Original Article

Clipless internal mammary artery harvesting for minimally invasive coronary artery bypass grafting using the shear-tip harmonic scalpel

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Background: The internal mammary artery (IMA) is the most commonly used graft in coronary artery bypass grafting (CABG) because of its superior long-term patency rate. However, its small diameter poses challenges in handling, and any vascular damage that may occur during harvesting can significantly affect surgical outcomes. The primary focus during IMA harvesting is to ensure safe and effective hemostasis without direct vascular injury, while ensuring secure and reliable ligation of the vascular branches. Various methods using multiple surgical instruments have been used for this purpose. Unlike traditional instruments, the shear-tip Harmonic scalpel offers more precise vessel branching control, while minimizing damage to surrounding tissues. In this study, we assessed the utility of the shear-tip Harmonic scalpel in patients undergoing minimally invasive coronary artery bypass grafting (MICABG).

Methods: From April 2019 to May 2023, a total of 40 patients underwent MICABG. The IMA was harvested using the shear-tip Harmonic scalpel with a clipless skeletonized technique. In this cohort, 5 patients underwent complete endoscopic harvesting, while 34 patients underwent direct visualization harvesting through minimal thoracotomy. Graft patency was assessed by measuring a Doppler flowmeter in the bypass conduit.

Results: Successful graft patency was achieved in all patients. The mean duration of IMA harvesting was 87 min. In total, 38 of the 40 patients underwent MICABG without the need for cardiopulmonary bypass, ensuring a stable procedure. There were no graft-related events or complications observed in any of the patients, and all were discharged without any issues. During a median follow-up period of 15.2 months, only one patient experienced graft occlusion necessitating intervention.

Conclusions: The utilization of shear-tip Harmonic scalpel for IMA harvesting in MICABG is feasible and yields stable early results.

Keywords: Harmonic scalpel; clipless internal mammary harvesting; minimally invasive cardiac surgery

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Introduction

Background

Coronary artery bypass grafting (CABG), which is performed to ensure revascularization of the left anterior descending artery (LAD) via the internal mammary artery (IMA), achieves superior long-term patency and major cardiovascular event-free survival compared to percutaneous coronary artery intervention (1). Graft patency of the LAD is the most important factor influencing both overall survival and event-free survival following coronary revascularization. However, this unique advantage has been associated with the invasiveness of sternotomy with or without cardiopulmonary bypass (CPB); this concern has resulted in the popularization of percutaneous coronary intervention (PCI), despite worse long-term outcomes and higher repeat procedure rates (2). To overcome this problem of invasiveness, a less invasive CABG technique has been implemented for anastomosis of the left internal mammary artery (LIMA) to the LAD on the beating heart via mini-thoracotomy (3,4). Since the introduction of this technique, the application of minimally invasive CABG (MICABG) has gradually increased (5).

Safe harvesting of the IMA during CABG is important to ensure successful surgery, and this procedure involves the use of various methods and instruments. The instrument used for harvesting the IMA must ensure hemostasis without causing direct damage to the intima and should facilitate dissection from the surrounding tissue. In MICABG, in which the surgical approach and view are limited, harvesting is difficult, meaning that adequate surgical instruments are required.

The Harmonic scalpel has been used as an ultrasonic cutter in a variety of equipment. The commercially available hook-type Harmonic scalpel is widely used surgically, and this product has been studied since 1997 (6). However, the usefulness of a shear-tip Harmonic scalpel has not been investigated. Unlike the existing hook or blade type, the shear-tip is expected to be easier to use in a limited field of view, as it could be more reliable for branch vessel hemostasis (7).

Highlight box

Key findings

- Utilization of the shear-tip Harmonic scalpel for internal mammary artery (IMA) harvesting in minimally invasive coronary artery bypass grafting (MICABG) was not only feasible but also yielded stable early results.
- MICABG with clipless IMA harvesting using a shear-tip Harmonic scalpel demonstrated successful graft patency and low complication rates.

What is known and what is new?

