Value of intraoperative transoesophageal echocardiography in monitoring left ventricular function in patients undergoing elective coronary artery bypass grafting

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Abstract

Background: Intraoperative transoesophageal echocardiography (IOTEE) is an integral part of many cardiac surgical procedures and is employed during major non-cardiac operations to monitor cardiac performance, particularly in high-risk patients. In the case of elective coronary artery bypass grafting (CABG) procedures this examination is performed according to experience and availability in a given centre.

Aim: To evaluate the value of IOTEE in monitoring left ventricular (LV) function in patients undergoing elective CABG with the use of cardiopulmonary bypass (CPB).

Methods: In fifty five patients (mean 66 ± 9 years), mean EuroSCORE: 4.5 ± 2.9 scheduled for elective CABG in CPB, IOTEE was performed after induction of anaesthesia, 5 and 30 min after weaning from CPB. Intraoperative parameters of LV function and volume (EDV/BSA) were compared with the data obtained by transthoracic echocardiography (TTE) performed before and 30 days after surgery.

Results: Significant depression of LV ejection fraction (LVEF) was found after induction of aesthesia (decline from 52.2 ± 11.2% to 49.8 ± 11.5%, p = 0.003). Subsequent improvement of LVEF was noticed at 1-month follow-up (p = 0.01). The highest wall motion score index (WMSI) (1.5 ± 0.43) was found after weaning from CPB, the lowest at follow-up (1.36 ± 0.4). Change of EF and WMSI at each stage of examination was significant (p < 0.001). Significant decrease of EDV/BSA was found 30 min after weaning from CPB (decline from 53.5 ± 23.2 to 49.1 ± 21.9 ml/m^2, p = 0.05). Significant depression of EF 5 min after weaning from CPB was detected only in patients with CPB time longer than 120 min (decline of 4.2%, p = 0.001).

Conclusion: Intraoperative transoesophageal echocordiography during elective CABG allows one to control difficult stages of the surgical procedure and to select patients at risk of perioperative haemodynamic deterioration. Our study supports the routine application of IOTEE in elective CABG.

Key words: coronary artery bypass grafting, left ventricular function, transoesophageal echocardiography

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Introduction

In the era of a widespread use of percutaneous myocardial revascularisation, patients referred to a cardiac surgeon usually suffer from a multi-vessel disease, low left ventricular ejection fraction (LVEF) and have concomitant disorders. Optimal management with such patients during surgery and the postoperative period, even if operated electively, presents a real challenge for the anaesthetic and surgical team.

Intraoperative transoesophageal echocardiography (IOTEE) is an integral part of many cardiac surgical procedures and is employed during major non-cardiac operations to monitor cardiac performance, particularly in high-risk patients. In the case of elective coronary artery bypass grafting (CABG) procedures this examination is performed according to experience and availability in a given centre.

The IOTEE enables complete assessment of cardiac performance, including preload, changes in volume of cardiac chambers according to heart cycle, LVEF and cardiac output. The IOTEE is an essential method to detect hypovolaemia and evaluation of the circulatory response to volume load [1-3]. The echocardiographic assessment of the dynamic disturbances of LV regional contractility is

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an even more sensitive examination to detect intraoperative myocardial ischaemia than ECG [4-7].

The purpose of this study was to examine the usefulness of IOTEE to monitor LV performance during elective CABG performed with the use of cardiopulmonary bypass (CPB). Changes in global as well as in regional LV function were evaluated during consecutive stages of the operation and were compared to the status at baseline and one month after surgery. The impact of CPB on the LV function parameters was also assessed.

Methods

Patients

This prospective study involved 55 consecutive patients who underwent elective CABG with CPB between January and September 2006. There were 18 (33%) women in the examined group of patients. Clinical characteristics of the studied population are outlined in Table I.

Anaesthesia

The same anaesthetic management was used in all surgical patients: midazolam in a dose of 7.5 to 15 mg was administered as pre-medication, then fentanyl, thiopental, pancuronium and inhalatory sevoflurane for anaesthesia induction.

Cardiopulmonary bypass – protocol and technique

The CPB protocol was as follows: priming consisted of Ringer solution 1000 ml + HAES 500 ml + mannitol 5 ml/kg, non-pulsatile flow approximately 2.4 l/min/m^2, membrane oxygenator with an integrated heat exchanger. Intermittent warm blood cardioplegic Calafiore solution [8] was administered 'antegrade' – directly to the aortic root (and/or directly to the coronary artery ostia or to earlier performed aorto-coronary bypass grafts).

