STUDY OF STERNAL END OF RIBS FOR AGE ESTIMATION IN THAI POPULATION

PINPAKA SUCOTCHADAT

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Entitled

STUDY OF STERNAL END OF RIBS FOR AGE ESTIMATION IN THAI POPULATION

Miss pinpaka sucotchadat
Candidate

Assoc. Prof. Somboon Thantakerngkit
M.D.
Major- advisor

Assoc. Prof. Sanjai Saengvichian
M.D.
Co- advisor

Clin. Prof. Somchai pholeamek
M.D.
Co- advisor

Prof. Liangchai Limlomwongse Ph.D.
Dean
Faculty of Graduated Student

Clin. Prof. Amnaj Kusalanan
M.D.
Chairman, Master of Science
Program in Forensic Science
Faculty of Medicine Siriraj Hospital

Thesis

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On

August 27, 2001

Miss Pinpaka Sucotchadat
Candidate

Assoc.Prof.SomboonThamtakerngkit
M.D.
Chairman

Assoc. Prof. Sanjai Saengvichain
M.D.
Member

Pol. Col. Leang Huiprasert
M.D.
Member

Clin. Prof. Somchai Pholeamek
M.D.
Member

Prof. Liangchai Limlomwongse Ph.D.
Dean
Faculty of Graduate Studies
Mahidol University

Clin. Prof. Piyasakol Sakolsatayadorn
M.D., FRCST
Dean
Faculty of Medicine Siriraj Hospital
Mahidol University

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Pinpaka Sucotchadat

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Age estimation is a critical part of person identification and is an important factor in forensic medicine. There are many techniques for age estimation, for example using high technique or simple technique. The purpose of age estimation is to be able to determine possible specific age or at least in the vicinity of real age.

This study is concerned with exploring sternal end of ribs for age estimation in Thai population. The alteration (metamorphosis at sternal end of rib) is related to age. When age increases, the change is more pronounced. The present study followed the methods applied by Iscan et al, which comprised of pit depth, pit shape, rim and wall configuration, depth of pit, the width of rib, and the thickness of ribs, respectively. The study sample of metamorphosis at sternal end of rib was performed in 245 right fourth ribs by seven methods for age estimation at death, using descriptive statistic and ONE WAY analysis of variance for age estimation. The CROSSTABS procedure was carried out to assess the statistical significance of the distribution each group by age using each method. Three methods consisting of depth of pit, the width of rib, and the thickness of rib cannot be applied for age estimation standard in Thai population. The other four methods consisting of pit depth, pit shape, rim and wall configuration, and phase method, showed some results that can be used for age estimation, particularly when analyzed using a combination of the four methods. A combination of the four methods is a useful tool for estimating stage of high frequency of population in each age interval in forensic medicine.

In conclusion, studies of right fourth rib for age estimation in Thai population using the combination of the four methods should be considered when estimating age. However, the method cannot be a definite standard for age estimation in Thai population at this time. This study may be a useful guideline in *medicolegal* investigation when only rib is available for investigation. Further research is, however, recommended.

4237655 SIFS/M: สาขาวิชา: นิติวิทยาศาสตร์; วท.ม. (นิติวิทยาศาสตร์)
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พิณผกา สุดชเดช: การประมาณอายุผู้ตายโดยใช้ส่วนปลายกระดูกซี่โครงในประชากรไทย (STUDY OF STERNAL END OF RIBS FOR AGE ESTIMATION IN THAI POPULATION) คณะกรรมการควบคุมวิทยานิพนธ์: สมบูรณ์ ธรรมเถกิงกิจ, พ.บ., สรรใจ แสงวิเชียร, พ. บ., พ.ด., สมชาย ผลเอี่ยมเอก, พ.บ., น.บ. 81 หน้า. ISBN 974 –04 – 0567 – 3

การวิเคราะห์อายุของผู้ตายเป็นส่วนหนึ่งที่มีความสำคัญในทางนิติเวชศาสตร์ มีหลายวิธีการที่สามารถใช้ในการประมาณอายุได้ ไม่ว่าจะเป็นวิธีการที่ใช้เทคนิคสูง หรือเทคนิคง่ายๆ แต่วัตถุประสงค์หลักของการประมาณอายุ นั่นก็คือ การที่จะสามารถระบุอายุได้ถูกต้อง หรือใกล้เคียงกับความเป็นจริงมากที่สุด

ในการศึกษาครั้งนี้ได้ศึกษาการเปลี่ยนแปลงบริเวณส่วนปลายของกระดูกซี่โครงด้านที่ติดกับกระดูกอก มาใช้ในการประมาณอายุ โดยอาศัยลักษณะการเปลี่ยนแปลงของรูปโครงสร้างของกระดูกในบริเวณนี้ ซึ่งการเปลี่ยนแปลงที่เกิดขึ้นมีความเกี่ยวข้องกับการเพิ่มขึ้นของอายุ โดยได้ประยุกต์วิธีการทดสอบของ Iscan และคณะ ประกอบด้วยวิธี pit depth, pit shape, rim and wall configuration, phase method, depth of pit, the width of rib, and the thickness of rib จากการทดสอบพบว่า 3 วิธีหลังไม่สามารถนำมาประยุกต์ใช้ในการประมาณอายุได้ และ 4 วิธีที่เหลือ ในแต่ละวิธีพบว่าสามารถใช้ในการประมาณอายุได้อย่างหยาบ แต่หากนำทั้งสี่วิธีมาพิจารณารวมกันแล้ว พบว่า สามารถนำมาประยุกต์ใช้ได้ผลดีขึ้น

โดยสรุปแล้ว การศึกษาในเรื่องนี้เพื่อนำมาประยุกต์ใช้ในการประมาณอายุ ควรพิจารณาทั้งสี่วิธีรวมกัน นั่นคือ pit depth, pit shape, rim and wall configuration, และ phase method. แต่จากการศึกษาพบว่ามีความไม่แม่นยำเพียงพอ ซึ่งทำให้ไม่สามารถนำวิธีนี้มาเป็นมาตรฐานแน่นอนในการประมาณอายุในประชากรชาวไทยได้ แต่วิธีนี้ก็ยังอาจมีประโยชน์นำมาใช้เป็นแนวทางในการตรวจทางนิติเวชในกรณีที่พบแต่กระดูกซี่โครงเพียงอย่างเดียว

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CHAPTER I

INTRODUCTION

Forensic medicine is a special field in medicine dealing with the interaction of medical science with the law, the name come from "forum". It provides one of the most fascinating of all the many branches of medicine, it is the study of the body, often dead, the quiet scientific assembly of the evidence it bear and the construction of reasonable inference based on these observation. There are many subjects involve in it such as anatomy, toxicology, serology, personal identification, pathology, dentistry, etc. Every specialty in medicine can have forensic aspects at some time or another, the relationship is two way, in that medical science can often assist the administration of justice, both in civil and criminal matters, while most branches of medicine can themselves become the objects of legal scrutiny when issues of malpractice arise (88).

Forensic medicine is very important in application for solving problems of a crime such as identification of the body who died of an unnatural cause, etc.

The identification of human skeleton or forensic anthropology is a part of forensic medicine which can greatly help to collection, analysis and reconstruction the event of evidence in each case (44). Persons who involve in this study are called forensic anthropologists, they are specialists in recovering and identifying human remains, they have training in anthropology, archaeology, criminalistic, medicine or pre-medicine, human osteology, recovery technique and analysis of human remains,

forensic anthropologist should be able to help the forensic investigator to recover, analyze and identify the remains. The importance of using skeletal remains for identification because of teeth and bone can be heated to temperatures approaching the melting point of skeletal mineral (more than 1,600 °C) without appreciable loss of microstructure or tertiary architecture (75). Therefor, the bone and teeth cannot be easily to destroyed. So, using of human skeletal identification is still popular in case of identification.

When collected human skeletons from a site, they are extensive enough to convey important information concerning the extreme variability which is manifested in all aspects of identification (62). Skeleton, complete sets of skeleton, parts of skeleton or single bone are essential evidences in medicolegal aspect. All of bones which were sent to forensic medicine laboratory for identification, will be cleaned first and labeled them, then the following study should be performed:

1. Identifying each bone. Is it really bone or false thing? Many materials such as plastic, piece of tree, piece of rock, foam insulation and the others may resemble the bone. They may cause confusion to forensic anthropologist. Therefore, crime scene investigation is essential for understanding circumstance, characteristic of scene, type of scene. For example, the area showed debris from the explosion, there are many things being exploded. Forensic investigator must be careful to observe the scene and separate the bone fragment from debris. They have to analyze and make sure that it is bone.

2. Is each bone human bone or animal bone? Forensic anthropologist will be able to recognize and separate human skeleton from animal bone. Sometimes, when the bones are collected from scene, they may be confused with animal bone fragments

such as monkey, dog, bear, etc., some of these are vertebrae, ribs, long bones, pelvis, and small bone may show difficult problem, they have similar characteristic with human bone such as fragment of bear's paw. Therefore, training, experience and time are required for determination.

3. Is it modern human bone? Estimating time since death is significant in forensic medicine. Sometimes, skeletal remains were buried in graveyard. It is difficult to prove whether the remains are ancient, fossil or modern human bone, especially when the corpse is in a coffin or wrapped in protective material such as heavy plastic, a shroud or some protective chemical will preserve soft tissue for a long period of time. It makes time since death difficult to estimate. In forensic medicine only the modern human bones are analyzed, most of the time dealing with a lawsuit. So, forensic anthropologist must separate the bone from the other by observation of morphological features, compare with known modern human bone or by special technique, using C^{14} tested (44). The unstable isotope of carbon, C^{14}, is present in every living organism. At death, carbon-14 begins to decay at a predictable rate and by measuring the remaining amount of the isotope one can determine an accurate measurement of the time since the death of organism. So, this method of study is necessary.

4. What bones are present? The forensic anthropologist has knowledge of human osteology. They should be present a figure and detail of the remains. Those bones may give an evidence which help to improve the forensic case study.

5. Those bones are of one person or more? The number of human bones has limited pieces (206 pieces) and many of them are paired such as long bone, rib bone, innominate bone etc. If more than one, identify and separate them. Each fragment of bone should be placed in normal anatomical position, but some cases may have

exceeding number of bones. So, It must be careful to distinguish the bone for specific individual. The specific characteristic of individual skeleton makes a person unique and this is helpful in separating one from others. Personal biological characteristics may include ante-mortem health, trauma, anomalies and congenital bone deformation (62, 78). After that, identified bones of each person as follows:

1. Sexing the skeleton. Using the method for sex determination such as the architecture of skull, pelvis, etc.

2. Estimating the age. Using skeleton for age estimation, most commonly indicator of physiological maturity is applied. Estimation of age depends on the biological maturity, the number and rate of developmental changes go down with increasing age, the aging process is different in each person.

3. Estimating the height of an individual. Usually the long bones are mostly used for estimation, by measuring and comparing with regression formulae. Inacuracy of estimation should be considered when only broken long bone is discovered or specific portions are missing.

4. Identifying race of a person if possible. Race is both a cultural and biological term (44). The definition of race, it means a local human population distinguished as a more or less distinct group by genetically transmitted physical characteristic or any group of people united or classified together on the basis of a common history, nationality or geographic distribution. The race is somewhat involved in the aging process, The aging process of bone is not different among races but growth of bone, density of bone and the others are influenced in bone deterioration causing characteristic difference of bones in various races (78). In forensic study, using the three races model, i.e. Mongoloid, Caucasoid and Negroid to describe spacious

genetic and morphological characteristic (81). For racial determination, skulls are frequently used by looking at the shape and relative size, slope, etc.

5. Using evidence on the bone such as study a trace of fracture bone from history and radiographic examination of the suspect, study dental characteristic, dental arch, dental mold, especially, at present they have progress knowledge " DNA fingerprint" from bone marrow, etc. to identify whose person those bones belong. For instance a trace of bullet, chopping wound, smashing from the solid object, etc. and also looking for the evidence on the bone to find the cause of death of the person.

