated for males and females separately with significant correlation. The standard error of estimate and R square model were also derived. Cross validating linear regression results of SPSS with machine learning showed almost similar results. The study suggests that posterior curve length of sternum in relation with post-mortem or cadaveric stature shows regional or geographic variation, a moderately positive correlation and relatively low reliability in estimating cadaveric stature, and thus, has limited forensic value.

Keywords

Fresh sternum; Posterior curve length; Cadaveric stature; Correlation; Regression equation; Machine learning.

Introduction

One of the four important attributes of identification is stature estimation. Most of the studies conducted previously in this regard were from long bones but in case of fractured, dismembered, mutilated or diseased remains other bones also comes in to play like bones of hand, feet, sternum, vertebrae etc. The total skeletal height of an individual estimated from dead body/corpse is different from the actual living stature because living stature does not takes into account the post-mortem changes like rigor mortis, intervertebral soft tissues thickness and age-dependent deductions in the actual height of that body.[1-3] Soft tissue thickness i.e. correction factor also needs to be added and ageing factor needs to be taken into consideration to obtain living stature of an individual.[4]

The present study was conducted to estimate the stature of an individual from the sternum which is a superficial bone and can be easily procured from cadavers without much damage during the autopsy procedure.[5] Owing to these factors, the sternum was selected for this study and as an identifying unit of stature. Most of the earlier researchers in this regard have confined their studies to stature estimation of a single sex. But only a few studies such as the present one have taken both the sexes into consideration and have derived a regression equations for both sexes. After undertaking a thorough search of the available literature, this preliminary study which is perhaps the first ever work to be done on correlation of cadaveric stature with sternum posterior curve length by using machine learning also as a tool for analysis was piloted. The present study was designed to develop a population specific regression formula to correlate the stature of an individual with the posterior curve length of the sternum in the Mewat region of Haryana.

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Material and Methods

The material used in the present study was obtained from dead bodies brought to the mortuary of Department of Forensic Medicine of a tertiary care hospital and teaching institute of rural south Haryana, for medico-legal autopsy between October, 2019 and May, 2020. The studied sample comprised the sterna of 74 adult individuals of age 18 to 95 years, including 39 males and 35 females of Mewat, Haryana. All participants of the study were positively identified at the time of post-mortem examination via personal identification documents to confirm their identity and date of birth. Ethical approval for the study was taken from the Institutional Ethics Committee and informed consent from the relatives of the deceased. All the sternum samples which were fractured, charred, diseased or deformed due to congenital or acquired causes were excluded from the study.

The length of the dead body or cadaveric stature was measured, using a measuring tape, from the vertex of the cranium to the

base of the heel with the body being placed in a supine position on the autopsy table.

Sternum was removed from the deceased by making a standard routine linear midline incision from chin to upper border of pubic symphysis. The clavicles were separated at the sternoclavicular joint and the sternal margins that articulate with the first seven pairs of ribs were carefully cut at the costosternal junction. After removing the sternum from the thoracic cavity it was cleaned and soft tissues were separeted from the bone. Posterior curve length of sternum was measured to the nearest using standard measuring tape. Measurements were taken keeping the fresh sternum bone on a flat surface and posterior curve length (PCL) was measured between suprasternal notch and the xiphoid process. The distance between the inferior point of the jugular notch and the inferior point of the xiphoid process was recorded. Three readings were taken and an average of the results was recorded. After taking all the measurements the bone was not preserved beyond the autopsy and was subsequently returned to the body. All data were recorded in an Excel spreadsheet and tabulated.

The data was analyzed using SPSS version 20.0 to derive a linear regression equation for estimation of cadaveric stature. Pearson's correlation coefficient was calculated to assess the correlation between stature and length of the sternum and Student t test was used to evaluate the significance. P value less than 0.05 was considered significant. The hypothetical regression equation is represented as Stature (S) = a + bX, where 'a' is the regression coefficient of the dependent variable (i.e., stature), 'b' stands for the regression coefficient of slope or independent variable (posterior curve length) and 'X' is the mean length. The R^2 and standard error of estimate (SEE) were calculated to assess the significance of regression. R^2 determines the degree of association of correlation that exists between PCL and the cadaveric stature/length. The standard error of estimate measures the accuracy of estimated figure, smaller is its value, better will be the estimates and vice-versa. Stature was estimated from the derived regression equations and was compared with the actual postmortem stature of the cadavers to assess the accuracy of the formulae.[4]

Similar to the SPSS analysis, R^2 value, regression coefficient of slope, correlation coefficient and regression coefficient of dependent variable were estimated by implementing linear regression algorithm (in python version 3.7) via a machine learning approach. Results obtained from machine learning method were then compared against the SPSS outcomes to cross validate the prediction of stature.

Results

The present study comprised of 74 samples of sterna with 39 male and 35 female samples. Test of normality (Kolmogorov-Smirnov test and Shapiro Wilk test) were done to demonstrate the normal distribution of samples taken from the same population. The significance (2-tailed) value for PCL for sternum was 0.06 and 0.195 respectively, which were >0.05, and thus establishes the fact that both male and female samples were normally distributed and taken from same population.

The stature of male and female cadavers ranged from 149cm - 181cm and 148cm-171cm, respectively. The posterior curve length of the male and female sterna ranged from 12-21cm and 13-20 cm, respectively. The mean length of the sterna formed 9.8% and 9.7% of the mean stature of the cadavers in males and females, respectively. The mean values of the cadaveric stature and the posterior curve length of the sternum are shown in Table 1.

Table 1: Descriptive statistics of posterior curve length (PCL) and stature of study subjects (cm)

Variables	Mean ± SD (cm)		
	Males (n = 39)	Females (n = 35)	Total (n = 74)
Cadaveric stature	167 ± 6.87	158.09 ± 6.15	162.85 ± 7.89
PCL	16.5 ± 2.08	15.43 ± 1.55	16.00 ± 1.92

PCL = posterior curve length of the sternum

Table 2: Regression models to estimate stature using the posterior curve length of the sternum

Method	Linear regression equation	R	R^2	SEE (years)
SPSS	Y=122.79 + (2.504 x PCL)	0.609	0.37	6.31
Machine learning	Y= 122.98 + (2.49 x PCL)	0.606	0.368	4.98

PCL = posterior curve length of the sternum; Y = stature; SEE = standard error of the estimate

Table 3: Result of linear regression equation for the present study

	Linear Regression model	R	R^2	SEE (years)
Male	Y=134.55+ (1.967 x PCL)	0.596	0.355	5.59
Female	Y=125.85+ (2.090 x PCL)	0.526	0.277	5.31
Total sample	Y=122.79+ (2.504 x PCL)	0.609	0.370	6.31

PCL = posterior curve length of the sternum; Y = stature; SEE = standard error of the estimate

Statistically significant correlation (p-value < 0.001) was observed between the posterior curve length of the sterna of males, females, and the total study population with the cadaveric stature. Coefficient of correlation (R) was observed to be 0.596 in males, 0.526 in females, and 0.609 in the total population.

Simple linear regression analysis was used to predict stature based on posterior curve length (PCL) of sternum (Table 2). The regression model developed was: Y=122.79 + (2.504 x PCL) with R^2 of 0.370. PCL was measured in centimetres and it was observed that the average stature increases by 6.24 cm for each 1 cm of PCL. The standard error of estimate for the regression model was 6.31. By applying the standard error 6.24, we can determine the stature of an individual with 68%

confidence. If we multiply the standard error of estimate by 2, stature can be estimated with 95% confidence.

To cross-validate our prediction of stature based on the PCL of sternum, we performed linear regression algorithms via a machine learning approach in python (Table 2). Observed results were almost similar to the results from SPSS analysis. The regression equation obtained was Y=122.98 + (2.49 x PCL) with R^2 of 0.368 and correlation coefficient of 0.606.

Table 3 shows bivariate regression analysis of both sexes for estimating stature on the basis of sterna posterior curve length. The standard error of estimate (SEE) in both the sexes was found to be higher, i.e., around 5-6 cm for almost all the variables. The linear regression analysis between post-mortem stature/cadaver length and the sternal posterior curve length in both the sexes was found to be significant.

Table 4: Comparison of the results of present study with the those in literature

Studies	R	R^2	SEE (years)	Linear regression model
Menezes et al.[7] (South Indian population)	0.638	0.407	5.64 (M)	Y=117.784 + (3.429 Sternal length)
Menezes et al.[8] (South Indian population)	0.639	0.408	4.11(F)	Y=111.599+(3.316×Length of the sternum)
Choudhary et al.[15] (Bengali population)	0.636 (M)	0.404	2.94 (M)	Y=137.58+1.15*sternal length
	0.843 (F)	0.711	2.230 (F)	Y=120.47+1.81*sternal length
Singh et al.[4] (Northwest Indian population)	0.318 (M)	0.101	6.83 (M)	Y= 138.93 + 0.20(MBL)
	0.318 (F)	0.101	6.65 (F)	Y = 128.85 + 0.22(MBL)
Manoharan et al.[9] (South Indian population)	0.78	0.608	4.8 (M)	Y=93.6+5.1* (MBL)
Jit et al.[10] (South Indian population)	0.629 (M)	0.396	5.97 (M)	Y=117.091+(3.41xsternal length)
	0.598 (F)	0.958	5.26 (F)	Y=115.059+(3.27x sternal length)
Marinho et al.[11] (Portugal population)	0.329	0.11	6.59	Y = 135.322 + 0.160 (Sternal Length)
Tumram et al.[12] (Central Indian population)	0.55	0.302	7.4 (M)	Y=90.65+4.8* total sternal length
Yonguc et al.[13] (Turkish population)	0.850	0.521	0.045	Y=111.198+ 0.370 (MBL)
Baraw et al.[14] (Delhi population)	0.872	0.770	3.5	Y=91.51+3.5 (PCL)
Present study using SPSS	0.609	0.370	6.31	Y=122.79+ (6.24 x PCL)
Using machine learning	0.606	0.368	4.98	Y= 122.98 + (2.49 x PCL)

PCL = posterior curve length of the sternum; MBL: combined length (manubrium+mesosternum)

Discussion

For many years anthropometric techniques are being used in forensic practice for estimation of stature. Every racial or ethnic group needs a different linear regression equation, and region wise studies are very essential as racial or ethnic variations arise in different geographic regions.[6] With the increasing frequency of mass disasters and crimes involving dismembered or mutilated bodies, estimation of stature from such remains has created problems in ascertaining identity of some victims as methods of estimating stature from the skeleton are mostly based on the long bones of the lower and upper extremities. Sternum is one of the bones that could be used to determine stature, when the body is recovered in such mutilated or dismembered state with absence of limbs.[7-8]

Earlier studies have dealt with stature estimation from a dry sternum.[7-10] Recently, various researchers (Table 5) used the fresh sterna for stature estimation to determine its applicability in forensic practice.[11-14] The present work consisted of direct measurement of the sternum in autopsy cases. Also the use of regression analysis to correlate with stature is a well established method in anthropological studies. In its natural position the inclination of the sternum is oblique from above, downward and forward. It is slightly convex in front and concave behind.[5,10,15] So we considered the posterior curved length of sternum as one of the variables in the present investigation.[5] Direct measurement in autopsy cases is more accurate and reliable than other works of morphometry with radiography and digital measurement.[5] In this study we wished to provide an alternative means to the estimation of stature with measurements of fresh sterna, namely when maceration cannot be carried out, due to time constraints for example, or when a fresh or decomposed mutilated cadaver is being identified.[14]

The observations of the present study showed that posterior curve length of sternum has a moderate positive correlation with cadaveric stature which also corresponds to that reported by other researchers from India and abroad (Table 4).[7-14] However, interpretations of the present study also concur with the findings of Singh et al.[4], Marinho et al.[11] and Tumram et al.[12], that sternal lengths are comparatively less correlated with stature and are thus, comparatively less reliable for stature estimation. Not only is the correlation between sternum posterior curve length and cadaveric stature comparatively less, but the standard error of the estimate is relatively large, resulting in confidence intervals for cadaveric stature which are also large and of limited use to discriminate between individuals of similar stature. Use of multiple bone lengths for stature estimation was found to be better than single bone length as R^2 or coefficient of determination was found higher in multiple regression analysis than simple linear regression.[4,11]

Another important consideration while scrutinizing different

stature estimation methods is that they are not universally applicable and several studies have demonstrated that a model developed from a specific population may not give as reliable estimates when applied to another.[11] This results mostly from differences in body proportions and differences in proportions between stature and bone size, that result from differences in environmental conditions during growth which affect these proportions.[1-4,11]

One of the few limitations of the present study was the small sample size. This can be rectified by a larger study group to examine the applicability of the results for use in forensic practice. Also more variables should be analysed for garnering more accuracy. The result of this study when compared to different geographical population yielded a varied predictive value. This regional variation concurs with previous studies also. Another lacuna of study could be the soft tissue adherence to the wet sternum bone sample which could have lead to lower accuracy in morphometry, however, it was uniform and minimal throughout.

In the present study, we also implemented basic linear regression as machine learning algorithm so as to cross validate or support the outcomes from SPSS analysis. The linear regression results calculated from both the systems appeared to be almost similar with standard error of estimate slightly lower in machine learning than the SPSS system result. However, the limited amount of data in this study restricted us from using machine learning approaches extensively. However, in future machine learning methods such as K-nearest neighbour, support vector machines, regression trees and random forest can be utilised to predict using large datasets.

Conclusion

Forensic anthropology is a good predictor of various collaborations that can be adjunctive in the process of identification. The studies which are conducted on a specific ethnic group can be an addition to the existing database of studies of various populations around the world so that a large international database is made available which can be of use in practical forensic investigation. Stature is one of the main tools for identification of unknown dead bodies. Apart from long bones which are mostly studies for this purpose other bones like sternum can also be used for estimating stature only when long bones are not available, as sternal PCL exhibits comparatively weaker correlation coefficients with cadaveric stature and higher standard error of estimate in regression analysis. This measurement and method of calculating cadaveric stature can be used, if immediate estimation is required, as the sternum is easily removed and dissected from a relatively fresh or badly decomposed body.

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ORIGINAL ARTICLE

Estimation of cadaveric stature from sternal measurements: An autopsy-based study

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Abstract

The aim of this study was to estimate cadaveric/post-mortem stature from dry sternum measurements by deriving regression equations. This study included dry intact sterna from 56 males and 44 females, aged more than 25 years, obtained during medico-legal autopsies. Stature and three sternal lengths i.e. length of the manubrium (ML), Mesosternal length (MSL) and combined sternal length (MBL), of each cadaver were measured. Stature and all measured sternal lengths were greater in males compared to females ($p<0.001$). Most of the sternal lengths were positively correlated with stature in sexes except male MSL and MBL. MBL had the highest correlation coefficient (0.525). On the other hand, the stepwise multiple linear regression equation derived from the combination of ML, MSL and MBL had the higher R2 value ($R2 = 0.337$) for cadaveric stature estimation. These findings suggested that measured sternal lengths can be used for estimation of sex. However, MSL and MBL measurements were found to be the most reliable sternal lengths for estimating sex. Our results revealed that sternum morphometry although shows moderate positive correlation with the cadaveric stature but is not a reliable tool for estimating stature when other skeletal bones are not available.

Keywords

Sternum; Cadaveric stature; Anthropometry; Correlation; Regression equation.

Introduction

One of the main information recovered from the bones is stature estimation which is one of the four main attributes of identification. Different morphometrical analysis of long and short bones helps us to estimate the stature of an individual by their individual correlation coefficients and regression analysis. Every racial or ethnic group need a different linear regression equation, and region wise studies which are very essential as racial or ethnic variations arise in different geographic regions.[1]

The total skeletal height of an individual estimated from dead body/corpse is different from the actual living stature because living stature does not takes into account the post-mortem changes like rigor mortis, intervertebral soft tissues thickness and age-dependent deductions in the actual height of that body.[2-4] Apart from long bones other bones like bones of hand, foot, vertebrae, sternum have also showed significant results in stature estimation of an unidentified corpses. Sternum is one of the few bones which is superficial and doesn't require much dismembering of body for its removal and thus used freely for anthropological purposes. Many researchers have used dry and fresh sternum morphometry for different forensic usage. The objective of the present investigation was to generate linear regression models for cadaveric stature estimation on the basis of different sternum measurements in North Indian population.

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Material and Methods

The material used in the present study was obtained from dead bodies brought to the mortuary of Department of Forensic Medicine of a tertiary care hospital and teaching institute of North India, for medico-legal autopsy during a period of one and a half year. The studied sample comprised of dried sterna of 100 adult individuals of age more than 25 years, including 56 males and 44 females. All of the study samples were positively identified at the time of post-mortem examination through police papers and personnel identification documents. Ethical approval for the research was obtained from the Institutional Ethical Committee and written informed consent was taken from the relatives of the deceased. All the sternum samples which were fractured, charred, diseased, or with deformities either congenital or acquired were excluded from the study.

The length of the dead body or cadaveric/post-mortem stature was measured, using a measuring tape, from the vertex of the cranium to the base of the heel with the body being placed in a supine position on the autopsy table.

Sternum was removed from the deceased by making a standard routine linear midline incision from chin to upper border of pubic symphysis. The clavicles were separated at the sterno-clavicular joint and the sternal margins that articulate with the first seven pairs of ribs were carefully cut at the costo-sternal junction. After removing the sternum from the thoracic cavity it was cleaned and soft tissues were scraped from the bone which was then allowed to macerate by immersing it in soap water for

two weeks. After this the sternum samples were transferred to a setup containing plain water. Subsequent to all the wet maceration, the sterna were cleaned and dried at room temperature. The following parameters were measured using the Helio's dial callipers which gives accurate reading, upto 1/100 of mm.

- Manubrial Length (ML): Midline distance from the suprasternal notch to manubrio-mesosternal junction.
- Mesosternal Length (MSL): Length of mesosternum measured from manubrium-mesosternum junction to mesosternum-xiphoid process junction.
- Combined Length (MBL): Combined length of manubrium and mesosternum i.e. Manubrial length + Mesosternal length

Measurements were taken keeping the sternum bone on a flat surface. Three readings were taken and an average of the results was recorded. All data were recorded in an Excel spreadsheet and tabulated.

The data was analyzed using SPSS version 20.0 to derive linear regression equations for estimation of stature. Pearson's correlation coefficient was used to assess the correlation between stature and length of the sternum, and, Student t test was employed to test significant differences, if any. P value <0.05 was considered significant. Both simple and multiple linear regression analyses were derived using different sternal lengths to estimate stature of the study population. R^2 and standard error of estimate (SEE) were calculated to assess the significance of regression.[5]

Results

The present study comprised of 100 sterna with 56 male and 44 female samples. Test of normality (Kolmogorov-Smirnov test and Shapiro-Wilk tests) were done to demonstrate the normal distribution of samples. The Sig. (2-tailed) value for all sternum lengths: the manubrial length (ML), mesosternal length (MSL) and combined length (MBL) was 0.095 and 0.204, respectively (p-value >0.05). Hence, both male and female samples were normally distributed.

The stature of male and female cadavers ranged from 152cm - 180cm and 148cm -170cm, respectively. The manubrial length (ML), mesosternal length (MSL) and combined length (MBL) of males ranged from 38-52 mm, 79-109 mm, and 119-159 mm respectively, and for females, ranged from 36-49 mm, 62-91 mm, and 100-134 mm respectively. All measurements (stature and sternal lengths) were significantly higher (p<0.001) in males as compared to females (Table 1). The mean values of each of the parameters along are depicted in Table 1.

Statistically significant correlation was observed between all the sternal lengths and the stature. The correlation coefficients for all these lengths for both the sexes are shown in Table 2. Table 2 also shows the bivariate linear regression analysis for estimating stature using the different sternal lengths for both the sexes. For males, females, and the total sample, manubrial length showed the least standard error of the estimate for their regression models (Table 2).

Table 3 shows the results for stepwise multiple regression analysis applied individually to the studied sternal lengths. It was observed that in males, R^2 increased gradually with increase in the number of variables up to the last step of regression with MSL being most significant and MBL the least.

Table 1: Descriptive statistics of stature, manubrial length, mesosternal length, combined length and stature of study subjects

Parameters	Mean ± SD		
	Males (n=56)	Females (n=44)	Total (n=100)
Cadaveric stature (cm)	167.86 ± 5.96	159.09 ± 5.57	164.00 ± 7.23
ML (mm)	45.74 ± 2.98	41.20 ± 3.31	43.74 ± 3.85
MSL (mm)	100.27 ± 6.24	78.35 ± 6.26	90.62 ± 12.58
MBL (mm)	145.90 ± 7.67	119.29 ± 8.84	134.20 ± 15.58

ML = manubrial length; MSL = mesosternal length; MBL = combined length

Table 2: Linear regression models to estimate stature using sternal lengths

Sternal length	Sample	R	R^2	Linear regression model	SEE(mm)
ML	Male	0.205	0.042	Y=149.12+ 0.410(ML)	5.88
	Female	0.212	0.045	Y=144.36+0.357(ML)	5.51
	Total	0.490	0.240	Y=123.78+ 0.920(ML)	6.34
MSL	Male	-0.036	0.001	Y=171.30-0.034(MSL)	6.01
	Female	0.047	0.002	Y=155.83+0.042(MSL)	5.63
	Total	0.525	0.276	Y=136.64+0.302(MSL)	6.19
MBL	Male	-0.059	0.003	Y=174.55-0.046(MBL)	6.00
	Female	0.106	0.011	Y=151.09+0.067(MBL)	5.60
	Total	0.522	0.272	Y=131.49+0.242(MBL)	6.20

ML = manubrial length; MSL = mesosternal length; MBL = combined length; SEE = standard error of the estimate

Table 3: Stepwise multiple regression models to estimate stature using sternal lengths

Sternal length	R	R^2	Regression model	SEE (mm)
MSL	0.525	0.276	Y=136.64+0.302(MSL)	6.19
MSL+ML	0.359	0.308	Y=125.26+0.206(MSL)+0.459(ML)	6.07
MSL+ML+MBL	0.244	0.337	Y=125.77+0.820(MSL)+1.041(ML) -0.608(MBL)	5.98

ML = manubrial length; MSL = mesosternal length; MBL = combined length; SEE = standard error of the estimate

Table 4: Summary table of previous studies

Studies	Sternal length	Sex	R	R^2	Model	SEE (mm)
Singh et al.[5] (2011)	ML	M	0.191	0.04	Y=154.38 + 0.26 (ML)	7.08
		F	0.217	0.06	Y=141.17 + 0.32 (ML)	6.82
	MSL	M	0.255	0.07	Y=150.90 + 0.18 (MSL)	6.97
		F	0.229	0.05	Y=144.02 + 0.16 (MSL)	6.83
	MBL	M	0.318	0.10	Y=138.93 + 0.20(MBL)	6.83
		F	0.318	0.10	Y = 128.85 + 0.22(MBL)	6.65
Yonguc et al.[14] (2014)	ML	M	0.656	0.353	Y=141.192 + 0.602 (ML)	0.103
		F	0.670	0.448	Y=120.276 + 0.827 (ML)	0.173
	MSL	M	0.746	0.314	Y=125.320 + 0.408 (MSL)	0.076
		F	0.372	0.138	Y=134.845 + 0.261 (MSL)	0.123
	MBL	M	0.850	0.521	Y=111.198 + 0.370 (MBL)	0.045
		F	0.740	0.547	Y=95.139 + 0.449 (MBL)	0.077
Tumram et al.[10] (2015)	ML	M	0.44	0.197	Y=130.84 +6.44 (ML)	7.9
	MSL	M	0.25	0.06	Y=135.55 +2.53 (MSL)	8.5
	MBL	M	0.55	0.302	Y=90.65+ 4.8(MBL)	7.4
Jit et al.[11] (2018)	MBL	M	0.629	0.396	Y=117.091+3.41 x (MBL)	5.97
		F	0.598	0.358	Y=115.059+3.27(MBL)	5.26
Present study	ML	M	0.205	0.042	Y=149.12+ (0.410 x ML)	5.88
		F	0.212	0.045	Y=144.36+ (0.357 x ML)	5.51
	MSL	M	-0.036	0.001	Y=171.30+ (-0.034 x MSL)	6.01
		F	0.047	0.002	Y=155.83+ (0.042 x MSL)	5.63
	MBL	M	-0.059	0.003	Y=174.55+ (-0.046 x MBL)	6.00
		F	0.106	0.011	Y=151.09+ (0.067 x MBL)	5.60

ML = manubrial length; MSL = mesosternal length; MBL = combined length; SEE = standard error of the estimate

Discussion

Accurate identification of skeletal remains depends on the type and condition of bone available. Numerous studies have been conducted to estimate stature using various skeletal remains. The accuracy of stature estimation was found highest with long bones.[2, 3] However, few researchers also estimated stature using small bones and reported high levels of accuracy.[4] Various statistical tools have been utilised to increase the accuracy of identification.

Many researchers found it convenient to study the sternum for estimation of cadaveric stature, as it is easily procured during autopsy without causing any external disfigurement to the subject.[6] In the present study, we assessed the correlation between the sternal measurements and cadaveric stature in a north Indian population and linear regression equations were derived for the estimation of cadaveric stature.

Most of the previous studies were conducted using either fresh or dry sterna. Majority of researcher measured the straight length of anterior surface of sternum. In the present study, dry sterna were used and straight length of sterna was measured using Helio's dial calliper.

Menezes et al. [7,8], Singh et al.[5], Marinho et al.[9], Tumram et al.[10] and Jit et al. (2018)[11] concluded that the sternum can be utilised to estimate stature only when long bones are not available. The sternal lengths exhibit weaker correlation coefficients with stature and higher standard errors of estimate.

In the present study, all the measurements showed higher mean values in males than females, which supports the finding of sexual dimorphism for most measured lengths (Table 1). Similar to the study conducted by Singh et al.[5], the use of multiple bone lengths for stature estimation was found to be better than a single bone length. The R^2 was found to be higher for multiple regression analysis as compared to simple linear regression (Table 3).

Cadaveric Stature**:** The mean stature in the present study (Table 1) was found to be 167.86±5.96 in males and 159.09±5.57 in females, respectively. Menezes et al.[7, 8], Nagesh and Kumar[12], Rastogi et al.[13], Younguc et al.[14], and Jit et al.[11] also observed cadaveric statures within same range their studies.

In present study, there was a significant correlation between cadaveric stature and Manubrial Length (ML) for both males and females. The correlation coefficient was comparable to the study by Singh et al.[5] However, other researchers reported more positive correlation coefficients in their studies (Table 4). The standard error of estimate in almost all the studies ranges from 5 to 7. The standard error of estimate in the current study is also in between 5 to 6.

There was a positive correlation between cadaveric stature and Mesosternal Length (MSL) in females. However, negative correlation was observed in males. Other researchers found higher correlation coefficients in both sexes when compared to the present study (Table 4). The standard error of estimate in almost all the studies ranges between 5 to 8, which was also observed in the this study.

There was a positive correlation between cadaveric stature and Combined Length (MBL) in females. However, negative correlation was seen in males. Other researchers reported a strong correlation coefficient in both sexes as compared to this study (Table 4). The standard error of estimate in almost all the studies ranges from 5 to 7, which was also observed in this study.

The current study is limited to the north Indian population and thus its applicability is limited to this population alone. In order to increase the accuracy and specificity, studies with large sample size and different geographical distribution should be

carried out. Also, the present study is of limited use in cases of estimation of cadaveric stature from non-macerated sterna and stature estimation in living individuals. Many researchers have also used the sternum for stature estimation in living beings by different radiological techniques i.e. X-ray[15] and CT scans.[16]

Conclusion

Based on the observations and results of different sternal measurements, it can be concluded that mean cadaveric stature and other sternal lengths were higher in males than females. On applying linear regression analysis, there was a significant correlation between cadaveric stature and ML measurement in males except in the case of MSL and MBL sternal lengths, whereas in female samples significant correlation seen for all measurements. The correlation coefficient in the present study is comparatively less as compared to other studies.

So, we conclude that the sternal measurement is not statistically significant for estimating cadaveric stature as compared to other long bones. However, these measurements could be used to determine stature in the absence of other significantly correlated bones.

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ORIGINAL ARTICLE

Analysis of medico legal deaths in adolescence: An Autopsy based study at coaching city, Kota

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Abstract

An adolescent is defined as an individual aged between 11-19 years. They constitute about 1.2 billion worldwide, and about 21% of Indian population. Mortality and morbidity occurring in this age group are mostly due to preventable causes. Mortalities in adolescents are cause of concern because they are the future of nation forming a major demographic and economic force. The purpose of this study is to analysis mortality in adolescents. Out of 1056 autopsies 94 victims were adolescents contributing 8.9% of total autopsies. Male deaths were more (about 60%) than female (about 40%) and all deaths increased with an increase in age. More than half of the total deaths (51%) were due to accidents, followed by suicides (43%). Females were prone to commit suicides. In suicidal deaths the most common cause was hanging following by poisoning. Use of appropriate safety measures and strict law enforcement may significantly reduce accidental deaths in adolescents. Suicides and homicides may be prevented by identification of risk factors, significant family support and proper psychological counselling.

Keywords

Adolescent mortalities; Accidental deaths; Suicidal deaths.

Introduction

Adolescence is a transitional stage of physical, physiological and psychological development from puberty to adulthood.[1] WHO defines an adolescent as an individual aged between 11-19 years i.e. those in the second decade of their lives. Around 1.2 billion people, or, one in six of the world population belongs to the adolescent group. In India about 21% (243 million) of population are adolescents.[2] The period of adolescence and puberty has a special importance because it is the most beautiful, most powerful, and most hopeful period of human life.[3] Mortality and morbidity occurring in this age group is mostly due to preventable causes. Studies showed that about 70% of deaths among adolescents were due to preventable causes such as unintentional injuries, homicides and suicides.[4] This is a cause for concern as adolescents are the future of our nation and they constitute the major demographic and economic force. The purpose of this study is to analysis medico legal deaths in adolescents. This study might help provide invaluable information and may be used by society and law enforcement authorities to prevent such mortalities. The aims and objectives are of the present study were to analyse the socio-demographic profile of victims of medico-legal deaths of adolescents and to analyse causes and manner of medico-legal deaths in adolescents and learn how to prevent such mortalities.

