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# Implications Of Cognitive Studies Of Fluid Mechanics Of Coronary Artery Bypass Surgery: A More Realistic View

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***Abstract***

*Coronary artery bypass surgery is currently a widely used technique for relief of the effects of coronary atherosclerosis. This disease of coronary arteries is a major cause of death. It has been found that, in the developed countries 25% –30% people become victims of the coronary heart disease, which is described by WHO as the modern epidemic.*

***Key words:*** *92C05, 92C10, 92C35, 92C45, 92C50, 76Z, 57R67*

## 1. Introduction

Coronary heart disease causes various complicated situations such as Angina Pectoris of effort, Myocardial infarction, Iregulaites and Arythmia, Cardiac failure and sudden death. Statistics reveal that over 600,000 American citizens die each year due to the presence of atherosclerotic obstructions in their coronary arteries.

In our country there is a lack of availability of data or information and yet the statistics may be put as follows: Coronary heart disease is diagnosed in 66 per 1000 males and 48 in per 1000 females in India (Nandini R, 2007). People in the age group of 51–60 are more vulnerable to the disease and within that age group males are more susceptible to coronary heart disease than the females.

These obstructions cause additional resistance to the flow of blood and thus are responsible for reducing the amount of oxygen that reaches heart muscle cells that lie downstream of the obstructions. Moreover, if not provided with sufficient oxygen these cells will die, and if a relatively large area of heart muscle is affected the result can be – we call myocardial infarction (death of heart muscle) or heart attack (Spain D M, 1966).

In order to relieve the effects of such obstructions surgeons have developed procedures whereby a segment of vein is grafted form the aorta (i.e., near the aortic valve) to a location downstream of the coronary artery obstruction [3]. Hence these new conduits bypass the obstruction, providing another route for the blood to reach the downstream cells. (Furuse et al.,1972) have the hemodynamics of this type of aorta-to-coronary artery bypass and have shown that a relatively simple fluid mechanical model explains the resulting hemodynamics with sufficient accuracy. On the other hand, the analysis of (Furuse et al., 1972) has been based on Poiseuille's law, which describes the steady, laminar flow of a Newtonian fluid through a straight, circular tube. We can represent the law:

$$\frac{\Delta P}{Q}=\left(\frac{128\mu}{\pi}\right)\times\frac{L}{D^4} \qquad (1)$$

where $\Delta P$ represents the pressure drop in a length $L$ of tube with diameter $D$. $Q$ and $\mu$ represent the rate of flow and viscosity of the fluid, respectively. Hence, we can interpret the right hand side of Eq. (1), as a resistance to flow $R$, ( Alan C Burton, 1972). Thus, we obtain:

$$Q=\frac{\Delta P}{R} \qquad (2)$$

which is analogous to Ohm's law. In other words, this analogy permits flow circuits to be analyzed in a manner similar to that for dc electrical circuits. Fig. 1 is a schematic diagram of the flow system considered by (Furuse et al., 1972) and Fig. 2 is the analogous flow circuit. But, (Furuse et al., 1972) in which did not present a general treatment for the case of an obstruction in a coronary artery will be presented here for completeness. Now, Fig. 2 is a parallel circuit, and from the Eq. (2) we can write:

$$Q_g=\frac{\Delta P}{R_g}$$

*and*

$$Q_a=\frac{\Delta P}{\left(R_0+R_a\right)}$$

where the subscripts $g$, $0$, and $a$ represents the graft, obstruction and artery respectively. Hence adding these two results, the total flow rate $Q$ through the graft-artery combination. We obtain:

$$Q=\frac{\Delta P}{\left[R_g\right]}+\frac{\Delta P}{\left[R_0+R_a\right]} \qquad (3)$$

From (Furuse et al., 1972 ) a quantity of interest is the ratio of the arterial flow rate, and this follows by dividing the result for $Q_a$ by Eq. (3). We obtain, after simplifying,

$$\frac{Q_a}{Q}=\frac{1}{\left[1+\left(R_0+R_a\right)/g\right]} \qquad (4)$$

Again we have derived the three resistances $R_g$, $R_a$ and $R_0$ from Eq. (1), (Furuse et al., 1972). Therefore,

