Research Paper

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# "Keshaw Constants" and "Keshaw Concept of Blood Volume Equality"-The Laws of Arterial Blood Circulation

Medical Science

**KEYWORDS :** Heart, Ventricles coronary arteries ascending aorta pulmonary trunk.

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## ABSTRACT

*In order to create the laws of arterial blood circulation tissue of ventricles of heart, coronary arteries, ascending aorta and pulmonary trunk was obtained at constant levels during autopsy from 300 human adults not suffering from any cardiovascular disease. Wall thickness and lumen circumference was measured in all these arteries to calculate pulse pressure, pulsatory power and volume of blood entering the lumen during each heart beat according to laws of arterial pulsation created by Keshaw Kumar (1993, 2015)1,2.*

*On the basis of observations and result obtained following laws of arterial blood circulation were created by Dr. Keshaw Kumar.*

*1. During each heart beat equal volume of blood enters and circulates in systemic as well as pulmonary circulations which is known as " Keshaw concept of blood volume equality".*

*2. A ratio of 3:1 exists between the arteries of systemic and pulmonary circulations as far as their pulse pressure, pulsatory power and wall thickness is concerned but in case of lumen circumference, volume of blood entering the lumen during each heart beat this ratio is 1:1 between the arteries of systemic and pulmonary circulations.*

*3. In an individual not suffering from any cardiovascular disease these above mentioned ratios (3:1 and 1:1) remain always constant and are known as "Keshaw Constants". Any deviation or alteration in "Keshaw Constants" in an individual is the indication of cardiovascular disease in that individual either in the form of right/left sided cardiac failure or in the form of cardiac coronary inefficiency.*

## INTRODUCTION

In the Edwin Smith Surgical Papyrus dating back to approximately 3000 BC, the heart was recognised as the anatomical centre of a system of blood vessels (Breasted 1930)[3]. For the first time Harvey W. (1628)[4] defined the relationship between the pulmonary and systemic circulations establishing the heart as a propulsive centre of the circulation and his concept of circulation was dependent on arteriovenous communications although Ibnan Nafis, Arabian Physician had already described the general features of the pulmonary circulation some 400 years before (Willius and Dry 1948)[5].

Diameter of coronary arteries was recorded by Baroldi and Scomazzoni (1967)[6]. Vogelberg (1957)[7] considered that coronary diameters increase up to the age of thirtieth year. Remington (1963)[8] described physiology of aorta and major arteries. Wright (1969)[9] performed the dissection study and mensuration of human aortic arch. Greenfield and Patel (1962)[10] showed relation between pressure and diameter in ascending aorta in man.

Keshaw Kumar (2003, 2007)[11,12] first of all discovered the "Keshaw Constants" and "Keshaw Concept of Blood Volume Equality". Keshaw Kumar et.al (2013)[13] noticed existence of "Keshaw Constants" in great arterial trunks of domestic mammals. Keshaw Kumar (2014)[14] reported existence and deviation/alteration of "Keshaw Constants" in coronary arteries of domestic mammals. Keshaw Kumar et. al (2013)[15] studied the existence of "Keshaw Concept of Blood Volume Equality" in systemic and pulmonary circulations of domestic mammals. Keshaw Kumar (2014)[16] observed the existence of "Keshaw Concept of Blood Volume Equality" between coronary arteries as well as between great arterial trunks of domestic mammals.

Present study was conducted in order to create the laws of arterial blood circulation in human beings.

## MATERIAL AND METHODS

Hearts of 300 human adults with right coronary arterial dominance were obtained immediately after their death due to accidents after knowing history from their relatives that they were not suffering from any cardiovascular disease. Tissue of ascending aorta, pulmonary trunk, right coronary artery, left coronary artery was taken 1 cm distal to their commencements while tissue of right and left ventricles was taken mid way between apex and crux of heart to be preserved in 10% formalin.

