Dipyridamole-thallium myocardial scanning in the pre-operative assessment of patients undergoing abdominal aortic aneurysmectomy

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Dipyridamole thallium scanning (DTS) is an imaging technique with good sensitivity for coronary artery disease (CAD). The purpose of this study was to compare the haemodynamic courses and the correlation between pulmonary capillary wedge pressure (PCWP) and central venous pressure (CVP) in patients with normal DTS (Group 1: n = 12) with those whose scans demonstrated CAD (Group 2: n = 11). Haemodynamic profiles were obtained prior to anaesthesia and at several times during surgery. The haemodynamic courses in both groups were similar with significant decreases in cardiac index, stroke index, and left ventricular stroke work index during aortic cross-clamping compared with values prior to anaesthesia. There were no significant changes in PCWP and CVP throughout the study. The correlations between PCWP and CVP were significant in both groups as were the correlations between the changes in PCWP and the changes in CVP observed at the time of cross-clamping. These correlations all had large standard errors of the estimate, however, making it impossible to predict the PCWP from the CVP with precision. It is concluded that, in a limited study population, an abnormal DTS did not identify patients in whom the PCWP and CVP correlated poorly during abdominal aortic aneurysmectomy.

La scintigraphie myocardique au thallium et dipyridamole (SMTD) est un outil diagnostique sensible à la présence de maladie coronarienne. Nous avons comparé le profil hémodynamique et la corrélation entre la pression bloquée de l'artère pulmonaire (PCWP) et la tension veineuse centrale (CVP) chez deux groupes de candidats à une résection d'anévrysme de l'aorte abdominale. Dans le groupe 1 (n = 12), les SMTD étaient normales tandis que dans le groupe 2 (n = 11) elles suggéraient une coronaropathie. Lorsqu'on les comparait aux valeurs pré-anesthésiques, les indices de débit cardiaque, de volume d'éjection et de travail ventriculaire gauche des deux groupes diminuaient lors du clampage aortique, sans changement significatif de PCWP ou de CVP. On a pu établir une corrélation significative entre PCWP et CVP de même qu'entre les changements de ces variables survenant lors du clampage. Toutefois, la grande variance résiduelle de ces corrélations empêchait de prédire avec précision la PCWP à partir de la CVP. Donc, dans cette étude sur un petit nombre, la SMTD n'a pu identifier les patients chez qui PCWP et CVP étaient dissociées lors d'une résection d'anévrysme de l'aorte abdominale.

Key words
ANAESTHESIA: cardiovascular;
HEART: assessment, ischaemia;
MEASUREMENT TECHNIQUES: pulmonary arterial, thallium-radionuclide imaging, venous pressure;
MONITORING: vascular;
SURGERY: vascular, aortic.

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Coronary artery disease (CAD) is responsible for the majority of cardiac complications in patients undergoing abdominal aortic reconstruction.[1-3] Previous studies have suggested that patients with clinical CAD are at risk of developing intraoperative myocardial ischaemia following infrarenal aortic cross-clamping and that pulmonary artery pressure monitoring is indicated in such patients.[4,5] More recent work has suggested that patients with clinical evidence of CAD and areas of ischaemic myocardium, as

demonstrated by dipyridamole thallium scanning (DTS), have up to a 50 per cent risk of severe cardiac morbidity or mortality following lower extremity or aortic vascular surgery.[6-9] These studies have included patients undergoing surgery for aortic aneurysmal or occlusive disease as well as peripheral vascular procedures; the anaesthetic techniques reported would no longer be considered appropriate for the patient with CAD, or were not reported at all. Furthermore, CAD can be clinically silent, and the indications for pulmonary artery pressure monitoring are not clearly defined. Several recent studies have shown that the preoperative resting ejection fraction, measured by radio-nucleotide angiography or by 2D echocardiography, is not a valid predictor of the relationship between CVP and PCWP during anaesthesia for aortic surgery.[10-12]

The present study was undertaken to assess the usefulness of DTS in the preoperative assessment of patients undergoing resection and grafting of infrarenal abdominal aortic aneurysms during a standardized anaesthetic. We were interested in comparing the intraoperative haemodynamic courses of patients with normal and abnormal scans and were particularly interested to assess whether an abnormal DTS identified those patients in whom the CVP and PCWP correlated poorly or who developed evidence of left ventricular dysfunction intraoperatively.

