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Mechanism of the Heart Using Graph Theory

V. Jude Annie Cynthia[a], E.Padmavathy[b] and P.Poorani [b]

[a]*Department of Mathematics, Stella Maris College,Chennai – 600 086, India.*

[b]*Department of Mathematics, Chevalier T.Thomas Elizabeth College for women, Chennai – 600 060, India*

ABSTRACT: The chambered muscular organ in vertebrates that pumps blood received from the veins into the arteries maintains the flow of blood through the entire circular system. In this paper we discuss the mechanism of the heart using the graph. We study about how the deoxygenated blood comes from and exits and how the oxygenated blood goes to the body using a digraph.

Keywords: Arteries; circular system; deoxygenated blood; digraph; oxygenated blood; veins; vertebrates

INTRODUCTION

Ever since the research started in bio-mathematical sciences, there is an enormous progress in its growth. The emergence of models and the existence of large data sets that require quantitative analysis, coupled with strong public support for accelerated progress in the biosciences, present a great opportunity for the mathematical sciences [2]. The quantitative analysis of fundamental problems in bioscience will require new ideas and new techniques. There already exist several mathematical bioscience research groups in departments of mathematics, statistics, computer science and biology as well as biostatistics centres in medical research facilities around the country. There is a need to encourage an influx of mathematicians and statisticians into mathematical biosciences and to nurture a new generation of researchers more meticulously than before [5]. These challenges motivated us to emerge into a new trend of using graph theory to model mechanism of human organs and to make its study at ease to everyone.

Blood consist of a fluid medium called plasma which transports food, carbon dioxide and nitrogenous wastes in dissolved form. Oxygen is carried by R.B.C.(red blood corpuscles). Many other substances like salts are also carried by blood to various parts of the body. Thus a network of tubes exits in the pumping organ to pump the blood around the body to reach all the tissues and a system in place to ensure that this network can be repaired if damaged [6].

In this paper we have shown the working of the pumping organ and a representation of the function using a digraph.

10. MODELING OF HEART USING DIGRAPH

10.1 Digraph

A *directed graph D* is an ordered triple ($V(D)$, $A(D)$, Ψ_D) consisting of a non empty set $V(D)$ of *vertices*, a set $A(D)$, disjoint from $V(D)$, of *arcs*, and *incidence function* Ψ_D that associates with each arc of *D* an ordered pair of (not necessarily distinct) vertices of *D*. If *a* is an arc and *u* and *v* are vertices such that $\Psi_D(a) = (u,v)$, then *a* is said to join *u* to *v* ; *u* is a *tail* of *a*, and *v* is its *head*. For convenience, we shall abbreviate ‗directed graph' to *digraph* [7].