Echocardiographic examination

Transthoracic (TTE) as well as TEE examinations were carried out using the same Hewlett-Packard Sonos 2500 echocardiograph equipped with a sector 2.5-3.5 MHz probe (TTE) and a multi-plane transoesophageal 5 MHz one. All examinations were done by the first author of this manuscript. Echocardiographic record (on VHS tape) was used for further measurements and calculations were done in five study stages. Baseline TTE study was performed on the day prior to surgery (stage I), and follow-up TTE control 30 days after the operation (stage V).

Three IOTEE acquisitions were carried out:

1. just prior to chest opening and CPB installation (stage II),
2. 5 min after CPB disconnection (stage III),
3. 30 min after CPB termination (stage IV).

Detailed examination comprised standard projections performed according to the ASE/SCA protocol [9].

The following parameters of LV performance were analysed: end-diastolic volume/body mass area (EDV/BSA), LVEF, wall motion score index (WMSI). All measurements and calculations of both TTE and IOTEE were carried out according to the guidelines of the European Society of Cardiology (ESC, EAE) and American College of Cardiology (ACC, ASE) published in the 2006 report [10].

Measurements of LV volume and EF were carried out using the Simpson formula for a two-plane ellipse. In the IOTEE, four- as well as two-chamber mid-oesophageal views were used to evaluate aforementioned parameters (Figure 1). Additionally, to assess LV apical segment regional contractility a long-axis gastric view was employed.

Statistical analysis

The results are expressed as means and standard deviation. The values of EF, WMSI, EDV/BSA in the consecutive study stages were compared using the χ^2

Table I. Characteristics of the examined group of patients

Age [years]	66.1 (± 9.41)
Gender	37-M (67%), 18-F (33%)
EuroSCORE	mean 4.53 (± 2.87), min. 0 max. 10
Risk factors	
arterial hypertension	43 (78%)
diabetes mellitus	20 (36%)
renal failure	15 (27%)
peripheral atherosclerosis	15 (27%)
gastrointestinal ulcer	10 (18%)
respiratory failure	9 (16%)
previous stroke	3 (5%)
heart failure	11 (20%)
obesity	15 (27%)
hyperlipidaemia	50 (91%)
smoking	32 (58%)
Previous myocardial infarction	40 (72%)
inferior	33 (73%)
anterior	12 (27%)
History of PCI	15 (27%)
Coronary angiography	
2-vessel CAD	19
3-vessel CAD	32
4-vessel CAD	4
LM stem	7
LV ejection fraction [%]	52.2 (± 11.23)
< 50%	23
< 40%	8
< 30%	2
WMSI	1.46 (± 0.43)

Abbreviations: CAD – coronary artery disease, LM – left main, LV – left ventricle, WMSI – wall motion score index

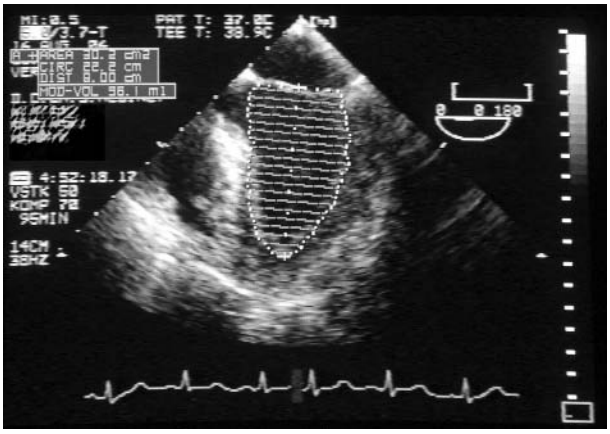

Figure 1. TEE – mid-oesophageal four-chamber view – LVESV measurement

test, and when a correlation between analysed factors was assessed, univariate analysis of variance with repeated measurements was used. The impact of CPB on EF changes was studied using bivariate analysis of variance with repeated measurements. Statistical functions and the 'data analysis module' of the EXCEL package were employed for statistical calculation.

Results

A summary of the perioperative clinical course and information regarding the types of grafts are presented in Table II.