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Material and Methods

The present study was conducted at the Department of Forensic Medicine, M.B.S. Hospital associated with Government Medical College Kota, Rajasthan. This study was conducted between 1st January 2019 and 31st December 2019 after obtaining ethical approval from the Institutional Research and Ethical Committee. All dead bodies brought for medico-legal post-mortem examination of adolescent victims (10-19 years) at M.B.S. Hospital mortuary were included in the study after obtaining an informed consent for participation in the study by relative of deceased. Cases wherein history regarding manner and cause of death were incomplete along with cases where no consent was obtained were excluded. Detailed information regarding circumstances of death was sought. The post-mortem examination was carried out and obtained information was correlated with the history and details mentioned in the police inquest. All collected data was then processed using Microsoft Excel and tabulated to deduce findings of the study.

Results

In the present study we analysed medico-legal deaths in adolescents (10-19 years) in Kota city of Rajasthan during the period of 1st January 2019 to 31st December 2019. Total 1056 autopsies were conducted during this study period.

Of the 1056 autopsies 94 victims were adolescents, contributing 8.9% of total autopsies. Male deaths were more with 56 cases (about 60%) as compared to female deaths with 38 cases (about 40%). The study showed that 76 (80%) deaths belonged to 15-19 years age group and only 18 (20%) deaths belonged to the 10-14 years age group. Maximum deaths (23; 25%) were observed in 18 year age followed by 19 year age (21deaths;

22%). Only one case was observed in 11 year age. These observations show that deaths increased with increase in age (Table 1).

Table 1: Age-wise distribution of adolescent deaths

Age (years)	Male	Female	Total
10	1	1	2
11	1	0	1
12	3	1	4
13	4	1	5
14	4	2	6
15	3	4	7
16	4	4	8
17	12	5	17
18	14	9	23
19	10	11	21
Total	56	38	94

Table 2: Distribution of victims according to manner of death

Manner of death	Male	Female	Total
Accidental	37	11	48
Suicidal	15	25	40
Homicidal	04	02	06
Total	56	38	94

Table 3: Manner of death distributed according to age of victims

Age (years)	Accidental	Suicidal	Homicidal	Total
10	1	1	0	2
11	1	0	0	1
12	2	1	1	4
13	3	1	1	5
14	4	2	0	6
15	4	3	0	7
16	3	5	0	8
17	5	10	2	17
18	14	8	1	23
19	11	9	1	21
Total	48	40	6	94

We also analysed manner of death and it was observed that maximum deaths with 48 cases (51%) were due to accidents followed by suicidal deaths (40 cases; 43%). Least number of deaths (6) occurred due to homicide. Out of the 48 accidental cases male deaths were more, with 37 cases (77%) as compared to females (11 cases; 23%). We also observed that female deaths were more due to suicides (25 cases; 63%) than males (15 cases; 37%) cases. In case of homicide there were 4 male adolescents and 2 female adolescents (Table 2). Maximum suicidal deaths in adolescents were observed in the 17-19 years age group and least deaths were in 10-13 years age group. In case of accidental deaths maximum deaths were observed in 18-19 years age group (Table 3).

Table 4: Age-wise distribution of cause of death in adolescents

	Age (years)										
Cause of death	10	11	12	13	14	15	16	17	18	19	Total
Injuries (n)	0	1	2	3	2	3	3	5	8	8	35
Poisons (n)	0	0	0	1	3	3	1	6	4	3	21
Snack bite (n)	1	0	1	0	0	0	0	0	2	1	5
Hanging (n)	0	0	0	1	1	1	2	6	7	4	22
Drowning (n)	0	0	0	0	0	0	1	0	1	1	3
Aspiration (n)	0	0	0	0	0	0	0	0	0	1	1
Burn (n)	1	0	1	0	0	0	0	0	0	2	4
E.C. (n)	0	0	0	0	0	0	1	0	1	1	3
Total	2	1	4	5	6	7	8	17	23	21	94

Table 5: Manner of death wise distribution of cause of death

Causes	Accidental	Suicidal	Homicidal	Total
Injuries	29	0	6	35
Poison	8	13	0	21
Snack bite	5	0	0	5
Hanging	1	21	0	22
Drowning	0	3	0	3
Aspiration	1	0	0	1
Burn	1	3	0	4
E.C.	3	0	0	3
Total	48	40	6	94

In this study we also analysed causes of death in adolescents and observed that maximum deaths occurred due to injuries (35 cases) followed by hanging with 22 cases. Out of the 35 deaths due to injuries most injuries were accidental in manner contributing to 83% deaths. According to the body part fatal

injuries were found on the thoraco-abdominal region in 16 cases and in 15 cases fatal injuries were located on the head. Only in four cases injuries were observed over limbs. 21 deaths resulted due to poisoning, out of which 13 cases were suicidal and 8 cases were accidental in manner. We also found 5 deaths due to snake bite, 3 deaths due to drowning and 4 deaths as a result of fatal burns. 3 deaths were a result of electrocution and one death was due to accidental aspiration of gastric contents. We observed 22 deaths due to hanging, out of which 21 cases were suicidal and only one death was due to accidental hanging (Table 4, 5).

Discussion

Adolescence is a uniquely human phenomenon. Adolescents are known to be moody, insecure, argumentative, impulsive, reckless and rebellious. In this age group testosterone and oestrogen give rise to a competitive streak, adventure, sexual excitement to opposite sex, and at the same time depression.[5] These changes increase violence and mortality rate in adolescents. Medico-legally this age group occupies a very important area of study.

In this study 94 deaths were related to adolescence age group contributing 8.9% of total autopsies. Rao et al. conducted their study on teenage deaths and observed less deaths (3.4% of total autopsies) around Guntur, Andhra Pradesh. A higher number in our study is expected as Kota is the coaching city of India and hence more adolescents are living in Kota and preparing for different competitive examinations. This results in higher adolescent population density in Kota as compared to other cities.

In our study male deaths were more than female deaths and all deaths increased with an increase in age. Similar result were observed by Rao et al.[5] and Ulucay et al.[3] In the latter adolescence phase of 15- 19 years, due to the gradual increase in exposure to outer world, journey to different places with friends and varying employment opportunities adverse influences affect adolescents, and so deaths were higher in this age group.

We analysed manner of death and observed that maximum deaths were due to accidents (51%) followed by suicide (43%) and homicide (6%). Similar findings were observed in the study published by National adolescent health information centre in 2003. According to this study about 45% deaths among adolescents were due to unintentional injuries and vehicular accidents.[4] Blum[6] conducted a study in United States and found similar observations of 48% deaths in adolescence and young adults due to unintentional injuries. In our study deaths due to suicide were 43% and due to homicide were about 6%. Similar findings were observed by Rao et al.[5] and Ulucay et al.[3] Blum[6] on the other hand observed that more deaths, 13% were due to homicide and less deaths 11% were due to suicide. Here in India parental and social restrictions are there to control the adolescents and it is difficult to get dangerous weapons and so the homicidal deaths were slightly less. In the present study suicidal deaths were very high (43%) compared to foreign studies. This is explained by the fact that socio- cultural and other factors such as study pressure, love and parental pressure are more in Indian scenario. We also observed that female deaths were more due to suicides. Female adolescents have been facing more problems like sexual assault, love failure, unwanted marriage, unwanted pregnancies and less emotional support by family members. These factors lead to increased suicidal deaths.

In this study most common cause of accidental deaths was injuries to thoraco-abdominal region and head injuries. Head and trunk are vital and vulnerable part of body, so proper protection of these parts of body is necessary during driving of vehicles. Helmet and seat belt are important protective gear in protecting the head and trunk. Patel[7] studied that this age group usually travelled by own vehicle or public transportation for work and this leads to road traffic accidents. In suicidal deaths most common causes of death were hanging and poisoning. Ulucayet al. [3] also found most common cause of death was hanging. Tiwari et al.[8] conducted a three years study on suicidal asphyxia deaths in Kota and found similar number of deaths by hanging and drowning. Sharma et al.[9] studied deaths in North India and found poisonings were most commonly used for committing suicides. Contrary to this study guns were used in about 66% of all suicides in USA.[3, 10]

Conclusion

In this study 8.9% of total autopsies were on adolescents. Male deaths were more than females and all deaths increased with an increase in age. 76 (80%) deaths belong to the 15-19 years age group and only 18 (20%) deaths belong to the 10-14 years age group. 48 adolescents died due to accidental or unintentional injuries out of which 37 victims (77%) were male. 40 (43%) deaths were recorded as a result of suicide. Suicidal deaths were more in 17-19 year old female adolescents. Most common method used to commit suicide was hanging followed by poisoning. Only six deaths occurred as a result of homicide. Suicides and homicides in adolescents may be prevented by identifying risk factors (mood disorder, impulsive behaviour), through family support and proper psychological counselling.

Majority of adolescents deaths were due to preventable causes. Motor vehicle accidents and accidents at work place were the leading cause of death. Efforts for prevention of accidents by using safety measures and strict law enforcement may significantly reduce mortalities in adolescents. Suicides and homicides in adolescents may be prevented by identifying risk

factors (mood disorder, impulsive behaviour), through family support and proper psychological counselling.

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ORIGINAL ARTICLE

Demography of victims of sexual assault: A prospective study in south Odisha

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Abstract

Sexual assault is a heinous form of physical coercion that involves use of violence by an individual upon another, mostly women and children. It is a type of abuse that inflicts torture and consequently, physical, psychological and social trauma. This prospective study was conducted on 206 victims of sexual offence who presented for examination to the Department of Forensic Medicine and Toxicology in a Medical College and Hospital in South Odisha between October 2013 and September 2015. Natural sexual offences constituted 56.80% of cases where 55.82% of cases were between the age group of 12 – 18 years and 82.04 % were Hindus. Most of the cases (50.48%) occurred in rural settings and 36.89% were literate upto the higher secondary level. Most of the victims (36.89%) were students, 84.47% were unmarried, 68.44% came from nuclear families, 55.83% of the victims were acquainted to the assailants as a lover or boyfriend. Most of the victims (33.02%) were reported after more than 1 month of incidence and time elapsed between incidence and medical examination for most victims (65.05%) was more than 72 hours.

Keywords

Sexual assault; Sex offence; South Odisha

Introduction

Sexual assault refers to a type of sexual behaviour or act that is threatening, violent, forced, coercive or exploitative and to which a person has not given consent or was not able to do so.[1] It inflicts torture and consequently, physical, psychological and social trauma. Globally, 35% of women have experienced some form of physical or sexual violence. About 20% of women and 5–10% of men have been victims of sexual violence in their childhood.[2] NCRB reported a staggering 36735 cases in India in 2014 alone.[3]

Sexual assault is regarded as a serious health and human rights problem. Grossly under- reported in India, it reflects the prevalent crime scenario and the status of women in society. Morbidity due to sexual assault is an emerging public health problem.

We have taken up this study due to the concern about the growing number of such cases in India. We hope that the data retrieved may be used to update the knowledge base and undertake better policy making decisions by the concerned authorities.

Materials and Methods

This prospective study was conducted on 206 victims of sexual offence in the Department of Forensic Medicine and Toxicology in a Medical College and Hospital in South Odisha between October 2013 and September 2015. The inclusion criteria was victims of alleged rape cases, victims of alleged kidnapping cases, victims accompanying parents/relatives/guardians, victims of alleged anal intercourse (sodomy) cases. The exclusion criteria was victims coming only for Ossification test, victims who does not consent for examination, victims booked under PITA/ Prostitution cases.

History was obtained from the victims, police and accompanying relatives and entered in a pre-designed performa (case record form). The treatment records were also perused for admitted patients.

Results

During the 1st year (October 2013 – September 2014), out of 109 cases, 5 were male and 104 females. In the 2nd year (October 2014 – September 2015), 2 cases were male and 95 cases were females. Across the two year period, a total of 206 victims of sexual assault were recorded. Seven of these individuals were male, and 199 were females.

Most of the cases were natural sexual offences (117 cases or 56.80%). Unnatural sex offences were most rare (7 cases or 3.39%). (Table 1) Majority of the victims (115 or 55.82%) belonged to the adolescent age group of 12-18 years. Minimum age of an alleged victim was 4 years. No victim of age more than 45 years was found in our study. (Table 2)

Majority of the victims (82.04%) were Hindus, while 15.05% of the victims were Christians, and 2.91% were Muslims. Most of the cases (50.48%) were from rural areas, followed by semi-urban areas (36.41%) and lastly the urban areas (13.11%).

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Majority of victims (36.89%) were educated upto higher secondary school level followed by primary school level educated (35.44%). Only 18 victims (8.74%) were college educated. (Table 3)

Majority of cases included students (36.89%) followed by unemployed individuals (32.52%) and labourers and maids (16.99%). Only 3.89% cases were reported from employed category. Most of the victims (50.97%) were from the lower socio-economic status population, followed by middle socio-economic status (47.09%) and lastly higher socio-economic status (1.94%). Most of the victims were unmarried (84.47%), while 13.59% were unmarried. Only 2 cases (0.97%) of divorced or widowed ladies were reported. Majority of the victims (141 or 68.44%) belonged to nuclear families. 33 (16.02%) victims were staying in joint families and 32 victims (15.54%) were staying alone.

Majority of the offenders (180 or 87.38%) were acquainted with the victims. Among them, lovers or boyfriends (115 or 55.83%) constituted more than the half of study population. Total strangers were reported in only 10 cases (4.85%) and 16 cases (7.77%) involved 2nd degree relatives. (Table 4)

The most common place of occurrence of alleged cases of sex offence were indoors in 161 cases (78.16%) and outdoors in 45 cases (21.84). Most of the victims (33.02%) reported 1 month after occurrence. Only 14.57% cases were reported immediately. (Table 5) Table 6 enumerates the time period between occurrence of the sexual offence and the day of medical examination. Time durations are categorized according to the period of spermatozoa survival inside the vaginal canal or uterine cavity. Most of the cases were produced for examination after 72 hours. Only 22 victims (10.68%) were produced within 24 hours. Majority of victims had consensual sex i.e. 154 (75.24%) and the rest non-consensual. The reasons behind consensual sexual act were false promises of marriage (51.61%) and love affairs (47.10%). Among non-consensual sex offence cases, 88.24% of victims were physically forced with ill intent. Possible reasons behind it would be loneliness, seduction or revenge for any past conflict.

Table 1: Distribution of sexual assaults as per manner of occurrence

Type of Sexual Offence Cases	n (%)	%
Natural Sex Offences	117	56.80
Kidnapping only	26	12.62
Kidnapping with Sex Offence	44	21.36
Unnatural Sex Offence	07	3.39
Cheating (Eloping) Cases only	12	5.83
Total	206	206

Table 2: Age distribution of the sexual assault victims

Age in years	n	(%)
0-12	14	6.8
12-18	115	55.82
18-30	71	34.47
30-45	6	2.91
>45	0	0
Total	206	100

Table 3: Educational status

Educational status	n	(%)
Illiterate	35	16.99
Primary	73	35.44
Higher secondary	76	36.89
College & above	18	8.74
School yet to attend	4	1.94
Total	206	100

Table 4: Relation of victim with offender

Relationship		N	(%)
Own relatives	First degree relatives	0	0
	Second degree relatives	16	7.77
Strangers		10	4.85
Acquaintance	Lover /Boy Friend	115	55.83
	Friends (Close friends, Class mates, Staffs & Colleagues etc.)	36	17.48
	Neighbours	19	9.22
	Tuition Master	10	4.85
Total		206	100

Table 5: Time elapsed between incidence and reporting

Time Period elapsed	N	(%)
Within 24 hours (Immediately)	30	14.57
Within 1 week	64	31.06
Within 1 month	44	21.35
After 1 month	68	33.02
Total	206	100

Table 6: Time elapsed between incidence and medical examination

Time duration	n	(%)
≤24 hours	22	10.68
>24 hours - ≤72hours	44	21.36
>72hours	134	65.05
Denied or cannot recalled	6	2.91
Total	206	100

Discussion

A total of 433 cases were brought for examination to our department: 207 cases from 1st October 2013 to 30th September 2014 and 226 from 1st October 2014 to 30th September 2015, respectively. Number of victims selected for the study as per the criteria laid down under materials and methods were 109 and 97 cases respectively, totalling 206 cases for the entire study period.

Out of the 206 cases under study, 96.6% were females (199 cases) and only 3.4% (7 cases) were males. All the males were victims of unnatural sexual offence and below the age of 18 years. On further analysis, it is also observed that the number of female victims increased by almost 2.5% whereas there was a reduction in the number of male cases by about 2.5% from the preceding year. It was observed that natural sex offence is highly prevalent in this region (56.80%) followed by kidnapping with sex offence in 21.36% and kidnapping only in 12.62% of cases. After amendment of POCSO Act, 2012 the total number cases registered under POCSO Act was 117 which is about 56.8% of total study population. The study showed an increase in 4.28% of cases registered under POCSO Act from the previous year.

The most vulnerable age group was 12-18 years comprising of 55.82% cases followed by the age group of 18-30 years (34.47%), 6.8% victims were in the age group 0-12 years and 2.91% victims were in the age group 30-45 years. The minimum age of the alleged victim recorded was 4 years. No victim of age more than 45 years was found in our study. Studies conducted by Manzoor et al.[4], Arif et al.[5], Haider et al.[6] and Nowsher et al.[7] reported similar findings. Sahu et al. reported that the most commonly affected age group was 16-19 years (60.8%).[8] Similarly, Ganguly et al. also found 71% cases of victim for the age group between 6-15 years.[9]

It was observed in our study that female victims represented 96.6% of cases and the male victims 3.4% of cases. All the males were victims of unnatural sexual offence. Similar results were observed by Bhowmik and Chaliha [10], Tamuli et al. [11] and Bandyopadhay et al. .[12] However, in Turkey Hüdaverdi observed that 82.1% were female and 17.9% male victims. This study reported greater number of male victims compared to our study.[13] Similarly, Irum and Arshad in Pakistan reported 67% females and 33% male victims.[14]

In our study, 82.04% cases were Hindus,15.05% cases Christians and 2.91% cases Muslims respectively. Different authors across India had observed similar findings.[10,11,15,16] Hinduism is the major religion in India and hence, a greater number of cases among the Hindu community. On the contrary, Al-Azad et al. in Bangladesh, Arif et al. in Pakistan had reported a Muslim preponderance.[5,17]

In our study, a rural predominance (50.48%) of cases were observed. Similar findings were also observed in Bangladesh by Abdul .[18] In a similar study in South Africa, Phaswana et al. reported that most of the victims were from urban areas which contradicts our results.[19] In India, rural population is larger than that of the urban population. Therefore, it is evident that cases from rural background would be more than that of the urban areas.

In our study, majority of victims (36.89%) were educated up to higher secondary level followed by primary - level educated (35.44%). 16.99% victims were totally illiterate and 8.74% victims were highly educated. Our findings correspond to studies by Abdul [18] in Bangladesh, El-Elemi et al. [19] in Egypt, Phaswana et al. in South Africa.[20] In contrast, Manzoor et al. [4] in Pakistan, and Sahu et al. [8] reported that the majority of victims were illiterate.

In our study, majority of the victims were students (36.89%) followed by unemployed (32.52%) and laborers including maids (16.99%). It was also observed that 9.71% of victims were married housewives and rest 3.89% belonged to employed category.

Manzoor et al.[4] in his study done in Pakistan and Abdul in Bangladesh noted that majority of the victims were unemployed (82.4%) and students (50%) respectively.[18] Similar studies conducted in India by Bhowmik and Chaliha [10] and Tamuli et al. [11] in Guwahati, Das et al. [16] in West Bengal and Kumar et al. reported that students were the common victims of sexual offence which is at par with our findings.[21] In Odisha, Sahu et al. also reported that most of the victims were unemployed (84.7%).[8] Students were more prone to sexual assault because of a lack of sex education in our society.

Almost half of study population fell under low socioeconomic category (50.97%) followed by medium category (47.09%) and a few were included in the high socioeconomic bracket (1.94%). Our findings coincide with that of other studies.[5,17]

Out of 206 victims examined, 84.47% were unmarried, followed by 13.59% married, 0.97% divorced and 0.97% widows. From this data, it is concluded that sexual offences are more common among unmarried girls. Manzoor et al. [4] in Pakistan, El-Elemi et al. [19] in Egypt, Phaswana et al. in South

Africa also reported similar findings.[20] However, some authors had obtained different findings. Haider et al. reported that majority of the victims (58.6%) were married.[6] Similarly, Suri et al. observed that married victims (96%) outnumbered unmarried.[22] Most of the victims of unmarried group were adolescents and sexually active. Due to less psychological maturity, they might not have been able to protect themselves from acquaintances or strangers.

68.44% of victims belonged to nuclear families, 16.02% to joint families and 15.54% of victims were staying alone or separated from family members. Similar study by Das et al. in Kolkata reported that 54% of victims belonged to nuclear families and 46% belonged to joint families.[21] Another study conducted by Suri et al. in Delhi reported that 48% of victims were living away from their families.[22]

78.16% of cases occurred indoors including the victim's own house (28.16%), accused's house 6.31%, relative's 8.74% and 34.95% in other places like hotels, hostels etc. 21.84% cases occurred outdoor. Similar, findings were also observed by Hüdaverdi in Turkey when he reported 36.9% of sexual assault cases in victim's own home.[13] Similarly, Al-Azad et al. also found that most of the incidents (36.95%) occurred in victim's house.[17] However, studies by Barman and Nabachandra [16] in Manipur and Kumar et al. [23] reported that the most common site of offence was at the accused's house or his relative's house. The high incidences of indoor occurrence especially in the victim's own house may be due to restrictions imposed on females to not go outside and subsequent advantage taken by the offenders when females are left alone back home. It may also be due to consensual sex in the absence of family members or relatives.

In our study, we observed that majority of offenders (87.38%) were acquainted with the victims for a variable time period; lover or boyfriend constituted more than the half of study population (55.83%). Total strangers were involved only in 4.85% of cases. No case of 1st degree relative was registered as offender. We deduced that in 95.15% of cases, the offenders were known to the victims and in the rest, the perpetrators were strangers. Manzoor et al. [4], Arpana et al. [15] and Kumar et al. reported similar findings.[16] Close proximity to the victim was used influence the victim in many cases. However, Hüdaverdi in Turkey and El Elemi et al. in Egypt reported that the perpetrators were not known to the victims in most of the cases.[13,20]

Most of the victims (33.02%) reported 1 month after the occurrence followed by 31.06% reporting between 1 to 7 days and 21.35% between 7 days to 1 month. Only 14.57% of victims reported within 24 hours of the occurrence. Sohail and Arshad observed that the average time of reporting was as early as 2 hours and as late as 240 days.[14] Khan et al. found that reporting time after the event of rape varied from 6 hours to 2 months.[24]

Time period between incidence and medical examination was categorized according to the possibility of survival of spermatozoa inside the vaginal canal or uterine cavity. Most of the cases were produced for examination after 72 hours of occurrence i.e. 65.05% cases. Tamuli et al. , in their study, noted that 23% of the victims were examined on 3rd day after the incidence.[11] The delayed reporting and medical examination of the victims was due to social stigma, possibility of resolving the matter through village gram panchayat initially, being considered promiscuous and responsible for incident, attendant humiliation and shame, embarrassment caused by appearance and cross examination, publicity in press, risk of losing love and respect from society, friends and that of her husband if married.

In our study 75.24% of victims had admitted to have given consent for the sexual act whereas in 24.76% of victims, offence was committed without consent. This data is similar to the observation of Barek in Bangladesh, who found that maximum incidences were consensual (73.86%).[18] Bandyopadhay et al. [5] and Arif et al. [12] had documented 4-6% of cases of non-consensual sex offence by administering alcohol or drug intoxication. Contradicting our finding, Suri and Sanjeeda and Kumar et al. found that most of the cases were non-consensual (69% and 60.56% of the victims respectively).[16,22]

Conclusion

Rape victims usually belong to the adolescent age group of 12-18 years and were mostly unmarried and unemployed. They often do not receive the care and attention they seek and deserve. There is a pressing need to have a well-structured scheme of intervention and assistance for such victims. Such crimes can be prevented by proper education, awareness, training on self-defence and strict enforcement of law and order.

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ORIGINAL ARTICLE

Histopathological changes in lungs, liver and kidneys in cases of death due to agricultural poisoning in a tertiary care centre: A cross sectional study

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Abstract
Medico legal deaths due to agricultural poisoning claim a substantial number of lives in Andaman and Nicobar Islands. Respiratory failure is the most common complication of OP poisoning leading to death. Histopathological studies of viscera in organophosphate poisoning cases help the autopsy surgeon in ascertaining out the secondary causes of death. Microscopy of three visceral organs-lungs, liver and kidneys of 40 cases of organophosphate poisoning were studied and the changes were correlated with the duration of survival post consumption. By knowing the exact histopathological changes in these organs, it is easier to attribute death to a failure of one of these organs as a consequence of organophosphate consumption. Knowing the rapidity of involvement of an organ is beneficial to the treating physician as well thereby helping him reduce the morbidity and hence mortality.

Keywords
Organophosphate poison; Histopathology; Lungs; Liver; Kidneys; Cause of death

Introduction

Organophosphates constitute a heterogeneous category of chemicals specifically designed for the control of pests, weeds or plant diseases. Their application is still the most effective and accepted means for the protection of plants from pests, and has contributed significantly to enhance agricultural productivity and crop yields.[1] Their common availability renders organophosphate insecticide poisoning a worldwide health issue with a high fatality rate, especially the suburban and rural population. Most of the pesticide poisoning and subsequent deaths occur in developing countries following a deliberate self-ingestion of the poison.[2] It is roughly estimated in India that 5 to 6 people per lakh population die due to poisoning every year and the most common cause of poisoning in India and other developing countries is organophosphorus compounds.[3] Medico legal deaths including OP poisoning claim a substantial number of lives in Andaman and Nicobar Islands. Respiratory failure is the most common complication of OP poisoning leading to death. In every centre carrying out medico legal work, autopsies of poisoning cases form a sizeable group and the autopsy surgeon is required to give his opinion regarding the final cause of death which in most cases can only be determined after looking into the chemical analysis report from the Forensic Science Laboratory and the histopathological reports of the viscera sent to the Department of Pathology. In most of the cases death may occur immediately due to respiratory centre and muscle paralysis after consuming poison or may be delayed for days or weeks together. Delayed causes of death may be due to ARDS, respiratory paresis, liver failure and renal failure. In the latter cases the determination of exact cause of death may be difficult as external appearance may not give any clue and the internal examination may sometimes not reveal anything much on gross examination. Histopathological examination can reveal such pathologies in major organs like lungs, liver and kidneys where the poison acts, gets absorbed and is finally eliminated. This study was conducted with an aim to study the progressing effects of the insecticide on organs and to give a much clearer opinion regarding the cause of death.

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Materials and Methods

This study was carried out in the Department of Forensic Medicine and Toxicology in collaboration with the Department of Pathology, ANIIMS, Port Blair, Andaman and Nicobar Islands for a period of 1 year with a sample size of 40 cases. It was ensured that in all 40 cases of ingestion of agricultural poisons, the three organs, lungs, liver and kidneys were collected and fixed in 10% formalin and sent for histopathological examination to Department of Pathology. The routine viscera were sent to the FSL for chemical analysis. Duration of survival in hours was noted in all cases. Cases which were treated in the hospital with a doubtful history of agricultural poison consumption were excluded from the study.

Results

The duration of survival post consumption has been divided into 3 categories: those who survived for less than 24 hours (<1 day), 24 hours to 72 hours of survival (1-3 days) and more than

72 hours of survival post consumption (>3 days). Out of the 40 cases, 6 cases (15%) survived for a duration of less than 24 hours,8 cases (20%) survived for a duration between 24 and 72 hours and 26 cases(65%) survived for a maximum duration; i.e more than 72 hours as shown in Table 1.

Table 1: Duration of survival (N=40)

Duration of Survival	n
<24 hours	6
24-72 hours	8
>72 hours	26

Table 2: Histopathological changes in the liver (N=40)

HPE findings	n	%
Congestion	21	52.5
Fatty changes	8	20
Centrilobular Necrosis	4	10
Alcoholic Hepatitis	5	12.5
Sinusoidal dilation	2	5

HPE = histopathological examination

Table 3: Comparing the changes in the liver with the duration of survival

	Duration of Survival		
HPE findings	<24 hours	24 -72 hours	>72 hours
Congestion	6	4 (50%)	11 (42.3%)
Fatty changes	0	2(25%)	6 (23%)
Centrilobular Necrosis	0	0	4 (15.3%)
Alcoholic hepatitis	0	2(25%)	3 (11.5%)
Sinusoidal dilation	0	0	2 (7.69%)
Total	6	8	26

HPE = histopathological examination

Table 4: Histopathological changes in the lungs (n=40)

HPE findings	n	%
Congestion	40	100
Suggestive of ARDS	38	95
Changes S/o Bronchopneumonia	2	5

HPE = histopathological examination

Table 5: Comparing the changes in the lungs with the duration of survival

	Duration of Survival		
HPE findings	<24 hours	24-72 hours	>72 hours
Congestion	0	0	26
Suggestive of ARDS	0	0	38
Changes S/o Bronchopneumonia	0	0	2

HPE = histopathological examination

Table 6: Histopathological changes in the kidneys (N=40)

HPE findings	N	%
Congestion	40	100
Suggestive of ATN	34	85

HPE = histopathological examination; ATN = acute tubular necrosis

Table 7: Comparing the changes in the kidneys with the duration of survival

	Duration of Survival		
HPE findings	<24 hours	24-72 hours	>72 hours
Congestion	40	+	+
Suggestive of ATN	0	8	26

HPE = histopathological examination; ATN = acute tubular necrosis; + = indication that congestion was associated with features suggestive of ATN

Table 8: Comparison between two studies on the HPE findings in the liver HPE findings

HPE findings	Present Study	Sutay and Tirpude[8]
Congestion	52.5%	46.51%
Fatty changes	20%	34.88%
Centrilobular Necrosis	10%	9.30%
Alcoholic Hepatitis	12.5%	2.33%
Sinusoidal dilatation	5%	6.98%

HPE = histopathological examination

Of the 40 specimens of liver sent for histopathological examination, congestion of the liver was observed in 21 cases (52.5%), followed by 8 cases (20%) showing fatty changes in the liver, 4 cases (10%) revealed centrilobular necrosis and 5 cases (12.5%) of alcoholic hepatitis and 2 cases(5%) of sinusoidal dilation of the liver as depicted in Table 2. All cases (6 cases-100%) which had a survival duration of less than 6 hours showed congestion of the liver. Cases with a survival between 24 hours and 72 hours showed congestion of liver in 4 cases (50%), and 2 cases (25%) each showed fatty changes and alcoholic hepatitis. Cases with a survival beyond 72 hours showed congestion in 11 cases (42.3), fatty change in 6 cases (23%), centrilobular necrosis in 4 cases (15.3%), alcoholic hepatitis in 3 cases (11.5%) and sinusoidal dilation of liver in 2 cases (7.69%) as shown in Table 3.