10.2 Mechanism of the Heart

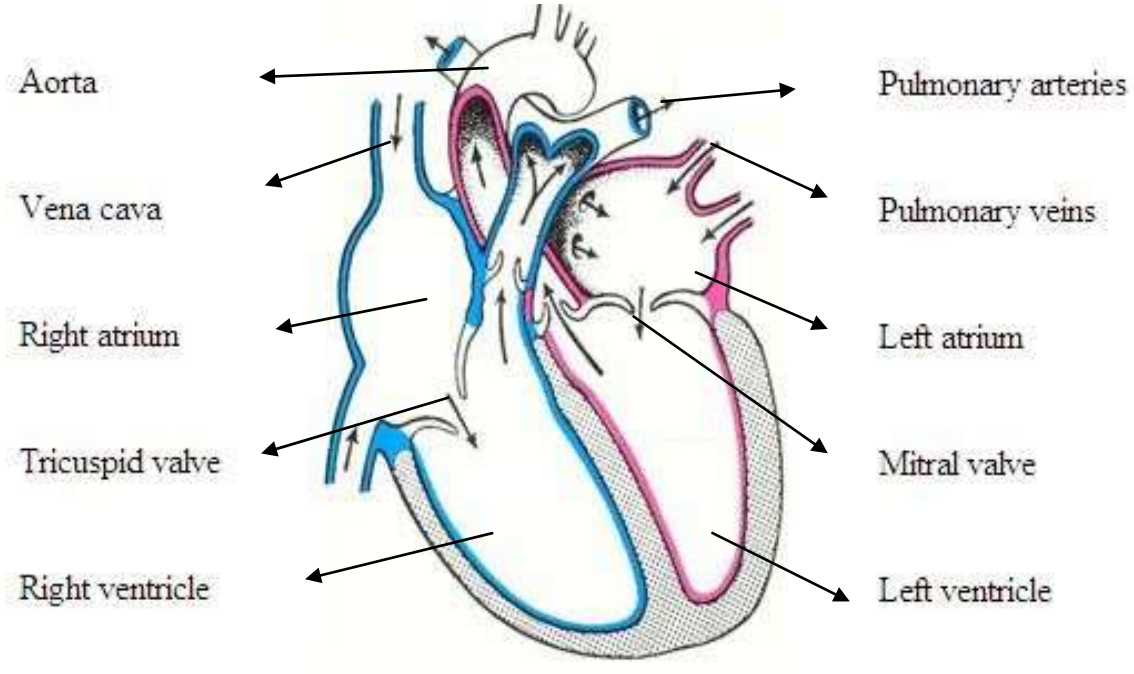

Figure 1: Heart

Oxygen rich blood from the lungs comes to the thin walled upper chamber of the heart on the left, the left atrium. The left atrium relaxes when it is collecting this blood. It then contracts, while the next chamber, the left ventricles, expands, so that the blood is transferred to it. When the muscular left ventricle contracts in its turn, the blood is pumped out to the body.

De-oxygenated blood comes from the body to the upper chamber on the right, the right atrium, as it expands. As the right atrium contracts, the corresponding lower chamber, the right ventricle, in turn pumps it to the lungs for oxygenation.

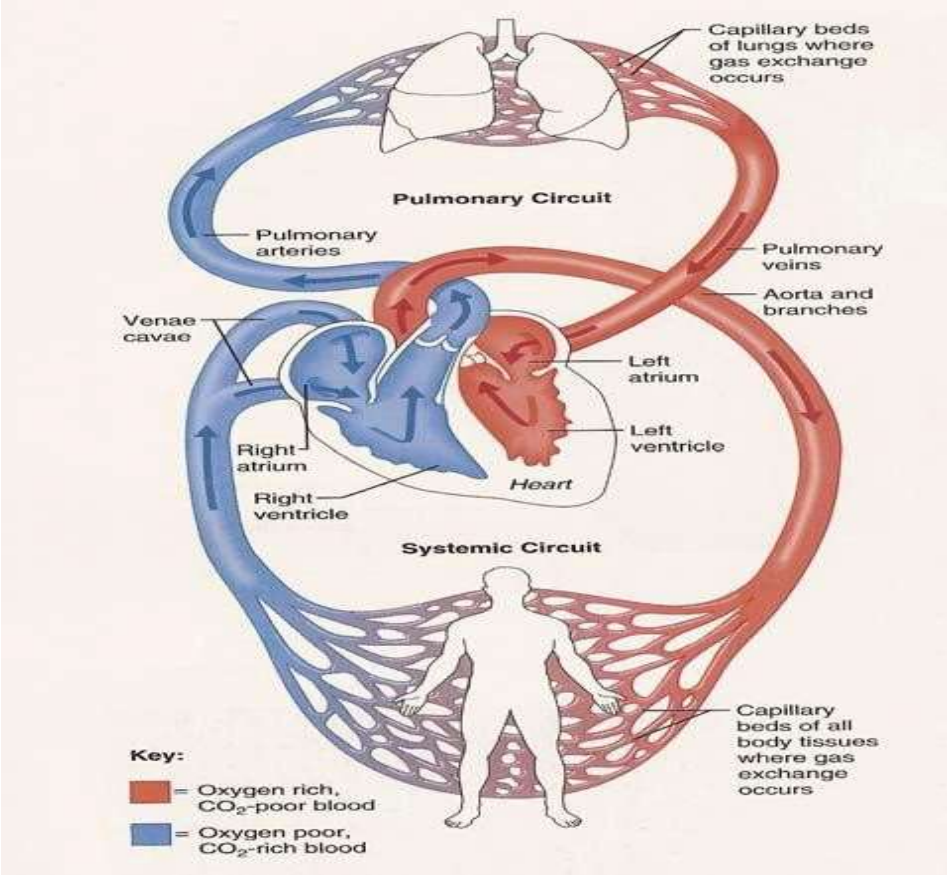

Figure 2: Oxygen enters the blood in the lungs

The separation of the right side and the left side of the heart is useful to keep oxygenated blood from mixing. Such separation allows a highly efficient supply of oxygen to the body [1]. This is useful in animals that have high energy needs, such as birds and mammals, which constantly use energy to maintain their body temperature.

