

Transoesophageal echocardiography during coronary artery bypass procedures: impact on surgical planning

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ABSTRACT

Introduction: Intraoperative transesophageal echocardiography (iTEE) is widely accepted and routinely used during heart valve surgery. However, the impact of iTEE among patients undergoing coronary artery bypass grafting (CABG) is less well documented. In this study, we aim to define the impact of iTEE in patients undergoing myocardial revascularization for severe coronary artery disease.

Methods: We analyzed clinical data and preoperative and intraoperative echocardiograms of all adults who underwent on pump coronary bypass and iTEE between January 2008 and December 2008.

Results: 521 patients (mean age 69 ± 14 years) were studied. New prebypass findings were obtained in 82 (15.7%) patients: in 62 (11.9%) of these patients, this information changed the surgical plan. New postbypass findings were obtained in 8 patients (1.5%) and the surgical plan was altered in 4 patients (0.7%).

Conclusions: Overall new findings were obtained in 90 patients (17.2%) and the surgical plan was altered in 66 patients (12.6%). These data support the routine use of iTEE among patients undergoing surgical myocardial revascularization.

Keywords: cardiac surgery, cardiac anesthesia, echocardiography, coronary artery by pass grafting.

INTRODUCTION

Intraoperative TEE (iTEE) was introduced in cardiac anesthesia in the late 1980s in the USA where it was primarily considered to be a tool for monitoring the left ventricle. It soon became clear that iTEE could give more information than just the state of the left ventricle.

In the last 10 years the use of iTEE has expanded enormously and is now recognized as an excellent intraoperative diagnostic tool. In selected patient groups, iTEE has been shown to be beneficial in cardiac surgery improving cardiac outcome; it often provides new and important information about pathophysiology and may guide both surgical and anesthetic therapy (1).

iTEE is an integral part of the treatment of patients undergoing valve surgery (2-6). Although iTEE is routinely used during mitral valve repair (MVR)(7-9), the impact of iTEE among patients undergoing coronary artery bypass grafting (CABG) is less

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well documented (10-15). All patients studied with iTEE should have a full and comprehensive examination of the heart during cardiac surgery. This systematic approach makes it more difficult to miss unsuspected abnormalities. Several sets of guidelines for a comprehensive examination have been published (16).

The purpose of the present study was to evaluate the impact of iTEE on surgical decisions-making in a group of patients undergoing on pump CABG, with reference to the mitral and aortic valve and the need for MV repair or MV replacement or AV replacement at the time of myocardial revascularization, and to other associated cardiac defects requiring surgical intervention.

METHODS

Between January 2008 and December 2008 we prospectively studied the perioperative course of all adults who underwent elective on-pump CABG of three cardiovascular surgeons in which iTEE examination was performed. The approval from the Ethics Committee and written informed consent were obtained from each patient. Patients were excluded from the study if they had complex congenital heart disease or prior cardiac surgery and if valve surgery was already planned. Clinical variables, hemodynamic and coronarographic studies, surgical and pathologic reports, and intraoperative echocardiographic reports were reviewed.

Echocardiography

Experienced cardiologists performed preoperative TTE examinations in all patients scheduled for CABG by using Sonos 5500 (Hewlett Packard®) equipment at last one month before surgery. Standard views and measurements were obtained in order to perform a complete preoperative evaluation.

According to our study protocol, iTEE was performed 30 minutes after induction of general anesthesia in all patients included in this study. A complete exam was obtained in each patient according to ASE/SCA guidelines (16).

In order to confirm preoperative diagnosis, left ventricular wall motion abnormalities were evaluated, which would also detect unexpected abnormalities of heart and valves structures. Images were obtained before and after bypass, after the hemodynamics had been stabilized.

All iTEE examinations were performed by 2 of 7 cardiac anesthesiologists, each with at least 3 years of iTEE experience, with the use of IE33 echocardiography system (Philips, Amsterdam, The Netherlands) with an omniplane probe. iTEE imaging was repeated after weaning the patients from cardiopulmonary bypass. All the CABG were performed by three cardiac surgeons.