Nine (18%) patients required catecholamine administration during cardiopulmonary support termination. Only in one case was intra-aortic counterpulsation introduced. Perioperative myocardial infarction was noted in one subject on day 4 following surgery. There were no deaths during surgery. Meanwhile, one patient died in the early postoperative period (day 5).

Changes in the echocardiographic LV function parameters in the consecutive study stages are summarised in Figures 1-4 and in Table III.

A significant (p = 0.003) decrease in LVEF from 52.2% in stage I to 49.8% in stage II (anaesthesia induction) was observed. In the following study stages, LVEF systematically increased (see Figure 2 and Table III). There were significant

Table II. Intraoperative data

Intraoperative data	Skin-to-skin time [min]	226.7 (± 59.9)
	CPB time [min]	90.0 (± 53.7)
	Aorta cross-clamping time [min]	48.4 (± 32.7)
	IOTEE study time	43.0 (± 5.1)
Grafts number/patient [%]	1	1 (1.8%)
	2	20 (36%)
	3	32 (58%)
	4	2 (3.6%)
Arterial grafts [%]		
	LIMA – LAD	96.4
	LIMA – D1	3.6
	LIMA – CX	1.8
CK-MB after surgery [ng/ml]		47.1 (± 90.3)

Table III. Changes in the echocardiographic parameters of left ventricular performance in consecutive study stages

	Stage I	Stage II	Stage III	Stage IV	Stage V
EF (%) – all pts	52.2 ± 11.2*	49.8 ± 11.5*	51.0 ± 11.9*	52.9 ± 10*	55.1 ± 9.5*
WMSI	1.46 ± 0.4*	1.47 ± 0.4*	1.5 ± 0.43*	1.42 ± 0.41*	1.36 ± 0.4*
Number of dysfunctional segments	356 (38%)	380 (41%)	384 (41.1%)	334 (35.7%)	266 (28.4%)
EDV/BSA [ml/m^2]	52.7 ± 20.3**	53.5 ± 23.2	51.9 ± 20.2	49.1 ± 21.9**	51.4 ± 18.0
EF in pts with CPB ≤ 60 min	59.5 ± 11.2	55.8 ± 12.5	59.6 ± 10.6	61.1 ± 8.7	61.2 ± 7.6
EF in pts with CPB 61-120 min	49.8 ± 9.3	48.2 ± 10.8	48.9 ± 9.1	50.1 ± 8.2	53.5 ± 7.3
EF in pts with CPB > 120 min	45.1 ± 10.1*	43.4 ± 7.4*	40.9 ± 11.2*	45.8 ± 6.7*	48.7 ± 12.2*

** p < 0.001, **p < 0.05 between stages I and IV*

Abbreviations: CPB – cardiopulmonary bypass, EF – ejection fraction, WMSI – Wall motion score index, EDV/BSA – end-diastolic volume/body mass area

LVEF changes between phases II and IV ($p = 0.004$), II and V ($p < 0.001$) as well as between I and V ($p = 0.013$). Univariate analysis of variance showed that changes of LVEF in the consecutive stages of the study reached high statistical significance ($p < 0.001$).

The mean value of WMSI increased from baseline (stage I) reached a peak value in the period directly after disconnection of CPB (stage III) and then systematically decreased (Table III). Differences between examined stages were proved to be of statistical significance in the χ^2 test: between phases II and IV ($p = 0.009$), I and V ($p = 0.003$), II and V ($p < 0.001$), III and V ($p < 0.001$) as well as between IV and V ($p = 0.041$).

Generally, in the examination on day 30 following surgery (phase V), improvement in myocardial contractility was recorded in 90 (25.3%) dysfunctional segments. Univariate analysis of variance revealed that changes in WMSI in the consecutive study stages reached a very high level of statistical significance ($p < 0.001$).

A significant difference between EDV/BSA measurements was found only at stage IV of the study ($p = 0.05$). There was a marked drop in the value of this parameter within 30 minutes after disconnection of CPB (stage of the chest closure) by 7% as compared with the baseline value (see Figure 3, Table III).

Examined subjects were split into three subgroups according to CPB duration:

- up to 60 min (18 subjects – 32.7%),
- 61-120 min (26 patients – 47.2%),
- exceeding 120 min (10 individuals – 18%).

