International Journal of Basic and Applied Medical Sciences ISSN: 2277-2103 (Online)
An Online International Journal Available at http://www.cibtech.org/jms.htm
2013 Vol. 3 (2) May-August, pp.22-29/Kaneriya et al.
Research Article

AGE DETERMINATION FROM FUSION OF THE STERNAL ELEMENTS

***Kaneriya D.[1], Umarvanshi B. [1], Patil D.[3], Mehta C. [1], Chauhan K.[1] and Vora R.[2]**
[1]*Department of Anatomy, Government Medical College, Surat, India*
[2]*Government Medical College, Bhavnagar*
**Author for Correspondence*

ABSTRACT
Determination of age from human skeletal remains for forensic and medico-legal purpose is an integral part. In present study all existing parameters are used for determination of age by study of sternum and data based has been developed for sternums of known age. In which parameters like, a pattern of fusion is examined and recorded in relation to age. The material for the present study consists of 50. The elements of each sternum - manubrium, body and xiphoid process were examined for their fusion. The manubrio-sternal, sternebral segments and the xiphisternal articulations were carefully examined for degree of fusion: complete, partial, absent. The fusion of the third and fourth sternebrae is complete at puberty. The fusion of the first and second, and the second and third sternebrae occurs between puberty and 25 years of age. The fusion of the xiphoid process with the body of sternum began after thirty years. The fusion invariably presents upto the age of forty-five. In most of the cases the fusion is complete after the age of fifty.The fusion of the manubrium with the body of sternum begins after the age of forty. The fusion is invariably present in varying degree in cases above fifty five years. Complete fusion, when present, occurs after the age of fifty. All these will help in determination of age from bone.

Key Words: *Sternum, Sternebrae, Medicolegal, Manubrium, Xiphoid*

INTRODUCTION
Determination of age from human skeletal remains for forensic and medico-legal purpose is an integral part. Still perfect identification of age from human skeleton remains relatively a difficult task. The experts are always facing problem in estimation of correct age of the specimen available.About 90% accuracy can be achieved if the specimen includes skull or pelvis.But without it difficult to judge the age with accuracy. In present study all existing parameters are used for determination of age by study of sternum and data based has been developed for sternums of known age. In which parameters like a pattern of fusion is examined and recorded in relation to age. This data base of measurement and indices are statistically analyzed and conclusions are drawn.

MATERIALS AND METHODS
The material for the present study consists of 50 (27 Male, 23 Female) sterna, obtained from the cadavers brought for medico-legal postmortem examination at Dept. of Forensic Medicine, Govt. Medical College, Surat. The sterna were removed from the cadavers by sectioning the costal cartilages just besides the costochondral junction. The sterna thus collected were put in a water bath containing solution of sodium hypo-chloride for a week for maceration. Then they were-cleaned and examined intermittently.Cases belonging to age more than 15 years were only considered. Deformed, diseased and fractured sterna were not included in the study. The age of deceased was obtained from the nearest relatives and police, and was verified by necessary documents in some cases where required. The age of the deceased were rounded off to full years (6 months and above were considered 1 year). The elements of each sternum - manubrium, body and xiphoid process were examined for their fusion. The manubrio-sternal, sternebral segments and the xiphisternal articulations were carefully examined for degree of fusion: complete, partial, absent.

RESULTS AND DISCUSSION

Fusion of the sternal elements

Table 1: Relation between the fusion pattern of the Sternebrae and age

Age Group	No. of Cases	No. of cases showing fusion of vertebra								
		1st & 2nd sternebrae			2nd & 3rd sternebrae			3rd & 4th sternebrae		
		C (Complete)	P (Partial)	A (Absent)	C (Complete)	P (Partial)	A (Absent)	C (Complete)	P (Partial)	A (Absent)
15-20	8	3	2	3	5	2	1	8	0	0
21-25	12	10	2	0	12	0	0	12	0	0
26-30	5	5	0	0	5	0	0	5	0	0
	25	Total no. of cases								

Note: Above 25 Years of Age, All samples show complete fusion of Sternebrae.

(i) Fusion of the Third and Fourth Sternebrae

As seen above 8 cases of (15 – 20) year's age group reveal complete fusion in all 8 cases .In 12 cases of 21 - 25 years age group and 5 cases of 26 - 30 years age group the fusion of the third and fourth sternebrae was complete.

(ii) Fusion of the Second and Third Sternebrae

The fusion of second and third sternebrae takes place between puberty and 20 years of age. The fusion is complete at about twenty years of age. No case was found with partial or absent fusion after twenty years of age.

