

Determination of Sex From the Human Adult Sternum: An Autopsy Based Study

Manjunatha K¹, Viswanathan K G², Chandan V³, Narasimhamurthy⁴

¹Assistant Professor, ²Professor & Head, ³Assistant Professor, ⁴Associate Professor, Department of Forensic Medicine & Toxicology, Basaveshwara Medical College & Hospital, Chitradurga

ABSTRACT

Determination of sex from the skeletal remains is of immense importance in the field of forensic medicine. Various anthropometric studies conducted in this part of the globe have demonstrated sternum as an important tool for determination of sex when less specific/sex indicative bones are available. This study aims to study, compare and analyze the sterna measurements among both sexes and evaluate the reliability of different parameters to determine sex from an adult sternum. 120 sterna (65 male and 55 female) were collected from the autopsy. After cleaning and drying for three weeks, three readings each were taken and the averages of the results were recorded in millimeters. Metric data was summarized as mean, standard deviations and percentage proportions. Among the five parameters used it was proven that the width of the sternum at the level of 4th rib was the most reliable parameter in determining the sex. The application of Hyrtl's law to the study proved that 40% of male sterna and 98.18% of female sterna obeyed it. The application of Ashley's rule of 149 and 136 revealed that 81.66% of male sterna and 90% of female sterna could be sexed accurately.

Keywords: Sternum, Anthropometry, Sex determination, Hyrtl's Law, Ashley's rule.

INTRODUCTION

The scope of forensic medicine expert has increased manifold with rapid industrialization, urbanization and increasing population. Sex determination of unidentified remains encountered in forensic situations is one of the prime tasks of a forensic medicine expert. In cases of mass disasters such as armed conflicts, terrorist massacres, airplane crashes, war related crimes, natural disasters, explosions, etc, when badly decomposed, mutilated or damaged human remains consisting of only a few bones or their fragments are recovered from the site, it becomes crucial to establish the identity, especially the sex of the missing individual. There are multiple parameters which aid in identification such as sex, race, stature, complexion features, hair, deformities, scars, tattoos, etc. Though a number of bones such as

skull, pelvis, femur ect have contributed significantly to this endeavor, these sex specific or sex indicative bones are not always found at such scenes. In such situations, forensic experts have to depend on less sexually dimorphic elements of human skeleton such as sternum. The motivation of the current study is to find out which are the reliable parameters which can be considered while sexing a sternum when a sternum is found either single or as a part of the skeletal remains.

MATERIALS AND METHOD

The sternum of all the cases autopsied was dissected using a standard midline incision excluding the sternum of age less than 18 years, intersex, fractured sternum, deformed sternum and those with diseases. The clavicles were disarticulated from the sternum by incising at acromio-clavicular junction. The sterna margins that articulate with the cartilages of the first seven pairs of ribs were carefully cut at the costo-sternal junctions. After removing the sternum, it is washed, soft tissues scraped, allowed to macerate by immersing in a bucket filled with soap water for two weeks. On the third week, the sternum was placed in the bucket filled with plain

Corresponding Author:

Dr Vishwanathan K G
Professor & Head
Department of Forensic Medicine & Toxicology
Basaveshwara Medical College & Hospital,
Chitradurga-577501

water. After the total of three weeks, the sternum were cleaned and dried at room temperature. While cleaning, repeated careful inspection was done to avoid separation of three segments of the sternum. The parameters like manubrial length, mesosternal length, combined length of manubrial and mesosternum, manubrio-corpus index and width of the sternum at the level of 4th rib were measured by using the Vernier calipers. Three readings each were taken and the averages of the results were recorded in millimeters. All measurements were taken keeping the sternum on a flat surface in anatomical positions. The data was entered in a prestructured proforma. Three readings each were taken and the averages of the results were recorded in millimeters. According to the Hyrtl's law the ratio between the length of the manubrium and that of the mesosternum is more than 1:2 in the case of women, and less in men. For sexing the European sterna Ashley (1956) formulated the "rule," according to which a male sternum exceeded 149 mm in length, where as the female sternum was less than 149 mm.