Aortic valve defects were assessed with 2D evaluation of aortic valve anatomy and planimetry on short axis view (transverse plane at 40°) and long axis view (longitudinal plane at 120°), and with spectral Doppler interrogation of transvalvular flow in deep transgastric aortic valve view.

We quantified the severity of the stenotic lesion with Doppler echocardiographic measurements of maximum jet velocity, mean transvalvular pressure gradient, and continuity equation valve area, as suggested by the "ACC/AHA/ASE 2003 Guidelines for the Clinical Application of Echocardiography" (17) and we defined aortic stenosis as: mild (area > 1.5 cm², mean gradient < 25 mm Hg, or jet velocity < than 3.0 m sec⁻¹), moderate (area between 1.0 and 1.5 cm², mean gradient between 25 and 40 mmHg, or jet velocity between 3.0 and 4.0 m sec⁻¹), or severe (area < than 1.0 cm², mean gradient > 40 mmHg, or jet velocity greater than 4.0 m sec⁻¹).

In patients with aortic regurgitation (AR), we evaluated the severity of AR with colour Doppler to measure the vena contracta and with CW Doppler to calculate pressure half time (PHT) and deceleration rate (DR) in addition to evaluation of LV cavity dilatation. We defined AR as: mild (vena contracta < 5 mm, PHT > 500 msec, DR < 200 cm/sec), moderate (vena contracta between 5-7 mm, PHT between 350-500 msec, DR between 250-300 cm/sec), or severe (vena contracta > 7, PHT < 200 msec, DR > 300 cm/sec) (17).

The severity of mitral regurgitation (MR) was determined by composite analysis of qualitative color flow Doppler imaging, pulmonary vein inflow by pulsed-wave Doppler, and vena contracta method quantification.

We defined MR as: mild (vena contracta < 3 mm; jet area < 3 cm², normal pulmonary vein flow pattern), moderate (vena contracta between 3-6.9 mm; jet area between 3-6 cm², blunt pulmonary vein flow pattern), or severe (vena contracta > 7 mm; jet area > 6 cm², reversed pulmonary vein flow pattern) (17).

The interatrial septum was visualized from the midesophageal level longitudinal view in order to identify a patent foramen ovale (PFO). A PFO was diagnosed if contrast material (air bubbles) was seen in the LA after release of positive airway pressure or if a left-to-right shunt was clearly identified by color Doppler mapping in the region of the fossa ovalis (18).

Surgical treatment

Based on echo findings, the surgical planning of patients scheduled for CABG, in whom a valve dysfunction or other heart abnormality was detected by iTEE as a new finding, was changed following the Recommendations by AHA/ACC published in 1998 (19) and revised in August 2006 (20).

RESULTS

Between January and December 2008, there were 537 patients who underwent CABG, all of whom had iTEE. Sixteen patients were excluded based on the exclusion criteria. The remaining 521 patients constituted our study group. 67% were men, 33% were women. Mean age was 69 ± 14 years (range 54-83). The New York Heart Association (NYHA) functional classification of the study patients showed that the majority of patients (58%) were preoperative NYHA functional class I; 36% of patients were in NYHA functional class II and 6% of patients were NYHA functional class greater than class II. The mean ejection fraction (EF) was 38% ± 8.2 as seen in *Table 1*.

Based on the iTEE findings, new information was obtained in 82 (15.7%) patients before the cardiopulmonary bypass. In 62 (11.9%) of these patients, this information changed the surgical plan.

Of the 521 patients undergoing CABG, 28 (5.3%) patients with negative preoperative TTE, MV surgery had not been planned preoperatively but was performed after detecting at least moderate MR or a significant structural MV abnormality by iTEE. In particular 21 patients had MV repair and 7 patients had MV replacement

Table 2 outlines the MR severity, pathology, and surgical procedures in these 28 patients.

