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Correlation between age and degree of fusion involving sternal joints

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ABSTRACT

Aims and objectives: The study is aimed to evaluate the relationship between age and degree of fusion among- a) manubrium and mesosternurm, b) xiphoid process and mesosternurm secondly to obtain regression formulae from the above, in males and females. **Materials & Methods:** A total of 100 sterna (50 males and 50 females) were collected from subjects of known age. The data was statistically analyzed for the relationship between fusion of joints and ages and regression equations were obtained, separately for males and females. A combined regression equation for both the sexes together, was obtained for use in situations where the sex of sternum is not known. **Results:** The mean age for onset and completion of these joints were calculated, followed by their regression equation for males and females respectively. Combined regression equation was also calculated for use where sex of the person is not known. Regression equation for age from grade of fusion between manubrium and mesosternum (Grade M) & between xiphisternum and mesosternum (Grade X) was Age = 28.151 + 8.599 Grade M + 3.403 Grade X. Regression equation for age from grade of fusion between manubrium and mesosternum (Grade M) & between xiphisternum and mesosternum (Grade X) was Age = 25.816 + 5.021 Grade M + 5.296 Grade X. For both sexes, regression equation for age from grade of fusion between manubrium and mesosternum (Grade M) & between xiphisternum and mesosternum (Grade X) was Age = 26.710 + 7.170 Grade M + 4.284 Grade X.

Key words: Sternum, Sternal joints, Degree of fusion, Age estimation.

INTRODUCTION

Age estimation of unidentified human skeletal remains is a considerable problem in Forensic Medicine. Determination of age is required in many medicolegal cases. Sternum has been studied by very few regarding its utility for estimation of age. Authors have described fusion of xiphoid process with mesosternum at about 40 years of age and that of manubrium with mesosternum at "Very old age" i.e. 55-60 years[1-3]. Forensic experts usually base their opinion on these observations. In view of its utility and limited studies, we have studied the fusion of these two joints for estimating age with the following aims and objectives: -

1. To study the relationship between age and degree of fusion among-

   a) manubrium and mesosternurm

   b) xiphoid process and mesosternurm

2. To obtain regression formulae from the above, in males and females.

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METHODS AND MATERIALS

The work was carried out in the mortuary of Forensic Medicine department at Lady Hardinge Medical College, New Delhi on cadavers brought for post mortem examination. A total of 100 sterna (50 males and 50 females) were collected from subjects of known age. Subjects above 18 year of age without any congenital or acquired bony defects only were included in the study. Each dissected sternum was properly labeled. The soft tissues were macerated, cleaned and dried. The degree of fusion between the manubrium and mesosternum & between mesosternum and xiphoid process was studied and graded according to the following scale-

1. 0 degree- no fusion present in the joint.
2. I degree-fusion present but less than half of joining surface
3. II degree- fusion present half or more than half of joining surface.
4. III degree-complete fusion present.

The data was statistically analyzed for the relationship between fusion of joints and the ages and regression equations were obtained, separately for males and females. A combined regression equation for both the sexes together, was obtained for use in situations where the sex of sternum is not known.

RESULTS

Fusion between manubruim and mesosternum in males

It was observed from findings that no fusion of manubrio-mesosternal joint (Grade 0) was seen to occur in almost all the cases who were below 41 years of age except one case who was in age group of 31-35 years. This group consisted of 22 cases (44%) out of total 50 cases studied in males. Grade I fusion was seen to start between age group of 41-45 years and consisted of 5 cases (10%) out of total 50 cases studied. Grade II fusion was seen to occur between age group of 46-55 years and consisted of 7 cases (14%) out of total 50 cases. Complete fusion (Grade III) was observed in subjects, most of whom were more than 56 years of age and above, except two cases in which complete fusion was observed in age group of 46-50 years. This group consisted of 16 cases (32%) out of total 50 cases. Mean age for onset of fusion (grade I) between manubrium and mesosternuim in males was found to be 42.6 ± 4.3359 years and for complete fusion (grade III) was 65.8125± 10.6847 years **(Table 1).**

Fusion between manubruim and mesosternum in females

It was observed that no fusion of manubrio-mesosternal joint (Grade 0) was seen to occur in women below 35 years of age. This group consisted of 21 cases (42%) of total 50 cases studied in females. However, there were 4 cases in age group of 36-46 years which did not show fusion of the joint. Thus, half the total number of cases studied, who were less than 45 years of age did not show any fusion of manubrio-mesosternal joint. The onset of fusion (Grade I) was seen in the age group 36-45 years and this group consisted of 8 cases (16%) out of total 50 cases. Grade II fusion was found in 5 cases which were between age group of 46-55 years. In one case, Grade II fusion was found in age group of 36-40 years. Thus grade II fusion was seen in 12% of total cases. Complete fusion (Grade III) was found in women who were 51years and more, in age. This consisted of 11 cases (22%) out of total 50 cases. Mean age for onset of fusion (grade I) between manubrium and mesosternuim in females was found to be 42.1250 ± 3.2705 years and for complete fusion (grade III) was 58.3636± 5.0055 years. Mean age for onset of fusion (grade I) between manubrium and mesosternuim in both sexes was found to be 42.3077 ± 3.5446 years and for complete fusion (grade III) was 62.7778± 9.4557 years **(Table 2)**.

Fusion between mesosternum and xiphoid process in males

The findings of the study showed that the males who were below 30 years of age did not show any fusion (Grade 0). Subjects in age group 31-35 years showed the mixed pattern of fusion where in 2 cases showed non fusion, 6 cases showed

grade I fusion, one case had grade II fusion. 5 cases between the age group of 36-40 years also showed a variable picture, where 2 cases had grade I degree of fusion, another 2 cases also had grade II fusion and 1 cases had grade III fusion. Complete fusion (Grade III) was seen in rest of subjects who were in age group of 41-45 years and above. All the cases who were more than 60years showed grade III fusion. Mean age for onset of fusion (grade I) between xiphisternum and mesosternuim in males was found to be 35.1250 ± 0.6409 years and for complete fusion (grade III) was 58.0000± 12.4811 years **(Table-3)**.

Fusion between mesosternum and xiphoid process in females

Cases those were below 30 years of age did not show any fusion. However, 2 cases in age group 31-35 years also did not show any fusion. At the same time, 3 cases in this age group showed grade I fusion. Grade I fusion was also seen in age group 36-40 yeas. 6 cases those were between age group 36-45 years showed grade II fusion. Complete fusion (Grade III) was seen in subjects who were of age group 41-45 years and above. This group had 20 cases out of the total of 50 cases which were studied. Mean age for onset of fusion (grade I) between xiphisternum and mesosternuim in females was found to be 35.8333 ± 1.4720 years and for complete fusion (grade III) was 53.1000± 7.2758 years **(Table 4)**.

Mean age for onset of fusion (grade I) between xiphisternum and mesosternuim in both sexes was found to be 35.4286 ± 1.0894 years and for complete fusion (grade III) was 55.9583± 10.8097 years.

