Türk Göğüs Kalp Damar Cerrahisi Dergisi 2012;20(4):749-754
doi: 10.5606/tgkdc.dergisi.2012.149

Original Article / Özgün Makale

Advantages of an inverted J-shaped partial sternotomy in off-pump revascularization of the left anterior descending coronary artery

Atan kalpte sol ön inen koroner arterin revaskülarizasyonunda ters J kısmi sternotominin avantajları

Tufan Şener,[1] Ali Şefik Köprülü,[2] Osman Eren Karpuzoğlu,[3] Levent Acar,[4] Hakan Gerçekoğlu[1]

[1]Department of Cardiovascular Surgery, Medical Faculty of Yeni Yüzyıl University, İstanbul, Turkey;
[2]Department of Anesthesiology and Reanimation, Medical Faculty of Yeni Yüzyıl University, İstanbul, Turkey;
[3]Department of Cardiovascular Surgery, Çamlıca German Hospital, İstanbul, Turkey;
[4]Department of Anesthesiology and Reanimation, Çamlıca German Hospital, İstanbul, Turkey

Background: In this study, we compared the clinical outcomes of two different surgical approach, full length median sternotomy (FLMS) versus inverted J shaped partial sternotomy (IJPS), in the off-pump revascularization of the left anterior descending (LAD) coronary artery.

Methods: Between January 2008 and January 2011, the data from 119 patients (79 males, 40 females; mean age 61.6±10.7 years) who were operated for off-pump surgical revascularization of the LAD 1-vessel LAD coronary artery were retrospectively analyzed. The patients were divided into two groups as retrospective and non-randomized, including IJPS and FLMS. There were 46 patients (23 males, 23 females) in the IJPS group and 73 patients (56 males, 17 females) in the FLMS group. Preoperative, perioperative and early postoperative data of both groups were compared retrospectively.

Results: Demographic characteristics were similar for both groups. There was no mortality, early graft insufficiency or myocardial infarction in either group. There was no need for conversion to FLMS in the IJPS group. The duration of mechanical ventilation was shorter in the IJPS group (209.67±109.7 min versus 429.45±267.3 min, p<0.001). The length of intensive care unit (ICU) stay was also shorter in the IJPS group (20.33±1.78 hours versus 22.85±14.46 hours, p>0.05). There was no difference in operation time between the groups. The postoperative amount of bleeding (453±87 ml in the FLMS group versus 418±72 ml in the IJPS, p<0.05) and blood and blood product usage (2.23±1.23 unit versus 1.63±1.21 unit, respectively in the FLMS and the IJPS group, p<0.05) were higher in the FLMS group. The length of hospital stay was shorter in the IJPS group (5.69±0.5 days versus 7.13±2.7 days, p>0.05), however there was no statistically significant difference between the groups. There was only one sternum detachment in the FLMS group (1.26%). No sternal dehiscence was observed in the IJPS group. Surgical site infection was seen in one patient in the IJPS group (3.3%) and in four patients in the FLMS group (%5).

Conclusion: Inverted J partial sternotomy is a technically safe and an effective approach with excellent cosmetic outcomes in the revascularization of the LAD coronary artery. Inverted J partial sternotomy is an optimal alternative minimal invasive surgical technique in the revascularization of the LAD coronary artery.

Key words: Hemisternotomy; minimal invasive heart surgery; off-pump coronary artery surgery; partial sternotomy.

Amaç: Bu çalışmada sol ön inen (LAD) koroner arterin cerrahi revaskülarizasyonunu gerektiren olgularda atan kalpte tam uzunlukta medyan sternotomi (FLMS) insizyonu ile ters J kısmi sternotomi (IJPS) insizyonunun klinik sonuçları karşılaştırıldı.

