

## Cardiothoracic Anesthesia, Respiration and Airway

### Clinical and echocardiographic diagnoses disagree in patients with unexplained hemodynamic instability after cardiac surgery

*[Des diagnostics cliniques et échocardiographiques contradictoires dans des cas d'instabilité hémodynamique inexpliquée à la suite d'une intervention en cardiologie]*

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**Purpose:** To investigate 1) if clinical indications match diagnostic findings from urgent transesophageal echocardiography (TEE) in hemodynamically unstable patients after cardiac surgery and 2) the clinical impact of the TEE findings.

**Methods:** Retrospective review of all postcardiac surgical intensive care patients who received an urgent TEE over a three-year period from July 1<sup>st</sup> 1997 until June 30<sup>th</sup> 2000. The clinician's presumed diagnosis based on hemodynamic and clinical evaluation was compared to TEE diagnosis. Surgical and medical interventions based on TEE results and the associated mortality were correlated.

**Results:** A hundred and thirty TEEs were performed for hemodynamic instability or suspected intracardiac vegetation or thrombus, all category I indications according to ASA guidelines. In 41.5% of patients the echocardiographic finding matched the presumed diagnosis. Patient management was significantly changed as a result of TEE findings in 58.5% of patients; 43.3% had changes in pharmacological therapy and 15.3% had a surgical intervention. Mortality was significantly lower in those who received a surgical intervention when compared to those who had changes in drug treatment ( $P < 0.05$ ).

**Conclusions:** The results of urgent TEE in hemodynamically unstable patients or patients with thromboembolic phenomena in the postcardiac surgical intensive care unit are unpredictable in over half of cases. Inappropriate management decisions may result without the information obtained from TEE examination. Clinical management is often modified as a result of TEE findings. TEE is essential in the management of hemodynamically unstable postcardiac surgical patients.

**Objectif:** Vérifier 1) la concordance entre les indications cliniques et les constatations diagnostiques de l'échocardiographie transoesophagienne d'urgence (ETO) chez des patients souffrant d'instabilité hémodynamique post-cardiologie et 2) les conséquences cliniques des résultats de l'ETO.

**Méthode :** Une révision rétrospective de tous les cas de soins intensifs post-cardiologie qui ont passé une ETO d'urgence entre le premier juillet 1997 et le 30 juin 2000 a été réalisée. Le diagnostic présumé du clinicien, fondé sur l'évaluation hémodynamique et clinique, a été comparé au diagnostic ETO. On a mis en corrélation les interventions chirurgicales et médicales fondées sur les résultats ETO et la mortalité associée.

**Résultats :** Cent trente ETO ont été réalisées pour instabilité hémodynamique, végétation intracardiaque présumée ou thrombus, toutes indications de catégorie I selon les critères de l'ASA. Chez 41,5 % des patients, les résultats de l'échocardiographie s'accordaient au diagnostic présumé. Après l'ETO, le traitement a été modifié de façon significative chez 58,5 % des patients; 43,3 % ont connu un changement de pharmacothérapie et 15,3 % ont subi une intervention chirurgicale. La mortalité a été significativement plus faible chez ceux qui ont eu une intervention chirurgicale, comparés à ceux qui ont reçu un nouveau médicament ( $P < 0,05$ ).

**Conclusion :** Les résultats de l'ETO d'urgence sont imprévisibles dans plus de la moitié des cas de patients souffrant d'instabilité hémodynamique ou présentant des troubles thromboemboliques à l'unité des soins intensifs post-cardiologie. Sans l'information fournie par l'ETO, des traitements inappropriés peuvent être administrés, mais les constatations de l'ETO peuvent, au contraire, permettre de modifier le traitement. L'ETO apparaît ainsi essentielle au traitement de l'instabi-

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*lité hémodynamique chez des patients qui ont subi une intervention en cardiologie.*

**P**OSTOPERATIVE cardiac surgical emergencies have high rates of mortality and morbidity, therefore prompt diagnosis and management are crucial. Since its introduction into clinical practice, transesophageal echocardiography (TEE) has become an invaluable technique in the diagnosis and management of cardiac pathology both in the operating room and critical care setting. It provides fast, noninvasive assessment of heart function and structure that is complementary and sometimes superior to invasive monitoring.<sup>1,2</sup> TEE provides several advantages over transthoracic echocardiography in the critical care setting where the quality of images obtained may be significantly reduced by mechanical ventilation.<sup>3,4</sup> Both the potential of superior imaging quality and its reproducibility provide a more accurate diagnosis or allow exclusion of suspected pathological changes.<sup>5</sup> Both the American Society of Anesthesiologists and Society of Cardiovascular Anesthetists, and the American College of Cardiology and the American Heart Association have published guidelines on the use of TEE. Both sets of guidelines advocate its use in patients with unexplained hemodynamic instability on a ventilator.<sup>6,7</sup>

The purpose of this study was to correlate the indications for and diagnosis of urgent TEE and patient outcome on the postcardiac surgical intensive care unit (ICU). We particularly examined whether the indication for TEE matched the diagnosis obtained and how the TEE changed clinical management.

