# Cardiothoracic ratio and the maximum transverse diameter of the heart

Science, Anatomy

CHAPTER ONE

# 1. 0 INTRODUCTION

Cardiothoracic ratio is the maximum transverse diameter of the heart divided by the greatest internal diameter of the thoracic cage (from inside of rib to inside to rib). (Herring, 2003).

In normal people, the cardiothoracic ratio is usually less than 50% but, in black people up to 55% may still be normal (Sutton 1988). Therefore the cardiothoracic ratio is a handy way of separating most normal heart from most abnormal heart. (Herring, 2003).

A heart can be greater than 50% of the cardiothoracic ratio and still be a normal heart (Herring, 2003). This can occur if there is an ultra cardiac cause of cardiac enlargement which include;

1. Pectus excavatum deformity

2. Straight back syndrome

3. Inability to take deep breath because ofobesity, pregnancy etc. (Herring 2003).

The ratio may also increase in elderly. This may be to an in folding of ribs, reducing the thoracic component of the ratio (Sutton 1985).

The transverse diameter of the heart can be measured directly on a radiograph at 1. 83m (6ft) upper limit of 16cm for men and 15cm for women are usual (Sutton 1985).

The advantage of a single measurement of that it can be held to be compared in serial films. At difference of 2cm is held to be a significant change. This applies only when the heart is originally normal (Sutton 1985).

Normally, the third of the cardiac shadow lies to the left of the midline and one-third to the right (Berry 2003). In normal individual, the transverse diameter of the heart on PA film is usually in the range of 11. 5cm to 15. 5cm. it lies less than 11. 5cm in about 5% of people and only rarely exceeds 15cm (Benny 2003).

The maximum transverse diameters of the cardiac shadow at the chest radiograph film consist mainly of the diameters of the left ventricle and right atrium as shown by radiograph (Hada, 1995). The ratio is influenced by many factors, not only left ventricular dilatation or hypertrophy but also dilatation of the other cardiac chambers and aorta, rotation and shift of the heart, respiratory phase, body posture and measurement errors (Hada, 1995).

Anatomy of the Heart

Development of the Heart

The development of the heart begins in the middle of the third week from the cardiac progenitor cells in the epiblast, immediately lateral to the primitive streak. Cells destined to form cranial segment of the heart, the outflow tract migrate first and cells forming more caudal portion, right ventricle, left ventricle and sinus venosus respectively migrate in sequential order.

Series of developmental processes later leads to formation of a horse-shoe shaped endothelial lined tube surrounded by myoblasts in the cardiogenic field. In addition to cardiogenic region, other clusters of angiogenic cells appear bilaterally, parallel and close to the midline of the embryonic shield. Theseclusters acquire a lumen and form a pair of longitudinal vessel called dorsal aorta. These vessels later gained connections via the aortic arches with the horseshoe shaped region that form the heart tube.

As the embryo folds cephalocaudally, it also folds laterally and as a result, the caudal regions of the paired cardiac primordial merge their caudal most ends.

Simultaneously, the crescent part of the horse- shoe shaped area expands to form the future outflow tract and ventricular regions.

Thus, the heart becomes a continuous expanded tube consisting of an inner endothelial lining an outer myocardial layer. The heart at this stage consist of three layers (a) Endocardium – forming the inner endothelial lining of the heart.

(b) Myocardium- forming the muscular wall

(c) Epicardium or Visceral pericardium- covering the outside of the tube.

Various parts of the heart later develop from the fused heart tube. (Sadler T. W 2000).

Gross Anatomy of the heart

The normal heart lies within the pericardial sac in the middle of the thorax slightly to the left of the middle (Sokolow 1979). The low pressure right atrium and right ventricle occupy the anterior portion of the heart and the higher pressure left ventricle and atrium his posteriorly (Sokolow 1977). The long axis of the heart from the apex of the left ventricle to the root of the aorta runs upwards and backward at an angle of about 300 from the horizontal plane and 450 from the sagital plane of the body (Sokolow 1977). The resisting and position of the heart vary with the build of the patient and with respiration. It assumes a more vertical position during inspiration in tall thin persons and more horizontal position during respiration in persons with heavier body build. (Sokolow1977).