Apart from its value in assisting for the identification of a dead person, the age of person either living or dead may be required in several special medico-legal situation, (1) the maturity of the fetus in relation to the crime of fetal destruction , (2) infants, in relation to child murder or infanticide, (3) in rape and other offense which depend on the age consent, (4) the age of marriage and capacity for procreation, (5) In determining adulthood for various civil law matters e.g. eligibility to obtain work permit.

Many parts of human skeleton can be used for estimation of age. Each part is important and may be used for different purpose. However, there are no definite skeletal evidence that provide a specific age, the difficulties may be due to many factors controlling individual bone such as growth hormone, endocrine system, dietary and the others. So, age determination depends on the general age of skeleton, before biological maturity, there are many biological and physical changes progressing in whole tissue including the bone tissue. After biological maturity, the number and rate of developmental changes are low and somewhat steady, when a

person reaches the 40th, 50th, and older. Individual person will have regular degenerative change from aging process throughout life.

The skeleton and teeth are the principal means whereby the age is estimated. Watson A Alan separates age into three groups (73); these are:

- the fetus and newborn child.
- from infancy up to 25 years.
- an adult over 25 years of age

1. The fetus and newborn child. The main medicolegal concern is in deciding whether or not the infant was legally viable (born after 28th weeks of pregnancy) and if viable, whether the child was sufficiently mature to withstand the difficulties of delivery and a separate existence. Conclusions are based on the weight and length of the infant, the distribution of the skeletal ossification centers, thus 28 weeks. (legal viability). The vertex-heel measurement should be 35 cm. (14 in) with a range of 32-37 cm. (13-15 in) and ossification centers are visible, when centers are generally appeared, the infant was mature at birth.

1.1 Prenatal ossification center appearance. After fetal bone formation, the ossification begins to occur at about 7th weeks. Ossification centers will appear at a different time such as in the skull, the sequence is as follow: 1. facial and calvarial centers, 2. basicranial centers, and 3. hyoid centers, etc. However, ossification centers identification may cause problem. No direct evidence of relation between parity and the rate of ossification in intrauterine life have been previously studied. There are variation of the number of ossification centers present for individual bone, and sometimes anomalies in number of ossification centers may occur.

1.2 Postnatal ossification center appearance and union center. It is variable on a part of bone, time, race and sex in normal individual case. So, on identification of the bone the following should be recognized: What part of the bone is it? What is the race? What is the sex? The complete union is important for concerning of age in young person because human biology are individually different and there are many factors controlling bone growth. For example, postnatal union center of ossification of femoral head appears approximately at 17-18 years of age, and that of proximal fibula is about 17.6-18.6 years of age, etc. (62).

2. Childhood to early adulthood. There are three ways to assess age at death as follows:

2.1 Dentition. Examination of the teeth is valuable in the identification of recent dental and of skeletal remains, because both temporary and permanent dentition are almost indestructible by the normal process of putrefraction and decomposition. The description of any dental peculiarities and particular of dental work together with the taking of impression, casts and dental X-ray should also be performed (73). An estimation of age with reasonable accuracy can be made for the period beginning at about 6 months up to 21 years, such accuracy is based on the respective times of eruption of the individual temporary and permanent teeth. The dental charts indicate the approximate dates at which the different teeth appear. For an estimation of age at death, the teeth and jaw are very helpful in this regard. The developmental stages of the teeth can be compared with published standard. Rate and pattern of tooth eruption and dental feature depend on individual dental growth. On identification by comparing with published chart, thereby it inform the chronology of tooth throughout deciduous and permanent teeth. Changes in the teeth commonly occur, depending on

diet, oral hygiene and many lifestyle factors. So, the estimation depends on direct observation, X-ray film and comparing with chronology of dental development chart.

2.2 Ossification centers. The bones of the human skeleton (mammalian skeleton) develop from a number of separate centers of ossification and growth. The process of appearance and union has, in the normal human skeleton, a sequence and a time that makes it a reliable age indicator. Selective bone in which certain centers of ossification can be seen, thereby determining the approximate age of a fetus or a newborn child from birth up to at least 5 years. The presence of ossification center is seen relatively by radiology (73). But Interpretation of result by radiology is complicated and it cannot give specific age with certainty.

2.3 Epiphyseal plate closure. This observation can be used in long bone in children and adolescent up to the age of about 18 to 20, each piece of bone has individual union time. It is related with maturity state of bone growth, so growth rate is important factor at this state. An estimation of age may be given by the fusion of epiphyses of the bone to their shafts. The time of closure generally follow a definite order but there is considerable individual variation, the accuracy increases with the number of observation (73). On X-ray film, it brings the problem of estimating and comparing epiphyseal plate closure on actual bone age and on X-ray film. Therefore, it is very difficult to be applied for interpretation concerning age estimation.

3. Skeletal age in later years. After the cessation of growth processes, aging is predominantly determined by a variety of biological and environmental factors. These cause a considerable gap between true chronological and estimated biological age causing uncertainty of age estimation of adult skeletons.

3.1 Cranial suture closure. It starts endocranially and proceeds ectocranially (it commences inside the skull and advances to the outside). The suture closure is related with the age, in adolescent age 15-20 years the skull sutures are not yet closed (62). Some sutures are not fully close and have appearance of the phenomenon of "lapsed union" ectocranially, because stages of endocranial closure come in advance of the stages of ectocranial. Age estimation concerning the closure of skull sutures cannot give specific narrow age range. Furthermore, in young adult the skull texture is smooth and viorine on both inner and outer surfaces. With increasing age, there are muscular marking, with depression and the other appearance on surface of the skull. So, they can be studied together. At present, suture closure is so highly variable.

3.2 The pubic symphysis morphology. The right and left pubic bones do not actually articulate, they are divided throughout life by the symphyseal cartilage. Therefore each pubic bone presents a symphyseal surface (62). Other changes occur as part of the natural aging process. There is obvious degenerative changes that occur at the cartilage-lining of weight-bearing joints, related to changing of surface of aging process. There are three major studies concerning the features of symphysis pubis by Todd's, Brook's, and Mckern & Stewart's theory. They described symphyses pubis as good age indicator. Osteological features of pubic symphysis are good for age estimation at least spans, approximately 5 years, particularly in the 3rd and 4th decades of life. Therefore, it is one of the best criteria for age determination.

3.3 Union of vertebral epiphyseal ring (36, 37). These are used to determine age at death of late teen to early 20's. Because other methods cannot be used to estimate in narrow range. This method is used to predict age in teenagers and young adults. The method is to study of pattern and stages of union of superior and inferior

epiphyses of vertebral central (epiphyseal ring). The relationship between stages of union and actual age is good. The data is helpful in estimating for early adult age.

3.4 Morphology of sternal rib end (1-5). This study was performed by observation and measurement at the sternal end of rib. From observation, it was found that the changes on sternal end of rib are associated with the age. There are more changes on it when the age is increasing. Morphology on sternal rib end deals with aging process, there are many controlling factors. This study helps to support identification of person and for more accuracy of age estimation.

3.5 Metamorphosis of the auricular surface of the ilium and sacrum. Sacro-iliac articular surface, age variability is too extreme to be definitive. In younger, it showed marks on bone less than in older individual. The morphology of surface can be used to predict the age which is the same as the morphology of pubic symphysis. But the study of this information has not been extensively performed.

3.6 Mineralization of costal cartilage (30-33, 54). The study, was performed by using soft X-ray of costal cartilage, it showed that an existence of mineralization will be increasing with age and there is no mineralization before 15 years of age and degree of mineralization are widely distributed in middle age. Furthermore, the mineralization of costal cartilage deals with some disease e.g. cardiac disease, emphysema, etc., endocrine factor and biochemical factor, but there is no relation with occupation. This study can be used for approximate age determination.

3.7 Microscopic or histological study in human cortical bone (23,38-40). Age estimation using human cortical bone reveals many techniques such as osteons counting, estimating the percentage of circumferential lamellar bone (numbers of lamellar per osteon), average haversian, etc., especially, osteon counting has been a

specialized technique for determining the age of person more than 20 years of age. Anthropologist discovered that looking at the ratio of different types of bone cells under the microscope require special equipment and training to take and read the sample. The factors influence this method are race, sex, metabolic disorder and the others. By comparing morphologic method and microscopic method, the microscopic structures of bone cortex by quantitative analysis are more accurate than morphologic method. Microscopic study is more reliable method than direct observation, therefore, it is an important tool in forensic medicine and anthropology.

3.8 Aspartic acid racemization (24-8, 35, 75). This study has been used for age estimation based on its presence in human dentine, femur, teeth, optic lens and brain. Because D- amino acid have been found in them. D-amino acid have a slower metabolic turnover and slower decomposition rate, aspartic acid have a highest racemization rate of all amino acid. There are studies using this information to study for age estimation by comparing D\L aspartic ratio by chemical method. The high D\L ratio was noted in younger age group and decreasing with age. It is presumptively related with environmental change.

Age estimation from the skeleton is thought to be less difficult for children. Many parts of the skeleton have been analyzed to estimate age at death, cranial suture closure and pubic symphyseal metamorphosis have been most favored skeletons (79, 80).

CHAPTER II

LITERATURE REVIEW

Skeletal cartilage

Cartilage is typically composed of largely of water (high water content of cartilage accounts for its resilience, that is, its ability to spring back to its original shape after being compressed), dense network of collagen fibers predominantly contains type II collagen, elastic fibers strongly embedded in chondroitin sulfate and amorphous ground substance. Mature cartilage cells or chondrocytes are filled in lacunae in the matrix. The cartilage contains no nerve and blood vessel except for perichondrium (surface of cartilage). Perichondrium acts like a girdle to resist outward expansion when the cartilage is compressed. It is capable of end using more stress than connective tissue. There are three types of cartilage tissue in the body, all types have the same basic component. The cells of mature cartilage are called chondrocytes, encased in small cavities (lacunae) with an extracellular matrix containing a jellylike ground substance and fiber. Three types of cartilage are as follows:

1. Hyaline cartilage, it is also called gristle, containing resilient gel as its ground substance (bluish-white and shiny substance), chondrocytes appear spherical and the only fiber type in their matrix is collagen fiber, it looks like frosted glass when freshly exposed. It provides support, flexibility, resilience, reduced frictions and absorb shock

at joint. It is the weakest of the three types of cartilage. It is the most abundant cartilage in the body. They include articular cartilages which cover the bone ends at movable joints, costal cartilage which connects the rib to the sternum, laryngeal cartilage which form the skeleton of the larynx, tracheal and bronchial cartilage which reinforce other passage ways of respiratory system, nasal cartilage which support the external nose.

2. Fibrocartilage: there are roughly parallelled rows of chondrocytes scattered among bundles of collagen fibers within the matrix. It's highly compressible and has great tensile strength, rigidity and is the strongest. They occurs in sites that are subjected to both heavy pressure and stretch.

3. Elastic cartilage: chondrocytes are in a thread-like network of elastic fibers within the matrix, It looks very much like hyaline cartilage, however, it contains more stretchy elastic fibers and better able to stand up to repeated bending. The flexible elastic cartilages are found in only two skeletal location; external ear and forming the epiglottis. So, it has strength, elasticity and maintains the shape of certain organ (50).

Cartilage formation.

The cartilage formation begins with the appearance of centers of chondrification, at first, the centers of chondrification represent little more than mesenchymal condensations. Soon, however, the chondroblast cells in the centers of chondrification secrete the extracellular matrix characteristic of cartilage. As chondroblasts become entrapped in the extracellular matrix that they secrete, they are now known as chondrocytes. As this entrapment occurs, cartilage begins to form. Later, the cartilage grows by two processes as follows:

1. Interstitial growth: cartilage increase rapidly in size by the division of existing chondrocytes and deposit increase amounts of matrix. It causes the cartilage to expand from within and this pattern occurs in young and pliable (childhood and adolescence).

2. Appositional growth: it occurs at inner chondrogenic layer of the perichondrium. The formation, first, the fibroblasts divided and differentiated into chondroblast respectively. Resulting in accumulation of the matrix on the surface of cartilage. A new layer formed under the perichondrium causing its growth in width. This pattern starts later than endogenous growth and it occurs through the adolescence (57).

With aging, the cartilage tends to calcify, there have mineralization, the cartilage changes into bone and chondrocytes will die (50).