(iii) Fusion of the First and Second Sternebrae

The fusion of first and second sternebrae begins at puberty and is complete by the age of 25 years. The present study is in accord with the fact.

Figure 1: Partial fusion of the sternebrae

(iv) Fusion of the Xiphoid Process with the Body of Sternum

The following table shows the pattern of fusion of the xiphoid process with the body of sternum in relation to age.

Table 2: Relation between fusion of xiphoid & body of sternum & age

Age Group	No. of Cases	No. of Cases showing Fusion		
		Complete	Partial	Absent
31-35	5	0	3	2
36-40	3	0	1	2
41-45	4	2	0	2
46-50	5	4	1	0
51-55	3	2	1	0
56-60	3	3	0	0
61 & Above	2	2	0	0
	25	Total No. of Cases		

It was observed that the fusion between the fourth sternebrae and the xiphoid process is absent in all the cases upto thirty years of age and fusion of the xiphoid process with the body of sternum begins after the age of thirty years. The fusion almost invariably continues upto the age of 45 years, as no sterna was found with absent fusion after this age. The fusion is not complete in 1 case which was observed in the age group of 51-55. Othervise most of the cases after this age shows complete fusion.

Figure 2: Complete fusion of manubrium with body

(v) Fusion of the Manubrium with the body of the sternum

Table 3: Fusion of Manubrium with body of sternum

Age group	No. of Cases	Degree of Fusion & No. of Cases		
		Complete	Partial	Absent
41-45	4	0	1	3
46-50	5	0	3	2
51-55	3	1	1	1
56-60	3	1	2	0
61-65	1	1	0	0
66 & Above	1	1	0	0

Table 3 shows that, all the cases below the age of the 40 years did not show either complete or partial fusion of the manubrium and the body of the sternum. In cases above 40 years of age, pattern of fusion is tabulated as shown in table 3.No case has been recorded with complete fusion below 50 years of age. Above 55 years fusion is complete/partial in all.

Figure 3: Partial fusion of manubrium with the body

Ashley (Ashley 1951, 1953, 1956a, 1956b, 1956c) presented the treasure of work on sternum with his rigorous study. He studied the sterna for age determination with almost all the existing parameters. He correlated the study in both the races - Whites & Negros. All his work was based on the observations taken from numerous cases which made his work quite substantial and concluding.Ashley, after studying a number of human sterna, divided the sterna into 3 types according to the shapes of the mesosterna. The difference in shapes was attributed to the type of ossification centers and the shape of that mesosterna achieved after the fusion. His type - 1 sternum consisted of narrow mesosterna with parallel sides; Type - 2 sterna consisted of mesosterna narrow above and wide below Type - 3 consisted of wide mesosternum with parallel sides. Unlike Peterson's sternal types, the classification shown by Ashley was more correct. These types were accepted and this study gave a new dimension to the study of sternum as it demarcated clearly all the sterna into three types which they could be classified and studied in details. Sterna for the estimation of the time of fusion of the human mesosterna with the manubrium and the Xiphoid process in males and females (Inderjit 1986) . This study comprised of 980 sterna (772 males & 208 females) after which Inderjit observed that the fusion of manubrium and the body and xiphoid process with the body was of no significance as vast variation were found in the pattern of the fusions by him in the study. Same author had not studied about the fusion of sternebrae (Inderjit 1986). In present study it has been observed that in all cases above the thirty years of age the fusion of all the sternebrae were complete in both sexes. But who studied for the time of fusion of mesosternum with manubrium and xiphoid process in 524 male and 228 female sterna obtained from medico-legal autopsy subjects aged 5 to 85 years (Dalbir Singh, Inderjit, Sanjeev 1994). Commencement of fusion between manubrium and mesosternum was present in the age group of 10-14 years (40 %) in male and 15-17 years (16.66%) in female subjects. Commencement of fusion between mesosternum and xiphoid process started in the age group of 18-20 years (6.45% males & 2.22% females). Incidence of complete fusion increased with advancing age reaching a maximum of 60% in the age group more than 66 years in males and 26.08% in females in age group 41-45 years. Study of 109 female sterna between age group of 18-50 years (Sun *et al.*,1995). Six