Myocardial thickness of right ventricle, left ventricle and tunica medial thickness of ascending aorta, pulmonary trunk, right coronary artery, left coronary artery was measured and mean thickness of wall was obtained separately for left ventricle, right ventricle, ascending aorta, pulmonary trunk, right coronary artery, left coronary artery. Similarly mean lumen circumference of all these arteries was also obtained by cutting the wall of arterial segments longitudinally to open their lumen to measure their lumen circumference.

Paraffin sections of 10 micron thickness of right coronary artery and left coronary artery were stained with orcein to obtain 100 times magnified photomicrographs in all the stained sections. In all the photomicrographs thickness of tunica media was measured between external elastic lamina and internal elastic lamina. Lateron actual thickness of tunica media was obtained after dividing the tunica medial thickness by 100 because photomicrographs were taken at the 100 times magnification.

Pulsatory power, pulse pressure and volume of blood entering the arterial lumen during each heart beat were calculated separately for each artery according to following laws of arterial pulsation created by Keshaw Kumar (1993, 2015)[1,2].

**1.** Pulsatory power of an artery is equal to pulse pressure multiplied by volume of blood entering the lumen of that artery during each heart beat.

**2.** Pulsatory power of an artery is directly proportional to wall (tunica media) thickness of that artery having 1mm wall thickness is reported as 2000 Joule per heart beat.

**3.** Arterial lumen circumference in millimeters equals with volume of blood in milliliters entering the lumen of that artery during each heart beat.

## OBSERVATIONS

### Ventricles of Heart

Mean wall thickness of left ventricle was 6mm while mean wall thickness of right ventricle was 2mm therefore pulsatory power calculated in case of left ventricle was 12000 Joule per heart beat and in case of right ventricle it was 4000 Joule per heart beat while volume of blood entering the lumen of right ventricle as well as left ventricle was 60ml. during each heart beat.

6mm x 2000 Joule = 12000 Joule per heart beat

2mm x 2000 Joule= 4000 Joule per heart beat.

Pulse pressure calculated in case of left ventricle was 200 mm Hg. while in case of right ventricle it was 67 mmHg.

12000 Joule » 60ml stroke volume = 200 mm Hg

4000 Joule » 60ml stroke volume = 67 mm Hg

In this way ratio of 3:1 was existing between wall thickness, pulsatory power and pulse pressure of left ventricle and right ventricle but ratio between volume of blood entering the lumen of right ventricle and left ventricle was 1:1 because 60ml. stroke volume of blood was also the volume of blood entering left ventricle as well as right ventricle from left atrium as well as right atrium respectively during each heart beat. (Table-I, II, III and IV)

| | | |
|---|---|---|
| 60 ml volume of blood entering the lumen of right as well as left atrium during each heart beat | = | 60ml. volume of blood entering the lumen of right as well as left ventricle during each heart beat. |

**Table- I**

**Ratio between wall thickness, pulse pressure, pulsatory power of left ventricle and right ventricle.**

| | Left ventricle | Right ventricle | Ratio |
|---|---|---|---|
| Wall thickness | 6 mm | 2 mm | 3 :1 |
| Pulsatory power | 12000 Joule per heart beat | 4000 Joule per heart beat | 3:1 |
| Pulse pressure | 200 mm Hg | 67 mm Hg | 3:1 |

**Table- II**

**Ratio between stroke volume of blood of left ventricle and right ventricle during each heart beat.**

| | Left ventricle | Right ventricle | Ratio |
|---|---|---|---|
| Volume of blood ejected during each heart beat | 60ml | 60ml | 1:1 |

**Table- III**

**Ratio between volume of blood entering the left ventricle and right ventricle during each heart beat.**

| | Left ventricle | Right ventricle | Ratio |
|---|---|---|---|
| Volume of blood entering lumen during each heart beat | 60ml | 60ml | 1:1 |

**Table- IV**

**Ratio between volume of blood entering the left atrium and right atrium during each heart beat.**

| | Left atrium | Right atrium | Ratio |
|---|---|---|---|
| Volume of blood entering during each heart beat | 60ml | 60ml | 1:1 |

**Great Arterial Trunks**

Mean wall thickness of ascending aorta was 1.5 mm and mean wall thickness of pulmonary trunk was 0.5 mm. while mean lumen circumference of ascending aorta as well as pulmonary trunk was 60mm. Therefore pulsatory power calculated in case of ascending aorta was 3000 Joule per heart beat while pulsatory power calculated in case of pulmonary trunk was 1000 Joule per heart beat.