Çalışma planı: Ocak 2008 - Ocak 2011 tarihleri arasında LAD koroner arterin atan kalpte cerrahi revaskülarizasyonu yapılan 119 hastanın (79 erkek, 40 kadın; ort. yaş 61.6±10.7 yıl) verileri retrospektif olarak incelendi. Hastalar retrospektif ve nonrandomize olarak IJPS veya FLMS gruplarına ayrıldı. Ters J kısmi sternotomi grubunda 46 hasta (23 erkek, 23 kadın) ve FLMS grubunda 73 hasta (56 erkek, 17 kadın) vardı. Her iki grubun ameliyat öncesi, ameliyat sırası ve erken dönem ameliyat sonrası verileri retrospektif olarak birbirleriyle karşılaştırıldı.

Bulgular: Her iki grubun demografik özellikleri benzer idi. Her iki grupta da mortalite, erken greft yetmezliği ve miyokard infarktüsü gözlenmedi. Ters J kısmi sternotomi grubunda FLMS'ye dönme gerekliliği olmadı. Ters J kısmi sternotomi grubunda mekanik ventilasyon süresi daha kısa idi (429.45±267.3 dakikaya kıyasla 209.67±109.7 dakika, p<0.05). Yoğun bakımda kalış süresi de, IJPS grubunda daha kısa idi (22.85±14.46 saate kıyasla 20.33±1.78 saat, p>0.05). Ameliyat süreleri açısından iki grup arasında farklılık saptanmadı. Ameliyat sonrası kanama miktarları (FLMS ve IJPS grubunda sırasıyla 418±72 mL'ye kıyasla 453±87 mL, p<0.05) ve kan ve kan ürünleri kullanım miktarları (FLMS ve IJPS grubunda sırasıyla 1.63±1.21 üniteye kıyasla 2.23±1.23 ünite, p<0.05) FLMS grubunda daha fazla idi. Hastane kalış süreleri IJPS grubunda daha kısa olmakla birlikte (7.13±2.7 güne kıyasla 5.69±0.5 gün p>0.05), iki grup arasında istatistiksel açıdan anlamlı farklılık yoktu. Tam uzunlukta medyan sternotomi grubunda sadece bir adet sternum dekolmanı gözlendi (%1.26). Ters J kısmi sternotomi grubunda sternal ayrışma gözlenmedi. Cerrahi insizyon enfeksiyonu IJPS grubunda bir hastada (%3.3), FLMS grubunda dört hastada (%5) gözlendi.

Sonuç: Ters J kısmi sternotomi insizyonu ile LAD koroner arter revaskülarizasyonu güvenli bir şekilde ve iyi estetik sonuçlar elde edilerek yapılabilir. Ters J kısmi sternotomi LAD koroner arterin revaskülarizasyonunda daha az cerrahi travma ile iyi bir alternatif yöntem olarak görünmektedir.

Anahtar sözcükler: Hemisternotomi; minimal invaziv kalp cerrahisi; atan kalpte koroner arter cerrahisi; kısmi sternotomi.

Available online at
www.tgkdc.dergisi.org
doi: 10.5606/tgkdc.dergisi.2012.149
QR (Quick Response) Code

Received: May 29, 2011 *Accepted*: January 24, 2012

Correspondence: Tufan Şener, M.D. Yeni Yüzyıl Üniversitesi Tıp Fakültesi, Kalp ve Damar Cerrahisi Anabilim Dalı, 34010 Zeytinburnu, İstanbul, Turkey.
Tel: +90 216 - 422 78 39 e-mail: tfnsener@yahoo.com

