

Age Estimation from Macroscopically Examining Sternal End of Right Fourth Rib by Using Pit Depth in Deceased males

KANWAL ZAHRA¹, MARYAM SHAHID², SALMAN KAZMI³, ARIF RASHEED MALIK⁴

^{1,2}MBBS, M. Phil Forensic Medicine and Toxicology, King Edward Medical University, Lahore

³MBBS, M. Phil Mayo Hospital, Lahore

⁴MBBS, M. Phil, Haematology, FCPS, Forensic Medicine and Toxicology

Professor of Forensic Medicine and Toxicology, King Edward Medical University, Lahore

Correspondence to: Kanwal Zahra, Email: kanwalzahra64@gmail.com

ABSTRACT

Objective: To estimate age by macroscopically examining sternal end of right fourth rib by using pit depth and quality of bone in deceased males.

Material and Method

Study design: Observational Study.

Setting: The study was done at the department of Forensic Medicine and Toxicology, King Edward Medical University, Lahore.

Duration of study: Duration of study was one year from June 2016 to May 2017.

Methods; Age was confirmed by documentary evidences like birth certificates, identification cards or national identity cards (CNIC). In the present study, the dead body was placed flat in supine position on the standard autopsy table. Right fourth rib was dissected along with the costochondral junction. The bones were kept fifteen minutes in boiling water to remove the remaining soft tissues and were dried at room temperature. Each rib was examined at sternal end macroscopically to ascertain the stage of morphological change which was separated into nine groups- phase 0 to phase 8 using Iscan method. The morphological changes observed were articular surface at costochondral junction, pit depth using pit caliper and overall quality of bone. After examination, the rib was placed back in the chest cavity; the body was stitched and handed over to police as case property. Data was collected via study proforma.

Results: Mean age was 42.29±21.02 with minimum and maximum value of 13 and 85. Mean pit depth is 4.41mm. 41(48.2%) cases have smooth firm and solid bone, 16(18.8%) have brittle and porous, 15(17.7%) have rough and porous, 8(9.40%) have fairly good quality, 5(5.90%) have good quality bone. Scatter plot shows linear line and highly significant positive results on basis of pit depth of sternal end of right fourth rib r-value 0.345 at significance level of 0.001. The final model for age estimation is Age = 8.05±7.70 (PIT DEPTH).

Conclusion: It is concluded that the age in dead body can be estimated on the bases of pit depth of right 4th rib based on different phases of Iscan method.

Keywords: Age estimation, costal cartilages, Iscan phase method, indentation, pit, medial end of rib

INTRODUCTION

Identity means determining the individuality of a person or dead body.¹ It is an integral part of forensic medicine. The identification may be complete when all information about a person is obtained or it may be partial when only some information is available.² The identification of a dead body is required in sudden and unexpected death in unclaimed bodies, fires, and explosion, railway or aircraft accidents, mutilated or decomposed bodies.^{2,3} Various macroscopic as well as microscopic parameters are used for identification. Among these methods the most common ones are age, sex, stature, race, external features i.e.; birth marks, scars, tattoos and finger printing.³ Unknown bodies can be identified using various parameters in which age is one of the most important component.⁴ The importance of age estimation with special significance in elders, criminals, civil and social matters cannot be denied. The determination of age in civil cases is required for employment, matrimonial issues, and attainment of majority, management of property, voting, senior citizen benefits and for major punishments.^{1,5} In the criminal cases determination of age becomes enormously important, such

as rape, murder, abduction, infanticide, juvenile delinquency and criminal responsibility. This assessment of age is done by forensic experts for the administration of justice and their conclusions are subject to questioning in court of law.⁶ Age-at-death estimation can be done in several ways i.e; by examining dental data, epiphyseal union of long bones, suture of cranium and sternal end of ribs.⁵ The significance of ribs for age estimation is (a) the sternal rib end depicts alterations and destruction in whole life (b) Age can be determined even from a single rib (c) Rib can conveniently be taken out by causing least harm to the corpse.⁷ Forensic anthropology involves the analysis of skeletal, partially decomposed or mutilated bodies that are not identifiable using traditional methods i.e.; fingerprinting.⁸ A forensic expert may also be requested to analyze materials from crime scene in any case especially in massive explosions, air crash and mass disasters.⁹ Although forensic anthropology is not typically used as a primary identification method it can be of considerable use in identification of unknown bodies in special circumstances i.e.; in highly fragmented specimens. This needs to confirm whether the material is bone and if bone whether human or