Table 1 - Demographic of patients.

Patients	521
SEX	67% male
AGE	69 ± 14 years
NYHA CLASS	I (58%)
	II (36%)
	III (6%)
EF%	38 ± 8,2

EF: ejection fraction.

Table 2 - *iTEE findings in 28 patients who underwent MV surgery in whom MV surgery was not planned before the operation.*

Patients	iTEE MV severity	Pathology	Procedure performed
3	Moderate (2 +)	Severely calcified MVA extending onto leaflet	Debridement of leaflet
7	Moderate-severe (3 +)	anuloectasia	MV annuloplasty
4	Moderate (2 +)	Thickening and retraction of MV, severe calcification of MV annulus	MVR
4	Mild (1 +)	Anterior leaflet of MV severely calcified	Decalcification of leaflet
5	Moderate (3 +)	Prolapse of mid portion of posterior leaflet	Annuloplasty with Carpentier ring
2	Moderate	Posterior tethering	MV annuloplasty
3	Severe (4 +)	No intrinsic abnormality of leaflets, MVA calcified and dilated	MVR

iTEE: intraoperative transesophageal echocardiography; MV: mitral valve; MVR: mitral valve replacement; MVA: mitral valve annulus.

There were 6 patients who had MV surgery planned at the time of CABG, but MV surgery was cancelled on the basis of the iTEE finding of less severe MR than was previously detected prior to surgery and/or adequate functional structures of the MV.

In 8 (1.5%) patients a severe aortic valve stenosis was found that required AVR.

In 2 (0.38%) cases aortic valve insufficiency was found: one case showing severe AR underwent AVR; the other case with moderate AR underwent AVR because of reduced LV function (EF < 50%).

In 21 (4%) patients a PFO was found and 15 patients (2.8%) underwent closure of patent foramen ovale.

In 3 cases (0.57%) a small (3-4 mm diameter), mobile mass on the aortic side of the cusps of the aortic valve was detected, and needed resection. In all cases histology results from the resected cusp confirmed fibroelastoma.

In 14 patients TEE suggested that cardioplegia be performed selectively due to mild-moderate aortic valve regurgitation.

Table 3 - *iTEE findings and their surgical impact.*

Patients	Basal TEE findings	Surgical impact
2	AV insufficiency	AV replacement
8	AV stenosis	AV replacement
28	MV abnormalities	MV surgery
6	MV regurgitation	Surgery cancelled
3	Mobile mass on aortic cusps	Resection
21	Patent foramen ovalis	15 Foramen closure
	Postbypass TEE findings	Surgical impact
7	RWMA	3 IABP
1	MR	MV repair

AV: aortic valve; MV: mitral valve.

New postbypass findings were obtained in 8 patients (1.5%) and the surgical plan was altered in 4 patients (0.7%).

In particular there were 7 patients who had a new wall motion abnormality (RWMA); a graft flow evaluation was done without alter the surgical plan. In 3 cases a intraaortic balloon was placed. In one case a MR was detected after a MV posterior pericardial annuloplasty, and a posterior commissural resuturing was again performed on-pump.

Table 3 summarizes iTEE findings and the resulting surgical implications.

DISCUSSION

In our experience, a primary and common indication for iTEE is patients undergoing CABG. iTEE was initially used in these cases to assess the wall motion abnormalities before and after cardiopulmonary bypass. It has since become important in assessing other cardiac abnormalities in patients undergoing CABG and has potential for use in concomitant MV or other cardiac surgery. ITEE provides high-resolution analysis of heart structure, especially the valve apparatus. The analysis of functional morphology of the MV generally permits identification of a primary defect in MV coaptation that may produce significant MR that will not improve even after successful revascularization of abnormally moving myocardium. In such cases, a MV procedure should be strongly considered at the time of CABG. Conversely, ischemic MR in the setting of severe coronary artery disease with otherwise structurally normal MV anatomy requires careful evaluation of left ventricular geometry and its impact on MV apparatus deformation.