### Methods

The study was conducted at the Toronto General Hospital, a major center for adult cardiac surgery referral, performing approximately 2,600 open-heart cardiac surgical procedures per year. Following Research Ethics Board approval the medical records of all critically ill patients admitted to the cardiovascular intensive care unit (CVICU) between July 1997 and June 2000 inclusively who had an urgent TEE performed were reviewed. The patients had all undergone elective or emergency cardiac surgical procedures with or without cardiopulmonary bypass. All patients were intubated and ventilated and most patients had extensive invasive monitoring, including a pulmonary artery catheter (PAC), information from which was interpreted by the attending physician and used to guide management. TEE studies were performed by a car-

diac anesthesiologist or an echocardiographer with advanced training in TEE; additional interpretation of all studies was performed by cardiologists from the echocardiographic laboratory. Echocardiographic results were classified into six categories: 1) aortic dissection; 2) cardiac tamponade; 3) valve dysfunction; 4) ventricular dysfunction; 5) vegetation or thrombus; and 6) other diagnoses. In addition, ventricular dysfunction was further divided into primarily left ventricular dysfunction or right ventricular dysfunction. Examinations were performed with a Hewlett-Packard Sonos 5500 echocardiograph and a 5-MHz multiplane transducer.

The indications for TEE were based on pre-TEE clinical assessment and hemodynamic variables and were documented in the medical record or on the TEE report. Patient mortality was also recorded. The indications were broadly classified into six groups: 1) exclusion of aortic dissection; 2) exclusion of cardiac tamponade; 3) exclusion of valvular pathology; 4) assessment of ventricular function; 5) exclusion of vegetation or thrombus; and 6) other indications (e.g., to rule out intracardiac shunt). The results of TEE were examined and compared to the indication for TEE. The number of cases in which the indication matched the result was noted, for example if a TEE was performed to exclude a cardiac tamponade and a cardiac tamponade was found. It was also noted whether there was a significant change in management as a result of TEE. Medical intervention was defined as a change in the dose or type of inotropic therapy, introduction of a new pharmacological agent such as inhaled nitric oxide or a fluid bolus of 500–1000 mL following examination. A surgical intervention was defined as a return to the operating room or the insertion of an intra-aortic balloon pump.

TABLE I Description of patient population according to surgical procedure

<i>Surgical procedure</i>	<i>Total CVICU patients (%)</i>	<i>Patients requiring urgent TEE (%)</i>
CABG	5,375 (67.8)	47 (36.2)
Aortic root surgery	440 (5.5)	10 (7.7)
Combined procedure (e.g., CABG & valve)	523 (6.6)	21 (16.2)
Congenital anomaly	352 (4.4)	8 (6.2)
Heart transplant	55 (0.7)	14 (10.8)
Single valve	917 (11.6)	21 (16.2)
Other	270 (3.4)	9 (6.9)
Total	7,932 (100)	130 (100)

CABG=coronary artery bypass graft; CVICU=cardiovascular intensive care unit; TEE=transesophageal echocardiography.

TABLE II Indications that agreed with TEE diagnosis

<i>Indication for TEE</i>	<i>Number of patients (%) with indication</i>	<i>Number (%) of TEE diagnoses agreeing with indication</i>
Dissection	5 (3.8)	0 (0)
Tamponade	35 (26.9)	7 (20.0)
Valve dysfunction	21 (16.2)	9 (42.9)
Ventricular function (left and right)	52 (40.0)	36 (69.2)
Vegetation/thrombus	12 (9.2)	1 (8.3)
Other	5 (3.9)	1 (20.0)
Total	130 (100)	54 (41.5)

TABLE III Diagnosis from TEE

<i>Diagnosis</i>	<i>Number of patients (%)</i>
Left ventricular dysfunction	51 (39)
Right ventricular dysfunction	18 (14)
Valve dysfunction	15 (12)
Hypovolemia	16 (12)
No abnormality	12 (9)
Other	9 (7)
Tamponade	8 (6)
Vegetation	1 (1)
Total	130 (100)

#### *Statistical analysis*

The baseline demographics of the group were analyzed using summary statistics: mean and range. Chi-squared analysis was used to assess whether mortality was related to a surgical or medical change in clinical management. A *P* value <0.05 was considered significant.