STATISTICAL ANALYSIS

The data was statistically analysed and from the relationship between fusion of sternal joints and age, following regression equation were obtained.

1. Males

Regression equation for age from grade of fusion between manubrium and mesosternum (Grade M) & between xiphisternum and mesosternum (Grade X).

Age = 28.151 + 8.599 Grade M + 3.403 Grade X

R^2 = 82.5% (significant)

2. Females

Regression equation for age from grade of fusion between manubrium and mesosternum (Grade M) & between xiphisternum and mesosternum (Grade X).

Age = 25.816 + 5.021 Grade M + 5.296 Grade X

R^2 = 88.9% (significant)

3. For both sexes

*Regression equation for age from grade of fusion between manubrium and mesosternum (Grade M) & between xiphisternum and mesosternum (Grade X).

Age = 26.710 + 7.170 Grade M + 4.284 Grade X

R^2 = 83.9% (significant)

Table 1: Showing the age and grades of fusion between manubrium and mesosternum in males (Grade M)

Age (in years)	Grade M				Total
	0.00	1.00	2.00	3.00	
18 – 25	5	-	-	-	5
26 – 30	3	-	-	-	3
31 – 35	8	1	-	-	9
36 – 40	5	-	-	-	5
41 – 45	1	4	-	-	5
46 – 50	-	-	4	2	6
51 – 55	-	-	3	-	3
56 – 60	-	-	-	5	5
> 61	-	-	-	9	9
Total	22	5	7	16	50

Table 2: Showing the age and grades of fusion between manubrium and mesosternum in females (Grade M)

Age (in years)	Grade M				Total
	0.00	1.00	2.00	3.00	
18 – 25	10	-	-	-	10
26 – 30	6	-	-	-	6
31 – 35	5	-	-	-	5
36 – 40	3	3	1	-	7
41 – 45	1	5	-	-	6
46 – 50	-	-	4	-	4
51 – 55	-	-	1	4	5
56 – 60	-	-	-	4	4
> 61	-	-	-	3	3
Total	25	8	6	11	50

Table 3 showing the age and grades of fusion between mesosternum and xiphoid process in males (Grade X)

Age (in years)	Grade X				Total
	0.00	1.00	2.00	3.00	
18 – 25	5	-	-	-	5
26 – 30	3	-	-	-	3
31 – 35	2	6	1	-	9
36 – 40	-	2	2	1	5
41 – 45	-	-	1	4	5
46 – 50	-	-	-	6	6
51 – 55	-	-	-	3	3
56 – 60	-	-	-	5	5
> 61	-	-	-	9	9
Total	10	8	4	28	50

Table 4: Showing the age and grades of fusion between mesosternum and xiphoid process in females (Grade X)

Age (in years)	Grade X				Total
	0.00	1.00	2.00	3.00	
18 – 25	10	-	-	-	10
26 – 30	6	-	-	-	6
31 – 35	2	3	-	-	5
36 – 40	-	3	4	-	7
41 – 45	-	-	2	4	6
46 – 50	-	-	-	4	4
51 – 55	-	-	-	5	5
56 – 60	-	-	-	4	4
> 61	-	-	-	3	3
Total	18	6	6	20	50

DISCUSSION

According to Susan Standring et al, in occasional individuals older than 30 years, the manubrium is joined to sternal body by bone but the intervening cartilage may be only superficially ossified; it is in the aged that this is completed [4]. According to Basmajian and Solenecker, the manubriosternal joint becomes ossified in 10% individuals after the age of 30 years[5]. Krogman & Iscan are of the view that the manubrium fuses with the body of sternum "in old age"[6]. Modi has stated that manubrium rarely unites with body of sternum except in old age[7]. In our study of manubriomesosternal joint in males, it was observed that fusion was seen to start between age of 41-45 years. Complete fusion was observed in subjects, most of whom were more than 56 years of age. Fusion of manubriomesosternal joint in females was seen to start between age of 36-45 years and complete fusion was seen in subjects who were 51 years or more in age. Mean age for onset of fusion in male was 42.6±4.3359 years and for complete fusion was a 65.8125±10.6847 year. In females, mean age for onset of fusion was 42.125±3.2705 years and for complete fusion was 58.3636±5.0055 year. Onset and completion of fusion was seen to occur earlier in females as compared to males.

According to Susan Standring et al, xiphisternal joint is a symphysis. It is usually transformed to synostosis by the fortieth year. It sometimes remains unchanged even in old age. According to Rentoul & Smith, fusion of mesosternum with xiphisternum occurs at 40 years. According to Krogman & Iscan, at the base of sternal body, there is a cartilage (ensiform or xiphoid) which may or may not calcify. According to Modi, xiphoid process unites with body at about 40 years of age. In our study of fusion between mesosternum and xiphoid process in males, it was observed that fusion was seen to start between age of 31-35 years and complete fusion was observed in subjects greater than 41 years of age. In females, it was observed that fusion was seen to start between age group of 31-35 years and complete fusion was observed in subjects greater than 41 years of age. Mean age for onset of fusion in males was 35.1250±0.6409 years of age and for complete fusion was 58±12.4811 year. In females, mean age for onset of fusion was 35.8333±1.4720 years and for complete fusion was 53.10±7.2758 year. There was negligible difference in age of onset of fusion in males and females but complete fusion occurred earlier in females.

SUMMARY AND CONCLUSION

In our study, we found that the study of fusion of manubriomesosternal joint and xiphiod process with mesosternum can help in estimating the approximate age of the individual. Mean age for onset of fusion of manubriomesosternal joint in males was 42.6±4.33 years and in females 42.12±3.27 years; for complete fusion in males was 65.81±10.68 year and in females 58.36±5.00 years. Mean age for onset of fusion of xiphoid process with mesosternum in males was 35.12±0.64 years and in females 35.83±1.47 years and for complete fusion in males were 58±12.48 years and in females 53.10±7.27 years.

Regression equations in males

Regression equation for age from grade of fusion between manubrium and mesosternum (Grade M) & between xiphisternum and mesosternum (Grade X) was Age = 28.151 + 8.599 Grade M + 3.403 Grade X.

Regression equations in females

Regression equation for age from grade of fusion between manubrium and mesosternum (Grade M) & between xiphisternum and mesosternum (Grade X) was Age = 25.816 + 5.021 Grade M + 5.296 Grade X.

Mean age for onset of fusion of manubriomesosternal joint in both sexes is 42.30±3.54 years and for complete fusion 62.77±9.45 years. Mean age for onset of fusion of xiphoid process with mesosternum joint in both sexes is 35.42±1.08 years and for complete fusion is 55.98±10.8 year.

For both sexes, regression equation for age from grade of fusion between manubrium and mesosternum (Grade M) & between xiphisternum

and mesosternum (Grade X) was Age = 26.710 + 7.170 Grade M + 4.284 Grade X.