- Safe IMA harvesting during CABG is important for surgical success, and it necessitates the use of various methods and instruments. In minimally invasive CABG, the surgical approach and view are limited and IMA harvesting is difficult.
- Use of the shear-tip Harmonic scalpel for IMA harvesting in MICABG could be a more efficient and reliable method than are traditional techniques.

What is the implication, and what should change now?

- The findings suggest that using a shear-tip Harmonic scalpel in MICABG is a safe and effective technique for revascularization in single- or multivessel disease.
- The shear-tip Harmonic scalpel in MICABG may lead to improved surgical outcomes, reduced complication rates, and enhanced patient recovery, given its well-established advantages and consistent high patency rates validated over time.

Rationale and knowledge gap

The bleeding or damage to the IMA that occurs during MICABG is difficult to manage compared to that occurring during conventional harvesting of the IMA through sternotomy. This can lead to a transition from minimally invasive access to sternotomy and can likely cause serious problems that may worsen the patient's recovery.

At Chungnam National University Hospital, South Korea, the shear-tip Harmonic scalpel (Harmonic HD 1000i shears, Ethicon Endo-Surgery, Cincinnati, OH, USA) has been used to harvest the IMA for years. This technique ensures complete hemostasis with minimal damage to surrounding tissues (*Figure 1*). The shear-tip scalpel is easy to use during MICABG, even with a limited field of view, and can reduce the number of instrument changes. MICABG was first introduced in our hospital in 2019. From its introduction, a shear-tip Harmonic scalpel was used for IMA harvesting.

Objective

In this study, we introduce the first experience of the use of a shear-tip Harmonic scalpel for IMA harvesting without a clip in MICABG. Furthermore, we report early surgical outcomes and postoperative complications, including major adverse cardiac and cerebrovascular events (MACCEs), associated with this technique. We present this article in

Figure 1 Harmonic HD 1000i shears (Ethicon Endosurgery, Cincinnati, OH, USA).

accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1810/rc).

Methods

This retrospective, observational, nonrandomized study included all patients who underwent MICABG using a shear-tip Harmonic scalpel at our center from April 2019 to May 2023. Forty patients were initially enrolled, of whom 39 who used only the IMA as a graft were enrolled in the study, after excluding one patient in whom the saphenous vein was used. IMA angiography was also performed during coronary angiography in all patients. Chest computed tomography was performed prior to surgery to determine thoracotomy suitability and anatomical deformity. The surgeon determined the preferred surgical approach following preoperative examination, and the patient eventually agreed to the recommended surgical approach, regardless of whether it was minimally invasive or not. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and approved by the Institutional Review Board of Chungnam National University Hospital (IRB No. 2021-07-121-001). The patients or the guardians provided written informed consent for all surgical procedures.

Indications & contraindications for MICABG

The indications for MICABG at our hospital are as follows:

(I) Single-vessel disease of the LAD (and a large diagonal branch).
(II) High-risk patients with contraindications for sternotomy and/or CPB.
(III) Patients with multivessel disease, targets that are too small, non-vital/scarred myocardium, and chronically occluded and collateralized vessels other than the LAD.
(IV) Patient chosen as part of a hybrid strategy followed by PCI in a staged procedure.

The contraindications for MICABG in our hospital are as follows:

(I) Emergency bypass surgery in hemodynamically unstable patients.
(II) Unfavorable chest anatomy (pectus excavatum and severe scoliosis).
(III) A history of surgery or radiation therapy for adhesions of the left hemithorax.
(IV) Intramyocardial, severely calcified, or very small LAD.

Surgical category and detail

We classified MICABG into three categories according to the number of target vessels and the surgical approach. For each patient, we drew a thoracotomy incision line that was easy to anastomose to the location of the IMA and target vessel prior to surgery, as shown in *Figure 2A*.