Revascularization of the left anterior descending artery (LADA) can be performed either with a direct coronary artery bypass or with coronary stenting. This type of stenting for the proximal LAD (proximal LAD stenosis with short segment extension and preferably type A lesion) is a minimally invasive procedure with a small percentage of complications and good short-term results.[1] On the other hand, it has been shown that coronary stenting in high-grade coronary lesions (type B and C) is associated with increased complication rates.[2] In this group of patients, direct coronary artery bypass surgery is the preferred procedure for the revascularization of the LAD.[3,4] Since surgical trauma is inevitable, the less invasive approaches gain importance, and one of these used for coronary revascularization is off-pump coronary artery bypass grafting (OPCABG). Developments in this procedure in the last decade have allowed surgeons to perform CABG in a less invasive manner and have prevented the adverse effects of extracorporeal circulation.[5,6] Making smaller incisions is another positive aspect of this procedure since it lessens the complication rates previously associated with large incisions. Minimally invasive direct coronary artery bypass grafting (MIDCABG) is a less invasive surgical method in which a limited length incision, mostly a left anterior small thoracotomy (LAST), is used. The left internal mammary artery (LIMA) is then harvested through the LAST. The LAD-LIMA in situ distal anastomosis is also performed through this limited left anterior thoracotomy. A few studies have shown that MIDCABG with a small anterior thoracotomy incision can be safely performed on selected patients with low postoperative mortality and morbidity.[7,8] In our study, we compared the clinical outcomes of the inverted J-shaped partial sternotomy, another surgical incision of limited length, with those of the full-length median sternotomy incision in the off-pump revascularization of the LAD.

PATIENTS AND METHODS

From January 2008 to January 2011, 119 patients (79 males, 40 females; mean age 61.6±10.7 years) were operated on for single LAD revascularization. The institutional ethics and research committee approved this study, and written informed consent was obtained from all participants. An inverted J-shaped partial sternotomy incision was used in 46 patients (IJPS group=23 males and 23 females). A full-length median sternotomy incision was used in 73 patients (FLMS group=56 males and 17 females). Data from these patients was collected prospectively.

All of the patients in the IJPS group were scheduled for single-vessel grafting for LAD proximal lesions not suitable for stenting based on their angiographic study. Morbid obesity [body mass index (BMI) >40], reoperation, chronic renal dysfunction, low ejection fraction (EF <30%), earlier surgery related with the lungs, severe chronic obstructive lung disease (COPD) [forced expiratory volume (FEV_1) and forced expiratory vital capacity (FVC) <50% of predicted value) with low values on the respiratory function test were the exclusion criteria used for scheduling patients for this study. Participants with diabetes mellitus (DM) were not excluded for a limited sternotomy. Likewise, patients with mild degrees of COPD were also not excluded.

In the FLMS group, some patients were scheduled for a full-length sternotomy preoperatively because of their physical conditions (higher BMI, etc.) or cardiac problems (recent myocardial infarction, etc.). Some patients underwent a full-length median sternotomy because they had planned to undergo more than one coronary artery grafting. However, these patients only had single-vessel grafting based on the surgical exploration done during the operation. The demographic features of the patients are given in Table 1.

Surgical techniques

The IJPS group: All patients were placed in a supine position and prepared as if they were undergoing a conventional cardiac surgical procedure. They were intubated in the standard way. A vertical skin incision was made from the third to the fourth intercostal space to the xiphoid process (10 to 12 cm). An inverted J line was drawn on the lower two-thirds of the sternum by electrocautery, and the incision was made starting from the xiphoid up to the third rib or the manubrium. The partial sternotomy was completed before the manubrium with a J curve through the left side of the sternum. The lower two-thirds of the left hemisternum was separated from the main sternum body which protects the LIMA (Figure 1). The LIMA was then harvested with the surrounding tissue by electrocautery under direct vision by using an asymmetrical sternal retractor designed for minimally invasive cardiac surgery (Aesculap AG, Tuttlingen, Germany). The proximal LIMA was harvested through the same window with additional retraction applied by the surgical assistant. The pericardium was opened up to the aortic root, and the distal anastomosis of the LAD and LIMA was performed through the partial sternotomy (Figure 2).