It was noted that patients with the highest baseline LVEF had the shortest CPB time, while those with the lowest LVEF had the longest CPB period. The differences between groups were significant ($p < 0.001$). The LVEF differed in the consecutive operation stages between the examined groups (see Figure 4, Table III). However, those differences were not significant in the group with the shortest CPB time (and simultaneously with the highest LVEF). In the group with intermediate CPB duration a significant improvement in LVEF was noted in the study stage V ($p = 0.014$). Thus, CPB not exceeding 120 min did not cause a marked LVEF drop in the early postoperative period (stages III and IV), whereas longer CPB duration was associated with a significant ($p = 0.001$) decrease in LVEF by 4.2%.

Discussion

Apart from the Swan-Ganz catheter, IOTEE is another useful tool for cardiac anaesthesiologists. It enables dynamic monitoring of haemodynamic patients' status and modification of therapeutic management. Its value in cardiac surgery has been gaining significance, especially after some limitations of monitoring with the Swan-Ganz catheter were revealed. Also, there is often a shortage of other visualisation modalities in the operating theatre [11-14].

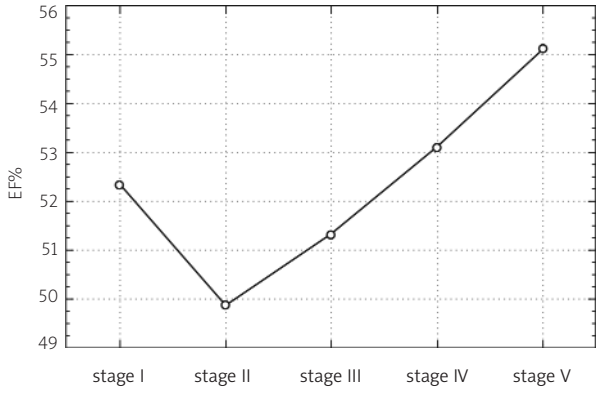

Figure 2. Changes in value of ejection fraction (EF%) in consecutive stages of the study

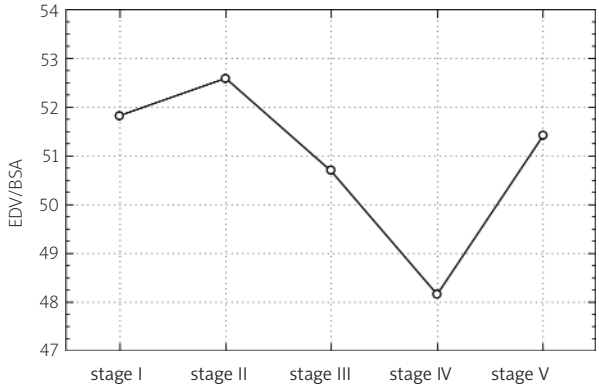

Figure 3. Changes in value of left ventricular end-diastolic volume index in consecutive stages of the study

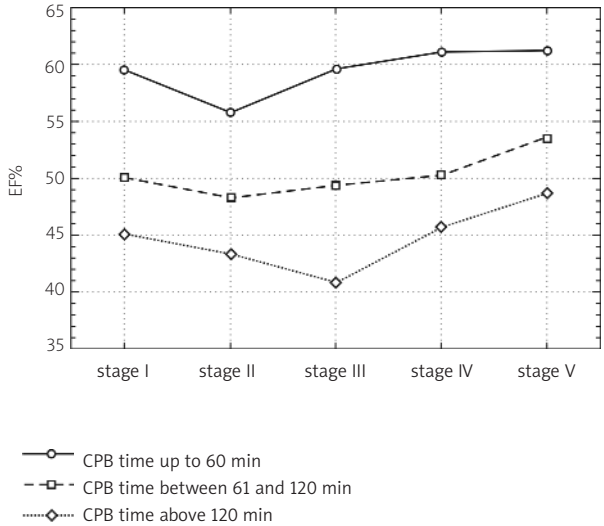

Figure 4. Variability of ejection fraction in relation to cardiopulmonary bypass time

Echocardiographic monitoring of acute haemodynamic disturbances during cardiac surgical procedures, assessment of the cardiac congenital malformation corrections and valve reconstructive surgical treatment were included as recommendations of class I in the American and European Heart Associations guidelines [15]. In this study the usefulness of IOTEE in monitoring of LV performance changes during the consecutive stages of elective CABG procedures was confirmed (recommendation of class IIa). A comparison of data either perioperative or one month after surgery enabled analysis of LV performance not only during CPB, but also after anaesthesia induction and more detailed evaluation of the final operative outcome.

