Radiological Age Estimation From Sternum

*** Silajiya D.A.,**Khubchandani H.T.*** Soni S.N.,**** Vora D.H.,*****Patel D.S.,******Shah K.A.**

*Prof & Head, Forensic Medicine Dept.,GMERS Medical College, Gandhinagar,

** Asst.Prof., ***Resident Doctor, ****Tutor, ****** Prof., Forensic Medicine Dept., B.J.Medical College, Ahmedabad.

***** Prof & Head, Forensic Medicine Dept.,GMERS Medical College, Sola, Ahmedabad.

Abstract : Introduction: Verification or determination of the age is prerequisite for personal identification in living as well as dead and age estimation is one of the important tasks for a medico-legal practice. Skeletal examination is important for identification of an individual either living or dead especially for the estimation of age. Material and Method: In the present study, authors have tried to work out the criteria for determination of age of the deceased with the help of sternum. Authors have studied 109 sterna procured from the cadavers with known age brought for post-mortem examination at the civil hospital, ahmedabad. Fusion of manubrium and xiphoid process with the body of sternum was studied radiologically. The data thus collected, were analysed statistically and conclusion was drawn. Result: According to the present study, for males, the age of fusion between xiphisterum and body of the sternum is at 42 years, for females, the age of fusion between xiphisterum and body of the sternum is at 44 years. In males, the fusion at manubrio-sternal starts at the age of 50 years and it completes after the age of 59 years but the exact age for complete fusion at manubrio-sternal joint could not be defined. Amongst females, the cases showing first degree fusion are seen increasing from the age of 54 years and complete fusion after the age of 64 years. But here also the exact pattern could not be defined. Conclusion: Estimation of age by radiology will be of very much helpful to the medicolegal experts in determining the age of unknown deceased as well as skeletonised remains. [Silajiya D.A et al NJIRM 2013; 4(4) : 108-114]

Key Words: Sternum, Age estimation, Manubrium, Xiphisternum, X-Ray,fusion.

Author for correspondence: Dr.D.H.Vora, Tutor, Forensic Medicine Dept., B.J.Medical College, Ahmedabad.
E mail: mahavirreturns@gmail.com

Introduction: Verification or determination of the age is prerequisite for personal identification in living as well as dead and age estimation is one of the important tasks for a medico-legal practice. In general, the method for age estimation is same whether the person is living or dead. It is carried out under 3 heads namely physical, dental and radiological examination. The major limitation is that the physical examination usually gives only a glimpse an empirical probability on the chronological age of the individual and best useful in before 14 years of age. The eruption of 28 permanent teeth is complete by the age of 16 years[1] The third molars erupt at around the age of 17-25 years. The growth of the human skeleton is of major importance and can be assessed radio logically to evaluate the aging process. The stoppage of growth process is indicative on x-ray examination as epiphyseal fusion in different long bones which is complete by the age of about 22 years.

So, we need some other strong criteria to accurately determine the age in middle and old age groups. Due to extreme variability in time period of closure of the sutures of cranial vault and lipping of lumbar vertebra, they cannot be considered dependable for precise age estimation. In comparison radiological examination of sternum is easy and applicable to both dead as well as living. So, fusion of xiphisternum with body of sternum and fusion of manubrium with the body of sternum can serve as an important tool for age estimation in middle aged and old aged persons.

Plenty of literature is available on radiological age estimation from epiphyseal fusion but majority are on younger subjects of less than 25 years age. Most of the studies on sternum are gross studies and did not include radiological assessment. The present prospective study of radiological age estimation from sternum in deceased of age group 35-65 years is carried out at the mortuary of Forensic Medicine Department, B. J. Medical College associated with Civil Hospital Ahmedabad during the two year period from November 2009 to October 2011.

The findings are compared with the similar studies by different authors at other geographic regions. Findings will be helpful to include sternal age

estimation as reliable indicator even in living subjects of middle and old age groups.

Jit and Bakshi[1] Studied about time of fusion of the human mesosternum with manubrium & xiphoid process in sterna obtained from 772 male and 208 female subjects from Punjab, Haryana and Chandigarh (India) varying in age from 5 to 85 years. This study is conducted in Nehru Hospital by Department of Anatomy at PGIMER, Chandigarh during their engagement in conducting post mortems in medico legal cases.Complete fusion of manubrium with the mesosternum was seen at 21 years or above in both sexes; though non-fusion could be seen even in a person above 60 years of the age. The xiphoid process did not fuse with the body of the sternum in males below 18 years and female below 21 years. Non-fusion of the xiphoid process was seen in 11.4 % of males above 66 years and 37.5 % female above 40 years. After the age of 18 – 20 years, the ossification of the sternum did not help in establishing the age of an individual. These observations were confirmed in an additional sample of 127 male and 38 female sterna.

