BRIEF REPORT

An Image is worth a Thousand Numbers. Transesophageal Echocardiography Monitoring in Cardiac Surgery

Una imagen vale más que mil números. Monitoreo transesofágico en cirugía cardíaca

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ABSTRACT

Background: Transesophageal echocardiography (TEE), a technique with almost universal applicability, is being used with increasing frequency in the operating room, and the use of a miniaturized device for hemodynamic monitoring based on TEE is particularly useful in critically ill patients during the postoperative period.
Objectives: The aim of this study was to evaluate the use of a miniaturized device for hemodynamic monitoring based on TEE analyzing the number of patients evaluated, the hemodynamic findings and the associated complications.
Methods: Unstable patients undergoing surgery were included between October 2010 and July 2012.
Results: The device was used in 252/1,435 (17.6%) patients; hypovolemia was the main finding in 165 (73.4%) patients. Mediastinal hematoma was detected in 4 patients (1.6%) and resolved with conservative management. Eight patients (3.2%) under ventricular assist devices presented events. In the 27 patients (10.7%) undergoing delayed sternal closure, the device helped to determine the time to sternal closure. No associated complications were reported.
Conclusions: This technique modified the initial diagnosis, and hypovolemia was the main finding. Patients with mediastinal hematoma could be managed with a conservative approach. The greatest benefit was achieved by patients under ventricular assist devices and by those undergoing delayed sternal closure. Further studies are necessary to determine the value of this technique.

Key words: Hemodynamic monitoring - Cardiac Surgery – Transesophageal echocardiography

RESUMEN

Introducción: El ecocardiograma transesofágico (ETE), de aplicabilidad casi universal y creciente desempeño en el quirófano, con el uso de un dispositivo miniaturizado para monitoreo hemodinámico basado en ETE se muestra particularmente útil en el posoperatorio del paciente crítico.
Objetivos: Evaluar el empleo de un dispositivo miniaturizado para monitoreo hemodinámico basado en ETE analizando el número de pacientes evaluados, los hallazgos hemodinámicos y las complicaciones asociadas.
Material y métodos: Se incluyeron pacientes inestables intervenidos entre octubre de 2010 y julio de 2012.
Resultados: Sobre 1.435 pacientes se utilizó el dispositivo en 252 (17,6%); la hipovolemia resultó el principal hallazgo en 165 (73,4%) pacientes. En 4 pacientes (1,6%) se detectaron hematomas mediastinales que se resolvieron con manejo conservador. Ocho pacientes (3,2%) bajo implante de dispositivos de asistencia presentaron eventos. En los 27 pacientes (10,7%) bajo cierre diferido del tórax, el dispositivo colaboró en determinar el momento para el cierre. No se observaron complicaciones asociadas.
Conclusiones: Esta técnica modificó el diagnóstico inicial, resultando la hipovolemia el hallazgo principal. Los pacientes con hematomas mediastinales pudieron manejarse en forma conservadora. Los pacientes bajo asistencia ventricular y aquellos bajo cierre diferido del tórax resultaron particularmente beneficiados. Una mayor experiencia determinará el valor de esta técnica.

Palabras clave: Monitoreo hemodinámico - Cirugía cardíaca - Ecocardiograma transesofágico

Abbreviations

LVEDA Left ventricular end-diastolic area	**CVP** Central venous pressure
TEE Transesophageal echocardiography	

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INTRODUCTION

The rationale for using pressures in critically ill patients comes from the basic principle which states that pressures reflect intravascular volume. Thus, patients with low pressures would have hypovolemia and those with high pressures would have fluid overload. (1)

However, such evaluation may provide uneven information about the real hemodynamic status in situations such as mechanical ventilation, open-chest conditions, pulmonary hypertension or diastolic failure.

Echocardiography is useful to evaluate ventricular function, taking into account that direct estimation of ventricular volume would be superior to the evaluation by ventricular pressures.

Unfortunately, its applicability in the postoperative period after cardiovascular surgery presents several limitations. (2)

Transesophageal echocardiography (TEE), a technique with almost universal applicability which is being used more frequently in the operating room, is useful in the postoperative period. By providing high-quality images, TEE allows direct evaluation of cardiac function, intravascular filling, collections inside the cavities, diastolic function and heart valves. (3, 4)

The aim of this study was to evaluate the use of a miniaturized device for hemodynamic monitoring based on continuous TEE (5) considering: 1) the number of patients evaluated, 2) indications for use, 3) usefulness of the technique to modify treatment, and 4) associated complications.

