Identifying the optimal monopolar electrocautery output power in pedicular internal thoracic artery harvesting: 20 or 40 watts?

Emin Can Ata, Gözde Erkanli Şentürk, Halil Ibrahim Saygi, Mustafa Özer Ulukan, Murat Uğurlucan, Korhan Erkanli, Metin Onur Beyaz, Erkan Yildiz

Abstract

Background: Monopolar electrocautery is an important tool for harvesting the pedicular internal thoracic artery (ITA) in cardiac surgery. The different power outputs of cautery may affect graft integrity and long-term patency. This study aimed to identify the optimal threshold of electrocautery power for ITA harvest.

Methods: This prospective study included 30 patients who underwent elective coronary artery bypass surgery at the Medipol Mega University Hospital. The ITA was harvested by monopolar electrocautery after a median sternotomy. The output of cautery was adjusted at 20 W in group A and 40 W in group B. Three to 4 cm of a distal ITA sample from each patient was examined under a light microscope by two independent pathologists.

Results: The ITA harvest time was longer in group A (21.2 ± 7.5 vs 10.3 ± 8.1 min, p < 0.001) than in group B. ITA free flow was similar in the two groups (43.6 ± 48.7 vs 51.7 ± 45.0 ml/min, p = 0.762). Mild to moderate injury in the endothelial and sub-endothelial sample was more frequent in the low-cautery group (p = 0.0037).

Conclusion: ITA endothelial integrity was found to be better preserved with 40W electrocautery. Moreover, 20W of monopolar electrocautery may not be safe in pedicular ITA harvesting.

Keywords: coronary artery bypass, electrocautery, endothelial injury, internal thoracic artery

Methods

This prospective study was carried out after the approval of the Istanbul Medipol University ethics committee (NO:10840098-604.01.01-E.3643). Patient consent forms were obtained before CABG. The study included two groups with an equal number of patients. All the patients were operated on by the same surgical team.

This study included 30 elective, isolated CABG patients operated on at Medipol Mega University Hospital between February and April 2019. Patients were randomly divided into two groups, and each group consisted of 15 patients. The mean age was 63.2 ± 8.6 (range 47–82 years). Female and male patients represented 36.7 and 63.3%, respectively. In the first group (group A), 20W of output power was used, and the output power was increased to 40W in the other group (group B) for ITA harvesting.

The primary endpoint of the study included an assessment by a permanent histologist of the wall integrity of the endothelial
layer of the ITA. The secondary endpoint was echocardiographic evaluation of all the patients, and angiographic evaluation of the patients with a damaged ITA 12 months after surgery.

Due to possible pre-existing ITA pathology, patients with diffuse vascular disease, uncontrolled or untreated diabetes mellitus, thoracic deformity or trauma, and radiotherapy after left-sided mastectomy were excluded from the study.

The ITA was harvested by two highly skilled surgeons in turn. In both groups, 2–3-cm-wide pedicular ITA was harvested from its subclavian origin to 2–3 cm beyond the musculophrenic and superior epigastric artery bifurcation using blunt and sharp dissection with an MEC (Medtronic Covidence Force Electrosurgical Generator, Minneapolis, USA).

In group A, MEC output was adjusted to 20W and ‘coagulation’ mode, whereas the output current was increased to 40W in group B. Dissection started from the sternal edge lateral to the pleura, endothoracic fascia and venous comitantes in all patients. Grasping or retracting the ITA with forceps was avoided entirely in order to prevent graft injury.

Proximal and distal haemostatic clips (Peters Surgical titanium haemostatic clips, small and medium size, France) to the ITA side branches and cautery division were preferred in group A. In this group, 15 to 25 metallic clips were used for this purpose (Fig. 1A). In group B, all the ITA side branches were directly devised by cautery at least 3 mm distally from the ITA main trunk. Approximately five to eight clips were placed on the stumps of the large side branches after the ITA was dissected (Fig. 1B). When the distal dissection reached the bifurcation, the musculophrenic branch was divided, and ITA harvesting extended to 2–3 cm distally to obtain maximal length, which occasionally is necessary.