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Study of sexual dimorphism in human sacrum - in North Karnataka

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ABSTRACT

Objectives: This study was under taken to know the sexual differences in an adult (north Karnataka) human sacrum & thus identify a male from a female sacrum using various parameters. **Materials & Methods:** 254 dried completely ossified grossly normal human adult sacrum of both sex (190 male & 64 female) is taken from anatomy department of Mahadevappa Rampure Medical College, Gulbarga. **Results:** In the study the male sacrum showed significantly higher values for i) ventral straight length, ii) ventral curved length, iii) maximum sacral width (breadth of S1), iv) minimum width of sacrum & v) Weight, than female sacrum, while the female sacral index showed higher values when compared with that of male. Identification point & demarking point (DP) helped in sexing the sacrum with certainity. The most useful index for sex determination of sacrum in this study was sacral index.

Summary & conclusion: after a detailed study & comparison of my work with others, I conclude that demarking point & identification point helped in sexing the sacrum with certainty. The most useful parameter in my study was sacral index. Continued study over a period of time in a defined area will definitely help in establishing the anthropometric standards for sexing the sacrum.

Key word : Sacrum, sexual dimorphism, parameters, sacral index.

INTRODUCTION

The bones of the body are the last to perish after death, next to the enamel of teeth. Hence, in establishing the personal identity with respect to sex, age & stature, medico legal experts, anatomist & anthropologist use the skeletal materials for giving their opinion. The exact establishment of identity of sex depends on the number of bones sent for examination. It was observed by Taylor [1] in his book of medical jurisprudence that the accuracy of estimating the sex from skeletal remains depends upon number of bone available-

*Skull +femur =97.35%

*Coccyx +sacrum =97.18%

*Pelvis =95%

*Skull alone =91.38%

*Femur =39.84%

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· Atlas vertebra= 31.18%

Krogman[2] made an estimate to decrease the above figures by 5-10%. Taylor[1] & Krogman[2] thus showed the statistical analysis, while the Stanfield's[3] postulation of evolutionary biology says that the genotypic variance is inversely proportional to the intensity of stabilizing the selection. This will explain the difference in the morphology of adult human males & females. Morphological features over the bones also depend on the nutritional, geographic & occupational factors .Till now various workers have quoted that skull & pelvis are of much help in determining the sex of the skeletal material. How ever it is observed that no much work is done over the bone "sacrum". Hence, the present work is an attempt to establish some parameters which will be of great help in sex identification, both in anthropometric & medicolegal study, of a defined area over a period of time.

MATERIALS & METHODS

The study was conducted in the department of Anatomy Mahadevappa Rampure Medical College, Gulbarga (North Karnataka). 254 sacra of both sexes (190 male & 64 female) were examined to complete the present study.

All the sacra used for the study were completely ossified & had no deformity.

From each sacrum following metrical data is recorded as in the manner described below:

1. Ventral straight length: with the help of sliding vernier caliper maximum straight length was measured in centimeters up to first decimal on the ventral side of the sacrum, as shown in figure – 1.

2. Sacral midventral curved length: the ventral concave median length in centimeters from midpoint of promontory to the midpoint of apex of the sacrum was measured by using the flexible ribbon tape as shown in figure - 2.

3. Maximum sacral width (anterior straight breadth at the level of S1): with the help of sliding vernier calipers maximum distance was noted between the midpoint of left & right alae of sacrum as shown in figure - 3.

4. Minimum sacral width: with the help of vernier calipers, the minimum distance was measured at the apex of the sacrum in cms as shown in figure – 4.

5. Weight of the sacrum: each sacrum was weighed on the scientific balance, weight recorded in grams up to first decimal point.

$$\text{Sacral index} = \frac{\text{Sacral width (width of S1)}}{\text{Sacral ventral straight length}} \times 100$$

Following formulae are used for calculating the values,

$$1.\ \text{Mean}\ (\bar{X}) = \frac{\text{Sum of all the values}}{\text{No. of values}}$$

$$2.\ SD = \sqrt{\Sigma \frac{(X-\bar{X})^2}{(N-1)}}$$

3. Range = Mean ± 3 SD

RESULTS

From the obtained values, demarking points (DP) is calculated on the lines of Jit & Singh[4] & the percentage of the bones, thus identified were found out in relation to each parameter.

Thus, the demarking points for ventral straight length of sacrum for males is >12cms & of females is <8.58. This would cover 99.75% of the samples & help in fixing the sex of an unknown sacrum with reasonable accuracy.

Similarly all the parameters were analyzed to arrive at the demarking points, & percentages of identified bones were recorded. Identification point (IP) is a limiting point of actual range of every measurable parameter in male & female.

The recordings of these detailed measurements are shown in table 1 & 2.

DISCUSSION

Taking into account, the various parameters of the sacrum, the merits & demerits of each measurement such as mean, it's definitive value for male & female, statistical significance were compared with other workers. Accordingly, in sexual dimorphism of human bones, Davivong's[5] has stated that as a general rule, the male bones are more massive & heavier than female bone. This rule also governs the size & articular surfaces as well. In his article on Australian aboriginal pelvis, has stated "sex determination by sacrum alone is never satisfactory, overlap of the male & female ranges is very extensive in every measurement of the bone.

Flanders[6] in also suggests that larger sample size is required in multivariate techniques & this method is more useful in sexing the long bones. But similar problem of overlap in male & female ranges in various parameters was awfully noticed. Similar difficulties were observed in the work of Hardlicka[7] & Raju et al[8] The reason for the overlap could be due to:

Considerable frequency of hypo masculinity in male bones or hyper feminity in female bones.

The above factor may be related to genetic, nutritional, socioeconomic & physical stress in the individual. The degree of overlap can however be reduced if the range is derived on the basis of mean ± 3 SD which gives 99.75% confidence limit thereby ensuring the statistical validity. Thus if genetic & geographic factors are important factors, then we can safely presume that the standards laid down for a defined area after extensive & co-related studies will remain constant for a long period of time .However, if predominant influences are observed to be the plastic ones (nutritional, life style & physical stress), it is hypothesized that the anthropometric standards will have to be evaluated from time to time in the perspective of such influences for their validity.

In discussion of every parameters an attempt has be made in the present work to simultaneously compare with others study.

For 190 male & 64 female sacra studied, the mean value for the ventral straight length in male is 11.10 cms and that for female 9.45 cms. Sacrum with ventral straight length measuring above 11.0 cms is definitely male and below 8.2 cms is definitely a female.

48.82 % male and 7.08 % female sacra did not over lap.

Mean value for male bones is significantly higher than in female bones.

14.43 % male and 15.39 % female bones fall beyond demarking point.

Difference between the male and female mean is statistically highly significant.

Table – 3 shows comparison of ventral straight length in cm with others study .Our findings are nearly consistant with the finding of Bagde[9].

Average valves (mean) for ventral curved length in male (190) is 11.26 cm & that for female (64) is 10.2 cm sacrum with ventral curved length measuring above 11.7 cm is definitely a male & below 9.2 cm is definitely a female

29.12% male & 29.81 % female sacra did not over lap

Mean value for male sacra is significantly higher than in female sacra.