non-human and then species specific tests are applied.^{10,11} Age is an ongoing process that occurs in osseous and non-osseous tissues. However, its estimation in the bony tissue is considered most advantageous for several reasons. Since the bony tissues are resistant to putrefaction, destruction by animals and can be found intact even if the rest of the body is mutilated, so considered the core of most forensic identification methods.¹² To evaluate sternal rib end Iscan developed a method which was found to be very useful for determination of age in dead bodies.^{13,14} It is one of the most feasible and reliable observational methods and gives a successful means for future studies to be carried on.^{15,16} Many studies has been found in literature on 4th sternum, while data regarding age estimation by pit depth of fourth sternum is inadequate specially at local level. However this study has been conducted estimate age by macroscopically by using pit depth and quality of bone of sternal end of right fourth rib, at tertiary care Hospital.

MATERIAL AND METHODS

This observational Study was done at the department of Forensic Medicine and Toxicology, King Edward Medical University, Lahore after taking ethical approval. The duration of study was one year from June 2016 to May 2017. All the fully intact ribs of adult male dead bodies with age of dead body in range of 13-85 years were studied. All the unknown dead bodies, where the age could not be confirmed and the autopsy cases with ribs having trauma or congenital bone diseases were excluded. Age was confirmed by documentary evidences like birth certificates and identity cards (NIC). The each dead body was placed flat and supine on the standard autopsy table. Right 4th rib from chest cavity with its junction with costal cartilage was taken from eighty-five male corpses presented for postmortem examination. The specimen was separated from body by cutting three centimeters medial to costal cartilage junction by rib cutter. The attached muscles to the rib were cut using scalpel. The remaining soft tissue was removed by keeping the bones in boiling water for fifteen minutes and was dried at room temperature. Each rib was examined at sternal end macroscopically to ascertain the stage of morphological change which was separated into nine groups, phase 0 to phase 8, using Iscan method.

Iscan Phase Method:

- Phase 0 (age 13-16): The sternal end of rib contains no depression with round and circular walls and margins. Bone is shiny and smooth.
- Phase one (age 17 to 19): A depression or pit starts developing on sternal end of rib where it articulates with costal cartilage. Pit depth is 1.1 to 2.5mm. The walls are round with well-defined margins. Bone shiny and smooth.
- Phase two (age 20 to 29): indentation becomes deepens in the form of a V shaped depression. The pit depth is 2.6-3.5mm. The margins are still circular and well defined. Bone has shiny , smooth surface.

- Phase three (age 30 to 39): The indentation further deepens to take shape of V. Pit depth is 3.6-4.5mm. The articular surface margins become irregular in shape and show scalloped pattern, the bone is shiny and smooth.
- Phase four (age 40 to 49): Indentation increased to 4.6 - 5.5mm and the shape is V shaped. Margins thinned and show irregularities and scalloped appearance. Bone texture is good but the surface is rough.
- Phase five (age 50 to 59): The pit depth is 5.6-6.5mm and is deep U shaped. Walls are thin. Margins become irregular. A new bone projects from the surface of the sternal end of rib. Bone is dull, shiny texture lost and its quality is poor
- Phase six (age 60 to 69): Indentation is 6.6-7.5mm and deep U. Walls become thin and bone projects from the surface. Overall texture of bone is dull with pores start appearing.
- Phase seven (age 70- 79): The pit is 7.6-8.5mm deep U shape. The walls are thin and rim has prominent bone formation. Bone is dull, with pores, quality is poor and loss of texture.
- Phase eight (age 80 and above): Indentation is deep more than 8.5mm and U shape. A well-developed bone formation which project from surface of sternal end. Bone itself is rough, dull, having pores, loss of texture.

The morphological change was observed as pit depth using pit caliper. After examination, rib of the each body was placed back in the chest cavity. Bodies were stitched and handed over to police as case property. All the data was recorded in study proforma.