Methods

Following approval by the University of British Columbia Screening Committee for Research Involving Human Subjects, 28 ASA physical status II to IV patients scheduled for elective abdominal aortic aneurysmectomy underwent DTS. Patients received 0.568 mg · kg^{-1} dipyridamole IV over four minutes to induce maximal coronary vasodilatation followed by 65 megaberquerals thallium-201. A 12-lead ECG was monitored throughout by a cardiologist. Following the thallium injection, images were obtained in several projections with a Picker gamma camera and dedicated computer. Scans were repeated three hours later allowing full recovery from the vasodilating effects of dipyridamole. A thallium defect on initial images which fills on later images, a redistribution defect, indicates initial hypoperfusion of viable myocardium and correlates with regional coronary artery disease. A persistent defect on both early and later images indicates an area of myocardial scarring or previous infarction.[13-15]

Patients were divided into two groups on the basis of their dipyridamole thallium scans: Group 1 patients (n = 12) had completely normal scans and Group 2 patients (n = 11) each had at least one redistribution defect. Patients with fixed defects on DTS (n = 5) were not included in the study.

All patients continued their cardiac medications until the time of surgery. Patients were premedicated with morphine 0.15 mg · kg^{-1} IM and diazepam 0.15 mg · kg^{-1} PO 90 min preoperatively. Intravenous, radial artery and pulmonary artery catheters were inserted under local anaesthesia. General anaesthesia was induced with fentanyl 5–6 μg · kg^{-1} and thiopentone 1–3 mg · kg^{-1}. Muscle relaxation was achieved with pancuronium 0.1 mg · kg^{-1}. Anaesthesia was maintained with nitrous oxide 50–70 per cent in oxygen and isoflurane 0–1.5 per cent end tidal to keep the mean arterial blood pressure within 15 per cent of preinduction values. Mannitol 0.25 g · kg^{-1} was given before aortic cross-clamping. Increases in blood pressure or filling pressures of more than 20 per cent above control values were treated with fentanyl 3–4 μg · kg^{-1} and then by increasing the isoflurane concentration to a maximum of 1.5 per cent end tidal. Persistent increases were treated with nitroglycerine 100 μg IV followed by an infusion of 0.5–2 μg · kg^{-1} · min^{-1}.

Patients were monitored with a Hewlett-Packard 785348 monitor and 78551A cardiac output computer. Leads II and V_5 were monitored with a five-lead system. Cardiac output measurements were made in triplicate with 10 ml normal saline at room temperature. Measured haemodynamic values included heart rate (HR), blood pressure (BP), cardiac output (CO), central venous pressure (CVP), pulmonary artery (PA) and pulmonary capillary wedge pressure (PCWP). Cardiac index (CI), stroke index (SI), systemic vascular resistance (SVR) and left ventricular stroke work index (LVSWI) were calculated by the monitor software.

Data were obtained two to three minutes before induction (control), two to three minutes before cross-clamping, 2, 15, 30, and 45 min after cross-clamping, two minutes after release of the cross-clamp (after release of the first limb where bifurcation grafts were used), during closure of the abdomen and 1–2 hr after reaching the recovery room. Further measurements were made any time a patient developed an acute increase in PA pressures (pulmonary artery diastolic pressure greater than 20 mmHg and PCWP greater than 18 mmHg).

All patients were kept heavily sedated postoperatively

TABLE Patient data (mean ± SD)

	Group 1	*Group 2*
Number	12	11
Male/Female	9/3	9/2
Age	68.5	69
Weight (kg)	70.8	70.6
ASA Status		
II	5	3
III	6	6
IV	1	2
Blood Loss (ml)	1489 ± 488	1539 ± 751
Colloid transfused (ml)	909 ± 554	1089 ± 607
Crystalloid transfused (ml)	4486 ± 1130	4866 ± 1507