The surgical procedures were as follows:

- ❖ Minimally invasive direct coronary artery bypass (MIDCAB): only one vessel was harvested and anastomosed via mini-thoracotomy under direct surgical view, either as a less invasive method, or as part of a hybrid revascularization strategy (8,9). In MIDCAB, LIMA-LAD was performed in all cases. In this procedure, the thoracic cavity was opened 5–8 cm in front between the fourth or fifth ribs on the left; if the intercostal space was narrow, the rib cartilage was cut to secure visibility, and rib approximation was performed post-surgically (*Figure 2B*).
- ❖ Endoscopic atraumatic coronary artery bypass (endo-ACAB): this technique required no rib spreading, and IMA was harvested using a thoracoscope or a controlled robotic hand telescope using two or more holes (10). In our endo-ACAB cases, we inserted three 5 mm ports according to the patient's anatomical structure, harvested

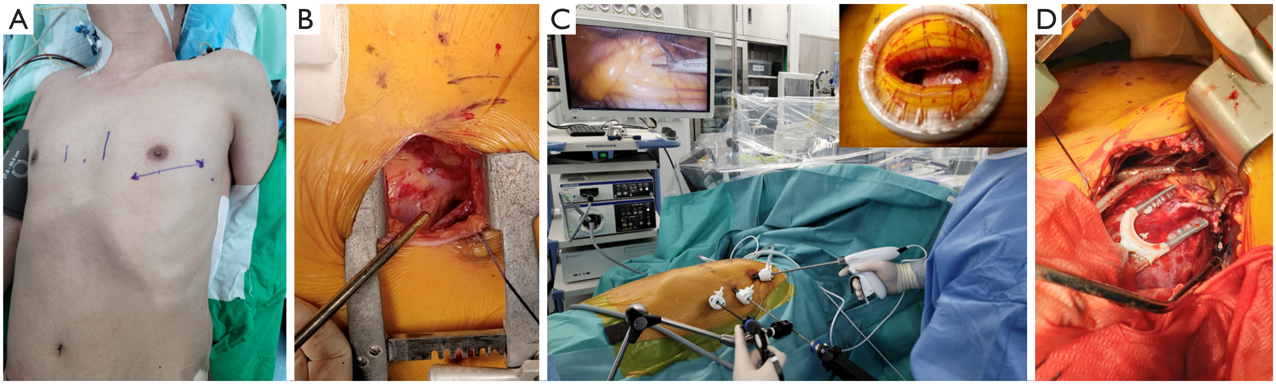
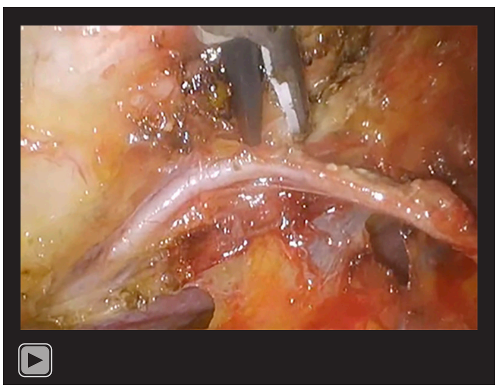


Figure 2 Modes of minimally invasive coronary artery bypass grafting: (A) preoperative preparation, (B) minimally invasive direct coronary artery bypass, (C) endoscopic atraumatic coronary artery bypass, and (D) minimally invasive cardiac surgery-coronary artery bypass grafting.



Video 1 Clipless internal mammary artery harvesting for minimally invasive coronary artery bypass grafting using a shear-tip harmonic scalpel.

the IMA while looking at the thoracoscope, and performed anastomosis without using rib traction after placement of a 4–6 cm thoracotomy window between the left fourth or fifth intercostal spaces (*Figure 2C*).

❖ Minimally invasive cardiac surgery (MICS)-CABG: in this technique, the beating-heart multivessel procedure (harvesting bilateral IMAs) was performed under direct or thoracoscope-assisted vision via anterolateral mini-thoracotomy (11). In our experience, MICS-CABG was performed in the thoracic cavity via an 8–10 cm anterolateral thoracic incision between the left fifth ribs, and bilateral IMAs were directly observed and harvested. The LIMA was anastomosed to the LAD in situ, and the right internal mammary artery (RIMA) was used to revascularize the lateral wall of the left ventricle from the Y-graft from the LIMA (*Figure 2D*).