Data Analysis: Data was entered in SPSS-21. Quantitative variables like age were presented as mean and standard deviation. Simple bar charts were made for categorical data. Scatter plot was made to see pattern of relation between quantitative data. ANOVA variance test was applied on pit depth, articular surface, rim and bone to see correlation between the quantitative variable. Regression model was designed to predict age taking Iscan method (phases). P-value ≤ 0.05 was considered as significant.

RESULTS

Mean age is 42.29 ± 21.02 with minimum and maximum value of 13 and 85. Mean pit depth is 4.41mm with minimum and maximum value of 0 to 8.8mm. Table .1

According to the quality of bone 41(48.2%) cases have smooth firm and solid bone, 16(18.8%) have brittle and porous, 15(17.7%) have rough and porous, 8(9.40%) have fairly good quality, 5(5.90%) have good quality bone. Table 2.

Scatter plot shows linear line and highly significant positive results on basis of pit depth of sternal end of right fourth rib r-value 0.132 at significance level of 0.001.Fig.1

Table 1: Descriptive Statistics of Age and Pit Depth

Variables	N	Minimum	Maximum	Mean \pm SD
Age (Years)	85	13	85	42.29 \pm 210.2
Pit Depth (mm)	85	0	8.8	4.41 \pm 2.63

Table 2: Frequency of bones cording to quality

Bone type	Frequency	Percentage
Smooth Firm & solid	41	48.2%
Good Quality	5	5.90%
Fairly good quality	8	9.40%
Rough & Porous	15	17.7%
Brittle and Porous	16	18.8%
Total	85	

Table 3: Regression formula of age estimation on basis of pit depth

Model	R ₂	B	Standard Error	t-statistic	P-value
Constant	0.941	8.050	1.093	7.367	0.000***
Pit Depth (mm)		7.760	.213	36.419	0.000***

