The value of nuclear angiography in the preoperative assessment of patients undergoing elective aortic surgery

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Eighteen patients undergoing elective aortic surgery, either for peripheral vascular insufficiency or abdominal aneurysm, were studied preoperatively by nuclear angiography. By this technique the resting ventricular function of each patient was measured. Nuclear angiography is a safe non-invasive technique which has been shown to have excellent correlation with conventional contrast angiography in the assessment of ejection fraction.

Throughout the intraoperative period, measurements of the central venous pressure and pulmonary capillary wedge pressure were taken simultaneously at approximately five-minute intervals.

An average of 18 data points was established in each case. The correlation between central venous pressure (CVP) and pulmonary capillary wedge pressure (PCWP) was examined.

Ten of our patients had preoperative resting ejection fractions less than 55 per cent. In only four of these

patients (40 per cent) was correlation between CVP and PCWP judged to be good intraoperatively.

Eight of our patients had preoperative ejection fractions greater than 55 per cent. Six of these (75 per cent) showed good correlation between CVP and PCWP intraoperatively.

We also assessed our ability to predict by purely clinical means which patients would show poor correlation between CVP and PCWP.

Evaluation on purely clinical grounds was as good as the scans at predicting in which patients CVP would not correlate with PCWP and we feel that the routine use of this test would not modify our use of Swan Ganz catheters for intraoperative monitoring in patients undergoing aortic surgery, in the future.

Key words

SURGERY: abdominal aortic; **MEASUREMENT TECHNIQUES:** nuclear angiography; **MONITORING:** Swan Ganz catheter, intraoperative monitoring.

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Elective aortic surgery has been shown to be associated with a high mortality, being approximately five per cent. The major causes of morbidity and death following aortic surgery are cardiac in origin, myocardial infarction being the most important.¹⁻³ This has great significance when considering how best to monitor such patients intraoperatively, in view of the potential for haemodynamic instability related to aortic cross-clamping, un-clamping, and to the large rapid fluctuations in intravascular volume.

The aim of this study was to assess the value of preoperative nuclear angiography in identifying patients in whom the central venous pressure (CVP) would correlate poorly with pulmonary capillary wedge pressure (PCWP).

Nuclear angiography is a non-invasive, safe and accurate method of assessing ejection fraction and

wall motion abnormalities of the heart. Its correlation with contrast angiography is excellent.^{4,5} The technique involves the injection of stannous pyrophosphate, which complexes with red blood cells *in vivo*. Fifteen minutes postinjection technetium 99m per-technetate is injected. This complexes with the stannous pyrophosphate RBC complex. Cardiac imaging is achieved using a gamma camera. Multiple frames are recorded and using computer techniques left ventricular end-diastolic and end-systolic silhouettes are outlined. The ejection fraction can then be computed. In addition wall motion abnormalities are detectable, signifying a poorly contractile area of ventricular wall.

All patients in the study underwent preoperative nuclear angiography. Intraoperatively, simultaneous measurements of CVP and PCWP were recorded at five-minute intervals. The correlation of CVP and PCWP was examined with reference to preoperative resting ejection fraction.

Assuming that non-correlation of CVP with PCWP is an indication that wedge pressure should be monitored, we compared our clinical assessment with the resting scan as a predictor of the need for Swan-Ganz catheter monitoring.

Methods

Eighteen patients who were scheduled for elective aortic surgery (either for peripheral vascular insufficiency or abdominal aortic aneurysm) involving infra renal cross-clamping of the aorta, were studied sequentially. There were no exclusions from the study. The protocol was approved by the University of Toronto Human Subjects Review Committee.

Each patient had preoperative radionuclide angiography. This was performed using an Ohio Nuclear Sigma series 420 gamma camera using a parallel hole general purpose collimator. Data collection and storage were handled with a Medtronic Data System Computer.

Subjects received 25 mg of Sn-PYP intravenously, followed in 15 minutes by 25 MC; Technetium 99m for *in vivo* labelling of red blood cells. A total of three million counts were collected to produce a cardiac image from a cardiac cycle that had been divided into 20 equal frames.