Joint

They are classified in to three types on the basis of their structural features as follow:

1. Fibrous joints (synarthroses). This joint has little mobility, they have a relatively simple development, they are formed from mesenchymal cells and connected by fibrous connective tissue, consisted of sutures and syndesmoses.

2. Cartilaginous joints. There are two types as follow:

2.1 Synchondroses (primary cartilaginous joints) are united by hyaline cartilage. They permit no movement but growth in the length of bone. They include epiphyseal plates(the union between the epiphysis and the diaphysis of a growing bone), spheno-occipital and manubrio- sternal synchondroses (76, 81).

Costochondral junction: the junction between ribs and costal cartilage. It is cartilaginous joints. No movement is possible(77).

2.2 Symphyses (secondary cartilaginous joints) are joined by a plate of fibrocartilage and slightly moveable joint. They include the pubic symphysis (symphysis means grow together) and the intervertebral disks (union between the bodies of the vertebrae).

3. Synovial joints. They are joints of great free movement, this joint consists of joint cavity, an articular cartilage, synovial membrane and articular capsule. They are classified base on axis of movement into plane, that are hinge, pivot, ellipsoidal, saddle and ball-socket joints (76, 81).

Ribs

They develop from secondary sclerotomes (the skeletal forming portions of somites, each sclerotome will contribute to the formation of the vertebrae, intervertebral discs, ribs and sternum of the axial skeleton), during subsequent development, the cartilaginous vertebral body differentiating from each secondary sclerotome will develop on three pairs of processes: neural arch, transverse and costal processes. Ribs or costal process, they grow ventrolaterally into the primitive body wall (somatopleura) with other somite derivatives and to give rise to the rib (57, 81).

Rib is a flat bone (this bone consists of two layers of compact bone separated by spongy bone and marrow), it has articular sufaces that are covered with cartilage of fibrous tissues and grow with replacement of connective tissue. The thin outer portion of bone possesses a large medullary cavity with an abundant blood supply. They are composed of twelve pairs, forming the flaring sides of the thoracic cage, all ribs attach

posteriorly to the thoracic vertebrae and curve inferiorly toward the anterior body surface. They are classified into three types:

1.True ribs, they are composed of upper seven pairs, their individual costal cartilage articulate with the sternum.

2. False ribs, their costal cartilage either attach indirectly to the sternum or do not attach to the sternum at all. The cartilage of eighth, ninth, and tenth pairs of ribs attach to each other and then to the cartilage of the seven pairs of ribs.

3. Floating ribs, they are composed of pairs of eleventh and twelfth ribs. Their anterior ends do not attach to the sternum. Instead they terminate in the abdominal muscle. They attach only posteriorly to the thoracic vertebrae (57).

Ribs may be classified into two types. i. e typical and atypical ribs:

1. Typical ribs, they are bowed flat bone, the bulk of a rib is called the shaft, superior border is smooth, inferior border is sharp and thin, with a costal groove on its inner face that lodges the intercostal nerves and blood vessels. Each rib consists of the following parts beginning at the articulation with the vertebral column(57).

The head: there are two facets that articulate with facets on the bodies of adjacent thoracic vertebra. A bony crest separates the inferior and superior articulating facet on the head of rib. The crest is attached to the intervertebral disc that lie between the body of the corresponding vertebra and the body of the vertebra above the rib.

The neck: it is parallel to the transverse process of the corresponding thoracic vertebra. An articulating tubercle on its posterior surface articulates with the transverse process of the vertebra. They have a crest that provide attachment for the superior costotransverse ligament. The dorsal rami of the intercostal nerves pass into

the muscle of the back below the neck of the ribs and sympathetic trunk lies on the anterior surface of the neck of rib.

The body: it is the main part of rib. A short distance beyond the tubercle, there is an abrupt change in a curvature of the shaft, this point is called costal angle.

The costal groove: this lies on the under surface of each rib and contains an intercostal vein, artery and nerve.

2. Atypical ribs: they are composed of first, second, eleventh and twelfth pairs of ribs.

First ribs: they are flattened in conformity to contour of upper thorax, quite broad with attachment areas for anterior and middle scalenes and grooves for subclavian vessels on upper surface.

Second ribs: they are transitional in form, with areas of attachment of posterior scalene muscle.

Eleventh and twelfth ribs: they are short, lacking tubercles for articulation with transverse processes and slight, if any, grooves for intercostal nerves and vessels (57).

Siding and sequencing of human ribs

Correct siding and sequencing of human ribs in anatomical position are essential to any physical/ forensic anthropology and medicolegal examination. The essential and destination of placing ribs in anatomical position are for:

1. Determine the number of individuals represented.

2. Match stab marks and gunshot wounds in clothing with the corresponding underlying ribs.

3. Provide information on the minimum number of puncture wound to the thoracic region.

4. To apply techniques for determining age at death using cartilaginous and osseous changes in the sternal end of the ribs.

5. Match premortem broken rib with dry bone specimens to confirm a positive personal identification base on premortem medical record(87).

When placing the human ribs in anatomical order, ribs are increased in length from the first through the seventh ribs and decreased from the eighth through the twelfth. The first, eleventh and twelfth ribs have a single articular facet while the second through the tenth ribs have double articular facets. The third through tenth ribs showed similar features and are called typical ribs. So, the first, second, eleventh and twelfth ribs are atypical. The typical ribs are composed of head with costal facet, neck, crest of neck(4^{th} -9^{th}), articular facet, tubercle (articular with transverse process of vertebrae), angle and costal groove.

An observation to siding of human ribs showed:

1. Superior edge is blunt and round while the inferior edge is sharp, the head that attaches to the vertebra is cupped end.

2. The outer surface of rib is convex and smooth while inner surface is somewhat irregular and has costal groove. The costal groove is inside the convexity of the rib (the costal groove is deepest and most prominent nearest the spine and gets shallower as it approaches the sternal end). When in this position, the convexity of the rib bends to the correct side (87).

Determining the sequence of human ribs.

After siding the ribs, lay them out in approximate anatomical order beginning with the smallest "C-shaped" rib (first rib) an ending with the shortest, straightest rib (twelfth rib). The heads of ribs 1, 2, 11, and 12 touch the table while the heads of ribs 3 through 10 are raised. Also note that the distance between the table and the heads of ribs 3 through 7 gradually increases while the distance for ribs 8 through 10 decreases, often resembling a bell-shaped curve. In most cases the head of rib 7 will form the "apex" of the bell-shaped curve by projecting above the other ribs. In some individuals the heads of ribs 7, 8, and 9 will be approximately equal in height.

Another trait useful in sequencing ribs is the relative size and shape of the head. The heads of ribs 1 through 4 are circular or ovoidal. The heads of ribs 5 through 7 are approximately equal in size and usually assume the shape of figure-eight. Generally, the inferior costal facet of ribs 8 and 9 are smaller than the superior costal facet. For ribs 11 and 12, each has a single, circular-shaped costal facet. Six other traits as the follows:

1. The shafts of ribs 3 through 6 are thick and rounded mediolaterally (i.e. internal to external surface, those of ribs 7 through 12 are narrower mediolaterally), usually with more prominent angles.

2. The distance from the tubercle near the articular facet to the angle (the roughened oblique line on the external rib surface for attachment of the ilio-costalis muscle) increases from ribs 4 through 11. Line up the articular facet tubercles by "stacking" the ribs on top of one another and comparing the relative position of the roughened line. This distance can also be obtained by measuring the length from the inferior costal facet (vertebral end) to the inferior point of angle, usually visible as a

small projection of bone on the inferior margin of the rib shaft. This feature proves to be the quickest and most accurate method for distinguishing complete and fragmentary ribs.

3. The costal groove is most prominent on ribs 5, 6, and 7.

4. Ribs 6, 7, and 8 are most similar in size and shape and are therefore the most difficult ribs to sequence. However, rib 7 will be the longest, followed by ribs 6 and 8. If the rib is fragmentary, determine its sequence using the position of the ilio-costalis line.

5. The sternal ends of rib 11 and 12 taper almost to a point.

6. The neck crest of rib 4 may or may not be separated from the single superior costal facet. Ribs 3 through 8 have a prominent neck crest that is separated from the upper margin of superior costal facet by a mild concavity. Rib 10 usually lacks a neck crest (87).

Human beings

There are four processes involving in human beings and all organisms from birth until death as follows:

1. Development process which is the process of changing of form and structure.

2. Growth process which is the process of an accumulation of substance resulting from balance of assimilation and dissimilation. There are many causes of growth process e.g. genetic factor, internal nutrition, etc. the growth stop will induce maturation and follows by aging process.

3. Maturation is the state in which reproductive function has been sufficiently established. Mature reproductive function is recognized as a beginning of the

maturation period which last until the start of aging with the decrease of activeness in life.

4. Aging process means a slowly and progressively degradation of a living organism as a whole, the causes of aging process are due to growth stop that induce degradation of living body with declined life function (60).

Many researchers applied the knowlesge on study of sequence of aging for age estimation especially changing of many parts of bone.

Age estimation using sternal rib end

Age estimation, using sternal rib end for assessment was first developed in 1984 by Iscan et al. (1-5), they found that sternal rib end are essential part of skeleton for age estimation. They developed two methods for assessment by using right fourth rib in white males and females, composed of component and phase method. The component method was based on morphological change of sternal rib end such as depth, pit shape, rim and wall configuration. They are composed of component I, II and III. Component I was the method of measuring pit depth, which was the formation and deepening of a cavity at sternal rib end by measuring the maximum depth using sliding caliper. Component II was the method of observing pit shape which involve in the changes in shape of pit, varying from no pit up to widely u-shape. Component III was the method of observing rim and wall configuration dealing with the change in the configuration of rim and wall of sternal rib end. Each component was divided into six stages depending on individual unique characteristic, the different of features can be used to estimate age at death. Intercostal variation and the different between sexes were two important factors in component method. For

phase method, they divided into nine phases base on morphological changes of sternal rib end. In phase analysis, they observed the costochondral junction with consideration of pit formation (shape and depth), and the change in the wall and rim surrounding the rib, including bone texture and density. This method was claimed to be reliable to use for age determination (1-5).

In 1993, Dudar JC. studied a technique for the identification of anatomical rib number and assessment of intercostal variation at the sternal rib end. This study indicated that using fourth sternal rib end for age estimation standard can be applied to other sternal rib end for estimating age at death when fourth rib was not available (85).

Afterward, in 2000, Oettle' AC and Steyn M. developed the Iscan's method for age estimation in south African black by phase analysis, they modified the content and age range of Iscan's method for suitable study in south African black, because they found that a tendency of maturation are at later age in this population. This study indicated that sternal rib end can be used for age estimation (6). Furthermore, in 2001, Yoder C. et al. Studied by examination of variation in sternal rib end morphology relevant to age assessment. They presented that the morphology of sternal end of right fourth rib gave accurate result analysis for age at death in both sexes. This technique was tested for its applicability on left and right II, III, V- IX. Tests were performed between phase scores obtained right and left ribs; right rib IV phase scores and scores obtained from the others in the right rib series; and between right rib IV scores and a composite score composed of the average of an individual's phase scores (omitting rib IV). Left ribs IV- IX were found not to vary significantly from their right counterparts. Although only right rib II was found to vary significantly from rib IV,

use of the other ribs in the series should be undertaken with caution due to questions concerning their statistical significance. A composite score is therefore recommended for use instead.

When age is increasing, metamorphosis of sternal end of rib will be increasing because the cartilage is more resistant to the effect of intermittent and pulsating pressure than bone, therefore, cessation of growth could render the sternal extremity of the rib susceptible to reshaping around the costal cartilage with which it articulates (1). The articular cartilage is resistant to compressive loads and is quite ductile. It is very fatigue resistant and is a viscoelastic tissue, the joints must also transmit load and be resistant to breakdown when load is applied across a joint over time, the fluid (synovial fluid) will flow away from the area of loading and indentation will occur. The bone has the capacity to change its structure over time, typically over months. These changes occurred in response to stress, age related changes of bone are both quantitative and structural. Osteoporosis of aging is particularly prominent in postmenopausal women with diminish bone density. Bone is resorbed more rapidly endosteally than it is laid down periosteally resulting in diminished quantity (58). There are many factors influence in aging pattern of rib and cartilage, for example, strenuous physical activity, endocrine disorder, chronic lung disease, hormonal production, diet, health and disease status, occupational, biochemical variation between individual, etc.(1-18).

