

# Minimally invasive mini-thoracotomy access as a surgical method in state-of-the-art treatment of single-vessel coronary heart disease

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## ABSTRACT

**Aim** To compare outcomes of two different surgical techniques of coronary artery bypass grafting (CABG) for treating isolated left anterior descending (LAD) coronary artery disease by full median sternotomy technique vs. minimally invasive approach via left anterior mini-thoracotomy.

**Methods** This retrospective, observational study, which included 61 elective patients, was conducted at the Clinic for Cardiovascular Surgery of the Clinical Centre of the University of Sarajevo in the period from June 2019 to January 2022. Patients were divided in two groups according to the operative technique used, the sternotomy CABG group of 30 patients where the access considered full median sternotomy, and the minimally invasive CABG group where left anterior mini-thoracotomy was performed. The groups were compared by previously defined primary and secondary clinical postoperative outcomes.

**Results** Out of 61 patients, the majority was males, 50 (82%). The analysis of the outcomes of the minimally invasive CABG surgery showed significantly shorter operative times ( $p=0.001$ ), less postoperative drainage ( $p=0.001$ ) and transfusion requirements, shorter mechanical ventilation duration ( $p=0.0001$ ), low major adverse cardiac and cerebrovascular events rates, as well as shorter Intensive Care Unit stay days with mean of  $3.3\pm 1.442$  days ( $p=0.025$ ), but no total hospital stay days with mean of  $6.7\pm 1.832$  days ( $p=0.075$ ) compared to sternotomy CABG group.

**Conclusion** Minimally invasive approach for CABG surgery in treating isolated single vessel LAD disease, together with the fast-track protocol, offers a reasonable alternative to full median sternotomy, leading to faster patients' overall recovery and improving the quality of life.

**Key words:** anaesthesia, revascularization, cardiac surgery

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## INTRODUCTION

The growing incidence of coronary artery disease (CAD) in the global population has placed coronary artery bypass surgery (CABG) in one of the most commonly performed surgical procedures worldwide (1-2). The CABG is considered as a gold standard for treatment of one-or-multivessel ischemic heart disease intended to relieve symptoms of the cardiovascular disease and to enhance patient's life expectancy (3). Although the opinion is widely accepted that surgical revascularization improves the survival, it still carries the risk of postoperative complications (4). Despite the ever-aging population and increased risk scores of the patients, postoperative outcomes have improved over time, due to the surgical technique advancements and more accurate patient selection, together with the optimization of anaesthesia and intensive care fast track protocol, leading to a decline of mortality and major morbidity (1,4).

In the past decades, different surgical techniques for CABG have evolved to minimize the surgical trauma and postoperative morbidity (1-4). Calafiore et al. popularized the technique of minimally invasive direct coronary artery bypass grafting (MIDCAB) for treating isolated coronary artery disease (5). New technological improvements establish the role of minimally invasive approaches via a small 5 to 10 cm incision of left anterior thoracotomy instead of sternotomy, mainly for isolated LIMA to LAD bypass grafting (4-6). Nowadays, the MIDCAB is among cardiac surgeons adopted as a patient-friendly technique due its reduced invasiveness, but it also gives respectable results comparable to other CABG techniques in treating single vessel ischemic disease (6,7). Minimally invasive approaches for CABG offer a reasonable alternative to sternotomy because of less surgical trauma, less wound infection rates, decreased blood loss and transfusion rates, decreased ventilation times and hospital stay, but also cosmetic advantages, leading to faster patient's overall recovery and the improvement of quality of life (3,6,7). While several meta-analyses of large multicentre studies of outcomes of conventional CABG and MIDCAB have been published (6,7), regional centres in developing countries are still lacking comprehensive analytical studies of MIDCAB outcomes.

The aim of the study was to compare clinical outcomes of two different operative techniques for

treating isolated LAD coronary artery disease, by the standard CABG surgery through the median full sternotomy technique vs. minimally invasive approach by left anterior mini-thoracotomy.