11. A MATHEMATICAL MODEL OF THE HEART

12.1 Mechanism of the Heart using Digraph

The following graph represents the mechanism of the heart.

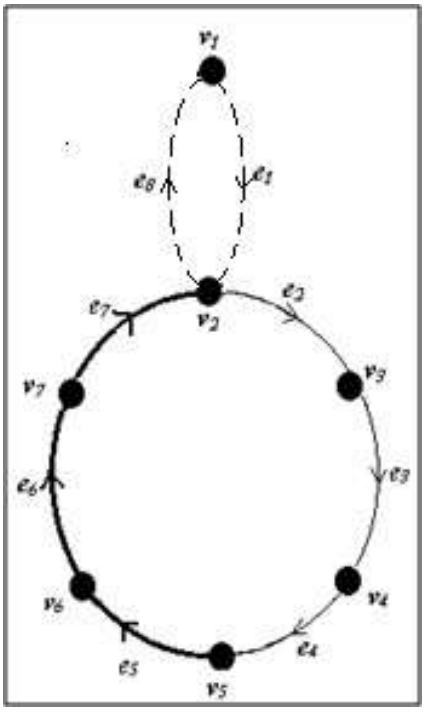

Figure 3: Digraph representing the mechanism of heart

v_1: Atmosphere	e_1: Oxygen rich air
v_2: Lungs	e_2: Pulmonary veins
v_3: Left Atrium	e_3: Mitral Valve
v_4: Left Ventricle	e_4: Aorta
v_5: Parts of the Body	e_5: Vena Cava
v_6: Right Atrium	e_6: Tricuspid Valve
v_7: Right Ventricle	e_7: Pulmonary Artries
	e_8: Deoxygenated Blood

The Dark lines in figure 3 represent the deoxygenated blood, the normal lines represent oxygenated blood and the dotted lines represent atmosphere air. In this graph the out degree of each vertex should be equal to the in degree since wherever the oxygenated blood flows the deoxygenated blood should come from there to the heart for purification.

The vertex v_2 (lungs) receives oxygen from the vertex v_1 (atmosphere). It contains an network of blood vessels these blood vessels combines the oxygen from the lungs with the blood and the oxygen rich blood goes to the vertex v_3 (left atrium) through the edge e_2 (pulmonary veins) from there the oxygen rich blood goes to the vertex v_4 (left ventricle) through the edge e_3 (mitral valve) then the oxygen rich blood goes to all over the parts of the body.

From the other parts of the body the deoxygenated blood goes to the vertex v_6 (right atrium) through the edge e_5(vena cava) then from there it reach the vertex v_7 (right ventricle) through the edge e_6 (tricuspid valve) from there the deoxygenated blood pumps to v_2 through the edge e_7 (pulmonary arteries) the blood vessels present v_2 collect the carbon dioxide from the deoxygenated blood and exits it.

3. REMARK

In this digraph we find that edge cut or vertex cut should not exist since removal of one such indicates the failure of the entire mechanism of heart.

It is important that vertices v_3 and v_4 are not adjacent to v_6 and v_7 so that there is no collapse of oxygen rich blood with the deoxygenated blood.

4. CONCLUSION

In this paper we discussed about the mechanism of heart using digraph which helps us to understand the function of heart in a simple fashion and how it circulates the pure blood to all parts of the body and how it exits the deoxygenated blood from all parts of the body.

5. FURTHER STUDY

The problem related to various heart diseases using graph theoretic approach is under study. Further we intend to extend our study to central nervous system.

6. ACKNOWLEDGMENTS

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