As shown in Table 4, of the 40 specimens sent, congestion of the lungs was observed in all cases. Associated with congestion, 2 cases showed changes of bronchopneumonia and remaining 38 cases revealed necrosis of epithelium with formation of hyaline membrane. Congestion of the lungs was seen in all cases which had a survival up to 72 hours. Cases with a survival beyond 72 hours showed congestion in 26 cases (100%). Necrosis of epithelium, with formation of hyaline membrane was observed in 38 cases (95%), changes of bronchopneumonia in 2 cases (5%) as described in Table 5.

Of the 40 specimens sent, congestion of both the kidneys was observed in all cases. Associated with congestion, features such as necrosis, degeneration and regeneration of tubular epithelium

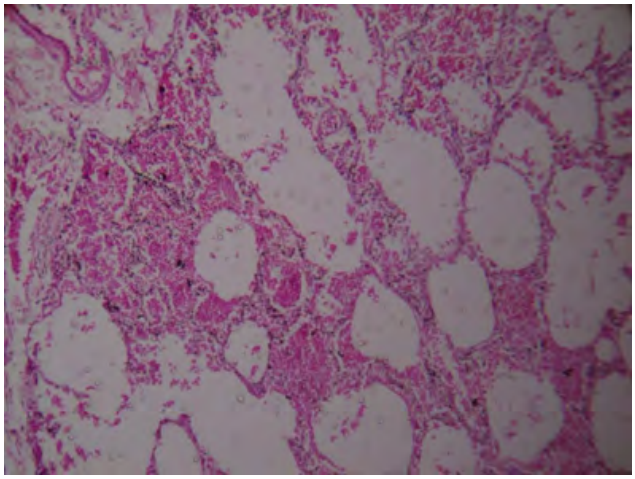

Figure 1: Histopathological slide showing pulmonary congestion in OP Poisoning.

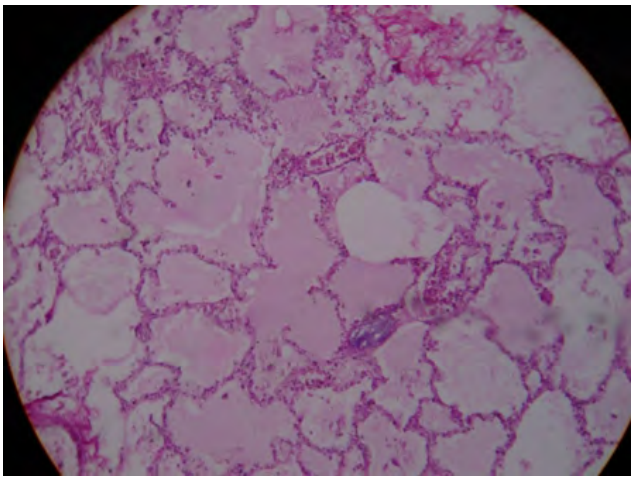

Figure 2: Histopathological slide showing pulmonary edema in Aluminum Phosphide poisoning.

suggestive of acute tubular necrosis were observed in 34 cases and tabulated in Table 6. Congestion of the kidneys was seen in all cases which had a survival up to 24 hours. Congestion associated with necrosis, degeneration and regeneration of tubular epithelium was observed in 8 cases (100%) within duration of survival of 24-72 hours and 26 cases (100%) beyond duration of 72 hours survival as shown in Table 7. Histopathological changes resulting from different poisons have been represented in Figures 1-11.

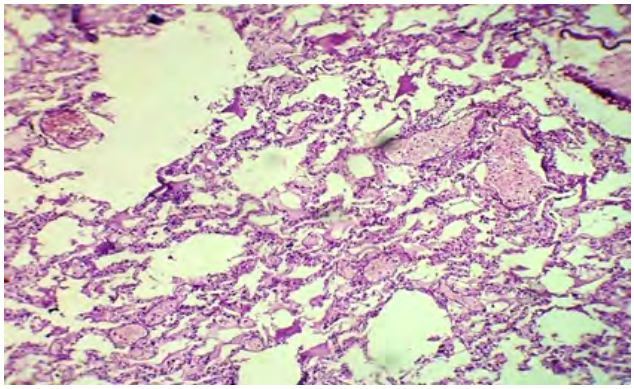

Figure 3: Histopathological slide showing of Diffuse Alveolar Damage in lungs (ARDS) in Carbamate Poisoning.

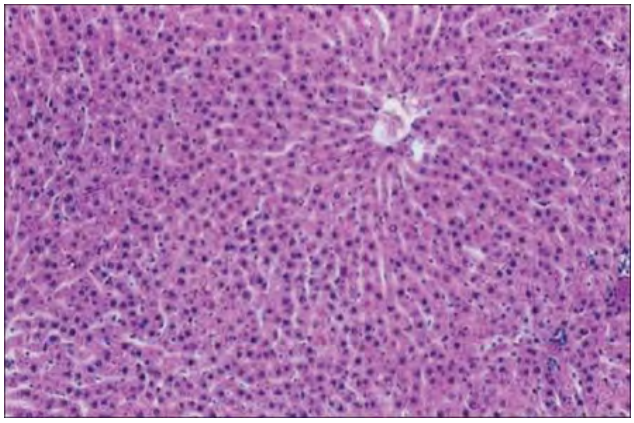

Figure 4: Histopathological slide showing liver congestion in Aluminum phosphide poisoning.

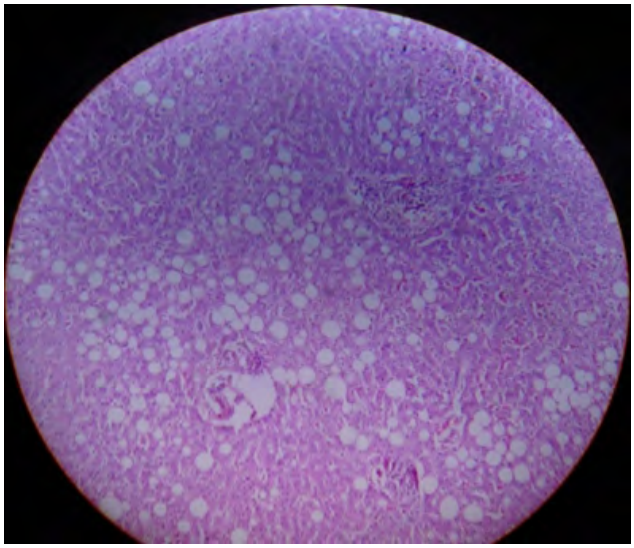

Figure 5: Histopathological slide showing Fatty change in the liver

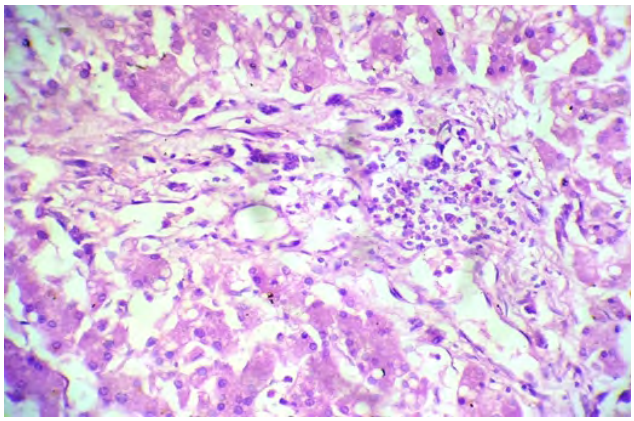

Figure 6: Histopathological slide showing portal inflammation in the liver

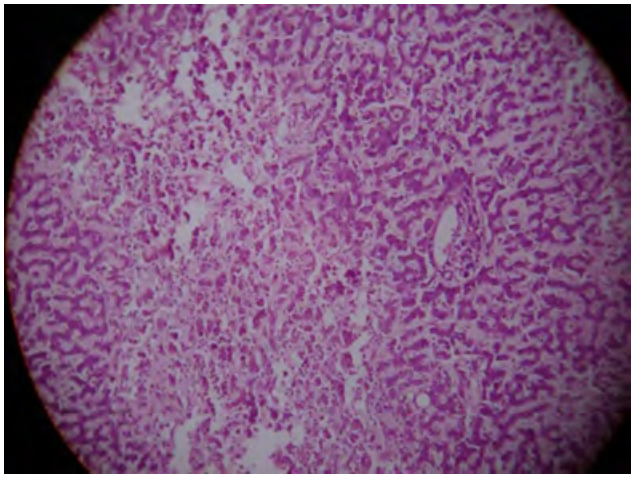

Figure 7: Histopathological slide showing Hepatic necrosis (centrilobular necrosis)

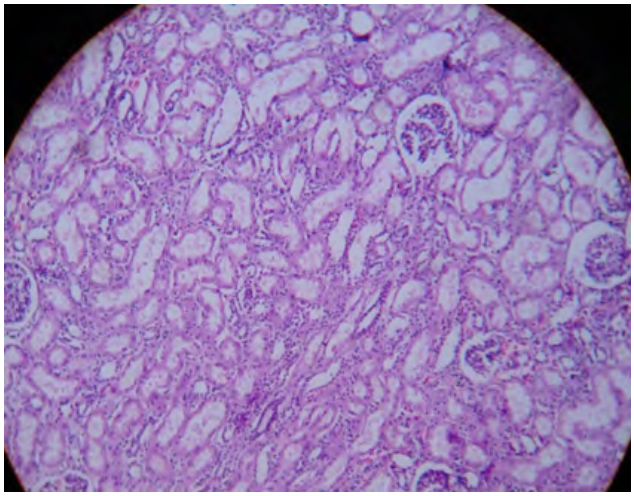

Figure 8: Histopathological slide showing degenerative changes in the kidney

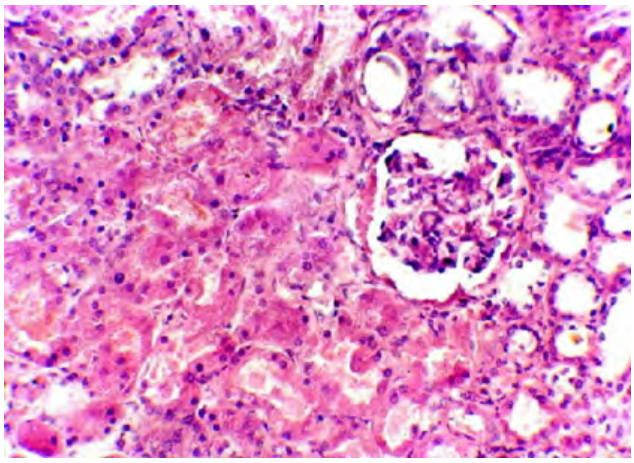

Figure 9: Histopathological slide showing cloudy degeneration in the kidney

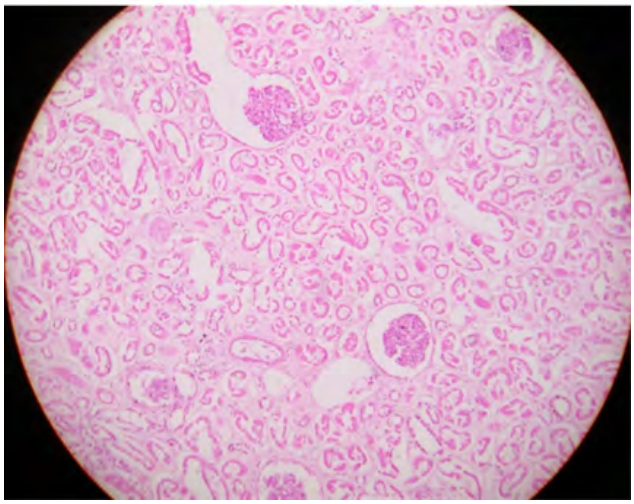

Figure 10: Histopathological slide showing acute tubular necrosis in kidney

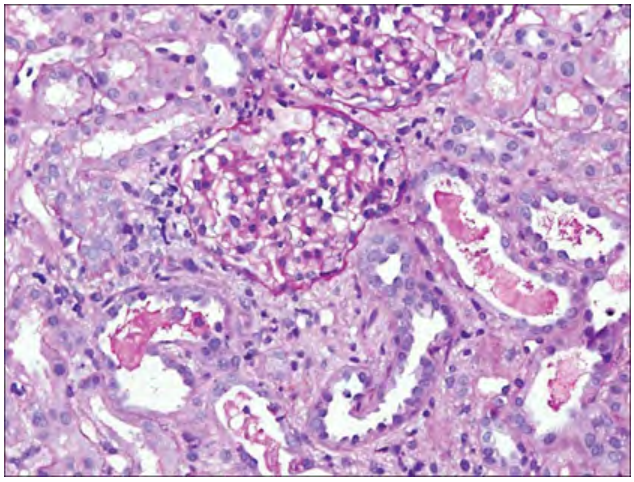

Figure 11: Histopathological slide showing acute tubular necrosis with tubular casts

Discussion

It is interesting to note in the present study that the deliberate ingestion of Organophosphate with suicidal intention is more common in males (65%) compared to that of females (35%) and is consistent with the studies conducted by Rao et al.[4],Gannur et al.[5], Agarawal et al.[6], contrary to the studies conducted by Chataut et al.[2], Paudyal et al.[7] The histopathological findings in the liver in the present study were compared with the findings of the study conducted by Sutay and Tirpude.[8] As depicted in Table 8, congestion of the liver was appreciated in a maximum number of cases in both the studies, 52.5% in the present study and 46.51% in the comparative study, followed by fatty changes in the liver in 20 % of cases in the present study compared to 34.88% centrilobular necrosis of the liver seen in 10% of cases in the present study compared to 9.30% in the comparative study. The microscopic feature least seen in the present study was the sinusoidal dilation of the liver amounting to 5% and the microscopic feature least seen in the comparative study was alcoholic hepatitis of 2.33%. Poison and toxin which are released during metabolism and hemolysis results in organ failure as a consequence of ARDS in lungs, centrilobular necrosis in the liver and acute tubular necrosis of the kidneys. Release of cytokines such as activated macrophages and activated neutrophils results in formation of hyaline membrane resulting in a stiff lung. Bronchopneumonia may be attributed due to aspiration.

Conclusion

In the present study which mainly concentrates on the histopathological findings it is to be noted that all the organs (lungs, liver and kidneys) sent for histopathological examination showed some effects of the poison ingested. The liver is the main organ for detoxification of poison and the kidneys are the main organs of excretion of the poison and this fact was evident from the congestion appreciated in these organs. Features such as ARDS secondary to ingestion was observed in all cases with a survival period beyond 72 hours. Features in the kidneys involving the tubules (degeneration, regeneration and necrosis) were appreciated in almost all cases. Through this study, the confusion among the autopsy surgeon regarding the final cause of death is minimized. A clearer and specific opinion regarding the cause of death can be opined in all cases showing features of ARDS, and death can be opined as respiratory failure resulting from organophosphate poisoning, and in cases showing acute tubular necrosis, the cause of death can be opined as acute renal failure as a result of organophosphate poisoning. Understanding the rapidity of involvement of an organ is beneficial to the treating physician as well thereby helping him reduce the morbidity and hence mortality.

Ethical clearance: A prior approval was obtained from the Institutional Ethics Committee

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ORIGINAL ARTICLE

Significance of weight for sexual dimorphism of talus bone

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Abstract

The present study aims to determine the sexual dimorphism of talus bone by using weight as a parameter. 100 pair of talus bones of known sex obtained from unknown or unclaimed cadavers brought to the mortuary for autopsy were included in the study. Weight of right talus and left talus of 50 males and 50 females was measured using an electronic weighing scale in this cross-sectional study. All the measurements in male talus were greater than the measurements in female talus bones. Univariate discriminant and logistic regression analyses were conducted on the data to estimate sex from the weight of the talus bone. The overall accuracy came out to be 89% in both sexes (84%-90% in males and 88% - 94% in females). In contrast to Identification and Demarcating points, Limiting point showed maximum classification accuracy in sex determination. Weight of talus bone thus showed statistically significant sexual dimorphism results and can be used to estimate sex along with other parameters

Keywords

Talus bone; Sexual dimorphism; Discriminant analyses; Logistic regression analysis; Weight.

Introduction

The determination of sex from an adult human skeleton is a fundamental task for forensic and physical anthropologists. In these fields, it is important to determine the sex of a human skeleton regardless of its state of preservation. Sexing of the bone is not only dependant on the morphological traits but also the morphometrical analysis. Standards of skeletal identification vary among different population and the same cannot be used for another population.[1] Identification of sex by weight have been carried out for femur[2,3], clavicle[4,5], hyoid[6,7] and almost all other bones of the human skeleton which shows some degree of sexual dimorphism. Most of these bones as described in the above studies are often recovered either in fragmented or in incomplete state, so it has become necessary to use denser or robust bones which are often recovered intact e.g., patella, talus, calcaneus.[8]

Tarsals are fairly dense bones and can be more durable than other bones, such as the pelvis that are usually employed to determine biological sex.[8,9] Another advantage of taking tarsal bones is that feet are often protected by shoes which may retard the damage to the bones due to external agents.[10] Keeping in view these points, the aim of the present study was to assess the weight of talus bone of both feet and in both sexes and to determine and compare accuracy of this parameter for differentiation of sex of an individual by applying different statistical methods.

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Material and Methods

The present study was conducted in the Department of Forensic Medicine of Pt. B.D Sharma PGIMS, Rohtak, where a total of 100 pairs of talus bones (50 male and 50 female), one from each foot were collected from unidentified dead bodies brought in the mortuary for medico-legal post-mortem examination. The study was a cross-sectional one, with purposive non-random sampling done on north Indian population. The study was started only after obtaining approval from the Institutional Ethical Committee. All the talus bones samples taken were from unidentified and unclaimed corpses aged more than 20 years from identifiable sex. Unknown and unclaimed dead bodies were chosen to avoid ethical dilemma due to undue disfiguration of known cadavers. The age of the subjects was derived from established bone age-based parameters. Dead bodies with any skeletal defects, congenital anomaly, bony fractures or fragmented and burnt bones were excluded from the study. Old age samples were not used because of appearance of age-related changes which could have affected the results. The bones were removed by causing minimal disfigurement of the body from each ankle joint in a planter flexed position by making a horizontal incision over anterior aspect of ankle joint midway between the two malleoli and exposing the superior surface of talus. Then, soft tissues were dissected from medial and lateral side of talus freeing the bone

of all its attachments. The separated bones from each foot were kept in two separate jars each containing plain tap water and the jars were labelled with the case id number, sex and the side of the foot. No chemicals were used to clean the bones to avoid any erosion of the bone. The bones were examined intermittently and once the soft tissue got separated, the bones were cleaned and dried at room temperature. All the bones were kept separately in duly numbered packets for further analysis. The dried bones were weighed using a digital weighing machine having an air tight chamber. Each bone was put over the weighing machine turn by turn and weighed to a precision of 0.01 gm. Three readings were taken with the electronic weighing machine at different times and the average was recorded. SPSS version 20 was used for analysis of results. Using the data obtained, a Kolmogórov–Smirnov test was performed to study the distribution of the sample and then a paired t test was performed to verify whether there were statistically significant differences between the right and left side. Descriptive statistics was used to calculate independent t test to verify whether statistically significant differences exist between two means and then further testing was done using discriminant analysis, logistic regression analysis and determination of identification, demarcating and limiting point. P-value of less than 0.05 was considered significant.

Identification Point for male talus was the maximum weight recorded for the female talus, while Identification Point for female talus was the minimum weight recorded for the male talus. All bones having weight more than the Identification Point for male were correctly identified as males and all bones having weight less than the Identification Point for female were correctly identified as females.[2-4] Demarcating Point was calculated by using mean ±3SD. Maximum weight recorded for the female talus by using calculated range was the Demarcating Point for male talus and the minimum weight recorded for the male talus by using the calculated range was the Demarcating Point for female talus. All bones having weight more than the Demarcating Point for male were correctly identified as males and all bones having weight less than the Demarcating Point for female were correctly identified as females.[2-7] Limiting point was chosen in the study, calculated from the average of male and female identification points.[6,7] Talus bone weighing greater than the limiting point was categorised as male and value less than that was grouped into female category.

Results

The purpose of the current study was to demonstrate that the talus bone showed significant sexual dimorphism and to explore and assess the degree of sexual dimorphism in weight of the bone to accurately estimate sex. The results of this study produced coefficients from a sample of talus bones recovered from North Indian males and females in medico-legal autopsy cases. Firstly, on applying normality test, the hypothesis that the sample did not follow a normal distribution was not rejected because of the results obtained on the Kolmogórov–Smirnov test ($p<0.05$). So, both the variables i.e., weight of talus on both sides were not normally distributed. On application of paired t-test on both the variables, no significant weight difference on both sides was found ($p>0.05$).

Table 1: Descriptive statistics for weight of talus

Talus weight	Sex	Mean	SD	Range	Mean ± 3SD
Right	Male	27.18	4.534	18 – 35	13.58 – 40.78
	Female	18.28	2.899	11 – 25	9.58 – 26.98
Left	Male	27.1	4.564	18 – 35	13.41 – 40.79
	Female	18.28	2.878	11 – 25	9.65 – 26.91

SD = standard deviation

Table 2: Linear discriminant analyses for weight of talus

Statistical tests		Right talus	Left talus
Canonical Discriminant Function Coefficients Unstandardised	Coefficients	0.263	0.262
	Constant	-5.972	-5.947
Univariate Discriminant Analysis classification result summary	Male (%)	84	84
	Female (%)	94	94
	Overall accuracy (%)	89	89

Wilk's lambda for WRT (0.418 and WLT (0.423); Canonical correlation for both sides = 0.76, and Sectioning Point being – 0.585

Table 3: Logistic Regression classification result summary

	Right talus	Left talus
Male (%)	84	90
Female (%)	94	88
Overall accuracy (%)	89	89

Table 4: Regression models derived in the present study

Variables	R	R^2	SEE	P-value
WRT	0.763	0.582	0.326	<0.001
Regression Equation	Y= 2.988-0.065(x)			
WLT	0.760	0.577	0.329	<0.001
Regression Equation	Y= 2.984-0.065(x)			

WRT = weight of right talus; WLT = weight of left talus; SEE = Standard Error of Estimate

Table 5: Correct classification percentage of talus weight using Identification Points, Demarcating Points and Limiting Points

Sex	WRT	WLT	WRT	WLT	WRT	WLT
	IP (Correct classification %)	IP (Correct classification %)	DP (Correct classification %)	DP (Correct classification %)	LP (Correct classification %)	LP (Correct classification %)
Male	25(66)	25(66)	26.98 (48)	26.91 (46)	21.5 (92)	21.5 (90)
Female	18(56)	18(54)	13.58 (2)	13.41 (2)	21.5 (88)	21.5 (88)

WRT = weight of right talus; WLT = weight of left talus; IP = identification point; DP = demarcating point; LP = limiting point

Table 6: Comparison of data of present study with previous studies

Population		n	Mean	SD	Range	Mean± SD	IP %	DP %
Singh et al.[14] in Varanasi Population	WRTM	60	24.06	4.90	15.10-36.80	9.36-38.76	77	28
	WRTF	24	15.66	3.70	6.00-20.50	4.56-26.76	46	4
	WLTM	56	23.09	4.94	15.20-34.60	8.27-37.91	71	32
	WLTF	24	15.03	3.49	6.00-20.00	4.56-25.50	42	8
Ahmad et al.[15] in Pakistani Population	WRTM	52	29.23	3.68	22.40-34.20	18.18-40.28	85.7	85.7
	WRTF	24	22.25	0.68	20.99-23.50	20.49-24.61	61	0
	WLTM	54	28.76	4.45	22.20-36.98	15.41-22.11	85.7	71.4
	WLTF	30	22.15	0.71	20.49-23.11	20.02-24.28	50	0
Patel et al.[16] in Gujrati Population	WRTM	57	20.53	4.00	10.74-28.26	8.53-32.53	3.51	0
	WRTF	44	15.53	4.42	7.26-27.51	2.26-28.79	15.91	2.27
	WLTM	70	20.42	3.98	10.91-31.60	8.49-32.35	8.57	2.86
	WLTF	50	14.76	4.23	6.46-26.33	2.05-27.43	18	6
Present population	WRTM	25	27.18	4.53	18-35	13.58-40.78	66	48
	WRTF	25	18.28	2.89	11-25	9.58-26.98	56	2
	WLTM	25	27.10	4.56	18.35	13.41-40.79	66	46
	WLTF	25	18.28	2.78	11.25	9.65-26.91	54	2

WRTM = weight of right talus in males; WLTM = weight of left talus in females; IP = identification point; DP = demarcating point

The result of the descriptive test, univariate discriminant analysis and logistic regression analysis is shown in Table 1, Table 2 and Table 3 respectively. The mean value of male talus bones on both sides was statistically more than females and there was an overlapping zone in which both values from males and females found (Table 1). In univariate analysis, each of the significant measurements was individually subjected to discriminant analysis to test its efficiency in sex estimation (Table 2).[10] The results from the univariate analysis that were greater than the sectioning point were considered male individuals, and results that were less than the sectioning point were considered female individuals, while the results that were equal to the sectioning point were classified as indeterminate.[6] The logistic regression analysis also showed almost similar classification result as that of univariate discriminant analysis i.e. overall classification accuracy of 89% in both the variables (Table 3).

In Table 4, a correlation analysis was performed to verify how the variables relate to sex; if they were significantly related or are more highly related, since it was indicative of its predictive value, providing information on which variables will offer better results in the discriminant analysis. Both the variables showed almost similar coefficient correlations of 0.76 i.e., high positive significant correlations with sex of individual (p-value<0.001).

Table 5 shows the accuracy percentages of sex estimation from the identification, demarcating and limiting points of talus weight of both sides. Almost similar results were achieved by both the variables. Limiting point showed maximum sex classification accuracy whereas the Demarcating point the least. Table 6 compares the results of the present study against previous studies.

Discussion

The talus bone in the postcranial skeleton was selected to verify the discriminant power of the weight of bone in sex differentiation. The most sexually dimorphic bones i.e., pelvis and skull were not always available whenever bone remains are recovered, though their morphological study makes it possible to determine sex with a high rate of reliability. Different approaches and new studies on other bones in the postcranial skeleton are necessary to verify the percentage of accurate classification which can be achieved on the basis of the study variables, taking into account both the bone in its entirety and in parts, because bones are not always recovered in the best state of preservation.[11] For a variable to be dimorphic, and therefore a good discriminator of sex, not only should the average value for each sex be different, but also the distribution of measurements should overlap as little as possible.[12]

Mean weight of both sides for each talus was found to be significantly larger in males than in females ($p < 0.001$), suggesting that all of these measurements have potential as sex indicators (Table 1). The significant differences between male and female tali are due to differences in body size and in muscular activity of the individual, also cortical bone in males has higher growth than in females.[8-10,13] Weight of talus was also used as a parameter for sexual dimorphism by Singh et al.[14], Ahmad et al.[15] and Patel et al.[16]. Findings of present study are tabulated, compared and discussed with findings of these researchers (Table 6).

The male tali are heavier than the female tali, for both right as well as left side, in all the population and studies compared to present

one (Table 6). Also, the mean weight of right talus is marginally higher than the left talus, for males as well as females. However, mean weight of talus of Gujarati population[16], for both right as well as left side, is less as compared to weight of talus of Varanasi[14], Pakistani[15] and present population. The percentage of tali classified by identification point in this study is less than the study conducted by Singh et al.[14] and Ahmad et al.[15] but more than Gujarati population (Table 6). Moreover, the percentage of tali classified correctly by demarcating point is less than Pakistani population but more than other two studies conducted in India. The percentage of female tali classified by demarcating point is comparatively far less than that of male and this observation is same in other studies also. Other three studies did not classify their results by using limiting point, which proved to be most successful in discriminating sex in talus bone in the current study.

This preliminary study is perhaps the first work done on ascertaining the sexual dimorphism of weight of talus by using discriminant and logistic regression as tool for analysis. The most common used means for sex discrimination in unidentified skeletal remains is Discriminant function analysis. But, as discriminant function equations are population specific, [8,9,11-19] the equations derived in the present study can be used for determination of sex from the talus weight available specifically from the study population. By applying univariate discriminant analysis, the overall sex classification result came out to quite similar for both the variables i.e., right and left tali as 89% with similar male and female accuracy rates (Table 2). There was no use of application of multivariate discriminant analysis in this study as the variables used were very few and also showed same results in all the different methods.

Various simulations have shown that the difference in results between logistic regression and discriminant analysis is negligible when sample sizes are over 50,[17] as is the case in the present study, and therefore the results of this study should still be comparable to those produced by others using discriminant analysis. Logistic regression also has the advantage of relatively simple calculation of the probability of belonging to one sex or the other. Logistic regression equations that include two or more measurements for an individual bone improve the allocation accuracy about half the time in the reduced sample, when compared to the best single measure from the same bone.[18] The overall classification result by logistic regression analysis is almost similar to the classification result of discriminant analysis i.e., 89%.

The fact that no statistical difference was found in both the variables after applying paired t-test, implies that both left and right side of talus weight can be used individually if any of the sides is not available for sex differentiation in routine forensic practice. This proposition was further strengthened in different statistical analytical results conducted by authors in which all the classification results showed almost similar results for both the variables. Our finding is in concordance with the observations concluded by Islam et al.[19] and Mediavilla et al.[11]

Conclusion

The mean value of the male talus bone for the weight parameter was more when compared to the value of female bone bilaterally. The identification and demarcating points were of limited use in sex determination whereas limiting point showed significant classification accuracy. The accuracy percentage of correct sex estimation in univariate discriminant function analyses was 89% and it was similar as compared to logistic regression analysis. The statistical analysis of weights of talus bilaterally showed similar results, which is in agreement with the results of other bones of hands and feet and thus, any side of talus, could be used independently for sex determination if the other is not available. Also, for estimating sex in any bone, single parameter may not be sufficient to decide the sex of the bone and it becomes crucial to include other parameters before deciding the sex from an unknown talus bone.