METHODS

We included patients in the postoperative period after cardiovascular surgery admitted between October 1, 2010 and July 1, 2012. A Swan-Ganz catheter was inserted to all the patients in the operating room according to our protocol and TEE was performed during surgery.

Invasive pressure monitoring was continued after the patients were admitted to the Cardiovascular Recovery Surgery Unit; pressures were measured each hour and the results were recorded in an electronic spreadsheet. A disposable TEE probe (ClariTEE, ImaCor, Unindale, NY) was implanted for monitoring in unstable patients, defined as those with systolic blood pressure <90 mm Hg for at least 30 minutes in the absence of hypovolemia, or requiring vasoactive drugs, or with elevated intracardiac pressures or right ventricular dysfunction (right atrial-to-left atrial area ratio >1, elevated pulmonary artery resistances and cardiac index <2.0 L/min/m2), and/or low cardiac output, or with high lactic acid levels, or those undergoing delayed sternal closure.

This device allowed qualitative and semi-quantitative observation of single-plane views: mid-esophageal four-chamber view with visualization of right and left chambers, transgastric short axis view evaluating global ventricular function and regional wall motion abnormalities, with direct observation of ventricular filling and estimation of left ventricular end-diastolic area (LVEDA) and superior vena cava view to determine its size, collapsibility, intravascular volume and response to volume expansion (Figure 1 A-C).

The usefulness of the device was analyzed, considering those situations in which it modified the initial impression obtained by measuring pressures.

Evaluation of conditions by TEE: In the transgastric view, hypovolemia was determined qualitatively by the presence of a small cavity with papillary muscles touching each other in systole and quantitatively by EDLVA < 12 cm2 or increase in EDLVA by 2 cm2 after passive leg raise. Right ventricular dysfunction was considered in the presence of variation or significant impairment of right ventricular free wall motion, tricuspid annular plane systolic excursion <2 cm and severe right ventricular enlargement. Cardiac tamponade was considered in the presence of mediastinal fluid collection and ventricular collapse.

Complications: The presence of traumatic lesions sec-

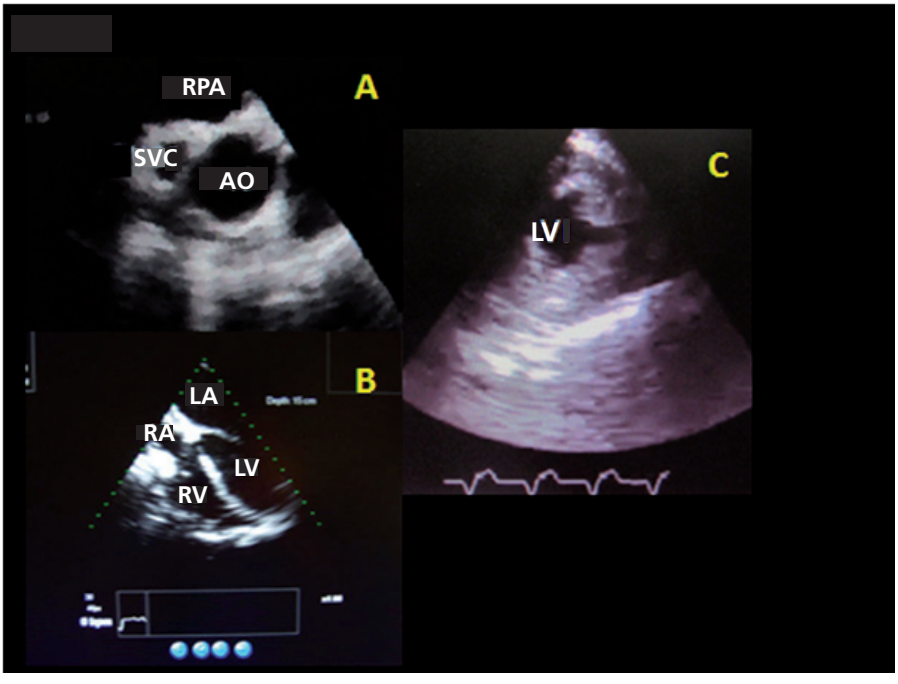

Fig. 1. The three basic TEE views obtained. A. Transgastric short axis view. B. Mid-esophageal four-chamber view. C. Superior vena cava view. RA: Right atrium. LA: Left atrium. AO: Aorta. RPA: Right pulmonary artery. SVC: Superior vena cava. RV: Right ventricle. LV: Left ventricle.

ondary to device implantation, permanence or malfunction was evaluated.

