## CARDIAC OUTPUT MEASUREMENT

Cardiac output is amount of blood delivered by the heart to the aorta per minute. It is a major determinant of oxygen delivery to issues. When the supply of blood from the heart is unable to meet the demand.

Due to this cardiac output may results in low blood pressure, reduced tissue oxygenation, poor renal function and shock. Blood pumper from the heart with each beat for adults is between 70 to 100ml, and cardiac output is 4 to 6 litres/min. Cardiac output is estimating by using the following methods.

- Direct method
- Fick's method
- Indicator dilution method
- Dye dilution method
- Thermal dilution method

### Direct Method

In this method cardiac output is measuring the stroke volume using an electromagnetic flow probe placed on the aorta and multiplying it by the heart rate. This method involves in surgery so not preferred in routine applications.

### Fick's Method

Cardiac output is measured by continuously infusing oxygen in or out from the blood and measure the amount of oxygen before and after passing.

Disadvantages:

- Method is complicated, difficult to repeat.
- Need catheterization

### Indicator Dilution method

Indicator dilution method is one of the most popular methods and it employees several different types of indicators. Two methods are generally employed for introducing the indicator in the blood stream.

1. Continuous Infusion method, but not widely used due to the indicator re-circular process.

2. Bolus injection method, amount of blood known by an indicator using dye and it is administered into the circulation.

The presence of indicator in the peripheral artery is detected by a transducer and displayed on a chart recorder. Therefore, the cardiac output on chart is in a curve form. That curve is called as dilution curve. The run of the dilution curve is self-explanatory.

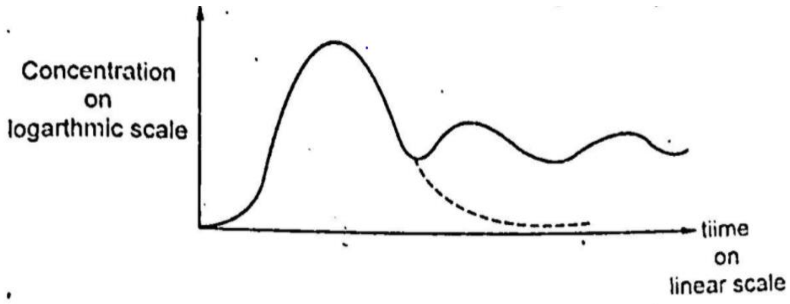


**Fig: Dilution curve**

For calculating the cardiac output from the dilution curve.

$$Q = \frac{M}{\left.\begin{array}{c}\text{Average concentration of indicator per litre}\\ \text{of blood for duration of curve}\end{array}\right\} \times \text{curve duration in seconds}}$$

$$= \frac{M \times 60}{\text{area under the curve}} \times \text{l/min}$$

M - quantity of the injected indicator in mg

$\dot{Q}$ - Cardiac output

C - Concentration of indicator

$$\therefore \boxed{Q = \frac{M}{\int_0^t C \cdot dt}}$$

The evaluation of the dilution curve is simplified replotting the curve on semilogarithmic scale paper.

**Dye Dilution Method**

The most used indicator substance is a dye. Indocyanine green dye is usually employed for recording the dilution curve.

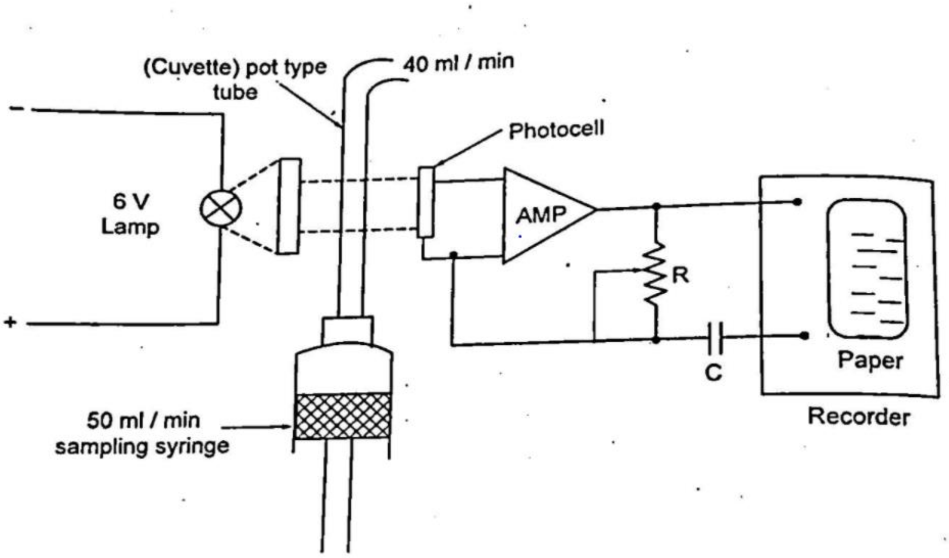


**Fig: Densitometer for dye concentration**

This dye is preferred because of its property of absorbing light in 800 nm. The concentration of cardiogreen is measured with the help of a infra-red photocell transducer. Densitometer is used for the quantitative measurement of dye concentration. The following diagram shows the diagrammatic representation of a densitometer.