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ORIGINAL ARTICLE

Mortuary management and public health

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Abstract

Mortuary is the place where autopsy of human beings where death due to unnatural circumstances is conducted. An attempt has been made by the investigators to conduct a study related to the standards of present mortuaries and to address the requirement for future challenges. A total of 16 autopsy centres were selected for the study during the period 2018-2019. This study is based on the available information provided from different mortuaries. Three teaching hospitals, five area hospitals and eight rural hospitals were selected. Post-mortem examination in Telangana state are done in designated hospitals run by the Government only. Teaching hospital mortuaries are provided with relatively good facilities like sanitation, permanent water supply, waste disposal and incineration plants as compared to area hospitals and rural hospitals. Menace of rodents is seen in all mortuaries present in teaching hospitals, area hospitals and rural hospitals. Addiction to alcohol is frequently seen among mortuary workers and even among the doctors. Number of post-mortem examinations in teaching hospitals is higher compared to area and rural hospitals. There are several areas in mortuaries, which are prone to producing infections and foul smells. As the bodies start decomposing, the foul smell increases and hence bacteria are also abundant in these areas. Extensive biological waste is produced. Maggots and other insects, all add to the poor conditions within mortuaries. All together the atmosphere in and around mortuary is poor and renovation of mortuaries is the need of the day.

Keywords

Mortuary; Autopsies; Public Health; Sanitation; Environment.

Introduction

The word mortuary is derived from mortem – death; the place where dead are examined. Earlier the equivalent word used was Morgue, which means a place where the dead bodies are stored. The mortuary is a place of mystery, sadness, grief or repulsion, and, to add to it often a poorly managed place. As a doctor, we expect some standards to be followed to run a mortuary.

Death of a human being, under unnatural circumstances invites the attention of the law. Subsequently, a medico-legal autopsy is done on that dead body to answer the questions posed by the Investigating officer. This requires a place to conduct the required autopsy. An Ideal Mortuary – Does it exist? The answer is always 'no' in the present scenario. However, something resembling an ideal mortuary can be prepared, even with the given resources. When we talk about an ideal mortuary, it starts from its location, structure, functions and the auxiliary services it provides to the society. The ideal location of any mortuary will be within the premises of the hospital, so that if any death occurs in the hospital, the body can be shifted there immediately. It is a functional unit which requires certain infrastructure, in terms of the erected structure and the equipment. The building requires some important rooms within it viz., dissection room, room for preservation of tissue and viscera, laboratory, room for receiving and disposal of dead bodies, body storing area, doctor's office with its ante-room, toilet facility for the doctors and mortuary staff, shelter for the relatives of the deceased with attached toilet, inquest room, and an additional room for other officials who visit the mortuary.

All mortuaries may not have the same amount of workload. Hence it may not be possible for the Government to provide all facilities to all mortuaries where the medico-legal autopsies are conducted. In some states, the medico-legal autopsies are conducted even in private hospitals where there is permission for such procedures. The managements of those hospitals also may not provide all the requirements of so called ideal mortuary. The techniques of conducting the medico-legal autopsies are changing by time with the advancement in Science and Technology and also in the quality of crime. Keeping in view the above facts, the facilities which are present today may not be sufficient to cater tomorrow's requirement.

That day is not far away, when an autopsy on a dead body will be completed without dissection, with answers to all questions. This is called a "Virtopsy".[1,2] When such virtual autopsies are encouraged, the scene of mortuary will be entirely changed.[3-5] But are the present mortuaries equipped to evolve accordingly? The present study was conducted to answer the above question.

A detailed study is needed on the available facilities in the existing mortuaries in the state in different setups, their capacity

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to meet the demands, their incapacities and lacunae, their ability to adopt any advancements in that setup. However, this study is based on the available information provided from different mortuaries of the present day and thus it may be lacking some important information in regard to the policy matters of the Government.

Material and Methods

The study of public health in relation to the mortuary needs a continuous observation and monitoring of the functioning of the mortuary.[6,7] Health related problems will be seen in people working in the area of mortuary, which includes doctors, paramedical staff, workers of the mortuary, scavengers, relatives of the deceased, officials, public workers, public representatives, etc.

Apart from the above, there are many fauna which thrive on biological waste, which includes rodents, roaches, frogs, ants, flies and beetles, etc.

These health hazards[8-10] are seen not only directly on men in the vicinity of the contaminated environment of the mortuary, but will also be carried by the other living organisms.

The Inclusion criteria for the study was all types of mortuaries near to Hyderabad, opinions expressed by the doctors working in the hospital and opinions of the persons who came to attend to these mortuaries. The exclusion criteria was mortuaries under renovation, mortuaries started one year back and opinions of persons who are not well versed with the mortuary proceedings.

All the data collected was analysed by using the Excel sheet and observations laid down. However, an attempt for comparing with other mortuaries is made.

Results

The present study is based on the information provided by the different autopsy centres of hospitals. Three teaching hospitals, five area hospitals and eight rural hospitals were selected for the present study. The teaching hospitals studied are Osmania Medical College, Hyderabad, Gandhi Medical College, Secunderabad, Kakatiya Medical College, Warangal, of Telangana state. The area hospitals studied are of Pargi, Vikarabad, Sangareddy, Jacherla and Nalgonda of Telangana state. Rural hospitals studied are Ibrahimpatnam, Sadashivpet, Zaheerabad, Kohir, Tandur, Medchal, Gajwel and Ramannapeta of Telangana state. The identity of the hospitals is not revealed in the present study as it was requested by the heads of those centres. (Figure 1)

Except for two rural hospitals, rest hospitals have an identified area to conduct autopsies. All teaching hospitals have a permanent structure for conducting autopsies. In one area hospital there is no permanent structure for mortuary and it is run in GI tin-shed, whereas five of eight rural hospitals have a permanent structure for mortuary and for the rest, it is done under temporary arrangements. The average number of post-mortem examinations in teaching hospitals varies from 7.1 to 13.6 to 14.2 per day. Whereas in area hospital it is ranging from 0.6 to 1.2 per day. In rural hospital, 0.1 to 0.4 post-mortem examinations are conducted per day. [11, 12]

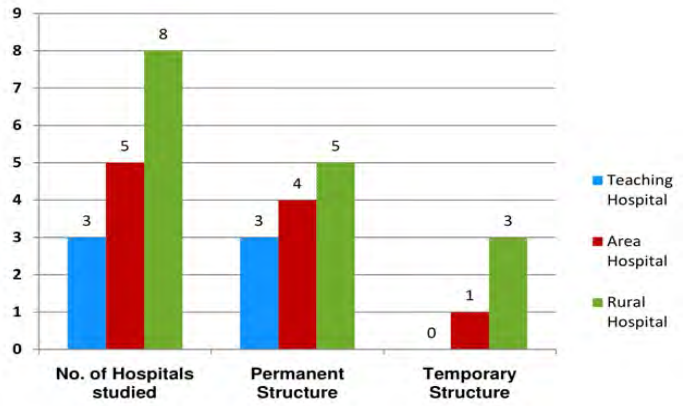

Figure 1: Number of hospitals studied and structure of mortuary

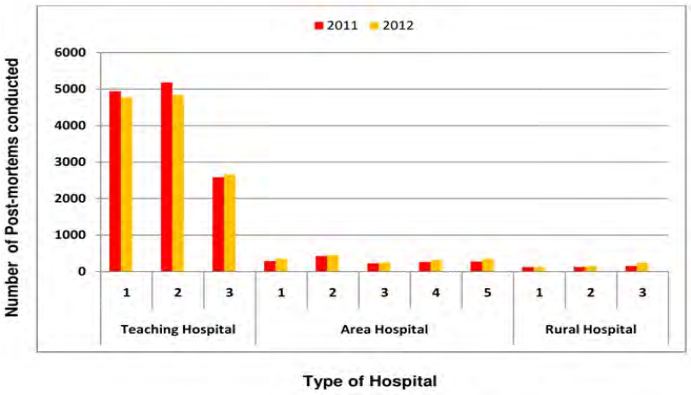

Figure 2: Number of post-mortem examinations conducted during 2011 and 2012 in hospitals

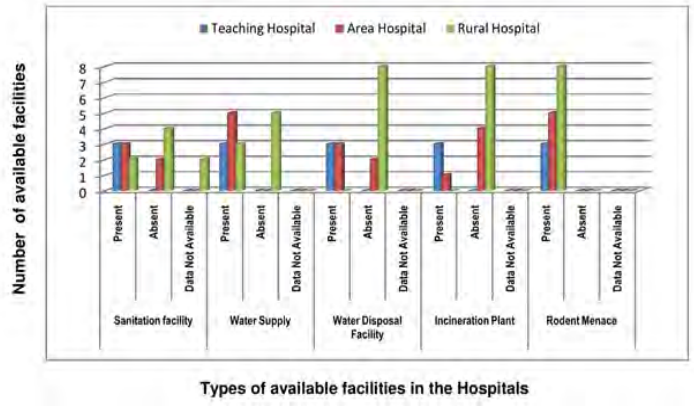

Figure 3: Availability of facilities in hospitals during 2011 and 2012

Information regarding the total number of doctors working in teaching hospitals was not made available. In area hospitals, about 17 to 25 doctors are working. In rural hospitals, the number of doctors is varying from 2 to 6.

Doctors qualified in Forensic Medicine (M.D. in Forensic Medicine) are working only in teaching hospitals and some area hospitals and no qualified doctors in rural hospitals in the surrounding areas of Osmania Medical College. Workload on the mortuaries of teaching hospitals appears to be decreasing as some centres in the periphery areas have been identified by the Government for conducting autopsies.

The average number of post-mortem examinations conducted by each doctor in teaching hospitals varies from 320, 400 and 520. In area hospitals, 12 to 20 autopsies[13, 14] are conducted in a year in average by each doctor. In rural hospitals, the total number of autopsies conducted in a year are around 20 to 50 by each doctor. (Figure 2)

Sanitation facility is present in all teaching hospitals. In 40% area hospitals, sanitation is available. In rural hospitals, it is seen only in 25% (2 of 8) of them. Permanent water supply facility is seen in all teaching hospitals. It is also seen in all area hospitals. But only in 27.5% (3 of 8) rural hospitals permanent water supply is established. (Figure 3)

Waste disposal is done according to the existing guidelines given by the Bio-medical waste management and handling norms in all teaching hospitals. It is observed in 60% (3 of 5) of area hospitals. Waste is not properly disposed in all rural hospitals. Incineration plant is established in all teaching hospitals and they are properly working to reduce pollution. In only one Area hospital, there is a functioning incineration plant present. No rural hospital has an incineration plant. Menace of Rodents is seen in all mortuaries present in teaching hospitals, area hospitals and rural hospitals. Sufficient data is lacking regarding the outbreak of infectious diseases.

Addiction to alcohol is frequently seen among the mortuary workers and even among the doctors. So far, 9 persons in teaching hospitals, 10 persons in area hospitals and 6 persons working in rural hospitals have been found to be chronic alcoholics. In teaching hospitals, 3 persons committed suicide and 1 person attempted to commit suicide. One person committed suicide in one of the rural hospitals. Data regarding the suicides was not available from the area hospital.

Familial disharmony is one of the social problems quite frequently seen among the workers of the mortuary. It is also seen in doctors who regularly visit the mortuary. On records, not many cases are found but, 6 persons from teaching hospitals [16, 17] had familial problems and 2 were facing marital problems. Only one doctor from the area hospital had familial problems. Opinion of the visitors and attendants of the deceased are not available as their stay in the mortuary area was short and many of them were reluctant to give such opinions.

Discussion

The present study was undertaken on the basis of information provided by the autopsy centre in hospitals, and identifies the common social and environmental problems which are of public health and importance. Hospitals present nearby Hyderabad were selected for the study. Kakatiya Medical College, Warangal; Gandhi Medical College, Secunderabad were also considered as they are the major centres conducting autopsies at their end.

Almost all centres have an identified area as 'Mortuary.' Many of them having a permanent structure, where water facility is available. But in some rural hospitals, autopsies are still done under temporary arrangements. Hospitals having all facilities are far away from the police stations and the political leaders put pressure on the medical staff to conduct autopsies in centres devoid of all facilities. Number of post-mortem examinations conducted is increasing with time. But in two teaching hospitals the number came down in the last year because other centres started taking the autopsy work nearby.

Osmania Medical College, Hyderabad, Gandhi Medical College, Secunderabad, and Kakatiya Medical College, Warangal, have several peripheral hospitals but the exact strength of the employed doctors is not available. However, qualified Forensic Medicine experts are available only in teaching hospitals and some area hospitals, and none in rural hospitals.

On an average, 300 to 500 post-mortem examinations are performed by a qualified Forensic expert in a teaching hospital. And in area hospital, the number of autopsies is between 12 and 20. This may be because less number of autopsies are conducted per year and more number of doctors are available even though they are not specialized. In rural hospital, the workload has increased a little from 20 to 50. This is once again because of less number of doctors available.

Sanitation is a major problem in rural and area hospitals because adequate staff will not be present and the employed staff has to look after other areas of the hospital and the workers invest very little time and effort towards mortuaries. Water supply is given at least to all mortuaries. However, in some rural hospitals, the water is made available by buckets.

Waste disposal many times invites public notice. It is more so when the mortuary is situated nearby a habitation. It is poorly managed in rural hospitals, as there may not be enough protest from the civilians. Incineration plant is a costly equipment, and its maintenance is even costlier. Hence, it may not be available

to many institutions. Fortunately, all teaching hospitals have the facility to burn biological waste.

Rodent menace is high in mortuary area due to the accumulation of biological waste. Fortunately, infections are uncommon in the existing mortuaries. It may not be due to the appropriate precautions being taken but due to the immunity levels of the people employed there.

As the mortuary is not an ideal area to be working in for most individuals, they often resort to alcoholism to escape from the foul smelling gases, unclean environment and from having to deal with death on a daily basis. Familial disharmony is rampant among the workers of the mortuary. Suicides are not frequently seen among the mortuary staff but there are some instances where persons commit suicides. Many of them are due to their personal and social reasons and may not be related to the working atmosphere.

Conclusion

Post-mortem examinations in Telangana state are done in designated hospitals run by Government only. There are different set-ups in hospitals to conduct post-mortem examinations. Many hospitals have a permanent structure for mortuary. The structure of the mortuary is not uniform in all hospitals. Teaching hospitals are provided with relatively good facilities in mortuaries. Mortuaries in area hospitals are good enough to conduct regular post-mortem examination work. In mofussil hospitals, permanent structures are not available to conduct post-mortem examinations. Many times, they are conducted under tin-sheds. No civilian is willing to enter the mortuary, unless their beloved are dead. Mortuary is a disagreeable place for many but is need of the present society. It needs to be improved[18] with respect to providing facilities required to conduct smooth medico-legal work. Many social problems are generated by the improperly maintained mortuaries and health hazards are not uncommon for the people exposed to the environment of mortuary. Lack of proper disposal facilities in some mortuaries is limiting their working capacity and thus renovation of mortuaries is the need of the day.

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ORIGINAL ARTICLE

Study of medical negligence cases decided by the state consumer disputes redressal commissions of Chandigarh, Punjab and Haryana

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Abstract
'Doctor' is a word which commands respect in the heart of the common man, and hence medical profession is considered a noble profession. But being a doctor has more responsibilities than privileges, which is reflected in the Hippocratic Oath, as well as our very own Charaka Samhita. A retrospective and prospective cohort study was done by perusing cases from 1st January, 2018 to 15thNovember, 2019 with the aim to study and analyze medical negligence cases in Chandigarh, Punjab and Haryana and to analyse the pattern of cases and reasons for filing suit, outcome and time schedule of the decision-making process by the Forum and the role of Expert medical opinion in decision making. In our study, 79.5% cases were from the private sector. Of the total 44 cases where deficiency was admitted by the three commissions, in 11 (25%) cases negligence/ deficiency of service was proved, while in 33 (75%) cases, the complainants were not able to prove the allegations of medical negligence against doctors/hospitals. In 15 (34.1%) cases, composite negligence was alleged by the complainant/ plaintiff. Furthermore, in 14 cases (31.8%), recommendations of the medical board, were sought and the commission accepted their findings in 11 cases (78.5%).General surgery and cardiology related cases accounted for 16.7% and 13% of the suits filed, respectively. In general, surgery and its subspecialties accounted for 42.6% and medicine accounted for 22.2 % of suits.

Keywords
Medical negligence; Composite negligence; Expert medical opinion; Consumer commission.

Introduction

Doctor is a word which commands respect in the heart of the common man, and thus medical profession is considered a noble profession. But being a doctor has more responsibilities than privileges, which is reflected in the Hippocratic Oath, as well as our very own CharakaSamhita.[1,2] The movement of consumer rights, which started from the West, also spread to the Indian subcontinent with the enactment of the Consumer Protection Act in 1986, and subsequently, included the medical profession under its ambit through an important judgment by the Hon'ble Supreme Court in 1995 in the Indian Medical Association vs V.P Shantha and Ors.[3,4] This, not only described the doctor as a service provider, but also made him liable under the Act for any deficiency of service.

However, way back in 1969, the Hon'ble Supreme Court, in Laxman Balakrishna Joshi vs Trimbak Bapu Godbole and anr, said: "A person, who holds himself out ready to give medical advice and treatment, impliedly holds forth that he is possessed of skill and knowledge for the purpose. Such a person, when consulted by a patient, owes certain duties: namely, a duty of care in deciding whether to undertake the case, a duty of care in deciding what treatment to give, and a duty of care in the administration of that treatment. A breach of any of these duties gives a right of action of negligence against him. The medical practitioner has discretion in choosing the treatment which he proposes to give to the patient and such discretion is wider in cases of emergency, but, he must bring to his task a reasonable degree of skill and knowledge and must exercise a reasonable degree of care according to the circumstances of each case."[5]

The Supreme Court, since then, has defined medical negligence from time to time, especially in Poonam Verma vs Ashwin Patel & Others (1996), Achutrao Haribhau Khodwa vs State of Maharashtra And Ors (1996) and Jacob Mathews vs State of Punjab and anr (2005).[6-8] Other important recent Supreme Court judgments are the V. Kishan Rao vs Nikhil Super Speciality Hospital (2010), Balram Prasad vs Kunal Saha & Ors(2013) and Dr.S.K. Jhunjhunwala vs Mrs. Dhanwanti Kumar (2018).[9-11] From the above judgments, it can be construed that medical negligence is an act of omission i.e. failure to maintain reasonable care and skill, or an act of commission i.e. doing something which a reasonable man, exercising reasonable degree of care and caution and professionally skilled would not do so in the said case/ situation, leading to damage/ harm to the patient. In all cases of alleged negligence, the first and foremost requirement is that the doctor-patient relationship must be demonstrable. The Hon'ble Supreme court has further redefined medical negligence in the Malay Kumar Ganguly vs Sukumar Mukherjee & ors (2009) by including overdose of medicines in its ambit.[12] It further made it clear that the standard of duty of

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care in medical services may be inferred after taking into account the position and stature of doctors or the hospital. Hence, degree of care is more for a specialist doctor as compared to an MBBS doctor. If a doctor claims himself as a specialist, but it turns out that he is not, deficiency of service would be presumed by comparing his skill to that of specialist.[13]

A recent survey by National Law School of India University (NLSIU), Bengaluru, cites increasing awareness among consumers, escalating cost of medical services, consumer mindset to enter litigation and flexible consumer forums; as the reasons behind increase in medical negligence cases in India.[14]As per a study by advocate Bajpai, there has been a 110 % rise in cases of medical negligence each year in India, with the majority of suits filed against hospitals, rather than individual doctors.[15]

Hence, the present study was conducted to probe into the reasons and factors responsible for medical negligence. The aims and objectives of the study were to analyze medical negligence cases in Chandigarh, Punjab and Haryana to ascertain pattern of cases and reasons for filing suit, outcome and time schedule of decision making process by forum and role of expert medical opinion in decision making.

Materials and Methods

A retrospective and prospective cohort study was undertaken, perusing cases from 1st January, 2018 to 15th November, 2019. After receiving the approval from the Institutional Ethics and Research Committee, the present study was undertaken and the judgments of the decided cases of State Consumer Disputes Redressal Commissions of UT Chandigarh and the states of Haryana and Punjab were accessed. The respective chairpersons had already been approached and permission received in principle to peruse the relevant documents. The judgments were downloaded from the respective portals: *http://confonet.nic.in/* and NCDRC website: *http://chdconsumercourt.gov.in/*, as all the judgments of decided cases are freely available on the public domain and continuous updating is done by the respective commissions on the public portal/ website. The relevant documents of the case file were also studied in the commission office. Incidence and prevalence were gauged after a complete analysis of all the medical negligence cases decided by the consumer commissions selected during study period. This was accompanied by an insightful analysis of the reasons behind filing the suit by the plaintiff or the petitioner. The general profile of the medical negligence cases and the specialties concerned, the damages awarded by the concerned commission, along with the duration within which such cases were adjudicated or disposed of was noted. Whether expert medical opinion was sought in the particular case and if sought, did it have a bearing on the outcome or decision making was also studied. All decided cases within the chosen time period, pertaining to medical negligence were included in the study while cases which are subjudice were excluded.

Results

An analysis of the cases revealed that Government health facilities were implicated in only 9 cases out of a total of 44 cases (20.5%) while private hospitals accounted for the rest 35 cases. The latter were further bifurcated into corporate hospitals and self-owned institutions which accounted for 11 (25%) and 24 (54.5%) cases respectively (Table 1).

Table 1: Distribution of cases – government vs private

Type of hospital/clinic		n	%
Government		9	20.5%
Private	Corporate	11	25%
	Self-owned	24	54.5%
Total		44	100%

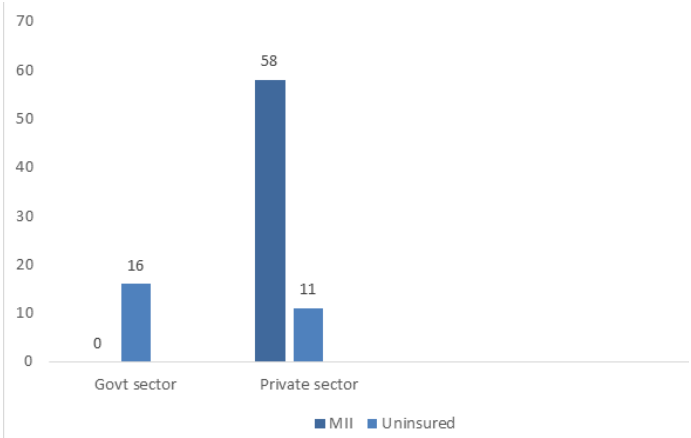
Table 2: Distribution of Cases – negligence proven vs not proven

Parameter		n	%
Negligence not proven		33	75%
Negligence proven fully or partly	Corporate	4	25%
	Self	6	
	Govt	1	

Table 3: List of the specialities involved, including cases of composite negligence

Speciality	n	%
General Surgery	9	16.66
Cardiology	7	12.96
Orthopaedics	5	9.25
Internal Medicine	4	7.407
Radiology	4	7.407
Ophthalmology	3	5.55
Neurosurgery	3	5.55
Gynaecology	3	5.55
Pathology	3	5.55
Dentistry	2	3.70
Ayurveda	2	3.70
ENT	2	3.70
Paediatrics	2	3.70
Hospital Administration	1	1.85
Nephrology	1	1.85
Anaesthesia	1	1.85
Plastic Surgery	1	1.85
Total	54	100

Figure 4: Representation of prevalence of medical indemnity insurance amongst health institutions and doctors



MII = medical indemnity insurance

Further analysis of the outcome of alleged medical negligence cases revealed that in 33 cases out of 44 (75%), negligence could not be proved when contested in the respective State consumer disputes redressal commission while in rest of the 11 cases in which negligence was proven, self-owned health facilities accounted for 6 cases, corporate hospitals for 4 cases while government hospitals only for 1 case (Table 2).

With respect to composite negligence it was observed that in 15 out of 44 cases (34.1%), composite negligence, i.e. negligence of more than one doctor was alleged by complainant/ plaintiff. Thus, the total number of doctors sued were 37 and out of these, composite negligence proved in 5 cases (33.3%). Furthermore, hospitals were made a party in 77.3 % cases (34 of total 44) (Table 3).

Again, as can be seen from Table 3 above, general surgery and cardiology related cases accounted for 16.7% and 13% of the suits filed, respectively. In general, surgery and its subspecialties accounted for 42.6 % and medicine for 22.2 % of suits.

In 70.7% cases, doctors had indemnity insurance cover. All these doctors/ institutions were from the private sector. This shows that risk of future medical negligence claims is becoming palpable in medical fraternity, more so, in private sector. (Fig 1)

As per the Hon'ble Supreme Court, in Jacob Mathews vs State of Punjab,[8] Expert medical opinion should be sought before proceeding against a doctor in an alleged medical negligence suit. In our study, in 14 cases (31.8%), recommendations of a medical board, were sought and the commission accepted findings in 11 cases (78.5%).

In only 7 cases, (15.9%), time period of decision making was 90 days or less. Frivolous complaints accounted for 11.3% of the total suits (5 of 44 cases). The commission did not charge any complainant. In 11 cases (25%), an appeal was made against decision of SCDRC in the National Commission.

Discussion

Mahatma Gandhi once said; "A consumer is the most important visitor on our premises. He is not dependent on us, we are on him. He is not an interruption to our work; he is the purpose of it. We are not doing a favour to a consumer by giving him an opportunity. He is doing us a favour by giving us opportunity to serve him."[16]

The Consumers International, formerly, International Organisation of Consumer Unions, the umbrella body for 250 organisations in over 120 countries, has endorsed 8 rights:[17] - Right to safety, right to choose, right to be informed, right to be heard, right to consumer education, right to redressal, right to satisfaction of basic needs and right to healthy environment.

The consumer rights 1 to 6 are also enshrined in the Consumer Protection Act, 1986.[3] (CPA) The provisions of this Act cover 'goods' as well as 'services'. The goods are those, which are manufactured or produced and sold to consumers through wholesalers and retailers. The services are in the form of banking, finance, transport, telephone, electricity, housing construction, insurance, medical treatment, entertainment etc. Excluded are those services that are rendered free of charge or under a contract of personal service.

A landmark judgment was delivered on 13 November 1995 by a 3-member Supreme court bench headed by Justice Agrawal in the Indian Medical Association vs. V.P. Shantha and Ors.[4] The central issue which arose for decision by the court was whether and, if so, a medical practitioner can be regarded as rendering 'service' under Section 2(1) (0) of the Act and can be proceeded against for 'deficiency in service' before a forum under the Consumer Protection Act, 1986. The court dealt with how a 'profession' differs from an 'occupation', especially in the context of performance of duties, and hence, the occurrence of negligence. The court noticed that medical professionals do not enjoy any immunity from being sued in contract or tort (i.e. in civil jurisdiction) on the ground of negligence. However, in the observation made in the context of determining professional liability as distinguished from occupational liability, the court referred to authorities, in particular, Jackson & Powell, and stated the principles, partly quoted from the authorities: "In the matter of professional liability, professions differ from occupations for the reason that professions operate in spheres where success cannot be achieved in every case and very often success or failure depends upon factors beyond the professional man's control. In devising a rational approach to professional liability which must provide proper protection to the consumer while allowing for the factors mentioned above, the approach of the courts is to require that professional men should possess a certain minimum degree of competence and that they should exercise reasonable care in the discharge of their duties. In general, a professional man owes to his client a duty in tort as well as in contract to exercise reasonable care in giving advice

or performing services. The principle of 'Bolam test' as laid down by McNair J in Bolam vs Friern Hospital Management Committee, is to be applied to determine the standard of care which is required by medical practitioner in an action for damages for negligence as the common law of England continues to remain applicable in the law of torts by virtue of Article 372 of the Constitution of India."[12,18,19] At present, the CPA exempts those hospitals and doctors, which offer free medical services to their patients. Recently, in 2017, Supreme Court stayed the National Consumer Disputes Redressal Commission order to include government hospitals treating patients free of cost by including them within the ambit of CPA.[20]

Present situation in respect of medical negligence in India

A study by Supreme Court advocate Mahendra Kumar Bajpai,who specialises in medical law, shows a 110 per cent rise in number of medical negligence cases in India every year. The study also reveals that 90 per cent of all cases in medical negligence involve hospitals, and 12 per cent of all the cases decided by consumer courts are of medical negligence. Between 60 to 66% of the filed cases are based on improper consent taken by the hospitals from relatives before performing certain procedures or switching hospitals, or improper documentation throughout the course of diagnosis and treatment.[14]

Another study conducted in India on medical negligence was the 'Pattern and reasons of medical negligence in Delhi and the profile of hospitals associated with it'.[21] In this study, of the 48 cases studied, 43 (89.6%) were of private hospitals and only 5 (10.4%) were from Government hospitals, which correlated very closely with the finding observed in our study which attributed 79.5% cases to private sector (54.5% belonged to self-owned institutions/ health facilities and 25% to corporate hospitals).Again, the study revealed that of the 48 cases, deficiency in service/unfair trade practice was proved only in 15 (31.3%) cases, while in 33 (68.6%) cases, complainants were not able to prove the allegations of medical negligence against doctors/hospitals, similar to our study in which negligence could not be proved in 33 (75%) cases, while in the rest of 11 (25%) cases, negligence could be proved either wholly or partly, particularly against private institutions (10 cases), while in only 1 case negligence was proved against a government hospital. The above study further stated that surgery and allied specialties were at major risk of allegation, with orthopaedics, obstetrics and gynaecology, general surgery and general medicine specialty doctors facing allegations of negligence in 14.3% cases each, followed by ophthalmology (12.2%), cardiology (10.2%) and ENT (4.1%), respectively. Dentistry alone faced allegations of medical negligence in 8.2% cases, which is significant. In our study also the findings were similar, with general surgery and cardiology accounting for 16.7 % and 13% of the suits filed, respectively, as shown in the representative Table 3. The reasons cited for the above ambiguity were lack of awareness and knowledge among all stakeholders (patients/ lawyers) and complexity of cases of medical negligence, lack of second opinion/ expert opinion on the issue of allegations of medical negligence or these not supporting the allegation.

