Age Determination from Sternal ends of the Ribs- an Autopsy Study

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Abstract
A random study of 500 cases for age determination from sternal ends of the ribs was carried out in the Department of Forensic Medicine and Toxicology, Govt. Medical College, Amritsar with joint supervision of Department of Anatomy. The aim of the study was to determine the age after death with minimal error. Currently there are different parameters available to determine the age of a person like study of teeth, ossification of bones and other ancillary data, but the accurate reliability of these measures is only limited to a particular age group i.e. 25± 5 years. For the age beyond this, many workers in different parts of the world have done their studies to accurately determine the age of a person from the skeleton. Study by Iscan et al (1984) has emphasized fair amount of accurate assessment of age from the sternal end of the ribs. The present study was a similar attempt to analyze the reliability and accuracy of Iscan et al’s (1984) work in this part of the world.

Key Words: Identity, Age, Ribs, Pit.

Introduction:
Identity means the determination of the individuality or recognition of a person of dead body. The identification of a dead body is required in cases of sudden and unexpected deaths in unclaimed bodies, fires, explosions, railways or aircraft accidents, mutilated or decomposed bodies; often need great medicolegal acumen. In Corpus Delecti, doctors have to establish two facts: Identity as well as Cause of death. Identity of a person is done by using various parameters in which Age is also one of the most important parameter [1]. Methods to estimate age at death are important for the study of skeletal remains, whether the context is biarchaeological, paleontological or forensic in nature [2].

To establish identity Department of Forensic Medicine and Toxicology, Govt. Medical College, Amritsar used the sternal end of 4th rib of both sides to assess the age of the victim. In this regard, sternal end of rib was chosen because it has been established to be a perfect bone to show the advancement of age. Also, it appeared to fit Howell’s criterion of showing advancements of age rather than the effects of “function and stress” [3].

Material and Methods:
The study was based on a collection of ribs of both sexes from 500 postmortem cases brought to the Mortuary complex of Govt. Medical College, Amritsar. Detailed data regarding age, sex and race were derived from birth record, relatives and police papers. The sternal extremity of 4th rib of both sides was chosen because it fairly represents true rib and can be easily extracted during a postmortem examination. The samples consisted of individuals above 17 years of age, as morphological metamorphosis at the sternal end of the rib is not observed until this age[4]. Each rib was examined in reference to feature like pit depth (component I), pit shape (component II) and rim and wall configurations (component III). Pit depth is one of the most obvious age related changes observed in sternal end of the rib. The maximum depth of this pit was measured with a depth caliper calibrated to 0.1 mm by keeping the caliper perpendicular to base of the pit. Component II deals with changes in the shape of the pit. Initially the pit showed only a slight, amorphous indentation; with in about one year from its first appearance, it developed into a V shaped structure. Over the next few years, the base of V widened to become U-shaped. As age increased the walls of the pit grew thinner forming a progressively wider U. Component III analyzes changes in the configuration of the rim and walls of the pit. The rim started as a smooth, regular border.
around the pit that rapidly assumed a scalloped but still fairly regular shape. Eventually, with advancing age the rim and walls became increasingly irregular, thin and sharp [5, 6]

The different data noted were recorded in the Performa framed for the purpose. Following the individuals analysis of each component they were summed to obtain a total score per rib. From the total score, mean bone age was calculated as per Iscan’s method. To test the significance of mean bone age as a factor in explaining and forecasting the observed age of a subject the simple regression analysis technique had been used.

**Observations:**
The present study was conducted on 500 dead bodies but the dissected out rib for the study purpose was obtained in good shape only in 395 cases. In rest of the cases, the end of the ribs were broken/distorted due to injuries/fractures. The study was conducted on the basis of method used by Iscan et al [6,7] In the current study, the known age of the corpses was recorded to compare with estimated age/test age.

Out of the total 395 cases, in 309 cases the known age (Actual age) of the deceased was available as per Performa from police papers/birth record/relatives and in 86 cases, no record related to the actual age was furnished by the police or was available from any other source, as the identity of these corpses was not known at the time of autopsy to the investigating officer. Distribution of cases with known/unknown age is shown in Table I.