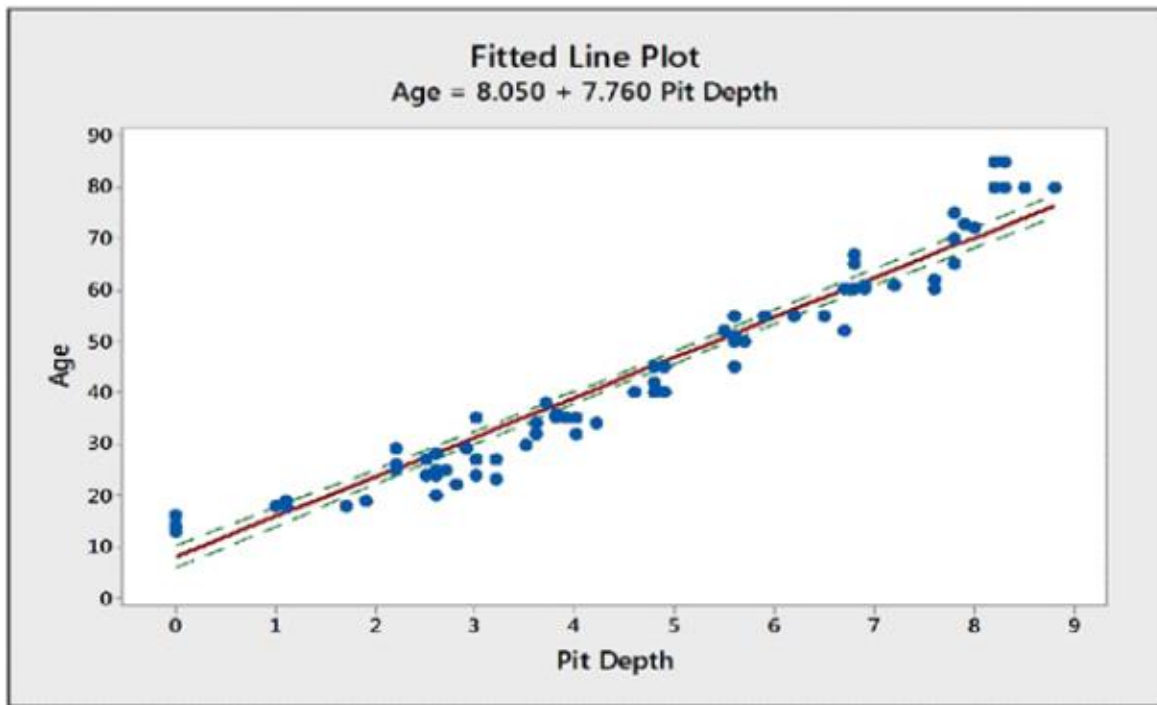


Fig 1: Scatter Plot Showing Age Estimation on Basis of Pit Depth
REGRESSION MODEL OF AGE ESTIMATION ON PIT DEPTH OF RIGHT 4TH RIB Age (Y) = 8.050 +7.760 Pit Depth (X)

DISCUSSION

The sternal ends of the right fourth rib of 85 male dead bodies were examined using Iscan method. The ribs were placed in one of the phases extending from zero to eight. In each phase articular surface, shape of rim, pit depth and overall quality of bone was observed. Pit depth was measured by pit caliper. The results were compared with past studies. The age wise distribution of cases according to phase analysis in present study was compared with studies of Iscan, as Padmakumar K et al,¹⁷ in Indian population, Meena MC et al¹⁸ in females Indian population and Meena MC et al¹⁹ in male Indian population. In this study the age interval between the phases was kept constant as compared with past studies where there was overlapping of ages among phases. So each phase was observed more precisely.²⁰ The earliest destructive and morphological changes started to appear from age 17 (phase1) that is also consistent with the studies. The mean age was found to be 42.29. However Khatri A et al²¹ reported that most common age group was 15-30 years. On other Muñoz A et al¹¹ mentioned age range between 17 to

92 years. In Fanton study on French 414 male corpses fourth ribs, the mean age was 49 years with range of 47-94 years.⁹ These result were found near to this study.⁹

In this study only male corpse was studied in the present study because female due to their hormonal and several other different characteristics needs separate studies. These anatomical differences between both sexes were described by Iscan. One of the most obvious ages related changes observed was the formation of pit at sternal end of rib. In the present study pit depth was measured by pit calliper. On the basis of values scatter plot showed positive results. In studies by Meena, and Verzeletti, best correlation was observed between pit depth and age.^{5,22} In this study regression analysis was done on basis of pit depth which showed p value of 0.000 and on basis of this regression model for age estimation was designed. By using this formula age can be determined in an unknown male body by measuring pit depth. On other hand Doshi SM et al²³ showed that the age prediction from pit depth of the sternal end of 4th rib is significant. While Cerezo-Román JI et

al²⁴ revealed that the ANOVA did not reveal a significant relationship between known age and the fourth rib pit depth. In this study there was a positive correlation between 4th rib pit depth and age (r=0.132). However Doshi SM et al²³ showed also similar findings. While no more studies found regarding this correlation. More work should be done to make valuable or not these findings.

CONCLUSION

Age is an ongoing phenomenon, though has to pass through progressive, static and retrogressive phases, and finally ends at demise of the individual. In the current study pit depth of right 4th rib efforts are utilized to explore the possible ways for age estimation. Through the findings of this study it is concluded that in dead body's age can be estimated on the bases of pit depth of right 4th rib. Regression model designed using pit depth to determine age. So, Pit depth and bone quality are best indicators for age determination however multivariable approach is required to obtain precise results. Further studies are suggested on this subject.

Limitation: Extraction of the remnant of cartilage portions very difficult and time consuming from the pit. During removal breakup of rib ends may make the ribs useless. Pit depth 4th rib obtains also a major issue.