Our study involved patients with multi-vessel disease, the majority had remote myocardial infarction and moderate operative risk according to EuroSCORE classification. More than half of the examined subjects (58%) had LVEF > 50%. The low mortality rate in our patients as well as the low percentage of patients that required both catecholamine support and intra-aortic balloon counterpulsation introduction in the early postoperative period may be explained by the relatively preserved LV function.

The two-plane Simpson method was used intentionally to evaluate EF and volume of LV in all examinations. It enabled the results of TTE studies carried out before and after surgery to be compared with intraoperative results. Owing to the careful selection of the appropriate echocardiographic views and avoiding shortening of the LV long dimension in the transoesophageal study, the findings in TTE and TEE are quite comparable [10, 16, 17]. In the daily clinical practice in the operating theatre, a transgastric view in the short axis is the most commonly employed and widely recommended echocardiographic view to calculate LV global function. Systolic-diastolic variability of LV cross-sectional area at the level of the papillary muscles (fractional area change – FAC) correlates with LVEF [2, 7, 10, 13]. Moreover, the Simpson method is also recommended in patients with regional myocardial contractility disturbances [10]. However, this method is more time-consuming, requires more experience, but is more accurate and similar to the real status.

Controversies may arise from comparison of the parameters describing LV function and volume between TTE and TEE. However, a combination of both TTE and TEE techniques is accepted, although used rarely [10, 16]. Performing all examinations using TEE in all patients was a possible alternative, although it could give rise to some ethical doubts.

Additionally, the reliability of our results was improved by the fact that all echocardiographic studies were performed by the same person.

Bergquist et al. examined accordance of LV performance evaluation during 75 CABG procedures, first done by five experienced cardiac anaesthetists (using a transoesophageal probe) and then completed by 'off-line' assessment by two experienced specialists in echocardiography. They found only moderate accordance of the LV systolic function assessment. If accepting error of 10%, accordance was reached in 75% of the studied cases. Specificity of the regional function assessment was between 50 and 100% and was found to be higher in the cases without any contractility disturbances, especially severe forms such as akinesis or dyskinesis. High accordance was noted in assessment of cardiac chambers filling ($p < 0.001$) [18].

Our study revealed that the most pronounced and statistically significant decrease of EF was noted after anaesthesia induction. The LVEF value similar to the baseline one was achieved within 30 min after disconnection of CPB (stage IV). Impairment of LV performance following anaesthesia induction revealed specific haemodynamic instability in patients with coronary artery disease at that time. It was characterised by a decrease in systemic blood pressure, tachycardia induced by stress related to general anaesthesia and endotracheal intubation, an impact of the anaesthetic agents and a low coronary flow reserve in patients undergoing CABG [19-22]. It was found that conventional ECG monitoring did not reflect properly the extent of LV dysfunction accompanying intubation and anaesthesia induction; the attempts of pharmacological prophylaxis of such adverse effects using nitroglycerine infusions were also tested [23, 24]. Brinke et al. compared haemodynamic parameters of LV function in patients referred for cardiac surgical operation while awake (i.e. coronary angiography) and after anaesthesia induction. As in our patients, a significant EF decrease after administration of the anaesthetic drug accompanied by a slight increase in diastolic LV volume was noted [21].

An improvement in LV contractility following CABG is associated with abatement 'stunning' or 'hibernation' of ischaemic myocardial areas. We observed in our patients a marked increase in WMSI (contractility compromise) at the study stage III (directly after CPB completion) followed by gradual improvement. This is consistent with the findings of some other authors. Bortone et al. noted an improvement in WMSI at 30 min after disconnection of CPB in 50 patients who underwent CABG [25]. Mavi et al. assessed either global LV systolic or regional function in 25 patients undergoing CABG 5 and 30 min after CPB and eventually one month after surgery. They noted a 13% drop in EF and an increase in WMSI by 15% at the 5th minute after cardiopulmonary bypass disconnection. Then, these parameters improved gradually to reach the baseline values 30 min after CPB completion, and further improvement in follow-up was observed [26]. A study performed using a similar monitoring system by Simon et al. showed a decrease of EF by 17% directly after CPB

disconnection [27]. The authors highlighted the impact of the method of intraoperative myocardial protection (various cardioplegic solution types) on the study findings.

However, Szulczyk et al. found that sudden LV contractility improvement following CABG was temporary, while permanent improvement in systolic LV function was observed within follow-up but later than 3 months after surgery. It may be associated with run-down of recruited faint reserves of 'hibernated' myocardium [11].