Vasaiya K K[2] Studied on human sternum as an index of age and sex. Authors have studied 112 sterna procured from the cadavers brought for post mortem examination at Ahmedabad. Only those cases with age more than 15 years were considered. They concluded that the fusion of xiphoid process with body of sternum starts after 30 years and in most of the cases the fusion is completed after 50 years. The fusion of Manubrium with the body of sternum begins after the age of 40 and completed after the age 55 years.

William et al in Gray's Anatomy [3] Mentioned that the Manubrio-sternal joint is usually symphysis, which ossify in old aged. In 10% of all over 30 years, the manubrium is joined to the sternal body by bone, but the intervening cartilage may be only superficially ossified; it is in the aged that this is complete. The Xiphi sternal joint is also a symphysis. This joint usually transformed to a synostosis by the fortieth year, it sometime remain unchanged even in old age.

Gautam et al [4] Studied on human sternum as an index of age and sex. Authors have studied 100 sterna procured from the cadavers brought for post mortem examination at Ahmedabad. Only those cases with age more than 15 years were considered. They concluded that the fusion of xiphoid process with body of sternum starts after 30 years and in most of the cases the fusion is completed after 50 years. The fusion of Manubrium with the body of sternum begins after the age of 40 and completed after the age 55 years.

Parikh[5] Mentioned that the xiphoid unites with the body of the Sternum at about 40 years and the manubrium unites with body at about 60 years. Subrahmanyam[6] Mentioned that the xiphoid unites with the body around 40 years, while the manubrium unites with the body around 60 years. The main objective of this study is to determine the earliest and latest ages of fusion of manubrio-sternal and Xiphi-sternal joints.

Material & Methods: The material for the present prospective study consists of randomly selected subjects as the study group from 6500 cadavers brought for post-mortem examination at mortuary of Forensic Medicine Department, B. J. Medical College associated with Civil Hospital, Ahmedabad during the period from November 2009 to October 2011.

After excluding subjects with criteria affecting the growth of bones and epiphyseal fusion like congenital deformities, fracture cases, chronic illness, on steroid therapy etc. total 109 subjects, 63 males and 46 females, native of Ahmedabad region, irrespective of their caste and religion with known birth date were selected. Out of them 105 subjects, 61 males and 44 females from the age group of 35-65 years were study samples whereas one male and one female of age 34 years and 66 years were control samples.

Informed written consent was taken from near relative of deceased to include the deceased as

subject for the study and also for the X-ray of the sternum bone.
Only those deceased with known age were considered for the study. Copy of ration card, S.S.C. certificate, birth certificate, identity card, driving license, voter's card, service record or pan card were considered as proof of age.

If the near relatives were not having any proof of birth at the time of post-mortem; they were given an envelope addressed to our department and pre-affixed postal stamp. Relatives were advised to send the copy of age proof by post. The age of the deceased was rounded off to full figures. To round off, up to 6 months were counted as previous year and 6 months and above were counted as next year e.g. 45 years 7 months age was rounded off to 46 years.

Preliminaries regarding all 109 subjects were recorded on specially designed proforma. The sterna were removed from the cadavers by sectioning the costal cartilages just medial to the costo-chondral junction. The x-rays in antero-posterior and lateral views were taken for each sternum in the Department of Radio-diagnosis, civil hospital, Ahmedabad.

On x-ray examination, the status of fusion at manubrio-sternal joint and xiphi-sternal joint were studied. Out of 4 control subjects, those below 35 years of age (one male and one female) were not showing even starting up of process of epiphyseal fusion at manubrio-sternal well as xiphi-sternal joints. Whereas, one male and one female of more than 65 years of age, were showing complete fusion at all the joints.

At manubrio-sternal joint the degree of fusion were graded according to the following scale which is more reliable and minimise inter observer error.
1. 0 degree: A dark black radiolucent line seen in the joint, complete separation of bony pieces, absent fusion.
2. I degree: Gap between join begins to decrease, fusion present less or more than half of joining surface, white dense line visible, partial fusion.
3. II degree: No gap between bony pieces, no white dense line visible, homogenous radio opacity seen, complete fusion.

