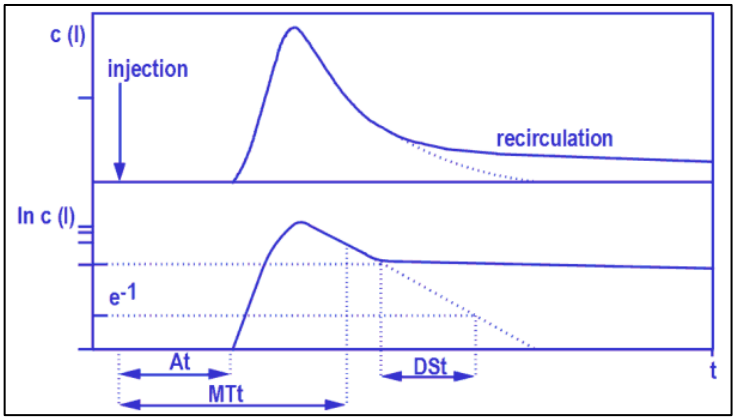
Cardiac Output by Thermodilution: Principles

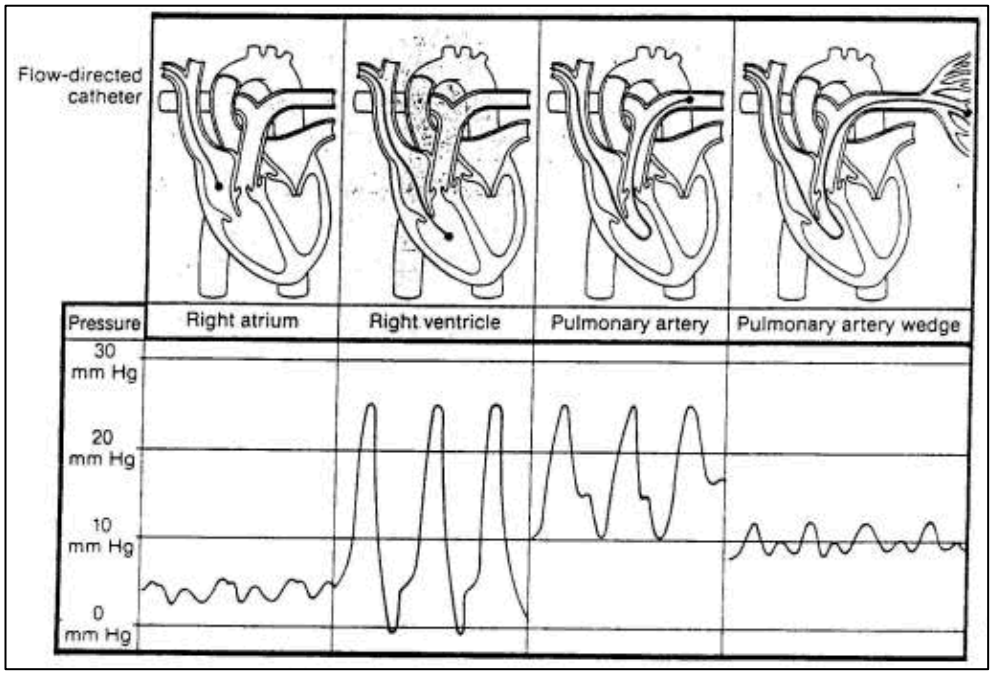
Anesthetic Pearls: The Principles of Cardiac Output Via Thermodilution Technique

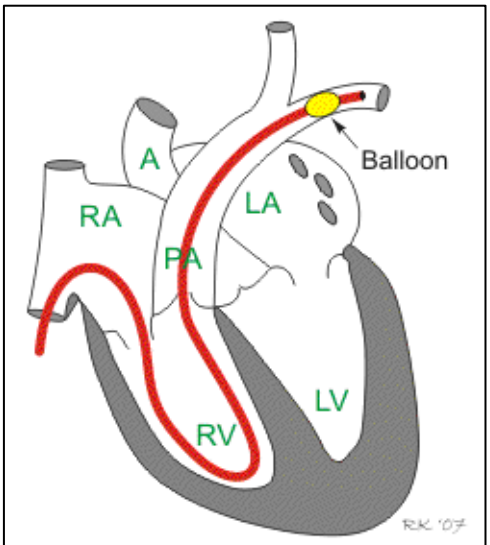
The technique of calculating cardiac output via thermodilution involves the **Fick principle**. This theory involves injecting a known volume of a fluid at a known temperature and then measuring the change this brings to the blood stream after it is injected over a known time period. By the mathematical principle of integrating the area under the curve, the cardiac output can be indirectly calculated via a volume based on the temperature differences. The temperature of the relatively cold injectate is measured by a thermistor outside the catheter where the fluid is injected. The second thermistor should be positioned in the pulmonary artery, and thus a right sided cardiac output is obtained. This measurement has been shown to be accurate under "most" circumstances but there are conditions that may lead to inaccurate measurements must be avoided to avoid misleading information.



Conditions that **must** be present for this indirect cardiac output measurement to be accurate:

1. "Complete" mixing of the indicator with the blood.
2. Relatively constant rate of flow is present. If the patient has an arrhythmia, the value may be falsely elevated / declined as the flow state will be greatly affected (unless the arrhythmia is constant).
3. The indicator must pass by the sensing thermistor only once and not be recirculated. Left to right shunts will result in falsely elevated cardiac outputs. Tricuspid regurgitation may also distort the values. Recirculation systemically is not a significant problem as indicator techniques involving dye, since the relatively small change in temperature is insignificant for the whole body.
4. The indicator volume must be accurate and given as a rapid bolus. The bolus should be given over a time < 4 seconds. If the volume injected is smaller than it should be, the cardiac output will be over-estimated; and conversely f the volume injected is greater than it should be, the cardiac output will be under-estimated.
5. The correct calibration constant must be used in the computer. There are different constants for different catheters and the temperatures of the injectate.
6. Other fluids of various temperatures are not being infused simultaneously. If cold blood or crystalloid is rapidly being given centrally this will distort the calcuation.
7. Conditions affecting venous return such as positive pressure ventilation should be kept constant. The cardiac output may vary as much as 25% when taken at various points of the ventilation cycle. The expiratory time is theoretically the most accurate (pick one consistent time for the calculated fluid injection during the ventilatory cycle).
8. Temperature difference must be great enough between the fluid injectate and the blood for an accurate measurement. Room temperature is usually adequate with the advantage of no need for ice, less chance of arrhythmia's due to the cold fluid, and less chance of re-warming error from the injectate sensor to the patient.





Balloon-tipped, Swan-Ganz catheter for measuring pulmonary capillary wedge pressure (PCWP).