## PATIENTS AND METHODS

### Patients and study design

This retrospective, comparative, observational study was conducted at the Clinic for Cardiovascular Surgery of the University Clinical Centre of Sarajevo in the period from June 2019 to January 2022. A total of 61 non-randomized, elective patients treated for isolated LAD artery disease were included in the study. The patients, 50 males and 11 females, at the age between 43 and 85 years, were categorized according to a surgeon's choice of a technique for isolated CABG in two different groups: sternotomy CABG group (n=30) and minimally invasive CABG group (n=31). Exclusion criteria were: multi vessel coronary artery disease, combined valvular and coronary artery surgery and urgent surgery. There was no significant difference in either group in the number of comorbidities and age.

The study was conducted in accordance with the Helsinki Declaration. The Institutional Ethical Committee approved the study and a written patient consent for the surgery was obtained.

### Methods

**Anesthesia and surgical technique.** The preoperative assessment was conducted by standard institutional protocol. Following the induction of anaesthesia, the patients were intubated with a single lumen endotracheal tube. Mechanical ventilation was adjusted to the protective ventilation technique. General anaesthesia was maintained by fast-track protocols to facilitate early extubation. The hemodynamics was monitored by standard invasive hemodynamic monitoring. To minimize the risk of bleeding antifibrinolytics were used in both patient groups. The heparinization was accomplished by standard doses of heparin. The surgical technique of the sternotomy CABG group assumed full median sternotomy, while in the minimally invasive CABG group the surgical approach was through a small up to 6 cm incision at the level of the left anterolateral 4<sup>th</sup> or 5<sup>th</sup> intercostal space depending on patients' ana-

tomy. Cell saver was used to minimize the risk of blood transfusions. After chest tubes placement and skin closure the patients were admitted to the Intensive Care Unit (ICU).

**Postoperative outcome.** Hemodynamics of the patients was continuously monitored postoperatively. Postoperative drainage was observed hourly until chest drain removal. Blood transfusions were required in haemoglobin values below 70 g/L. In patients with signs of postoperative bleeding, blood, fresh frozen plasma and platelet transfusions at platelet count (PLT) of  $<50.000 \cdot 10^9/L$  were indicated. Urgent chest revision was performed in the case when the criteria for open chest exploration by institutional protocols were met. Postoperatively, the antiplatelet therapy was administered by the earlier accepted guidelines on the day of surgery.

The primary outcome of the study was to compare the postoperative drainage and transfusion requirements, as well as the duration of surgery and invasive mechanical ventilation, length of ICU stay and total hospital stay, between the patient groups.

The secondary outcome was to compare and measure by the follow-up of infection rate, new onset of arrhythmia or myocardial infarction (AMI), inotropic drugs and mechanical support requirement (intra-aortic balloon pump - IABP), extracorporeal membrane oxygenation - ECMO) needed for surgical chest revision, occurrence of cerebrovascular and endothoracic incidents (pneumo-or haemothorax) and lethal outcome.

Major adverse cardiac and cerebrovascular events (MACCE) were defined as in-hospital, death, acute myocardial infarction (AMI), or acute ischemic stroke, and were evaluated during hospitalisation time.

**Statistical analysis**

Categorical data were presented as percentage. Continuous data were expressed as mean of numbers. The data were presented in the form of figures and tables. The assessment of normality of data was tested with the Shapiro-Wilk test and Kolmogorov-Smirnov test. Appropriate parametric and non-parametric tests were conducted for different types of variables, Fisher exact test or  $X^2$  test for categorical data and t-test for continuous data. The statistical significance of the tests was set on  $p < 0.05$ .

