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Age Estimation by Fusion of Mesosternal Segments in Living Beings by Radiological Examination in Bikaner

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Abstract

Background: More studies are needed to know the accuracy of a radiological report regarding age estimation especially in living person. Therefore, this study was planned to assess the age estimation by fusion of mesosternal segments in living beings by radiological examination in Bikaner region. The main aim of this study was to decide the approximate age between 6 to 30 years with the help of fusion of segments of body of sternum.

Methods: Present study was carried out in Department of Forensic Medicine and Toxicology in collaboration with Department of Radiology of S.P. Medical College, Bikaner. 100 persons of either gender, belonging to the age group (6-30 years) were selected for this study.

Results: Regarding fusion between 3rd and 4th segment, maximum participants (84.00%) had a complete fusion followed by 11.00% partially fused and 5.00% non-fused. The earliest partial fusion between 3rd and 4th segments was seen in the age of 6-9 years in both males and females. This partial fusion was absent after the age of 15 years in both male and female. Regarding fusion between 2nd and 3rd segment, maximum participants (59.00%) had a complete fusion followed by 23.00% non-fused and 19.00% partially fused. Among the male earliest partial fusion between 2nd and 3rd segments was

seen in the age of 10-12 years while in female, earliest fusion was seen in the age of 6-9 years. No partial fusion was present after the age 21 years in female and after 24 years in male. Regarding fusion between 1st and 2nd segment, maximum participants (43.00%) had a non-fusion between followed by 32.00% completely fused and 24.00% partially fused. With increasing age, the incidence of complete fusion between 1st and 2nd segment steadily rises and reaches 94.86% at age 25-27 years.

Conclusion: From this study, it was concluded that the common age range for fusion of the sternebrae are as follows: 1st– 2nd= 25 – 27 years, 2nd– 3rd= 22-24 years, 3rd– 4th= 13-15 years.

Keywords: Sternebrae, Age, Medicolegal

Introduction

The sternum is formed by fusion of two cartilaginous sternal plates flanking the median plane. The arrangement and number of centres of ossification vary according to the level of completeness and time of fusion of the sternal plates, and to the width of the adult bone.[1]

Union between mesosternal segments proceeds from below upwards, by the age of 25 years they all are united. So, it could be perfectly utilised as a versatile tool of age estimation in this age group, especially in cases of age disputes.

Suprasternal or episternal ossicles, paired or single, occur in about 7% of sterna. These (ossicles) may fuse to the manubrium or articulate posteriorly at the lateral border of the jugular notch (supra-sternal notch). The ossicles are cartilaginous at birth, and ossify during adolescence. [2,3] Often conflicts also arise in the court of law when a radiological report shows a difference in age estimation, while the party produce a document showing a different age. So, dispute arises regarding difference in age. Age estimation in second and third decades is mainly done by radiological examination of long bones and pelvis by performing the x-ray of elbow, wrist and pelvis respectively, but there are very few studies of age estimation by fusion of segments of body of sternum for age estimation between 6 to 30 years of age. [4]

More studies are needed to know the accuracy of a radiological report regarding age estimation especially in living person. Therefore, this study was planned to assess the age estimation by fusion of mesosternal segments in living beings by radiological examination in Bikaner region. The main aim of this study was to decide the approximate age between 6 to 30 years with the help of fusion of segments of body of sternum.

Materials and methods

This study was carried out in Department of Forensic Medicine and Toxicology in collaboration with Department of Radiology of S.P. Medical College, Bikaner.

This study was conducted on total 100 numbers of cases. The age of subjects was determined by fusion of segments of mesosternum by Anteroposterior & lateral views of digital X- Rays.

