AXIAL FLOW PUMP FOR CARDIAC ASSISTANCE: PRELIMINARY RESULTS

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Abstract-- This paper presents an axial flow blood pump for ventricular assistance. To allow assessment of pump's hydrodynamic performance and efficiency a testing set up was assembled. According to the results, this pump can supply a minimum flow rate of 2.2 L/minute.

Introduction

Mechanical assist devices can be classified according to their therapeutic application as: total artificial heart, biventricular, univentricular, intra-aortic baloon pump (IAP), and rotary pump. This paper presents an axial flow pump which has been developed and tested "in vitro".

The axial pump can be compared to an IABP as regard its physical dimensions and the maneuvers it requires for its clinical application .

Its basic operating system is composed of a) a driving electric motor (Bosch 500 W / 110 V/ 25000 rpm maximum ratings), b) a rotation transmission cable c) a screw like element. (see Figure 1).

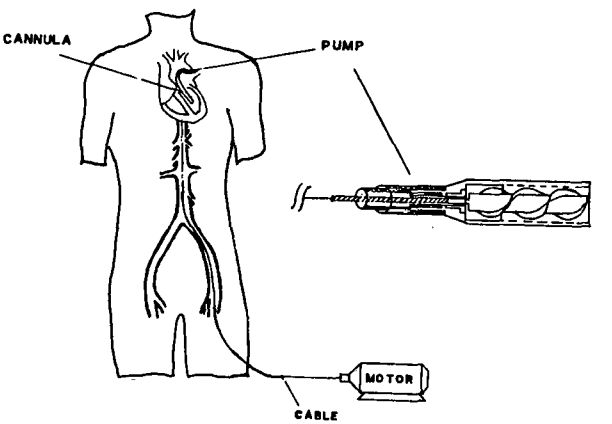

Figure 1. Axial flow blood pump assembly.

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The most important factors to be considered for evaluating the performance of an assist device are: the effective degree of circulatory aid, the degree of hemolisys and the complexity involved with its application.

There are several possible sources of hemolisys whenever blood is artificially pumped e.g. shear stress, velocity gradient, solid surface interaction, centrifugal forces, cell-cell interactions and turbulence. Although it is very difficult to isolate the exact influence of each one of these factors it is known that the main cause of mechanical cell damage is the hydrodynamic shear rate.

Williams (1973) has studied shear-induced fragmentation of red cell and found that in very low concentration the shear stress required to disrupt a red cell is 50 N/m^2 (during 5 min.) and that this value was influenced by the time of exposure. Richardson (1973) found a correlation of the time of exposure (residence time) of a human erytrocytes to various shear stress rates and the hemolisys rate. Reul (1983) investigated the correlation of residence time and shear stress rate based upon Richardson's work and defined a normal range of shear rate in the circulation.

The exact influence of shear stress and transit time is a controversial issue and therefore the determination of the safe region of operation of a pump must be determined as a function of its specific geometric caractheristics and its operating condition.

In vitro testing

To study the hydrodynamic performance of the pump a testing set up was built (fig.2) The set up allowed the measurement of flow rate for varying pressure gradient (output - input), which is proportional to the water height column (08). A valve (04) controls fluid inlet in chamber 1 as to maintain it at a constant level. A second reservoir is used to provide flow rate measurement (03).

To access pump performance, two parametres were measured: the necessary electric power for actuating the pump itself, (considered as the cable and screw assembly) and the effective hydraulic power delivered by it.

A load testing condition was defined for a flow rate of 2.2 L/min against 100 mmHg pressure gradient. Thus, the following procedure was carried out:

a) the effective power delivered was indirectly estimated by varying the power consumption of the motor itself, which is the power difference measured with the motor isolated (zero load) and when the above defined load is imposed to it. A power variation of 7.5 W was obtained.