Ethical considerations

The protocol was reviewed and approved by the Institutional Ethical Board

RESULTS

Among 1,435 patients undergoing cardiovascular surgery, 252 patients (17.6%) underwent hemodynamic monitoring based on continuous TEE using 266 probes, with an average observation time of 49.5 hours (8-72 h).

A central venous line but not a Swan-Ganz catheter was implanted to 6 patients who underwent pulmonary embolectomy and endarterectomy and in 5 of the 11 patients operated on for congenital heart defects.

The indications for TEE-based monitoring are described in Figure 2.

Hypovolemia (despite high pressures) could be detected in 76 (71.17%) of 106 patients with hypotension (Figure 3 A and B), in 27 (59.9%) of 52 patients with high lactic acid levels, in 22 (62.9%) of 35 patients with low cardiac index, in 19 (59.4%) of 32 patients with abnormal right-side chamber pressure elevation and in 21 (77.8%) of 27 patients undergoing delayed sternal closure.

This technique allowed the detection of right-side chamber hematomas in 4 patients (1.6%) producing compression but without signs of cardiac tamponade, which did not require surgical drainage based on continuous observation and absence of growth.

Eight patients (3.2%) under left ventricular assist devices presented suction events that were resolved after modifying device parameters. Nevertheless, these patients presented subsequent increase of lactic acid levels and required long-term device implantation and evaluation of the inflow device cannula (Figure 3 C-E).

In the 27 patients (10.7%) undergoing delayed sternal closure, TEE-based monitoring helped to determine the time to sternal closure which was successful and occurred between 36 and 72 hours.

There were no traumatic complications associated with the device, and the information obtained in the three basic views was optimal in all the patients.

DISCUSSION

The use of hemodynamic monitoring based on continuous TEE started in 2011 with a flexible 5.5-mm in diameter miniaturized probe connected to a dedicated TEE system. The device can remain in situ for 72 hours, allowing continuous or repeated monitoring (see Figure 3). (6, 7)

Our experience determined that hypotension was the most frequent indication. In this case, despite normal or elevated central venous pressure (CVP) values, echocardiography detected that the cause of hypotension was hypovolemia. This result modified the treatment with indication of fluid resuscitation instead of unnecessary vasoactive or inotropic drugs.

It is well recognized that the estimation of intravascular volume status by hemodynamic monitoring with catheters is not reliable. In an extensive meta-analysis, Marik et al. commented, not without exaggeration, that CVP was no better than "flipping a coin" for decision-making. (1)

The use of the device coincided with the beginning of the Heart Mate II program. The postoperative period of these patients has certain distinctive features which make it particularly appropriate for monitoring, as the development of right ventricular dysfunction, the need of repeated evaluation of pulmonary vasodilators, complications associated with the ventricular cannula, delayed sternotomy closure or right ventricular suction events. Thus, TEE-based monitoring is the routine monitoring method in our institution. (8-10)

Lactic acid elevation was also detected in patients during the first 24 hours, which was suggestive of low cardiac output or systemic hypoperfusion, but with fa-