7.35% male & 7.21 % female sacra fall beyond demarking point.

Difference between male & female mean is statistically highly significant.

Table 3 shows comparison of ventral curved length in cm with others study. Our findings are nearly consistant with the findings of Davivongs[5].

Average value for maximum transverse length (width) in male (190) is 10.42 cm & that for female (64) is 10.63 cm sacrum with maximum width measuring above 12.1 cm is definitely a male & below 6.5 cm is definitely a female.

3.07 % of male & 0% female sacra did not over lap.

The male samples 0.57 % & 0% of female fall beyond demarking point.

The sex difference in mean values in maximum

width in male & female is not statistically significant.

Table 3 shows comparison of maximum width of sacrum in centimeters with others study. Our findings are nearly consistant with the findings Raju et al.[8]

Average value for sacral index in males (190) is 94.24 & that for females (64) is 113.19

None of the samples of male & female sacra overlap

Mean value of female is significantly higher than male.

0.53% of male & 0% of female sacra fall beyond demarking point.

Difference between male & female mean is statistically highly significant.

Table 3 shows the comparison of sacral index with others study. Our findings are nearly consistant with Raju et al[8].

CONCLUSION

After a detailed study of 254 sacra (190 male & 64 female) & comparing with other workers it can be concluded that: identification point & demarking point help in sexing the sacrum with certainity. The most useful index for sex determination of sacrum in our study is sacral index. Continuance of such studies in a defined area over a period of time will definitely help in establishing the anthropometric standards. Such studies will also be useful to observe the changing trends if any , in the metric measurements which may be influenced by the environmental socioeconomic factors , physical stress & genetic factors.

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Table 1: Shows the measurements of various parameters of male sacrum.

Sl. No	Parameter	Total no. Bones	Range	Mean	Standard Deviation	Statistical Significance	D.P	I P	Percentage Beyond D.P.	Percentage of Identified Bones
1	Ventral. Straight Length	64	7.8-11.11	9.45	0.85	Highly Significant	< 8.58	< 8.2	15.39 %	7.08 %
2	Ventral. Curved length	64	8.5-11.5	10.02	0.803	Highly Significant	< 8.84	< 9.6	7.21 %	29.8 %
3	Maximum Width of Sacrum.	64	9.2-12.1	10.63	0.691	Not Significant	< 7.72	< 6.5	0 %	0 %
4	Minimum. Width of sacrum	64	2.0-3.0	2.31	0.30	Highly Significant	< 1.35	< 2	0 %	15.15 %
5	Weight. in grams.	64	20.0-75	39.84	12.07	Highly Significant	< 18.55	< 35	3.92 %	34.4 %
6	Sacral index	64	91.89-146.15	113.19	10.26	Highly Significant	< 58.9	< 58.9	0 %	0 %

Table 2: Shows the measurements of various parameters of female sacrum

Sl. No	Parameter	Bones No	Range	Mean	Standard Deviation	Statistical Significance	D.P	I P	Percentage Beyond D.P.	Percentage Identified Bones
1	Ventral. Straight Length	64	7.8-11.11	9.45	0.85	Highly Significant	< 8.58	< 8.2	15.39 %	7.08 %
2	Ventral. Curved length	64	8.5-11.5	10.02	0.803	Highly Significant	< 8.84	< 9.6	7.21 %	29.8 %
3	Maximum Width of Sacrum.	64	9.2-12.1	10.63	0.691	Not Significant	< 7.72	< 6.5	0 %	0 %
4	Minimum. Width of sacrum	64	2.0-3.0	2.31	0.30	Highly Significant	< 1.35	< 2	0 %	15.15 %
5	Weight. in grams.	64	20.0-75	39.84	12.07	Highly Significant	< 18.55	< 35	3.92 %	34.4 %
6	Sacral index	64	91.89-146.15	113.19	10.26	Highly Significant	< 58.9	< 58.9	0 %	0 %

D.P -Demarking point **, I.P** –Identification point , **C.R** – Calculated range

Table 3: Shows the comparison between our study & various investigators

Sl. no	Parameters	Investigators	Male				Female				S.S.D
			N	X	R	S.D	N	X	R	S.D	P
1	Ventral straight length	Bagde{1981} Our study{2003}	65 190	10.21 11.0	8.7-11.2 8.2-13.3	0.571 0.84	30 64	8.85 9.45	7.7-10.2 8.2-11.1	0.648 0.85	<0.001 <0.001
2	Ventral curved length	Davivongs{1963} Our study {2003}	50 190	10.43 11.26	8.2-11.5 9.2-14.1	0.71 0.85	50 64	9.71 10.0	8.1-11.0 8.5-11.5	0.674 0.803	<0.001 <0.001
3	Maximum width	Raju et al {1980} Our study{2003}	117 190	10.47 10.42	8.6-12.0 6.5-14.2	0.65 0.90	83 64	10.3 10.6	8.5-11.7 9.2-12.1	0.654 0.691	N. S N.S
4	Sacral index	Raju et al {1980 } Our study{2003}	33 190	100.85 94.24	74.7-129 54.5-152	8.71 11.78	11 64	111.3 113.1	88.4-134 91.9-146	7.67 10.3	<0.001 <0.001

N- Sample size; x-mean, **S.D**-Standard deviation **;** **P**-Probability**,** **N.S** –Not significant; **S.S.D**-Statistically significant difference between the two sexes.

Figure 1: Shows Sacral Ventral straight length

Figure 2: Shows Sacral Midventral curved length.

Figure 3: Shows Maximum sacral width

Figure 4: Shows Minimum sacral width

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Pattern and frequency of Throat-Skeleton injuries in Hanging and Strangulation

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ABSTRACT

Study of frequency of fractures of neck structures in hanging and strangulation cases were done in the department of Forensic Medicine and Toxicology, Govt. Medical College, Amritsar. 45 (2.26%) cases of Hanging & Strangulation were studied out of total 1983 autopsy cases. In this paper various aspects have been discussed in relation to the presence or absence of fractures of bony structure of neck in hanging and strangulation cases.

Key words: Hyoid Bone, Hanging, Strangulation, Fracture

INTRODUCTION

Hanging is one of the most common methods to commit suicide; whereas strangulation is used in homicide. Investigation of a person found hanging raises a single question-whether it is homicide or suicide?

When performing forensic autopsy, the careful examination of neck structures, Hyoid-laryngeal complex injuries play a decisive role in diagnosis of asphyxial death.

Many authors have given importance to presence or absence of fractures of neck structure in hanging and strangulation cases especially whenever opinion about accidental or homicidal or suicidal death has to be given in suspected cases. Different authors have different observation for the same.

MATERIAL AND METHODS

After collecting preliminary data as written in police paper, external findings in hanging and strangulation cases were noted down. Neck structures were inspected; careful neck dissection was conducted for presence or absence of fractures of bony structures of neck. The tongue, larynx and trachea were removed carefully. Then the findings were confirmed by meticulous dissection to observe hemorrhage in and around the fractured area. Fractured piece of bone was taken and preserved in 10% formalin solution before subjecting them to histopathological examination as per procedure (Culling *et al.*, 1985).