The FLMS group: In this group, all patients underwent surgery while in a supine position, and a full median sternotomy was performed in all cases. The LIMA was harvested with electrocautery via an asymmetrical sternal retractor (Aesculap AG, Tuttlingen, Germany). The pericardium was opened fully and suspended,

Table 1. Demographic characteristics of the patients

	IJPS group (n=30)			FLMS group (n=79)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (years)			60.63±9.7			61.67±11.4	0.596
Gender							
Female	23	50		17	23		0.004
Male	23	50		56	77		0.004
Diabetes mellitus	7	23.3		17	23		0.352
Peripheral arterial disease	5	16.6		18	25		0.094
Left ventricular ejection fraction (%)			58.3±10.3			52.93±11.9	0.008
Number of MIs in the last three months	7	23.3		22			0.080
Chronic obstructive pulmonary disease	1	3.3		10	14		0.048
Canadian Cardiovascular Society Class III-IV	1	3.3		5	7		0.403

IJPS: Inverted J-shaped partial sternotomy; FLMS: Full length median sternotomy; SD: Standard deviation; MI: Myocardial infarction.

and the distal anastomosis of the LAD and LIMA was performed in the usual way.

The off-pump coronary artery revascularization technique

Heparin was given (1 to 1.5 mg/kg) to each patient to keep the activated clotting time around 300 seconds. The LAD was proximally occluded with a 4-0 polypropylene suture. Distal occlusion was not used. Intracoronary shunts were not routinely used, but vacuum stabilizers (Estech, OPVAC Synergy II Stabilizer, San Ramon, California, USA) were employed for stabilization. Anastomosis was done with two running 8-0 polypropylene sutures. A routine sternotomy closure was performed after two thorax tubes (36 French) were inserted, one into the thorax and the other into the mediastinum. In the IJPS group, three or four steel wires were enough to stabilize the hemisternotomy. An additional steel wire was placed obliquely from the upper part of the divided left sternal body to the right sternal body for further stabilization.

Statistical analyses

InStat version 3.1a (GraphPad Software, La Jolla, California, USA) was used for statistical validation of the data, which was given as mean ± standard deviation (SD). Statistical differences between the two groups were evaluated with Student's t test and Fisher's exact test, and $p<0.05$ was accepted as being statistically significant.

RESULTS

The results of the postoperative data are given in Table 2. The age and gender of the patients in the two groups were similar. The EF values of the patients in the FLMS group

Figure 1. This shows an inverted J-shaped partial sternotomy in which a limited incision is performed extending from the xiphoid process to the manubrium, leaving the upper one-third of the sternum intact.

Figure 2. This shows an inverted J-shaped partial sternotomy in which the left anterior descending-left internal mammary artery distal anastomosis is performed through the limited window created by the partial sternotomy.

Table 2. Postoperative data

	IJPS group (n=46)			FLMS group (n=73)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Operation time (min)			210.97±31			244.52±69.7	NS
Mechanical ventilation time (min)			209.67±109.7			429.4±267.3	<0.05
Bleeding (ml)			418±72			453±87	<0.05
Blood (erytrocyte suspension) usage			1.63±1.21			2.23±1.23	<0.05
ICU stay (hours)			20.33±1.78			22.85±14.46	NS
Total hospital stay (days)			5.69±0.5			7.13±2.7	NS
Postoperative atrial fibrilation	2	6.6		5	6.3		NS
Sternum detachment	0	0		1	1.26		NS
Surgical site infection	1	3.3		4	5		NS
Reoperation	0	0		0	0		NS
Mortality	0	0		0	0		NS

IJPS: Inverted J-partial sternotomy; FLMS: Full length median sternotomy; SD: Standard deviation; ICU: Intensive care unit; SSI: Surgical site infection; NS: Non spesific.

were lower than those of the IJPS group, but there was no statistically significant difference. The patients with comorbidities, like peripheral arterial disease, COPD, and recent myocardial infarction, were higher in number in the FLMS group, and those with a higher angina class (Canadian Cardiovascular Society Class III-IV) were also predominantly in the FLMS group.