Accordingly, in all patients, a double-lumen endotracheal tube was inserted under general anesthesia, the left chest was raised approximately 20°–30° above, and the left arm was fixed to the lower side of the operating table. For IMA harvesting, skeletonization was performed using the shear-tip Harmonic scalpel, omitting the use of vascular clips in the branch of the IMA. Metzenbaum scissors or electrocautery were used to dissect the tissue surrounding the IMA, following a standard procedure. The shear-tip Harmonic scalpel was mainly used for branch ligation and division and for dissecting the proximal segment of the IMA. This was also used in the deep regions of the IMA to remove fatty tissue from the endothoracic fascia.

The LIMA is located in the fatty tissue adjacent to the pleura, and we can simultaneously dissect the surrounding tissue and seal the branches using the shear-tip Harmonic scalpel. The vein is cut between the instruments, and the artery is progressively harvested in a skeletonized fashion using this scalpel rather than scissors and vascular clips. The conventional method requires a lot of effort and time as it involves placement of vascular clips in the distal and proximal segments of the mammary branches, followed by dissection with Metzenbaum scissors. Clip manipulation can lead to injury or misplacement, resulting in severe bleeding. This characteristic highlights a major difference in our procedure and the need to avoid vascular injuries. Additionally, the clear surgical view provided by this technique is advantageous. In cases of multivessel revascularization, the RIMA is harvested using the same method. The thymus and pericardium can also be opened using this type of scalpel (*Video 1*).

Table 1 Preoperative data of the enrolled participants (N=39)

Variables	Value
Age, years	70 [30–86]
Male/female	27/12
Comorbidities	
Hypertension	21 (53.8)
Diabetes	19 (48.7)
Dyslipidemia	10 (25.6)
Stroke	3 (7.7)
COPD	3 (7.7)
Chronic kidney disease (on hemodialysis)	5 (12.8)
Dementia	3 (7.7)
Liver cirrhosis	2 (5.1)
Prior cerebrovascular accident	2 (5.1)
Prior percutaneous coronary intervention	15 (38.5)
Hybrid coronary revascularization†	6 (15.4)
CCS angina class	
No angina	5 (12.8)
I	10 (25.6)
II	17 (43.6)
III	5 (12.8)
IV	2 (5.1)
Left ventricular ejection fraction	60 [29–70]
Diagnosis	
Stable angina	12 (30.8)
Unstable angina	12 (30.8)
Myocardial infarction	15 (38.5)
Coronary artery disease	
Left main disease	12
Single vessel	13
Double vessel	19
Triple vessel	7
Types of surgery based on urgency	
Elective, planned	21 (53.8)
Urgent*	15 (38.5)
Emergent#	3 (7.7)

The data are presented as median [range], number, or number (percentage) where appropriate. †, coronary artery bypass grafting as part of hybrid coronary revascularization, patient plan to perform percutaneous coronary intervention after surgery; *, target time of decision to operation room within hours; #, target time of decision to operation room within minutes. COPD, chronic obstructive pulmonary disease; CCS, Canadian Cardiovascular Society.

Notably, the use of clips during the harvesting process was deliberately avoided. IMA harvesting using a shear-tip Harmonic scalpel was introduced and performed by the corresponding author. The details of this instrument have been described previously (8). Off-pump coronary artery bypass was performed using a vacuum stabilizer under a beating heart. Following anastomosis, the blood flow and pulsatility index (PI) from the graft to the target vessel were determined using a transit time flow meter (MiraQ, Medistim, Norway), and patency was checked.

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics (IBM Corp., Armonk, NY, USA). Demographic and clinical characteristics are summarized using frequency and percentage for categorical variables and mean ± standard deviation (SD) for continuous variables.

Results

The preoperative data of the 39 enrolled patients are shown in *Table 1*. The primary reasons for MICABG were single-vessel disease requiring revascularization in 24 patients, frailty in 11 patients, and part of a hybrid procedure in 6 patients. Five patients without angina had severe frailty and poor activity performance.