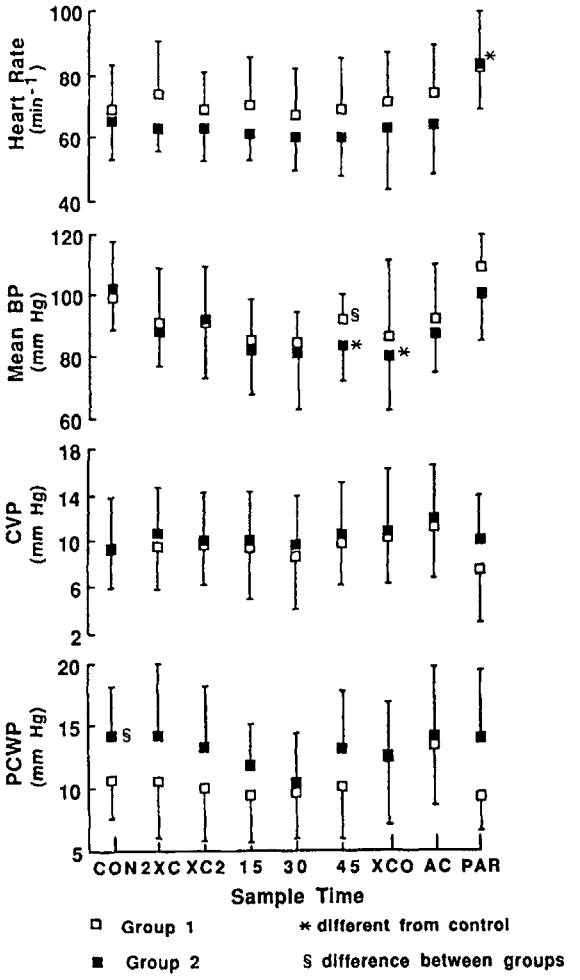

FIGURE 1 Haemodynamic variables throughout study period. Group 1 – normal DTS (n = 12); Group 2 – abnormal DTS (n = 11). Sample times: CON (pre-induction), 2XC (two minutes before aortic cross-clamping), XC2, 15, 30, 45 (time after cross-clamping), XCO (two minutes after cross-clamp release), AC (during closure of the abdomen), PAR (recovery room).

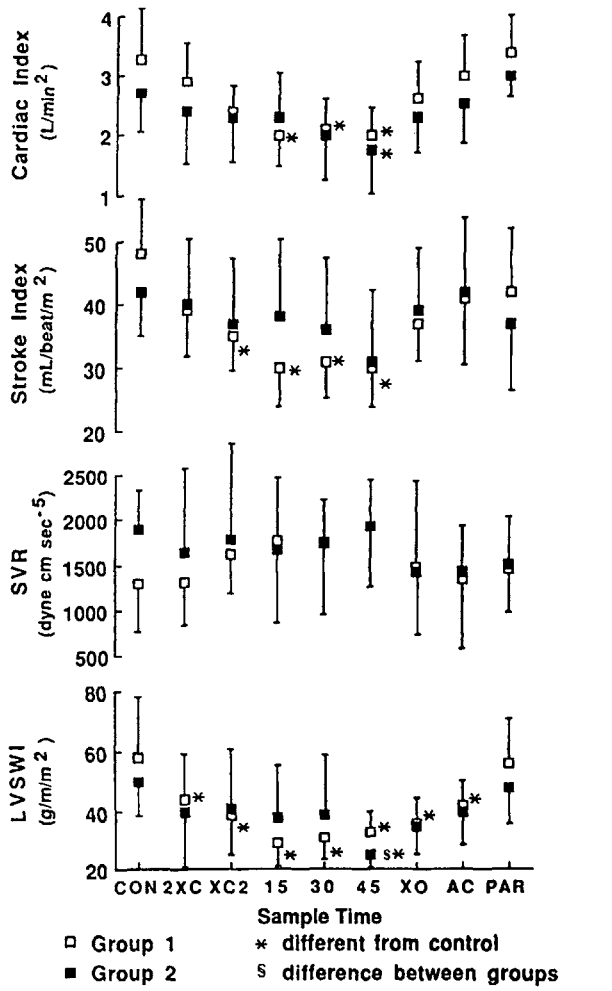

FIGURE 2 Haemodynamic variables throughout study period. Group 1 – normal DTS (n = 12); Group 2 – abnormal DTS (n = 11). Sample times: CON (pre-induction), 2XC (two minutes before aortic cross-clamping), XC2, 15, 30, 45 (time after cross-clamping), XCO (two minutes after cross-clamp release), AC (during closure of the abdomen), PAR (recovery room).

and their lungs were ventilated mechanically until such time as their core temperature was at least 36.5° C and standard criteria for extubation were met. Patients were kept in the intensive recovery area for at least 24 hr postoperatively. Postoperative ECG's were done on days one and three routinely but were repeated thereafter only if clinically indicated.