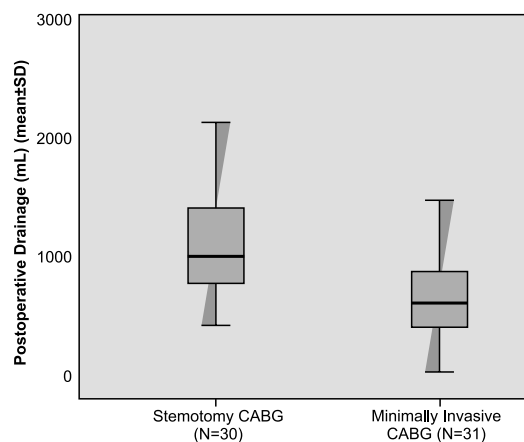
**RESULTS**

Out of the total of 61 patients, the majority were males, 50 (82%); 27 (44%) were older than 65 years of age, while 34 (56%) were categorized in the age group between 40-65 years.

In the sternotomy CABG group, the mean age was  $65.5 \pm 10.5$  years, while in the minimally invasive CABG group the patients mean age was  $63.38 \pm 9.48$  years ( $p = 0.161$ ).

The mean time of the duration of surgery was  $206 \pm 77$  minutes in both groups, whereas the duration of minimally invasive CABG procedure was significantly shorter than in the sternotomy CABG surgery,  $175 \pm 65$  minutes and  $239 \pm 76$  minutes, respectively ( $p = 0.001$ ).

The analysis of the drainage showed statistically significant differences between compared groups, where the mean amount of the drainage in the postoperative period was greater in the sternotomy CABG group in comparison to minimally invasive CABG group,  $1188 \pm 620$  mL and  $704 \pm 419$  mL, respectively ( $p = 0.001$ ) (Figure 1).



**Figure 1. Postoperative drainage (mL) in sternotomy coronary artery bypass grafting (CABG) and minimally invasive CABG group (mean ± SD)**

The minimally invasive CABG group showed less transfusion requirements compared to patients of the sternotomy CABG group, 12 (39%) and 18 (60%), respectively. The analysis of blood derivatives supplementation among the total study population showed that FFP was used in 19 (33%) patients, whereas more frequent demand of FFP was evident in the minimally invasive CABG group compared to the sternotomy CABG group, 13 (42%) and seven (23%), respectively (Table 1).

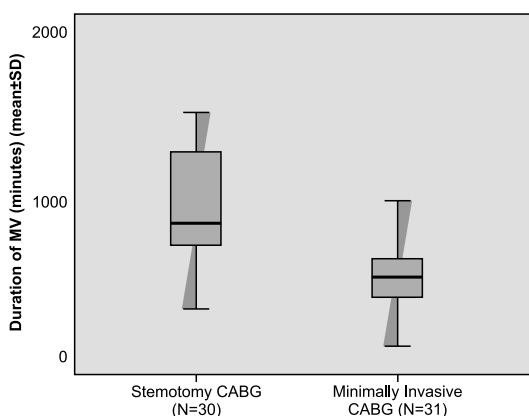
**Table 1. Postoperative patient data during the Intensive Care Unit stay**

Variable	Sternotomy CABG (N=30)	Minimally invasive CABG (N=31)	p
<b>MACCE</b>			
AMI (No; %)	1 (3.3)	3 (9.7)	0.671
CVI (No; %)	3 (10)	2 (6.5)	0.614
Death (No; %)	3 (10)	2 (6.5)	0.614
<b>MV duration (minutes) (Mean±SD)</b>	1300±1658	698±1167	0.0001
<b>Endopleura disorders (No; %)</b>			
	1 (3.3)	2 (6.5)	0.573
<b>Revision (No; %)</b>			
	2 (6.7)	3 (10)	0.668
<b>Transfusion requirements (%)</b>			
Blood transfusion	60	39	
FFP	23	42	
<b>Infection (No; %)</b>			
	2 (6.7)	1 (3.2)	0.612
<b>LOS (days) (Mean±SD)</b>			
	4.3±2.963	3.3±1.442	0.025
<b>Hospital stay (days) (Mean±SD)</b>			
	8±3.833	6.7±1.832	0.075

CABG, coronary artery bypass grafting; MACCE, major adverse cardiac and cerebrovascular events; AMI, acute myocardial infarction; MV, mechanical ventilation; SD, standard deviation; FFP- Fresh frozen plasma;

Postoperative chest revision was indicated in five (8%) patients. The revision was done in three (10%) in the minimally invasive CABG group and in two (6.7%) patients in the sternotomy CABG group (p=0.668) (Table 1).