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OBSERVATIONS

Total number of 1983 cases were brought for postmortem examination , out of which 45 cases of hanging and strangulation were studied.

Table 1. Incidence and distribution of deaths due to hanging and strangulation

Total no. of autopsy cases	Hanging cases		Strangulation cases		Total	
	No.	% age	No.	% age	No.	% age
1983	25	1.26	18	0.90	43	2. 16

Two cases were those in which cause of death as per autopsy report was other than hanging and strangulation. There was one case of manual strangulation. Total number of cases of hanging and ligature strangulation were 42.

Table II. Age wise and sex wise distribution of hanging and strangulation deaths

Age in years	Hanging				Strangulation				Total	
	Male		Female		Male		Female			
	No.	% age	No.	% age	No.	% age	No.	% age	No.	% age
0-10	-	-	-	-	-	-	-	-	-	-
11-20	1	4.0	4	16	1	5.5	1	5.5	7	16.27
21-30	8	32.0	4	16	2	11	5	27.7	19	44.18
31-40	6	24.0	-	-	3	16.7	1	5.5	10	23.25
41-50	1	4.0	-	-	2	11	-	-	3	6.97
51-60	-	-	1	4.0	-	-	1	5.5	2	4.65
> 60	-	-	-	-	1	5.5	1	5.5	2	4.65
Total	16	64.0	9	36	9	50	9	50	43	100

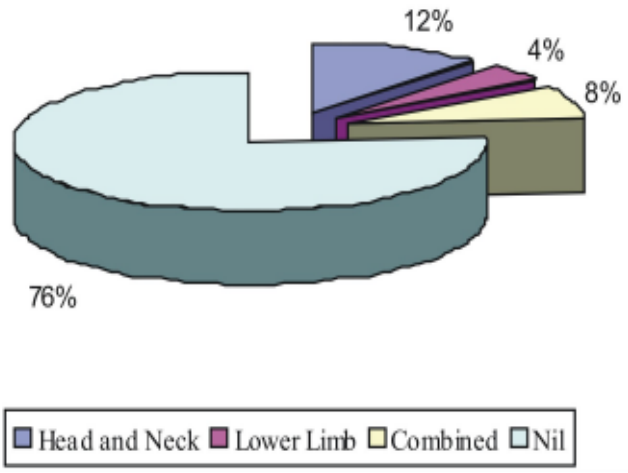
As per table II maximum i.e. 19 (44.2%) cases of hanging and strangulation deaths were reported in age group 21-30 years. Out of 25 cases, 16 (64%) males and 9 (34%) female died due to hanging. Out of 18 case of strangulation equal (50%) cases were reported both in male and female. No case of hanging and strangulation death was reported in 0-10 years of age groups.

Table III. Incidence and distribution of associated trauma in hanging and strangulation deaths

Region of the body	Type of asphyxial death					
	Hanging		Strangulation		Total	
	No.	% age	No.	% age	No.	% age
Head and Neck	3	12.0	8	44.4	11	25.58
Chest	-	-	-	-	-	-
Abdomen	-	-	-	-	-	-
Upper Limb	-	-	2	11.1	2	4.65
Lower Limb	1	4.0	-	-	1	2.32
Combined	2	8.0	7	38.8	9	20.92
Nil	19	76.0	1	5.5	20	46.5
Total	25	100	18	100	43	100

As per Table III, out of 25 case of hanging death, the associated trauma was found maximum in on head and neck in 3 (12%) cases (Fig 1). In 18 cases of strangulation, maximum trauma was found on head and neck in 8 (44.4%) case (Fig 2). No associated trauma was found in 19 (76%) cases of hanging and 1 (55.5%) cases of strangulation.

Fig. 1: Incidence of Association trauma in Hanging



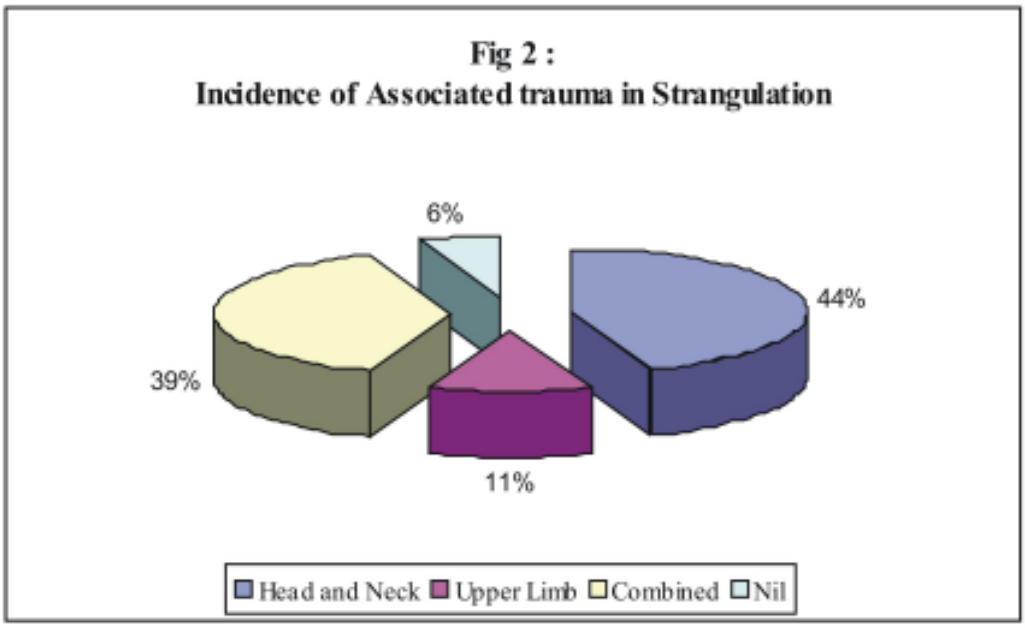
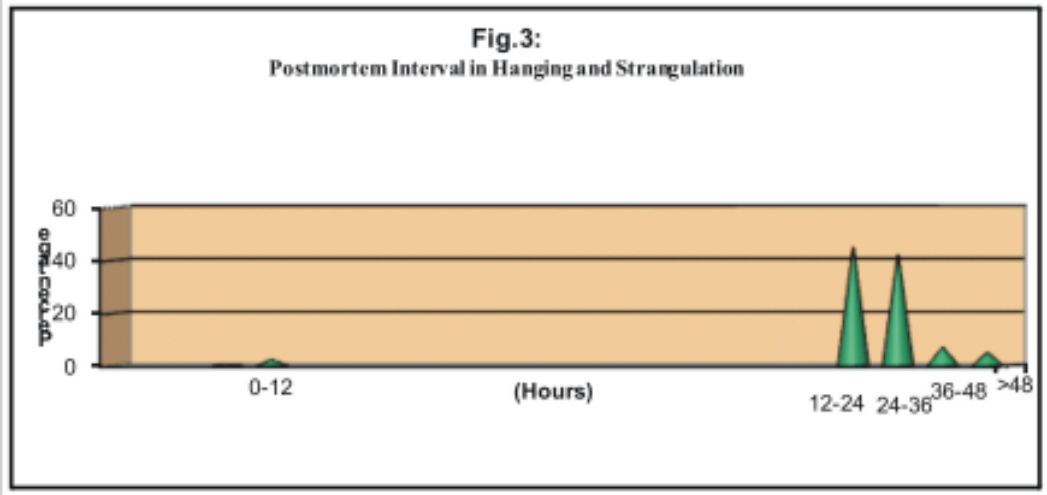