Working:

- In order to avoid the formation of bubbles, a pot type tube should be flushed with a silicon in ether.
- A flow rate of 40ml/min is preferred in order to get a short response time as possible for the sampling catheter.
- The sampling syringe has a volume of 50ml/min.
- The output of the photocell is connected to a low drift amplifier. It has high input impedance and low output impedance.
- The amplification is directly proportional to the resistance value of the potentiometer R.
- A potentiometer recorder records the amplified signal on a 200mm wide recording paper with a speed of 10mm/sec.

**Thermal Dilution Method:**

A thermal indicator will produce a resultant temperature change in the pulmonary artery and the integral is inversely proportional to the cardiac output.

$$Cardiac\ Output = \frac{\text{a constantx(blood temp} - \text{injected temp)}}{\text{area under dilution curve}}$$

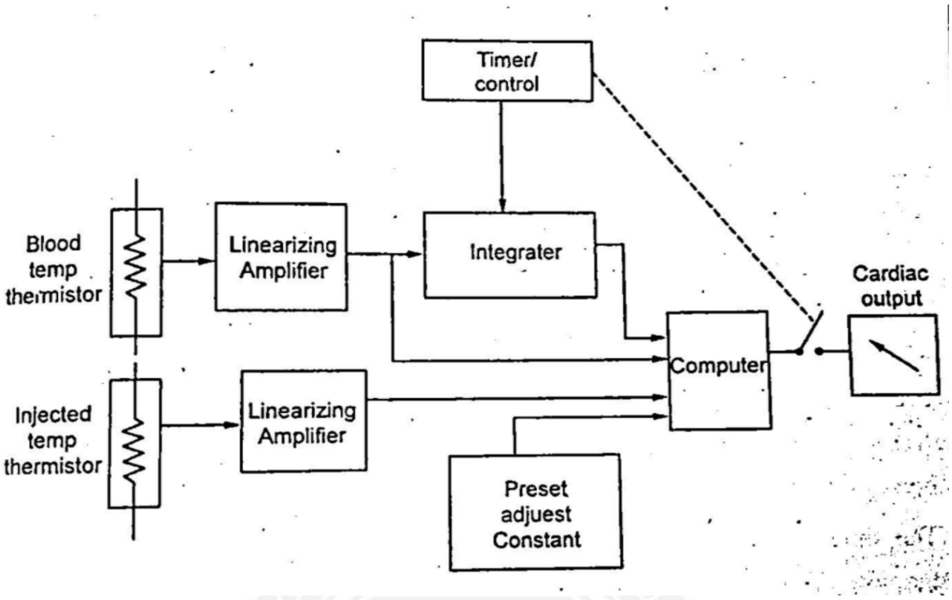


**Fig: Block diagram of thermal dilution method**

The system calibration is based upon the use of an injection of 10ml of 5% dextrose solution at a room temperature in the range of 18-28$^{o}$C. In this range, the injected temperature is measured to an accuracy of ±0.2$^{o}$C and displayed on a meter. The above figure shows the block diagram of thermal dilution method.

Working:

A solution of 5% dextrose in water at room temperature is injected as a thermal indicator into the right atrium. The injected temperature is sensed by a thermistor and the temperature difference between injected and blood is circulating in the pulmonary artery is measured.

The reduction in temperature of pulmonary artery is integrated with respect to time and the blood flow in the pulmonary artery is computed electronically by a computer. The integrator responds to a $\Delta_T$. Signal corresponding to a maximum temperature change of typically 0.3$^{o}$C with reference to a $T_b$ (initial temperature of blood ($^{o}$C)).

It may vary from one patient to another over a range of 30-40$^{o}$ C. Then the summing, multiplication, division operations required for the evaluation of cardiac output are performed by a simple computing circuit by a computer.

The timer/control unit generates the switching signal necessary for proper integration. The cardio output is displayed in two ranges 0-10 l/min and 10-20 l/min.

**Measurement of Cardiac Output:**

- Impedance Technique: Cardiac output can be determined electronically by the impedance method.
- Ultrasound Method: Used to measure the velocity of blood flow in the ascending aorta by the application of doppler principle.
- Bioreactance Method: A method for non-invasive hemodynamic monitoring is based on bioreactance method.