



## A comparison of lower ministernotomy (manubrium-sparing sternotomy) and standard median sternotomy in coronary artery bypass surgery

*Koroner arter baypas cerrahisinde alt ministernotomi (manibrium koruyucu sternotomi) ve standart median sternotominin karşılaştırılması*

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### ABSTRACT

**Background:** In this study, we aimed to compare early outcomes of lower ministernotomy (manubrium-sparing sternotomy) and standard median sternotomy in coronary artery bypass grafting surgery.

**Methods:** Between January 2015 and December 2016, a total of 28 patients (15 males, 13 females; mean age 64.5±10.1 years; range 43 to 82 years) who underwent coronary artery bypass grafting surgery at the Department of Cardiovascular Disease were retrospectively analyzed. Of these patients, 14 patients were operated with lower ministernotomy (manubrium-sparing sternotomy; group 1) and 14 patients were operated using standard median sternotomy (group 2). Data including age, gender, body surface area, preoperative clinical findings, intraoperative variables, postoperative complications, the amount of transfusion products, hemoglobin and hematocrit values, drainage volumes, intubation duration, mortality, and length of intensive care unit and hospital stay of both groups were compared retrospectively.

**Results:** There was no statistically significant difference in the cross-clamp time, cardiopulmonary bypass time, and total procedure time between the groups. There was a statistically significant difference in the amount of chest tube drainage, the need for blood transfusion which was lower in the ministernotomy group, and postoperative hematocrit levels, postoperative hemoglobin levels and postoperative SaO<sub>2</sub> levels which were higher in the ministernotomy group. There was a statistically significant difference in the ventilation time and length of stay in the intensive care unit and hospital in favor of the ministernotomy group. The study showed no statistically significant difference in the mortality rate between the two groups.

**Conclusion:** Our study results show that the manubrium-sparing sternotomy may be a feasible alternative to surgery through classical median sternotomy for, particularly, patients who are obese, diabetic, and have poor respiratory functions.

**Keywords:** Coronary artery bypass grafting; minimally invasive surgical procedure; sternotomy.

### ÖZ

**Amaç:** Bu çalışmada, koroner arter baypas cerrahisinde alt ministernotomi (manibrium koruyucu sternotomi) ve standart median sternotominin erken dönem sonuçları karşılaştırıldı.

**Çalışma planı:** Bu çalışmada Ocak 2015 - Aralık 2016 tarihleri arasında Kalp ve Damar Cerrahi kliniğinde koroner arter baypas greftleme yapılan toplam 28 hasta (15 erkek, 13 kadın; ort. yaş 64.5±10.1 yıl; dağılım 43-72 yıl) değerlendirildi. Bu hastaların 14'üne alt ministernotomi (manibrium koruyucu sternotomi; grup 1) ve 14'üne standart median sternotomi (grup 2) uygulandı. Yaş, cinsiyet, vücut yüzey alanı, ameliyat öncesi klinik bulgular, ameliyat sırası değişkenler, ameliyat sonrası komplikasyonlar, transfüzyon ürün miktarları, hemoglobin ve hematokrit değerleri, drenaj miktarları, entübasyon süresi, mortalite ve yoğun bakım ünitesi ve hastanede kalış süresi verileri iki grup arasında retrospektif olarak karşılaştırıldı.

**Bulgular:** Gruplar arasında kros-klemp süresi, kardiyopulmoner baypas süresi ve toplam işlem süresi açısından istatistiksel olarak anlamlı bir fark yoktu. Göğüs tüpü drenaj miktarı, ministernotomi grubunda daha düşük olan ameliyat sonrası kan transfüzyonu ihtiyacı ve ministernotomi grubunda daha yüksek olan ameliyat sonrası hematokrit düzeyleri, ameliyat sonrası hemoglobin düzeyleri ve ameliyat sonrası SaO<sub>2</sub> düzeyleri arasında istatistiksel olarak anlamlı bir fark vardı. Ventilasyon süresi ve yoğun bakım ünitesinde ve hastanede kalma süresi ministernotomi grubunun lehine istatistiksel olarak anlamlı idi. Bu çalışmada mortalite oranları açısından iki grup arasında istatistiksel olarak anlamlı bir fark yoktu.