Table IV. Postmortem interval in hanging and strangulation deaths

Postmortem Interval (Hours)	Type of asphyxial death					
	Hanging		Strangulation		Total	
	No.	% age	No.	% age	No.	% age
0-12	-1-1------2-111-125-21-11125	-	1	5.5	1	2.3
12-24	12	48	7	38.8	19	44.8
24-36	11	44	7	38.8	18	41.9
36-48	1	4	2	11.1	3	6.97
>48	1	4	1	5.5	2	4.95
Total	25	100	18	100	43	100



As per table IV, 86.08% cases were autopsied in post-mortem interval of 12-36 hours which shown the normal time lag due to the procedure followed in this part of country for fulfilling the legal requirement for conducting an autopsy (fig3).

Table V. Sex wise incidence and distribution of hyoid bone fracture and thyroid cartilage fracture (individually) in hanging and strangulation deaths

Types of asphyxia	Hyoid fracture present				Thyroid fracture present			
	Male		Female		Male		Female	
	No.	% age	No.	% age	No.	% age	No.	% age
Hanging (n=25)	-	-	-	-	-	-	-	-
Ligature strangulation (n=17)	-	-	1	5.5	2	11.1	1	5.5
Manual strangulation (n=1)	-	-	-	-	-	-	-	-

As per Table V, out of 17 case of ligature strangulation, hyoid bone fracture was observed in 1 (5.5%) female case only and no bone fracture was observed in hanging cases. No hyoid bone fracture was observed in 1 (5.5%) case of manual strangulation. Thyroid cartilage fracture was observed in 2 (11.1%) in male and 1 (5.5%) in female cases of ligature strangulation No case of thyroid cartilage fracture was observed in hanging death.

Table VI. Incidence and distribution of combined fracture of hyoid and thyroid cartilage in hanging and strangulation deaths

Type of asphyxia	Fracture present				Total	
	Male		Female		No.	% age
	No.	% age	No.	% age		
Hanging (n=25)	-	-	-	-	-	-
Ligature strangulation (n=17)	1	5.5	1	5.5	2	11.1
Manual strangulation (n=1)	-	-	-	-	-	-

As per Table VI, out of 17 case of ligature strangulation, 1 (5.5%) male case and 1(5.5%) female case had both thyroid and hyoid bone fracture. No case of fracture of hyoid and thyroid cartilage was observed in hanging and manual strangulation death. No combined fracture of hyoid and thyroid cartilage was observed in 1 (5.5%) case of manual strangulation.

SUMMARY & CONCLUSION

1. In the present study 2.16% cases were declared on autopsy of hanging and strangulation deaths .
2. In the present study maximum number of cases i.e. 44.18% were reported in the age group 21-30 years. . The reason for this can be attributed due to increasing aggression and early losing of temper among the person of third decade. In the hanging cases 64% male and 36% female cases were observed in present study.
3. Associated trauma on head and neck was found in 44.4% cases of strangulation in the form of abrasion, bruises and occasionally laceration which indicates that these is great relative movement between the victim and the assailant during the time of crime.
4. 86.08% cases were autopsied in post-mortem interval of 12-36 hours which shown the normal time lag due to the procedure followed in this part of country for fulfilling the legal requirement for conducting an autopsy. Tabata (1998) conducted autopsy in 53.3% cases of compression of neck in 12-24 hours.
5. In the present study, hyoid bone was fractured in 5.5% cases of strangulation. The difference in incidence in various study may be due to multiple factors as mentioned by Pollanen and Chaisson (1996) i.e. magnitude of force applied to neck, rigidity of hyoid bone, age of victim, shape of hyoid.
6. In 25 cases of hanging the present study, hyoid bone was not fractured in any case. This may be due to less age group reported in our study where as fracture is reported more frequent in person over the age of 40 years.
7. In ligature strangulation 17.64% cases had thyroid cartilage fracture according to our study. A fracture of the cervical spine is rare because it requires a drop of some five feet or more.
8. As per our study combine fracture of hyoid and thyroid cartilage was reported in 11.1% cases of ligature strangulation. Davidson and Marshall (1986) reported 16.2% of combine fracture of hyoid and thyroid cartilage.

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Pattern of poisoning cases reported at Kasturba Hospital, Manipal

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ABSTRACT

Introduction: Poisoning is an important health hazard and one of the leading causes of morbidity and mortality worldwide. **Aims & Objectives:** The study aims to gather epidemiological information regarding poisoning in Manipal such as the incidence, age, gender, religion, type of poisoning, circumstance of poisoning and outcome, so as to formulate recommendations that could probably help to reduce the morbidity and mortality due to poisoning, and preventable health hazard. **Materials & Methods:** The study comprises 592 cases of acute poisonings; admitted to Kasturba Hospital, Manipal, which is a tertiary care teaching hospital, situated in coastal Karnataka, South India, for a period of 3 years (January 2006 to December 2008). **Results:** Of the total 1,49,454 patients admitted in the hospital for treatment during the three years study period, 592 patients were for to acute poisoning. This was less than 1% of all admissions. Of these 57% were males and 43% females. The majority (30%) cases were from age group of 21–30 years. Most (63.7%) poisonings were suicidal and only 35.8% were accidental in nature. The mortality outcome was 66 out of 592 cases. It is important to realize that the present study is restricted to this tertiary health care centre; hence it may be thought to be difficult to draw conclusions for the whole population of Udupi District. However, it emphasizes the need for giving priority for prevention and treatment of poisoning in the health care of the population of Karnataka especially of Udupi District.

Key words: Poisoning; Pattern of poisoning; Suicide; Mortality; Organophosphorous poison.