1.5mm x 2000 Joule = 3000 Joule per heart beat

0.5mm x 2000 Joule = 1000 Joule per heart beat

Pulse pressure calculated in case of ascending aorta was 50mm Hg and pulse pressure calculated in case of pulmonary trunk was 17 mm Hg.

3000 Joule » 60ml = 50 mm Hg.

1000 Joule » 60ml = 17mm Hg.

Therefore a ratio of 3:1 was existing between wall thickness, pulse pressure, pulsatory power of ascending aorta and pulmonary trunk. (Table-V)

During each heart beat 60ml. volume of blood (Stroke Volume) entered the lumen of ascending aorta as well as pulmonary trunk because lumen of ascending aorta as well as pulmonary trunk was 60mm.

60mm lumen circumference = 60ml. volume of blood entering during each heart beat.

Therefore ratio between volume of blood entering the lumen of ascending aorta and pulmonary trunk was 1:1 which was also the ratio between mean lumen circumference of ascending aorta and pulmonary trunk. Table-VI

**Table- V**

**Ratio between wall thickness, pulsatory power, pulse pressure of ascending aorta and pulmonary trunk.**

| | Ascending aorta | Pulmonary trunk | Ratio |
|---|---|---|---|
| Wall thickness | 1.5mm | 0.5mm | 3:1 |
| Pulsatory power | 3000 Joule per heart beat | 1000 Joule per heart beat | 3:1 |
| Pulse pressure | 50mm Hg | 17mm Hg | 3:1 |

**Table- VI**

**Ratio between lumen circumference, volume of blood entering during each heart beat of ascending aorta and pulmonary trunk.**

| | Ascending aorta | Pulmonary trunk | Ratio |
|---|---|---|---|
| Lumen circumference | 60mm | 60mm | 1:1 |
| Volume of blood entering lumen during each heart beat | 60ml | 60ml | 1:1 |

**Coronary Arteries**

Mean wall thickness of left coronary artery was 0.3mm (fig-1) and mean wall thickness of right coronary artery was 0.1mm (fig-2). while mean lumen circumference of right coronary artery as well as left coronary artery was 10mm. Therefore pulsatory power calculated in case of left coronary artery was 600 Joule per heart beat and pulsatory power calculated in case of right coronary artery was 200 Joule per heart beat.

0.3mm x 2000 Joule = 600 Joule per heart beat

0.1mm x 2000 Joule = 200 Joule per heart beat.

Pulse pressure calculated in case of left coronary artery was 60mm Hg and pulse pressure calculated in case of right coronary artery was 20mm Hg.

600 Joule » 10ml = 60mm Hg

200 Joule » 10 ml = 20mm Hg

Therefore ratio between pulse pressure, pulsatory power, wall thickness of left coronary artery and right coronary artery was 3:1. (Table-VII)

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Mean lumen circumference of left coronary artery as well as right coronary artery was 10mm therefore during each heart beat volume of blood entering the lumen of left coronary artery as well as right artery calculated was 10ml.

10mm lumen circumference = 10ml. volume of blood entering the lumen during each heart beat.

Therefore ratio between lumen circumference as well as volume of blood entering the lumen of left coronary artery and right coronary artery was 1:1. (Table-VIII)