Method for X-ray examination:

Study was carried out by Digital technique. After taking X-ray of sternum bone anteroposterior and lateral view, the film was developed by standard technique and the film will be studied for fusion of segment of the body of sternum and radiological age was concluded. Age as stated by them was further confirmed by Aadhar card /secondary school certificate, any document reflecting their exact age viz Birth certificate, or entry in their school record. The persons belonging to the age group (6-30 years) selected for the study of either gender were included in the study irrespective of their socioeconomic, religious and educational status, each person so chosen

on the basis of criteria as mentioned above were evaluated clinically in details as per the proforma.

Criteria for data analysis of fusion of ossification centres were:

1. Stage I: Centre has appeared but there is no union: +
2. Stage II: Union has started but there is incomplete union: ++
3. Stage III: Recent union, here there is a complete fusion of sternal segment: +++
4. Stage IV: Old union, here there is a complete fusion of sternal segment, with the disappearance of scar: ++++

Finally, the observations were arranged in tabulated form and appropriate statistical tests of significance were applied. The data was analysed and the conclusions were drawn after comparing and discussing with similar type of the work carried out by foreign and Indian authors.

Inclusion and Exclusion Criteria

Inclusion Criteria

- Sterna without any obvious pathology between the age of 6 to 30 years
- Subjects living in Bikaner region for more than 5 years.
- Subjects free from any physical disability or endocrinal anomaly.
- Subjects with accurate record of their date of birth.

Exclusion Criteria

- Deformed, Diseased and Fractured sterna.

Observation

Table 1: General characteristics.

Mean age	17.67±6.83 yrs
Male: female	58:32

The mean age of the studied participants was found to be 17.67±6.83 years with a minimum age of 6 years and maximum age of 30 years. 58.00% were male and 42.00% were female.

Table 2: Fusion between 1st and 2nd segment in different age groups.

	Sex	Age groups (years)								Total
		6-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	
Non-fused	M	13	4	5	4	1	0	0	0	27
	F	4	4	4	1	2	1	0	0	16
	Total	17	8	9	5	3	1	0	0	43
Partially fused	M	0	0	2	2	3	4	0	0	11
	F	0	0	2	4	1	4	2	0	13
	Total	0	0	4	6	4	8	2	0	24
Recent completely fused	M	0	0	0	1	5	5	6	1	18
	F	0	0	0	1	3	4	1	4	13
	Total	0	0	0	2	8	9	7	5	31
Old completely fused	M	0	0	0	0	0	0	0	2	2
	F	0	0	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	2	2
Total	M	13	4	7	7	9	9	6	3	58
	F	4	4	6	6	6	9	3	4	42
	Total	17	8	13	13	15	18	9	7	100

Regarding fusion between 1st and 2nd segment, a total of 27 male and 16 female had non-fusion and they were from 6-24 years age group. Cases with partial fusion were distributed in 13-27 years age group. Recent complete fusion cases were absent in 6-15 years age groups. There were only 2 old complete fusion cases and that too were male from 28-30 years age group. Among the males, the earliest partial fusion was seen in the 13-15 years age. With increasing age, the incidence of complete fusion steadily rises and reaches 94.86% at age 25-27 years.

Among the females, fusion between 1st and 2nd segment commences in the 13-15 years age which was similar to the males. With increasing age, the incidence of complete fusion steadily rises and reaches 83.33%% at age 22-24 years. However, a few cases of partial fusion are still present in the older groups until the age of 27 years.

Table 3: Fusion between 2nd and 3rd segment in different age groups.

	Sex	Age groups (years)								Total
		6-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	
Non-fused	M	13	2	2	0	0	0	0	0	17
	F	3	1	2	0	0	0	0	0	6
	Total	16	3	4	0	0	0	0	0	23
Partially fused	M	0	1	3	3	1	2	0	0	10
	F	1	2	2	2	1	0	0	0	8
	Total	1	3	5	5	2	2	0	0	18
Recent completely fused	M	0	1	2	4	7	5	3	1	23
	F	0	1	2	4	5	9	3	3	27
	Total	0	2	4	8	12	14	6	4	50
Old completely fused	M	0	0	0	0	1	2	3	2	8
	F	0	0	0	0	0	0	0	1	1
	Total	0	0	0	0	1	2	3	3	9
Total	M	13	4	7	7	9	9	6	3	58
	F	4	4	6	6	6	9	3	4	42
	Total	17	8	13	13	15	18	9	7	100

