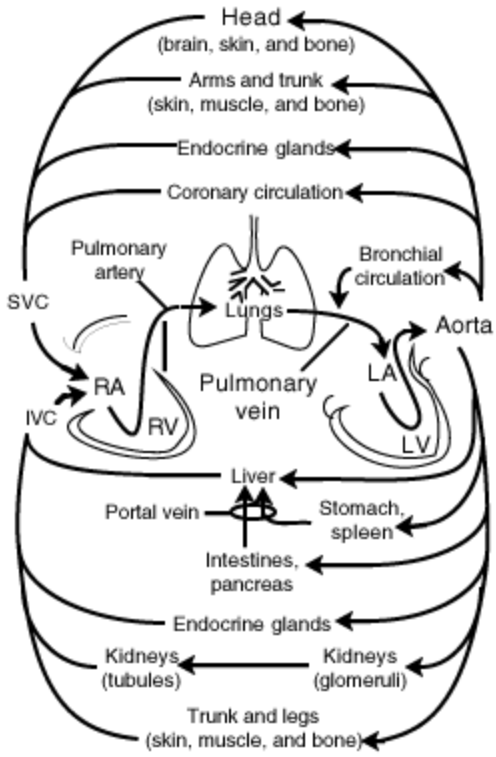
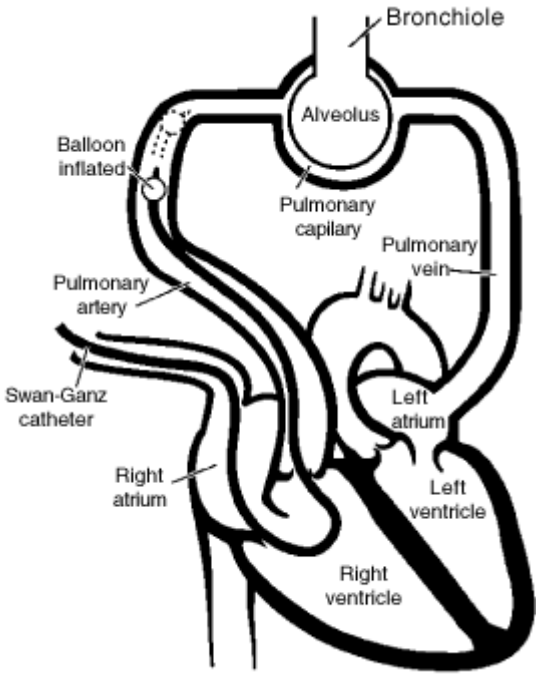
Put the Heart into Mathematics: Cardiac Output, Rates of Change and Accumulation

Background

Measurement of cardiac output as just described is a common procedure in hospitals. Patients returning from cardiac surgery have a Swan-Ganz catheter inserted as described. Measurements of cardiac output may be made hourly for the first 24 hours, followed by measurements every 2 hours for the next two days. The following passage appears in *Medical Physiology*.

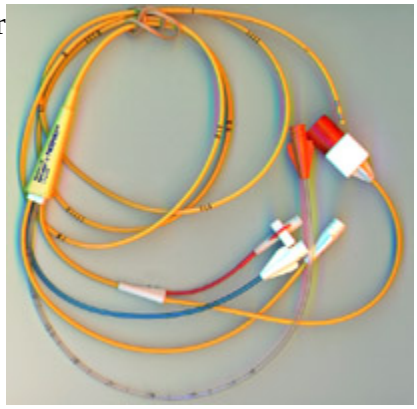
The Thermodilution Method. In most clinical situations, cardiac output is measured using a variation of the dye dilution method called *thermodilution*. A Swan-Ganz catheter (a soft, flow-directed catheter with a balloon at the tip) is placed into a large vein and threaded through the right atrium and ventricle so that its tip lies in the pulmonary artery. The catheter is designed so a known amount of ice-cold saline solution can be injected into the right side of the heart via a side pore in the catheter. This solution decreases the temperature of the surrounding blood. The magnitude of the decrease in temperature depends on the volume of blood that mixes with the solution, which depends on cardiac output. A thermistor on the catheter tip (located downstream in the pulmonary artery) measures the fall in blood temperature. Using calculations similar to the dye dilution method, the cardiac output can be determined.





Schematic diagrams of the cardiovascular system copied from *Medical Physiology*. The diagram to the left illustrates the total cardiovascular system. To the right is a diagram of the heart and a Swan-Ganz catheter threaded throughout the right atrium and into the pulmonary artery.

Swan-Ganz Catheter



The photo shows a Swan-Ganz catheter. The two gray bands near the tip are where the balloon is attached. The balloon is inflated by using a syringe attached to the rectangular lead with the red arrow to push air through a small hole between the bands. The balloon is used for other measurements on the heart as well as aiding insertion.

The square white box with red (cylindrical) cap is used to attach the catheter to a computer, which measures the temperature and calculates the cardiac output. The temperature is measured using a metal wire, which comes to the surface about 2 inches from the tip and looks like a small hole in the tube.

Other Ports: The white port with yellow wire is the PA Distal port, which allows connects to a small hole at the very end / tip of the catheter.

The white port with blue wire is the Prox. Injectate port, which allows for the injection of material through a small hole about 12 inches from the tip (3 black even thin lines).
The orange port with clear wire is the RV Pacing/Infusion Port ,which allows for the injection of material through a small hole about 8 inches from the tip (2 black even thin lines).