Within each group all haemodynamic values were compared with control using a one-day analysis of variance and then with the Student Neuman Kuels test. Between-group comparisons were made with the independent Student's t test. The relationship between CVP and PCWP was assessed with linear regression analysis for each group, as was the relationship between the change in CVP and the change in PCWP at the time of cross-clamping. The incidence of acute increases in PA pressures suggestive of myocardial ischaemia was compared between groups with Fisher's exact test. $P < 0.05$ was considered significant. Data are expressed as mean ± SD.

Results

There were 12 patients in Group 1 and 11 patients in Group 2.

Demographic data are summarized in the Table. There were no differences between Groups 1 and 2 when compared for age, weight, height, ASA physical status, blood loss, colloid and crystalloid replacement.

The haemodynamic changes throughout the study are shown in Figures 1 and 2. There were no differences between groups at any time for the following variables:

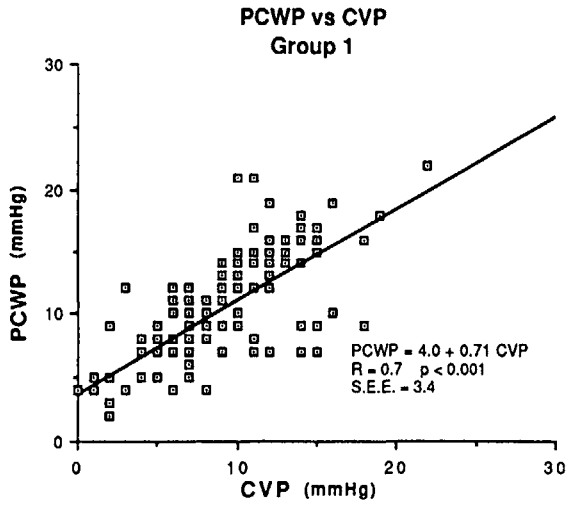

FIGURE 3 Relationship between PCWP and CVP for Group 1 patients (normal DTS) throughout the study.

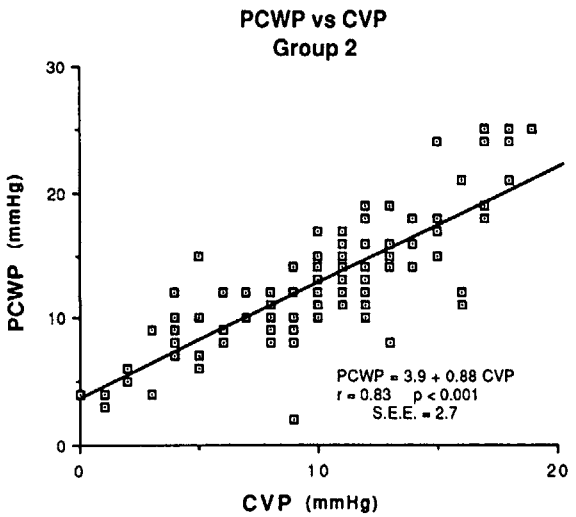

FIGURE 4 Relationship between PCWP and CVP for Group 2 (abnormal DTS) throughout the study.

heart rate, CI, SVR, SI, and CVP. Before induction of anaesthesia the PCWP for Group 1 was less than for Group 2; at 45 min post cross-clamp the mean BP and LVSWI for Group 1 were greater than for Group 2. Group 1 patients showed a greater decrease in CI, LVSWI and SI during cross-clamp compared with control than did Group 2.

In both Groups 1 and 2 the PCWP correlated significantly with the CVP (Figures 3 and 4). At the time of aortic cross-clamping the observed changes in PCWP and CVP also correlated significantly within each group (Figures 5 and 6).

There were two patients in Group 1 and Six in Group 2 who developed evidence of left ventricular dysfunction with acute increases in pulmonary artery pressure (PAD > 20 mmHg, PCWP > 18 mmHg) and evidence of prominent V waves on the PCWP tracing. The frequency of these events did not reach a statistically significant difference ($P = 0.06$). These epidodes occurred during the period of aortic cross-clamping in six out of eight cases. There were no ST segment changes observed.