The aforementioned study stressed that there is a need to create awareness and interaction among medical fraternity and patients and advocate dealing with medical negligence cases. Forensic medicine expert can play a great role in this field by either practicing as an expert for filing cases of medical negligence in various consumer courts or by providing consultation to aggrieved patients or aggrieved hospital/doctors. [21]

Another hospital-based study titled 'role of liability in medical negligence', found doctors negligent in 15 cases i.e., 41.7 % and vicariously liable in 3 cases i.e., 8.3 %. Among these 36 cases of medical negligence, informed consent was obtained from 30 patients i.e., 83.2 % while implied consent was obtained from 3 patients i.e. 8.4 % and no consent was obtained from 3 patients i.e. 8.4 %.[22]

A pertinent study analysing 4450 autopsies was carried out due to suspicion of medical malpractice in 17 German institutes of forensic medicine from 1990 to 2000 by the German Federal Ministry of Health. They reported that Medico-legal autopsies are still a very sufficient method to evaluate cases of medical malpractice as 2863 were clarified by autopsy.[23]

Time frame under CPA

As per the statute, the State commission disputes redressal commission shall not admit a complaint, unless filed within two years from the date on which the cause of action has arisen, unless the complainant satisfies the commission regarding sufficient cause for not filing the complaint within stipulated period and the reason for condoning such delay is recorded by the presiding member or judge. Any appeal against the order of the State commissions under the act must be filed within 30 days of the order. A complaint filed in the Consumer commission should be adjudicated within a period of 90 days from the date of notice received by opposite party and within 150 days if it requires analysis or testing of commodities. However, no time limit has been laid down for the disposal of an appeal or revision petition.[3,24] Our study revealed in only 7 cases, (15.9%), time period of decision making was 90 days or less was adhered to by the respective consumer commissions.

Conclusion

Proper documentation as it is the best defence for a doctor in a court of law against a plea of negligence. It is generally said that "if you have not documented it, you have not done it" in a court of law. Documentation of positive findings and important negative findings in the case file by a doctor proves due diligence. SCDRCs should preferably follow a uniform method

of trial in medical negligence cases viz. Constitution of medical board & speedy redressal of consumer complaints in a time bound manner. Referral cases should be properly documented with proper referral slip indicating reasons for and the condition in which patient is being referred. A doctor should not refuse a patient during emergency and should give life-saving treatment. But, if an urgent referral is required to higher centres in view of specialist consultation and management, it would be prudent to refer such a patient but the referring doctor should ideally communicate with the specialist in charge of the referral unit of the availability of bed and requisitioned diagnostic modality or treatment facility. Updating medical knowledge by means of CMEs, etc is one of the important requirement during practice of medicine. Better communication skills, ethical medical practice based on pillar of evidence based medicine, empathy and a sound medical knowledge with awareness of one's capabilities & limitations important to save oneself from negligence suits.

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ORIGINAL ARTICLE

Students' perception about 'Model Answer' method as a reflective tool for assessment & teaching-learning in Forensic Medicine

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Abstract

Assessment is an integral part of the curriculum and it is always being attempted to connect teaching with learning. Formative assessment has been established as the best way to monitor a student's progress during the learning process. The essence of assessment is the purpose for which an assessment is done. Formative assessment is formative only if the teacher provides feedback to the student. Assessment without feedback may be a lost opportunity for a student to understand and correct the mistake. Challenges have also been perceived previously for providing feedback. Simply providing unstructured feedback might not ensure student's proper understanding of their use as desired by the teacher. The department of Forensic Medicine and Toxicology at our institute practices 'Model Answer' method to provide structured feedback following each formative assessment of medical students for the past few years. The model of 'model answer' used in this study differs from the previously suggested models with few modifications such as it is completely structured, enriched with specific and elaborative feedback and following up the assessment as early as possible. This study is an effort to note the perceptions of students about the effectiveness of the method. Most of the students agreed that this method helped them to learn from assessment, clarify concepts, to discuss commonly occurring mistakes, to learn from other's mistakes, to improve their writing skills, to identify their mistake and understand the appropriate response with reasons. Furthermore, they agreed that the method provided an opportunity for discussion and hence it leads to transparent and unbiased assessment. Structured feedback is essential to inform students about what they are doing well and what requires improvement. The structured model answer method with feedback may create a culture which includes an assessment for learning.

Keywords

Assessment; Feedback; Medical education; Model answer; Teaching-learning

Introduction

In medical education, the use of formative assessment for improvement in instructional practices and student performance has always been of concern. Best way to monitor students' progress during the learning process is formative assessment.[1, 2] Formative evaluation is differentiated from formative assessment in the evaluation of assessment-based evidence to provide feedback to and inform teachers, students, and educational stakeholders about the teaching and learning process.[2] Assessment drives learning is a universal fact and teaching-learning is always attempted to connect with an assessment.[3]

Recently, many suggestions prompted to drift the stream from 'assessment of learning' towards 'assessment for learning'.[4, 5] It clarifies to move away from the sole dependence on strong testing at the end of a period of learning, towards multiple moderate assessments throughout the period of learning combined with rich feedback.[4] Assessment for learning approach gives the learner enough opportunity to learn and improve before the final assessment of learning.

A vital part of the assessment is the purpose for which any assessment is done. However, a test that was designed to give formative feedback exists as formative, only if the teacher uses it to provide feedback to the student.[2] Assessment without feedback or unstructured feedback would wipe out the essence of 'assessment for learning'. As a consequence of this lost opportunity for correction, the student may end up making similar mistakes in subsequent assessments.

No transition is easy ever. Challenges have been faced while changing to the 'assessment for learning' culture.[4] The utility for feedback can be measured by the relevance of time when the feedback is given, and the level of receptivity of the participants for the feedback. Simply providing unstructured feedback after assessment might not ensure students' proper understanding that they would use it appropriately as desired by the teacher. At the same time, there are studies documenting the difficulties encountered in using 'feedback' in formative assessment.[4,6]

The department of Forensic Medicine and Toxicology practices 'model answer' method to provide structured feedback following each formative assessment of undergraduate medical students for past few years. This article is an effort to document the perceptions of students about the effectiveness of the model

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answer feedback method where structured feedback is provided to them after a formative assessment.

Materials and Methods

Preparation of 'Model Answer'

The discipline of Forensic Medicine and Toxicology is taught to undergraduate medical students in their second year of MBBS (Bachelor of Medicine and Bachelor of Surgery) curriculum for a duration of one and a half years in India. The department of Forensic Medicine and Toxicology at our institute, conducts a total of five formative assessments in this period. For the past few years, the activity of providing structured feedback is being practiced in the department. Following each theoretical examination, faculties prepare an answer to each question which was asked in a structured manner in well advance and that too validated internally. Score distribution of all structured questions and average expectation level from students are considered while preparing this model answer. It is then reviewed by peers and if required, changes are made to finally devise 'Model Answer' for particular question paper following discussion among faculty and peer.

Application of 'Model Answer'

Faculty assesses and scores for all answers in the assessment sheets of students, considering the content of answer and score distribution keeping the 'model answer' as a reference. The mistakes in answers are highlighted to draw attention. Faculty notes down the commonly made mistakes within the answers of students and captures some images of them keeping confidentiality and anonymity. After scoring all answer-sheets, the faculty proceeds to arrange a session with the students to display and discuss model answers in detail and the mistakes committed by them. Assessment of answer sheets is done as soon as the exam is over. The session for discussing 'model answers' and giving constructive feedback is also arranged as early as possible following the assessment.

In this session, the students are briefed about the method and are provided with their respective assessed answer-sheets. Faculty then displays the model answer for each question one by one using an audio-visual aid through a power-point presentation (PPT). Display of each answer is accompanied with a detailed feedback from the faculty regarding 'what to write', 'how to write' and 'what not to write' in response to the particular question asked, with justifications for the same. Students are then instructed to verify their score distribution for a particular answer according to the displayed model answer. Captured images demonstrating the common errors committed by students pertaining to any particular answer are displayed in PPT keeping the anonymity of the students. These common mistakes are also discussed to bring clarity of concepts. Additionally, the students are guided on appropriate application and utility of figures, graphs and pictures in the answers. Importance of legible handwriting is also emphasised upon in general. The same way all the questions in the paper are taken up and discussed one after the other by the faculty.

By providing a very conducive, non-threatening and healthy environment, all students are then given equal opportunity to inform faculty about any ambiguity they find in model answers and/or in score distribution or marking of their answers that are contrast to the model answer specified, or any unchecked answers or totalling errors, if any. All rational errors are then corrected and updated appropriately by the faculty.

Collection and analysis of the student's perception of the study

After the approval from the Institutional Ethics Committee, the study was conducted in our institute which is designated by the Medical Council of India as the Nodal Centre for National Faculty Development Programme in India. Participants were undergraduate medical students who had completed their second year in profession and had experienced the 'Model Answer' part of formative assessment and feedback method during their term with the Forensic Medicine and Toxicology department.

The participants were briefed about the study objectives “understanding perception about the model answer feedback method's effectiveness” as they had experienced it first-hand. They were explained that participation was voluntary and anonymous responses only were sought for in the survey. Since no personal identifiers were sought from the students, they were asked to respond freely and fearlessly to the survey.

Following a briefing about the study purpose and process, the anonymous questionnaire sheet was handed over to the volunteering participants to elicit their perceptions. The response sheet consisted of fifteen questions about various key aspects of the model answer method. These feedback questions were consensually agreed upon by the peers before administration. Students were instructed to indicate their choice for all fifteen questions by ticking the most likely alternative out of strongly disagree, disagree, neutral, agree, strongly agree for all the questions. In order to maintain anonymity, the filled responses were collected from the students by an office help who had no involvement in the study.

Data collected from students were analysed using the STATA 14 (Statistical software package created by Statacorp). Exploratory data analysis was done to understand the distribution of responses. The responses were clubbed in major domains from the questionnaire (learning from assessment, the process of assessment and facilitation and expectations) and responses collected on the five-point Likert scale (strongly disagree, disagree, neutral, agree, strongly agree) were merged to

disagree, neutral and agree for analysis and presentation purpose.

Results

All 86 students who were present on the day of the survey from a batch of 97 students, voluntarily participated and responded to the questionnaire about their perception on the 'Model answer' feedback method. There were 54 female participants. There were no statistically significant differences observed in the distribution of the frequencies in the table across gender ($p>0.05$). Other results have been tabulated (Table 1).

S. No.	Statements	Agree		Neutral		Disagree	
		N	%	N	%	N	%
	Learning from assessment						
1.	It generates my interest in learning.	77	89.53	7	08.14	2	2.33
2.	It assists me to clarify the concept being assessed.	75	87.21	9	10.47	2	2.33
3.	It helps me to improve writing skills.	74	86.05	10	11.63	2	2.33
4.	It helps me to identify my mistakes.	77	89.53	6	06.98	3	3.49
5.	It is useful to me to learn from others' mistakes and discussion over it.	67	77.91	16	18.60	3	3.49
6.	It is useful to me to enhance learning.	67	77.91	18	20.93	1	1.16
	Process of assessment						
7.	It is useful to me to verify distribution of obtained score for each answer.	71	82.56	12	13.95	3	3.49
8.	It is useful to me to verify error in total score.	67	77.91	15	17.44	4	4.65
9.	It is useful to me to verify unchecked answer if any.	67	77.91	19	22.09	0	0.00
10.	I get equal opportunity among plenary for verification, discussion & clarification of doubts with faculty.	66	76.74	13	15.12	7	8.14
11.	It makes an assessment transparent.	63	73.26	21	24.42	2	2.33
12.	It provides me a satisfaction of an assessment.	62	72.09	21	24.42	3	3.49
	Facilitations and Expectations						
13.	Faculty take interest and help sufficiently.	71	82.56	13	15.12	2	2.33
14.	It helps me to improve performance in subsequent assessment.	77	89.53	7	8.14	2	2.33
15.	I look forward to have more of this in other disciples.	73	84.88	12	13.95	1	1.16

Discussion

Use of formative assessments in the classroom directly resulted in marked changes in educational outcomes as seen from the study by Dunn et al.[2] Assessment without feedback is likely to wipe out the purpose of assessment for learning.[7-9] One decade ago, a consensual framework for good assessment was developed at the Ottawa Conference for "Assessment of Competence in Medicine and the Healthcare Professions."[10] The framework for single assessment identifies construct validity, reproducibility, equivalence, acceptability, feasibility, educational benefit and timely feedback as key elements. This approach motivates learners and provides educators with the opportunity to drive learning through assessment.[11, 12] Feedback after the formative assessment is considered as a reflection of assessment and also a good method of teaching-learning.[9,13,14]

Challenges have been perceived while transiting from the traditional assessment 'of' learning culture to an assessment 'for' learning.[4] Simply providing unstructured generic feedback after assessment does not ensure that the students would have understood their shortcomings and will improve upon it the next time. At the same time, difficulties have been faced in using feedback for formative assessment.[4,6] Formative feedback is defined as information communicated to the learner that is intended to modify the learner's thinking or behaviour for the purpose of improving learning.[15] Another challenge is a hindrance to being receptivie to the feedback. Despite the best efforts of medical educationalists, there is evidence of dissatisfaction for the quality and effectiveness of feedback that students received.[16-18] One study remarked students generally perceived that they haven't received any in-depth feedback or just had it within a line or just had ticks all the way through. Thus, it is questionable they could use such feedback to improve performance. The same study also noted recommendation from students for the provision of generalised group feedback while personalised feedback was difficult to achieve.[12] Quality of feedback is compromised when it is either vague with ambiguity, or negative, or too late to be useful or out of context.[19-21]

Many studies have suggested different criteria for effective feedback.[22-24] Over the past few years, medical education has witnessed a profound use of rubric i.e. set levels of criteria that teachers often use to assess or evaluate students' work.[25] Their disadvantage is they can be vague and might be perceived as difficult to understand by the students.[26] In a few instances, exemplars were used as feedback; which are examples of exemplary writing selected from students' assignments which seemed to be providing incomplete information. One potentially a holistic approach, suggested by Huxham, is the use of model answers.[27] He defined model answers as ideal responses, which would receive full marks, generated by the tutor and distributed identically to all students involved in an assessment.[27] It would allow students to know what the final piece of writing should look like.

A quantitative synthesis of the research and literature review is still lacking for the use of model answers in medical education,

especially in the subject of forensic medicine and students' perceptions towards that. The usefulness of model answer and exemplars was demonstrated by a limited number of studies.[27-29] A large group of students can be addressed at once through model answers more feasibly as compared to individual comments. It shortens the duration of feedback. Also, by eliminating individual feedback, it eliminates negative feedback and its consequences. It requires students to divulge into active engagement with feedback and compare their work with the model answer which satisfies important criteria of effective feedback. Furthermore, the model answer explains the structured marking criteria, hence clearly demonstrates the desired standard.

The model of 'model answer' used in this study differs from the standard model answer as suggested by Huxham[27] with few modifications such as it is completely structured, rich with specific and elaborative feedback, following the assessment as early as possible. It discusses commonly occurred mistakes, suggests an improvement in writing skills, allows the student to identify their mistakes and understand the appropriate response with reasons. The method provides an opportunity for discussion and hence it leads to transparent and unbiased assessment.

Formation of the key for the assessment involves the adoption of different approaches by the teachers over the period.[26,30,31] Among them, the 'product-oriented approach' mainly focused on the content which emphasizes on the correctness property and the 'process-oriented approach' involves the stages of writing, which are illustrated and practised from generation of ideas to compilation, through a series of activities which include planning, gathering information, drafting and revising.[30] In his research, Tangpermpoon suggested that the best teaching practices, however, involve a combination of both product and process approach.[31] Our method of the model answer in the current study adopted both the aforesaid approaches in a way as it describes 'what to write' (product-oriented) as well as 'how to write' (process-oriented) for each question in focus.

Elaboration of feedback following the model answer should be different for various types of question. In short answer question, the model answer is standard and it is understood by students in a simplified manner until required to be explained otherwise. For multiple-choice typed question, while the model answer is showing the only correct answer, the feedback should include the reason being it as well as the reasons for ruling out remaining options i.e. distractors. The model answer serves the purpose only if it is validated and structured for essay typed questions which allow students to compare the small elements of their answers with those of model answers.

Many researchers expressed students' dissatisfaction towards lack of timeliness, consistency and poor quality of the feedback they received.[32,33] The requirement of timeliness of feedback has been validated via literature review as well.[34] Immediate feedback is a tool for effective feedback. It provides an opportunity for the students to improve in subsequent assessment tasks and it also acts as a form of reassurance.[35,36]

Challenges have been perceived with feedback practices.[37] When students are either not given feedback or it is given in an unstructured manner, it leads to the repetition of similar mistakes in subsequent assessments. It was perceived by students in a previous study that vague rubrics lead to variation in marks scored.[12] It suggests the requirement of structured model answer. In the feedback method adopted here, the mistakes are discussed properly and corrected, reducing chances for further repetition considerably. As a faculty who took the students through this process, we felt that the students benefitted well from the process and it helped the students understand their mistakes and correct them in time. This belief of ours is also endorsed by the responses of the students. (Table 1) Students also agreed about learning concepts from others' mistakes shown and discussed in plenary. Hartley et al. in their study revealed that misunderstanding the context of the question (what is being asked in the question) was one of the potential reasons for poor scoring. [17] The model answer would be potentially enabled to eliminate such general mistakes in subsequent assessments as they are discussed in plenary with a focus on understanding the context.

Meticulous observation is required for accurate evaluation and feedback. There are lesser chances of favouritism or assessor bias in this method as whatever bias is there (if at all) would be exposed when the students critically review their assessed sheets against the consensually agreed-upon model answer.

Black and William in their extensive review of the literature reported that feedback focused on the task, rather than the self, is generally more effective.[38] Here, the model answer is task-focused while individual feedback may be interpreted by students as more personal. The task-focused feedback such as model answer method enhanced students' performance in subsequent assessments. As model answer addresses the mass of students, it lacks the advantage of individual feedback. However, by careful observation during the assessment, common mistakes of students can be addressed and discussed. It might be perceived as lacking personal empathy and guidance when compared to individual feedback.

An appropriate model answer with rich feedback satisfies the key components of effective feedback namely observation of performance, evaluation of performance, guidance to the next level of performance and facilitation of performance improvement.[33] In short, the model answer method involves formal, constructive and formative feedback.

Although the process of preparing a model answer for the

assessments done is tasking on the faculty in terms of time invested and efforts put to make things crystal clear to the students, the efforts are worth it as witnessed the students improving their knowledge through the process. The ultimate objective is to make our students competent. Through this method, we found that it helps enhance the understanding of Forensic Medicine. The application of this method might be helpful in many other disciplines by the efforts invested by the faculty in the process.

Although any transition is never easy, it is the need of the hour to align our assessment to the objective of having a competent student at the end of the medical curricula. If we want good learning to occur, the assessment needs to be 'for' learning rather be 'of' learning when there are opportunities for correction i.e. formative assessment. Providing appropriate feedback with rational explanation timely enhances learning as observed in our study. Also, the students are receptive to feedback when it is maintaining confidentiality, at the same time providing insight on how better the questions could be answered. The transparency in the method of the model answer feedback method enhances the confidence of students in the faculty and also promotes a healthy and non-threatening ambience for learning.

Conclusion

Emerging issues with regard to the assessment of students include transparency, relevance, fairness, specificity, being meaningful and timely feedback of the assessed tasks. Students as important stakeholders should actively seek information and feedback to support their learning. Educators need to utilise the assessment framework effectively in the development of assessment tasks in order to encourage learning and keep the students engaged. Feedback provider should discuss and direct students about what should be the next target level as well as how to get there. Structured feedback is essential to inform students about what they are doing well and what requires improvement. The structured model answer method with feedback is perceived by the student as the answer to that. This method is one of the steps for creating a culture that promotes reflection and goal setting, so learners may monitor their progress systematically. Model answers with a rich feedback method gained considerable receptivity to students in Forensic Medicine. It emerged as a useful reflective tool for assessment as felt by the faculty and based on the students' feedback. A current need of change in culture which includes assessment for learning would be satisfied on larger scale through model answer method.

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ORIGINAL ARTICLE

Post-mortem peripheral smear: A forensic diagnostic tool?

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Abstract

The current study of post-mortem peripheral smears was conducted in Department of Forensic Medicine, Osmania Medical College with the main objective of studying the seasonal variability of autolysis of cell lines in peripheral circulation. In the study sample of 73 subjects, peripheral smears were made in the morgue immediately after collecting blood by venepuncture. Smears were stained with Leishman stain (A Romanowsky stain) within 2 hours of preparation and light microscope was used to study changes. The changes in cell morphology, membrane integrity, cytoplasmic and nuclear changes were studied in detail using valuable information from previous studies and conclusions were arrived at. At the outset white blood cells are most suitable for TSD predictability among others in peripheral smear because they withstand extraneous variables like refrigeration and show a similar degree of autolytic changes across all seasons. The validity of all such studies on cell lines for TSD was discussed from medico legal perspective. The take home message is all the microscopic changes studied in present study provided no added advantage significantly apart from traditional gross changes like rigor mortis, algor mortis, post-mortem lividity. If properly used on regular basis, algor mortis can enhance the quality of our reporting in India with respect to TSD.

Keywords

Post-mortem peripheral smear; Time since death; Microscopic forensics.

Introduction

The importance of estimating time since death has been appreciated for centuries.[1] It is the most vexatious question faced by a forensic pathologist all his life time. No single gross or microscopic post-mortem change can accurately predict the time elapsed after death. Each and every gross observation like algor mortis, rigor mortis, decomposition changes, microscopy and thantochemistry supplement each other in arriving at a predictable range of time since death. Review of literature shows good number of studies were done to evaluate cellular changes that occurred in blood after death to estimate time since death.[2-6] The aims and objectives of the study were to study changes in RBC, WBC and platelets with regard to time since death, to verify if studying microscopic changes of cell lines provide any advantage in complementing the gross changes in interpreting time since death, to study the pace of cellular changes in refrigerated and unrefrigerated cadavers and to study variability in pace of microscopic autolysis in summer and winter seasons.

A total of 73 cases in which time of death is known were studied as part of the study. 42 of these individuals were males, while 31 were females. The first phase of study was initiated in January 2018 during which 20 cases were studied. The subsequent phase of the study was conducted in May 2018 with a sample size of 53 cases. The sampling model followed is non-random purposive sampling.

The results obtained were used to predict time since death in 30 cases for which sampling was done randomly between January and May 2018. In these cases, our range of time elapsed since death was compared with the records to predict accuracy.

In 29 cases pre refrigeration and post refrigeration sampling was compared. It was not possible to compare the same in all cases due to receipt of bodies at odd hours and other cases being autopsied directly without being kept in cold storage.

Materials and Methods

Blood samples were collected from femoral vessels before autopsy. In case of failure of above method, blood was collected from common carotid artery, internal jugular vein or directly from heart using a 5cc syringe. Smears were prepared on the spot and stained using Leishman's stain. Light microscopy was used to study the prepared slides. The morphology of cells was studied and included the shape of cell, the cell membrane, cytoplasm and changes in the nucleus.[6]

Cases in which time since death was known precisely and within 48 hours of post-mortem interval were included in the study. Mutilated dead bodies, charred dead bodies, any cases with history of oncological, infectious or haematological diseases were excluded.

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Results

Demographic profile of the case and cause of death were not studied in detail during this study. However, care was taken to make the sample representative. The test population of 30 cases used for testing the results obtained in the study comprised of 22 males and 8 females. The cause of death for the population was asphyxia in 7, RTA in 12, poisoning in 6, and 5 had died due to other causes.

Table 1: Time intervals during which the respective changes in RBC are seen in summer and winter

RBC Cell Changes	Summer	Winter
Normal, no membrane or cytoplasmic changes	0-3 hours	0-5 hours
Dysmorphic RBC, central pallor intact and periphery red	3-12 hours	5-16 hours
Grossly dysmorphic RBC, central pallor reduced and periphery red	12-22 hours	12-24 hours
Grossly dysmorphic RBC, central pallor lost and periphery pale	20-31 hours	22-36 hours
Mixture of lysed and intact RBC, central pallor lost and periphery pale	24-36 hours	30-42 hours
Completely lysed RBC	20-48 hours	30-48 hours

Table 2: Time interval (in hours) during which the respective changes in WBC are seen in summer and winter

Cell type and autolytic changes	Summer	Winter
Neutrophils		
Pyknosis	6-12	6-12
Cytoplasmic & Nuclear vacuolation	12-18	12-18
Nuclear Fragmentation	16-24	16-24
Disintegration	>36	>48
Acidophils		
Pyknosis	6-12	6-12
Cytoplasmic & Nuclear vacuolation	12-18	12-18
Nuclear Fragmentation	16-24	16-24
Disintegration	>36	>48
Monocytes		
Pyknosis	6-12	6-12
Cytoplasmic & Nuclear vacuolation	12-18	12-18
Nuclear Fragmentation	>24-36	>24-36
Disintegration	>36	>36
Lymphocytes		
Nucleus Swollen, cytoplasm and cell membrane indistinct	>24	>24
Pyknosis	>36	>40
Nuclear Fragmentation	>48	>48
Disintegration	--	--

Table 3: Time interval during which the respective changes in platelets are seen in summer and winter

Platelets	Summer	Winter
Present	16-20 hours	16-22 hours
Absent	>16-20 hours	>16-22 hours

Table 4: positive predictability of results in the present study

Time range	Cases Studied	N	%
0-6 hours	5	4	80
6-12 hours	5	4	80
12-18 hours	5	3	60
18-24 hours	5	2	40
24-36 hours	5	1	20
36-48 hours	5	4	80

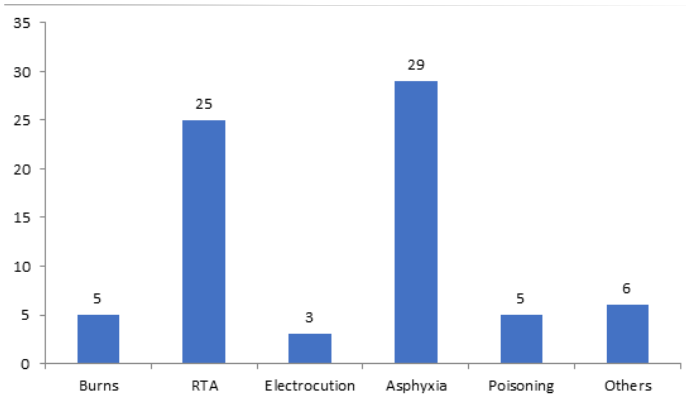

Figure 1: Cause of death profile for study population

In samples from refrigerated cadavers, RBC's discoid configuration transformed to echinocytic, spherocytic, and demonstrated crenation artefacts. However, the integrity of cell was preserved. WBC cell changes were stalled from further autolysis once they were refrigerated at 4 degrees centigrade in 22 cases and 7 cases showed further autolytic changes when smears were compared at autopsy. Increased fragility of WBC was demonstrated by presence of smudge cells in 8 cases along with disintegration of nuclear lobes and occasional nuclear budding and ragged cell membrane. It is difficult to opine whether they are storage artefacts or autolytic changes. Platelets showed no significant change pre and post refrigeration. Hence, it can be concluded that further autolysis of platelets is stalled by storing the cadaver at 4 degrees centigrade.

Because there was a wide variation in findings with respect to autolytic changes, we are presenting the autolytic changes seen in RBC (Table 1), WBC (Table 2) and platelets (Table 3) in time ranges. It can be inferred that the below mentioned changes in all cell lines were seen against the mentioned time period in our cross-sectional observation. A word of caution here is that they were not followed up during the range. Positive predictability of results is given in Table 4. The distribution of cases based on their cause of death is shown in Figure 1. Asphyxia was the leading cause of death, followed by road

traffic accidents.

The previous studies by Bardale et al.[6] and Kumar et al.[7] in this area were extremely helpful in the analysis of our data. The ranges in the study are upper and lower limits when the changes were noted first.

Discussion

The evidence required for legal medicine purposes in not just of indicative nature, it must be of probative standards. When the standard of proof required is beyond reasonable doubt to sustain the case fit for prosecution, the results of current study or previous studies conducted in this area of time since death is only of academic interest with almost no practical utility. It has been clearly established by this study that refrigeration of the corpse and seasonal variations cast a profound shadow of doubt in interpretation of results. The wide ranges of unpredictable changes in autolysis of cell lines makes standardization of data very difficult and hence further researchers are advised to desist from pursuing any research in this area. Peripheral smear cannot help in understanding the changes happening over lower ranges of time. Sub cellular and molecular forensics may provide some useful answers by studying over expression of some genes after death[8], degradation patterns of mRNA[9] etc.

In fact, a thorough research in molecular forensics is going to provide peculiar gene expression patterns that were actually silenced all during life and may provide new insights to understanding disease and evolution of the branch of personalized medicine.

When the results obtained in the study are used as a test for 30 cases the positive predictability of our results is shown in Table 4. No additional advantage is provided by these microscopic changes when compared to gross post-mortem changes in our study.

Conclusion

Future research in this area is strongly discouraged. With molecular autopsy making inroads in to Indian subcontinent, mRNA degradation-based methods and post-mortem gene activation-based methods are to be conducted in Indian scenario

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REVIEW ARTICLE

Covid-19 pandemic: Medico legal aspects in anaesthesia practice

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Abstract
Anesthesiology is a specialty that delivers prompt and positive results in patient care. It is natural for the general population to expect the highest degree of care and services from anesthetist. In the present time, patients are much more aware of their rights and medical procedure-related negligence. If any catastrophe occurs, it grabs news headlines very quickly. Laypeople suspect negligence in such cases, and these cases land up in the court of law. In the courts, decisions are left to the judiciary, which can be potentially influenced by the opinion of the general public. There has been a rising trend in medical negligence cases registered in consumer courts after the decision of the Supreme Court, that the services provided by an anesthesiologist come under the word "service" of Consumer Protection Act (1986). So the apprehension amongst the anesthesiologists regarding the legal issues is rising. And it has more value in the present COVID-19 pandemic to deal with. This article highlights the importance of maintaining the standard of care and protocols by which anesthesiologists can avoid legal consequences. Doctors should have legal awareness so that they can defend their cases in courts properly. There is a need to maintain a healthy doctor-patient relationship, good record keeping, and to provide a reasonable standard of care.

Keywords
COVID-19; Medico-legal; Anesthesia; Pandemic

Introduction

Anesthesiology is a specialty with high risk, and ordinary people are not aware of this very fact. Risk is even higher in the present COVID-19 pandemic, and the anesthesiologists are amongst the most vulnerable healthcare population. The 2019-novel Coronavirus is officially called SARS-CoV-2 and is the cause of the recent pandemic.[1] It has affected almost 205 countries till date as per the WHO datasheet.[2] With the advances in the medical field, availability of safer drugs, improved quality of instruments and higher monitoring standards has made the practice of anesthesia safe as compared to older times but "To err is only human" is a common saying since ages. So anesthesiologists are unknowingly bound to make mistakes on particular occasions and complications may ensue. At times, these mistakes may be severe enough to cause morbidity and mortality.