Also, deep evaluation of the aortic valve is important in CAD patients.

Aortic valve pathology is often associated with coronary artery disease. There is evi-

dence for interventional behaviour in aortic valve abnormalities during CABG procedures. It is very important to consider the increased risk of reintervention after CABG in order to correct an aortic valve defect. This risk is probably higher than the risk associated with prolonging the pump during the same procedure.

We found 82 (15.7%) new prebypass findings in a study population of 521 patients. The new findings resulted in a change in the surgical decision-making plan of 62 patients (11.9%).

New postbypass findings were obtained in 8 patients (1.5%) and the surgical plan was altered in 4 patients (0.7%).

New findings (pre and postbypass) were obtained in 90 patients (17.2%) and the surgical plan was altered in 66 patients (12.6%).

The most common new finding was PFO in 21 patients that was closed in 15 patients. The reason for closure of the PFO was based on our policy to prevent potential postoperative hypoxia under mechanical ventilation, according which large PFO, or situations such as pulmonary hypertension, elevated CVP, right ventricular dysfunction require closure of PFO in patients undergoing cardiac surgical procedures.

In 28 (5.3%) patients, unplanned MV surgery was added to CABG based on the intraoperative echo findings.

In addition, there were 6 (1.1%) patients whose MV surgery was cancelled based on the TEE.

Our study specifically reports the utility of iTEE in the evaluation of cardiac structures during CABG procedures.

The impact of iTEE has been established in a number of settings but primarily in MV repair (8, 9). With additional experience, the utility and impact of TEE in the setting of other cardiac surgical procedures has become apparent (21, 22).

Studies have documented the impact of

6 iTEE on valve surgery, with changes in the operative plan based on transesophageal echocardiography findings in 11% to 14% of cases (23-25). Additionally, iTEE was found in the detection of problems with surgical procedure and subsequent need to return to cardiopulmonary bypass reported in 2% to 6% (26).

Other studies have evaluated the role of iTEE in patients undergoing CABG surgery. One of the most recent from Fatema et al. reported new findings (prebypass and postbypass) in 13% of patients undergoing elective CABG and the surgical plan was altered in 5.5% of patients. They support the use of iTEE in patients undergoing coronary artery bypass graft surgery. Comparing his data with other studies, Fatema et al. concluded that the overall impact of iTEE was lower than in studies that focused on high-risk patients. Our results show almost the same incidence of new findings by iTEE, but they show a higher incidence of surgical intervention. We may speculate that some interventions were not necessary so the patients were at increased risk; or we may speculated that the TTE obtained before surgery, was not as accurate.

Limitations. There are several causes of possible hemodynamic disturbance in the operating room, such as anesthetic drugs, mechanical ventilation, surgical manipulations of the heart, some of which can dramatically affect left ventricular loading and thus influence iTEE assessment. Although we routinely optimize hemodynamics before echocardiography, such factors could not be controlled in this retrospective study.

Quantitative analysis of MR severity was not performed in all patients in this study, allowing for subjective interpretation of MR severity in 2 cases. Interpretation of MR severity by transthoracic versus transesophageal echocardiography can also be variable, particularly with technically difficult transthoracic imaging windows. Such

variability in assessment of MR could not be assessed in the current study.

Also we admit the lack of outcome data at this stage, although follow-up analysis was not the goal of this study.

CONCLUSIONS

iTEE plays an important role in surgical decision-making during CABG procedures. In our series, additional information that altered the surgical plan was found in 66 patients (12.6%) undergoing CABG.

While further studies should be performed to investigate on the impact of this issue on the patients' outcome, these data support the routine use of iTEE in a unselected group of patients undergoing surgical myocardial revascularization: the impact of iTEE in surgical management was relevant so we do believe that iTEE must have a special place in cardiac surgery, and it should be used by experienced hands to correctly diagnose the pathophysiology of heart disease.

There is no conflict of interest.

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