Using computer techniques with semi-automated programs, left ventricular end-diastolic and end systolic silhouettes and background regions were outlined. The ejection fraction was calculated as

$$EF = \frac{EDC(bc) - Esc(bc)}{EDC(bc)}$$

Where

EDC (bc) = background corrected end diastolic counts

and

Esc (bc) = background corrected end-systolic counts

The result of the radionuclide angiography was unknown to the anaesthetist at the time of surgery.

A standard anaesthetic protocol was followed. All patients received preoperative medication consisting of morphine 0.15 mg·kg⁻¹ and perphenazine 0.05–0.1 mg·kg⁻¹ intramuscularly one hour prior to surgery.

Monitoring consisted of routine monitoring plus the V₅ electrocardiogram and an arterial line and a triple lumen heparin bonded pulmonary artery catheter (Edwards Lab. #93A 131 H 7F) which were inserted under local anaesthesia, prior to induction.

Cardiac output measurements were performed at approximately five minute intervals and calculation of the systemic vascular resistance was done using the formula

Systemic vascular resistance
dyne·sec·cm⁻⁵

$$= \left[\frac{\text{Mean Blood Pressure} - \text{Central Venous Pressure}}{\text{Cardiac output}} \right] \times 80$$

Nitrous oxide with oxygen in concentrations of 50–70 per cent were used for maintenance. Hypertension was treated by infusion of nitroprusside, (0.01 per cent), the infusion rate being titrated to maintain the patient's blood pressure at ward blood pressure levels. Propranolol was used concomitantly to control tachycardia. The cardiac output and systemic vascular resistance were used as guides for the use of these agents.

Isoflurane 0.5–1 per cent was used for maintenance in three patients and enflurane 0.5–1 per cent in two patients, where blood pressure control was difficult.

An average of 18 data points were noted in each case. At each data point the central venous pressure and pulmonary capillary wedge pressure were measured using the same transducer and monitor

TABLE I Results of preoperative ejection fraction compared with intraoperative correlation between CVP/PCWP.

Patient Number	Ejection fraction	Wall motion	Number of data points	% Non-correlation	CVP = PCWP
1	28%	Septal inferoapical dyskinesis anterior akinesis	14	92	No
2	30%	Large area of dyskineses of anterior wall? apical aneurysm	12	100	No
3	39%	Severe septal hypokinesis severe anterior hypokinesis	19	84	No
4	40%	Septal and interolateral hypokinesis	11	18	Yes
5	42%	Septal hypokinesis generalised left ventricular hypokinesis	19	63	No
6	50%	Normal wall motion	14	14	Yes
7	51%	Septal hypokinesis	23	4	Yes
8	51%	Normal wall motion	20	100	No
9	53%	Inferoapical akinesis	20	30	No
10	53%	Normal wall motion	15	13	Yes
11	56%	Normal wall motion	22	38	No
12	57%	Normal wall motion	17	11	Yes
13	57%	Normal wall motion	24	20	Yes
14	58%	Septal and inferoapical akinesis	21	19	Yes
15	60%	Normal wall motion	13	100	No
16	65%	Normal wall motion	22	0	Yes
17	65%	Normal wall motion	17	6	Yes
18	71%	Normal wall motion	13	13	Yes

(Bentley Trantec Transducer; Tektronic Vitatek 414 OPT 21). The central venous pressure was considered not to correlate with pulmonary capillary wedge pressure if a difference of five torr was present.

Results

Table I compares the results of the preoperative ejection fractions with the percentage of data points at which the central venous pressure failed to correlate with the pulmonary capillary wedge pressure. The CVP reading was considered to correlate with its simultaneous PCWP reading if the difference between the two values was less than five torr and the two values changed in the same direction.

If more than 20 per cent of the data points did not show correlation between CVP and PCWP, the CVP was considered to be an unsatisfactory monitor of intravascular volume, in that patient.