There were no deaths in the study patients. One patient developed an ischaemic cardiac complication and a patient in Group 2 with clinical evidence of severe coronary artery disease and an abnormal DTS had an episode of unstable angina two weeks postoperatively. This was thought to be due, at least in part, to moderately severe anaemia.

Discussion

Patients undergoing abdominal aortic surgery are at risk with a perioperative mortality rate of three to eight per cent.[1-3] The cardiac morbidity rate in these patients ranges from 7 to 38 per cent depending on the severity of preoperative cardiac risk factors.[16-17] In spite of the significant incidence of cardiac morbidity and mortality associated with aortic reconstruction the indications for PA monitoring in these patients are not well defined. For example, several investigators have shown that the resting nuclear ejection fraction and 2D echocardiography were not useful in predicting the relationship between PCWP and CVP during aortic surgery.[10-12]

Attia *et al.*[4] and Gooding *et al.*[5] suggested that the presence of clinical CAD is an indication for PA monitoring and that the period of cross-clamping is particularly stressful. In those reports, however, the anaesthetic management may not have been appropriate for the patient with CAD because it consisted only of oxygen, nitrous oxide, muscle relaxant and small increments of morphine to an unspecified total.

Previous studies have examined two patient populations: those with aneurysmal aortic disease and those with aortoiliac occlusive disease. Johnston *et al.* showed that patients with occlusive disease, and in particular those with well developed periaortic collateral circulation, do not respond as dramatically to cross-clamping as do patients with aortic aneurysms.[18] Cunningham *et al.* recently reported similar observations throughout the cross-clamp period.[19] We attempted to standardize our study population by including only patients undergoing resection of abdominal aortic aneurysms; all patients received a standardized anaesthetic technique which included fentanyl, nitrous oxide and isoflurane.

Dipyridamole thallium scanning would seem to be an accurate way to identify patients with CAD with a

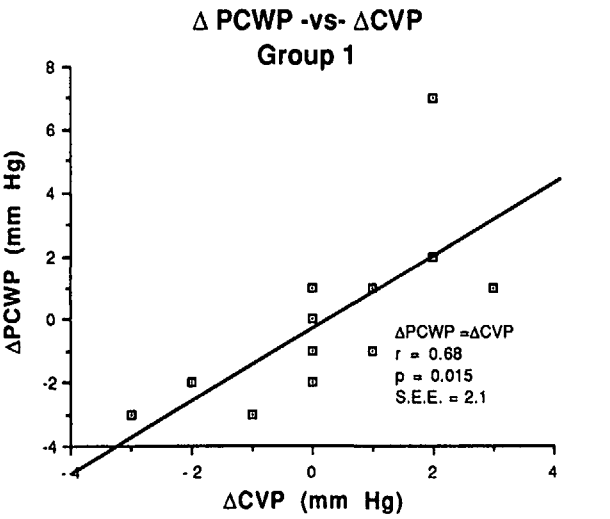

FIGURE 5 Relationship between changes in PCWP and changes in CVP for Group 1 patients (normal DTS) from two minutes before to two minutes after aortic cross-clamping.

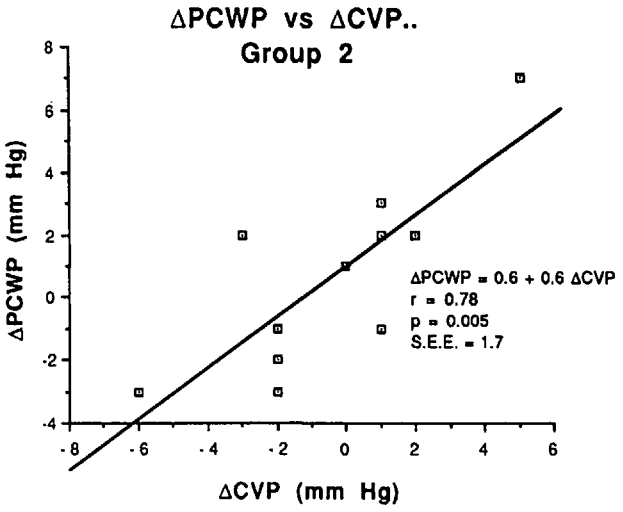

FIGURE 6 Relationship between changes in PCWP and changes in CVP for Group 2 patients (abnormal DTS) from two minutes before to two minutes after aortic cross-clamping.