#### **Results**

During the 36-month study period, 7,932 postcardiac surgical patients were admitted to the CVICU and urgent TEE was performed on 130 patients for category I indications.<sup>6</sup>

#### *Study population*

The total CVICU population from June 1997 until July 2000 and the study population are described in Table I according to types of surgery. The mean age of the patients under study was 61 yr (range 22–83 yr) and the mean cardiopulmonary bypass time was 140 min (range 46–320 min), six operations were performed without cardiopulmonary bypass. Eighty (61.5%) patients were male and 50 (38.5%) female.

#### *Indication for TEE and findings*

Tables II and III show the indication for TEE and results of TEE respectively. Table IV demonstrates the

most common TEE diagnosis for each specific clinical indication. Overall in only 41.5% of cases echocardiographic findings agreed with the presumed diagnosis based on clinical evaluation before the TEE examination. Table II shows, for each indication for emergency TEE the number of results that agreed with that indication. Assessments of valve pathology or ventricular function were the only two indications in which the most common result agreed with the indication. 42.9% of patients who had TEE performed to rule out valve dysfunction were found to have a valve lesion and 69.2% in whom the indication was to assess ventricular function were found to have severe left or right ventricular dysfunction. Ventricular dysfunction was the most common finding (57.1%) where the indication was to exclude cardiac tamponade and no abnormality was found in 66.6% of patients in whom a vegetation or thrombus was suspected.

#### *Clinical impact of TEE*

In 76 (58.5%) patients, clinical management was changed as a result of the findings of TEE. In 56 (43.3%) patients, medical management was altered, most commonly by a change in inotrope therapy but also by *iv* fluid boluses, diuretics, heparin and direct current cardioversion or the addition of inhaled nitric oxide for patients with predominantly right ventricular failure. Twenty (15.3%) patients had a surgical intervention as a result of the TEE findings; in five, an intra-aortic balloon pump was inserted on the CVICU, 14 returned to the operating room and one patient had a radiological dilation of an inferior vena cava obstruction. Of those patients who returned to the operating room eight had evacuation of hemopericardium, there were two mitral valve replacements (MVR), one reoperative aortic valve replacement (AVR), one reoperative MVR and tricuspid valve annuloplasty, one reoperative AVR, MVR and atrial septal defect closure and one left ventricular aneurysm excision. The overall mortality amongst all study patients was 31 (23.8%) whilst the total cardiac surgical mortality during the study period was 2.2%. There was no statistical difference in the mortality of patients who had a change in management as a result of TEE (13 patients) compared with those who did not (18 patients). However those patients who underwent a surgical change in management had a significantly lower mortality (three out of 17) than those who had a medical change in management (15 out of 41) *P* <0.05.

#### **Discussion**

We reviewed our experience of urgent TEE in the postcardiac surgical intensive care population. The

TABLE IV Most common TEE diagnosis for each indication

<i>Indication for TEE</i>	<i>Number of patients (%) with indication</i>	<i>Most common diagnosis from TEE</i>	<i>Number (%) of patients</i>
Dissection	5 (3.8)	All different	5 (100)
Tamponade	35 (26.9)	Ventricular dysfunction	20 (57.1)
Valve dysfunction	21 (16.2)	Valve dysfunction	9 (42.9)
Ventricular function	52 (40.0)	Ventricular dysfunction	36 (69.2)
Vegetation/thrombus	12 (9.2)	Normal	8 (66.6)
Other	5 (3.9)	Ventricular dysfunction	2 (40.0)
Total	130 (100)		

majority of our postcardiac surgical patients have an uncomplicated course and are 'fast-tracked', being extubated within six hours of CVICU admission.<sup>8</sup> Less than 15% of our patients run into any complication and the majority of these patients are managed by clinical assessment and with data obtained from invasive monitoring including the PAC. Our study indicated that in only 41.5% of cases the presumed clinical diagnosis agreed with the TEE diagnosis. Clinical management was changed as a result of TEE findings in 58.5% of patients and if the change in management was a surgical intervention then mortality was significantly lower than if there was a change in pharmacological therapy. This may be explained by the fact that most patients were investigated by TEE when hemodynamically unstable and unresponsive to maximal medical therapy, therefore a surgical intervention was a much more significant change in management than a change in drug therapy and therefore more likely to change outcome. One could argue that unless a surgically redeemable cause was being sought, urgent TEE is not helpful in improving patient outcome. However, since we have shown that in only 41.5% of cases the indication for the TEE matched the result, surgically correctable reasons for hemodynamic disturbance may be missed if fewer TEEs are performed.

