

A novel method for measuring total coronary blood flow, and myocardial oxygen consumption.

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Introduction

An examination of blood gas results and a cardiac output allows the easy measurement of coronary sinus blood flow and estimation of myocardial oxygen consumption.

Method

During routine coronary artery bypass surgery, a pulmonary artery sample is taken for blood gas analysis before and after insertion of the coronary sinus cannula. A sample is taken from the cannula as part of the usual de-airing procedure. A thermodilution cardiac output is measured. If it is desired to measure myocardial oxygen consumption in addition to coronary sinus flow, an arterial blood gas sample is also taken.

A computerized evaluation of these blood oxygen content and cardiac output results a measure of coronary sinus blood flow, and myocardial oxygen consumption. The formulae and derivation are given below.

Derivation of formulae:

Where:

Q = flow

C = oxygen content

t = PA, total flow

ra = Right Atrial -collected from PA as described.

cs = coronary sinus

v = mixed venous, no CS flow diversion.

a = arterial

m = myocardial

Oxygen content x PA flow = CSflow x CScontent + RAflow x RA(mixed venous) content

$$Q_t.C_v = Q_{ra}.C_{ra} + Q_{cs}.C_{cs}$$

but as $Q_t = Q_{ra} + Q_{cs}$, therefore $Q_{ra} = Q_t - Q_{cs}$

so substituting,

$$Q_t.C_v = (Q_t - Q_{cs}).C_{ra} + Q_{cs}.C_{cs}$$

therefore,

$$Q_t.C_v - Q_t.C_{ra} = Q_{cs}.C_{cs} - Q_{cs}.C_{ra}$$

more simply,

$$Q_t (C_v - C_{ra}) = Q_{cs} (C_{cs} - C_{ra})$$

thus, coronary blood flow,

$$Q_{cs} = Q_t (C_{ra} - C_v) / (C_{ra} - C_{cs})$$

and myocardial oxygen consumption therefore approximates to

$$mVO_2 = Q_t (C_{ra} - C_v) (C_a - C_{cs}) / (C_{ra} - C_{cs})$$

A case to illustrate:

$$Q_t = 5.0 \text{ l/min}$$

$$C_{ra} = 12.7 \text{ ml/dl}, C_v = 12.1 \text{ ml/dl}, C_{cs} = 7.2 \text{ ml/dl}, C_a = 15.3 \text{ ml/dl}$$

Therefore ,

$$Q_{cs} = Q_t (C_{ra} - C_v) / C_{ra} - C_{cs} = 55 \text{ ml/min},$$

And,

$$mVO_2 = Q_t (C_{ra} - C_v) (C_a - C_{cs}) / C_{ra} - C_{cs} = 4.4 \text{ ml / min}$$

Discussion

Use of content difference to calculate flow is not new, though the use of the surgical coronary sinus cannula to divert coronary sinus from mixed venous blood collected from the pulmonary artery is, we believe, novel and useful. The resulting difference in pulmonary artery composition gives valuable insight to the coronary circulation draining by the coronary sinus. The resulting measure from the calculation is a true measure of flow, rather than a velocity converted to flow –as is common with echo techniques. Further, it is unfortunate that the direction of the coronary sinus is almost perpendicular to any easily achieved transesophageal ultrasound beam, so making velocity measurements in it nearly impossible. While our technique may provide data useful for comparisons, it may be difficult to verify it in absolute terms. It is interesting to note that the value for coronary flow in the example is low, as might be expected for this patient undergoing coronary artery bypass grafting. Perhaps it may be useful to compare flow before and after surgical or pharmacological intervention? The study continues, to explore its capabilities and limitations. We also continue to consider means for validation.