$$R_g=C\times\frac{L_g}{D_g^4}\quad;\quad R_a=C\times\frac{L_a}{D_a}$$

and

$$R_0=C\times\frac{L_0}{D_0^4}$$

where, C is the constant term, indicates $128\mu/\pi$. After introducing constants $k_1$ and $k_2$ to express $L_0$ and $D_0$ in terms of $L_a$ and $D_a$, respectively which gives us, such that

$$L_0 = k_1 \times L_1$$

and

$$D_0 = k_2 \times D_a$$

then we obtain

$$R_0 + R_a = C \times \frac{L_a}{D_a^4}\left(1 + \frac{k_1}{k_2^4}\right)$$

Now Eq. (4) becomes

$$\frac{Q_a}{Q} = \frac{1}{\left[1 + \left(L_a/L_g\right) \times (D_g/D_a)^4 (1 + k_1/k_2^4)\right]} \tag{5}$$

In other words, if we substitute, $k_1 = 0.2$ and $k_2 = 0.5$ then $L_a/L_g = 0.4$; $D_g/D_a = 2.0$ which are representative value from (Furuse et al., 1972), hence Eq. (5) indicates

$$\frac{Q_a}{Q} = 0.0358$$

Now, from the above derivations it has been concluded that more than 96% of the total flow rate follows the vein bypass in reaching the heart muscles cells that lie downstream of the obstruction. Hence the clinical implications of this relatively large flow rate through the vein bypass, as well as considerations of flow velocities in the vein graft, have been discussed at length in (Furuse et al., 1972; Alan C Burton, 1972).

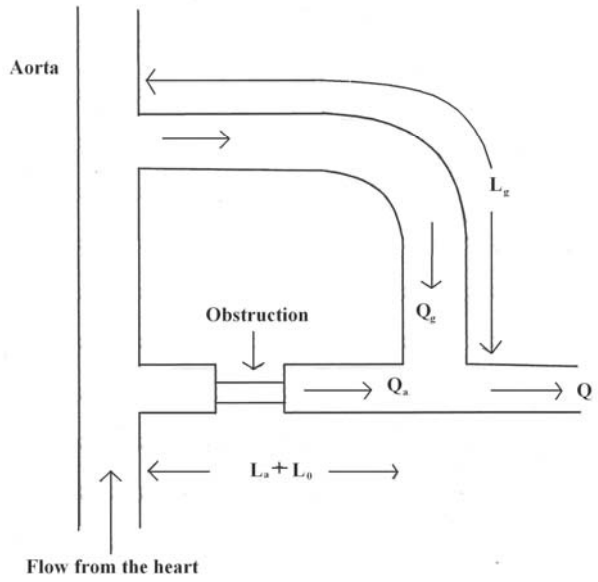


Figure 1. Schematic diagram of the coronary artery – vein graft flow system

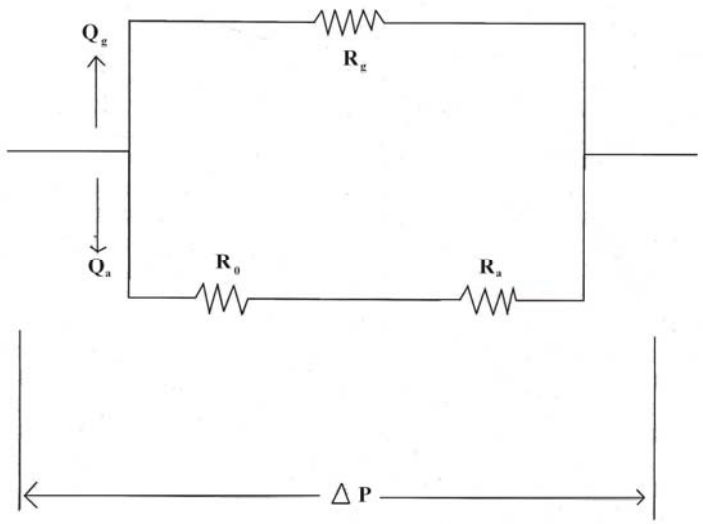


Figure 2. Analogous flow circuit for the flow system of Fig. 1

## 2. Factors responsible of stroke

Two types of factors are responsible for stroke, permanent and temporary. In the former one, age, sex and heredity are recognized as some important causes of heart stroke which are beyond the control of the patient and the physician. It has been seen that coronary heart disease occurs in the particular age group 35–45 and brain stroke usually takes place after the age of 40. With the increase in age of the person, he or she becomes more vulnerable to both types of stroke incidences. As far as sex differences are concerned, it is the males rather than the females who are at the risk of heart and brain strokes. Moreover, 40 percent of the heart diseases are found to be the result of heredity factors and the remaining sixty percent occur because of external causes.