INTRODUCTION

Acute poisoning is an important clinical emergency and contributor to morbidity and mortality. Nearly one million people are affected globally every year.[1] Poisoning, though common has remained a largely neglected area of research in India. The word poison means "a substance that causes injury, illness, or death, especially by chemical means". Consumption of such substances either intentionally or accidentally results in death or serious injuries. The health impact of chemical exposures and poisoning is well recognized in most industrialized countries, where chemical safety and poison control programmes are established. The Toxic Exposure Surveillance System (TESS) data, compiled by the American Association of Poison Control Centers, for example, provides evidence about toxic exposures and subsequent health effects throughout the United States, and is utilized to identify emerging hazards, to focus prevention

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and education programmes and to guide clinical research and training.[2] In contrast, most developing countries like India have not yet fully recognized the risks posed by chemicals on human health and the environment. One reason is the lack of sound national epidemiological data on toxic exposures and poisoning. Some case studies and hospital-based retrospective and prospective studies have documented poisoning-related morbidity and mortality and the changing trend of chemical exposures. According to World Health Organization, more than three million poisonings occur in developing countries, particularly among agricultural workers.[3] Pattern of poisoning in a given area depends upon the availability of poisonous substance, occupation prevalent in the society, religious and cultural influences. The present study attempts to gather epidemiological information regarding poisoning in Manipal such as the incidence, age, gender, religion, type of poisoning, circumstance of poisoning and outcome, so as to formulate recommendations that could probably help to reduce the morbidity and mortality due to poisoning, a preventable health hazard.

MATERIAL AND METHODS

The study comprises 592 cases of acute poisonings; admitted to Kasturba Hospital, Manipal, which is a tertiary care teaching hospital, situated in coastal Karnataka, South India, for a period of 3 years (January 2006 to December 2008). It is a tertiary level hospital, which caters to wide variety of people of Karnataka and border district of Kerala. Patients with idiosyncratic or adverse reaction to prescribed drugs and food poisoning excluded from this study. The data regarding the incidence, age, gender, religion, type of poisoning, circumstance of poisoning and outcome collected from the medical records. The nature of poison/agents involved was determined from the circumstantial evidence, reliable history, presentation of remaining stuff/container from which the poison had been consumed and suggestive clinical feature. The poisons/drugs classified in different groups based on their characteristics. The data collected using the proforma was entered in the computer in data base and analyzed using SPSS 11.0 software.

RESULTS

One lakh forty nine thousand four hundred fifty four patients were admitted in the hospital during the period of 3 years (January 2006 to December 2008). Of these, 592 patients admitted with acute poisoning, as depicted in the Table No. 1. This was less than 1% of the total admission.

Maximum numbers of poisoning cases were found to be in the age group of 21 to 30years, followed by the age group of 11 to 20 years, and 31 to 40 years respectively, as depicted in the Table No. 2. In our study, we observed that males outnumbered females, it constitute 57% (male) as depicted in the Table No. 3. 94.6 % of the victims were Hindus, followed by 2.7% Christians and 2.7% Muslims, as depicted in the Table No.4.

The most common poison was oragnophosphorous insecticides followed by therapeutic medications and snakebite envenomation as depicted in the Table No. 5. It was observed in our study that most common circumstance of poisoning was suicidal followed by accidental and homicidal respectively, as depicted in Table No. 6. It was observed in our study that, 88.8% of cases reported to our hospital had survived while 11.2% cases had expired, as depicted in the Table No.7.

DISCUSSION

Morbidity and mortality due to acute poisoning is a worldwide phenomenon and has enormous medical, legal and social significance. Self poisoning is one of the oldest methods tried for intentional self harm (suicide). There are reports available from different parts of the world highlighting various substances abused for acute poisoning and their toxicity. From Western countries, drugs have reported as the commonest substances abused with mortality rates varying

between 0.4% and 2.0%.[4] Reports available from certain Asian (SriLanka) and African countries (Uganda) describe organophosphates and drugs as the commonly abused toxic substances with reported mortality rates varying from 2.0% to 2.1%. [5, 6]

Nearly one million people are affected by poisoning globally every year.[1] The mortality worldwide is estimated to be 0.6% of all deaths per year as per WHO. In India deaths due to poisoning accounts for more than 50,000 people every year.[7] The age group with maximum incidence of poisoning was between 21 - 30 years and the poisoning is significantly less in the extremes of age. The high incidence of poisoning in the above age group is in accordance with the trends observed nationally and globally. [8-11] It is obviously due to the fact that this age group is the determining factor of the life in terms of studies, service, marriage and other life settlement factors. Therefore, they are subjected to substantial amount of mental stress and strain during this period. Prevalence of males was more in our study when compared to females, corroborating with other studies.[12, 13] Male preponderance in this study could be accounted to the fact that males are more often exposed to the stress and strain of day to day life, as well as to the occupational hazards than the females in this part of the world. However, studies from the some parts of India, United Kingdom, Iran, Turkey, and Tokyo reported more cases of poisoning in females, indicating the varying trends at different places. [14-18]

Majority of the poisoning victims belong to the Hindu faith reflecting the distribution of population following different religion. Hindus constitute around 84% of the regional population, 12% follow Islam and 2% are Christians.[19] Hindus are predominantly engaged in agriculture related occupations. The fact that farming community is more prone to poisoning may be responsible for this high rate of poisoning among Hindu community. Harming ones own life is considered 'haram' and strictly forbidden in Islam, the Muslim religion. This may be the reason for low incidence of poisoning among Muslims as such.[19]

Bulk of the poisoning (38.34%) cases were due to Organophosphorous insecticide poisons and was in accordance with studies conducted at national and international levels.[13, 20] The use of certain poisons depends on the availability and accessibility of the agent to an individual. Organophosphates continue to be the most commonly used agrochemicals in southern and western part of the country because of its easy availability and low cost.[21] However, the pattern of poisoning observed in the western studies revealed, prescription related drugs to be the most preferred poison.[15, 22]

Suicidal poisoning forms a bulk of the total poisoning victims, which is not only a national phenomenon but also a global one.[4,12,23] This high incidence of suicide by poisoning is attributed to a general belief that poisoning kills with a minimal suffering. Human life is full of stress. Hormones, peer pressure, self-esteem, confusion, self-doubt, expectations, pressure to succeed, academic responsibilities, maladjustment, financial uncertainty and physical diseases are some of the factors contributing to this stress during different age groups. Suicide is often an impulsive act resulting from the inability to adjust with their surroundings and cope with the stress they are exposed to. In the absence of emotional support and understanding, one may resort to suicide as a solution to ones problem and stress. Three poisoning cases belonging to the age group less than 10 were homicidal in nature. Homicidal pediatric poisoning cases were also reported by Surjit S et. al.[24] and Teresa A et. al.[25] Mother was the perpetrator of the crime of the homicidal cases in our study. The mortality rate in poisoning victims was 11.2%, where as the mortality rate ranged from 2.4% to 15% in various national and international studies.[4, 26, 27] No deaths were reported in study conducted at Sultanate of Oman.[28]

CONCLUSIONS AND RECOMMENDATIONS

1. Poisoning constitutes less than 1% of the total hospital admissions.

2. Males are affected more often than the females; male to female ratio being 1.4:1.
3. Sixty eight percent of poisoning victims were in the 2nd to 4th decade of life.
4. Organophosphorous insecticide poison was the most common type of poison that was observed in 38% of the cases.
5. Most of the poisoning victims belong to Hindu faith.
6. Among the circumstances of poisoning, suicidal poisoning was predominant (63.7%) followed by accidental (35.8%) and homicidal (0.5%).
7. The mortality rate in our study is 11.2%.