REFERENCES

- Khandare S V, Bhise SS, Shinde AB. Age estimation from cranial sutures: CT scan study. *Indian J Basic Appl Med Res.* 2014;3(4):203–11.
- Chandra S, Dwivedy S, Sah K, Sinha S. Application of modified reverse panoramic radiograph on lambdoid suture for age estimation. *Quant Imaging Med Surg.* 2015;5(4):519–51923.
- Akhlaghi M, Taghaddosinejad F, Sheikhzadi A, Valizadeh B, Rezazadeh Shojaei SM. Age-at-death estimation based on the macroscopic examination of Spheno-occipital sutures. *J Forensic Leg Med.* 2015;
- Vij K. Textbook of Forensic Medicine & Toxicology: Principles & Practice [Internet]. 2014. 612 p. Available from: <https://books.google.com/books?id=lp1rAwAAQBAJ&pgis=1>
- Meena MC, Rani Y, Sharma GK. Age Estimation from the Rib by Components Method Analysis in Indian females. *Phys Anthropol.* 2014;10:143–9.
- Remediation E. *Olfaction Science and Law.*
- Yaşar İşcan M, Loth SR, Wright RK. Age Estimation from the Rib by Phase Analysis: White Males. *J Forensic Sci.* 2015;
- Stout SD, Dietze WH, İşcan MY, Loth SR. Estimation of Age at Death Using Cortical Histomorphometry of the Sternal End of the Fourth Rib. *J Forensic Sci.* 2015;
- Fanton L, Gustin MP, Maujean G, Bernard O, Telmon N, Malicier D. Geometric and harmonic study of the aging of the fourth rib. *Int J Legal Med.* 2016;
- Salem NH, Aissaoui A, Mesrati MA, Belhadj M, Quatrehomme G, Chadly A. Age estimation from the sternal end of the fourth rib: a study of the validity of İşcan's method in Tunisian male population. *Legal Medicine.* 2014 Nov 1;16(6):385-9.
- Muñoz A, Maestro N, Benito M, Sánchez JA, Márquez-Grant N, Trejo D, et al. Sex and age at death estimation from the sternal end of the fourth rib. Does İşcan's method really work? *Leg Med.* 2018;
- Steyn MYIM. *The Human Skeleton in Forensic Medicine.* Third. Illinois: CHARLES C THOMOS PUBLISHERS LTD USA; 2015.
- Yoder C, Ubelaker DH, Powell JF. Examination of Variation in Sternal Rib End Morphology Relevant to Age Assessment. *J Forensic Sci.* 2015;
- Cerezo-Román JI, Hernández Espinoza PO. Estimating age at death using the sternal end of the fourth ribs from Mexican males. *Forensic Sci Int.* 2014;
- Aktas EÖ, Koçak A, Yemisçigil A, Aktas S. Intercostal variation for age estimation - Are the standards for the right 4th Rib applicable for other ribs? *Coll Antropol.* 2014;
- Cattaneo C. *Forensic anthropology: developments of a classical discipline in the new millennium.* *Forensic Sci Int.* 2017;
- Padmakumar K, Girish S, Geetha O. Age Estimation from the Rib by Phase analysis—An autopsy study in males. *Indian Internet Journal of Forensic Medicine & Toxicology.* 2009;7(3):79-86.
- Meena MC, Rani Y, Naik SK, Murari A. Age estimation from IV rib by phase analysis in Indian females. *Australian Journal of Forensic Sciences.* 2013 Mar 1;45(1):55-64.
- Meena MC, Rani Y, Naik SK, Murari A. Age estimation from the IV rib by phase analysis in Indian males. *Australian journal of forensic sciences.* 2012 Sep 1;44(3):261-71..
- Dedouit F, Bindel S, Gainza D, Blanc A, Joffre F, Rougé D, et al. Application of the İscan method to two- and three-dimensional imaging of the sternal end of the right fourth rib. In: *Journal of Forensic Sciences.* 2016
- Khatri A. Estimation of Age from Sternal End of

- Fourth Rib in Western Rajasthan Population: A Microscopic Study. Asian Journal of Biomedical and Pharmaceutical Sciences. 2015:15.
22. Verzeletti A, Terlisio M, De Ferrari F. Age-at-death estimation in Caucasian females from the morphological analysis of the sternal end of the fourth rib. Leg Med. 2013 Jan 1;15(1):47-9.;
 23. Doshi SM, Doshi PM. Age Estimation by Depth of Pit at Sternal End of Fourth Ribs in Males-a Quantitative Approach. Indian Journal of Forensic Medicine & Toxicology. 2016;10(1):137-41.
 24. Cerezo-Román JI, Espinoza PO. Estimating age at death using the sternal end of the fourth ribs from Mexican males. Forensic science international. 2014 Mar 1;236:196-e1.