RESULTS

In the present study, the length of the manubrium of both male and female sexes fall in the range 46-54 for males and 41-48 for females with a mean length of 50.43 for males and 44.29 for females with a standard deviation of 2.03 in males and 2.20 in females. The demarking point is >50.89 for males and <44.34 for females. The calculated range was found to be 44.34-56.52 for males and 37.69-50.89 for females. The limiting point was 47.36 which gives us a regression point of 47.36 with which can say that if the value is >47.36, it is a male and if the value is <47.36 it is a female. Therefore in this study, for the parameter of manubrium length, out of 65 male sterna, 60 male sterna could be sexed correctly accounting to 90.30%. Out of 55 female sterna, 50 could be sexed correctly accounting to 90.90%. For the above parameter, t value is 15.718 and the p value obtained is <0.001, hence the parameter is statistically highly significant.

The length of mesosternum of both male and female sexes fall in the range 84-107 and 64-94 for females with a mean length of 99.27 for males and 80.92 for females with a standard deviation of 6.42 in males and 8.75 in females. The demarking point is >107.17 for males and <80.01 for females. The calculated range was found to be 80.01-118.53 for males and 54.67-107.17 for females. The limiting point was 90.09 which gives us a

regression point of 90.09 with which we can say that if the value is >90.09, it is a male and if the value is <90.09 it is a female. Therefore in this study, for the parameter of mesosternum length, out of 65 male sterna, 56 male sterna could be sexed correctly accounting to 86.10%. Out of 55 female sterna, 49 could be sexed correctly accounting to 89%. For the above parameter, t value is 12.878 and the p value obtained is <0.001, hence the parameter is statistically highly significant.

The combined lengths of both the manubrium and mesosternum of both male and female sexes fall in the range 133-158 and 105-145 for females with a mean length of 149.70 for males and 125.21 for females with a standard deviation of 8.05 in males and 10.74 in females. The demarking point is >157.43 for males and <125.55 for females. The calculated range was found to be 125.55-173.85 for males and 92.99-157.43 for females. The limiting point was 137.45 which gives us a regression point of 137.45 with which we can say that if the value is >137.45, it is a male and if the value is <137.45 it is a female. Therefore in this study, for the parameter of combined lengths, out of 65 male sterna, 56 male sterna could be sexed correctly accounting to 86.10%. Out of 55 female sterna, 46 could be sexed correctly accounting to 83.60%. For the above parameter, t value is 13.919 and the p value obtained is <0.001, hence the parameter is statistically highly significant.

The sternal index/manubrio corpus index of both male and female sexes fall in the range 47.95-56.97 and 51.08-65.15 for females with a mean length of 50.91 for males and 55.12 for females with a standard deviation of 2.37 in males and 4.08 in females. The demarking point is <67.36 for males and >43.80 for females. The calculated range was found to be 43.80-58.02 for males and 42.88-67.36 for females. The limiting point was 53.01 which gives us a regression point of 53.01 with which we can say that if the value is <53.01, it is a male and if the value is >53.01 it is a female. Therefore in this study, for the parameter of mesosternum length, out of 65 male sterna, 51 male sterna could be sexed correctly accounting to 78.40%. Out of 55 female sterna, 38 could be sexed correctly accounting to 69.09%. For the above parameter, t value is -8.744 and the p value obtained is <0.001, hence the parameter is statistically highly significant.

The width of sternum at the level of the fourth rib of both male and female sexes fall in the range 44-54 for

males and 42-53 for females with a mean length of 51.47 for males and 45.03 for females with a standard deviation of 1.88 in males and 2.87 in females. The demarking point is >53.64 for males and <45.83 for females. The calculated range was found to be 45.83-57.11 for males and 36.42-53.64 for females. The limiting point was 48.25 which gives us a regression point of 48.25 with which we can say that if the value is >48.25 , it is a male and if the value is <48.25 it is a female. Therefore in this study, for the parameter of width of sternum at the level of the fourth rib, out of 65 male sterna, 62 male sterna could be sexed correctly accounting to 95.38%. Out of 55 female sterna, 53 could be sexed correctly accounting to 96.36%. For the above parameter, t value is 14.241 and the p value obtained is <0.001 , hence the parameter is statistically highly significant.