During CABG procedures, the myocardium is subjected to ischaemia several times. The most important factors causing myocardial ischaemia include aortic cross-clamping (particularly the period between cross-clamping and heart asystole induced by the cardioplegia infusion and between subsequent doses of cardioplegia administration), surgical manipulations, volume and pressure overload, and low perfusion pressure during cardiopulmonary bypass. Moreover, reperfusion defined as time to restoration of the optimal perfusion and reoxygenation (restoration of supply with oxygenated blood) may paradoxically augment ischaemic injury to the myocardium.

Extracorporeal circulation is one technique of myocardial protection against ischaemia and reperfusion injuries. Nowadays, operations involving CPB still form a majority of cardiac surgical procedures. However, CPB is associated with a risk of complications related particularly to the hormonal and inflammatory response. Cardiac function directly after disconnection of the CPB is thus a result of the beneficial impact of revascularisation and post-perfusion injury. The latter not uncommonly requires catecholamine administration or intra-aortic balloon pump employment in the early postoperative period. In our patients, the expected adverse impact of CPB and ischaemia on systolic cardiac performance was observed only in patients with the longest CPB time (> 120 min). An additional factor of negative outcome was the most pronounced EF impairment in this group. The significant decrease in EF seen directly after CPB disconnection was fortunately only temporary.

In our study no additional important factors such as severity of the coronary artery disease, concomitant surgical procedures, or EuroScore result that might impact on CPB time prolongation or might have an association with low EF at baseline in the group with the longest CPB time were analysed.

Changes in diastolic LV volume corresponding with preload and LV compliance in the consecutive stages were inconsiderable. The IOTEE confirmed the observation of marked decrease in LV volume during thoracic cavity closure related to oedema of cardiac, mediastinal and lung tissues that in cases of longer operation may lead to so-called 'intrathoracic tightness syndrome'.

Every operation performed with CPB is associated with a dislocation of large amounts of fluid from the vascular bed to the extravascular space. In extreme cases of prolonged CPB interstitial oedema may be so pronounced that closure of the thoracic cavity may be found impossible (due to a significant decrease in systemic flow). This procedure is then postponed, even by many hours. Monitoring LV diastolic volume by means of IOTEE is useful not only to detect but also to control management of this serious complication.

In this study, many other advantages of IOTEE use such as monitoring of air microbubbles or other embolic material in the cardiac chambers (8 patients in the examined group), evaluation of unexpected valvular changes in structure and impairment of their function were not analysed. They are beyond the scope of this study and they require separate discussion.

To conclude, IOTEE is very useful in the evaluation of cardiac performance and its changes during CABG with CPB. It enables identification of the operation stages that are associated with the highest risk of cardiac performance impairment.

Study limitations

1. A low number of patients in the examined group and a low proportion of subjects with impaired EF.
2. A relatively short period of follow-up limiting conclusive remarks with respect to the prognostic value of the observed changes in LV performance.
3. To confirm repeatability of the IOTEE results it would be necessary to carry out the inter-observer variability test.

Our experience indicates that intraoperative echocardiography should be performed more often than nowadays also during elective CABG.

References

1. Feinberg MS, Hopkins WE, Davila-Roman VG, et al. Multiplane transesophageal echocardiographic doppler imaging accurately determines cardiac output measurements in critically ill patients. *Chest* 1995; 107: 769-73.
2. Oxorn DC. Intraoperative echocardiography. *Heart* 2008; 94: 1236-43.
3. Cheung AT, Savino JS, Weiss SJ, et al. Echocardiographic et hemodynamic indexes of left ventricular preload in patient with normal et abnormal ventricular function. *Anesthesiology* 1994; 81: 376-87.
4. Koide Y, Keehn L, Nomura T, et al. Relationship of regional wall motion abnormalities detected by biplane transesophageal echocardiography and electrocardiographic changes in patients undergoing coronary artery bypass graft surgery. *J Cardiothorac Vasc Anesth* 1996; 10: 719-27.
5. Hunsaker RP. Intraoperative transesophageal echocardiography: standard monitor and diagnostic instrument for difficult situations? *J Clinic Anesth* 2005; 17: 155-7.
6. Bergquist BD, Bellows WH, Leung JM. Transesophageal echocardiography in myocardial revascularization: II. Influence on intraoperative decision making. *Anesth Analog* 1996; 82: 1139-45.
7. Poortmans G, Schupfer G, Roosens C, et al. Transesophageal echocardiographic evaluation of left ventricular function. *J Cardiothorac Vasc Anesth* 2000; 14: 588-98.