There was no marked statistical difference in the operation times between the two groups. Bleeding amounts (453±87 ml in the FLMS group versus 418±72 ml in the IJPS group; p<0.05) and blood and blood product usage (2.23±1.23 versus 1.63±1.21 units in the FLMS and the IJPS group, respectively; p<0.05) were higher in the FLMS group.

Intensive care unit (ICU) stays were slightly shorter in the IJPS group, but this difference was not statistically significant. On the other hand, there was a statistically significant difference between the two groups with regard to mechanical ventilation time (209.67±109.7 in the IJPS group versus 429.4±267.3 in the FLMS group; p<0.05).

Postoperative hospital stays were longer in the FLMS group, but they were not statistically significant (5.69±0.5 in the IJPS group versus 7.13±2.7 in the FLMS group; p<0.05).

There was no statistically significant difference in the number of patients with postoperative atrial fibrillation between the two groups. There was no sternal dehiscence in the IJPS group, and only one sternal dehiscence (1.26%) was observed in the FLMS group. Surgical site infection was observed in one patient (3.3%) in the IJPS group and in four patients (5%) in the FLMS group. There was no reoperation for bleeding or mortality in either group.

DISCUSSION

Critical stenosis of the proximal part of the LAD is an absolute indication for revascularization. An excellent survival rate is seen with LAD grafting with the LIMA and a high percentage of graft patency (92% in a 17-year follow-up) is also possible compared with that performed with other conduits.[4]

Faster healing of patients, is also seen with LAD-LIMA grafting done in a minimally invasive or less traumatic manner.[10,11]

The full-length median sternotomy is the standard type of incision for cardiac surgery. This type of incision has the advantage of providing excellent exposure to all aspects of the heart and also being fast and easy. On the other hand, it leaves a large central scar extending from the level of the suprasternal notch to the xiphoid process. Stability of the thorax may be affected in the early stages after surgery. Sternal instability leads to patient discomfort while performing daily activities in the period immediately after surgery, which results in superficial respiration, fitful sleep, and restlessness.

In an inverted J-shaped partial sternotomy, the sternum is not completely divided.[12] The upper part of the sternum, including the manubrium, is left intact. The right part of the sternum and the upper part of the left half of the sternum remain as a single body. Since the sternum is kept as a whole body, the probability of sternal detachment is very low compared with a full-length median sternotomy. Physical recovery is faster in an inverted J-shaped partial sternotomy. However, the main problem with this procedure is subluxation of the costachondral joint, which can persist over the long-term, and pseudojoint formation.[13]

A learning curve exists for LIMA harvesting through a limited partial sternotomy because it is a technically demanding procedure. After an inverted J-shaped partial sternotomy is completed, the distal two-thirds of the LIMA can be easily harvested with direct vision, as usual. Harvesting of the proximal part of the LIMA is technically more difficult, but 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 hemoclips in most cases.

The LIMA should be protected while splitting sternum in J-shape. As mentioned above, a partial sternotomy is completed with an inverted J-shaped curvature ending in the second intercostal space below the manubrium. Application of the J curvature is done carefully with an oscillating saw, and in most cases, a narrow sternal bone border is left intact, which can be split easily with the application of a mammary retractor.

In contrast to a minithoracotomy, the inverted J-shaped partial sternotomy can be easily and rapidly extended to a full sternotomy when technical problems are encountered or when the exposure is not adequate. In the minithoracotomy incision, an additional incision is needed. In our study, there was no conversion to the full-length sternotomy in the IJPS group.

Early separation from ventilation, less postoperative bleeding, less blood and blood product usage, early mobilization, faster healing of the surgical incision, and lesser surgical wound complications are the advantages of an internal J-shaped partial sternotomy, and these may result in shortened ICU and hospital stays for the patients.

There was no collected data concerning postoperative pain in our series. Some of the patients in the IJPS group could have experienced more pain; however, they did well overall in early respiratory exercises. Postoperative pain and respiratory function tests are other parameters that can be evaluated in future studies involving patients who undergo this type of procedure.