Prevention of poisoning rests on a number of strategies. To develop any intervention programmes, a clear understanding of problem, risk factors and causes, situation-context of occurrence are required. To facilitate this understanding, good research delineating human, product and social/environmental factors are required to identify what can be done before any poisoning occurs, in the event of an act or after such instances. Good documentation helps in developing strategies and approaches to prevent such acts occurring in future. In addition, it requires cooperation of Governments, industry, health professionals and all others to develop integrated approaches.

Organophosphates were responsible for deaths in the majority of cases; but organophosphate compounds are important to sustain crop production. In agricultural country like India, loss of crops due to insects or pests can't be taken lightly, hence instead of banning a particular pesticide, the following measures could be adopted : all chemical should be properly labelled ; storage and sale of insecticide should be controlled through strict legislation and regulation ,and open market sale of this chemical should be banned; a fixed quota as needed per individual should be available through the specialized agency; and the public should be educated about the hazards of pesticides and their sale and proper handling.

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Table 1. Year wise distribution of cases of poisoning

Year	Total admissions No	Poisoning cases No
2006	44,966	188
2007	51,320	201
2008	53,168	203
	1,49,454	592

Table 2. Age incidence (n=592)

Age group in years	No of cases	Percentage (%)
< 10	50	08.5
11-20	132	22.3
21-30	180	30.3
31-40	91	15.4
41-50	57	09.6
51-60	41	6.9
>61	41	6.9

Table 3. Gender distribution (n=592)

Gender	No. of cases	Percentage (%)
Male	340	57.4
Female	252	42.6

Table 4. Religion-wise distribution of poisoning victims (n=592)

Religion	No. of cases	Percentage (%)
Hindu	560	94.6
Muslim	16	2.7
Christian	16	2.7

Table 5. Type of poisoning (n= 592)

Nature of poison	No. of cases	Percentage (%)
Oragnophosphorous insecticides	227	38.34
Carbamates	22	3.71
Rodenticides	47	7.93
Chlorinated hydrocarbons	6	1.00
Petroleum products	25	4.22
Therapeutic drugs	91	15.37
Narcotics	10	1.68
Corrosives	32	5.40
Irritants	28	4.72
Plant poisons	19	3.20
Snake bites	79	13.34
Insect bites	6	1.00

Table 6. Circumstance of poisoning (n=592)

Circumstances	No. of cases	Percentage (%)
Suicidal	377	63.7
Accidental	212	35.8
Homicidal	3	0.5

Table 7. Outcome (n=592)

Outcome	No. of cases	Percentage (%)
Survival	526	88.8
Expired	66	11.2

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Fatal hair dye poisoning: A case report

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ABSTRACT

Paraphenylene diamine (PPD) is common ingredient in most of the hair dye preparations and posing emerging threat as a suicidal agent. Clinical manifestations include numbness & burning of mouth, throat and vomiting along with respiratory distress and dysphagia. Rhabdomyolysis, intravascular hemolysis, oliguria/anuria, acute renal failure and toxic myocarditis have also been associated with the compound. This case report provides autopsy and toxicological findings in an intentional ingestion of hair dye preparation.

Key words: Hair dye, paraphenylene diamine, death, autopsy, toxicological findings

INTRODUCTION

Paraphenylene diamine (PPD) is common ingredient in most of the hair dye preparations[1]. Ingestion of PPD leads to angioedema, asphyxia, dysphagia, oliguria/anuria, acute renal failure, rhabdomyolysis, intravascular hemolysis, coagulation derangements and toxic myocarditis. Fatality is related to acute renal failure or myocardial damage[2,3] . This case report provides autopsy and toxicological findings in an intentional ingestion of hair dye preparation.

CASE REPORT

A 27-year unmarried male was brought to private hospital with suicidal consumption of hair dye (Trade name concealed) at about 04:00 PM. On examination, patient was violent. He was managed supportively but develops cardiorespiratory arrest on same day at about 07:30 PM.

A forensic autopsy was conducted at Government Medical College & Hospital, Nagpur which, discovered cyanosis with blood tinged froth oozing from mouth and nostrils. There was a fresh incised wound at left forearm on flexor aspect. Internal examination showed congested and edematous brain with fresh patchy subarachnoid hemorrhages scattered at multiple places. Mucosa of oral cavity, upper airway and upper alimentary tract was blackish in colour, swollen and corroded at places. Blood was dark and watery. Except petechial hemorrhages on epicardium, grossly heart was unremarkable. Lungs were congested and edematous. Abdominal organs were congested. On microscopy, brain and lungs were congested and edematous. Heart, liver and spleen were congested. Kidney showed congestion, edema and cloudy changes. Chemical analysis, conducted at Regional Forensic Science Laboratory Nagpur, revealed presence of PPD. In stomach and intestine PPD content was 1.5 mg per 100 gm whereas in liver, spleen and kidneys, it was 0.83

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mg per 100 gm. Blood and gastric lavage levels were positive for PPD.

DISCUSSION

The stated hair dye is an emulsion type of preparation and contains PPD (not exceeding 4%), liquid paraffin, cetostearyl alcohol, sodium lauryl sulphate, EDTA disodium, resorcinol, and propylene glycol. On most of the occasions, PPD is responsible for the clinical features but toxicity due to disodium EDTA, in addition to PPD, is also reported. Resorcinol is a corrosive and causes methemoglobinemia[2].

Hair dye ingestion is an uncommon cause of attempted suicide in India as compared to some parts of the world such as Africa[2,4]. However, recent review of Indian literature revealed that PPD is emerging threat for suicidal purpose[3,5-7].

Early manifestations (patient presenting within 4 to 6 hours of ingestion) include numbness & burning of mouth, throat and vomiting along with respiratory distress and dysphagia. Late manifestations (usually after 12 hours of ingestion) include rhabdomyolysis, intravascular hemolysis, oliguria/anuria, acute renal failure and toxic myocarditis [1].

The respiratory syndrome following the ingestion of PPD is represented by asphyxia and respiratory failure secondary to inflammatory edema involving cricopharynx and larynx [4]. The autopsy showed black staining, edema and erosion of upper airway. Therefore early securing of airway is cornerstone in PPD management and treating physicians need to be aware about such clinical presentation.

The kidneys are particularly vulnerable to the toxic effects of PPD. Hemolysis, rhabdomyolysis, methemoglobinemia and direct tubular toxicity are the possible mechanisms for acute renal failure [3, 8]. Postmortem examination showed features of cloudy degeneration to acute tubular necrosis [3]. The morbidity and mortality are high once renal failure develops [9]. However, with timely intervention, renal failure can be prevented. The fresh hemorrhages noted at autopsy suggest coagulation derangement caused by hair dye and clinically needs proper evaluation and management.

The published literature revealed consumption of hair dye suspension from 100 ml to 300 ml (average 141.6 ml) to be fatal [2, 3]. In the stated case, the chemical analysis revealed that the 1.5 mg per 100 gm of PPD in stomach & intestine and 0.83 mg per 100 gm in liver, spleen & kidneys proved fatal.

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