There were many studies applying the sternal end of rib for age estimation in black and white population (1-6). To our knowledge, the study of metamorphosis at sternal end of rib has not been performed in Thailand. As we know that the metamorphosis of sternal end of rib are different among race, age, and sex, therefore,

we decided to perform the study applying the sternal end of rib for age estimation for Thai population. Hopefully, this study will be useful and applicable for medico-legal investigation in Thailand in the future.

CHAPTER III

METHODOLOGY

Research Design

Objective:

To study metamorphosis at sternal end of vertebrosternal ribs for age estimation in Thai population.

Specific objective:

Age estimation standard by using sternal end of ribs in Thai population.

Study Design

Population and sample:

- Target population:

Groups of Thai male and female bodies which were autopsied at Forensic Pathology Division, Forensic Medicine Department, Faculty of Medicine Siriraj Hospital and at Institute of Forensic Medicine, The Thai Royal Police, Bangkok, Thailand. They must be known of age, sex, race and cause of death. Bone diseases and other diseases which might effected bone were excluded from the study, such as AIDS, cancer, syphilis, bone deformity and rib fracture.

- Sample population:

The right fourth ribs at sternal side were collected from groups of Thai male and female bodies from Forensic Medicine Department, Faculty of medicine, Siriraj

Hospital and Institute of Forensic Medicine, The Thai Royal Police, Bangkok, Thailand, with known age, sex, race and cause of death. Total number of 245 ribs were obtained, the age and sex of the specimens are shown in table 1.

Table 1: Age distribution of both sexes.

Age interval (years)	Sex		Total	percent
	female	male		
< 20	7	13	20	8.2
20-25	6	36	42	17.1
26-30	4	24	28	11.4
31-35	5	21	26	10.6
36-40	7	24	31	12.7
41-45	4	20	24	9.8
46-50	5	14	19	7.8
51-55	0	12	12	4.9
56-60	6	12	18	7.3
61-65	3	4	7	2.9
66-70	1	3	4	1.6
71-75	5	5	10	4.1
>75	2	2	4	1.6
Total	55	190	245	100

Material:

The samples consisted of 245 specimens of right fourth ribs. All of those ribs were obtained at autopsy room. The ribs were removed by cutting the costocartilage

near sternum and cut the rib about 4-6 inches from chondrosternal junction. The soft tissue was removed from each rib and the number of each specimen is coded. Then the specimens were immersing in water about 4-6 weeks. Finally, all soft tissue including the costal cartilage were easily removed from the ribs by immersing them in warm water (about 70 °C) with detergent for 10-20 minutes, then cleaned and let them lay drying in sunlight about 2-3 days.

Method:

For age estimation, using sternal end of ribs based on metamorphosis of the features at costochondral junction.

Objective of analysis:

1. Consideration of the depth and shape of the depth.
2. Consideration of the rim and wall configuration.
3. Consideration of the quality of bone.

Method I: pit depth.

The method was developed by Iscan et al. (1). At sternal end of rib, the maximum depth of the pit was measured with vernier caliper calibrated to 0.02 mm. in term of millimeter unit, this measurement is taken where the distance between the base of pit and the adjacent anterior or posterior wall is greatest. The vernier caliper was held perpendicular to the base of the pit. The cranial and caudal sides of the end of rib were not used because of the presence of long bone projections in some specimens were shown (1).

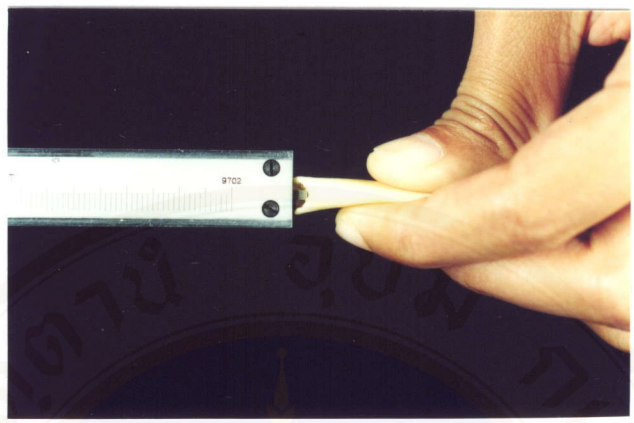


Fig. 1: Measurement of pit depth of rib.

This method is divided into the following seven stages.

Stages and appearance:

0: There is flat or slightly billowy extremity with no indentation greater than 1.1 mm.

1: There is definite pit formation with depth ranging from 1.1-2.59 mm.

2: Pit depth ranging from 2.6-4.59 mm.

3: Pit depth ranging from 4.6-7.09 mm.

4: Pit depth ranging from 7.1-10.09 mm.

5: Pit depth of 10.1 mm. or more.

6: The specimens which cannot be analyzed.

Method II: pit shape.

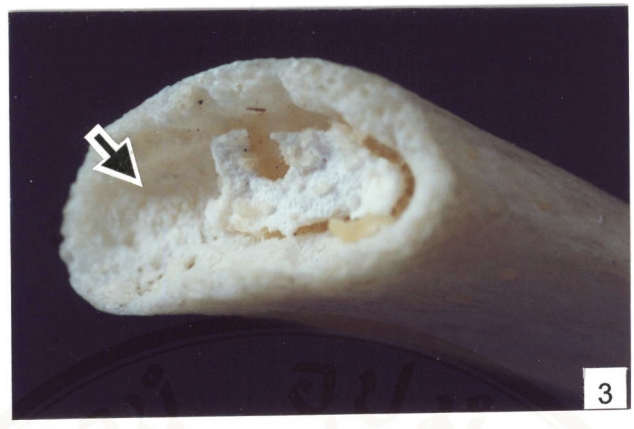
The method was developed by Iscan et al. It is involved in changing in the shape of the pit by observation at the sternal end of rib. This method is divided into six stages.

Stages and appearance:

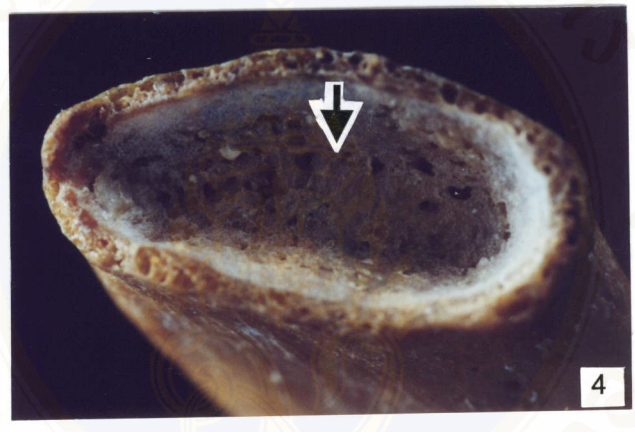
Stage 0: There is no pit formation at articular surface.

Stage 1: There is presence of pit formation, which is shallowed.

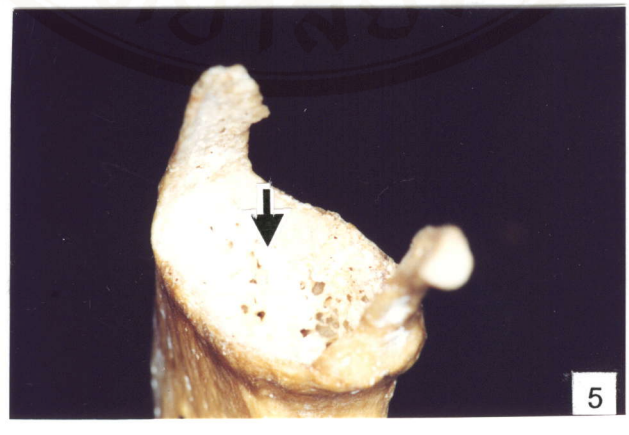
Stage 2: The pit presents with V-shape and thick wall.



Stage 3: The pit assumed a narrow U-shape and fairly thick wall.



Stage 4: The pit is wide U-shaped and thin walled.



Stage 5: The pit is still wider U-shaped and deeper, the texture of bone is poor, more brittle and most deteriorated.

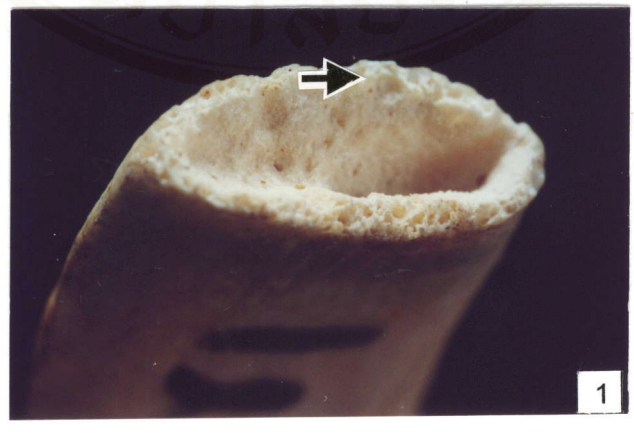
Fig. 2: Stages and appearance of pit shape method.

Method III: rim and wall configuration.

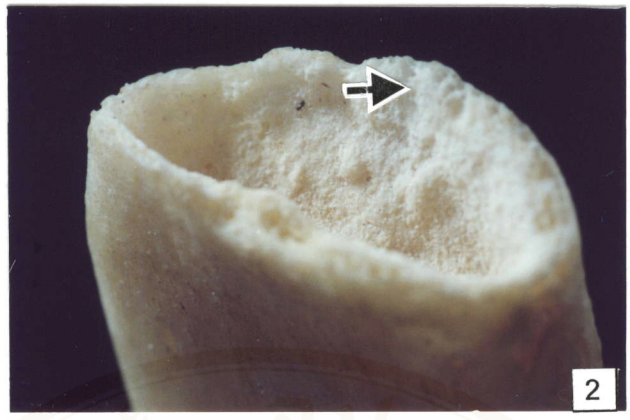
The method was developed by Iscan et al. It involved in the change in the configuration of rim and wall at the sternal end of rib. This method is divided into six stages.

Stages and appearance:

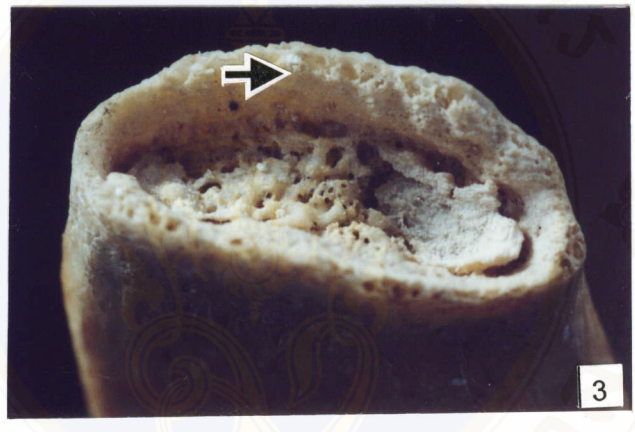
Stage 0: The specimen is smooth, rounded rim and no wall formation.



Stage 1: Rim is still smooth and round, the wall formation is beginning with shallowed pit.

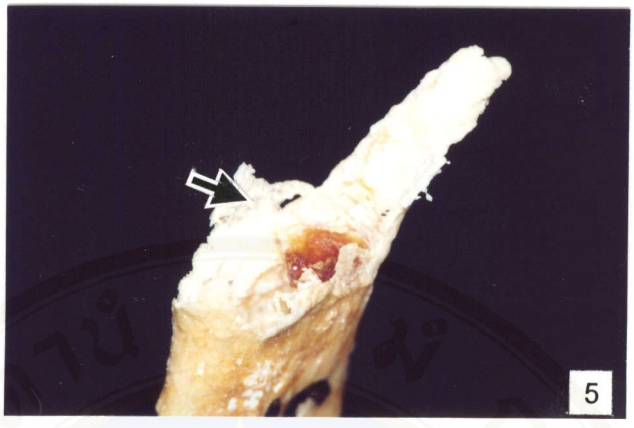


Stage 2: There is scalloped pattern or slightly rim with thick wall, the texture of bone is dense, good and smooth surface.



