



## Tissue & Organ Preservation

### The Artificial Heart

*Notes from W. H. Burns, M.D., et al.*

An implantable heart represents the ultimate in refinement of the cardiac prosthetics. There is a big unknown area involving the physiological changes that will accompany prolonged blood pumping. Even more awesome are the effects of blood clotting and metabolic changes which might accompany a mechanical system. Changes in the pulmonary circuit, possible carcinogenic effects of materials used, and exogenous heat production, all point to eventual medical complications in any system selected.

It appears that currently the two major problems involved are those of preventing clot formation and the selection or development of proper materials for the blood pumping chambers. Embolic and thrombotic phenomena currently pose the greatest threat to the overall success of artificial heart development, especially any total replacement. The importance of material selection in an artificial heart system which requires atraumatic blood handling without clotting or noticeable wear in a system not readily inspected cannot be minimized.

So, the following obstacles in the development of an artificial heart system were anticipated:

1. Thrombosis and embolic phenomena.
2. Hemolysis.
3. Material fatigue.
4. Limitations of the prosthetics.
5. The need for responsive controls.
6. Space limitations.
7. Efficiency.
8. Difficulties in animal testing.

Initially a study period was undertaken, and the following goals and guidelines were established, which for the most part have been followed:

1. Duplicate the human heart as nearly as possible.
2. The need for pulsatile blood flow.
3. A four-chambered heart, with two pumping chambers and two passive reservoirs.

4. A heart controlled by venous filling.
5. An electrically oriented system.
6. The need for an active and relatively unencumbered life for the patient.

The use of a closed-loop electrohydraulic system was selected for reasons of size, efficiency, reliability, and atraumacy of blood handling. The hydraulic and ventricular packages were combined into a single package—the Intra-pericardial Pumping Module (IPM). An ellipsoidal solid proved to be an ideal package form. The cross-section of the IPM approximates an ellipse with a 9 cm. minor axis and a 12 cm. major axis. Its height approaches 15 cm. The weight of this unit is 2000 grams and it displaces approximately 1200 cc.

This system has a cardiac output capability of from 5 to 12 Liters per minute per ventricle at 180 mm. of mercury. The energy demand rates vary proportionately with cardiac output. Maximum demand rate is 22 watts. The parallel redundancy utilized in the critical components enhances overall reliability and negates the possibility of a catastrophic failure because of breakdown in a single component. Should a malfunction occur, the system will continue to function normally at a reduced cardiac output of 6 Liters per minute.