8. Calafiore AM, Teodori G, Mezzetti A, et al. Intermittent antegrade warm blood cardioplegia. *Ann Thorac Surg* 1995; 59: 398-402.
9. Shanevise JS, Cheung AT, Aronson S, et al. Guidelines for performing a comprehensive intraoperative multiplane transesophageal echocardiography examination. *Anesth Anal* 1999; 89: 870-84.
10. Lang RM, Bierig M, Devereux RB, et al. Recommendations for chamber quantification. *Eur J Echocardiography* 2006; 7: 79-108.
11. Szulczyk A, Szwed H, Pasierski T, et al. Przydatność śródoperacyjnej echokardiografii przezprzełykowej do oceny odwracalnych zaburzeń kurczliwości lewej komory. *Pol Przegl Kard* 2002; 3: 219-24.
12. Kucewicz E, Czech B, Juszczyk G, et al. Ocena porównawcza dwóch metod śródoperacyjnego pomiaru rzutu minutowego serca (termodilucji i echokardiografia przezprzełykowa) u chorych poddawanych zabiegom pomostowania tętnic wieńcowych z użyciem krążenia pozaustrojowego. *Anesth Inten Terap* 2003; 35: 83-7.
13. Kucewicz E, Czech B, Krajewski J, et al. Śródoperacyjna ocena frakcji wyrzutowej (EF) i frakcji zmiany pola (FAC) wyliczanych echograficznie u pacjentów poddawanych operacji rewaskularyzacji tętnic wieńcowych. *Anesth Inten Terap* 2005; 37: 6-11.
14. Fox J, Glas K, Swaminathan M, et al. The impact of intraoperative echocardiography on clinical outcomes following adult cardiac surgery. *Sem Cardiothorac Vasc Anesth* 2005; 9: 25-32.
15. Cheitilin MD, Armstrong WF, Aurigemma GP, et al. ACC/AHA/ASE 2003 guideline update for the clinical application of echocardiography – summary article: a report of the ACC/AHA Task Force on Practice Guidelines. *J Am Coll Cardiol* 2003; 42: 954-70.
16. Colombo PC, Municino A, Brofferio A, et al. Cross-sectional multiplane transesophageal echocardiographic measurements: comparison with standard transthoracic values obtained in the same setting. *Echocardiography* 2002; 19: 383-90.
17. Hozumi T, Shakudo M, Shah PM, et al. Quantitation of left ventricular volumes and ejection fraction by biplane transesophageal echocardiography. *Am J Cardiol* 1993; 72: 356-9.
18. Bergquist BD, Leung JM, Bellows WH. Transesophageal echocardiography in myocardial revascularization: I. Accuracy of intraoperative real-time interpretation. *Anesth Analg* 1996; 82: 1132-8.
19. Giles RW, Berger BHJ, Barash PG, et al. Continuous monitoring of left ventricular performance with the computerized nuclear probe during laryngoscopy and intubation before coronary artery bypass surgery. *Am J Cardiol* 1982; 50: 735-41.
20. Roy WL, Edelist G, Gilbert G, et al. Myocardial ischemia during non-cardiac surgical procedures in patient with coronary artery disease. *Anesthesiology* 1979; 51: 393-7.
21. ten Brinke EA, Klautz RJ, Tulner SA, et al. Hemodynamics and left ventricular failure in heart failure patients: comparison of awake versus intra-operative conditions. *Eur J Heart Failure* 2008; 10: 467-74.
22. Slogoff S, Keats AS. Does perioperative myocardial ischemia lead to postoperative myocardial infarction? *Anesthesiology* 1985; 62: 107-14.
23. Thomson IR, Mutch WA, Culligan JD. Failure of intravenous nitroglycerin to prevent intraoperative myocardial ischemia during fentanyl-pancuronium anesthesia. *Anesthesiology* 1984; 61: 385-93.
24. Niimi Y, Morita S, Watanabe T, et al. Effects of nitroglycerin infusion on segmental wall motion abnormalities after anesthetic induction. *J Cardiothorac Vasc Anesth* 1996; 10: 734-40.
25. Bortone F, Mazzoni M, Repossini A, et al. Myocardial lactate metabolism in relation to preoperative regional wall motion and to early functional recovery after coronary revascularization. *J Cardiothorac Vasc Anesth* 2003; 17: 478-85.
26. Mavi M, Celkan MA, Ilcol B, et al. Hemodynamic and transesophageal echocardiographic analysis of global and regional myocardial functions, before and immediately after coronary artery bypass surgery. *J Card Surg* 2005; 20: 147-52.
27. Simon P, Mohl W, Neumann F, et al. Effects of coronary artery bypass grafting on global and regional myocardial function: an intraoperative echocardiographic assessment. *J Thorac Cardiovasc Surg* 1992; 104: 40-5.