# 1. 2 THE CHAMBERS OF THE HEART

The heart consists of four (4) chambers; that is the right and left atria and the right and left ventricle.

### 1. 2. 1 The Right Atrium

The right atrium consists of two (2) embryological portions. (Malcolm 1977). The most posterior thin walled portion into which the vena cava and coronary sinus empty in from form the sinus venosus and is compose of similar tissues to that of the great vein. (Malcolm 1977). The more anterior muscular portion includes the right arterial appendage and the tricuspid valve ring (Malcolm 1977)

The fossa ovalies lies in the site of the foramen ovale (Malcolm 1977). This inter-atrialcommunicationwithin which is present during fetal life permits the

flow of oxygenated blood from the inferior vena cava into the heart (Malcolm 1977).

The patent foramen Ovale remain open or potentially open in about 15% of normal subjects (Malcolm 1977) but since it is a flap value which only allows flow right or left, it is normally functionally closed (Malcolm 1977).

### 1. 2. 2 THE RIGHT VENTRICLE

The right ventricle is triangular in shape and forms a cresentric, shallow structure wrapped over the ventricular septum (Malcolm 1977), it can divided into a lower inflow portion containing the tricuspid valve and upper outflow tract from which pulmonary trunk arises. (Malcolm 1977).

The line of demarcation between the two portions consists of bands of muscles formed by the cristasupra ventricularis (Malcolm 1977). The outflow tract of the right ventricles is derived from the embryologically distinct bulbus cordis in contrast to the inflow portion which arises from ventricular tissues (Malcolm 1977).

### 1. 2. 3 THE LEFT ATRIUM

The left atrium like the right is composed of a vein like portion which the pulmonary vein drains and make muscular anterior portion which includes the left atrial appendage (Malcolm 1977).

Its wall is slightly thicker than that of the right atrium and the inner area corresponding to the fossa ovale can be seen on its right upper surface (Malcolm 1977).

### 1. 2. 4 THE LEFT VENTRICLE

The left ventricular cavity is shaped like an egg. The base or the egg is formed by the mitral valve ring. The wall of the left ventricle accounts for about 75% of the mass of the heart.

The aorta and mitral ring lies close to one another with the layer anterior mole cusp of mitral valve adjacent to the left and posterior cusp of the aortic valve (Malcolm 1977).

The posterior immobile cusp of the mitral valve is shorter and together with the anterior cusp is lethered to the anterior and posterior papillary muscles in a parachute like shared by the two (2) cusps (Malcolm 1977).

The interventricular septum which forms the outright anterior aspect of the left ventricle bulges into the right ventricle making the cross section of the mid portion of the left ventricle circular shape (Malcolm 1977).

## 1. 3 EXTERNAL APPEARANCE OF THE HEART

### 1. 3. 1 ANTERIOR ASPECT

As viewing anteriorly, the longest area of the surface of the heart is formed by the triangular shaped right ventricle with the pulmonary trunk arising from the apex of the triangle above and to the right of the right ventricle, one can see right atrium appendages as an ear shape structure overlying the root of the aorta (Sokolow 1997). The grove between the right atrium and ventricle (Coronary sulcus) is often filled with fat and is occupied by the right coronary artery.

Above the right atrium, the superior vena cava is seen entering the right atrium from the back . The anterior aspect of the heart reveals only a small part of the left ventricle lying to the left of the right ventricle and forming the apex of the heart (Sokolow 1977).

The anterior interventricular sulcus often contains fat and is occupied by the anterior descending branch of the left coronary artery (Sokolow 1977).

The only portion of the left atrium visible from the front is the left atrial appendages, which lies side of the origin of the pulmonary trunk. The lungs normally covers most of the anterior surface of the heart especially during inspiration having only a small area opposed to the back of the sternum and left ribs (Sokolow 1977).