In our study, the patients were non-randomly separated into the FLMS group or the IJPS group. Some patients who planned to have multi-vessel CABG were designated directly for a full median sternotomy. The patients with comorbid conditions were more likely to undergo a full median sternotomy, so some of the adverse outcomes were related to that instead of the length of the incision.

The non-randomized nature of the study is a limiting factor for drawing clear conclusions, but an internal J-shaped partial sternotomy can be safely performed in the single-vessel revascularization of the LAD with excellent cosmetic results.

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.

REFERENCES

1. Cisowski M, Drzewiecki J, Drzewiecka-Gerber A, Jaklik A, Kruczak W, Szczeklik M, et al. Primary stenting versus MIDCAB: preliminary report-comparision of two methods of revascularization in single left anterior descending coronary artery stenosis. Ann Thorac Surg 2002;74:S1334-9.
2. Wilensky RL, Selzer F, Johnston J, Laskey WK, Klugherz BD, Block P, et al. Relation of percutaneous coronary intervention of complex lesions to clinical outcomes (from the NHLBI Dynamic Registry). Am J Cardiol 2002;90:216-21.
3. Cameron A, Davis KB, Green G, Schaff HV. Coronary bypass surgery with internal-thoracic-artery grafts--effects on survival over a 15-year period. N Engl J Med 1996;334:216-9.
4. Loop FD, Lytle BW, Cosgrove DM, Stewart RW, Goormastic M, Williams GW, et al. Influence of the internal-mammary-artery graft on 10-year survival and other cardiac events. N Engl J Med 1986;314:1-6.
5. Hammon JW. Extracorporeal circulation: The response of humoral and cellular elements of blood to extracorporeal circulation. In: Cohn LH, editor. Cardiac surgery in the adult. New York: McGraw-Hill; 2008. p. 370-89.
6. Hammon JW. Extracorporeal circulation: Organ damage. In: Cohn LH, editor. Cardiac surgery in the adult. New York: McGraw-Hill; 2008. p. 389-414.
7. Aydin NB, Sener T, Akbulut T, Kehlibar IK, Turkoglu T , Karuzoglu OE, et al. Minimally invasive direct coronary artery bypass grafting versus stenting for patients with type B or C lesions in the proximal left anterior descending artery: Preliminary report-comparison of clinical outcomes and costs. Presented at the 16th Annual Meeting of the Mediterranean Association of Cardiology and Cardiac Surgery; 2004 September 26-29, Bodrum, Turkey. The Heart Surgery Forum 2004;7(Suppl 2):B134.
8. Herz I, Mohr R, Moshkovitz Y, Ben-Gal Y, Adam SZ, Braunstein R, et al. Revascularization of the left anterior descending artery with drug-eluting stents: comparison with arterial off-pump surgery. Heart Surg Forum 2004;7:E490-2.
9. Sawhney N, Moses JW, Leon MB, Kuntz RE, Popma JJ, Bachinsky W, et al. Treatment of left anterior descending coronary artery disease with sirolimus-eluting stents. Circulation 2004;110:374-9.
10. Calafiore AM, Giammarco GD, Teodori G, Bosco G, D'Annunzio E, Barsotti A, et al. Left anterior descending coronary artery grafting via left anterior small thoracotomy

without cardiopulmonary bypass. Ann Thorac Surg 1996;61:1658-63.

11. Niinami H, Takeuchi Y, Ichikawa S, Suda Y. Partial median sternotomy as a minimal access for off-pump coronary artery bypass grafting: feasibility of the lower-end sternal splitting approach. Ann Thorac Surg 2001;72:S1041-5.
12. Li W, Li Y, Chong WC, Sim EK. Application of inverted J-shaped partial sternotomy in intracardiac operations. Asian J Surg 2005;28:218-22.
13. Niinami H, Takeuchi Y, Suda Y, Ross DE. Lower sternal splitting approach for off-pump coronary artery bypass grafting. Ann Thorac Surg 2000;70:1431-3.