Regarding fusion between 2nd and 3rd segment, among the male earliest partial fusion was seen in the age of 10-12 years while in female, earliest fusion was seen in the age of 6-9 years. No partial fusion was present after the age 21 years in female and after 24 years in male. 95.65% male and 88.88% female had recently complete fusion in the age of 25-27 years. Complete fusion was observed in both sexes by the age 22-24 years.

Table 4: Fusion between 3rd and 4th segment in different age groups

	Sex	Age groups (years)								Total
		6-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	
Non-fused	M	3	0	0	0	0	0	0	0	3
	F	2	0	0	0	0	0	0	0	2
	Total	5	0	0	0	0	0	0	0	5
Partially fused	M	5	1	1	0	0	0	0	0	7
	F	1	1	2	0	0	0	0	0	4
	Total	6	2	3	0	0	0	0	0	11
Recent completely fused	M	5	2	5	3	2	1	0	0	18
	F	1	2	2	2	1	0	0	0	8
	Total	6	4	7	5	3	1	0	0	26
Old completely fused	M	0	1	1	4	7	8	6	3	30
	F	0	1	2	4	5	9	3	4	28
	Total	0	2	3	8	12	17	9	7	58
Total	M	13	4	7	7	9	9	6	3	58
	F	4	4	6	6	6	9	3	4	42
	Total	17	8	13	13	15	18	9	7	100

Regarding fusion between 3rd and 4th segment, the earliest partial fusion was seen in the age of 6-9 years in both males and females. This partial fusion was absent after the age of 13-15 years in both male and female. 100% recently complete fusion was present in the females in the age of 19-21 years and 22-24 years in males

Discussion

Identification of an Individual whether living or dead is one of the most crucial tasks in medico-legal practice. The experts always face problems in identifying whether skeletal remains are of human origin or not, as well as estimation of correct sex, age, stature etc. It is an exacting, painstaking and time-consuming process that requires considerable scientific knowledge and expertise. Stature of an individual is subject to psychological, environmental, genetic and nutritional factors. Sternum is an important bone in anthropological and forensic contexts. The sternum being safely placed in the chest has high degree of physical resistance and thus, is preserved as evidence in highly mutilated and decomposed cases. This study is an attempt to examine the average age of fusion of segments of mesosternum and to compare fusion of segments in both sexes. Present study was carried out in department of Forensic Medicine and Toxicology in collaboration with department of Radiology of S.P. Medical College, Bikaner. 100 persons of either gender, belonging to the age group (6-30 years) were selected for this study. There are considerable variations in ossification of bones in different regions of the same country. These characteristics are influenced by various factors like geographical location, climate, diet, heredity, socioeconomic status, habits, etc. especially in a multi ethnic country like India. Therefore, it is difficult to