### 1. 3. 2 LEFT SIDED ASPECT

When viewed from the left side, the ventricle and the left atrium occupy most of the surface of the heart (Sokolow 1977). The posterior interventricular groove separates the left ventricle above from the right ventricle below. The posterior descending branch of the right coronary artery lies in the groove. The anterior ventricular groove runs almost vertically in the view separating the left ventricle from the left atrium (Sokolow 1977). The coronary sinus and circumflex branch of the left coronary artery lies in the groove and complete the ring of blood vessels forming the bases of the corona (crown) after which the blood vessels supplying the heart are named (Sokolow 1977).

### 1. 3. 3 POSTERIOR ASPECT

The back of the heart mainly on the diaphragm is largely occupied by the left atrium and ventricle plus portions of the right atrium and ventricle (Sokolow 1977).

The point at which all four (4) chambers meet posteriorly as called the crux at the heart; because of the cross – shape pattern of the blood vessels lying at the function of the posterior interventricular groove and the anterior ventricular groove (Sokolow 1977). The vessels forming the crux are; the coronary sinus and the posterior descending coronary artery. This latter vessel may be a branch of either the right or the circumflex branch of the left coronary artery depending on whether the right or left coronary artery is largely (dominant) (Sokolow 1977).

The pulmonary vein enter the back of the left atrium and the pattern may vary but the two right and the left pulmonary veins are normally present (Sokolow 1977).

### 1. 3. 4Right Side Aspect

When viewed from the right side, the right atrium and ventricle occupies most of the surface (Maurice 1977). The posterior and the anterior vena cava enter the atrium at the back and the aorta runs upward from the middle of the heart (Maurice 1977). The outflow tract of the right ventricle and the pulmonary trunk form the upper border of the heart in this view (Maurice 1977).

# 1. 4 THE HEART WALL

The heart wall is composed of the three layers of tissue, namely the; epicardium, myocardium and endocardium (Stephen 1988). The epicardium and the visceral pericardium are two names for the same structure. The sinus pericardium is called epicardium when considered a part of the heart and the visceral pericardium when considered a part of the pericardium (Stephen 1988).

### 1. 4. 2 THE MYOCARDIUM

This is the thick middle layer of the heart, which composed of cardiac muscle cells and is responsible for the ability of the heart to contract, (Stephen 1988).

### 1. 4. 3 THE ENDOCARDIUM

This is the smooth inner surface of the heart chamber, which consist of the simple squamous epithelium over a layer or connective tissue (Stephen 1988).

The smooth inner surface allows blood to move easily through the heart. The heart valves are formed by a fold as the endocardium, making a double layer of endocardium with connective tissue in between (Stephen 1988).

# 1. 5 OBJECTIVE OF THE STUDY

The objectives of the study are

To measure the heart diameter, thoracic diameter and cardiothoracic ratio of normal individual in University of Maiduguri Teaching Hospital, Nigeria.

To give the comparison between the heart diameter, thoracic diameter and

cardiothoracic ratio between males and females.

CHAPTER TWO

# 2. 0 LITERATURE REVIEW

In 1919, Danzer undertook one of the earliest studies of the cardiothoracic ratio. After investigation nearly 500 patients without the aid of hemodynamic parameters, He determined that any measurement over 0. 5 or 50% was suspicious and over 0. 52or 52% was definitely pathological.

A latter report by comeau and white in 1942 found that 15 to 25% of normal patient had a cardiothoracic ratio greater than 0. 5 or 50% and advised that using CT ratio prediction labels based upon six, image technique and phase of respiration.

A significant relationship was found between the radial measurement and age, which differ within ethnic group groups. The median value of cardiothoracic ratio was 43% in Caucasians, 44% in Asian and 46% in Africans. (Ashcroft Maills' and Mekol). Mekol concluded that a single upper limit (e. g. 50%) for cardiothoracic ratio is unsatisfactory. It all subject with values of cardiothoracic ratio greater than 50% in the present sample had been recalled for more dedicated cardio logical investigation; this would have affected 2. 2% of Caucasians, 4. 1% of Asians and 9. 3% of Africans limit of 5. 3% in Caucasians, 52% in Asian and 53% in Africans would include 2. 2%, 2. 4% and 2. 6% of each subject of these racial groups. (Mekol1982).