In the ICU period of stay a significant difference in the duration of mechanical ventilation between selected groups was found, with shorter mean ventilation time in the minimally invasive CABG group, 698±1167 minutes, compared to 1300±1658 minutes in sternotomy CABG group (p=0.0001) (Figure 2).



**Figure 2. Duration of mechanical ventilation (MV), postoperatively in sternotomy coronary artery bypass grafting (CABG) group compared to minimally invasive CABG group**

In the analysis of ICU length of stays (LOS) statistically significant differences were observed between the groups, with shorter mean of ICU

days in the minimally invasive CABG group (3.3±1.442 days vs. 4.3±2.963 days; p=0.025), while the total hospital stay days did not significantly differ between the compared patient groups (6.7±1.832 days for minimally invasive CABG group, vs. 8±3.833 days for sternotomy CABG group; p=0.075) (Table 1).

Regarding major adverse cardiac and cerebrovascular events (MACCE), postoperative ischemic incidents in the early postoperative period during hospitalization were presented in five (out of 61; 8%) patients; three patients in the sternotomy CABG group and two patients in the minimally invasive CABG group. A slightly higher frequency of cerebrovascular insults in the sternotomy CABG group was noticed (p=0.614). Postoperative acute myocardial infarction (AMI) was slightly more frequent in the minimally invasive CABG group compared to the sternotomy CABG group, three (9.7%) and one (3.3%), respectively (p=0.671). None of the patients required the support of IABP or ECMO.

The infection rate did not show a significant difference between selected patient groups, although it was slightly lower in the minimally invasive CABG group than in sternotomy CABG group, one (3.2%) and two (6.7%), respectively (p=0.612). There was no significant difference in the occurrence of endopleural disorders like pneumo-or haemothorax (p=0.73). The postoperative overall lethal outcome was noticed in 5 (8.2%) patients; 3 patients in the sternotomy CABG group and 2 patients in the minimally invasive CABG group (p=0.614) (Table 1).

**DISCUSSION**

The aim of our study was to present the minimally invasive surgical approach to the single-vessel (LAD) coronary disease treatment as a plausible alternative to open surgery by comparing clinical outcomes in the early postoperative period. Several recent studies were published to present potential benefits of the minimally invasive surgery (2,6,7). With the growing recognition of potential benefits of minimally invasive surgery, the interest in MIDCAB surgery among cardiac surgeons is continuously raising. This observational study conducted in a regional cardiac surgery centre, also showed significant advantages in faster overall recovery and return to daily activities after

minimally invasive approaches together with the ICU fast track protocol, especially in the high-risk population.

Since the population is aging and expressing high risk comorbidities, cardiac surgeons all over the world strive for various techniques to reduce the risk associated with conventional CABG surgery (4). The term minimally invasive still remains not well specified, since it can be defined as avoidance of the cardiopulmonary bypass due to its adverse systemic effects, as well as a sternal sparing technique requiring special endoscopic instruments and advanced equipment to access the LAD through the 4<sup>th</sup> or 5<sup>th</sup> intercostal space via left anterior mini-thoracotomy (8,9).