Known age wise distribution of 309 cases is shown in Table II. Maximum cases were reported in the age group 21-30 years (112) and minimum were reported in the age group of >60 years (14). Sexwise distribution of 309 cases is shown in Table III. Out of 309 cases, 244 cases were males and 65 cases were females. Area wise distribution of 309 cases is shown in Table IV. 143 cases belonged to urban area and 166 cases belonged to rural area. All 309 cases were studied and scoring was done. Mean bone age was calculated from these scores as per Iscan’s method. To test, the significance of mean bone age as a factor in explaining and presenting the known/actual age of the subjects varied in the 3 age groups.

These groups were made to make sure that whether the mean bone age and the known/actual age of the subjects varied in the 3 age groups.

Groupwise values of mean actual age (Ȳ), calculated, calculated mean bone age (X̅), Standard deviation (±S.D) and 95% Confidence interval of 309 cases was calculated as shown in Table V.

**Results & Discussion:**
In the present study, no significant changes were observed in the metamorphic developments at the sternal end of the 4th rib of the two sides as concluded by Yoder et al (2001)[8] as well. In the present study, statistical analysis showed (as shown in Table V) that in the first age group (17-30 years) for right sided 4th rib, the estimated regression line of known/actual age (Y) on the calculated mean bone age (X) was computed to be Y=7.92+0.646 X with the standard error of regression coefficient 0.0031. This gave highly significant value of t=208.38. Moreover coefficient of determination r²=49%, indicated that 49%, indicated that 49% of known/actual age is explained by the single factor of mean bone age which was again found to be highly significant (computed t of r²=11.62). In the same age group for the left sided 4th rib, the estimated regression line of known/actual age (Y) on the calculated mean bone age (X) was computed to be Y=6.76±0.692 X with the standard error of regression coefficient 0.0031. This gave highly significant value of t=223.22. Moreover coefficient of determination r²=52% indicated that 52% of known/actual age is explained by the single factor of mean bone age which was again found to be highly significant (computed t of r²=12.21).

In the age group of 31-44 years for right sided 4th rib, the estimated regression line of known/actual age (Y) on the calculated mean bone age (X) was computed to be Y=28.48±0.204 X with the standard error of regression coefficient 0.0020. This gave highly significant value of t=69.58. Moreover coefficient of determination r²=21% indicated that 21% of known/actual age is explained by the single factor of mean bone age which was again found to be highly significant (computed t or r²=4.54). In the same group, for the left sided 4th rib, the estimated regression line of known/actual age (Y) on the calculated mean bone age (X) was computed to be Y=29.9±0.167 X with the standard error of regression coefficient 0.0024. This gave highly significant value of t=69.58. Moreover, coefficient of determination r²=23% indicated that 23% of known/actual age is explained by the single factor of
mean bone age which was again found to be highly significant (computed t of $r^2=4.82$).

In the age group of 45 years and above for the right sided 4th rib, the estimated regression line of known/actual age ($Y$) on the calculated mean bone age ($X$) was computed to be $Y=0.543\pm1.085\times X$ with the standard error of regression coefficient 0.0221. This gave highly significant value of $t=49.09$. Moreover coefficient of determination $r^2=36\%$ indicated that 36% of known/actual age explained by the single factor of mean bone age which was again found to be highly significant (computed t of $r^2=7.29$). In the same age group for the left sided 4th rib, the estimated regression line of known/actual age ($Y$) on the calculated mean bone age ($X$) was computed to be $Y=-9.27+1.29\times X$ with the standard error of regression coefficient 0.027. This gave highly significant value of $t=47.77$. Moreover, coefficient of determination $r^2=40\%$ indicated that 40% of known/actual age was explained by the single factor of mean bone age which was again found to be highly significant (computed t of $r^2=7.87$).

Results of the present study showed that the age of a subject can be estimated from metamorphic changes in the costochondral junction of 4th ribs of both sided in all the age groups, as the t-values computed in all the cases were found to be highly significant (i.e. $t>3$).