Among the temporary causes of heart disease (*Cardiovascular Nutrition–Disease Management and Prevention–American Dietetic Association* 2006 ; Boon N A 1985) smoking and high blood pressure are recognized as the highly contributing factors. In the developed countries, the management of heart diseases has got the utmost priority in the health care policies and practices, and the same kind of sincerity and seriousness is needed in the countries like India as well.

### 2.1. Problem statement

In today's world, most deaths are attributable to non-communicable diseases (32 million) and just over half of these (16.7 million) are as a result of CVD; more than one third of these deaths occur in middle-aged adults. In developed countries; heart diseases and stroke are the first and second leading cause of death of adult men and women. These facts are familiar and hardly surprising in some of the developing countries, CVD have also become the first and second leading causes responsible for one-third of all deaths (*Cardiovascular Nutrition–Disease Management and Prevention–American Dietetic Association* ; 2006). We discuss four patterns of cardiovascular disease morality at four different stages of epidemiological transition have been shown in Table 1.

Table 1. Deaths caused by cardiovascular diseases at four different stages of the epidemiological transition

| Stage | CVD deaths (%) of total | Predominant CVD | Affected SEAR populations |
|---|---|---|---|
| [1] Age of pestilence and famine | 5–10 | RHD, infectious and nutritional cardiomyopathies | Some rural areas |
| [2] Age of receding pandemics | 10–35 | As above plus hypersensitive heart disease and haemorrhagic Stroke | SEAR as a whole-rural population |
| [3] Age of degenerative and man made disease | 35–55 | All forms of stroke; IHD is a relatively young ages | Urban population |
| [4] Age of delayed degenerative diseases | <50 | Stroke and IHD at older ages | ---------- |

Developing countries of South East Asia Region (SEAR) are typically in the second stage of this transition while some rural population are still in stage one, many urban population have entered third stage characterized by very high CVD morality. It is now well established fact that a persistently high cholesterol level can almost certainly precipitate a cardiac event such as Coronary heart disease (CHD). Unhealthy dietary practices include a high consumption of saturated fats, salt and refined carbohydrates as well as low consumption of vegetables and fruits and these tend to cluster together. Some of the dietary measures, on the strength of evidence on lifestyle factors and risk of developing cardiovascular disease, have been shown in Table 2.

The achievements claimed by this paper are:

(1) There is no specific cause for coronary heart attack – particularly a few factors influence it, such as some are modifiable and other one non-modifiable.

(2) Some precautionary measures such as changing the food is the principal remedy, WHO categorized the remedial measure to decrease fats 20% – 30% from total energy of the food, to maintain cholesterol i.e., 100 m gm per 1000 K cal or less than that.

(3) Avoid hard drinking; using table salt less tan 5 gm every day, the quantity of saturated fat in food is less than 10% from the total energy.

(4) The high blood pressure is the principal informer for coronary heart disease.

[a] The major CVD (Cardiovascular diseases) risk factors of the tobacco use, in appropriate diet and physical inactivity explain at least 75-85% of the new cases of coronary health disease.

[b] In the absence of elevation of these risk factors. Coronary heart disease (CHD) is a rare cause of death.

[c] The vast majority of the populations in almost all countries are at risk of developing CVD disease of higher than optimal levels of main risk factors.

Table 2. Summary of strength of evidence on lifestyle factors and risk of developing cardiovascular diseases

| Evidence | Decreased risk | No relationship | Increased risk |
|---|---|---|---|
| Convincing | Regular physical activity; Linoleic acid fish and fish oils (EPA&DHA) (Vegetables and fruits including berries); Potassium low in moderate alcohol intake (for coronary heart disease) | Vitamin E | Myristic and palmitic acids; Trans fatty acids High sodium intake Overweight High alcohol intake (for stroke) |
| Probable | α-Linolenic acid Oleic acid NSP Wholegrain cereals Nuts (unsalted) Plant sterols/stanols Folate | Stearic acid | Dietary cholesterol Unfiltered boiled Coffee |
| Possible | Flavonoida Soy products | ---------- | Fats rich in lauric acid Impaired fetal nutrition Beta carotene supplements |
| Insufficient | Calcium Magnesium Vitamin C | ---------- | Carbohydrates Iron |

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