Title: CARDIAC OUTPUT MEASUREMENT USING POTASSIUM DILUTION

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Introduction. The most commonly used technique of measuring cardiac output in a patient is that of indicator dilution, with thermodilution being the predominant method. Either room-temperature or iced saline injectates are used as the diluent and changes in pulmonary artery temperature are used as the indicator. Iced saline is the most preferred diluent. In this paper an alternative technique is proposed, that of potassium dilution. An intravascular potassium sensor is placed in the pulmonary artery by a flow-directed catheter and an indicator dilution curve obtained by using room-temperature normal saline, or any other non-potassium-containing solution. The curve obtained which is similar to other dilution curves indicates the washout of potassium. Cardiac output is calculated by the familiar mass balance equation.

Methods. This technique was initially tried on an in-vitro flow bench with excellent results ($r^2 = 0.99$). Experiments were then performed on mongrel dogs by attaching an Ionetics potassium probe to an American Edwards Swan-Ganz catheter and floating the catheter into a branch of the pulmonary artery. Simultaneous thermal and potassium dilution curves were obtained using a 5 ml room-temperature injectate. Thermal dilution flow was measured by a Sorenson cardiac output computer. Potassium dilution flow was measured by graphically integrating the curve of electrical difference between the potassium selective electrode and a saturated Calomel electrode. All measurements were performed in triplicate and the results averaged. Cardiac output was varied by the use of positive (dopamine) and negative (propranolol) inotropic drugs.

Results. A plot of the comparison between thermal dilution and potassium dilution is shown in the accompanying figure. There is excellent correlation between the two techniques ($r^2 = 0.97$). At the higher end of the cardiac outputs there appears to be a greater divergence from the identity line. However only one point was outside $\pm$ 10% of the thermal dilution measurement.

Discussion. The standard equation of flow using indicator dilution is F = indicator injected/integral of change of indicator. This equation must be modified in this technique since the washout involves only plasma and not red blood cells. Consequently the equation used to calculate cardiac output is given by

$$C.O. = \frac{KV_I}{(1 - \text{Hematocrit}) \int_0^\infty \Delta E(t)dt}$$

where K = constant, V_I = volume of injectate, $\Delta E(t)$ is the recorded electrical difference between sensor and reference electrode. If the hematocrit is rapidly changing, as it frequently does during certain surgical procedures this technique is at a decided disadvantage.

However the use of an intravascular potassium sensor can be advantageous, especially after cardiopulmonary bypass when there are rapid changes in potassium concentration. As the technology of ion selective sensors improves the technique of ion dilution may prove to be a viable alternative to thermal dilution. These ion selective sensors can function in a dual role, providing both sensing of ion concentrations and flow measurements

References.

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