Stage 3: There is no scalloped pattern, rim becomes more irregular, wall is thinning but the texture of bone is still dense, good and smooth.

Stage 4: Rim has become sharper with increased irregularity, and thin walled, the bone texture is less dense, with noticeable deterioration. There is bony projection at cranial and caudal margins of the rib.



Stage 5: Rim is very sharp, highly irregular, there is long bony projection. Wall is very thin. The quality of bone is very poor.

Figure. 3: Stages and appearance of rim and wall configuration method.

Method IV: phase method.

The method was developed by Iscan et al. (2-3). Age estimation from sternal end of rib is separated into nine stages.

Stages and appearance:

Stage 0: Articular surface is flat or billowy with regular rim and rounded edge, bone itself is smooth and firm.

Stage 1: There is beginning of amorphous indentation at articular surface, with presence of billowing. Rim is rounded and regular, some cases have scalloped pattern. Bone is firm and smooth.

Stage 2: Pit is now deeper and assumed V-shape appearance form by anterior and posterior wall. Wall is thick and smooth. Rim is that of scalloped pattern or slightly wavy with rounded edge. Bone is firm and smooth.

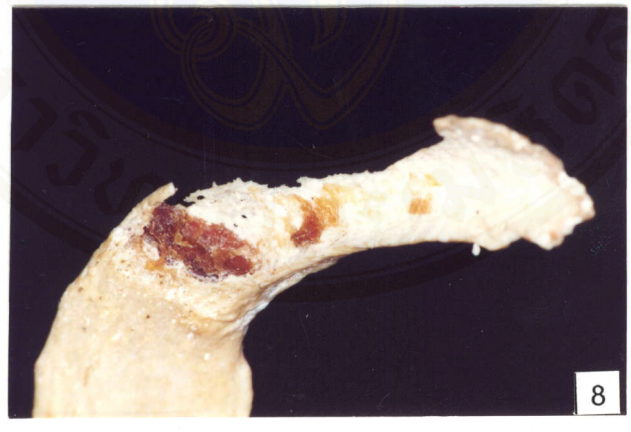
Stage 3: There is deepening pit (narrow to moderately U-shape), wall is still fairly thick with rounded edge. Some scalloped pattern may still be present. Rim has become more irregular, bone is still quite firm and smooth.

Stage 4: Pit depth is increasing, shape is still a narrow to moderately wide U, the wall is thinner but the edge remained rounded. Rim is more irregular with no scalloped pattern. The bone itself lost weight and firmness. The quality of bone is still good.

Stage 5: There is little change in pit depth, moderately wider U-shape. Wall shows further thinning, the edge becomes sharp. Rim shows increased irregularity. No scalloped pattern is seen in this stage, there is bony projection presence in some cases. The bone is fairly good but it has some sign of deterioration with evidence of porosity and loss of density.

Stage 6: Pit is noticeably deep with wider U-shape. The wall is thin with sharp edge. Rim is irregular and exhibit bony projection. The bone is noticeably lighter in weight, thinner and more porous especially inside of the rib.

Stage 7: Pit is deep with wide to very wide U-shaped. The wall is thin, sharp and fragile. The edge is irregular, with presence of bony projection. The bone islight in weight, the quality of bone is brittle with significant deterioration and obvious porosity.



Stage 8: Pit is very deep and widely U-shaped, the floor of the pit is absent or filled with bony projection in some cases. The wall is extremely thin, fragile, brittle and sharp. There is increasing irregular edge with long bony projection. The bone itself is light in weight, thin, brittle, friable and more porous, therefore, the quality of bone is very poor

Fig. 4: Stages and appearance of phase method.

Method V: depth of pit.

Measurement of the pit depth in sternal end of rib. The maximum depth of the pit is measured with vernier caliper calibrated to 0.02 mm. Each rib was measured for pit depth in term of millimeter unit. This measurement is taken where the distance between the base of pit and adjacent anterior or posterior wall is greatest, the vernier caliper is held perpendicular to the base of the pit. The cranial and caudal side of the rib are not used because of the presence of long bone projections are shown in some specimens.

Method VI: the width of rib.

Measurement the of width in sternal end of rib is performed, by using vernier caliper calibrated to 0.02 mm. Each rib is measured for the width in term of centimeter unit. The maximum width of the rib is taken where the distance between the upper and lower border is greatest which is about 1 inch from the end of rib, the vernier caliper is held perpendicular to the rib.

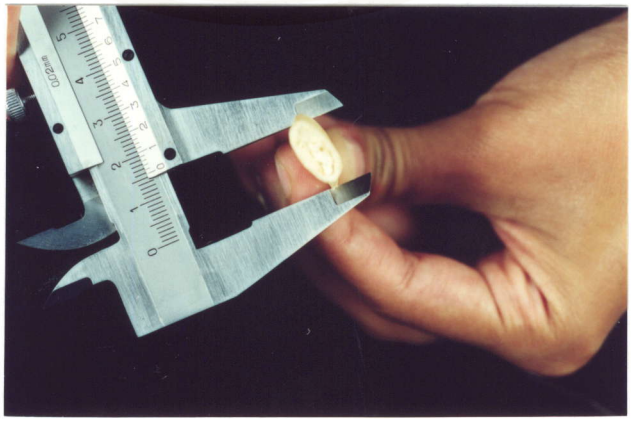


Fig. 5: Measurement of the width of rib.

Method VII: the thickness of rib.

Measurement the thickness at sternal end of rib is performed by using vernier caliper calibrated to 0.02 mm. Each rib is measured for the thickness in term of centimeter unit. The maximum thickness is taken where the distance between anterior (skin side) and posterior (lung side) wall is greatest which is about 1 inch from the end of rib, the vernier caliper is held perpendicular to the rib.

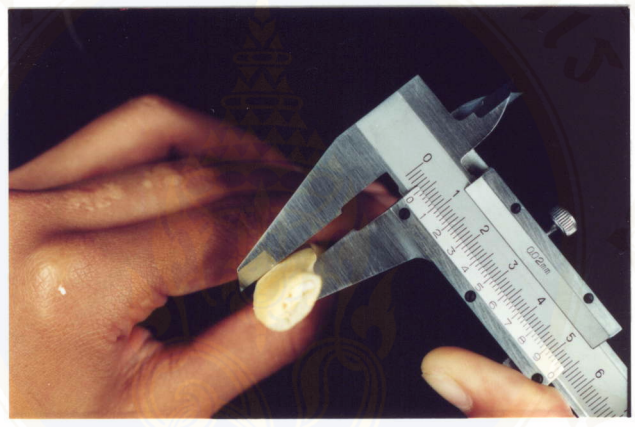


Fig. 6: Measurement of the thickness of rib.

CHAPTER IV

RESULT

Study of metamorphosis at sternal rib end was performed in 245 right fourth ribs by seven methods for estimating age at death, using descriptive statistics and ONE WAY analysis of variance for age assessment. The CROSSTABS procedure was carried out to assess the statistical significance of the distribution of individual by age and each method consisted of pit depth, pit shape, rim and wall configuration, phase method, respectively. ONE WAY analysis of variance was carried out to evaluate the statistical significance of the distribution of individual by age and depth, width and thickness of sternal ribs end, respectively. The results of each method revealed as follows:

Method I: pit depth.

The distribution of specimens according to pit depth was based on the depth of sternal ribs. Initially, the pit is flat or billowy, then, it is merely an amorphous. Afterwards, there are variations of the pit depth. The CROSSTABS procedure was carried out to evaluate the statistical significance of them by age and pit depth. The result of this method attained significant value. The Pearson chi-square had been shown that the variation between stages of pit depth was statistically significant in all age intervals at a probability level less than 0.001.

Table 2: the result of pit depth in each age interval.

Age interval (Years)	Pit depth							Total
	0	1	2	3	4	5	6	
< 20	13	7						20
20-25	2	26	14					42
26-30	2	18	8					28
31-35	1	10	12	2			1	26
36-40		11	13	1			6	31
41-45		5	11	4			4	24
46-50		2	7				10	19
51-55			6				6	12
56-60		2	5				11	18
61-65	1	1	1				4	7
66-70			2				2	4
71-75		2		1	1	1	5	10
> 75							4	4
Total	19	84	79	8	1	1	53	245

Method II: pit shape.

The distribution of specimens according to pit shape was based on the shape of pit depth of sternal rib. It begins from no shape of the pit, then the pit appears as shallow, amorphous pit. Next, it shows V-shape to wider U-shape and more deepening of the pit. The CROSSTABS procedure was carried out to assess. The statistical significance of them by age and pit shape of this method has been shown significant value, the Pearson chi-square showed that the variation between stages of pit shape was statistically significant in all age intervals at a probability level less than 0.001.

Table 3: the result of pit shape in each age interval.

Age interval (years)	Pit shape						Total
	0	1	2	3	4	5	
< 20	11	5	4				20
20-25		8	12	19	3		42
26-30		1	2	21	4		28
31-35				9	13	4	26
36-40		1			29	1	31
41-45					24		24
46-50					18	1	19
51-55					10	2	12
56-60					16	2	18
61-65					6	1	7
66-70					2	2	4
71-75			2		2	6	10
> 75					2	2	4
Total	11	15	20	49	129	21	245

Method III: rim and wall configuration.

The distribution of specimens according to rim and wall configuration was based on changes in the features of rim and wall of the pit at sternal rib end. The rim starts out as a smooth, regular border around the pit, next, it is rapidly assumed a scalloped pattern or slightly wavy rim. Finally, with advancing age the rim is more irregular, sharp and fragile. The wall begins from no wall formation, when the pit starts to

appear, it shows thick wall, when age is increasing, it shows more thin, sharp and irregularity. The CROSSTABS procedure was carried out to evaluate the statistical significance of them by age and configuration of rim and wall. The result of this method attained significant value. The Pearson chi-square showed that the variation between stages of rim and wall configuration was statistically significant in all age intervals at a probability level less than 0.001.

Table 4: the result of rim and wall configuration in each age interval.

Age interval (years)	Rim and wall configuration						Total
	0	1	2	3	4	5	
< 20	11	5	4				20
20-25		7	12	21	2		42
26-30		1	2	22	3		28
31-35				13	11	2	26
36-40		1		3	26	1	31
41-45				4	20		24
46-50				7	11	1	19
51-55				5	6	1	12
56-60				1	14	3	18
61-65				1	5	1	7
66-70				1	1	2	4
71-75			2		2	6	10
> 75					2	2	4
Total	11	14	20	78	103	19	245

Method IV: phase method.

The distribution of specimens phase was based on changes note in the shape, pit depth, forms, texture and quality of the sternal rib end. The morphology of sternal rib end begins with flat or billowy articular surface, rounded edge, no wall formation, the texture and quality of bone is good. Initially, the pit is merely an amorphous, next, there is indentation between anterior and posterior wall shown on a V-shape. With increasing age, the pit is becoming wider and deeper. Along with the pit, the rim begins from a regular, rounded border, scalloped or slightly wavy pattern, it shows fairly regular edge, on over the years, it is increasingly sharp and irregular. The texture and quality of bone itself start from dense, smooth, and firm. When age is increasing, there is appearance the deterioration of bone such as thinning, brittle, fragile, porous and more deteriorate in elderly. The CROSSTABS procedure was carried out to evaluate the statistical significance of them by age and phases, this analysis have been shown that the variation between phases was statistically significant in all age intervals at a probability level less than 0.001.

Table 5: the result of phase method in each age interval.

Age interval (years)	phases									Total
	0	1	2	3	4	5	6	7	8	
< 20	12	4	4							20
20-25		8	12	18	4					42
26-30		1	1	23	3					28
31-35				8	9	3	3	3		26
36-40		1			6	15	8	1		31
41-45					2	8	14			24
46-50						10	9			19
51-55					1	6	3	2		12
56-60						4	11	1	2	18
61-65						4	2		1	7
66-70						2			2	4
71-75			2			1	1		6	10
➢ 75								2	2	4
Total	12	14	19	49	25	53	51	9	13	245

Method V: depth of pit.