**Sonuç:** Çalışma sonuçlarımız manibrium koruyucu sternotominin özellikle obez, diyabetik ve solunum fonksiyonu kötü olan hastalarda, klasik median sternotomi cerrahisine iyi bir alternatif olabileceğini göstermektedir.

**Anahtar sözcükler:** Koroner arter baypas greftleme; minimal invaziv cerrahi işlem; sternotomi.

Received: April 02, 2017 Accepted: May 05, 2017

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### Cite this article as:

Kaya U, Çolak A, Ceviz M, Becit N, Kocak H. A comparison of lower ministernotomy (manubrium-sparing sternotomy) and standard median sternotomy in coronary artery bypass surgery. Turk Gogus Kalp Dama 2017;25(4):528-34.

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Minimal invasive approaches have been increasingly used in cardiac surgery.<sup>[1,2]</sup> Compared to median sternotomy, the length of incision and surgical trauma have been shown to be reduced with minimal invasive approaches. In addition, accelerated healing process, reduced morbidity and shortened length of hospital stay have been reported. Several studies have shown that long-term outcomes are improved in minimal invasive surgery.<sup>[3]</sup> Ideal minimal invasive surgery should provide to access all cardiac regions easily through the least specialized surgical equipment, and it should also ensure the patient to return to normal daily life in a short time period.<sup>[4]</sup> Manubrium-sparing sternotomy can visualize the full image of the heart through a smaller incision with existing equipment used in classical median sternotomy, allowing the advantages of minimal invasive surgery. Manubrium-sparing sternotomy in which the manubrium sterni are protected also maintain the continuity of the shoulder girdle, supporting postoperative respiratory mechanisms, and patients usually recover faster and return their normal lives in an early period.<sup>[5]</sup>

In the present study, we report early outcomes of lower ministernotomy (Manubrium-sparing sternotomy) and standard median sternotomy in coronary artery bypass grafting surgery (CABG).

## PATIENTS AND METHODS

This retrospective study included a total of 28 patients (15 males, 13 females; mean age  $64.5 \pm 10.1$  years; range 43 to 82 years) who were diagnosed with diabetes and coronary artery disease with a body surface area (BSA) of  $\geq 1.9$  m<sup>2</sup> and underwent CABG at Ataturk University, Faculty of Medicine, Department of Cardiovascular Surgery between January 2015 and December 2016. All operations were performed by a single surgical team. Manubrium-sparing sternotomy was performed in 14 patients (group 1), whereas standard median sternotomy was performed in 14 patients (group 2). Data including age, sex, BSA, preoperative clinical findings, intraoperative variables, postoperative complications, the amount of transfusion products, hemoglobin and hematocrit values, drainage volumes, intubation duration, mortality, and length of intensive care unit and hospital stay were recorded.

Inclusion criteria were as follows: males and females with coronary artery disease (CAD) as demonstrated by coronary angiography and indication of elective CABG surgery, obesity, BSA of  $\geq 1.9$  m<sup>2</sup>, poor preoperative respiratory functions (abnormal spirometry, low SaO<sub>2</sub> levels) and high pulmonary artery pressure (PAP) values. Exclusion criteria were as follows: patients

who were switched to another surgical technique in the intraoperative period.

The study protocol was approved by the Ataturk University Faculty of Medicine Ethics Committee. A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Simple descriptive pain scale and postoperative analgesia (fentanyl) infusion time used routinely and recorded on the intensive care unit patient chart were used to evaluate postoperative pain in all patients operated in our clinic. Using the simple descriptive pain scale, the patient was instructed to indicate the level of pain by marking between no pain (0) and unbearable pain (10).