The xiphoid process varies much in form; it may be broad and thin, pointed, bifid, perforated, curved, or deflected considerably to one or other side, so above grading is not suitable for xiphisternal joint.[5,9]

It is graded, using a binomial scale of presence or absence of fusion that should minimise inter observer error and increase replicability.[3]
1 degree: A dark black radiolucent line seen in the joint, complete separation of bony pieces, absent fusion.
2 degree: No gap between bony pieces, homogenous radio opacity seen, fusion present.
Findings of x-ray were also recorded on the proforma, tabulated, analysed and compared with similar studies by different authors.

Result: Observations of the present study are depicted in the table no. 1 and 2.

Discussion: It can be seen from table 1 that amongst male subjects, except an isolated case at the age of 36 years, there was no fusion (described as 1 degree fusion for the present study) between xiphisternum and body of the sternum up to 42 years. After 42 years of age, majority of x-rays were showing fusion (described as 2 degree fusion for the present study) at xiphisternal joint. Thus, according to present study, for males, the age of fusion between xiphisterum and body of the sternum is at 42 years.

While looking towards females, majority of the subjects after 44 years of age shows fusion (2 degree fusion) at xiphi-sternal joint. Thus, according to present study, for females, the age of fusion between xiphisterum and body of the sternum is at 44 years.

Here, in 5 males and 3 females, xiphisternum had failed to appear as an anatomical variation. These subjects are marked with * in table 4 and the

status of fusion is considered as 1 degree for the present study.

Table 1 : Age And Sex Wise Distribution Of Cases And Status Of Fusion Between Xiphisternum And Body Of The Sternum

Age in years	Male			Female			Total
	No. Of Cases	Degree of fusion		No. Of Cases	Degree of fusion		
		Present (2)	Absent (1)		Present (2)	Absent (1)	
35	4	0	3 + 1*	3	0	3	7
36	2	1	1	2	0	1 + 1*	4
37	2	0	1 + 1*	2	0	2	4
38	1	0	1	2	0	2	3
39	1	0	1	2	0	2	3
40	2	0	2	1	0	1	3
41	1	0	1	2	2	0	3
42	3	3	0	1	0	1	4
43	2	2	0	1	0	1*	3
44	1	1	0	1	1	0	2
45	3	2	1	2	1	1	5
46	1	0	1*	1	0	1*	2
47	2	2	0	1	1	0	3
48	4	4	0	2	2	0	6
49	2	2	0	1	1	0	3
50	2	1	1*	1	1	0	3
51	2	2	0	2	2	0	4
52	1	1	0	1	1	0	2
53	2	1	1	1	1	0	3
54	1	1	0	2	2	0	3
55	2	2	0	1	1	0	3
56	2	1	1*	1	1	0	3
57	1	1	0	2	2	0	3
58	1	1	0	2	2	0	3
59	1	1	O	1	1	0	2
60	1	1	O	1	1	0	2
61	2	2	0	1	1	0	3
62	2	1	1	0	0	0	2
63	2	2	0	0	0	0	2
64	3	3	0	1	1	0	4
65	5	5	0	3	3	0	8
Total	61	43	13 + 5*	44	28	13 + 3*	105

*Xiphisternum not appeared.

Table 2 : Age And Sex Wise Distribution Of Cases And Status Of Fusion Between Manubrium And Body Of The Sternum

Age in years	Male				Female				Total
	No. of cases	Degree of fusion			No. of cases	Degree of fusion			
		II	I	0		II	I	0	

35	4	0	0	4	3	0	0	3	7
36	2	0	0	2	2	0	0	2	4
37	2	0	0	2	2	0	0	2	4
38	1	0	0	1	2	0	0	2	3
39	1	0	0	1	2	0	0	2	3
40	2	0	1	1	1	0	0	1	3
41	1	0	0	1	2	0	0	2	3
42	3	0	0	3	1	0	0	1	4
43	2	0	1	1	1	0	0	1	3
44	1	0	0	1	1	0	0	1	2
45	3	0	1	2	2	0	1	1	5
46	1	0	0	1	1	0	1	0	2
47	2	0	0	2	1	0	0	1	3
48	4	0	1	3	2	0	0	2	6
49	2	0	0	2	1	0	0	1	3
50	2	0	1	1	1	0	1	0	3
51	2	0	1	1	2	0	0	2	4
52	1	0	1	0	1	0	0	1	2
53	2	0	1	1	1	0	0	1	3
54	1	0	1	0	2	0	2	0	3
55	2	0	2	0	1	0	1	0	3
56	2	0	2	0	1	0	1	0	3
57	1	0	1	0	2	1	1	0	3
58	1	0	1	0	2	0	2	0	3
59	1	1	0	0	1	1	0	0	2
60	1	1	0	0	1	0	1	0	2
61	2	0	1	1	1	0	1	0	3
62	2	1	1	0	0	0	0	0	2
63	2	1	1	0	0	0	0	0	2
64	3	2	1	0	1	1	0	0	4
65	5	3	2	0	3	3	0	0	8
Total	61	9	21	31	44	6	12	26	105

Table 3 : Comparision Study On Age Of Fusion Between Manubrium And Body Of The Sternum.