Of the ten patients whose preoperative ejection fractions were less than 55 per cent, four or 40 per cent showed good correlation between CVP/PCWP intraoperatively. Of the eight patients whose preoperative ejection fractions were greater than 55 per cent, six or 75 per cent subsequently showed good correlation between CVP/PCWP. This information is summarised in Table II.

Table III outlines the clinical problems presented in our group of patients. Our usual practice is to use

TABLE II Summary of results

	Number of patients	CVP = PCWP
Ejection fraction less than 55%	10	4 (40%)
Ejection fraction greater than 55%	8	6 (75%)

PCWP as the measure of intravascular volume in individuals who have evidence of ischaemic heart disease or cardiac failure. Patients in whom such monitoring was indicated clinically are marked with an asterisk.

On the basis of clinical evaluation alone, eleven of the eighteen patients would have been expected to show poor correlation between CVP/PCWP. In seven of the 11 this was the case.

In only one case did clinical evaluation predict that CVP would be an adequate monitor when in fact did not prove to be the case.

Discussion

There are considerable haemodynamic stresses in aortic surgery. Aortic cross clamping, unclamping and the large fluid shifts and potential for large blood loss make close haemodynamic monitoring essential. No consensus on use of Swan Ganz catheters exists. Several authors, however, advocate their use.⁶⁻⁸

TABLE III Clinical evaluation with respect to need for intraoperative Swan-Ganz monitoring

Patient Number	Age (years)		CVP = PCWP
1*	65	history of AHA I angina	No
2*	82	past history of MI, HT, CCF	No
3*	60	past history of MI, ACB A. Fib. CCF	No
4	50	ASA I	Yes
5*	67	history of MI	No
6*	68	history of MI, ACB, HT	Yes
7	68	HT	Yes
8*	58	ACB, HT, elevated Cr	No
9*	68	ECG evidence of old MI (asymptomatic)	No
10*	72	HT, history of CCF	Yes
11*	73	NIDDM, CVA, HT, ECG, T V ₅ -V ₆	No
12	60	ASA I	Yes
13*	75	history of HT, ECG suggestive of old MI	Yes
14*	72	Prev. ACB, CVA	Yes
15	68	HT	No
16	61	Elevated Cr	Yes
17	70	Previous AVR	Yes
18	56	ASA I	Yes

* = Patients with clinical indications for use of intraoperative Swan Ganz catheter.

Abbreviations: MI = Myocardial infarction. A.Fib. = Atrial fibrillation. CCF = Congestive cardiac failure. Cr. = Creatinine. NIDDM = Non-insulin dependent diabetes mellitus. CVA = Cerebrovascular accident. HT = Hypertension. ACB = Aorto coronary bypass. ASA = ASA physical status classification.

Our present approach to these patients involves the use of intraoperative Swan Ganz monitoring in individuals with a history suggestive of either poor ventricular function or myocardial ischaemia, on the assumption that in these individuals the CVP does not give accurate information about left-sided filling pressures.

A resting cardiac scan will give information about resting left ventricular function.⁹ Manzano has shown that when using contrast angiography the EF does predict in which patients CVP/PCWP is reliable. Our results confirm that those individuals with poor ejection fractions, show poor correlation between CVP and PCWP. A normal scan, however, did not guarantee good correlation between CVP and PCWP in our patients. This failed to be the case in two of the eight patients studied. A possible explanation for this might be the occurrence of intraoperative ischaemia. We did not however, document by ECG any ischaemia in these two cases.

In Table III we have summarised the main clinical findings in our patients. Using our present indications for SG catheterisation we would have

used SG catheters in those individuals marked with an asterisk. By so doing we would have missed one patient (#15), whose CVP did not correlate with PCWP. However, the resting cardiac scan was normal in this individual also. We therefore are of the opinion that the routine use of preoperative resting cardiac scans would not modify our use of Swan Ganz catheters for intraoperative monitoring of patients undergoing aortic surgery in the future. Nicholas *et al.*¹⁰ reported that nuclear angiography was not able to predict which patients would show poor correlation between CVP and PCWP. We do not agree with this. In our opinion, resting nuclear angiography does predict fairly well what will occur intraoperatively with respect to CVP/PCWP correlation. We feel that the main limitation of its accuracy is that resting scans do not unmask patients who may by virtue of coronary stenosis have hearts which, while normal at rest, behave abnormally in stress situations. Aortic surgery may well become such a stress situation. An evaluation of exercise nuclear angiographic scans may prove to be valuable.