## Operative techniques

The patients were pre-medicated 30 min before anesthesia induction by oral 0.3 mg/kg midazolam. Then, electrocardiography, pulse oximetry, and non-invasive blood pressure monitoring were performed. Anesthesia was induced by inhalation of sevoflurane in the mixture of oxygen 50% and air 50%. When an intravenous line was inserted, we switched to total intravenous anesthesia with midazolam-fentanyl rocuronium bromide. Ventilator settings were adapted to maintain normocapnia. Following anesthesia induction and intubation, radial artery and jugular vein catheters were inserted to all patients. The body temperature was monitored by thermal sensors placed in the rectum. The patient was placed in the supine position and draped. In group 1 patients, a vertical skin incision 8-10 cm in length was made in the midline over the lower sternum extending from one finger breadth distal to manubrio-sternal angle till one finger breadth proximal to the base of the xiphoid process. The sternum was divided vertically in the midline from the xiphoid process till the third intercostal space and, then, at that point transversely to the right and the left without touching the right and left the internal mammary artery using an oscillating saw. In group 2 patients, classical median sternotomy was performed. The left internal thoracic artery (LIMA) which was prepared as a pedicled graft in all patients, the long saphenous vein and/or radial artery grafts were harvested. The LIMA was used in all patients. The LIMA was prepared with one-third proximal portion by clipping first intercostal branch, while pulling manubrium sterni upwards in the patients undergoing ministernotomy. Following heparinization, an arterial cannula on the ascending aorta and two-stage venous cannula were placed. None of the patients required

femoral cannulation. Then, cardiopulmonary bypass (CPB) was initiated. The body temperature was reduced to 32 °C. The ascending aorta was cross-clamped and cardiac arrest was achieved by antegrade hypothermic crystalloid cardioplegia. Hemofiltration was performed, when necessary. To preserve myocardium, blood cardioplegia was performed in 15 to 20 min intervals during cross-clamping. Distal anastomoses were performed during aortic cross-clamping, while proximal anastomoses were performed with partial aortic clamp during re-heating of the patient. In the patients with redundant proximal anastomoses in the ministernotomy group, end-to-side proximal anastomosis on another appropriate graft was performed to reduce the number of proximal anastomoses on the ascending aorta.

### Statistical analysis

Statistical analysis was performed using the SPSS version 13.0 software (SPSS Inc., Chicago, IL, USA). Descriptive data were expressed in mean ± standard deviation or number and percentage. The difference between the groups for nominal data was analyzed using the chi-square test. Continuous variables were assessed using the Student t-test and Mann-Whitney U test. A *p* value of <0.05 was considered statistically significant.

## RESULTS

All patients were diabetic and with similar age and BSA values. There was no significant difference in the demographic characteristics of the patient groups. The mean age was 58.9±10.6 (range 47 to 74) years in group 1 and 62.7±11.7 (range 48 to 81) years in group 2. Eight patients (57.1%) were males and six patients (42.9%) were females in group 1, while the number of female and male patients was equal in

group 2. The mean BSA was 2.0±0.2 m<sup>2</sup> in group 1 and 2.0±0.1 m<sup>2</sup> in group 2, indicating no statistically significant difference. Baseline demographic characteristics are shown in Table 1.

The mean left ventricular ejection fraction (LVEF) was 50.2±9.2% in group 1 and 58.3±5.3% in group 2 (*p*=0.043). Eight patients (57.1%) in group 1 and six patients (42.9%) in group 2 had chronic obstructive respiratory disease, while five patients (35.7%) in group 1 and four patients (28.6%) in group 2 had hypertension. Two patients in group 1 had tracheostomy. The mean PAP was 36.5±11.2 mmHg in group 1 and 33.9±5.3 mmHg in group 2 (*p*=0.036). The mean LVEF was significantly lower and PAP was significantly higher in group 1, compared to group 2.

The mean bypass number (number of distal anastomosis) was 4.1±0.8 in group 1 and 4.3±0.5 in group 2. The number of proximal anastomosis was 2.3±0.7 in group 1 and 2.5±0.9 in group 2. The mean cross-clamp time was 53.2±10.2 min in group 1 and 51.8±12.5 min in group 2, while the mean CPB duration was 89.1±25.6 min in group 1 and 91.4±18.9 min in group 2. The mean duration of surgery was 4.8±0.4 h in group 1 and 4.7±0.4 h in group 2. There was no statistically significant difference in the intraoperative data between the groups. Intraoperative variables are shown in Table 2.