Murphy M. L. in 1985 took routine posterior and lateral chest radiograph in 268 patients and analyzed to determine heart size. The coronary artery of

this determination was compared with a specific ventricular mass derived from a postmortem cardiac partition technique. The data indicated that in the majority of cases (greater than 70%) a normal sized heart or cardiomegaly can be correctly determined from the chest x – ray either by subjective arterial or chamber enlargement or management of the transverse diameter (Murphy M. L. 1985).

A recent meta-analysis of 29 studies determined that cardiomegaly on the cardiothoracic ratio was the best reason for predicting a reduced ejection fraction, with a sensitivity and specificity of 51% and 79% respectively (Badgett 1996).

Comeau in 1942 said that it is important to recognize compounding factors of cardiomegaly such as an epical fat, a transversely positional heart. An expiratory film or decrease in thoracic width.

In 1987, Kabala used a computed Tomography model in eight patients to show how the heart diameter and cardiothoracic ratio might change between anterior-posterior chest radiograph taken on 103 patients without cardiacfailureand 106 with cardiac failure. An upper limit of cardio thoracic ratio of 55% and of heart chamber or 165mm in males and 150mm in females was shown to practice usefuldiscriminationbetween normal and abnormal heart size (Kabala 1987).

The cardiothoracic ration thoracic ratio increased with age in both sex but females have longer cardiothoracic ratio than men.

Portable films taken in the anterior-posterior and supine position enlarge the appearance of cardiac silhouette (Milne 1988).

CHAPTER THREE

# 3. 0 MATERIALS AND METHODS

## 3. 1 SUBJECTS

A retrospective study was carried out in the university of Maiduguri Teaching Hospital, Department of Radiology, and using normal chest radiograph of two hundred and ninety-one (291) patients.

## 3. 2 SAMPLE SELECTION

The sample includes the normal chest radiographs taken from 2007-2009. All chest radiographs with abnormal result were excluded from the study. The age, sex from the chest radiographs was obtained. Hypertensive subjects were excluded.

## 3. 3 MEASUREMENT

A straight line drawn near the rule meddled of the heart shadow. Another line as in “ a” from the right heart border to order to the first line was drown. A third line was drown from the left heart co-order furthest from the in the middle of the heart shown as the “ b”. The two were then added together, the cardiothoracic rube as the own of the line “ a” and “ b” divided by the largest transverse internal diameter of the thoracic cage as shown on the figure 3. 1 below.

Figure 3. 1 measurement of the cardio thoracic ratio.

Cardiac diameter=> A= B are the maximum extensions of the heart to the left and right of the midline respectively.

CHAPTER FIVE

# 5. 0 DISCUSSION

The cardiothoracic ratio of males and females in the various age groups will be determined in future study.

The ratio increased with age in both sexes but was more marked in females than males.

Oberman in 1967 reported that women have higher cardiothoracic ratio than males. Men had larger cardiac diameter than women. The higher cardiothoracic ratio in women was due to their smaller thoracic diameter. This report supports the present study.

Edge in1984also reported that the increase in cardiothoracic ratio with age found particularly in women was mainly due to contraction of the thoracic diameter rather than an increase in the cardiac diameter.

Decrease in the chest diameter with advancing age indicates that cardiothoracic ratio over estimates the heart size in the elderly.

Nikol and Wade in 1982 attributed that Africans have larger cardiothoracic ratio because they have smaller thoracic diameter and larger cardiac diameter.

It was also noted that environmental factors such as poor nutrition and infection may cause cardiac enlargement with resultant increase in cardiac diameter and cardiothoracic ratio.

## 5. 2 CONCLUSION

The higher cardiothoracic ratio in females may suggest the reason of their susceptibility to infections arising from the heart and this could be correlated to clinical data.

## 5. 3 RECOMMENDATION

I recommend that any research on cardiothoracic ratio is best with chest radiographs. Females should always keep good hygiene because of their susceptibility to infections because of their large cardiothoracic ratio.

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