morphological characteristics and their changing degree in the female sternum were observed and scored. The data were statistically processed by quantification theory I and stepwise regression analysis on a computer and the following regression equation for age estimation of the female sternum was calculated: y = 19.28 + 1.83x1 + 1.66x2 + 3.02x3 + 1.57x4 + 3.02x5 + 7.75x6 + 1.25x7 + 3.45x8 + 4.88x9 + 0.82x10 + 2.76x11 + 2.48x12 + 7.84x13 + 1.26x14 + 3.80x15 (the correlation coefficient R = 0.9774, the standard deviation S = 2.20, F > 0.01). For convenience, the changing degree of the morphological characters and the equation were also converted into two tables. This method of age estimation on the female sternum is simple and accurate and is of importance to forensic medicine and anthropology. The fusion of manubrium and xiphoid process with mesosternum in 118 sterna (67 males and 51 females) of known age (Chandrakant *et al.,* 2012). They concluded that none of the sterna aged below 30 years showed fusion of mesosterno-xiphisternal junction. Nonfusion of mesosterno-xiphisternal junction was reported till the age of 48 years in males and 46 years in females. Manubrio-mesosternal junction was observed to be very variable with regard to fusion status as the joint remained unfused even in the elderly ages. Based on the variability of the fusion of manubrio-mesosternal and mesosterno-xiphisternal junctions observed in the study, they concluded that the sternum alone is not reliable for estimation of age in South Indian population. 343 sternums collected from the autopsy cases at Govt. Medical College, Chandigarh (Singh *et al.,* 2013). They have found that more males, particularly older subjects, had a mesosternal foramen. The frequency of mesosternal foramen, arch-shaped prominence on the manubrium and radial strips on mesosternum significantly increased but that of lateral projection of manubrium decreased in the 30+ year age-group (older individuals). The different shapes of costal incisures, jugular notch and xiphoid process were found to have significant age differences. The number of cases with fused elements significantly increased with advancing age. The sternal elements fusion showed a variable pattern and hence was not found to be a reliable criterion. Chi-square analysis revealed significant differences between two age-groups of individual sex in the distribution of 3 of the 8 nonmetric traits. Significant age differences were noticed in the frequency of occurrence of mesosternal foramina between the younger and older age groups. The logistic regression analysis of the scores classified 70.0% sternums to their age-group. Though present findings may not be enough for absolute personal identification, these traits can still serve as important identification tools if antemortem radiographs/CT or MRI scans are available for comparisons, or help classify an unknown sternum to its age category based on the morphological features. In present study the fusion of third and fourth sternebrae were complete by the age of puberty. Fusion of second and third sternebrae takes place between the puberty and twenty-five years of age. The fusion was complete above twenty five years of the age. The fusion of first and second sternebrae takes place between the puberty and twenty-five years of age. The fusion was complete above twenty five years of the age.Total number of cases in Inderjitsingh males 632; females 162, present study males 25 and females 20. Inderjit had studied age groups of 18 years onwards whereas the present study was done for 15 upwards for comparison; cases between15 to 18 are not included in table 4.As below in complete fusion, Inderjit had found that cases were randomly scattered between the age group of 15 to 61 and above both in males and females. In present study between the age group of 15 to 40 years no case of complete fusion has been found both in male and female. In 41 to 61 and above years age group cases were randomly scattered both in males and females.In absent fusion (non - fusion), Inderjit had found more aggregation of the cases between the age group of 15 to 35 years both in males and females. In present study cases were randomly scattered up to the age group of 45 years both in males and females. Inderjit had studied age groups of 18 years onwards whereas present study was done for 15 upwards.

In complete fusion Inderjit had found that cases were randomly scattered in the age group of 21 to 61 and above years in males. In females cases were randomly scattered between the age group of 21 to 41 and above years. In present study no case has been noted up to the age group of 50 years in males and 60 years in females.In partial fusion, Inderjit had noted that cases were more aggregated between the age

Table 4: Relation between fusions of Xiphoid Process with the Body of Sternum & Age

Age Group	Complete (Number/Percentage)				Partial (Number/Percentage)				Absent (Number/Percentage)			
	Inderjit		Present		Inderjit		Present		Inderjit		Present	
	M	F	M	F	M	F	M	F	M	F	M	F
18-20	3/5.9	0	0	0	6/11.8	4/13.3	0	0	42/82.3	26/86.7	2/66.6	1/33.3
21-25	18/16.6	6/11.7	0	0	10/9.2	2/3.9	0	0	80/74	43/84.3	5/41.6	7/58.3
26-30	7/7.6	7/28	0	0	26/28.2	0	0	0	59/64.1	18/72	3/60	2/40
31-35	20/23.5	6/28.5	0	0	17/20	2/9.5	2/66.6	1/50	48/56.4	13/61.9	1/33.3	1/50
36-40	21/32.8	3/33.3	0	0	27/42.1	1/11.1	1/50	0	16/25	5/55.5	1/50	1/100
41-45	22/39.2		1/50	1/50	15/26.7		0	0	19/33.9		1/50	1/50
46-50	34/61.8		2/66.6	2/100	6/10.9		1/33.3	0	15/27.2		0	0
51-55	30/78.9	11/42.3	1/50	1/100	1/2.6	3/11.5	1/50	0	7/18.4	12/46.1	0	0
56-60	23/76.7		2/100	1/100	2/6.6		0	0	5/16.6		0	0
61 & Above	34/64.15		1/100	1/100	10/18.8		0	0	9/16.9		0	0