There were only 184 specimens of right fourth ribs available for evaluation by this method to measure the depth of pit in each rib. ONE WAY analysis of variance was carried out to evaluate them. The results were calculated for mean, standard deviation, standard error, minimum, maximum and 95% confident interval for mean

of the pit depth. ONE WAY analysis of variance indicated that the difference between age interval is statistically significant at $P < 0.001$ level.

Table 6: the result of the depth of pit in each age interval.

Age Interval (years)	N	Mean (mm)	Std. Deviation (mm)	Std. Error (mm)	95%Confidence Interval for mean		Min. (mm)	Max. (mm)
					Lower Bound	Upper Bound		
< 20	12	1.138	.049	.014	.082	.145	.46	2.00
20-25	42	2.164	.078	.012	.192	.240	.50	4.00
26-30	28	2.168	.076	.014	.187	.246	.16	3.64
31-35	25	2.828	.098	.019	.242	.323	.56	4.90
36-40	25	2.719	.089	.018	.234	.308	1.18	4.72
41-45	20	3.465	.119	.027	.290	.402	1.5	5.54
46-50	9	3.069	.097	.032	.232	.381	1.14	4.08
51-55	6	3.743	.036	.014	.336	.411	3.30	4.28
56-60	7	3.277	.073	.027	.260	.395	2.24	4.12
61-65	3	1.626	.124	.071	-.146	.472	.70	3.04
66-70	2	3.040	.051	.036	-.153	.761	2.68	3.40
71-75	5	8.268	.949	.424	-.351	2.005	1.48	24.62
Total	184	2.709	.198	.014	.242	.148	.16	24.62

Method VI: The width of rib.

There were 245 specimens of right fourth rib. Each rib was measured for the width. ONE WAY analysis of variance was carried out to assess them. The results were calculated for mean, standard deviation, standard error, minimum, maximum and 95% confident interval for mean of the width of ribs. It indicated that the difference between age intervals is statistically significant at $P<0.001$ level.

Table 7: the result of rib width in each age interval.

Age Interval (years)	N	Mean (cm)	Std. Deviation (cm)	Std. Error (cm)	95%Confidence interval for mean		Min. (cm)	Max. (cm)
					Lower Bound	Upper Bound		
< 20	20	1.426	.324	.072	1.094	1.398	.636	1.688
20-25	42	1.545	.188	.029	1.487	1.604	1.134	1.980
26-30	28	1.634	.196	.037	1.559	1.710	1.206	1.900
31-35	26	1.656	.165	.032	1.589	1.723	1.310	1.978
36-40	31	1.552	.202	.036	1.478	1.626	1.172	1.952
41-45	24	1.636	.197	.040	1.553	1.720	1.286	2.060
46-50	19	1.616	.221	.050	1.510	1.723	1.152	1.930
51-55	12	1.707	.233	.067	1.559	1.855	1.408	2.130
56-60	18	1.620	.186	.044	1.528	1.713	1.274	2.038
61-65	7	1.475	.185	.069	1.304	1.646	1.258	1.864
66-70	4	1.938	.460	.230	1.205	2.669	1.628	2.618
71-75	10	1.597	.292	.092	1.388	1.806	1.150	2.078
> 75	4	1.695	.162	.081	1.437	1.952	1.466	1.832
Total	245	1.581	.244	.016	1.549	1.611	.636	2.618

Method VII: The thickness of rib.

There were 245 right fourth ribs. Each rib was measured for the thickness. ONE WAY analysis of variance was carried out to evaluate them. The results were calculated for mean, standard deviation, standard error, minimum, maximum and 95% confident interval for mean of the thickness of ribs. It indicated that the difference between age intervals is statistically at $P<0.05$ level.

Table 8: the result of thickness of the rib.

Age Interval (years)	N	Mean (cm)	Std. Deviation (cm)	Std. Error (cm)	95% Confidence Interval for Mean		Min. (cm)	Max. (cm)
					Lower Bound	Upper Bound		
< 20	20	.346	.076	.017	.309	.381	.226	.500
20-25	42	.402	.071	.011	.380	.424	.240	.530
26-30	28	.419	.098	.018	.381	.458	.266	.688
31-35	26	.428	.100	.019	.387	.469	.198	.658
36-40	31	409	.093	.017	.374	.444	.240	.600
41-45	24	.460	.087	.018	.423	.496	.292	.636
46-50	19	.425	.058	.013	.396	.453	.272	.518
51-55	12	.433	.102	.029	.368	.497	.272	.676
56-60	18	.422	.105	.025	.370	.457	.266	.628
61-65	7	.413	.119	.045	.303	.532	.300	.560
66-70	4	.401	.068	.033	.294	.509	.304	.462
71-75	10	.348	.070	.022	.298	.399	.272	.492
> 75	4	.322	.091	.045	.177	.467	.238	.438
Total	245	.410	.092	.059	.399	.422	.198	.688

CHAPTER V

DISCUSSION

This study shows the result of age assessment in two hundred and forty-five right fourth ribs, one hundred and ninety of these ribs were from male individual and fifty-five from female individual. Their age range was between 0-80 years. Age estimation was based on the morphology at sternal end of ribs. Seven methods were performed for age estimation standard in Thai population. The methods consist of pit depth, pit shape, rim and wall configuration, phase, the depth of pit, the width of rib, and the thickness of rib. The result of each method was shown in table 2, 3, 4, 5, 6, 7, and 8, respectively. When analyze in each method for age estimation standard in Thai population, it was found that each individual method cannot be used to predict for specific age, because of the overlapping between the age interval and it cannot be applied for age estimation standard in high reliability. Therefore, each method which reveal high frequency of sample will be analyzed in each age interval as follow:

Table 9: The stage of high frequency of population with each age interval of pit depth method (from table 2).

Age interval(years)	Stage of pit depth
< 20	0
20-25	1
26-30	1
31-35	1-2
36-40	1-2

Table 9(continue)

41-45	2
46-50	2-6
51-55	2
56-60	5
61-65	6
66-70	6
71-75	1-6
>75	6

Stage 0,1 and 2 of pit depth are shown in early age group up to age range between 51-55 years, stages 3 and 4 are not present in our specimen, while stage 6 of pit depth is seen in age range of 61 and up. The appearance of flat or slightly billowy extremity with no indentation greater than 1.1 mm. is seen in population less than 20 years old.

Definite pit formation with depth ranging from 1.1-2.59 mm. is seen in age interval of 20-40 years.

Pit depth ranging from 1.1-4.59 mm. is found between age interval of 31-40 years.

Pit depth ranging from 2.6-4.59 mm. is found in age range of 41-45 and 51-55 years.

Pit depth of 10.1 mm. or over is found in age range of 55-60 years.

The appearance of the specimen which cannot be analyzed is found in age range of 46-50, 61-65, 66-70, and 71-80 years.

Most of the specimens from over sixty years old cannot be analyzed because the cartilage is filled with base of pit, the reason of this phenomena is due to calcification of cartilage when age is increasing. This method shows high overlapping of age range. It can roughly be applied for age estimation with low confident value.

Table 10: stage of high frequency of population with each age interval of pit shape method (from table 3).

Age interval (year)	Stage of pit shape
< 20	0
20-25	2-3
26-30	3
31-35	4
36-40	4
41-45	4
46-50	4
51-55	4
56-60	4
61-65	4
66-70	4-5
71-75	4-5
>75	4-5

In considering stages of pit shape, there is no pit formation at articular surface in the group of less than 20 years old.

The age range of 20-25 years reveals the pit with V-shape to a narrow U-shape and thick wall to fairly thick wall.

The age range of 26-30 years shows that the pit assumes a narrow U-shape and fairly thick wall.

The age range of 31-65 years shows that the pit is wide U-shape with thin wall.

The age range of 66-80 years shows that the pit is wide to wider U-shape and thin wall, the texture of bone is poor, more brittle and most deteriorated.

Characteristics of stage 4 are found in wide age range from 31-70 years, therefore, this method is not appropriate for age estimation.

Table 11: the stage of high population with each age interval of rim and wall configuration (from table 4).

Age interval (year)	Stage of rim and wall configuration
< 20	0
20-25	3
26-30	3
31-35	3-4
36-40	4
41-45	4
46-50	4
51-55	3-4
56-60	4
61-65	4
66-70	5
71-75	5
>75	4-5

Consideration of the features of rim and wall at sternal end of rib reveals that the specimens from population of less than 20 years old show smooth with rounded rim and no wall formation.

The age interval of 20-30 years shows no scalloped pattern, rim become more irregular, but the texture of bone is still dense, good and smooth.

The age interval of 31-35, and 51-55 years show the same finding as in the age range of 20-30 years and rim becomes sharper with increased irregularity and thin

walled, the bone texture is less dense with noticeable deterioration, there is bony projection at cranial and caudal margins of rib.

The age range of 36-65 years except for age group of 51-55 years show that rim becomes sharper with increased irregularity and thin walled, the bone texture is less dense with noticeable deterioration, there is bony projection at cranial and caudal margins of rib.

The age range of 66-80 years shows that rim becomes sharper with increased irregularity and thin walled, the bone texture is less dense with noticeable deterioration, there is bony projection at cranial and caudal margins of rib.

This method discloses high overlapping of age, it shows wide age range. Therefore, it cannot be used to predict specific age as well as pit depth and pit shape method.

Table 12: Stage of high frequency of population with each age interval of phase method (from table 5).

Age interval (year)	Stage of phase method
<20	0
20-25	2-3
26-30	3
31-35	3-4
36-40	5
41-45	6
46-50	5-6

Table12 (continue)

51-55	5
56-60	6
61-65	5
66-70	5-8
71-75	8
>75	7-8

Most of population with age less than 20 years, the appearance of articular surface is flat or billowy with regular rim and rounded edge, bone itself is smooth and firm.

The age range of 20-25 years reveals both stages 2 and 3. Stage 2 shows that pit is deeper and assume V-shape appearance of anterior and posterior wall, wall is thick and smooth, rim shows scalloped pattern or slightly wavy with rounded edge, bone is firm and smooth. Stage 3 reveals deepening pit (narrow to moderately U- shape), wall is still fairly thick with rounded edge, some scalloped pattern might still be present, rim becomes more irregular, the bone is still quite firm and smooth.

The age range of 26-30 years shows deepening pit (narrow to moderately U-shape), wall is still fairly thick with rounded edge, some scalloped pattern might still be present, rim has become more irregular, the bone is still quite firm and smooth.

The age range of 31-35 years reveals both stages 3 and 4. Stage 3 shows deepening pit (narrow to moderately U-shape), wall is still fairly thick with rounded edge, some scalloped pattern might still be present, rim become more irregular, the bone itself is still quite firm and smooth. Stage 4 show that pit depth is increasing, shape is still a narrow to moderately wide U, the wall is thinner but the edge remains

rounded, rim is more irregular with no scalloped pattern, the bone itself loses weight and firmness, the quality of bone is still good.

The age range of 36-40, 51-55, and 61-65 years disclose stage 5, showing little change in pit depth, moderately wider U-shape, wall shows further thinning, the edge becomes sharp, rim shows increased irregularity, no scalloped pattern is found in this stage, there is bony projection in some cases, the bone is fairly good but shows some sign of deterioration with evidence of porosity and loss of density.

The age range of 41-45, and 56-60 years disclose stage 6 and shows that pit is noticeably deep with wider U-shape, the wall is thin with sharp edge, rim is irregular and exhibited bony projection, the bone is noticeably lighter in weight, thinner and more porous especially inside of rib.

The age range of 46-50 years reveals both stages 5 and 6. Stage 5 shows little change in pit depth, moderately wider U-shape, wall shows further thinning, the edge becomes sharp, rim shows increased irregularity with no scalloped pattern in this stage, there is bony projection in some cases, the bone is fairly good but shows some sign of deterioration with evidence of porosity and loss of density. Stage 6 shows that pit is noticeably deep with wider U-shape, the wall is thin with sharp edge, rim is irregular and exhibited bony projection, the bone is noticeably lighter in weight, thinner and more porous especially inside of ribs.