sensitivity of 85 to 93 per cent.[13,14] The procedure is relatively non-invasive and does not require the patient to perform any exercise. The DTS is associated with a lower incidence of angina and of ST segment depression during the procedure itself than is exercise thallium scanning.[20]

We wondered if the presence of CAD as diagnosed by DTS might identify patients in whom the PA catheter was particularly useful. Specifically, we hypothesized that the correlation between PCWP and CVP might be better in patients with a normal DTS. Our results, however, show little difference between groups in the haemodynamic changes observed throughout the study period. In both groups the decrease in cardiac output and therefore in derived cardiac indices is similar to previous reports.[19,21] In fact our patients in Group 1 had a greater decrease in CI, SI, and LVSWI compared with control than did patients in Group 2. This apparent difference may have been because the CI for Group 1 tended to be greater than for Group 2 at control (3.3 vs 2.7 $L \cdot min^{-1} \cdot m^2$) but not significantly so ($P = 0.09$).

In both groups there was a significant correlation between PCWP and CVP throughout surgery. The changes in PCWP also correlated with the changes in CVP at the time of aortic cross-clamping. We observed a greater degree of correlation between PCWP and CVP than did Ansley *et al.* or Gallacher *et al.*[10,11] This may have been because several of the patients in those reports had very low resting left ventricular ejection fractions. We did not measure ejection fractions in our patients, but by history and physical examination none of our patients had evidence of impaired ventricular function. Although a significant correlation between PCWP and CVP was found in both groups of patients it must be emphasized that the standard error of the estimate for each correlation was large so that the PCWP could not be accurately predicted from the CVP. These findings are similar to those of Ansley *et al.* and Rice *et al.*[10,22]

Acute increases in PA pressures, often with associated large "V" waves on the PCWP tracing may be an earlier indicator of myocardial ischaemia than ST segment changes.[23] Such changes were observed in two patients with normal DTS and in six patients with redistribution defects on DTS. The differences between groups in the incidence of observed changes in PA pressures suggestive of myocardial ischaemia were not statistically significant ($P = 0.06$). Our limited sample size may have prevented us from detecting a significant difference.

Boucher *et al.* reported that even a single redistribution defect on DTS, without other clinical factors, identified a group of patients in whom 50 per cent sustained life-threatening or fatal ischaemic cardiac complications following aortic or lower limb vascular surgery.[6] They recommended that every patient scheduled for vascular surgery should undergo DTS as did Leppo *et al.* in a retrospective study of 100 patients.[7] On the other hand, Eagle *et al.* found that patients who did not have clinical evidence of ischaemic heart disease had a low incidence of postoperative complications and concluded that DTS is only indicated in patients with at least one of the following: angina, diabetes mellitus, congestive heart failure or previous myocardial infarction.[8] Cutler *et al.* reported their experience in 100 patients undergoing

abdominal aortic surgery using myocardial infarction as their end-point for assessing the value of DTS in predicting cardiac morbidity. They found that only those patients with two or more redistribution segments of DTS were at high risk for postoperative myocardial infarction.[9]

The studies by Boucher *et al.*, Leppo *et al.*, Eagle *et al.* used heterogeneous patient populations undergoing a variety of abdomimal and peripheral vascular procedures. The authors used differing end points in defining cardiac morbidity in their reports. Unfortunately, none of the details of the intraoperative or postoperative management are reported in these outcome studies.

It is difficult to assess the value of DTS in predicting cardiac morbidity or mortality in patients undergoing major vascular surgery. Our observations do not clarify the issue. Only one of our patients with a redistribution defect who also had severe clinical CAD had an episode of unstable angina postoperatively. Our limited sample size does not allow us to make any conclusions about the value of DTS in predicting cardiac morbidity after vascular surgery. Further studies are necessary and they should include details of perioperative patient management.

In conclusion, we found that dipyridamole thallium scanning did not identify a subgroup of patients undergoing abdominal aortic aneurysmectomy in whom PA monitoring was particularly useful. Patients with normal and abnormal scans followed a similar haemodynamic course throughout surgery and the early postoperative period. Although there was a significant correlation between PCWP and CVP in both groups of patients throughout surgery, including the time of cross-clamping, the standard errors of the estimate were large, making it impossible to predict precisely the PCWP from the CVP at any given time.

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