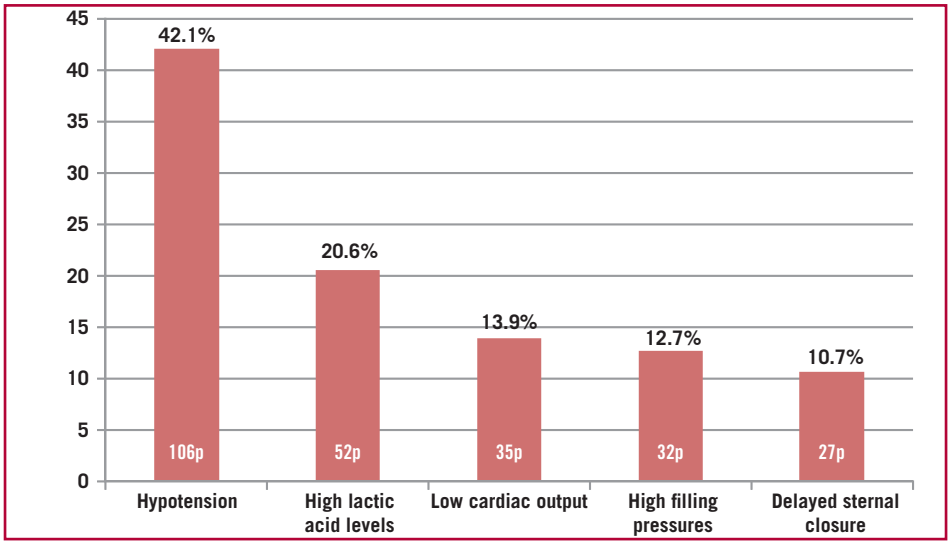

Fig. 2. Reasons for device implantation. p: Patients.

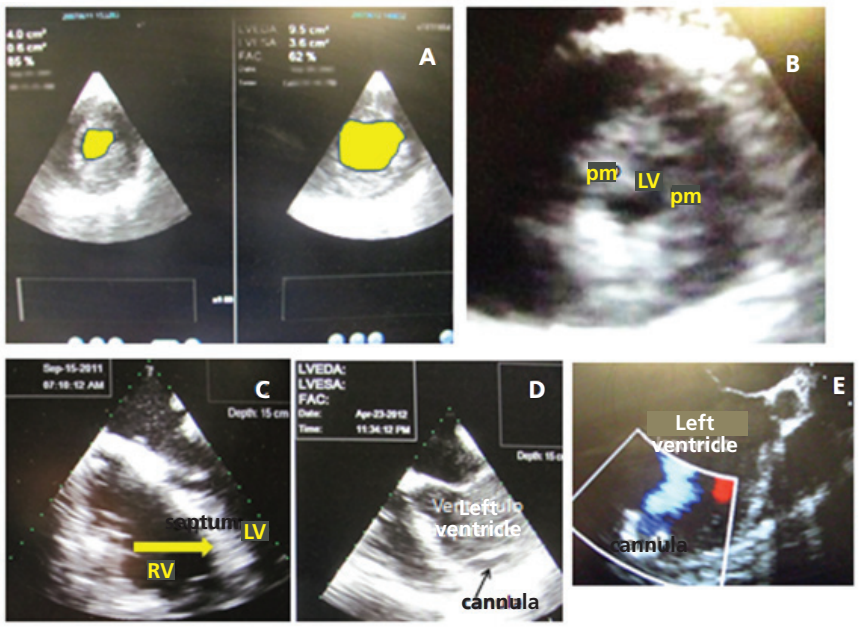

Fig. 3. A. Determination of end-systolic area (left) and end-diastolic area (right) with a value suggestive of hypovolemia. B. Observation of hypovolemia, with small ventricular cavity and papillary muscle (pm) contact in systole. C. Suction event with left displacement of the interventricular septum, right ventricular (RV) enlargement and reduced left ventricle (LV) due to the suction produced by the device. D and E. Evaluation of the device inflow cannula.

vorable outcome. (11)

Of note, the use of the device allowed a conservative approach of pericardial hematomas producing compression but not cardiac tamponade, avoiding the morbidity of an unnecessary reoperation. This approach was possible due to the direct and repeated observation of the collection and its repercussion on cardiac function, a concept suggested by Costachescu et al. but that was technically impossible to implement. (3)

The device also allowed monitoring of patients with open chest, another condition that alters the interpretation of intrathoracic pressures, contributing to emphasize the concept that direct visualization and not indirect estimation by pressures might reconsider the "classic" paradigm established in hemodynamic monitoring.

Study limitations

Our analysis was performed on a highly specific population of patients in the postoperative period after cardiovascular surgery, including patients under ventricular assist devices. Therefore, the results observed might not be applicable to other group of critically ill patients.

CONCLUSIONS

The use of TEE-based monitoring modified the diagnostic presumption in most unstable patients, thus changing their management.

Further studies with larger populations are necessary to determine the exact value of this technique.

Conflicts of interest

None declared

(See author´s conflicts of interest forms in the web / Supplementary Material)

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