MIDCAB was the most common surgery (28 patients), followed by endo-ACAB (5 patients), and MICS-CABG (6 patients). None of the patients underwent median sternotomy. Concomitant procedures included five cases of pleural adhesiolysis, one permanent pacemaker insertion in a patient with a known ventricular block, one minimally invasive aortic valve replacement in a severely frail patient by right mini-thoracotomy, one right ventricular repair during surgery, one diagonal artery aneurysmal repair, and one diaphragmatic plication in a patient with existing left diaphragmatic paralysis.

The intraoperative data of the enrolled patients are shown in *Table 2*. Revascularization through the anastomosis of the IMAs to the target coronary artery was successful, with adequate flow and PI below 5 in all patients (45 IMAs). Transit time flow was 5 mL/min in one patient. We visually checked whether LIMA flow was sufficient before anastomosis and performed a revision. However, the size of the LAD was small; therefore, blood flow was low, and the PI was 4.8. Graft patency was confirmed by epicardial

Table 2 Operative data of the enrolled patients (N=39)

Variables	Value
Intraoperative data	
IMA harvesting time, min	
Induction to LIMA harvesting time†	87 [25–164]
RIMA harvesting time	24 [19–50]
Intraoperative IMA transit time flow measurement	
LIMA-LAD flow, mL/min	22 [5–73]
LIMA-LAD pulsatility index	2.1 [1.7–4.8]
RIMA-OM (Y-graft from LIMA-OM) flow, mL/min	22.3 [17–30]
RIMA-OM pulsatility index	2.3 [1.9–3.5]
Total ventilation time, hours	10 [4–20]
On-site extubation	12 (30.8)
Postoperative data	
Transfusion	
No transfusion (perioperatively)	7 (17.9)
RBC*, pack	2.33 [2–5]
Intensive care unit stay, hours	23 [11–96]
Hospital day, days	6 [3–22]
Early postoperative complications	
MACCEs	1#
Surgical wound infection	2
Pleural effusion needs to be drained	4
Pneumonia	1
Acute kidney injury	1
Postoperative bleeding	1#

The data are presented as median [range], number, or number (percentage) where appropriate. †, it takes time to prepare and set the correct position before harvest of the internal mammary artery, we therefore measure the time between immediately after intubation and left internal mammary artery harvest. *, one pack of red blood cell includes 400 cc. #, one patient developed cerebral infarction, which explains the minor dysarthria and non-scalpel-related bleeding. The patient was discharged without any sequelae. IMA, internal mammary artery; LIMA, left internal mammary artery; RIMA, right internal mammary artery; LAD, left anterior descending artery; OM, obtuse marginal artery; RBC, red blood cell; MACCEs, major adverse cardiac and cerebrovascular events.

ultrasonography after the revision. One patient experienced right ventricular perforation while retracting the heart, and CPB was performed through the left femoral artery and vein. However, anastomosis was performed under the beating heart without any cases of cardiac arrest. Except for one patient with right ventricular injury and one concomitant procedure of minimally invasive aortic valve replacement, 37 patients underwent MICABG without CPB.