Table 5: Relation between fusions of Manubrium with the Body of Sternum & Age

Age Group	Complete(Number/Percentage)				Partial(Number/Percentage)				Absent (Number/Percentage)			
	Inderjit		Present		Inderjit		Present		Inderjit		Present	
	M	F	M	F	M	F	M	F	M	F	M	F
18-20	0	0	0	0	14/37.8	7/46.6	0	0	23/62.1	8/53.3	2/66.6	1/33.3
21-25	9/9.5	2/6	0	0	34/36.1	18/54.5	0	0	51/54.2	13/39.3	5/41.6	7/58.3
26-30	7/10.6	1/5.2	0	0	24/36.3	8/42.1	0	0	35/53	10/52.6	3/60	2/40
31-35	4/6.4	2/11.1	0	0	13/20.9	10/55.5	0	0	45/72.5	6/33.3	3/60	2/40
36-40	5/10.2	1/8.3	0	0	19/38.7	7/58.3	0	0	25/51	4/33.3	2/66.6	1/33.3
41-45	6/12.2		0	0	16/32.6		0	1/50	27/55.1		2/100	1/50
46-50	8/22.2		0	0	11/30.5		2/33.3	1/50	17/47.2		1/33.3	1/50
51-55	4/17.3	7/30.4	1/50	0	6/26	12/52.1	1/50	0	13/56.5	4/12.5	1/50	0
56-60	5/27.7		1/50	0	6/33.3		0	0	7/38.8		0	0
61 & Above	4/13.7		1/100	1/100	12/41.3		0	0	13/44.8		0	0

group of 15 to 45 years and then randomly scattered between the age group of 46 to 61 and above years in males. In females cases were randomly scattered in all age group. In present study no case of partial fusion has been found between the age group of 15 to 45 years in males and 15 to 40 years in females.
In absent fusion Inderjit had noted that more cases were aggregated between the age group of 15 to 45 years in males. In females cases were randomly scattered.
In present study cases were randomly scattered up to the age of 55 years in males and up to 50 years in females.

REFERENCES

Ashley G T (1951). The Observations on the Human Sternum. *Anatomical Society of Great Britain & Ireland; Journal of Anatomy* **85(**4) 412.
Ashley G T (1953). Typing of the Human Sternum - An analysis of the ossification in 520 sterna in the developmental stages. *Anatomical Society of Great Britain & Ireland; Journal of Anatomy* **87(**4) 439.
Ashley G T (1956a). The Human Sternum-The influence of sex & age on its measurements; *Journal of Forensic Medicine* **3**27 – 43.
Ashley G T (1956b). The relationship between the pattern of ossification and the definitive shape of the mesosternum in man. *Journal of Anatomy* **90** 80- 105
Ashley G T (1956c). A comparison of human and anthropoid mesosterna.*American Journal of Physical Anthropology* **3** 449 – 461
Chandrakant HV, Kanchan T, Krishan K, Arun M and Pramod Kumar GN (2012).Estimation of age from human sternum: an autopsy study on a sample from South India. *International Journal of Legal Medicine* **126**(6) 863-868.
Dalbir Singh, Inderjit and Sanjeev (1994). Time of fusion of mesosternum with manubrium and xiphoid process. *Journal of the Anatomical Society of India* **43**(2)125-135
Jit I and Bakshi (March 1986). Time of fusion of the human mesosternum with manubrium and xiphoid process. *Indian Journal of Medical Reserch* **83** 322-331.
Singh J and Pathak RK (**2013).** Sex and age related non-metric variation of the human sternum in a Northwest Indian postmortem sample: A pilot study.*Forensic Science International* **10** 228(1-3)181.
Sun YX, Zhao GC and Yan W (1995). Age estimation on the female sternum by quantification theory I and stepwise regression analysis. *Forensic Science International Journal* **30** 74(1-2)57-62.