Nowadays, as a result of commercialization and limited interaction in medical practice, mutual trust is lacking in the doctor-patient relationship. The present pandemic has also contributed to increasing this gap between doctors and patients. Patient and their attendants suspect negligence on the part of treating physicians whenever a casualty occurs, and such cases are filed in the court of law. Allegations are coming from the patients and their relatives accusing doctors of being a source of infection to the patients. With the introduction of the Consumer Protection Act in 1986[1] and incorporation of medical professionals under it, there has been a constant rise in cases registered of medical negligence with the consumer forum.[3] This results in rising apprehension among practicing anesthesiologists. WHO has formulated standardized protocols for safely conducting surgery and anesthesia like surgical safety checklist, standard operative procedures (SOPs) for obtaining consent, anesthesia machine checklist, and so on.[4] Indian Society of Anesthesiologists (ISA) had also issued an advisory to ensure the safety of patients and anesthesiologists in the perioperative period during the present COVID-19 era. In the absence of specific treatment or vaccine for COVID-19, preventive measures like regular hand washing or using alcohol-based sanitizer, use of personal protective equipment, not touching face and maintaining social distancing are essential to reduce the spread of infection.[1]

A medico-legal awareness must be present among practicing doctors to defend any cases filed against them in court. Anesthesiologists not abiding by the standard of care protocol and exhibiting negligence are liable for issuing of malpractice suits. Important medico-legal issues related to anesthesia practice are discussed below.

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Informed consent

"Every human being of adult years and sound mind has a right to determine what shall be done with his body, and a surgeon who operates without the patient's consent commits an assault

for which he is liable to damages".[5] Informed consent is a procedure in which patient decides and gives permission for treatment and invasive/non-invasive procedures after achieving an explicit knowledge of implications and facts of undergoing actions mentioned above. It is a procedure or process and not merely a signed legal document, contrary to common belief. The responsibility of obtaining consent for method or treatment lies with the doctor performing or providing the same.[6] Indian Penal Code (IPC) also highlighted the importance of informed consent in sections 88 and 89, which protects the anesthesiologist against any mishap. Sec. 88 IPC state that *"Nothing which is not intended to cause death, is an offense by reason of any harm which it may cause, or be intended by the doer to cause, or be known by the doer to be likely to cause, to any person for whose benefit it is done in good faith, and who has given a consent, whether express or implied, to suffer that harm, or to take the risk of that harm."*[7] While sec. 89 state that *"Nothing which is done in good faith for the benefit of a person under twelve years of age, or of unsound mind, by or by consent, either express or implied, of the guardian or other person having lawful charge of that person, is an offence by reason of any harm which it may cause, or be intended by the doer to cause or be known by the doer to be likely to cause to that person."*[7]

Conditions for obtaining an informed consent are first when the patient can think and decide rationally. Secondly, he has received information regarding all relevant facts, including diagnosis, nature, and purpose of treatment modalities, potential risks, and benefits of a particular therapy and alternative options if available. Informed consent should be based on adequate information regarding the procedure, or treatment.[8] AAGBI strongly recommends that a pre-operative assessment clinic is the best place for obtaining permission.[9] The physicians should focus on facilitating open communication with patients.[10]

Key points to remember while taking informed consent can be summarized as below:

a. It should be taken when the patient is conscious and coherent and not under the influence of any drugs.
b. Consent should be taken only after explaining it in the patient's language, use an interpreter whenever required.
c. The patient should be explained about the procedure, its risks and benefits, and alternatives.
d. The patient can accept or refuse any treatment (patient autonomy principle).
e. In conditions where the patient is with altered mental status, unconscious, disabled or incompetent to provide consent, next of kin may provide consent.
f. If a person is under twelve years of age, or of unsound mind consent to be given by parents/guardians.
g. Under life-threatening emergency conditions, consent should be waived and implied; still, documentation is a must. Relatives can be informed later about the decision taken.
h. Tele-consultation guidelines have been issued in India by the Board of Governors. If consent is obtained from parents/guardians over the telephone or any other electronic media, it should be documented in the presence of two disinterested witnesses before proceedings.

Malpractice

Medical malpractice is defined as a doctor's failure to exercise the standard degree of care while managing ailments of the patients.[11] Medical malpractices legally describes a specific type of negligence in which a professional (anesthesiologist) fails in following standard care and protocol and results in causing harm to a patient. To prove medical malpractice, the following things should be established:

a. The duty owed by a physician to him
b. The physician failure in fulfilling a duty: there was a breach in the duty of care
c. Standard of care and protocols not followed
d. Breach resulting in harm to the patient, the existence of close relation between act and resultant harm.

It should be kept in mind even when anesthesiologists act appropriately, and adverse outcomes may still occur; hence it becomes essential to inform the patients about potential risks and to set appropriate expectations before initiation of procedure/treatment. Bolam's principle states that "*doctors if acted in accordance with a practice accepted as proper by a body of responsible and skilled medical opinion, will not be found negligent*."[12]

Standard of care

Standard of care is the general protocol of how an anesthesiologist must act in any particular case. These standards of care protocols came to exist firstly as a result of an increase in awareness of the general public regarding anesthesia, it's safety and potential risks and secondly increasing number of lawsuits filed against anesthesiologists with the increase in insurance premiums. These circumstances led them to develop ways to reduce anesthesia-induced morbidity and mortality. The court utilizes this protocol to determine whether the medical personnel failed to perform his responsibilities or duty.[13] The standard of care is specific and subjective for each case based on the guidelines laid down by various anesthesia societies. If any lawsuit is filed against any anesthesiologist in

the court of law, then the defendant anesthesiologist will be compared with any reasonable and advisable anesthesiologist from the country.[14]

Anesthesiologists should follow the standard of care during any and all cases:

a. Anesthesia machine and breathing circuits to be checked; and emergency resuscitation equipment and drugs to be kept ready before proceeding for any case.
b. He should be present throughout while dealing with any cases of regional and general anesthesia.
c. Continuous monitoring and evaluation of vital parameters such as ventilation, oxygenation, body temperature, and circulation have to be done.
d. In general anesthesia cases, clinical signs like chest expansion, auscultation for breath sounds, reservoir breathing bag observation should be continuously done. End-tidal carbon dioxide ($etCO_2$) monitoring is also encouraged whenever possible and available. Correct position of endotracheal tube/laryngeal mask airway(LMA) to be ensured and confirmed by capnography.[15]

Another critical issue that has a close link with the standard of care during the present COVID-19 pandemic is to acquire infections from the healthcare workers. Anesthesiologists work close to the patients, thus increasing the chances of disease spread from doctors to patients if they are infected. Recently, in State of Rajasthan (India), the possible root of transmission to the patients was believed to be the same private hospital whose coronavirus-infected doctors treated hundreds of patients before themselves testing positive.[16]

In this scenario, anesthesiologists can be charged with sec. 269 and 270 IPC.[7] Sec.269 states *"Whoever unlawfully or negligently does any act which is, and which he knows or has reason to believe to be, likely to spread the infection of any disease dangerous to life, shall be punished with imprisonment of either description for a term which may extend to six months, or with fine, or with both."* While sec 270 state *"Whoever malignantly does any act which is, and which he knows or has reason to believe to be, likely to spread the infection of any disease dangerous to life, shall be punished with imprisonment of either description for a term which may extend to two years, or with fine, or with both."* That's why it is crucial to mention the risk of infection spread from the anesthesiologist to the patient. Many a times the infected person does not show any evidence of infection, and he continues to do his routine work without knowing his infectivity. This important fact has to be highlighted to the patient while taking consent. And, obviously wilfully hiding information by healthcare professionals regarding their infectivity status amounts to crime according to the above-mentioned sections of IPC.

Privacy and confidentiality

The right to privacy has been an integral part of medical ethics. International Code of Medical Ethics mandates that the health practitioner must maintain confidentiality regarding personal information of the patient, which they encounter during the treatment. Healthcare professionals can inform their colleagues who are involved in the treatment protocol of the patient but cannot notify the third party without taking consent from the patient. But, in specific situations like the COVID-19 pandemics, where the ultimate goal is to protect the society, the information of the patients can be divulged to the Government officials.

Apart from the doctors' duty towards their patients and society, it's also a moral duty of the patient and the community to behave responsibly towards the doctors and other health care professionals. Still, recently even in this pandemic time of COVID-19, there have been numerous shameful incidents of violence against doctors while they were discharging their duties in the frontlines of India's battle against COVID-19 pandemic. So for the prevention of such heinous acts, the government of India made new amendments on 22nd April 2020 to the Epidemic Diseases Act, 1987. The latest modifications include punishment for any kind of violence against doctors/health workers in the form of imprisonment for up to 7 years. The offense has been designated as a non-bailable offense. In the case of grievous hurt to the doctors, the accused can face imprisonment from 6 months to 7 years with or without fine ranging from Rs 1 lacks to 5 lacks. The investigations for such cases have to be completed within 30 days of the incident. [17]

Advanced directives

These are specific instructions to direct providers of the patient regarding the proceedings if the patient himself can no longer make decisions due to illness. Various types of advanced directives like a living will, health care proxies are present. In a living will, there are specific instructions regarding any course of treatment; for instance, it may specify that patient does not want to receive interventions like intubation, ventilator support, or CPR. However, in health care, a power of attorney, that is, another individual is appointed to make decisions on the patient's behalf.

Do not intubate (DNI)/Do not resuscitate (DNR)

Some individuals may not opt for life-saving procedures like intubation or CPR. This decision is taken by patients with end-stage diseases or terminal illnesses. Ultimately it should be kept in mind that it is the patient's right to decide whether to resuscitate or not in case of cardiac arrest. Therefore it is

imperative to discuss specific preferences of a patient before shifting to the operation theatre as these choices cannot be placed on hold once the patient is posted for surgery. This should include a discussion regarding the procedures or therapies which are acceptable or not to the patient intraoperatively. Methods or treatment usually include intubation, CPR, use of vasopressors, defibrillators. All the information should be communicated to the whole operative team and must be documented. The anesthesiologists should be very cautious in helping patients in determining their resuscitation status in the operation theatre, as our society is heterogeneous and multicultural, and assuming that a physician and patient share the same moral values is incorrect.[18,19] The American Society of Anesthesiologists has published guidelines for anesthesia care of patients with DNR orders.[20]

a. When confronted with a surgical patient who has a DNR order, schedule a meeting before surgery to include anesthesiologist, surgeon, or physician of record. The patient or patient's surrogate to review and discuss any existing directives which limit the use of resuscitation procedures or any clarification/modification of DNR directives during the anesthesia, based on the patient's preference solely.
b. Any clarification or modification of the DNR orders, as discussed in meeting with the patient and their relatives should be appropriately documented. These discussions may lead to the following possible outcomes:
c. *Full attempt at Resuscitation*- There will be a complete suspension of DNR orders during the time the patient is under anesthesia and in the postoperative period directly following.
d. *A limited attempt at resuscitation defined concerning specific procedures*- The patient or surrogate refuses certain particular procedures associated with resuscitation, such as chest compressions or defibrillations. The anesthesiologist must explain those procedures essential to the successful outcome of the planned anesthetic (intubation) and those procedures which are not.
e. *A limited attempt at resuscitation defined concerning patient's goals and values*- The anesthesiologist and surgical team should use their clinical judgment in determining which resuscitation procedures are appropriate or not given the circumstances and based on the patient's goals and values. Will the resuscitation be quick and restore the patient, or will it be more likely than not, leave the patients with permanent impairments?
f. In case of an emergency, the patient's consent is presumed, and CPR should be administered. If there is a DNR order, proceed as if the patient desires all resuscitative measures during the perioperative period.

The Expert Witness

The medical malpractice suits cover those issues, which are sometimes beyond the comprehension of the court and jury, so it results in assigning an "expert witness" by the court for establishing whether standard of care protocols were followed or not by the defendant anesthesiologist. Medical doctors are not only expert witnesses but also at certain times ordinary witnesses. They must be acknowledged in their field of expertise and expected to help or support through their skills and experience for the explanation of events that occurred in the case.[21,22]

The following criteria should be fulfilled by an anesthesiologist to serve as an expert witness:[22]

a. He should be active and familiar with practice in clinical anesthesiology
b. He should be holding qualification certified by the board or an equivalent degree
c. He should have a currently valid and unrestricted license for medical practice

As an expert witness, following guidelines to be ensured while providing the service as one:[22]

a. He should evaluate the case while keeping in mind the accepted protocol of standard of care.
b. He must assess any substandard practice that is alleged regarding patient care.
c. He must be prepared to present his evidence for peer revision.
d. The fees collected by an expert witness should not be a result of the trial but of the time spent at work.
e. He should differentiate between unfavourable results or adverse effects/events as medical malpractice is not always linked with negligent practice.
f. The review should be complete and truthful regarding medical facts without ignorance of any crucial information in favour of either of the parties.

Conclusion

The anesthesiologist should maintain a standard of care, be competent and skilled throughout their carrier, including the present pandemic. They should keep their mental and physical health in sound condition and must not hesitate to seek expert advice from their colleagues as and when needed. Thus, in conclusion, anesthesiologists should practice ethically while following particular guidelines like good record keeping, healthy doctor-patient relationship and be up-to-date with recent advances to provide proper standards of care that will keep them safe from the false malpractice and negligence

allegations, as the general public is becoming more and more aware regarding their rights.

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REVIEW ARTICLE

Guidelines assessment and practices during COVID-19 autopsies

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Abstract
'PANDEMIC': A word which shook the whole world due to the fear of severe acute respiratory syndrome (SARS) - coronavirus-2 (CoV-2) outbreak in Wuhan, China which affected myriad lives worldwide till date. These numbers are increasing rapidly causing an inevitable rise in autopsy cases. Many reputed organizations stepped forward and released guidelines regarding the post-mortem examination in suspected COVID-19 cases. At present we are equipped with various such guidelines. Centre of Disease Control (CDC), Royal College of Pathologists (RCP) and WHO guidance are considered worldwide which elaborate the risks, precautions and safety measures for the Health care worker. In India, Ministry of Health & Family Welfare (MOHFW) has framed the guidelines on dead body management. The following article is a review of the guidelines given by various apex bodies with a pragmatic approach regarding applicability and feasibility in the Indian scenario with certain recommendations.

Keywords
COVID-19; CDC; RCP; WHO; MOHFW; Guidelines.

Introduction

Many countries worldwide are raising concerns regarding Coronavirus Disease 2019 (COVID-19) since December 2019. Different associations and stakeholders have issued guidelines in different parts of the world for the management of dead bodies, the risks involved and protection of health professionals. The brief guidance by RCP following the outbreak of the COVID-19 emphasizes that if a death is confirmed as resulting from COVID-19 infection, there is no need for a post-mortem examination and the Medical Certificate of Cause of Death should be issued. It also recommends levels of staff experience to be mandated for undertaking risky maneuvers in HG3 cases.[1] CDC document provides specific guidance for the collection and submission of postmortem specimens from known or suspected deceased COVID-19 cases. It also provides recommendations for biosafety and infection control practices during specimen collection and handling and during autopsy.[2] The interim guidance is recommended by WHO for all those, including managers of health care facilities and mortuaries, religious and public health authorities, and families, who attend to the bodies of person, suspected or confirmed COVID-19 cases.[3]

The CAP (College of American Pathologists) Autopsy Committee recommends that only individuals properly trained in performing EID (Emerging infectious diseases) autopsies, with adequate personal protective equipment (PPE) and appropriate facilities should perform autopsies on patients with known or suspected COVID-19.[4] DGHS, MoHFW, Government of India has issued guidelines on dead body management in COVID-19 and also on rational use of PPE.[5, 6] International Committee of the Red Cross (ICRC) issued general guidance for the management of the dead related to COVID-19 for those involved in the management of the dead in relation to the pandemic. This is divided into two levels- General guidance and support in the management (handling) of the dead- Technical recommendations for Healthcare & Death Care workers and Preparatory Guideline for a Mass Fatality Response Plan.[7]

In China, they have developed the Guide to Forensic Pathology Practice for Death Cases related to Coronavirus Disease 2019 (COVID-19) which describes the background investigation, autopsy room requirements, personal prevention and protections, external examinations, autopsy practices and auxiliary examinations for institutions and staff.[8] Imperial college, London have outlined the hazard group categorization, pathological features and approach to the autopsy in suspected COVID-19 cases to aid mortuary workers.[9] The interim guidelines by Italy recommends the management of corpse with suspect, probable or confirmed COVID-19 respiratory infection for the personnel potentially exposed to material from corpses, including body fluids, in morgue structures and during autopsy practice.[10]

According to a study on the resistance of severe acute respiratory syndrome corona virus, the virus can survive for 2 days in hospitals or domestic sewage and dechlorinated tap water, for 3 days in faeces, and 17 days in urine at 20°C away from light. However, at 4°C, the virus can survive longer than

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14 days in the above mentioned water settings, and longer than 17 days in faeces. Human coronaviruses can remain infectious on surfaces for up to 9 days.[3] In a case report of a patient dying with Middle Eastern respiratory syndrome corona virus, the virus was detected in nasal secretions even 3 days after death. Operators are highly likely to be infected with pathogens during the autopsy of infectious diseases when gloves and skin are punctured by sharp objects. Therefore, prevention and control measures should be taken seriously during postmortem examination in infectious disease deaths.[8]

Categorization of infectious hazards

The categorization of infectious hazards across all areas of medicine is regulated by the Health and Safety Executive's (HSE) Advisory Committee on Dangerous Pathogens (ACDP). Control of substances hazardous to health (COSHH) defines four containment levels.[1, 9] These hazard groups (HG1–4) are assigned according to the risk of human infection, the likelihood spread and access to treatment or prophylaxis. HG3 agents can cause severe human disease and may be a serious hazard; the agent may spread to the community, but usually effective prophylaxis or treatment is available. SARS-CoV-2 has recently been categorized as a HG3 organism. [1, 12]

The incubation period of COVID-19 is approximately 14 days and at times lasts for 24 days or more.[13] It may be possible that a person can get COVID-19 with close contact (i.e. within about 6 feet) via respiratory droplets or by touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes.[2] In the mortuary infections may be acquired via puncture, skin contamination, ingestion, inhalation or contamination of mucosal surfaces.[1]

Obstacles to COVID autopsy

These include the fact that even with the proper personnel equipment, and facilities, the risk of possible infection can be mitigated but not eliminated. A further complication in the case of COVID-19 is the unknown rate of asymptomatic carriage. Published estimates of the asymptomatic carriage are in the range of 18%- 30% with some authors suggesting even higher rates. [10] A preliminary report from China found that 59% of patients who tested positive were either asymptomatic or mildly symptomatic. The lack of a suspicious clinical history does not guarantee that a person is free of the novel coronavirus. In the face of these risks and uncertainties and the infrastructural demands of the COVID pandemic, some hospitals in USA have made the decision to temporarily suspend the performance of all autopsies. [4] Asymptomatic infected persons, patients in incubation period, unidentified dead bodies and cases with negative result may not meet the diagnostic criteria for suspected cases, but should be treated as suspected COVID-19 death cases as false negative result is not uncommon. [11]

Information relevant to the autopsy & staged autopsy

In cases of autopsies on patients with unknown COVID-19 status, COVID testing should be performed to ascertain status prior to performing the autopsy. This is referred to as a staged autopsy by the Royal College of Pathologists. [4, 9] The autopsy should also be performed in a manner to completely document co-morbidities. [4] Information about the circumstances of death, standard clinical information, location of death and knowledge of past (International) travel, laboratory data and microbiology data (positive and negative) are critical. In addition travel history of any relatives at home, any symptoms like fever, cough, cold and shortness of breath, any history of contact with suspect, any comorbid condition, recent visit to hospital, history of home quarantine, history of being tested for COVID are important. This information along with clinical features is important in identifying suspected cases. [11] It is important not to assume that the information provided is accurate. [1]

Biosafety and infection control practices during autopsy

Safety and wellbeing of staff involved in managing the dead of COVID-19 should be the utmost priority. Latest recommendations from national and international health organizations are important. [7] All updated RCP and CDC guidelines for postmortem COVID-19 testing and autopsy procedures can be followed. [1, 2]

Human Resource Management & Mortuary Factors

Inexperience and lack of upfront protective practices are risk factors for accidentally acquiring potentially severe infections. Training is to be provided to HCWs. [5, 14] Keep all the necessary equipment in the vicinity and close the door while performing the autopsy. [8] Allow only one person to cut at a given time, Dissect one body cavity at a time. Limit the number of personnel working in the autopsy suite at any given time. [2, 4, 5] Minimally invasive autopsies (MIA) with needle sampling is recommended by RCP. [1] A logbook including names, dates, and activities of all workers participating in the postmortem and cleaning of the autopsy suite should be kept to assist in future follow up, if necessary. [2]

The mortuary must be kept clean and properly ventilated. Aerosol generating procedures such as use of an oscillating bone saw should be avoided for known or suspected COVID-19

cases. Consider using hand shears as an alternative cutting tool. If an oscillating saw is used, attach a vacuum shroud to contain aerosols.[1, 2] Round ended scissors and PM40 blades should be used.[1, 5] CDC recommends the use a biosafety cabinet for handling and examination of smaller specimens and other containment equipment whenever possible.[2] Use caution when handling needles or other sharp objects, and dispose of contaminated equipment in puncture-proof, labeled closed containers. Clothing worn by deceased must be disposed of as contaminated special waste.[8] After the procedure, body should be disinfected with 1% Sodium Hypochlorite and placed in a body bag, the exterior of which will again be decontaminated with 1% Sodium Hypochlorite solution.[5] Instruments used during the autopsy should be cleaned and disinfected immediately after the autopsy.[3]

Engineering Control Recommendations

Autopsies of known or suspected COVID-19 cases should be conducted in Airborne Infection Isolation Rooms (AIIRs). These rooms are at negative pressure to surrounding areas, have a minimum of 6 air changes per hour (ACH) for existing structures and 12 ACH for renovated or new structures, and have air exhausted directly outside or through a HEPA filter. If an AIIR is not available, ensure the room is at negative pressure with no air recirculation to adjacent spaces. [2] The recommended mortuary set up can be (biosafety level) BSL-2 or BSL-3. [15]

PPE Recommendations

Check the integrity of the PPE. [8] The donning and doffing of PPE should be done cautiously. Double surgical gloves interposed with a layer of cut-proof synthetic mesh gloves, fluid-resistant or impermeable gown, waterproof apron, goggles or face shield, N-95 respirator or higher like PAPR (Powered, air-purifying respirators), surgical scrubs, shoe covers, and surgical cap should be used as per routine protocols. [1, 2, 5, 6]

After removing PPE, discard the PPE in the appropriate laundry or waste receptacle. Reusable PPE (e.g., goggles, face shields, and PAPRs) must be cleaned and disinfected according to the manufacturer's recommendations before reuse. Immediately after doffing PPE, wash hands with soap and water for 20 seconds. If hands are not visibly dirty and soap and water are not available, an alcohol-based hand sanitizer that contains 60%-95% alcohol may be used. [2] PPE gives as much protection as reasonably possible against the majority of HG3 infections, including blood-borne viral agents. Only infective aerosols (e.g. TB) are not 100% protected against. [1]

Collection of Postmortem Specimens

CDC recommends collecting and testing postmortem nasopharyngeal swabs (NP swabs) and if an autopsy is performed then lower respiratory specimens (lung swabs). RCP recommends BAL (Lower respiratory tract) and blood for serology also. [2]

The preferred specimens would be a minimum of eight blocks and fixed tissue specimens representing samples from the respiratory sites listed below in addition to specimens from major organs (including liver, spleen, kidney, heart, GI tract) and any other tissues showing significant gross pathology. [1, 4] The recommended respiratory sites include:

1. Trachea (proximal and distal)

2. Central (hilar) lung with segmental bronchi, right and left primary bronchi

3. Representative pulmonary parenchyma from right and left lung [2]

Cleaning and Waste Disposal Recommendations

Ensure workers are trained about hazardous chemicals used in the workplace. Keep ventilation systems active while cleaning. Use disposable gloves, long-sleeved fluid-resistant gown, eye protection, N-95 respirator. Use disinfectants that are believed to be effective against COVID-19. Use of tongs and other utensils can minimize the need for personal contact with soiled absorbent materials. Large areas contaminated with body fluids should be treated with disinfectant following removal of the fluid with absorbent material. Dispose of human tissues according to routine procedures for pathological waste. Clean and disinfect or autoclave non-disposable instruments using appropriate precautions with sharp objects. Materials or clothing that will be laundered can be removed from the autopsy suite in a sturdy, leak-proof biohazard bag that is tied shut and not reopened. These are then sent for laundering according to routine procedures. Wash reusable, non-launderable items (e.g. aprons) with detergent solution on the warmest setting possible, rinse with water, decontaminate using disinfectant, and allow items to dry completely before next use. Keep camera, telephones, computer keyboards, and other items in the autopsy suite clean by wiping after use with appropriate Environmental Protection Agency (EPA)-approved disinfectant. When cleaning is complete and PPE is removed, follow hand hygiene protocol.

Safe management of dead body of COVID-19

The safety and well-being of everyone who handles bodies should be the first priority. The dignity of the dead, their cultural and religious traditions, and their families should be respected and protected. Standard infection prevention control

practices should be followed at all times. These include:

1. Hand hygiene.

2. Use of PPE.

3. Safe handling of sharps.

4. Disinfect bag housing dead body; instruments and devices used on the patient.

5. Disinfect linen and environmental surfaces. [3, 5]

It is advisable to collect nasopharyngeal swabs at the emergency department/casualty/ward/ICU and then send it for COVID-19RT-PCR test in all Suspected/ Latent/ Unascertainable cases before moving the body to mortuary for preservation if the same was not done procedurally. SARS-CoV-2 RNA may still be detected up to 3 days postmortem and possibly longer. The existing mortuary facility for body storage should be strictly divided into COVID-19 and Non COVID-19 bodies. [11]

Packing the Body for Transfer from patient room

Remove all lines, catheters and other tubes. Ensure that any body fluids leaking from orifices are contained. Any puncture holes or wounds (resulting from removal of catheter, drains, tubes, or otherwise) should be disinfected with 1% hypochlorite and dressed with impermeable material. Plug oral and nasal orifices of the dead body to prevent leakage of body fluids. If the family of the patient wishes to view the body at the time of removal from the isolation room or area, they may be allowed to do so with the application of Standard Precautions. Place the dead body in leak-proof plastic body bag. The exterior of the body bag can be decontaminated with 1% hypochlorite. The body will be either handed over to the relatives or taken to mortuary. All used/ soiled linen should be handled with standard precautions, put in bio-hazard bag and the outer surface of the bag disinfected with hypochlorite solution. The health staff who handled the body should remove PPE, perform hand hygiene steps and provide counseling to family members. [5] Management of the emotional reactions of the relatives throughout the grieving process is often the prime responsibilities of the doctors. [11]

Environmental cleaning and disinfection

As human coronaviruses remains infectious on surfaces for days, cleaning the environment is of paramount importance. All surfaces of the isolation area (floors, bed, railings, side tables, IV stand, etc.) should be wiped with 1% Sodium Hypochlorite solution, allowing a contact time of 30 minutes and then be allowed to air dry. Environmental surfaces, where the body was prepared, should first be cleaned with soap and water, or detergent solution. After cleaning, disinfect with a minimum concentration of 0.1% sodium hypochlorite (bleach), or 70% ethanol should be used on the surface for at least 1 minute. [3]

Transportation and Burial/Cremation

The body, secured in a body bag, exterior of which is decontaminated poses no additional risk to the staff transporting the dead body. The personnel handling the body may follow standard precautions (surgical mask, gloves). The vehicle, after the transfer of the body to cremation/ burial staff, will be decontaminated with 1% Sodium Hypochlorite. [5]

COVID 19 body can be buried or cremated. Crematorium/ burial Ground staff should be sensitized that COVID 19 does not pose additional risk. The staff will practice standard precautions of hand hygiene, use of masks and gloves. Viewing of the dead body by unzipping the face end of the body bag (by the staff using standard precautions) may be allowed. Bathing, kissing, hugging, etc. of the dead body should not be allowed. [3, 5] Ensure that family members reduce their exposure as much as possible. Children, older people (>60 years old), and anyone with underlying illness (such as respiratory illness, heart disease, diabetes, or compromised immune systems) should not be involved in preparing the body. [3]

The funeral/ burial staff and family members should follow hand hygiene after cremation/ burial. The ash does not pose any risk and can be collected to perform the last rites. Large gatherings at the crematorium/ burial ground should be avoided as part of the social distancing measure. [5]

Recommendations

1. If death is confirmed due to COVID-19 infection, there is no need to conduct post-mortem examination and the Medical Certificate of Cause of Death should be issued.
2. Knowledge, experience, preparation and updating with recent protocols issued by the international and national associations and stakeholders are the key aspects in managing any possible COVID-19 post-mortem examination.
3. All health care workers- all the personnel associated with the care of the dead, from doctors to mortuary staff, to hearse van drivers and crematorium/ burial ground staff should follow the precautions in managing such cases.
4. Standard operation protocols for safe and effective practice are essential.
5. Staged autopsy is preferred in such situations.
6. Nasal swabs are the preferred method for confirming COVID-19 infection that can be obtained from the

deceased. If a deceased person is suspected of COVID-19 infection, nasal swabs should be taken and examined. This will improve the tracing and safety of the Health care worker and relatives involved in the process of body handling.

7. Ensure safe and dignified management of Covid-19 dead bodies including preservation, transportation and disposal.

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REVIEW ARTICLE

Application of maxillary sinus and nasal aperture morphology for forensic identification with the aid of CBCT imaging: A review

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Abstract

Bone remodelling of the cranium determines the enlargement of the maxillary sinus. The process involves the resorption of the internal walls of the maxillary sinus minutely exceeding the growth of maxilla. During this process, there is bone deposition taking place at the medial border of the nasal cavity, and simultaneous resorption of the lateral wall of the nasal cavity causing differences in quantitative measurements of the nasal aperture too. Maxillary sinuses have been reported to stay intact even though the skull and other bones of the cranium may be severely disfigured in victims who are incinerated or during external trauma. Any morphometric measurements like the width, the depth or the height may be used to investigate the accuracy and reliability of maxillary sinus data for purpose of human identification and sex estimation. These dimensions can be correlated with the measurements of the nasal aperture and this will also give an insight into the role of the midface in development of the cranium. These measurements are also important anthropometric parameters for classifying the race of an individual whose identity is unknown.