A careful patient selection is of crucial importance to accomplish satisfactory results (6-8). Our study population is similar to several large comparative studies such as Kayatta et al. and Diegeler et al. studies, choosing younger male patients between 40 and 65 of age with lower body mass index and favourable chest anatomy characteristics for MIDCAB surgery (7,8). In the pioneer studies of Diegeler et al. reviewing indications and selection factors for minimally invasive surgery, several conditions are considered as unfavourable for MIDCAB, such as diffuse disease, smaller vessel diameters, calcifications, anatomical exposure difficulties, especially in obese women with large breasts (8). On the other hand, Hage et al. presented that older population with multiple comorbidities, especially diabetic disease, may have a greater benefit of sternal bone preservation and lower wound infection risk by minimal invasive cardiac surgery (10). Although our research could not prove statistically significant difference in postoperative infection rate between observed groups, the deep sternal wound infection was more frequently present in the sternotomy CABG group. As there is no sternal heal present, the patients have no mobility restrictions and can quickly return to normal life activities (8). Our study has emphasized a shorter operative time as an additional factor prioritizing the minimal invasive approach by exposing the patient to less surgical stress to avoid the activation of various inflammatory systemic mechanisms associated with higher risk of postoperative complications as presented by Kraft et al. (9).

Similar to results of the meta-analysis of Hage et al. in our single-centre study we have shown that

the mini-thoracic approach led to less postoperative drainage, resulting in significant lower blood transfusion rates in the MIDCAB group compared to sternotomy CABG group (10). The certainly benefit of the MIDCAB surgery to reduce blood loss and transfusion requirements, who carries the risk of transfusion-related complications as TRALI (transfusion-related lung injury) and infection, has been shown in several recommendations for blood management strategies as in the 2017 EACTS guidelines (11-13). The mini-thoracic approach evidently minimizes blood loss by different mechanisms including less tissue trauma by small incisions and tissue retractions and dissections, use of lower systemic heparin dose, standard use of cell salvage and lack of haemodilution and coagulation trauma caused by cardiopulmonary bypass (13). The results of our study regarding the significantly lower postoperative bleeding in the minimally invasive CABG group are comparable with those of the study by Menkis et al. published in the consensus statements of the International Society for Minimally Invasive Cardiothoracic Surgery. Therefore, minimally invasive approach could be an acceptable alternative to conventional surgery due to less bleeding, lower transfusion rates, decreased mechanical ventilation times, as well as less ICU and hospital stay (13). In our study we have shown that the minimally invasive approach ensures early extubation minimizing ventilator-related pulmonary complications in the early postoperative period in accordance to studies underlining the importance of early implementation of enhanced recovery after surgery (ERAS) protocols in cardiac surgery (14-17). In our study ERAS protocols such as the early oral liquids intake, early patient mobilization, could be successfully implemented in the minimally invasive CABG group. Although, our results showing significantly shorter ICU length of stay (LOS) are comparable with other large observational researches such as the Reser et al. study, we could not prove the significant difference regarding the hospital stay days among our patient groups (18).

Cardiovascular complications still remain a major source of mortality and morbidity. The analysis of our research population, consisted of mostly elderly male patients, have shown that the incidence rate of major cerebrovascular events was 8% of the total study population. As the study by Kang et

al. presented, older age ( $\geq 65$  years), male gender, in combination with chronic renal or pulmonary disease and diabetes mellitus, are considered as independent strong predictors of major adverse cardiac and cerebrovascular events (MACCE) and death among CABG patients (19,20).

Our research has some of limitations regarding the small sample size which could have some impacts on statistical measurements and data analysis. Surgeon's experience, the learning curve for minimally invasive procedures and technological capabilities are playing a crucial role in the performance of this type of surgery. Larger prospective studies should be conducted at our centre to provide more accurate results to be comparable with large cardiovascular centres in minimally invasive access in treating coronary artery disease, considering the fact that this met-

hod is implemented in our practice in the past few years.

In conclusion, although technically challenging, the minimally invasive approach through mini-thoracotomy for single-vessel revascularization surgery could be considered in a carefully selected group of patients as an acceptable alternative to full sternotomy technique due its advantages in patient's postoperative recovery and reduction of costs, the highest burden of healthcare system in developing countries.

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No specific founding was received for this study.

## TRANSPARENCY DECLARATION

Conflicts of interests: Non to declare.

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