The postoperative data of the enrolled participants are shown in *Table 2*. The median observation period was 15.2 (1.0–48.5) months. Twelve patients (30.8%) were extubated from the operating room, and the mechanical ventilation time in the intensive care unit was 3 hours. The median periods of intensive care unit stay, and hospital stay were 23 hours and 6 days, respectively. The chest tube was maintained for a median of 2 days. Other complications, such as postoperative chest tube insertion by closed thoracostomy due to pleural fluid, were identified in four patients, followed by two cases of wound infections, one of aspiration pneumonia, and one of acute renal failure. Bronchoscopy was performed in one patient for toileting; however, bleeding occurred due to a rapid increase in blood pressure immediately after the procedure, and bleeding control reoperation was performed. At that time, the bleeding occurred in the damaged part of the blood vessel caused by electrocautery during dissection of the surrounding tissue and was not caused by branch vessel ligation with the Hamonic scalpel. Additionally, postoperative bleeding control was performed in one case due to bleeding in the LIMA wound and not due to the Harmonic scalpel. During the follow-up period, 16 patients (41.0%) underwent postoperative coronary angiography and contrast-enhanced chest computed tomography to confirm that the graft was patent without any specific symptoms. Furthermore, one patient who underwent diagonal aneurysmal repair with MIDCAB (LIMA-LAD) developed chest pain 10 months after surgery, and PCI was performed on the LAD due to occlusion of the LIMA. This patient had 60% stent restenosis that was not severe concomitant with LAD before surgery, and the diagonal aneurysm resolved after surgery, resulting in a competitive flow in the LIMA-LAD graft. All patients were discharged without any postoperative surgical events. There were no surgery-related deaths; however, three patients died during follow-up due to sepsis unrelated to surgery.

Discussion

Key findings

This study investigated the clinical outcomes of 39 patients who underwent MICABG with clipless IMA harvesting using a shear-tip Harmonic for the first time in our

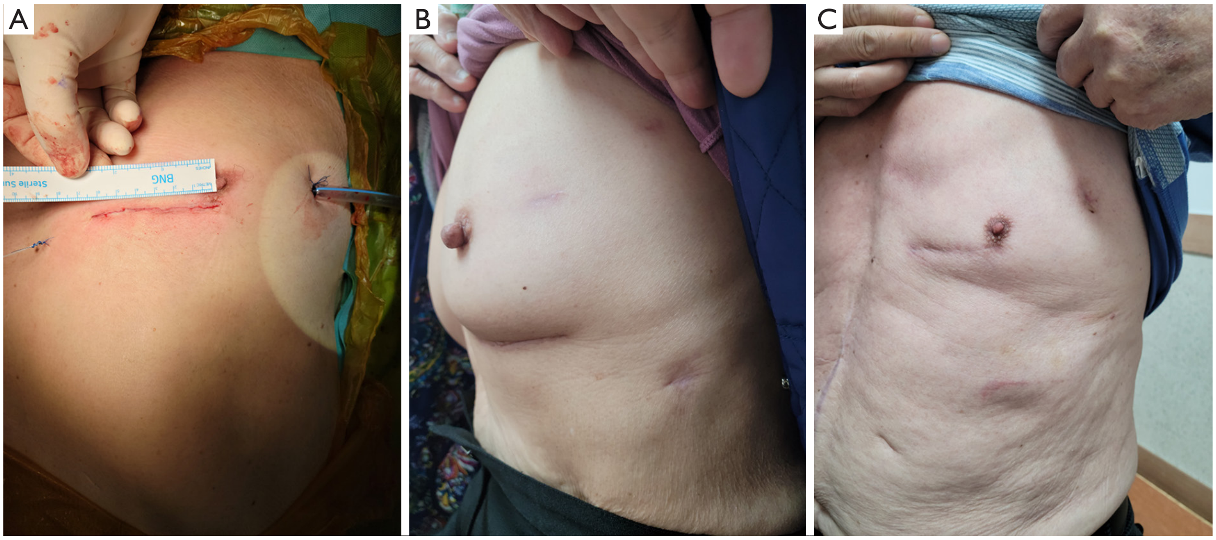


Figure 3 Postoperative wounds following (A) minimally invasive direct coronary artery bypass, (B) endoscopic atraumatic coronary artery bypass, and (C) minimally invasive cardiac surgery-coronary artery bypass grafting.

center. Graft patency was confirmed by transit time flow measurement, and the PI was less than 5 in all patients. Nonetheless, the results of intraoperative graft patency and early postoperative outcomes differed from those of a systematic review and meta-analysis (11-13).