Iscan et al (1984-85)[6,7] concluded that age at death can be estimated from a rib within about 2 years in 2nd decade to about 7 years in the 5th and 6th decades of life and Singh et al (1999)[9] revealed that age can be estimated from sternal end of 4th rib with an accuracy ranging between ±2 years upto 3rd decade and about ±8 years in the older age which is quite invariance with our study. However, from the present study, we could analyze that in the age group of 17-30 years, calculated standard deviation for the right 4th ribs came out to be 4.00 and for left 4th rib was 3.98 with 95% confidence interval of 17.49-33.17 and 17.50-33.14 respectively which is quite accurate. But, in the second age group, the reliability falls as the calculated standard deviation of this group for right sided 4th rib was 7.89 and for left sided 4th rib were 7.70 with 95% confidence interval of 24.45-55.38 and 25.23-55.43 respectively. In the third age group (45 years and above), the standard deviation again came out to be more reliable i.e. 4.72 for the right sided 4th rib and 4.12 for the left sided 4th rib with 95% confidence interval of 38.95-57.45 and 40.07-56.22 respectively.

Conclusions:

Even if the study gave us rough estimation of age by using the method of Iscan et al, on sternal end of ribs, but the multifactorial parametric approach to assess the age will be far more better than a single parameter i.e. assessment of age from sternal end of the 4th rib.

### Table I

<table>
<thead>
<tr>
<th>Known/Unknown age</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>With known age</td>
<td>309</td>
<td>78.22</td>
</tr>
<tr>
<td>Without known age</td>
<td>86</td>
<td>21.78</td>
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<tr>
<td>Total</td>
<td>395</td>
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### Table II

<table>
<thead>
<tr>
<th>Age group (in years)</th>
<th>Number</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>17-20</td>
<td>27</td>
<td>8.73</td>
</tr>
<tr>
<td>21-30</td>
<td>112</td>
<td>36.24</td>
</tr>
<tr>
<td>31-40</td>
<td>69</td>
<td>22.33</td>
</tr>
<tr>
<td>41-50</td>
<td>64</td>
<td>20.71</td>
</tr>
<tr>
<td>51-60</td>
<td>23</td>
<td>7.44</td>
</tr>
<tr>
<td>&gt;60</td>
<td>14</td>
<td>4.53</td>
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<tr>
<td>Total</td>
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<td>100.00</td>
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</table>

### Table III

<table>
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<th>Sex</th>
<th>Number</th>
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<tbody>
<tr>
<td>Male</td>
<td>244</td>
<td>78.96</td>
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<tr>
<td>Female</td>
<td>65</td>
<td>21.04</td>
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<tr>
<td>Total</td>
<td>309</td>
<td>100.00</td>
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Table IV

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean actual age (Y)</th>
<th>Calculated mean bone age (X)</th>
<th>S.D.</th>
<th>95% confidence interval</th>
</tr>
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<tbody>
<tr>
<td>For Right Side Ribs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st Group (17-30 Years)</td>
<td>24.29</td>
<td>25.33</td>
<td>4.00</td>
<td>17.49-33.17</td>
</tr>
<tr>
<td>2nd Group (31-44 Years)</td>
<td>36.64</td>
<td>39.92</td>
<td>7.89</td>
<td>24.45-55.38</td>
</tr>
<tr>
<td>3rd Group (45 Years And Above)</td>
<td>52.84</td>
<td>48.20</td>
<td>4.72</td>
<td>38.95-57.45</td>
</tr>
</tbody>
</table>

| For Left Side Ribs |                     |                              |      |                         |
| 1st Group (17-30 Years) | 24.29               | 25.32                        | 3.99 | 17.50-33.14             |
| 2nd Group (31-44 Years) | 36.64               | 40.33                        | 7.70 | 25.23-55.43             |
| 3rd Group (45 Years And Above) | 52.84               | 48.15                        | 4.12 | 40.07-56.22             |

Table V

<table>
<thead>
<tr>
<th>Area</th>
<th>Number</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Urban</td>
<td>143</td>
<td>46.28</td>
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<tr>
<td>Rural</td>
<td>166</td>
<td>53.72</td>
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<tr>
<td>Total</td>
<td>309</td>
<td>100.0</td>
</tr>
</tbody>
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References