One patient in group 2 underwent revision surgery due to bleeding in the early postoperative period. The mean amount of tube drainage was 196.2±90.9 mL in group 1 and 364.3±100.8 mL in group 2. Two patients (14.3%) in group 1 and seven patients (50%) in group 2 required blood transfusion. The amount of tube drainage and blood transfusion requirement (24 h) were statistically significantly lower in group 1.

**Table 1. Preoperative demographic and clinical data**

Preoperative data	Group 1 (ministernotomy)			Group 2 (full-sternotomy)			<i>p</i>
	n	%	Mean±SD	n	%	Mean±SD	
Age (year)			58.9±10.6			62.7±11.7	0.39
Gender							0.15
Males	8	57.1		7	50		
Females	6	42.9		7	50		
Body surface area (m <sup>2</sup> )			2.0±0.2			2.0±0.1	0.27
Left ventricular ejection fraction (%)			50.2±9.2			58.3±5.3	0.043
Diabetes mellitus	14	100		14	100		0.89
Chronic obstructive pulmonary disease	8	57.1		6	42.9		
Hypertension	5	35.7		4	28.6		
Mean pulmonary artery pressure (mmHg)			36.5±11.2			33.9±5.3	0.036

SD: Standard deviation.

**Table 2. Intraoperative parameters**

Intraoperative time	Group 1 (ministernotomy)		Group 2 (full-sternotomy)		<i>p</i>
	Mean±SD		Mean±SD		
Mean numbers of distal anastomoses	4.1±0.8		4.3±0.5		0.16
Mean numbers of proximal anastomoses	2.3±0.7		2.5±0.9		0.53
Cross-clamp time (min)	53.2±10.2		51.8±12.5		0.29
Cardiopulmonary bypass time (min)	89±25.6		91.4±18.9		0.38
Total procedure time (hours)	4.8±0.4		4.7±0.4		0.35

SD: Standard deviation.

Three patients (21.4%) in group 1 and five patients (35.7%) in group 2 required postoperative inotropic support. One patient in group 2 was implanted an intra-aortic balloon pump due to low cardiac output. Postoperative hemoglobin, hematocrit, and SaO<sub>2</sub> levels were statistically significantly higher in group 1 than group 2 (Table 3). The mean postoperative analgesic infusion (fentanyl) duration was 11.3±3.9 h in group 1 and 20.1±5.8 h in group 2, indicating significantly lower duration in group 1 (*p*=0.001). In addition, pain scores on Days 1 and 2 were in favor of the ministernotomy group. In group 2, one patient (7.1%) had sternal wound infection and received medical treatment. No revision surgery was needed in both groups due to sternal infection, while one patient in group 2 underwent revision surgery due to sternal instability. Two patients (14.3%) in group 1 and four patients

(28.6%) in group 2 developed postoperative atrial fibrillation (AF), indicating a significantly lower rate in group 1. No acute myocardial infarction or acute renal insufficiency was observed, while one patient in group 2 developed stroke due to cerebral embolism. The patient was treated with intra-arterial fibrinolysis into the cerebral artery without any sequelae. The mean ventilation time was 6.6±2.8 h in group 1 and 7.7±4.3 h in group 2, indicating significantly shorter time in group 1 (*p*=0.045). In addition, the mean length of intensive care unit and hospital stays was 2.6±0.8 and 10.9±4 days in group 1, respectively and 3±2.1 and 12.8±9.7 days in group 2, respectively. The mean length of hospital stay and intensive care unit were significantly lower in group 1 (*p*=0.032, *p*=0.018, respectively). No in-hospital mortality was observed. The early postoperative outcomes of the patients are shown in Tables 3 and 4.