The age range of 66-70 years reveals stages 5 and 8. Stage 5 shows little change in pit depth, moderately wider U-shape, wall shows further thinning, the edge becomes sharp, rim shows increased irregularity with no scalloped pattern in this stage, there is bony projection in some cases, the bone is fairly good but shows some sign of deterioration with evidence of porosity and loss of density. Stage 8 shows that

pit is very deep and widely U-shape, some cases show absence of the floor of the pit, the wall is extremely thin, fragile, brittle and sharp, there is increasing irregular edge with bony projection, the bone itself is light in weight, thin, brittle, friable and more porous, so, the quality of bone is very poor.

The age range of 71-75 shows only stage 8, but age over 75 years shows both stages 7 and 8. Stage 7 shows that pit is deep with wide to very wide U-shape, the wall is thin, sharp and fragile, the edge is irregular, with bony projection. The bone is light in weight, the quality of bone is brittle with significant deterioration and obvious porosity. Stage 8 reveals that pit is very deep with widely U-shape, some cases show absence of the floor of the pit, the wall is extremely thin, fragile, brittle and sharp, there is increasing irregular edge with bony projection, the bone itself is light in weight, thin, brittle, friable and more porous.

In conclusion, the phase method includes the consideration of pit depth, pit shape, rim and wall configuration and the quality of bone at sternal end of rib. The result shows more specific age than considering individual pit depth, pit shape and rim and wall configuration methods, respectively. However, overlapping result is still prominent in age group of 4^{th} decades and up.

Tables 6, 7, and 8 which consider for mean and standard deviation of depth of pit, width of ribs and thickness of ribs, respectively. The result reveals no different value of mean and standard deviation for age estimation by these three methods. Therefore, these three methods cannot be applied for age estimation standard for Thai population. The other four methods which consist of pit depth, pit shape, rim and wall configuration and the phase method, when consider in each method, the study reveals some rough result for age estimation, and when all four methods are considered in

combination in each age interval, the result shows more confident value as shown in table 13.

Table 13: Stage of high frequency of population in each age interval with each method (combined result of table 9, 10, 11, 12).

Age interval (years)	Stage of pit depth	Stage of pit shape	Stage of rim and wall configuration	Stage of phase
<20	0	0	0	0
20-25	1	2-3	3	2-3
26-30	1	3	3	3
31-35	1-2	4	3-4	3-4
36-40	1-2	4	4	5
41-45	2	4	4	5-6
46-50	2-6	4	4	5-6
51-55	2	4	3-4	5
56-60	5	4	4	6
61-65	6	4	4	5
66-70	6	4-5	5	5-8
71-75	1-6	4-5	5	8
>75	6	4-5	4-5	7-8

The result from this table shows that the chance of age estimation standard in Thai population when using four methods to estimate age at death by right fourth sternal end of rib, the age at death may be predictable, if stage of pit depth, pit shape, rim and wall configuration, and phase method is in stage 0, this appearance assumes the age of less than 20.

Age interval of 20-25 years shows that the pit depth is in stage 1, pit shape is in stage 2 and 3, rim and wall configuration is in stage 3, and phase is in stage 2 and 3.

Age interval of 26-30 years shows that the pit depth is in stage 1, pit shape with rim and wall configuration and phase is in stage 3.

Age interval of 20-25 years shows that the pit depth is in stage 1 and 2, pit shape is in stage 4, rim and wall configuration and phase is in stage 3 and 4.

The age range of 36-40 years shows that pit depth is in stage 1 and 2, pit shape is in stage 4, rim and wall configuration is in stage 4, and phase is in stage 5.

The age range of 41-45 years shows that the pit depth is in stage 2, pit shape with rim and wall configuration are in stage 4 and phase is in stage 6.

The age range of 46-50 years shows that the pit depth is in stage 6, pit shape with rim and wall configuration are in stage 4, and phase is in stage 5 and 6.

The age range of 51-55 years shows that the pit depth is in stage 2, pit shape is in stage 4, rim and wall configuration is in stage 3 and 4, and phase is in stage 5.

The age range of 56-60 years shows that the pit depth is in stage 5, pit shape with rim and wall configuration are in stage 4, and phase is in stage 6.

The age range 61-65 years shows that the pit depth is in stage 6, pit shape with rim and wall configuration are in stage 4, and phase is in stage 6.

The age interval of 66-70 years shows that the pit depth is in stage 6, pit shape is in 4 and 5, rim and wall configuration is in stage 5, and phase is in stage 5 and 8.

The age range of 71-75 years shows that the pit depth is in stage 1 and 6, pit shape is in 4 and 5, rim and wall configuration is in stage 5, and phase is in stage 8.

In the age group of over 75, it shows that pit depth is in stage 6, pit shape is in 4 and 5, rim and wall configuration is in stage 4 and 5, and phase is in stage 7 and 8.

By using four combined methods for age estimation, the result shows more specific age interval, and more confidence for age estimation. However, this study cannot be a definite standard for age estimation in older age group from 4^{th} decades and up.

In this study, age change may not essentially be the same on both sides of ribs, and intercostal variation is important for age estimation. The true reasoning of

alteration at sternal end of ribs related with age is not known. It occurs by many factors, the main factor is aging process, and mechanism of physiology and biology of the human such as deterioration of bone when age is increasing, cartilage ossification, genetic influence, physical activity, respiration, chest expansion, nutritional disparity and the others. So, these factors may cause the changing at sternal end of rib when age is increasing.

CHAPTER VI

CONCLUSION and RECOMMENDATION

Age estimation in Thai population using sternal end of rib was studied in total number of two hundred and forty-five right fourth ribs for which one hundred and ninety were from Thai males and fifty-five from Thai females. Their age range was between 0-80 years. The use of sternal end of rib for age assessment is relatively easy to apply, it does not require special equipment or complicated method. The good reason for this is that the sternal end of rib is changing throughout life. The age estimation was based on the morphology at sternal end of ribs, seven methods were used for age assessment standard in Thai population. There were only four methods applicable, composed of pit depth, pit shape, rim and wall configuration, and phase method, respectively. Although these methods may be used for age estimation, but there is overlapping between the age range. Therefore, combination of four methods should be applied when sternal end of rib is used for age estimation, because combined four methods showed less overlapping result between age range than when only one method was applied.

However, this study cannot be a definite standard for specific and accurate age estimation for Thai population in all age range due to limitation of accuracy which mostly confined in young age group below 20.

Restriction of the study

1. The number of specimens was not large enough, especially in old age and female due to limited number of forensic cases of female and old age during the specimen collecting period.
2. It was designed for specific using of right fourth sternal end of rib only.
3. The study was applied for Thai population, especially in Thai male.

Recommendation

From this study, it is highly recommended that when using right sternal end of rib for age estimation in Thai population, combined four methods give higher confident value than using only one method. As mentioned above that the study of sternal end of rib may not be a definite standard for accurate age estimation in Thai population, but in some medicolegal cases which only the rib is available for investigation, this study may be a useful guideline of such investigation.

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APPENDIX

DATA

No.	Cases	Age (Years)	Sex	pitd	Pits	rim	phase	Depth (mm)	Width (cm)	Thick (cm)
1	f128	<20	f	0	0	0	0	.046	1.200	.230
2	f139	<20	f	0	0	0	0	.080	1.109	.310
3	f155	<20	f	0	0	0	0	.	1.490	.300
4	f17	<20	f	0	0	0	0	.	.636	.278
5	f51	<20	f	0	0	0	0	.	.726	.226
6	p1	<20	f	0	0	0	0	.064	1.000	.380
7	34	<20	m	0	0	0	0	.	.892	.236
8	46	<20	m	0	1	1	1	.050	1.600	.340
9	5	<20	m	0	0	0	0	.	1.030	.300
10	f103	<20	m	0	0	0	0	.	.734	.308
11	f12	<20	m	0	0	0	0	.	1.500	.358
12	f15	<20	m	0	0	0	0	.	1.192	.332
13	f67	<20	m	0	1	1	1	.080	1.464	.422
14	f95	<20	f	1	1	1	0	.128	1.580	.390
15	31	<20	m	1	2	2	2	.130	1.688	.420
16	64	<20	m	1	1	1	1	.168	1.470	.500
17	67	<20	m	1	2	2	2	.130	1.560	.450
18	f138	<20	m	1	1	1	1	.150	1.484	.452
19	f170	<20	m	1	2	2	2	.200	1.412	.354
20	f96	<20	m	1	2	2	2	.140	1.156	.330
21	57	>75	f	6	4	4	7	.	1.832	.352
22	f48	>75	f	6	4	4	7	.	1.466	.238
23	33	>75	m	6	5	5	8	.	1.782	.438
24	f150	>75	m	6	5	5	8	.	1.700	.262
25	7	20-25	f	0	1	1	1	.100	1.430	.276
26	f117	20-25	f	0	1	1	1	.050	1.134	.414
27	f119	20-25	f	1	1	1	1	.142	1.432	.488
28	f144	20-25	f	1	1	1	1	.140	1.300	.378
29	19	20-25	m	1	3	3	4	.180	1.554	.380
30	2	20-25	m	1	2	2	2	.210	1.760	.406
31	20	20-25	m	1	1	1	1	.114	1.624	.420
32	48	20-25	m	1	3	3	3	.170	1.700	.530
33	58	20-25	m	1	3	3	3	.190	1.756	.290
34	75	20-25	m	1	4	4	4	.116	1.810	.240
35	82	20-25	m	1	3	3	3	.220	1.574	.394
36	86	20-25	m	1	3	3	3	.220	1.754	.410

37	f126	20-25	m	1	4	3	4	.194	1.454	.384
38	f127	20-25	m	1	2	2	2	.156	1.814	.440
39	f131	20-25	m	1	3	3	3	.170	1.250	.370
40	f136	20-25	m	1	2	3	3	.250	1.364	.428
41	f143	20-25	m	1	1	2	1	.200	1.560	.304
42	f149	20-25	m	1	3	3	3	.128	1.432	.300
43	f23	20-25	m	1	3	3	3	.226	1.766	.336
44	f38	20-25	m	1	3	3	3	.174	1.740	.400
45	f79	20-25	m	1	2	2	2	.170	1.550	.470
46	f84	20-25	m	1	2	2	2	.150	1.520	.384
47	f85	20-25	m	1	3	3	3	.118	1.360	.336
48	f90	20-25	m	1	3	3	3	.246	1.620	.478
49	f93	20-25	m	1	1	1	1	.142	1.564	.360
50	p12	20-25	m	1	1	1	1	.184	1.524	.424
51	p14	20-25	m	1	3	3	2	.230	1.638	.498
52	p5	20-25	m	1	3	3	3	.246	1.600	.460
53	26	20-25	f	2	2	2	2	.400	1.260	.300
54	f105	20-25	f	2	2	2	2	.268	1.370	.510
55	16	20-25	m	2	3	3	3	.330	1.980	.442
56	f114	20-25	m	2	3	3	3	.276	1.392	.414
57	f132	20-25	m	2	3	3	3	.266	1.212	.438
58	f18	20-25	m	2	2	2	2	.260	1.464	.338
59	f32	20-25	m	2	4	4	4	.318	1.440	.478
60	f43	20-25	m	2	3	3	3	.344	1.700	.500
61	f63	20-25	m	2	3	3	3	.256	1.606	.486
62	f76	20-25	m	2	2	2	2	.290	1.520	.470
63	f92	20-25	m	2	2	2	2	.364	1.430	.440
64	f98	20-25	m	2	3	3	3	.276	1.776	.360
65	p10	20-25	m	2	2	2	2	.316	1.410	.440
66	p20	20-25	m	2	2	2	2	.292	1.756	.300
67	80	26-30	f	0	1	1	1	.016	1.278	.374
68	f68	26-30	f	0	3	3	3	.100	1.206	.420
69	f108	26-30	f	1	3	3	3	.206	1.370	.266
70	24	26-30	m	1	3	3	3	.200	1.660	.310
71	42	26-30	m	1	4	3	3	.246	1.752	.394
72	52	26-30	m	1	3	3	3	.158	1.300	.326
73	60	26-30	m	1	2	3	3	.236	1.566	.310
74	f113	26-30	m	1	3	3	3	.248	1.736	.688
75	f121	26-30	m	1	3	3	3	.256	1.880	.380
76	f125	26-30	m	1	3	3	3	.176	1.564	.406
77	f159	26-30	m	1	2	2	2	.176	1.890	.360
78	f169	26-30	m	1	3	3	3	.170	1.578	.610
79	f27	26-30	m	1	3	3	3	.186	1.750	.388
80	f33	26-30	m	1	4	4	4	.120	1.844	.400
81	f34	26-30	m	1	4	4	4	.230	1.658	.398
82	f34p	26-30	m	1	3	3	3	.168	1.700	.394
83	f80	26-30	m	1	3	3	3	.148	1.870	.444