References

- 1 Baird RT, Gurry JF, Kellam JE. Abdominal aortic aneurysms: recent experience with 210 patients. *Can Med Assoc J* 1978; 1229-35.
- 2 Thompson J, Hollier L, Patman RD. Surgical management of abdominal aortic aneurysms. *Ann Surg* 1975; 181: 654-60.
- 3 Whitmore AD, Clowes AW, Hechman HB. Reduced operative mortality associated with maintenance of optimal cardiac performance. *Ann Surg* 1980; 192: 414-9.
- 4 Federman J, Brown ML, Tancredi RG. Multiple gated acquisition cardiac blood pool isotope imaging. Evaluation of left ventricular function correlated with contrast angiography. *Mayo Clin Proc* 1978; 53: 625-33.
- 5 Follard FD, Hamilton GW, Larson SM. The radio-nuclide ejection fraction. A comparison with contrast angiography. *J Nucl Med* 1977; 18: 1159-66.
- 6 Bush H, Legerfo FW, Weizel RD. Assessment of myocardial performance and optimal volume loading during elective abdominal aortic aneurysm resection. *Arch Surg* 1977; 112: 1301-6.
- 7 Silverstein PR, Caldera D, Cullen DJ. Avoiding the haemodynamic consequences of aortic cross clamping and unclamping. *Anesthesiology* 1979; 50: 462-6.
- 8 Raiz S, Peter T, Raiz O. Haemodynamic and cardiometabolic effects of infrafenal aortic and common iliac artery declamping in Man - an approach to optimal volume loading. *Acta Anesthesiol Scand* 1979; 23: 579-86.
- 9 Mangano, DT. Monitoring pulmonary arterial pressure in coronary artery disease. *Anesthesiology* 1980; 53: 364-70.
- 10 Nicholas, GG, Martin DE, Osbakken MD. *Arch Surg* 1983; 118: 1256-8.

Résumé

Dix-huit patients subissant une chirurgie aortique éle-ctive soit pour insuffisance vasculaire périphérique ou anévrisme abdominal ont été étudiés en période pré-opératoire par angiographie nucléaire. Par cette technique la fonction ventriculaire de base de chaque patient était mesurée. L'angiographie nucléaire est une technique non invasive et sécuritaire qui a déjà été démontrée comme ayant une excellente corrélation avec l'angiographie de contraste conventionnelle dans l'évaluation de la fraction d'éjection.

Tout au long de la période per-opératoire, les mesures de la pression veineuse centrale et la pression capillaire pulmonaire bloquée ont été prises simultanément environ toutes les cinq minutes.

En moyenne 18 points de données ont été établis dans chaque cas. La corrélation entre la PVC et la PCP fut examinée.

Dix de nos patients avaient une fraction d'éjection de base de moins de 55 pour cent. Chez seulement quatre de ces patients (40 pour cent) la corrélation entre la PVC et la PCP a été jugée adéquate en période per-opératoire.

Huit de nos patients avaient une fraction d'éjection supérieure à 55 pour cent. Six de ceux-là (75 pour cent) avaient montré une bonne corrélation entre la PVC et la PCP per-opératoire.

On a aussi évalué notre capacité de prédire par des moyens cliniques lesquels des patients auront une corrélation pauvre entre la PVC et la PCP.

L'évaluation basée uniquement sur des moyens cliniques était aussi bonne que le "scan" pour prédire chez quel patient la PVC n'aurait pas une bonne corrélation avec la PCP, et nous pensons que l'utilisation de routine de ce test ne modifiera pas dans le futur notre décision d'utiliser le cathéter de Swan-Ganz pour le monitoring per-opératoire chez les patients subissant une chirurgie aortique.