**Table 3. Postoperative early outcome**

Postoperative complications	Group 1 (ministernotomy)			Group 2 (full-sternotomy)			<i>p</i>
	n	%	Mean±SD	n	%	Mean±SD	
Re-exploration for bleeding	0	0		1	7.14		
Amount of chest tube drainage (mL)			196.2±90.9			364.3±100.8	0.003
Need for blood transfusion	2	14.3		7	50		0.016
Intra-aortic balloon pump	0	0		1	7.1		
Inotropic requirement	3	21.4		5	35.7		
Postoperative hematocrit levels			29.7±3.2			24.9±2.9	0.034
Postoperative hemoglobin levels			9.4±1.4			8.4±1.05	0.018
Postoperative SaO <sub>2</sub> levels			94.3±2			88.6±16.3	0.022
Analgesic infusion requirement (hour)			11.3±3.9			20.4±5.8	0.001
Wound infection	0	0		1	7.14		
Sternal instability	0	0		1	7.14		
Revision for sternal instability	0	0		1	7.14		
Revision for sternal infection	0	0		0	0		
Acute myocardial infarction	0	0		0	0		
Postoperative atrial fibrillation	2	14.3		4	28.6		
Stroke	1	7.14		0	0		
Acute renal failure	0	0		0	0		

SD: Standard deviation; SaO<sub>2</sub>: Oxygen saturation.

**Table 4. Summary of postoperative early outcome**

	Group 1 (ministernotomy)	Group 2 (full-sternotomy)	<i>p</i>
	Mean±SD	Mean±SD	
Ventilation time (hour)	6.6±2.8	7.7±4.3	0.045
Stay in intensive care unit (days)	2.6±0.8	3±2.1	0.032
Hospital stay (days)	10.9±4	12.8±9.7	0.018
Hospital mortality	0	0	

SD: Standard deviation.

## DISCUSSION

The last decade showed a growing tendency for less invasive surgical techniques, while maintaining surgical efficiency either through alternative or smaller incisions in an attempt to reduce surgical trauma, improve cosmesis, and minimize the risk of wound infection. This would be reflection the length of functional recovery duration of hospital stay and amount of expected cost. However, these techniques are minimally invasive for the patients and maximally uncomfortable for the surgeons.<sup>[6]</sup> As modern cardiac surgery has improved the prognosis of most types of operations, less invasive approaches and cosmetic results have become important issues. Nevertheless, the definition of the term of minimally invasive still remains unclear and often is focused on the size and location of incisions.<sup>[7]</sup>

There are several advantages of the lower ministernotomy approach. The skin incision, approximately 8-10 cm, is much smaller than the traditional midline sternotomy incision. Nevertheless, sternal elevation and retraction provides adequate and familiar exposure to the heart and great vessels. The entire heart is accessible through a small skin incision. The operative field is viewed directly without requirement for video-assisted visualization or specialized instrumentation.<sup>[8]</sup> The incision may be easily and rapidly extended to a full sternotomy in case of technical problems or if exposure is not adequate, in contrast to paramedian, transverse sternal, or intercostal incisions, which are more difficult to extend.<sup>[9]</sup> Complete coronary revascularization to all branches of the coronary arteries including those on the posterior wall of the left ventricle in the circumflex distribution can be performed through a ministernotomy incision on CPB using traditional graft conduits, including the internal mammary artery, radial artery, and saphenous vein. Grafts may be anastomosed proximally to the ascending aorta. Coronary revascularization through a ministernotomy is the simplest method in patients with normal-sized hearts and good distal coronary artery

targets for anastomosis. It is difficult, when the heart is enlarged due to poor function or chronic arterial hypertension, in obese or deep-chested patients, and in patients with diffuse coronary disease.<sup>[10]</sup> In our study, all patients were diabetic with similar age and BSA values. In addition, obesity, poor preoperative respiratory functions, low LVEF, and high PAP were the inclusion criteria for partial sternotomy. Harvesting of the proximal part of the LIMA is technically more difficult; however, it is still possible to harvest the proximal one-third of the LIMA by shifting the manubrium upwards. The first costal branch can be occluded with a hemoclip in most cases.<sup>[11]</sup> Although the LIMA was prepared in a classical way in both groups, higher total procedure time in ministernotomy group can be attributed to the fact that the time of the LIMA preparation took longer in lower ministernotomy group.