DISCUSSION

In our study, out of 65 sterna, 26 male sterna obey Hyrtl's law accounting 40%, and out of 55 female sterna, 54 sterna obey Hyrtl's law accounting to 98.18%. The study correlates with study conducted by *Narayan et al*¹, 81.48% of female sternums obey Hyrtl's law and 34.12% of male sternums obey Hyrtl's law. In our study, the mean manubrium lengths of the male sternums were found to be 50.43mm and for female sternums, it was 44.29mm. The male manubriums ranged from 46mm-54mm and female manubriums ranged from 41-48mm. This study correlates with the study conducted by *Gautham R S et al*² which concludes that lengths of male manubriums ranged from 35mm-70mm and the female manubriums ranged from 40mm-61mm. In our study, the mean mesosternal lengths of the male sternums were found to be 99.27mm and for female sternums, it was 80.92mm. The male manubriums ranged from 84mm-107mm and female manubriums ranged from 64-94mm. This study correlates with the study conducted by *Dahiphale et al*³ which concludes that lengths of male manubriums ranged from 77mm-120mm and the female manubriums ranged from 51mm-88mm. In our study, the mean combined lengths of the male sternums were found to be 149.70mm and for female sternums, it was 125.21mm ranging from 133mm-158mm and female manubriums ranged from 105mm-145mm. This study correlates with the study conducted by *Gautham R S et al*² which concludes that lengths of male manubriums was 148mm and the female manubriums was 124.00mm. In our study, the manubrio-corpus index of

the male sternums were found to be 50.91 and for female sternums, it was 55.12 ranging from 47.95-56.97 in males and female manubriums ranged from 51.08-65.15. This study correlates with the study conducted by *Atal DK et al*⁴ which concludes that manubrio-corpus index of the male sternums was 46.09 and the female manubriums was 56.70mm. In our study, the width of the male sternums at the level of 4th rib were found to be 51.47mm and for female sternums, it was 45.03mm. This study correlates with the study conducted by *Mukhopadhyay PP et al*⁵ which concludes that width of the male sternums at the level of 4th rib was 51.47mm and that of females was 45.03.

CONCLUSION

The mean manubrium lengths of the male sternums were found to be 50.43mm and for female sternums, it was 44.29mm. The male manubriums ranged from 46mm-54mm and female manubriums ranged from 41-48mm. With a limiting point of 47.36mm, it was observed that 92.30% of males and 90.90% of females could be sexed correctly. p value was found to be <0.001 and hence statistically highly significant. In our study, the mean mesosternal lengths of the male sternums were found to be 99.27mm and for female sternums, it was 80.92mm. The male manubriums ranged from 84mm-107mm and female manubriums ranged from 64-94mm. With a limiting point of 90.09mm, it was observed that 86.1% of males and 89.0% of females could be sexed correctly. p value was found to be <0.001 and hence statistically highly significant. In our study, the mean combined lengths of the male sternums were found to be 149.70mm and for female sternums, it was 125.21mm ranging from 133mm-158mm and female manubriums ranged from 105mm-145mm. With a limiting point of 137.45mm, it was observed that 86.1% of males and 83.6% of females could be sexed correctly. p value was found to be <0.001 and hence statistically highly significant. In our study, the manubrio-corpus index of the male sternums were found to be 50.91 and for female sternums, it was 55.12 ranging from 47.95-56.97 in males and female manubriums ranged from 51.08-65.15. With a limiting point of 53.01mm, it was observed that 78.4% of males and 69.09% of females could be sexed correctly. p value was found to be <0.001 and hence statistically highly significant. In our study study, the width of the male sternums at the level of 4th rib were found to be 51.47mm and for female sternums,

it was 45.03mm. With a limiting point of 48.25mm, it was observed that 98.38% of males and 96.36% of females could be sexed correctly. p value was found to be <0.001 and hence statistically highly significant. The characteristic feature of this study is the fact that this new parameter (width of the sternum at the level of 4th rib), which was not applied for sexing in many previous studies and yet it happens to be the most reliable of all the other parameters. The application of Hyrtl's law to the study proved that 40% of male sterna and 98.18% of female sterna obeyed it. The application of Ashley's rule of 149 and 136 revealed that 81.66% of male sterna and 90% of female sterna could be sexed accurately.

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