Keywords

Maxillary sinus; Nasal aperture; CBCT; Nasal cavity; Forensic facial reconstruction; Morphology

Introduction

The identification of unknown human remnants continues to be a challenge for Humanitarian and Law enforcement agencies worldwide. Metric data of human body parts has been given utmost importance amongst morphological research. The roles of forensic anthropology in legal medicine and archaeological institutes have become effectively evident in the identification of perpetrators of crime, unidentified bodies, estimation of age, sex, race, stature, aesthetic and functional loss, etc. [1] The pre-requisite and solution to ease of collection of such metric data lies in the analyses of body parts with 3-dimensional imaging modalities usually Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and Cone Beam Computed Tomography (CBCT). [2] Numerous studies have already highlighted the advantage of CBCT over other 3-dimensional imaging techniques, especially concerning head and neck areas. Additionally, CBCT offers distinct advantages over other technology as it is non-invasive and comparatively economical.

During many mass disasters, even when the skull and other bones where heavily disfigured and also in incinerated head remnants, maxillary sinuses have been reported to stay intact. The morphometric measurements which aid to investigate the reliability of maxillary sinus parameters such as the width, the depth, and the height of maxillary sinuses and the accuracy to which they can also be used for individual identification as well as for sex estimation are interesting areas to be explored.

The anatomic association of the maxillary sinus with the human nasal aperture, and its effects on the various shapes and sizes, as well as the ethnic influences on both the structures may result in different appearances of the face. The nasal aperture is an anthropometric parameter of significance for designating the race and sex of the individual whose identity is unknown. A nasal index is an anthropometric index which is influenced by ethnicity and may be utilized for various applications in forensic identification.

This manuscript aims to review the applications of the maxillary sinus and nasal aperture dimensions as an aid for individual identification as well as sexual dimorphism and the application of CBCT imaging modality in determining the same.

Morphometric analysis of the nasal aperture measurements and nasal index

Various studies depicting the importance of morphometric analysis of the human skull have been published in recent years. But the analysis of the nasal aperture and its correlation to the maxillary sinus is sparsely found in the literature. Among the very few studies conducted, one study was conducted by Sharma et al. to provide baseline data of the nasal ergonomics for males and females of the Hindu community of Gwalior region. Nasal length, breadth, height and depth were measured

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using a digital vernier calliper. This study provided baseline data for people of Gwalior region which would be valuable in nasal anthropometry for forensic application and medical management especially in reconstructive surgery, rhinoplasty.[3]

Establishing sexual dimorphism with the aid of 3D imaging is a new concept. Forensic estimation of sex requires population specific baseline data for precise identification. Applying such data, a study was conducted by Tengku et al. to measure the nano-facial parameters to model the nasal prostheses from the CT data of 30 normal healthy subjects. The study results which showed sexual dimorphism in males and females for nasal characteristics were applied during the prosthesis fabrication. It can be concluded that the baseline data derived from a 3-D imaging modality gives more advantages over the conventional methods prosthesis fabrication in terms of time and accuracy of nose shape.[4]

A study conducted by Moreddu et al. to evaluate correlations between sexual dimorphism and the dimensions of the Piriform aperture also used 3D-CT scan reconstructions. Landmarks positioning around the piriform aperture of the faces of 79 females and 91 males from Marseille (France) were analysed in conventional and geometric morphometrics methods. The facial measurements showed a statistically significant sexual dimorphism.[5]

In Indian context there is lack of anthropological baseline data for various populations. Kotian et al. performed a study of South Indian population from measurements of dimensions of nasal aperture and nasal index using Multidetector Computed Tomography scans to discover the possibility of sex determination. The height and width of nasal aperture from 84 males and 66 females aged 12 - 80 years was considered for the study which showed significant positive results.[6]

As reported in literature, the nasal dimensions and nasal index has been used in studies to establish the identity of individuals. The nasal aperture measurements as well as nasal index is a useful tool in revealing sexual dimorphism and also is an essential anthropological tool in human identification for analysing racial and ethnic differences.

Morphometric analysis of the maxillary sinus

The dimensional accuracy of maxillary sinus in cadavers even after heavy trauma signifies the importance of research related to the same. A study was carried out to analyse the accuracy and reliability of maxillary sinus by Sidhu et al. for gender determination using morphometric parameters. Morphometric parameters of maxillary sinus from lateral cephalogram of 50 subjects were analyzed using AutoCAD 2010 software (Autodesk, Inc.). The results showed that the discriminant function (DF) score close to 0.838 was supposed to be males, whereas, those whose DF score was closer to −0.838 was indicative of females. Also, DF analysis revealed that 76% of the originally grouped cases were classified correctly.[7]

Estimation of various dimensions of the maxillary sinuses using 3D imaging modality was conducted by Kiruba et al. on 200 subjects using head CT and their correlation to the sex of individuals. The height, width, and depth of the maxillary sinuses were measured using a Philips Brilliance 64 CT. They concluded that these dimensions of maxillary sinuses obtained may be beneficial for the ENT surgeons when planning for endoscopic sinus surgery besides serving as support for gender determination in forensic identification.[8] After the advent of the CBCT imaging modality Tambawala et al. conducted a study to evaluate the sexual dimorphism of maxillary sinus dimensions using the same. The height, depth, and width of bilateral maxillary sinuses from 30 CBCT scans was retrospectively measured and the data was subjected to statistical analysis. The overall values were significantly higher in the males when compared to the females. The height of the sinuses was determined using the best predictor in determining sexual dimorphism with the use of CBCT thus ruling out the complete dependence on the usage of other conventional 3-dimensional imaging for forensic applicaions.[9]

Significance of correlation between nasal aperture and maxillary sinus morphometric measurements

The anatomic proximity of nasal aperture and maxillary sinus in the facial skeleton, accounts for their direct relation between the growth pattern as well as anthropological measurements. A study was conducted by PrzystaNska et al. on CT images to assess age-related changes in maxillary sinus diameters correlated to diameters of the facial skeleton in which retrospective analysis of CT images of the head of 170 patients aged between 0–18 years was performed. Specific orientation points were identified in every patient and the distances were measured between them. The maxillary sinuses of every patient were bilaterally measured in three planes- horizontally, vertically, and antero-posteriorly. The correlation and determination coefficient through statistical analysis revealed that every measurement of maxillary sinus recorded correlated with mid-face dimensions.[10] Hence, the data obtained from such a correlation can be applied for aesthetic nasal surgeries, prosthesis fabrication for nasal reconstruction and archaeological research other than for forensic identification purpose. Hence, in this review we highlight the importance of studies in this direction within various population subsets for baseline data collection and also applicability of the research that relates the described morphometric measurements identifiable using Cone Beam Computed Tomography which confers increased effectiveness to the method.

Significance of CBCT imaging over other modalities

With the limited horizon of 2D radiology in the field of imaging and diagnosis, the advent of CBCT has given new hope towards better management of patients as well as increased forensic applications. There is a dearth of subject data in the Indian scenario available for forensic applicability which can be overcome by widening the application of CBCT. There are numerous existing studies and the future scope of conducting studies on areas of forensic applicability like age estimation,[11] sex estimation,[12] airway spaces,[13, 14] paranasal sinuses,[15] soft tissue, and hard tissue landmarks and measurements, [16, 17] in facial recognition and reconstruction,[17] etc. CBCT being a 3D imaging modality had the advantage of being non-invasive, comparatively economic,[18] lower radiation dose with better diagnostic accuracy having a 1:1 proportional ratio of face to image.[19,20] Hence more studies in different populations, specifically in Indian population needs to be conducted to enhance the ability of this method of imaging in the practice of Forensic Odontology.

Conclusion

Morphometric measurements of maxillary sinus and nasal aperture need to be constantly studied due to their importance and the degree of difficulty in predicting. Hence, we highlight the importance of further study in this direction as there is no literature specifically relating to the same. Various specific points need to be chosen that can be readily identified and measured on a CBCT which will add applicability to the method. Besides, a larger sample size representative of particular population is required to be researched for higher accuracy in forensic identification and subsequent other applications as highlighted in the review.

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REVIEW ARTICLE

Dental Pulp in Forensic Dentistry

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Abstract

Forensic Odontology, the branch of dentistry that is centered on dental or oro-facial findings has become an essential component of forensic science over the years. The identification of dental remains is of prime significance when the deceased individual is skeletonized, decomposed, burned, or eviscerated. Pulp plays an important role in forensic odontology as pulpal tissue can be used to determine age, sex and blood group antigen by molecular analysis. The present article discusses the uniqueness of pulp and how it can be used as an aid for determination of certain traits when no other remains are available.

Keywords

Forensic dentistry; Pulp; Personal identification; Forensic odontology

Introduction

Forensic Odontology is a sub-discipline of Forensic Medicine and Dentistry that focuses on the adequate assortment and presentation of dental findings. Dental and orofacial findings have shown to play a vital role in the identification of deceased individuals through the comparison of ante-mortem and post-mortem records.[1] Oscar Amoedo is regarded as the father of forensic dentistry.[2] The Federation Dentaire Internationale (FDI) characterizes forensic odontology as "that subdivision of dentistry that within the interest of justice, deals with the proper handling and examination of dental evidence and the best possible analysis and presentation of dental findings.[3]

The first ever utilization of forensic odontology to recognize a dead subject was done in the late 60's AD.[5] Wide scale use of forensic odontology was made in order to recognize the victims during the incident that occurred at World Trade Center in the United States. Over the last couple of decades, forensic odontology has been utilized in civil as well as criminal cases and has been designated as an integral part of forensic science owing to the fact that dental tissues are unaffected even when exposed to extreme temperatures or situations. Forensic odontology has applications in all disciplines of dental sciences.

The most indestructible constituent of the human body is the teeth which may remain more or less robust for a long time past death. They also contain particulars about the physiological and pathological occurrences during the life of a person which resides as markers inside the hard tissues of the teeth. During a disaster even after the other tissues are destroyed, teeth have been found to remain intact. Teeth are the most durable organs in the body which can withstand a temperature of 1600°C without the loss of its microstructure.[4] The dental pulp, the soft connective tissue at the core of the tooth is well protected from external influences like temperature, humidity and pressure. It remains a source of valuable forensic information long after the other less protected tissues of the body are lost. Here, we review the role of the dental pulp in forensic identification.

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Dental pulp

Dental pulp can be construed as a lavishly vascularized and innervated connective tissue of mesodermal inception encased by dentin which communicates with the periodontal ligament.[6] Pulp comprises of fibroblasts, defense cells like histiocytes, plasma cells, pluripotent undifferentiated mesenchymal cells, and stem cells. The apical foramen serves as a passage for blood vessels, lymph vessels and nerves. The pulpal tissue has been clinically proven for determination of certain traits which are discussed below.

Dental pulp in blood group identification

The term blood group is applied to acquired antigens recognized on the red cell surfaces by specific antibodies.[7] The ABO blood group framework, first laid down by Karl Landsteiner in 1900, remains the rampart of forensic blood group examinations. The utilization of blood group in medicolegal considerations depends on the certitude that once a blood group is established in an individual, it stays unaltered all through life.[8] Blood grouping from teeth could assist in identification of individuals by narrowing the search via exclusion of persons with different blood groups. Dental pulp contains numerous blood vessels and blood group antigens are present in tooth pulp. It has been suggested that blood group

antigens in the pulp are preserved even up to 2 years after the death of an individual.[8] The absorption-elution technique has proved to be markedly more sensitive than others. A study conducted by Saxena et al. proved the sensitivity of blood group determination using dental pulp by the absorption-elution technique to be 80% accurate.[9] Several other studies conducted by various authors have shown similar results with regard to blood group determination by the pulpal tissue.[10, 11,12] Pulp tissue is one of the most shielded tissues, encompassed from all sides by the dental hard tissues. Postmortem changes in pulp are seen very late and since pulp remains one of the most protected tissues, it is easily available for examination. The noteworthy character of teeth as one of the most enduring integral remnants of the human body empowers its effective use in forensic sciences.

Sex estimation and DNA from pulp

DNA is preserved in the teeth and bones for a very long period and thus is a valuable source of information.[13] Pulp is a good source for extraction of DNA. Restriction fragment length polymorphism, polymerase chain reaction (PCR), and microarrays are various methods to effectively analyze DNA.[14] The most acknowledged strategy for sex estimation is DNA molecular analysis. Soft tissue within coronal and radicular pulp chamber consists of odontoblasts, fibroblasts, endothelial cells, peripheral nerve, undifferentiated mesenchymal cells and nucleated components of blood which are all rich sources of DNA.[15] Sweet and Sweet in 1995 presented a case of human remains identification using a preserved unerupted third molar which enabled 1.35 µg DNA extraction from the dental pulp.[16] In a study conducted by Pötsch, et al. in 1992, the results using DNA extracted from the dental pulp did not show any difference when compared to the patterns obtained from DNA isolated from blood samples or available lung tissues.[17]

Barr Bodies

Barr bodies are strongly stained chromatin material present in nucleus of female somatic cells which plays a pivotal role in sex estimation.[18] Barr bodies look like letter sets, for example, V, W, S, or X. In a forensic setting with a time duration of about a month, sex estimation is possible using X and Y chromosomal examination. Simple stains such as Papanicolaou stain can be used to visualize Barr bodies.[19] The investigation of Barr bodies gives important data and adequate proof in remains pertaining to burnt and embalmed bodies. Under entombment conditions, Barr body test can be utilized to estimate sex with 98.9% accuracy.[20]

F-Bodies

F-bodies are available in Y chromosomes and can be utilized in sex estimation. Various investigations have been done to identify F-bodies from pulpal tissue. The most effective and solid technique to estimate sex is by fluorescent staining of Y chromosome in sound pulps. A study conducted in the year 2010 determined gender by pulp tissue using fluorescent Y body test and reported 100% specificity for freshly extracted teeth and those examined one month later.[21] Similar results have been observed in other studies as well.[22, 23]

Age estimation using dental pulp

Age estimation has applications both in postmortem identification as well as in living individuals where chronological age is under dispute. If age can be precisely evaluated, it will essentially limit the field of potential identities that should be compared against the remains so as to set up a constructive identification.[24] As age progresses, continuous deposition of secondary dentin occurs in such a way that it diminishes the dimension of the pulp cavity that can be observed by radiography which might be considered as a guideline for age estimation in a person. Evaluation of coronal pulp tooth ratio in forensic perspective acts as an indicator in age estimation for unidentified indiviuals.[25] Minimal changes in pulp tissue are be noted at 6 hours after removal of tooth and pulp tissue can be maintained for three days, something which cannot be done with other body tissues.[26] Daud et al. in their study used the histological method for age determination and found that cell density of dental pulp cells of crown and root region changes with age.[27] They also reported that fibroblasts of the older age group appeared to be flattened and spindle shaped when compared with the fibroblasts of the younger age group.

Conclusion

The utilization of features of human dentition as a guide to identification is widely acknowledged within the forensic field. Dental pulp can be used as an indicator to estimate age and sex using different methods such as Barr body and F body test. In addition, the dental pulp is a warehouse for blood group antigen and DNA thus facilitating identification of deceased individuals. Further research should be aimed in the direction of establishing the accuracy of various methods using dental pulp as an aid with regard to its forensic application using a large diversified sample size.

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REVIEW ARTICLE

Potential utility of Touch DNA in forensic investigations

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Abstract

Chance prints available at the crime scene and secondarily transferred cellular material can be a good source of DNA if processed properly. DNA transferred on to the contact surface is directly correlated to perspiration, and the shedder status of an individual. The advantage of this technique is that the latent fingerprints can be first used for fingerprint analysis by application of powder method and can then be processed for generating profiles. This review article focuses on the individual specific factors affecting transfer of DNA, impact of handling time, pressure and environmental factors etc. This literature survey has been done to summarize the various factors influencing touch DNA recovery, its methods of collection and extraction. It is crucial to analyse DNA recovery using various protocols. This article discusses the significance and potential utility of touch DNA in investigation of medico-legal cases.

Keywords

Forensic Science; Touch DNA; Perspiration; Epithelial cells; Fingerprint; Genotype.

Introduction

In forensic investigations, the analysis of trace evidences recovered from crime scene is very crucial. The mutual exchange of traces, which takes place between the criminal, victim and the crime scene, plays a very significant role in the identification of people and in tracing the culprits in cases of murder, physical violence, sexual assault, child abuse, hit and run etc.[1] Biological evidences i.e. blood, semen, saliva, urine etc. are considered as the most reliable sources of identification as these evidences provide conclusive information about suspects and victims.[2] These samples are routinely analysed for determining the source of origin, species, sex, race and age in forensic investigations.[3] There are a number of techniques such as blood grouping, immunoassays and RNA based analysis, etc. for determination of origin of species and sex determination. DNA analysis has proved to be the best technique for the personal identification due to its uniqueness and higher power of discrimination. DNA evidences were proven significant for the first time by two renowned cases in which Florida rapist Tommie Lee Andrews was convicted and in the other case the conviction of Gary Dotson was overturned on the basis of DNA analysis.[4]

In India, the crime rate is increasing at an alarming rate and with every passing year, there is an increase in registered crime cases. An increase of 3.6% and 1.3% in registered cases was observed in 2017 and 2018. [5, 6] It is assumed that the conviction rate depends on the sensitivity, specificity and accuracy of the techniques and results obtained from them. Though the complete DNA profile can be generated with a small quantity of biological samples, in few cases, biological evidences may be present in negligible amount that might be untraceable (e.g. latent fingerprints). When detected, the quantity is not sufficient to get a complete DNA profiles. With increase in crime rate, the significance of effective collection and processing of such evidences is pertinent to enhance DNA yield. Therefore, the methods which can detect the traces of DNA (touch DNA/contact trace DNA) transferred during contact of individual with any surface has proved to be highly significant. In the absence of any other body fluids, cells which are transferred/shed with every contact (direct/indirect) at the crime scene (weapon of offence, victim, documents, clothing etc.) can be a substantial in forensic investigations. [7] The present review article provides an overview of the concept of touch DNA, i.e. types and methods of transfer, DNA analysis protocols, factors affecting transfer of DNA and its advantages and limitations.

Transfer of trace DNA

The quantity of trace DNA detected may vary with its mode of transfer. Primary transfer of DNA is by direct contact through touching, speaking, coughing or sneezing. While speaking, coughing or sneezing, mucous along with saliva is transferred which contains leucocytes and epithelial cells and these can be utilised for DNA extraction.[8] By touching any object, DNA gets transferred through epidermal cells, however, the transfer of these cells (shedder status) may vary among individuals depending upon their perspiration rate.[9-11] The studies suggest that the shedder status of an individual can directly influence the quantity of touch DNA and the DNA of a good shedder can

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be recovered from an object even by secondary transfer. Moreover, relative DNA shedding propensity of fingers is more than the palmar surface.[10-12]

The secondary transfer of DNA (indirect transfer from individual to individual or individual to items like glass, fabric and wood) is quite common.[13] Though, the amount of DNA is comparatively less than primary transfer, it can be significant when no other evidence is available. On the basis of secondary transfer, individuals can be classified into two categories i.e. good shedder and bad shedder.[11,14,16] Szkuta et al. observed that the relative shedding ability of depositor and the contributing individual and the delay in deposition of a handprint are two factors that have substantial effect on the resultant detection of the contributing profile.[11,15] However, no impact of shedding was observed by Phipps et al. on the DNA amount.[16] In assault cases, it is important to analyse the persistence of offender's DNA on accessible parts of the victim. Bowman et al. analysed DNA transfer with medium pressure and without friction, in another case with heavy pressure with friction on the wrist and upper arm of the victim and concluded that DNA transfer increases with increase in pressure and friction.[17] On clothes, along with the wearer's DNA which is directly correlated to the shedder status of the wearer, secondary transfer of DNA from multiple contributors can also be observed.[18]

Impact of surface on touch DNA

In addition to shedder status, touch DNA recovery is dependent on the type of surface on which cells have been transferred. It has been observed that quantity of touch DNA transferred through latent fingerprints onto porous surfaces is higher than non-porous surfaces.[19] However, a few studies reported appreciable DNA recovery from non-porous objects like glass, cups etc. in sexual assault cases. [20,21] Studies have also been conducted to recover touch DNA from the cartridge case or ammunition wherein the transfer occured while loading magazines.[22] Meixner et al. reported the persistence of touch DNA on pig skin smeared with human blood even after several days of submersion is in cold water.[23]

Impact of handling time on touch DNA

Handling time plays a significant role in touch DNA recovery as it is directly correlated with the duration of contact and interval between deposition and collection. Different handling time sufficient to transfer has been reported by various researchers. Breathnach et al. concluded that at least 15 seconds of handling time is required for a successful DNA profile to be generated.[24] In 2019, Sessa et al. used swabbing, cutting and adhesive tape lifting methods for sample collection from a brassier and concluded that a successful DNA profile can be generated even if the garment is touched for two seconds.[25] The objects which are regularly used by any person may contain DNA of regular users in addition to that of the recent depositor and may produce mixed DNA profiles. Meakin et al. analysed the deposition and persistence of directly and indirectly transferred DNA on regularly used knives and observed that DNA attributed to the regular user persisted for at least a week, declining with increasing time between DNA deposition and recovery.[26] In a similar study conducted by Butcher et al., <16% non-donor DNA from indirect transfer events was recovered from knives. The ratio of DNA transfer between regular user and secondary user was observed to be approximately 4:1, 2:1 and 1:1 for specific durations of use by the second user of 2, 30 and 60 seconds, respectively. [27] In a study conducted by Helmus et al. the probability of obtaining DNA from post-use cleaned objects was tested.[28] The study concluded that DNA traces (blood, saliva, epithelial cells) on different objects (knives, plates, glasses, and plastic lids) can persist on the surface despite cleaning (by hand-washing). However, use of dishwasher rendered almost everything completely DNA free.

Impact of deposition pressure

As mentioned earlier, in assault cases, handling pressure and friction plays a significant role in the pre-deposition of DNA. There is direct correlation between pressure and friction with DNA recovery and a gradual decrease in DNA recovery can be observed with the passage of time.[17] Hefetz et al. examined DNA recovery from finger marks on glass, polythene and paper under a range of weights from 0.1 to 10 kg and demonstrated significant increase in DNA recovery with an increase in deposition pressure.[29]

Impact of environmental factors

Environmental factors like heat, temperature, UV radiations, humidity etc. affect DNA persistency. Different kind of pollutants at a crime scene greatly accelerate the degradation rate of trace materials, thus, making their testing and analysis difficult.[30] Biological samples like blood, keratinocytes etc. show highly variable persistence of DNA in tropical rainforest climate as compared to items placed indoors at an ambient temperature.[31] The analysis of touch DNA on submerged skin revealed that cold water samples yielded a completely reproducible DNA profile even after 7 days, whereas, the recovery rate reduced to 2 days when submersion was in room temperature water and warm water. The recovery was further affected by the presence of water insects and snails in the pond, and, mud in the stream.[23] Impact of water pressure and temperature on touch DNA analysis was reported by Helmus et al. Maximum recovery (up to two weeks) from cotton clothes (rinsed for different duration using tap, pond, bathtub and river water) was observed during the winter season and in water flowing with low pressure.[28]

Touch DNA collection techniques

To achieve optimal results for the forensic analysis of trace

DNA, choosing the right collection technique is crucial.[32] For homicidal cases, touch DNA can be recovered from the murder weapon such as knife, firearms etc. Whereas, it can be detected from documents in forgeries and from the stolen items in cases of burglary. Many methods of collection of touch DNA have been standardized i.e. swabbing, cutting, scraping and tape lifting etc. Scraping and tape lifting are the preferable techniques as these are non-destructive techniques, [32] but, cutting method can be employed for clothes. A moistened cotton swab can be used on non-porous surfaces such as glass, plastic etc. by moving and rotating it on the target surfaces with low pressure. Thomasma et al. (2013) advocated that a detergent-based swabbing solution yields more DNA than that of moistening swabs, due to the amphiphilic nature of detergents.[33] Many types of swabs are available commercially i.e. cotton swab, SimpleSwab2™ swab, 4N6FLOQSwabs®: Genetics, SwabSaver®, Prionics cardboard evidence collection kit, COPAN 4N6FLOQSwabs™ (Genetics variety), Puritan FAB-MINI-AP, Sarstedt Forensic Swab, iPrep Forensic Kit, and PrepFiler *Express* BTA™ Kit and SceneSafe Fast™ etc. and can be used to collect cellular components.[22,32,34] In a comparative study conducted by Comte et al. four swabs (Prionics cardboard evidence collection kit, COPAN 4N6FLOQSwabs™ (Genetics variety), Puritan FAB-MINI-AP and Sarstedt Forensic Swab) were compared for trace DNA collection and they concluded that the COPAN 4N6FLOQSwabs™ (Genetics variety) are the most convenient swabs to use.[34] In a study comparing iPrep Forensic Kit, and PrepFiler *Express* BTA™ Kit and SceneSafe Fast™ minitapes, conducted by Stoop et al. , SceneSafe Fast™ minitapes method gave encouraging results with phenol chloroform extraction method.[32] Kirgiz and Calloway promoted FTA paper scraping method over conventional methods due to its potential to give higher DNA yields from touch DNA evidence deposited on non-porous surfaces. [35]

In forensic investigations, fingerprints are a valuable source for DNA profiling. Latent fingerprints are usually visualized with powder methods and then often transferred to tapes or gelatin lifters for storage. Studies concluded that gelatin lifters are more promising for DNA recovery as more than 80% of the DNA from a fingerprint gets transferred to the gelatin lifter.[34] Subhani et al. observed that sufficient amount of DNA profile was generated when fingerprints were lifted with one of the four powders i.e. black powder, magnetic powder, aluminum powder and magnetic flake powders and three lifting methods i.e. tape lifting, gelatine and Isomark™. [36] A non-destructive Diamond™ nucleic acid dye technique was also explored for the detection of cellular material from fingerprint and lip prints by staining. [37, 38]

Touch DNA analysis

a. Extraction and purification of touch DNA: For extraction of DNA from any biological sample, many organic and inorganic extraction protocols e.g. organic extraction (phenol-chloroform based), Chelex method and Silica-based method, magnetic bead based, have been established. As the amount of sample and the subsequent DNA quantity is less in trace evidences, recovery of sufficient DNA for complete profile generation is essential. In comparative analysis of three commonly used DNA extraction protocols i.e., organic extraction (phenol-chloroform based), Chelex method and Silica-based method, Sowmyya concluded that silica-based extraction is best for touch DNA as it recovered in higher quantity as compared to other methods.[38] It is recommended to purify DNA especially in cases of secondary transfer to remove the contaminants.[31]

b. DNA Quantification: After extraction and purification, the sample is processed for quantity and quality. Capillary electrophoresis, Fluorescent inter-chelating dye, Yield gel technique, Dot blot technique and Real-time quantitative PCR can be used to determine the quantity of DNA in trace samples.[39] Real-time quantitative PCR has been found to be a better option as it determines the most appropriate downstream method for genotyping.[40]

c. Amplification and genetic analysis: Autosomal STR and Y-STR amplification kits are used commonly for direct PCR which includes AmpFlSTR® Identifiler® Direct, AmpFlSTR NGM SElect™ Express and AmpFlSTR Yfiler® Direct. In a comparative analysis for the efficiency of two extraction kits (DNA IQ™ System and Casework Direct Kit (both Promega Corporation)) for touch DNA samples, Casework Direct Kit was found to be better.[41]

d. **DNA profiling and evaluation**: It has been observed that the profiles generated by primary transfer are more promising than those by secondary transfer.[19] Sessa et al. conducted a study to analyse impact of handling time on handlers' and wearers' DNA (wearing brassieres) using swabbing, cutting and adhesive tape lifting.[25] In this study, cutting method gave better profile for handlers and adhesive tape lifting method gave significant DNA profile for wearers. Cavanaugh and Bathrick concluded that full DNA prolife was obtained from donors characterised as good shedder and partial DNA profile was obtained may be due to allele imbalance in heterozygous loci.[40] Kanokwongnuwut et al. concluded that full DNA profile was obtained from enhanced and stained fingerprints and partial profile was obtained when staining and dusting process was applied.[36] In a study conducted by Meixner et al., full DNA profile was obtained from blood stains even after several days.[23] Helmus et al. concluded that during indoor experiments, full DNA profile was obtained from cloth after rinsing followed by keeping it in a bathtub for one week.[28] Also, the complete profile from touch DNA has been obtained from screwdrivers, shirt/t-shirt collar and steering wheels. [42]

Conclusion

Touch DNA analysis is an important technique for challenging samples where traces of biological samples are transferred. Touch DNA can be transferred either directly or indirectly onto porous as well as on non-porous surfaces. The persistence of DNA on different surfaces, its collection methods and improvement in these techniques are the areas of concern. Many factors that can influence the quantity of touch DNA i.e. shedder status of an individual, pressure applied, type of surface and handling time are subject specific variables. However, the impact of environmental factors and improvement in collection methods and DNA extraction protocols are controllable factors and are areas of improvement.

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CASE REPORT

An unexplained death in the COVID-19 isolation ward: A case report

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Abstract

A 35-year-old male was referred for autopsy from a District Headquarter hospital, where he was admitted to the COVID isolation ward with suspicion of being infected. His clinical history was a day of fever with chills and abdominal pain. He was alone overnight in the isolation ward post collection of his nasal swabs for screening and blood for routine laboratory tests. However, he was found lying dead on the floor within 18 hours of hospitalization.

Keywords

COVID 19; Sudden death; Unexpected death; Medico-legal autopsy

Introduction

Sudden or unexpected death occurs from unnatural means mostly by road traffic accidents, poisoning, violence or assault, etc. [1] Various works of literature show that there are numerous organic pathologies inside the human body which are fatal and can cause natural death of a healthy person before any medical diagnosis. The World Health Organization defines sudden death as 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 a terminal illness.[2] Unnatural, suspicious deaths must be investigated to determine the actual cause of death.

COVID-19 is Corona Virus Disease caused by a novel coronavirus known as SARS-CoV-2, a β-coronavirus. It was first reported in Wuhan, China at the end of 2019 and gradually reported all over the world. [3] WHO declared it as pandemic on 11th March 2020. As of today, it is a global burden with over a million positive cases and lakhs of deaths. In India, the first case of COVID-19 was reported in Kerala on 30th January 2020 and since then the number of positive cases has increased with increasing mortality.[4] Considering the huge number of cases and its impact on health, especially mental aspect, a diffused panic is prevalent not only amongst frontline workers (so-called COVID warriors) but also amongst the common population. We hereby report a case of sudden unexpected death of a young adult found on the floor in a COVID 19 isolation ward of a government tertiary care center without any contact history but suffering from fever and mild abdominal pain which was found later to be a case of acute biliary septic shock (ABSS) following a meticulous post mortem examination.