After an ideal length of ITA was prepared and a histological sample was extracted, ITA free-flow was measured by pouring water through it and into a small bowl for 20 seconds. The amount was collected with a 50-ml syringe and multiplied by three to determine ITA free flow. Systolic blood pressure and heart rate were kept at about 90–100 mmHg and 60–80 beats/min during the ITA free-flow measurement to minimise haemodynamic involvement. Then 5 ml of 40-mg diluted papaverine HCl at 37°C was applied topically over the ITA pedicle, not directly into the ITA.

After ITA harvesting, the 3–4-cm arterial sample, including the stump of the musculophrenic branch, was extracted from the distal part of the ITA. Harvested samples were divided into two pieces and fixed in 10% formaldehyde solution, dehydrated in graded concentrations of alcohol series and embedded in paraffin. After taking 3-μm sections, haematoxylin and eosin staining was performed. The histopathological evaluations were performed by two histologists independently and blindly.

Histopathological results were noted as damaged or undamaged specimens. The undamaged specimen included: (1) the vessel wall was intact (×5), (2) the integrity of the endothelial cells and subendothelial elastic fibres were preserved (×40). Samples with a detached subendothelial layer (×5), irregular endothelial layer and separated subendothelial layer were accepted as damaged specimens. All patients with damaged ITA samples were followed up after one year and ITA patency was evaluated by angiography.

### Statistical analysis

For statistical analysis, the SPSS version 24.0 program (SPSS Inc, Chicago, IL, USA) was applied. The normal distribution of variables was examined by histogram graphs and the Kolmogorov–Smirnov test. Mean and standard deviation values are used to present descriptive analyses. Fisher’s exact test was compared with 2 × 2 tables. While normally distributed (parametric) variables were evaluated among the groups, the Student’s *t*-test was used. The Mann–Whitney *U*-test was used to evaluate non-parametric variables. A *p*-value < 0.05 was evaluated as statistically significant results.

### Results

The two groups were found to have similar co-morbid factors, which means they were comparable. The pre-operative baseline characteristics of the patients are shown in Table 1. The ITA harvest time was an average of twice as long in group A than in

### Table 1. Pre-operative clinical characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group A (n = 15)</th>
<th>Group B (n = 15)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>62.5 ± 7.1</td>
<td>64.1 ± 8.5</td>
<td>0.785*</td>
</tr>
<tr>
<td>Female gender, n (%)</td>
<td>6 (40)</td>
<td>5 (33.3)</td>
<td>0.705**</td>
</tr>
<tr>
<td>Body surface area (m²)</td>
<td>1.86 ± 0.21</td>
<td>1.88 ± 0.19</td>
<td>0.602*</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>26.9 ± 12.2</td>
<td>26.5 ± 12.8</td>
<td>0.540*</td>
</tr>
<tr>
<td>Diabetes mellitus, n (%)</td>
<td>4 (26.7)</td>
<td>7 (46.7)</td>
<td>0.260**</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>6 (40)</td>
<td>4 (26.7)</td>
<td>0.441**</td>
</tr>
<tr>
<td>Hyperlipidaemia, n (%)</td>
<td>3 (20)</td>
<td>4 (26.7)</td>
<td>0.667**</td>
</tr>
<tr>
<td>Smoking, n (%)</td>
<td>8 (53.3)</td>
<td>5 (33)</td>
<td>0.273**</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease, n (%)</td>
<td>1 (6.7)</td>
<td>4 (26.7)</td>
<td>0.171**</td>
</tr>
<tr>
<td>Number of bypass graft</td>
<td>3.7 ± 1.1</td>
<td>3.6 ± 0.9</td>
<td>0.521***</td>
</tr>
</tbody>
</table>

*Student’s *t*-test, **Fisher’s exact test, ***Mann–Whitney *U*-test.  

**Fig. 1. Harvested internal thoracic artery (ITA). A: ITA harvested with 20W cautery, more than 20 pieces of haemoclips were applied. B: ITA harvested with 40W cautery, less than 10 pieces of haemoclips were applied.**
group B (21.2 ± 7.5 vs 10.3 ± 8.1 min, p < 0.001). Higher output of electrocautery facilitated the dissection.