TEE has been reported to be a useful tool in the intraoperative management of cardiac surgical patients and some have advocated its use in all cardiac surgical patients.<sup>9-12</sup> In particular Click *et al.* reviewed 3,245 intraoperative TEE examinations and found that new information was found before bypass in 15% of patients, directly affecting surgery in 14% of patients. The use of TEE in the critical care setting has also been increasing and it is frequently used to aid diagnosis and management of patients with acute hemodynamic disturbance.<sup>1,3,13,14</sup> The American Society of Anesthesiologists and Society of Cardiovascular Anesthesiologists' practice guidelines for perioperative transesophageal echocardiography divide indications

for TEE into three categories. Category I indications are supported by the strongest evidence or expert opinion. TEE is frequently useful in improving clinical outcomes and is often indicated depending on individual circumstances. Category II indications are supported by weaker evidence or expert consensus and TEE may be useful in improving clinical outcomes in these settings. Category III indications have little current scientific or expert support.<sup>6</sup> The use of TEE in intensive care for unstable patients with unexplained hemodynamic disturbances or thromboembolic problems such as suspected intracardiac thrombus or vegetation (if other tests or monitoring techniques have not confirmed the diagnosis or patients are too unstable to undergo other tests) are category I indications.

TEE confirmed the clinical diagnosis in 41.5% of patients. This is in general agreement with a previous study by Reichert *et al.* that compared TEE diagnosis in hypotensive patients after cardiac operations with diagnosis from hemodynamic variables obtained from the PAC.<sup>15,16</sup> They found agreement in diagnoses in 50% of their patients. It may be assumed therefore that in the proportion of patients in which the pre TEE diagnosis was incorrect that these patients could have received incorrect treatment if the TEE had not been performed.

As a secondary issue we examined the clinical impact of urgent TEE in our patients. In the general critical care setting (medical and surgical ICUs) there are several studies reporting the clinical impact of urgent TEE in hemodynamically unstable patients.<sup>11,13,16</sup> Treatment is changed in between 44-62% of patients with a PAC *in situ* as a result of TEE examination. The literature on the clinical impact of TEE on the cardiac surgical intensive care population is lacking. The fact that it can aid diagnosis and be used for hemodynamic monitoring such as preload assessment is documented but few studies describe whether the intervention changed patient management.<sup>18,19</sup> In over half of our patients (58.5%) clinical management was changed as a result of the findings from

TEE, a similar proportion to that found in the general ICU population. The overall mortality in the group studied was 23.8%, almost ten times that of our total cardiac surgical population (2.2%) reflecting the severity of the patients' conditions in this study population.

Urgent TEE examination was used in a very small proportion (1.6%) of the total cardiac surgical population in the CVICU during the study period and all examinations were for class I indications. Some may suggest that we were underutilizing this important investigative technique, however our total overall mortality during the study time period of only 2.17% is below the average expected mortality for such a complex surgical population.

There are limitations to the use of TEE on the CVICU. The technology is expensive and qualified training is necessary to perform and interpret examinations. It is time consuming and may divert the attention of the attending physician away from other patients on a busy ICU. Although there is a very low incidence of complications there is a small risk of esophageal damage.<sup>20</sup> Therefore it is important that TEE be only used when clinically indicated.

The main limitations of our study are that it was retrospective, and as a case series it supports but does not prove the importance of TEE in the postcardiac surgical ICU. TEE examinations were requested at the discretion of the attending physician and there was no control group of hemodynamically unstable patients who were not investigated with TEE. Although the clinical diagnosis was made by an experienced intensivist the criteria for clinical diagnosis were not standardized and agreement between clinicians was not examined. In addition, the physician performing the TEE examination was not blinded to the presumed clinical diagnosis and inter-observer variability may have existed in TEE diagnosis since many diagnoses, for example hypovolemia are subjective. In addition, data regarding diastolic dysfunction was not collected. It is, however, one of the few studies looking particularly at the postcardiac surgical intensive care population and was performed in a very large unit. To properly assess the impact of TEE on clinical management and outcome, prospective, randomized controlled trials involving large numbers of patients are needed.

In summary we have shown, in our population, that the result of urgent TEE in critically ill patients with unexplained hemodynamic disturbance or thromboembolic problems is unpredictable in over half of the patients. Inappropriate management decisions may result without the information obtained from TEE examination. Patient management is often changed as a result of TEE and if this is a surgical

intervention, mortality is lower. Therefore TEE complements the routine monitoring of hemodynamically compromised patients postcardiac surgery.

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