In the present study, the amount of chest tube drainage and blood transfusion was lower during 24 h postoperatively in group 1, compared to group 2 and, accordingly, group 1 had significantly higher hematocrit values. One patient in group 2 underwent revision surgery due to bleeding in the early period, whereas no patient required revision in group 1. We believe that performing smaller incisions on both sternum and skin in patients undergoing minimal invasive procedure can reduce the amount of bleeding, and also reduce the blood transfusion need and the amount of chest tube drainage. These results correspond well to the concepts of minimally invasive techniques and the results of Sun et al.<sup>[5]</sup>

Following surgery, once the patients were transformed to the intensive care unit, the level of their pain is questioned using a simple descriptive pain scale. According to the World Federation of Societies of Anesthesiologists (WFSA) Analgesic Ladder, pain can be expected to be severe and may need controlling with strong parenteral opioids in combination with local anesthetic blocks and peripherally acting drugs immediately after an operation. Normally, postoperative pain should decrease with time and the need for

drugs to be given by injection should cease. There is, then, a step down to oral opioids and finally to non-steroidal anti-inflammatory drugs and acetaminophen on its own.<sup>[12]</sup> Lower median ministernotomy approach reduces the pain from over-stretching of the ribs and thoracic ligaments, and the wound is less painful than the conventional full sternotomy. In our study, the mean postoperative analgesic infusion (fentanyl) duration and pain scores on Days 1 and 2 were in favor of the ministernotomy group.

The postoperative chest wall function and, thus, total lung compliance are greatly preserved, particularly in elderly patients, while providing adequate and familiar exposure of the heart and great vessels.<sup>[5]</sup> This bone-limited median sternotomy appears to be associated with accelerated healing and is more stable and less painful. There is also less potential for wound infection and blood loss. Recovery is accelerated, allowing a shorter intensive care unit stay and earlier hospital discharge, with an overall reduction in cost. Re-operation should be less difficult. Finally, but not least important, is the cosmetically appealing skin incision.<sup>[5,9]</sup> In the present study, no wound infection was observed in patients undergoing ministernotomy, and postoperative SaO<sub>2</sub> levels were higher in these patients than group 2. Postoperative ventilation time and length of hospital and intensive care stays were also found significantly shorter in the ministernotomy group. In addition, lower postoperative AF rates in group 1 may be explained by improved respiratory functions and less pain.

This can be attributed to preserved integrity of the sternoclavicular girdle and sternal stability as well as reduced pain which, in turn, becomes reflected on respiratory mechanics and weaning from mechanical ventilation. These findings are similar to those concluded by Modi *et al.*,<sup>[13]</sup> as well as the results of Cheng *et al.*<sup>[14]</sup> In the study by Guizilini *et al.*<sup>[15]</sup> evaluated pulmonary functions in 18 patients after ministernotomy and conventional median sternotomy, and reported that CABG with ministernotomy was associated with improvement and recovery in pulmonary functions compared to conventional sternotomy. Also, we did not experience wound infection, dehiscence or sternal instability, and this may be attributed to the intact upper sternum.

Only one patient in group 2 (7.1%) developed postoperative stroke, but there was no statistically significant difference between both groups regarding the incidence of postoperative stroke. This may reflect the fact that de-airing was not compromised by the minimally invasive approach.<sup>[16]</sup> Moreover, there

was no statistically significant difference between the ministernotomy and the conventional groups in mortality rate. This result is similar to the study made by Modi *et al.*<sup>[13]</sup>

The retrospective nature is a limitation of this study. However, there have been very few large prospective, randomized studies on this subject. Another limitation is the lack of long-term functional status follow-up. Therefore, further studies for larger number of patients are required to evaluate the long-term results and need for surgical re-interventions.

In conclusion, lower partial ministernotomy by preserving manubrium sterni has several advantages in coronary artery bypass grafting, such as smaller skin incisions, no need to use any special tools, less postoperative bleeding and blood transfusion need, improved respiratory functions, less ventilation time, less intensive care need, and improved wound healing. Our early-term results for minimally invasive bypass operations suggest the appropriateness of that approach for coronary artery bypass grafting. Minimally invasive approach does not compromise surgical exposure and enables the performance of coronary bypass procedures without an additional risk.

#### **Declaration of conflicting interests**

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

#### **Funding**

The authors received no financial support for the research and/or authorship of this article.

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