Monitorowanie funkcji lewej komory u chorych poddanych planowej chirurgicznej rewaskularyzacji serca w krążeniu pozaustrojowym. Znaczenie echokardiografii śródoperacyjnej

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Streszczenie

Wstęp: Śródoperacyjne echo przezprzełykowe (IOTEE) jest jedną z istotnych części wielu operacji kardiochirurgicznych i stosowane jest podczas zabiegów niedotyczących serca w celu monitorowania czynności hemodynamicznej, szczególnie u chorych wysokiego ryzyka. W przypadku chorych poddawanych planowej operacji pomostowania naczyń wieńcowych (CABG) metoda ta jest stosowana w zależności od doświadczenia zespołu leczącego i dostępności w danym ośrodku.

Cel: Zbadanie przydatności IOTEE w monitorowaniu funkcji lewej komory (LV) podczas planowych operacji CABG w krążeniu pozaustrojowym (CPB). Ocenie poddano zmiany globalnej i regionalnej funkcji LV podczas kolejnych etapów operacji w porównaniu z badaniem przedoperacyjnym oraz miesiąc po operacji. Przeanalizowano wpływ CPB na zachowanie się parametrów funkcji LV.

Metody: Grupę badaną stanowiło 55 chorych (66,1 ± 9 lat), *EuroSCORE*: 4,5 ± 2,9, kwalifikowanych do planowego CABG. Wykonywano dwa badania przezklatkowe (TTE) – wstępne i 30 dni po operacji, oraz trzykrotnie badanie IOTEE – przed podłączeniem do CPB oraz 5 i 30 min po odłączeniu od CPB. Oceniano następujące parametry funkcji LV: frakcję wyrzutową (EF%) mierzoną metodą Simpsona dla dwupłaszczyznowej elipsy, wskaźnik kurczliwości WMSI oraz wskaźnik objętości rozkurczowej (EDV/BSA).

Wyniki: Wykazano istotny spadek EF po indukcji znieczulenia (z 52,2 ± 11,2 do 49,8 ± 11,5, p = 0,003), a następnie systematyczny jej wzrost o 2,9% (p = 0,01) miesiąc po operacji. Najwyższą wartość WMSI (1,5 ± 0,43) stwierdzono bezpośrednio po wyjściu z CPB, a najniższą w badaniu kontrolnym (1,36 ± 0,4). W jednoczynnikowej analizie wariancji zmiany EF% oraz WMSI na każdym etapie badania były znamienne statystycznie (p < 0,001). Istotna zmiana EDV/BSA miała miejsce jedynie 30 min po wyjściu z CPB (spadek z 53,5 ± 23,2 do 49,1 ± 21,9 ml/m^2, p = 0,05). Negatywny wpływ krążenia pozaustrojowego na funkcję LV zaobserwowano tylko u chorych, u których czas CPB był równy lub dłuższy niż 120 min (spadek wartości EF% bezpośrednio po odłączeniu od CPB o 4,2%, p = 0,001).

Wnioski: Śródoperacyjna echokardiografia przezprzełykowa jest wysoce przydatna w ocenie funkcji serca i jej zmian podczas operacji rewaskularyzacji serca w krążeniu pozaustrojowym. Umożliwia wyodrębnienie etapów operacji, które wiążą się z największym ryzykiem pogorszenia funkcji serca. Zdobyte doświadczenia wskazują, że echokardiografia śródoperacyjna powinna być stosowana szerzej niż dotąd przy planowych operacjach rewaskularyzacji serca.

Słowa kluczowe: rewaskularyzacja chirurgiczna serca, krążenie pozaustrojowe, funkcja serca, śródoperacyjna echokardiografia przezprzełykowa

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