Author	Year	Location	Age of Onset (years)	Age (years) of Completed	Mean age (years)
Jit et al[1]	1986	Punjab	Male 21, Female 21	-	-
Vasaiya K K[2]	1992	Ahmedabad	Male 43, Female 45	Male 55 Female 55	-
Gautam et al[4]	2003	Ahmedabad	40	55	-
Das S K[7]	2005	Kolkata	28	-	-
Tailor et al[8]	2008	Surat	46	60	-
Wadhawan et al[9]	2010	New Delhi	Male 46-50, Female 51	-	Partial 42.30 Complete 62.77
Gaur et al[10]	2010	Pune	31-35	>41	-
Vora D H[11]	2010	Rajkot	Male 43, Female 40	M:60, F: 55	-

Garg et al[12]	2011	Punjab	Male 37, Female 35	-	M:54.37, F:57.00
Present study	2011	Ahmedabad	Male 50 Female 54	M:59 F:64	-

Table 4 : Comparision Study On Age Of Fusion Between Xiphisternum And Body Of The Sternum.

Author	Year	Location	Age of onset (years)	Age of Completed(years)	Mean age (years)
Jit et al [1]	1986	Punjab	Male 18, Female 21	-	-
Vasaiya K K [2]	1992	Ahmedabad	Male 32, Female 33	Male 50, Female 50	-
Gautam et al [4]	2003	Ahmedabad	31-35	Male 50, Female 50	-
Das S K [7]	2005	Kolkata	32	-	-
Tailor et al [8]	2008	Surat	-	More than 40 for both sexes	-
Wadhawan et al [9]	2010	New Delhi	Male & Female 31-35	-	Partial 35.42 Complete 55.95
Gaur et al [10]	2010	Pune	31-35	>41	-
Vora D H [11]	2010	Rajkot	Male 34, Female 35	Male 45, Female 44	-
Garg et al [12]	2011	Punjab	Male 36, Female 35	-	Male 50.04 Female 46.42
Present study	2011	Ahmedabad	-	Male 42, Female 44	-

As per the study of Vora D.H. [11] in male the age of fusion of xiphoid with the body of sternum is 34 to 45 years while in females this age is 35 to 44 years. As per the study of Vasaiya K. Xiphoid fuses with the mesosternum in males and females at the age of 32 to 50 years and 33 to 50 years respectively. So findings of the present study is similar to the findings of other Indian studies.

It can be seen from table 2 that amongst males, up to 49 years of age, majority did not show even starting up of process of fusion (described as 0 degree fusion for the present study) between manubrium and body of the sternum. Between the age of 50 to 58 years, a high number of subjects were showing that the gap between joint begins to decrease, white dense line visible indicating partial fusion (described as I degree fusion for the present study). At the ages of 59 and above plenty of cases (9 cases) are showing complete fusion at manubrio-sternal joint (described as II degree fusion for the present study), but the cases showing I degree fusion (6 cases) are also remarkable. This suggest that for the present study group, the fusion at manubrio-sternal starts at the age of 50 years and it completes after the age or 59 years but the exact age for complete fusion at manubrio-sternal joint could not be defined.

Amongst females, the cases showing I degree fusion are seen increasing from the age of 54 years and complete fusion after the age of 64 years. But here also the exact pattern could not be defined.

As per the study of Vora D.H. age of fusion of manubrium with the body of sternum in males and females is 43 to 60 years and 40 to55 years respectively. According to Vasaiya K.K. this age is 43 to 55 years and 45 to 55 years in males and females respectively.

Conclusion: From the present study, it was concluded that: On an average, in males the fusion at xiphi-sternal joint completes at around the age of 42 years. On an average, in females the fusion at xiphi-sternal joint and completes at around the age of 44 years. On an average, in males, the fusion at manubrio-sternal joint begins at around the age of 50 years and completes at around the age of 59 years. On an average, in females, the fusion at manubrio-sternal joint begins at around the age of 54 years and completes at the age of 64 years and above. It is noted that xiphi-sternum had failed to appear in 8 out of 105 subjects (7.61 %) under present study. In included 5 males (8.2 % of males under study) and 3 females (6.82 % of

females under study). So, the question of fusion at xiphi-sternal joint does not arise in these cases.

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