**Table- VII**

**Ratio between wall thickness pulsatory power pulse pressure of left coronary artery and right coronary artery.**

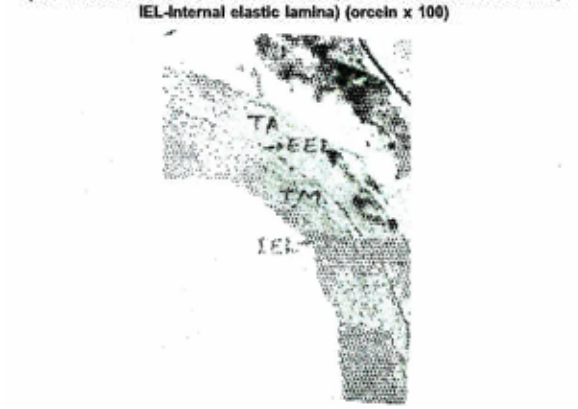
| | Left coronary artery | Right coronary artery | Ratio |
|---|---|---|---|
| Wall thickness | 0.3mm | 0.1mm | 3:1 |
| Pulsatory power | 600 Joule per heart beat | 200 Joule per heart beat | 3:1 |
| Pulse pressure | 60mm Hg | 20 mm Hg | 3:1 |

**Table- VIII**

**Ratio between lumen circumference, Volume of blood entering the lumen during each heart beat of left coronary artery and right coronary artery.**

| | Left coronary artery | Right coronary artery | Ratio |
|---|---|---|---|
| Wall thickness | 10mm | 10mm | 1:1 |
| Volume of blood entering during each heart beat | 10 ml | 10ml | 1:1 |


Fig. 1–T.S. of human left coronary artery 1cm distal to its commencement. (T.A. Tunica Adventitia; TM-Tunica Media; EEL-External elastic lamina; IEL-Internal elastic lamina) (orcein x 100)




T.S. of human right caronary artery 1cm distal to its commencement. (T.A. Tunica Adventitia; TM-Tunica Media; EEL-External elastic lamina; IEL-Internal elastic lamina) (orcein x 100)

**Fig-2**

**DISCUSSION**

A ratio of 3:1 was existing between the structures related to systemic circulation (left ventricle, ascending aorta, left coronary artery) and the structure related to pulmonary circulation (right ventricle, pulmonary trunk, right coronary artery) as far as their wall (tunica media) thickness, pulsatory power and pulse pressure was concerned but in case of lumen circumference and volume of blood entering the lumen during each heart beat this ratio was 1:1 betweem the structures related to systemic and pulmonary circulations. In an individual not suffering from any cardiovascular disease these above mentioned ratios (3:1 and 1:1) remain always constant and are known as "Keshaw Constants". Any deviation/alteration in the "Keshaw Constants" in an individual is the indication of cardiovascular disease in that individual either in the form of left/right sided cardiac failure or in the form of cardiac coronary inefficiency (Keshaw Kumar, 2003, 2007, 2014)[11,12,14]. Keshaw Kumar (2014, 2009)[14,17] declared the right coronary arterial dominance as a normal coronary arterial pattern and left coronary arterial dominance as an abnormal coronary arterial pattern because in right coronary arterial dominance "Keshaw Constants" were existing in the ratio of (3:1 and 1:1) while in left coronary arterial dominance this ratio was (4:1 and 1:1) i.e. alteration/deviation of "Keshaw Constants".

Left coronary artery belongs to systemic circulation because it supplies left ventricle which is a part of systemic circulation and right coronary artery belongs to pulmonary circulation because it supplies right ventricle which is a part of pulmonary circulation (Keshaw Kmar 2003, 2014)[11,16].Coronary arteries are actually vasavasorum of developing arterial heart.

According to Keshaw Kumar (2003, 2007, 2014)[11,12,14] the area of systemic circulation is approximately three times larger than the area of pulmonary circulation, therefore arterial pulse pressure is three times more in arteries related to systemic circulation than the arteries related to pulmonary circulation and blood ejecting force by left ventricle is three times more than the blood ejecting force by right ventricle and this is the reason that wall thickness, pulsatory power of left ventricle, ascending aorta, left coronary artery is thrice more than the wall thicknesss, pulsatory power of right ventricle, pulmonary trunk, right coronary artery respectively.