Comparison with similar research

The IMA is a special vessel that rarely causes arteriosclerosis, and its graft patency rate when anastomosed to the LAD has been reported to be 95% per decade (1). Endothelium-derived relaxing factor and prostacyclin are secreted in the IMA, which is resistant to thrombus formation, and does not cause plaque proliferation or arteriosclerosis, owing to the continuity of the inner elastic layer (14). Nevertheless, harvesting of the bilateral IMA is reported to increase the risk of deep sternal wound infections, while the minimally invasive nature of the technique introduces technical difficulties. These disadvantages have limited the widespread use of this technique despite its excellent postoperative outcomes (15). Minimally invasive cardiac surgery has recently attracted attention in a variety of fields, including surgeries for CABG, valve, and arrhythmias. Among them, MICABG, which is performed while avoiding sternotomy, aortic management, and CPB, has been reported as a possible MIDCAB procedure since its introduction in the 1990s (7,8,16). This procedure begins with a bypass from the LIMA to the LAD and has developed into an extended concept of MICS-CABG for multivessel disease (17). The primary advantage of MICABG is that surgery is performed without sternotomy, thus avoiding deep sternal infections and mediastinitis (18). Furthermore, sternotomy is not required, which results in quicker healing, faster recovery of basic activities, earlier removal of the chest tube, and high rates of extubation in the operating room. Finally, complications such as acute respiratory failure after surgery can be minimized; indeed, patients who underwent MICABG required fewer transfusions and had a lower rate of wound infections than those who underwent traditional off-pump CABG (19). This allows the patient to recover, ambulate, and be transferred to the general ward faster, thereby reducing the hospitalization period (20). Furthermore, the cosmetic advantages were better with MICABG than with sternotomy, while the postoperative outcomes were similar (*Figure 3*). However, despite these encouraging results, only few cardiac surgery centers currently apply MIDCAB as the first-choice approach for LAD revascularization owing to technical difficulties, low incidence of patients with isolated LAD lesions, and lack of support for a hybrid strategy from referring interventional cardiologists. Nevertheless, cardiac surgery centers that have developed a serious MICABG program have reported very good results in terms of feasibility, safety, and efficacy, and data on long-term follow-up are currently available, further supporting the adoption of MICABG for appropriate patients (21).

Explanations of findings

The IMA can be harvested as a skeletonized or a pedicled graft. Skeletonization may be used for a longer time than can the pedicle method, making it easier to anastomose the coronary arteries sequentially, reduces postoperative wound infection, and ensures better blood flow to the coronary arteries immediately after surgery (22). However, skeletonization of the IMA is technically more difficult, can damage the IMA during harvesting, and requires more delicate manipulation than pedicled harvesting. During skeletonization, Metzenbaum scissors and electrocautery are commonly used to separate the IMA from the surrounding tissue of the sternum prior to clipping the branch vessels (23). Electrocautery can cause endothelial damage or graft wall thrombosis (24,25). Electrocautery devices deliver electrical energy resulting in heat ranging from 100–1,200 ℃ in the tissue, which can result in thermal damage to surrounding tissues within 2 cm (26,27). Furthermore, electrocautery can produce smoke, which can obstruct the surgical view in minimally invasive surgeries with limited space. Due to these shortcomings, cutting devices using energy such as high frequency, argon, and ultrasonic waves have commonly been applied in recent years.

Ultrasonic energy devices such as Harmonic scalpels are the most recently introduced surgical instruments that can simultaneously cut and cauterize tissue. The Harmonic scalpel has two cutting mechanisms: the first is the cutting effect of the longitudinal vibrating tip (vibrating 55,500 times/s over a distance of 50–100 µm), which is used to incise high-density tissues such as muscle and fibrous connective tissue; and the second is a cavitational fragmentation cutting mechanism, which is used to disrupt low-density tissues such as fat and parenchyma. Using this latter mode, the tissue planes can be quickly and easily separated ahead of the tip. Producing lower heat (~100 ℃) and less smoke than standard electrocautery causes less thermal injury and does not disturb the surgical field of view (28). According to both Erkut *et al.* and Yuan *et al.*, Harmonic scalpels have shorter graft harvest times, higher postoperative graft blood flow rates, and significantly fewer clips than electrocautery for hemostasis (29,30). Fukata *et al.* investigated the histological effects of an ultrasonic scalpel on blood vessel walls and found that thermal damage was limited to the depth of the connective tissue of the tunica externa of the blood vessels (31). Bulat *et al.* further investigated the effect of thermal damage on vascular endothelial cells using electrocautery and a high-frequency ultrasonic scalpel for harvesting IMAs, and reported that the degree of endothelial damage was 2.8 times greater in the electrocautery than in the high-frequency ultrasonic scalpel group (32).