follow a single standard data for determination of age for the entire country. Many workers around the world have done a lot of research on estimation of age based on the ossification of long bones. Age of an individual below 25 years can be opined to an age range of 2 years, though the findings get lesser as age progresses. For older individuals, however, age related findings on bones are fewer still. The use of the sternum for age estimation, however, is having greater promise as the changes encourages all ages. Regarding fusion between 3rd and 4th segment, maximum participants (84.00%) had a complete fusion followed by 11.00% partially fused and 5.00% non-fused. The earliest partial fusion was seen in the age of 6-9 years in both males and females. This partial fusion was absent after the age of 13-15 years in both male and female. 100% recently complete fusion was present in the females in the age of 19-21 years and 22-24 years in males. Findings of present study are in agreement with the findings of other Indian studies conducted by Tayal et al (2013)[5], Kaneriya D et al (2013)[6], Tailor et al (2013)[2], Manoharan et al (2016)[7] and Kumar et al (2019)[8] in different parts of the country. Although foreign studies have reported comparatively lower[9] and higher[10] earliest age of fusion of 3rd and 4th sternebrae. The segments of the mesosternum are known as sternebrae. Accessory ossification centers are frequently found in the manubrium and the mesosternum. Multiple ossification centers form as a result of endochondral ossification, especially in the cartilage segments of the mesosternum that are located on both sides of the mid-line. These points of ossification can be symmetrically positioned on both sides of the midline. Additionally, these points may be arranged in an irregular manner due to the asymmetry of the costal joints. Two or more ossification centers that develop in the cartilage structures merge over time in the craniocaudal direction as endochondral ossification continues. The fusion of the sternebrae occurs in the caudocranial direction. After fusion is complete, the sternebrae form in the body.[10]

This observation is in good agreement with the findings of Manoharan (2007, 2016)[7,10] who reported that almost all cases above 21 years of age showed fusion between all segments of the body of the sternum. This was in accordance with the fact that the fusion of the third and fourth sternebrae completes by the age of puberty.[5] Comparison of age of fusion of 2nd & 3rd sternebrae findings of present study are in general agreement with the findings of other Indian and foreign studies conducted by Tayal et al. (2013)[5], Kaneriya D et al (2013)[6], Tailor et al (2013) [(2)], Manoharan et al (2016)[7], Kumar et al (2019)[8], Baker et al. (2005)[9] and Bayarogullari et al (2014)[10]. Present study included several rare cases with incomplete fusion up to the age of 15; however, fusion of the ossification centers in our cases was largely consistent with the literature. Past studies have reported that fusion in the sternebrae occurred in the caudocranial direction, and fusion was complete before 25 years of age. In our cases, fusion of the third and fourth sternebrae and the second and third sternebrae was fully complete from 22-24 years of age.

Regarding fusion between 2nd and 3rd segment maximum participants (59.00%) had a complete fusion followed by 23.00% non-fused and 19.00% partially fused. Among the male earliest partial fusion was seen in the age of 10-12 years while in female, earliest fusion was seen in the age of 6-9 years. No partial fusion was present after the age 21 years in female and after 24 years in male. 95.65% male and 88.88% female had recently complete fusion in the age of 25-27 years. Comparison of age of fusion of 1st & 2nd sternebrae findings of present study are

in general agreement with the findings of other Indian and foreign studies conducted by Tayal et al (2013)[5], Kaneriya D et al (2013)[2], Tailor et al (2013) [(2)], Kumar et al (2019)[8], Baker et al (2005)[9] and Bayarogullari et al (2014)[10]. Fusion of the first and second sternebrae was complete from 25-27 years of age. Regarding fusion between 1st and 2nd segment maximum participants (43.00%) had a non-fusion between followed by 32.00% completely fused and 24.00% partially fused. Among the non-fused, these were 27 male and 16 female who were from 6-14 years age group. Among the males, the earliest partial fusion was seen in the 13-15 years age. With increasing age, the incidence of complete fusion steadily rises and reaches 94.86% at age 25-27 years. Among the females, fusion between 1st and 2nd segment commences in the 13-15 years age which was similar to the males. With increasing age, the incidence of complete fusion steadily rises and reaches 83.33%% at age 22-24 years. Thus, in the present study the fusion of the second and first sternebrae was in accord with the fact that the fusion of first and second sternebrae takes place at 25-27 years of age.[5]

Conclusion

From this study, it was concluded that the common age range for fusion of the sternebrae are as follows:

- 1st– 2nd= 25 – 27 years
- 2nd– 3rd= 22-24 years
- 3rd– 4th= 13-15 years

The present study has attempted to provide a reference for age determination from the fusion of sternebrae for a population of Bikaner. The fusion of sternebrae is independent of sex of individual.

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