Although the area of distribution of blood is three times larger in systemic circulation than the area of distribution of blood in pulmonary circulation but this is an arrangement of nature that during each heart beat equal volume of blood enters and circulates in systemic as well as pulmonary circulation (Keshaw Kumar 2003, 2007, 2014)[11,12,16] to maintain equilibrium between venous blood returning to right as well as left atria and arterial blood ejected by right and left ventricles in ascending aorta as well as pulmonary trunk. If this equilibrium between venous blood returned to heart and arterial blood ejected from heart during each heart beat is lost there will be stagnation of blood either in right/left atrium or in right/left ventricle resulting into right/left sided cardiac failure (Keshaw Kumar, 2003, 2007, 2014)[11,12,16]. Therefore for proper and normal functioning of heart equal volume of blood must be entering and circulating in systemic as well as pulmonary circulation during each heart beat. In otherwords "Keshaw Concept of Blood Volume Equality" must be existing between systemic and pulmonary circulations for proper and normal functioning of heart.

This is also an arrangement of nature that there must be an equilibrium maintained between volume of blood deoxygenated and volume of blood oxygenated during each heart beat in living beings. In other words entire oxygenated blood must be deoxygenated and entire deoxygenated blood must be oxygenated during each heart beat. In both the conditions when during each heart beat volume of deoxygenated blood is more than oxygen-

ated blood, life of individual will not be possible due to cyanosis. Therefore it is essential for life that in an individual equal volume of blood must be entering and circulating in systemic as well as pulmonary circulations during each heart beat (Keshaw Kumar 2007,2014)[12,16].

Aorta is not a static organ, it is infact a dynamic structure, its inherent distensibility being responsible atleast in part for the pulse wave pattern produced by left ventricular ejection (Remington, 1963)[8]. Further more it has also been shown that changes in circumference and diameter may correlate quite closely with intra aortic pressure changes (Greenfield and Patel (1962)[10]. Pulse pressure of blood varies considerably in the peripheral arteries, (Wehn 1957)[18].

Baroldi and Scomazzoni (1967)[6] gave means of 4mm and 3.2mm in case of coronary artery diameters at their origins, the left exceeds the right in about 60% hearts, the right being larger in 17%, the vessels approximately equal in 23%. Vogelberg (1957)[7] considered that coronary diameters increase upto the age of thirtieth year. In the present study finding of 10mm lumen circumference in left as well as right coronary artery resembles with findings of Baroldi and scomazzoni (1967)[6] where in case of 23% hearts diameters of both the coronary arteries were equal. In present study findings of 10mm lumen circumference in case of both the coronary arteries 1cm distal to their commencements resemble with the 3.2mm diameter of coronary arteries at their origin observed by Baroldi and Scomazzoni (1967)[6] .Findings of 0.3mm wall (tunica media) thickness of left coronary artery and 0.1mm wall (tunica media) thickness of right coronary artery resemble with the findings of Keshaw Kumar (2003,2007)[11,12]. Findings of 6mm wall (myocardium) thickness of left ventricle and 2mm wall (myocardium) thickness of right ventricle resemble with the findings of Keshaw Kumar (2007)[12]. Findings of 1.5mm wall (tunica media) thickness of ascending aorta and 0.5 wall (tunica media) thickness of pulmonary trunk and 60mm lumen circumference of ascending aorta as well as pulmonary trunk resemble with the findings of Keshaw Kumar (1993, 2007)[1,12].

On the basis of results obtained in the present study following laws of arterial blood circulation were created by Dr. Keshaw Kumar.

**1.** During each heart beat equal volume of blood enters and circulates in systemic as well as pulmonary circulations which is known as " Keshaw concept of blood volume equality".

**2.** A ratio of 3:1 exists between the arteries of systemic and pulmonary circulations as far as their pulse pressure, pulsatory power and wall thickness is concerned but in case of lumen circumference, volume of blood entering the lumen during each heart beat this ratio is 1:1 between the arteries of systemic and pulmonary circulations.

**3.** In an individual not suffering from any cardiovascular disease these above mentioned ratios (3:1 and 1:1) remain always constant and are known as "Keshaw Constants". Any deviation or alteration in "Keshaw Constants" in an individual is the indication of cardiovascular disease in that individual either in the form of right/left sided cardiac failure or in the form of cardiac coronary inefficiency.

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