The hook, blade, and shear types depend on the shape of the tip, with the shear-tip providing easy dissection and stable cutting. Several studies have been conducted on hook-type Harmonic scalpels (clipless or not), yielding similar results to those achieved using electrocautery (33,34). The shear-tip Harmonic scalpel can secure up to 7 mm of blood vessels, has excellent precision and multifunctionality, and can achieve advanced hemostasis (35). The Harmonic scalpel, which has many advantages, is more useful for MICABG, which is associated with greater technical difficulty in harvesting the IMA, limited surgical view, and narrow surgical space. The position of the IMA is deep; therefore, the use of long instruments is required. Owing to the nature of the long-shaft instrument, the longer the length, the greater the transfer of the tremor from the surgeon. This can cause inaccuracy in the movement and manipulation of instruments, which reduces the overall accuracy. Considerable effort is required to accurately clip the distal and proximal parts of the branches and to cut them using scissors. Electrocautery can cause thermal damage to the clip if placed in a branch of the IMA. This may cause a disaster if the clip is touched by the electrocautery (36). In particular, endo-ACAB requires more time than any other approach due to the need to alternate the use of instruments.

The shear-tip aids in the skeletonization of the IMA and sealing of the branch vessels prior to cutting. The shear tip also saves more time than the clip by triggering it only once, requiring continuous pressure on the branch for approximately 1–2 s until the branch turns white or black. The hook-type Harmonic scalpel is also easy to operate like a shear-tip, and can reduce the harvesting time of grafts; however, it does not guarantee complete hemostasis of branch blood vessels >2 mm. Unlike the shear-tip Harmonic scalpel, this device carries a greater risk of bleeding, as tension must be applied to incompletely sealed cuts because the branch vessel cannot be grabbed (35). Hemostasis is technically difficult to achieve in cases where bleeding occurs in a branch vessel owing to the limited field of view and incomplete hemostasis in the narrow space of MICABG, which can be time-consuming and cause damage to the graft. Harmonic scalpels can cause thermal injury to surrounding tissues, and the shear tip takes time to cool. The shear-tip is narrow and sharp; as a result, fewer sides are holding the branch. Even a small incision opens sufficient space between the IMA and branch, reducing thermal injury. The energy level can also be adjusted. Little energy prevents the rapid increase in heat. The careful manipulation of the instrument is advised when the branches adjacent to the IMA are being dissected. We believe that little training is required to harvest the IMA using this scalpel, and cardiothoracic surgeons can perform this procedure efficiently.

Implications and actions needed

The primary limitation of this study is its monocentric design, with all surgeries performed by a single operator skilled in CABG, which limits the applicability of our proposed method. Furthermore, we did not collect long-term data, as this method has only recently been introduced in our center. In addition, postoperative angiography, and pathological evaluation of the harvested IMAs could be conducted to further prove the safety of this method. Larger studies assessing the usefulness of the shear-tip Harmonic scalpel in homogeneous disease entities by several operators are necessary to demonstrate the feasibility of the proposed method and to encourage its widespread adoption.

Conclusions

Our initial experience with MICABG using the shear-tip Harmonic scalpel indicates the safety and efficacy of this technique in single- or multivessel disease revascularization. This scalpel is suitable for MICABG and IMA harvesting. Future studies with homogeneous data and more cases are needed to validate our study findings.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1810/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1810/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and approved by the Institutional Review Board of Chungnam National University Hospital (IRB No. 2021-07-121-001). The patients or the guardians provided written informed consent for all surgical procedures.

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