

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 mesosternum, b) xiphoid process and mesosternum 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 $\text{Age} = 28.151 + 8.599 \text{ Grade M} + 3.403 \text{ Grade X}$. Regression equation for age from grade of fusion between manubrium and mesosternum (Grade M) & between xiphisternum and mesosternum (Grade X) was $\text{Age} = 25.816 + 5.021 \text{ Grade M} + 5.296 \text{ Grade X}$. For both sexes, regression equation for age from grade of fusion between manubrium and mesosternum (Grade M) & between xiphisternum and mesosternum (Grade X) was $\text{Age} = 26.710 + 7.170 \text{ Grade M} + 4.284 \text{ Grade X}$.

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 years¹⁻³. 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 mesosternum
- b) xiphoid process and mesosternum

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 manubrium 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 mesosternum 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 manubrium 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 51 years 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 mesosternum 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 mesosternum 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 mesosternum 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 years. 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 mesosternum 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 mesosternum 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).

$$\text{Age} = 28.151 + 8.599 \text{ Grade M} + 3.403 \text{ Grade X}$$

$$R^2 = 82.5\% \text{ (significant)}$$

2. Females

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

$$\text{Age} = 25.816 + 5.021 \text{ Grade M} + 5.296 \text{ Grade X}$$

$$R^2 = 88.9\% \text{ (significant)}$$

3. For both sexes

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

$$\text{Age} = 26.710 + 7.170 \text{ Grade M} + 4.284 \text{ Grade X}$$

$$R^2 = 83.9\% \text{ (significant)}$$

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 completed⁴. According to Basmajian and Solenecker, the manubriosternal joint becomes ossified in 10% individuals after the age of 30 years⁵. 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 age⁷. 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 xiphoid 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 $\text{Age} = 28.151 + 8.599 \text{ Grade M} + 3.403 \text{ Grade X}$.

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 $\text{Age} = 25.816 + 5.021 \text{ Grade M} + 5.296 \text{ Grade X}$.

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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