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Case study

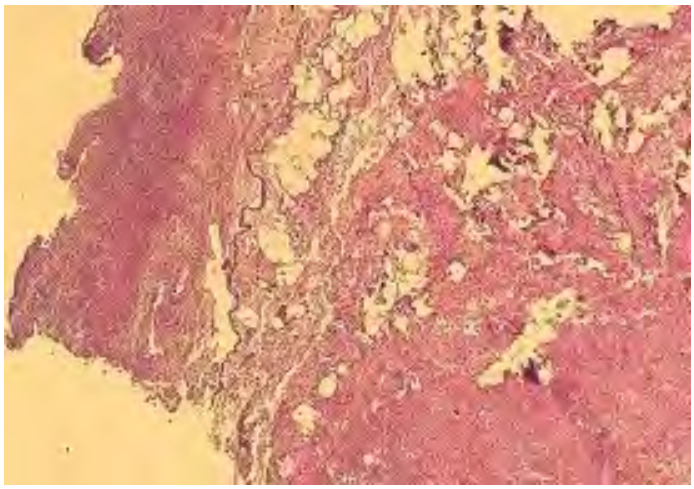
A 35-year-old, unmarried male, data entry operator by occupation in a government office, engaged in registration of migrant workers due to COVID 19, reported to OPD of district headquarter hospital with complaints of fever, and mild abdominal pain for one day. He was immediately admitted to the COVID isolation ward where no other patient was present after collection of his nasal swabs, blood for CBC. The patient spent the whole night alone in that ward. He had established communication with relatives over the telephone during this process. However, the next day he did not respond to calls and when the nurse entered to check on him, he was found dead near the bathroom. An inquest was done over the body and referred for autopsy. An autopsy was done after the COVID test which came as negative. The relatives revealed that he was suffering from fever with chills and complained of abdominal pain for one day without any other notifiable medical problems. The deceased was looking healthy with irregular marks of abrasion around the neck (Fig 1 and 2) with congested face and conjunctivae. There were no perceptible injuries over the body except the same type of abrasion on the inner side of the right flank, perineal region, and on the inner side of the right ankle. There were red ants crawling over the body. On dissecting the skin underneath of neck injuries suspicion regarding neck compression was ruled out. The heart and lungs were intact without any gross features of any pathology. Blood was collected from the heart for a thick smear to rule out Malaria. The stomach contains around 200 ml of blackish fluid with pungent odour and with a healthy inner mucosal wall. The liver (Fig 3) was intact but appeared smaller than the normal size and weighed 1000gm. During the collection of routine viscera for poisoning whitish pus-like fluid was seen gushing from the gall bladder. The luminal surface of the gall bladder was found

flattened and smeared with whitish pus. All structures of the three cavities were found intact without any gross pathological changes except the findings in the liver and gall bladder. The cause of death remained obscure even when the liver and gall bladder tissue was subjected to histopathological examination. On further inquiry, a relative revealed a history of abdominal pain 2 years back following which the patient was advised to take a bland diet but there were no supportive prescription or imaging documents.

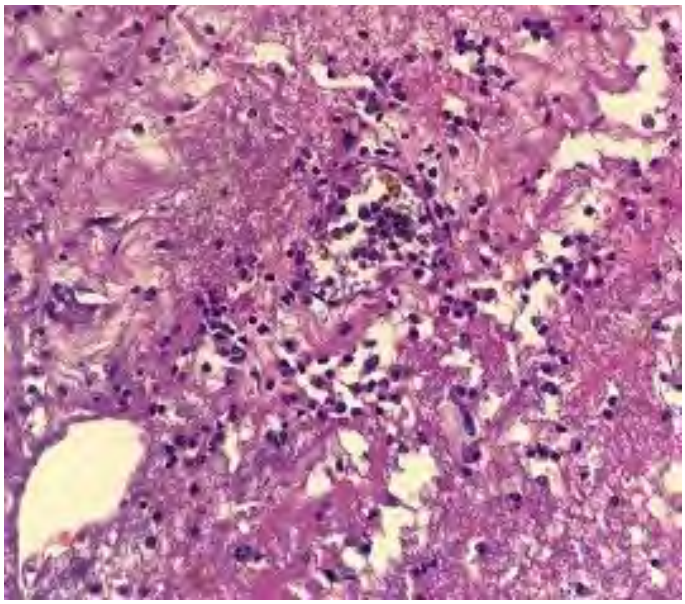
The histological examination of sections from the right lobe liver and gall bladder was performed in our histology laboratory. Microscopy showed necrotizing cholecystitis along with fat necrosis on the wall of gall bladder (Fig 4 and 5) with normal liver architecture. Postmortem blood smear for malaria came as negative. Total leucocyte count was 11,800 and the differential count (DC) showed neutrophilia (82%). From our autopsy findings, previous medical history of the deceased, haematology findings, and histopathological examination we opined the cause of death as acute biliary septic shock (ABSS) which is a natural disease process.

Figures 1 and 2: External examination of neck showing suspected ligature mark

Figures 3: Cut section of liver along with gall bladder



Figures 4: Necrotizing cholecystitis and fat necrosis as seen under microscope (40X)



Figures 4: Necrotizing cholecystitis and fat necrosis as seen under microscope (100X)

Discussion

When a disease is undiagnosed and the medical officer is unable to certify the cause of death then such cases should be subjected to autopsy. In especially brought dead and sudden unexpected death of young, police is usually informed to book the case under the medico-legal category, to rule out any foul play, and to decipher the cause of death. Sudden unexpected natural death (SUND) in an adult without any significant history of prolonged illness has been a subject of continuing interest amongst medical professionals. Chaturvedi et al. studied SUND in young adults chiefly in the age group of 30-35 years and observed that non-cardiac causes significantly predominated (73.4%) over cardiac causes (7.8%) and

gastrointestinal (GI) diseases including hepatic and pancreatic diseases, were the leading cause of death.[5]

The acute presentation of empyema gall bladder is pain over the upper abdomen of varying degrees from mild to a severe degree, fever with chills, and being associated with leucocytosis.[6] There were cases where neither bile duct obstruction nor cholangitis was observed, although the septic focus was in the biliary tract. [7] E. coli was the most common aerobic pathogen in the bile and blood culture.[6] Those cases which were not intervened early, died of septic shock, or by multi-organ failure.

Conclusion

Early detection and early surgical operation might have saved some expired ABSS patients and reduced the high mortality incidence. In this particular autopsy, external marks on the neck and the stomach findings created misperception but due to meticulous post-mortem examination along with histopathological examination we were able to ascertain cause of death.

Ethical clearance: A prior approval was obtained from the Institutional Ethics Committee

Conflict of interest: None to declare

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CASE REPORT

Sudden death in a 2-year-old child: Role of Ascaris infestation and other possibilities

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Abstract
More than a billion people worldwide are infested with one or more parasite especially intestinal nematodes. Amongst the intestinal nematodes, Ascaris lumbricoides is the most common parasitic infestation. Ascariasis tends to occur more commonly in places where sanitation is minimal along with poor personal hygiene, and human faeces is used to fertilise crops, which is usually seen in underdeveloped or developing countries. Children are more likely to be infested and have higher worm load. Sudden death attributable to ascariasis per se is unusual; instead, it often leads to chronic malnutrition. A rare case is reported where death resulted from airway obstruction by a single ascaris worm in a two-year-old child.

Keywords
Forensic Pathology; Ascaris lumbricoides; Asphyxia; Sudden Death

Introduction

More than a billion people worldwide are infested with one or more species of intestinal nematodes.[1] Ascariasis plagues more individuals in the world than any other parasitic infestation. An estimated 807-1,221 million people in the world are infested with *Ascaris lumbricoides* [2] which implies that approximately 1 out of 4 people have ascariasis. In some tropical areas, almost whole of the population has ascariasis. Ascariasis tends to occur more frequently in places where sanitation is minimal along with poor personal hygiene and where human faeces is used to fertilise crops. Children are more likely to be infested and have higher worm load. [2]

Ascariasis leads to malnutrition and growth retardation. Ascaris infestation has been related to many complications such as acute airway obstruction[3,4,5], peritonitis secondary to perforation[3], torsion/ gangrene of the intestines[6], laryngeal spasm[7], pneumonitis[8], gastrointestinal obstruction[8], anaemia[9], etc. On undertaking a literature search in Pubmed with keywords 'Ascariasis', 'Asphyxia' and 'Death', we found that till date only about a dozen cases have been reported in all which Ascaris infestation was associated with fatal or near-fatal complications. Only in one case, sudden asphyxial death has been reported concerning Ascaris infestation.[3] Here, we report a case of a two-year-old child wherein the worm was found near the tracheal opening but the exact cause of death could not be determined. The differentials are discussed.

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Case Report

Our team received information from the police that the dead body of a two-year-old child has been found at his home. The parents of the deceased were daily wage workers who had four children. The deceased was the third sibling in the order. At the time of the incident, the mother was not present at home as she was caring for the fourth sibling hospitalised for some sickness. The people who were present at home included the father and the other two siblings. According to the statement of the father, he discovered that his son who had gone to sleep last night did not respond in the morning. Thence, he called the neighbour to have a look where it was discovered that he was no longer alive. The father was under the influence of alcohol, and he was nabbed and interrogated by the police. The police suspected foul play on the part of the father as the child was not suffering from any apparent illness when he went to sleep.

The residence of the deceased was in a labour colony where houses are compactly constructed with small rooms and narrow passages. The family of the deceased used to live in a small room of size 10' x 5', which was used as kitchen, bedroom and dining room as well. The room did not have any ventilation and had only one door for the entry. There was no provision of ceiling fans or any source of illumination. The body of a two-year-old child was present in supine position. The boy looked poorly nourished. There was pinkish-purple discolouration present over the front of thighs and front of chest and abdomen (Figure. 1). The dead body was shifted to the mortuary.

The blanket in which the body was wrapped was smelling of urine. Scalp hairs were uncombed. The dead body showed signs indicative of chronic malnutrition. The eyeballs were sunken into the orbits. There was presence of debris and sand particles all over the body. Appreciable cyanosis was present on the finger and toenails (Figure 2). No external injuries were appreciated on the body. Two abrasions were noticed, one

measuring 0.5 cm X 0.2 cm over the tip of the nose and the other one measuring 3 cm X 2 cm just below the right kneecap, on the anterior aspect of the right leg which were about 3 to 5 days old.

The neck dissection did not show any signs of physical trauma. The internal organs were pale and unremarkable. Gastric cavity contained about 50 ml of partially digested food. The pleural and peritoneal cavities showed no fluid collections. To our surprise, after 'dropping down the tongue' when the traction was being made on the posterior pharyngeal wall to separate it from the underlying cervical fascia, we noticed a pinkish cylindrical object near the tracheal opening. While manoeuvring the upper part of the trachea, we noticed a live worm which had meanwhile made its way out of the tracheal opening to the posterior pharyngeal wall (Figure 3). The worm was isolated from the tissue block. On observation, it was found to be an adult *Ascaris lumbricoides* male measuring 11.8 cm and 3.5-4mm thick (Figure 4). The area surrounding the vocal cords and rima epiglottidis was inflamed and showed mucosal oedema. At this stage of the autopsy, it was required to look keenly into the rest of the gastrointestinal system for the presence of other similar members.

Figure 1: Dead body of the child as found at his home on the arrival of police

Figure 2: Appreciable cyanosis seen over the finger-nails

We collected samples from the stomach and intestinal wash for microscopic examination so as to document the presence of any ova. Sections from both the lungs showed mild to focally moderate interstitial lymphocytic inflammatory infiltrate predominantly peri-bronchial in location along with mild fibrosis. No parasitic ova or larva was noted in the lung samples. The toxicological screening of the samples was unremarkable. With the above findings it was difficult to opine the exact cause of death. Various differentials which were thought of are discussed in the discussion part below. The cause of death given in the post mortem report was “exact cause of death cannot be opined however death due to natural causes cannot be ruled out”. This was given because in medico-legal cases the investigating officer is mostly concerned with the cause of death being either natural or unnatural. If death is natural then investigation can be closed however in unnatural cases investigation needs to be continued.

Figure 3: Live *Ascaris lumbricoides* as discovered wriggling over the posterior pharyngeal wall during necropsy

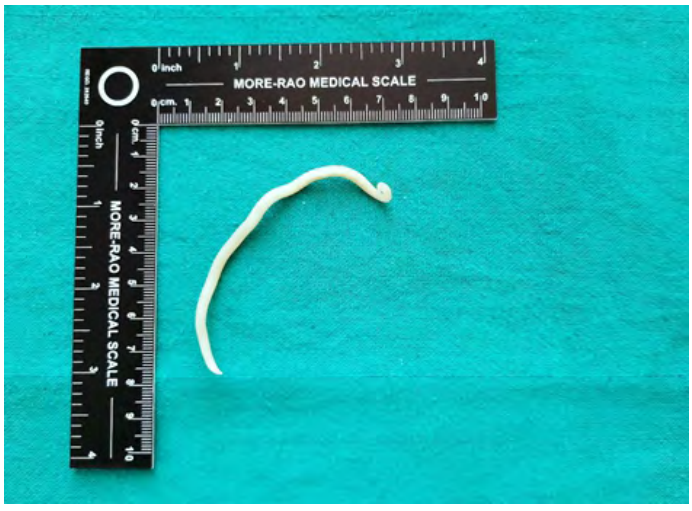

Figure 4: Formalin-fixed specimen of the same *Ascaris lumbricoides*

Discussion

Ascaris lumbricoides is a parasitic nematode which belongs to the order Ascaridida with human being the only host. [10] The presence of adult Ascaris in the body other than within the intestines has been termed as *ectopic ascariasis.* [10] Adult worms have been reported to cause obstructive jaundice, hemorrhagic pancreatitis, appendicitis and liver abscesses. Occasionally, adult worms can pass through the oesophagus and cause a fatal mechanical block in the respiratory pathway. Such migration will be more likely if the host is sleeping or suffers from some debilitating condition.

Till date three cases have been reported where sudden death was attributed to the presence of Ascaris. The various causes were diffuse peritonitis secondary to perforation of the duodenal wall [3], torsion and gangrene of ileum [6] and subacute suffocational mechanical asphyxia. [3] However, in the third case, the authors reported presence of seven adults in the upper respiratory tract of a 4-year old child. In our case, we found only one Ascaris worm in the peri-epiglottic region in a 2-year-old child. Ascaris is a slippery worm, and it can be a problematic task for a forensic pathologist to explain whether a single adult worm is capable of obstructing the pediatric laryngeal lumen or not. Airway obstruction by ascaris has been reported in few cases and is an uncommon complication. Such occurrences were seen in critically ill patients; the most likely explanation is the migration of the worm from the gastrointestinal tract to the respiratory tract during the period of stress or fever. [4] In the present case, there was no history of any serious illness although it was revealed that the deceased child was suffering from low-grade fever for the last four-five days.

Investigation of sudden death in a child has always been a challenging task for a forensic pathologist. In the present case, the critical concern of the investigating officer was to find the cause of death, and ascertain whether his father killed the child or not? The only significant finding that could be attributed to the cause of death in the reported case was the presence of single live ascaris in the peri-epiglottic region with associated inflammatory changes in the same region. However, giving the definitive cause of death as acute airway obstruction in the upper respiratory tract by a single Ascaris was difficult. We also did not find other members elsewhere. So, ruling out of other causes was done via additional investigations described in the case report. After investigation of all the evidences we could not conclude a definitive cause of death. The differentials which may have led to death of the child other than the airway obstruction are as follows.

Firstly malnutrition, this differential was first in the list because there were features of chronic malnutrition evident on the body. Usually chronic malnutrition does not lead to sudden death however in this particular case sudden nature may be an apparent one as in low socio-economic society symptoms are usually neglected until they are very severe and also the child will not be able to speak much if there are problems.

Secondly, death can be due to asphyxia secondary to hypoxic hypoxia as they lived in a congested place with many people around. The area was ill-luminated, no ventilation and dirt all around. All these must have cumulatively led to hypoxia and finally to death. Supportive evidence to this is presence of cyanosis in the nail beds, though not pathognomonic.

Thirdly, it could have been due to an unknown animal bite leading to anaphylaxis leaving no evidence externally and internally apart from laryngeal oedema. Although definitive cause cannot be opined, the authors are of the opinion that the death might have occurred due to obstruction combined with malnutrition.

As a suggestion preventive administration of anti-helminthic drugs should be done especially in the high-risk groups residing in developing countries along with focus on nutrition.

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CASE REPORT

Exsanguinated to death: A case of death due to wild boar attack

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Abstract
Wild beasts are responsible for a group of potentially lethal injuries, and India being a land of villages, attacks on humans by wild animals are not uncommon in rural India. While death due to a wild boar attack is rare, it is not unusual to encounter such cases. Death occurs if the incident occurred in uninhabited locations, leading to the victim's exsanguination. Due to the circumstances where the body was found and the nature, multiplicity of the injuries on the victim's body, the investigating officer could be misled and suspect it to be a case of homicide. The hallmark of a wild boar attack is the characteristic penetrating injuries on the lower part of the body, however, once the victim falls on the ground, the injury can be present anywhere on the body. This case is reported for the awareness on possible injuries in such unnatural deaths and to discuss the predisposing factors for such attacks.

Keywords
Animal attack; Blunt penetrating injuries; Indian boar attack; Wild boar attack.

Introduction

The ferociousness of the wild boar is legendary and has been documented since ancient times. [1] They have the ability to defend themselves from natural predators aggressively, and this ferocious behavior of wild boar has also been established against the human beings as well, on a variety of occasions. [2]

A wild boar is a wild pig with a striking resemblance to domestic pig with two canines protruding outward and upward of the lower jaw mainly for attacking or defending purposes. The length of an adult boar can vary from 5 feet 5 inches to 5 feet 10 inches and the height is about 3 feet to 3 feet 5 inches. An adult male can weigh approximately 68-227 kgs while female weighs about 36– 150 kgs. The Indian wild boar- *Sus cristatus* is slightly taller than the Europian wild boar- *Sus scrofa*. The young ones are usually born between the months of March and May after a four-month gestation period between November to January. Variety of vegetation like corn, tubers, roots, berries etc. form their principal diet; however, they also feed on reptiles, eggs, insects, worms and so on. They are largely nocturnal. They have very poor eyesight, while their sense of hearing and smell are excellent. They are rarely dangerous to people when left alone. When provoked, they are known to defend themselves ferociously and attack the enemy with their strong snout and tusks leading to lethality. [3]

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Case Report

A 45-year-old male left home informing his wife and children that he would collect tubers, around 3PM in the afternoon and assured them to be back by 6PM in the evening. When he didn't return by 10PM a search team was sent for him and they found him in a semiconscious state, in a semi forested abandoned agricultural land which is known to be habited by wild boars and had tracks of wild boar on the ground. He told his by-standers that a wild boar had attacked him approximately around 7:30 PM on his way back home. On being shifted to hospital, he was declared dead on arrival.

A medicolegal autopsy was conducted on the body the next day. The body was that of a middle-aged man with a stature of 178cm and weight of 60kgs. Post mortem lividity was present on the back of the body and was not fixed. Body was cold and stiff. (Kindly note that the body was kept in the cold chamber)

The following injuries were observed on the body:

1. Penetrating lacerated wound measuring 6cm x 4cm pleural cavity deep, lacerating the intercostal muscle, directed inwards and upwards was present on the left side of the chest in the 8th intercostal space along the mid-axillary line. It was present approximately 118cm above the outer aspect of the left heel. (Fig 1)
2. Penetrating lacerated wound measuring 8cm x 1.5cm muscle deep directed downwards was present on the outer aspect of the left thigh, 16cm lower and 12cm outer to left anterior superior iliac spine. (Fig 2)
3. Penetrating lacerated wound measuring 7cm x 4cm muscle deep was present on the outer aspect of the left thigh 19cm lower and 7cm outer to the left anterior superior iliac spine. (Fig 2)
4. Penetrating lacerated wound measuring 10cm x 5cm

muscle deep was present on the outer aspect of the left thigh 5cm lower and 5cm outer to injury number 2. (Fig 2)

5. Penetrating lacerated wound measuring 18cm x 10cm bone deep was present on the front aspect of the upper one third of the left thigh which was directed downwards and inwards, with transaction of the femoral artery, femoral vein, the tributaries of the femoral vein and the femoral nerve. It was present 92cm above the inner aspect of the heel. (Fig 3 & 4)
6. Reddish coloured multiple grazed abrasions of varying size from 20cm x 15cm to 3cm x 3cm were present on the entire back on an area of 40cm x 30cm.
7. Perforating lacerated wound measuring 15cm x 9cm muscle deep was present on the back aspect of the left upper thigh 20cm lower to the left posterior superior iliac spine and was directed inwards and downwards.
8. Perforating lacerated wound measuring 12cm x 7cm muscle deep was present on the back aspect of the left upper thigh 3cm lower and 2 cm inner to injury number 7, directed upwards and outwards.All the above-mentioned injuries were ante-mortem in nature with injury number 1 and injury number 5 being fatal. None of the injuries were clean cut and injury number 6 appeared to have resulted during the struggle of the victim to survive the attack. The internal organs were pale and left lung had lacerations corresponding to injury number 1 and was collapsed. Rest of the internal examination was unremarkable.

Figure 1: Penetrating lacerated wound on the left side of the chest.

Figure 2: Penetrating lacerated injuries on the left thigh.

Figure 3: Penetrating lacerated wound on the left thigh

Figure 4: Transection of the femoral artery

Discussion

While death due to a wild boar attack is rare, it is not unusual to encounter such cases especially if the incident has taken place in uninhabited location leading to the exsanguination and untimely death of the victim.

In the present case except injury number 1,6 and 9, all the other injuries are present on the lower limbs mostly on the front aspect of the thigh and the outer aspect of the thigh indicating that the animal is not more than that particular height which is most likely a wild boar. The injuries which are at the chest level (injury number 1 and 9) are most likely inflicted by the boar after the deceased had collapsed on the ground while injury number 6 resulted during the struggle.

The boar has very typical way of attacking its target where it steadily rushes forward pointing its snout and tusks forwards towards the direction of the target and inflicts the injuries. It goes back, takes position and repeatedly attacks the target till the victim is incapacitated with multiple penetrating injuries, which can have a fatal consequence if the victim does not get the timely medical help. [4] The number of injuries sustained points towards the repeated nature of attack which is typical to a wild boar. [4]

It has also been reported that most of the mauled victims or the deceased had injuries sustained over the lower abdomen and lower limbs. In the present case too most of the injuries listed above are at the level of the lower limbs which can be attributed that the animal is most likely a wild boar. [4]

The pattern of injuries are not typical of a homicidal attack and the anatomical position of the injuries are at the level of a boar's tusks while attacking indicates that the offending animal is most likely a wild boar. The direction of injuries sustained during an attack by a canine or a wild cat is most of the time above from downwards due to their predominantly strong and big canines. [4] Attacks from these animals invariably will be associated with the bite marks, scratch marks and loss of associated soft tissues.[5] The penetrating injuries perpetrated by the wild boars are most of the time are in the horizontal plane or below upwards due to the positioning of the wild boar's tusks.[4]

A defensive attack by the wild boar can most of the time be expected if it suddenly comes across humans or we unknowingly enter its territory.[3] Many times, such encounters take place in unpopulated, uninhibited wilderness than the usually travelled paths by humans.[3]

In the above case too, the attack had taken place in a semi forested abandoned agricultural land which is a known habitat for wild boars where an untamed boar could have easily encountered the victim. Thus people living or strolling in such areas are the easy targets for the animals.

This case is being reported for its rarity and its presentation and to create awareness for the possible injuries and predisposing factors of a wild boar attack.

Ethical clearance: A prior approval was obtained from the Institutional Ethics Committee

Conflict of interest: None to declare

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CASE REPORT

Hue of aspiration reflected the nature of poison and cause of death: A case report of copper sulphate ingestion

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Abstract

Most of the times, the cause of death in suspected poisoning cases is given only after receipt of chemical analysis report. In inquest papers it is usually mentioned as unknown poisoning as the suspected cause of death. Here we are presenting a case brought dead in casualty of PGIMS, Rohtak with a history of consumption of some unknown poisonous substance at home. During post-mortem examination bluish coloured granular semi-liquid aspirated material was observed in the esophagus and trachea reaching up to the bronchioles which indicated not only the immediate cause of death as aspiration of gastric contents, but, also the nature of poison i.e. Copper Sulphate which is believed to be a rare poison nowadays. The detail of this case with photographs has been discussed.

Keywords

Copper sulphate; Poisoning; Aspiration

Introduction

A 30-year-old male with alleged history of ingestion of some poisonous substance at home was brought dead to casualty of Pt BD Sharma, PGIMS, Rohtak, Haryana, India. During autopsy it was observed that the body had bluish green froth around the mouth and nostrils (Figure 1). Larynx and trachea had a bluish substance adherent to its mucosa which was observed to be reaching beyond secondary bronchioles. The esophagus was full of bluish granular substance (Figure 2). Stomach contained 500 ml of semi-solid bluish material and all internal organs were congested (Figure 3). Bluish tinge was noticed on the surface of brain. Cause of death was ascertained as aspiration of gastric contents.

Discussion

Copper sulphate forms bright blue crystals containing five molecules of water [$CuSO_4 . 5H_2O$]. It is used chiefly for agricultural purposes as a pesticide and in leather industry and also in making home-made glue. Burning of copper sulphate in houses and shops (as a good luck charm and for religious activities) is a common practice among Buddhists and Hindus. It was also used as a precipitator in heavy metal poisoning and was used to treat gastric and topical exposure to phosphorous. [1, 2] Copper content of the body is 150gms. The safe daily intake of dietary copper is 2 to 3 mg while the actual requirement is only 0.8mg/day.[3,4] Copper Sulphate ingestion (accidental or deliberate) is a rare form of poisoning usually limited to the Indian subcontinent.[2] Its incidence is reported to be 34% and 65% of the total poisoning cases in two studies from Agra and New Delhi in 1960's. However, there was a decline to 3.85 and 3.33% between 1977-1982 and 1982-1987 respectively. [1] A recent survey shows the incidence to be only 1% of the total poisoning cases.[5] The immediate symptoms following ingestion of Copper Sulphate universally are gastrointestinal in the form of nausea, vomiting and cramping abdominal pain. Vomiting usually occurs within 15 minutes of ingestion and vomitus is characteristically greenish-blue.[1] Superficial or deep ulcerations of gastric and intestinal mucosa are also reported.[6] Copper Sulphate poisoning with symptoms of delusion have also been reported.[7] Suicide by intravenously injecting a solution of Copper Sulphate, used as an antifouling agent in paints has also been reported. Zhukov and Novoselov (1983) reported a case of fatal poisoning with blue vitriol, wherein a 39 years old lady introduced blue vitriol into the uterine cavity in an attempt to interrupt a two-month pregnancy.[5]

A significant correlation was found between the levels of whole blood copper and the severity of manifestations.[3] No correlation was found between plasma copper concentrations and prognosis in a previous study by Wahal et al. The overall mortality rates vary from 14-18.8%.[1] Lethal dose of ingested copper sulphate is between 10-20g.[2] Decreasing the absorption by immediate dilution with water or milk is advisable. In Copper Sulphate poisoning vomiting is likely to occur spontaneously and hence patient may require antiemetic therapy.

If corrosive esophageal or gastric damage is suspected upper GI endoscopy should be carried out, ideally within 12-24h in order to gauge the severity of injury.

Patients with symptomatic methemoglobinemia should be

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treated with methylene blue. Oxygen should be administered while preparing for methylene blue therapy. Hypotensive episodes should be treated with fluids, dopamine and noradrenaline. There is little clinical experience pertaining to the use of chelators for acute Copper Sulphate intoxication- British anti Lewisite (BAL), D-penicillamine, 2, 3-dimercapto-1-propane sulfonate, Na+ (DMPS) and Ethylene diamine tetra acetate (EDTA) have been used. [1] Colour changes associated with commonly encountered poisons have been listed under Table 1.

Table 1: Colours/Common Names of different Poisons

Name of the poison	Colours/Common Names
Copper sulphate	Blue vitriol (large blue crystals)
Ferrous sulphate	Green vitriol (bluish green crystals)
Aluminium phosphide	Greyish green tablets
Copper acetoarsenite	Parish green
Copper subacetate	Bluish green masses or powder
Copper arsenite	Sceele's green
Copper carbonate (native)	Mountain green

Figure 1: Bluish froth observed around mouth and nostrils

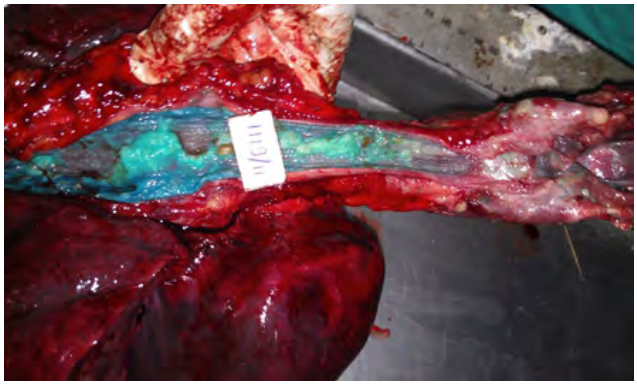

Figure 2: Bluish granular material present along the esophagus

Figure 3: Congestion of internal organs

Conclusion

Copper sulphate poisoning, which is mostly suicidal, is associated with high mortality in severe cases due to methemoglobinemia, hepatotoxicity and renal failure. In cases with severe poisoning cardiovascular collapse, hypotension and tachycardia can occur early within a few hours of poisoning and may be responsible for early fatalities. Copper sulphate is emetic but deaths due to aspiration are not reported. This case highlights the need to spread information, education and communication material amongst masses regarding preliminary steps to be taken in all poisoning cases like putting the patient in left lateral position to prevent aspiration, which could save many lives.

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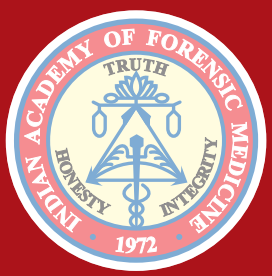
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