84	f89	26-30	m	1	3	3	3	.230	1.660	.466
85	f9	26-30	m	1	3	3	3	.188	1.900	.444
86	p3	26-30	m	1	3	3	3	.180	1.846	.416
87	8	26-30	f	2	3	2	3	.256	1.864	.368
88	12	26-30	m	2	3	3	3	.286	1.612	.388
89	22	26-30	m	2	3	3	3	.290	1.442	.324
90	f154	26-30	m	2	3	3	3	.338	1.554	.462
91	f156	26-30	m	2	3	3	3	.300	1.648	.554
92	f8	26-30	m	2	3	3	3	.270	1.610	.640
93	f86	26-30	m	2	4	4	4	.364	1.620	.360
94	p2	26-30	m	2	3	3	3	.330	1.410	.450
95	f28	31-35	f	0	4	3	4	.056	1.530	.198
96	30	31-35	f	1	3	3	3	.148	1.516	.374
97	f146	31-35	f	1	3	3	3	.210	1.590	.480
98	37	31-35	m	1	4	4	5	.188	1.618	.380
99	66	31-35	m	1	4	4	4	.180	1.614	.336
100	84	31-35	m	1	4	3	4	.240	1.630	.578
101	f10	31-35	m	1	3	3	3	.230	1.768	.450
102	f130	31-35	m	1	4	4	4	.236	1.670	.412
103	f29	31-35	m	1	4	3	3	.240	1.672	.292
104	f30	31-35	m	1	4	4	6	.246	1.310	.432
105	f5	31-35	m	1	4	3	5	.230	1.830	.508
106	44	31-35	m	2	3	3	3	.320	1.694	.412
107	55	31-35	m	2	3	3	3	.264	1.920	.470
108	63	31-35	m	2	3	3	4	.350	1.810	.640
109	f100	31-35	m	2	4	4	4	.374	1.668	.354
110	f110	31-35	m	2	5	4	6	.312	1.744	.364
111	f13	31-35	m	2	4	5	7	.286	1.716	.410
112	f137	31-35	m	2	5	5	7	.410	1.420	.350
113	f147	31-35	m	2	3	3	4	.324	1.760	.458
114	f168	31-35	m	2	4	4	4	.370	1.510	.420
115	f41	31-35	m	2	3	3	3	.354	1.688	.658
116	f61	31-35	m	2	5	4	6	.256	1.728	.454
117	f75	31-35	m	2	4	4	4	.290	1.854	.380
118	36	31-35	f	3	5	4	7	.468	1.500	.400
119	f47	31-35	m	3	4	4	5	.490	1.978	.542
120	p16	31-35	f	6	3	3	3	.	1.324	.388
121	3	36-40	f	1	4	4	5	.208	1.570	.418
122	59	36-40	f	1	4	4	4	.218	1.468	.400
123	f42	36-40	f	1	4	4	5	.160	1.388	.276
124	f54	36-40	f	1	4	4	5	.250	1.214	.306
125	p11	36-40	f	1	4	4	4	.182	1.370	.272
126	p18	36-40	f	1	4	4	5	.150	1.172	.264
127	18	36-40	m	1	1	1	1	.118	1.432	.354
128	f20	36-40	m	1	4	3	4	.230	1.672	.388
129	f31	36-40	m	1	4	4	5	.178	1.340	.330
130	f59	36-40	m	1	4	4	6	.232	1.730	.480

131	p9	36-40	m	1	4	4	5	.214	1.708	.324
132	f107	36-40	f	2	4	4	5	.282	1.246	.240
133	32	36-40	m	2	4	4	4	.370	1.466	.570
134	68	36-40	m	2	4	4	5	.266	1.726	.510
135	69	36-40	m	2	4	4	5	.324	1.720	.378
136	9	36-40	m	2	4	3	4	.272	1.364	.484
137	f104	36-40	m	2	4	4	5	.270	1.432	.444
138	f115	36-40	m	2	4	4	6	.334	1.952	.506
139	f151	36-40	m	2	4	4	5	.370	1.750	.408
140	f152	36-40	m	2	4	4	5	.280	1.664	.440
141	f157	36-40	m	2	4	4	5	.312	1.430	.370
142	f3	36-40	m	2	4	4	6	.270	1.696	.500
143	f37	36-40	m	2	4	4	5	.428	1.260	.362
144	f44	36-40	m	2	4	4	6	.408	1.740	.416
145	f69	36-40	m	3	4	4	5	.472	1.474	.522
146	1	36-40	m	6	4	4	6	.	1.566	.548
147	39	36-40	m	6	4	4	7	.	1.862	.320
148	40	36-40	m	6	4	3	4	.	1.716	.376
149	47	36-40	m	6	4	4	6	.	1.776	.420
150	f165	36-40	m	6	5	5	6	.	1.668	.600
151	p6	36-40	m	6	4	4	6	.	1.550	.454
152	f1	41-45	f	1	4	4	5	.164	1.824	.526
153	f122	41-45	f	1	4	4	5	.156	1.426	.348
154	f166	41-45	f	1	4	3	4	.150	1.368	.464
155	17	41-45	m	1	4	4	6	.244	2.060	.412
156	f102	41-45	m	1	4	4	6	.326	1.406	.456
157	11	41-45	m	2	4	4	6	.274	1.490	.338
158	13	41-45	m	2	4	4	6	.252	1.750	.464
159	71	41-45	m	2	4	4	5	.348	1.702	.544
160	f101	41-45	m	2	4	4	6	.440	1.800	.546
161	f129	41-45	m	2	4	4	6	.444	1.668	.382
162	f25	41-45	m	2	4	4	5	.412	1.754	.436
163	f36	41-45	m	2	4	4	6	.330	1.700	.528
164	f4	41-45	m	2	4	4	6	.446	1.474	.396
165	f46	41-45	m	2	4	3	5	.262	1.690	.556
166	f6	41-45	m	2	4	4	5	.404	1.832	.410
167	f83	41-45	m	2	4	3	5	.300	1.978	.472
168	f106	41-45	m	3	4	3	4	.512	1.770	.560
169	f21	41-45	m	3	4	4	6	.452	1.466	.372
170	f55	41-45	m	3	4	4	6	.554	1.286	.636
171	f72	41-45	m	3	4	4	6	.460	1.682	.520
172	f39	41-45	f	6	4	4	6	.	1.456	.292
173	4	41-45	m	6	4	4	6	.	1.660	.352
174	f16	41-45	m	6	4	4	6	.	1.450	.514
175	f162	41-45	m	6	4	4	5	.	1.592	.520
176	f140	46-50	f	1	4	4	5	.224	1.244	.340
177	f87	46-50	f	1	4	4	5	.114	1.272	.272

178	70	46-50	f	2	4	3	5	.408	1.670	.364
179	f120	46-50	m	2	4	4	5	.354	1.876	.488
180	f133	46-50	m	2	4	3	5	.370	1.670	.432
181	f134	46-50	m	2	4	3	5	.390	1.930	.436
182	f2	46-50	m	2	4	3	5	.268	1.736	.442
183	f24	46-50	m	2	4	3	5	.374	1.462	.518
184	f73	46-50	m	2	4	3	5	.260	1.748	.448
185	f11	46-50	f	6	4	4	6	.	1.152	.436
186	f161	46-50	f	6	4	3	5	.	1.418	.346
187	56	46-50	m	6	4	4	6	.	1.726	.458
188	f64	46-50	m	6	4	4	6	.	1.812	.454
189	f65	46-50	m	6	4	4	6	.	1.620	.420
190	f70	46-50	m	6	5	5	6	.	1.666	.418
191	f77	46-50	m	6	4	4	6	.	1.770	.480
192	f81	46-50	m	6	4	4	6	.	1.480	.450
193	f94	46-50	m	6	4	4	6	.	1.832	.464
194	p17	46-50	m	6	4	4	6	.	1.636	.410
195	51	51-55	m	2	4	3	5	.344	1.610	.442
196	85	51-55	m	2	5	5	7	.390	1.964	.348
197	f112	51-55	m	2	4	4	5	.390	2.130	.676
198	f14	51-55	m	2	4	3	5	.428	1.986	.426
199	f158	51-55	m	2	4	3	5	.364	1.770	.532
200	f60	51-55	m	2	4	3	7	.330	1.408	.420
201	41	51-55	m	6	5	4	4	.	1.756	.390
202	43	51-55	m	6	4	4	6	.	1.768	.400
203	53	51-55	m	6	4	4	5	.	1.416	.484
204	f26	51-55	m	6	4	3	5	.	1.620	.452
205	p13	51-55	m	6	4	4	6	.	1.460	.354
206	p7	51-55	m	6	4	4	6	.	1.600	.272
207	f148	56-60	f	1	4	4	6	.244	1.524	.384
208	f52	56-60	m	1	4	4	6	.224	1.410	.494
209	f123	56-60	f	2	4	4	6	.380	1.648	.478
210	14	56-60	m	2	4	4	6	.390	1.928	.348
211	62	56-60	m	2	4	4	5	.412	1.688	.336
212	f45	56-60	m	2	4	4	8	.320	1.420	.266
213	f53	56-60	m	2	4	3	5	.324	2.038	.386
214	65	56-60	f	6	4	4	6	.	1.274	.274
215	f109	56-60	f	6	4	4	6	.	1.522	.304
216	f97	56-60	f	6	4	4	6	.	1.566	.422
217	p15	56-60	f	6	4	4	6	.	1.696	.424
218	25	56-60	m	6	4	5	6	.	1.716	.524
219	73	56-60	m	6	4	4	5	.	1.774	.460
220	f142	56-60	m	6	4	4	6	.	1.526	.628
221	f153	56-60	m	6	5	5	8	.	1.576	.436
222	f163	56-60	m	6	4	4	6	.	1.488	.334
223	f19	56-60	m	6	4	4	5	.	1.760	.496
224	f71	56-60	m	6	5	5	7	.	1.618	.618

225	72	61-65	f	0	4	3	5	.070	1.412	.300
226	61	61-65	f	1	4	4	5	.114	1.360	.324
227	f62	61-65	m	2	4	4	6	.304	1.846	.494
228	f167	61-65	f	6	5	5	8	.	1.258	.300
229	f160	61-65	m	6	4	4	5	.	1.442	.560
230	f78	61-65	m	6	4	4	6	.	1.522	.556
231	f91	61-65	m	6	4	4	5	.	1.484	.360
232	f111	66-70	m	2	4	3	5	.340	1.628	.462
233	f135	66-70	m	2	5	5	8	.268	2.618	.420
234	f145	66-70	f	6	5	5	8	.	1.692	.304
235	f164	66-70	m	6	4	4	5	.	1.812	.420
236	76	71-75	f	1	2	2	2	.216	1.384	.370
237	81	71-75	f	1	2	2	2	.148	1.618	.276
238	77	71-75	m	3	5	5	8	.520	1.378	.286
239	f74	71-75	m	4	5	5	8	.788	1.646	.364
240	10	71-75	f	5	5	5	8	2.462	1.396	.418
241	50	71-75	f	6	5	5	8	.	1.150	.272
242	79	71-75	f	6	5	5	8	.	1.824	.492
243	54	71-75	m	6	5	5	8	.	1.974	.328
244	78	71-75	m	6	4	4	5	.	1.522	.300
245	f99	71-75	m	6	4	4	6	.	2.078	.380

BIOGRAPHY

NAME	**Miss Pinpaka Sucotchadat**
DATE OF BIRTH	**19 November 1976**
PLACE OF BIRTH	**Nakornsrithammaraj, Thailand**
INSTITUTIONS ATTENDED	**Chiangmai University, 1995-1998: Bachelor of Science (Radiologic Technology)**
	Mahidol University, 1999-2001: Master of Science (Forensic Science)