After harvest, ITA free flow was measured in the same fashion in all patients. The maximum and minimum free flow was measured as 118 and 36 ml/min, respectively. When comparing the two groups, no difference was found in terms of ITA free flow (43.6 ± 48.7 vs 51.7 ± 45.0 ml/min, p = 0.762) (Table 2). Neither ITA spasm nor gross haematoma was inspected in either group right after harvest.

The mean diameter of ITA measured under the light microscope was similar between the groups (1.52 ± 0.35 vs 1.56 ± 0.3 mm, p = 0.463). Under light microscope evaluation, there were more damaged endothelial samples in group A than in group B (p = 0.0037, odds ratio: 7.875, 95% CI: 1.96–31.68) (Table 2). In more than half of the patients in group A, the subendothelium of the ITA was dispersed and disrupted, and some patients had visible luminal evagination of the endothelium and subendothelium (Fig. 2). In comparison with the patients in group A, in 86.7% of patients in group B, the endothelium and sub-endothelium showed normal morphology (p = 0.029, odds ratio: 7.43, 95% CI: 1.23–45.01) (Fig. 3).

No postoperative complications, such as re-exploration for bleeding, renal failure, peri-operative detectable myocardial infarction, mediastinitis and stroke, were observed in either group. Six months after the operation, echocardiographic evaluation showed no new regional wall abnormality or worsening of left ventricular function, and exercise stress tests were not found to have any positive signs of ischaemia.

One year after the operation, 10 patients with damaged ITA samples were followed up for angiography for ITA visualisation. Coronary angiography showed no ITA stenosis or occlusion in any of these patients (Fig. 4). No deaths or cardiac events occurred during this period.

Table 2. ITA harvesting time, diameter, free flow and endothelial injury rate

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group A (n = 15)</th>
<th>Group B (n = 15)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvest time (min)</td>
<td>21.2 ± 7.5</td>
<td>10.3 ± 8.1</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td>Diameter (mm)</td>
<td>1.52 ± 0.35</td>
<td>1.56 ± 0.30</td>
<td>0.463*</td>
</tr>
<tr>
<td>Free flow (ml/min)</td>
<td>43.6 ± 48.7</td>
<td>51.7 ± 45.0</td>
<td>0.762*</td>
</tr>
<tr>
<td>Length of ITA (cm)</td>
<td>20.3 ± 2.7</td>
<td>19.1 ± 3.4</td>
<td>0.298*</td>
</tr>
<tr>
<td>Damaged ITA sample, n (%)</td>
<td>14 (47)</td>
<td>3 (10)</td>
<td>0.0037**</td>
</tr>
<tr>
<td>Injured ITA patient, n (%)</td>
<td>8 (53.3)</td>
<td>2 (13.3)</td>
<td>0.029**</td>
</tr>
</tbody>
</table>

*Student’s t-test, **Fisher’s exact test.
Discussion

Using the ITA is the gold standard for grafting the left anterior descending artery to the anterior cardiac wall during CABG. The improved outcome using the ITA is due to its superior long-term patency. The ITA has a discontinuous internal elastic lamina and a relatively thin media with multiple elastic laminae and the absence of a significant muscular component, which explains its reduced tendency for spasm and the development of atherosclerosis. Moreover, compared with all other arterial and venous conduits, it shows increased production of anti-inflammatory and vaso-active molecules, particularly nitric oxide.

However, the ITA is more vulnerable to traction injury, which is associated with intimal fracture, creating an intimal flap that may restrict flow or initiate a subintimal dissection. This lesion is specific to the ITA and may decrease its long-term patency. MEC is a basic tool for precise, fast and bloodless preparation of both pedicular and skeletonised ITA grafts in cardiac surgery. The fundamental performance of electrocautery dissection is created by continuous thermal energy from an electric current to the conductive tissue, which leads to vapourisation and ionisation of the water content in the tissue adjacent to the electrode and ultimately ablates the soft tissue.

Several factors might be blamed for ITA endothelial injury. The leading cause is direct touching of the cautery tip with the ITA or the metallic clip, which causes a gross diathermal injury.

Secondly, we believe improper use of the MEC causes an invisible burn depth injury to the endothelium. The transformation of electrical energy into heat occurs in the following Joules law, which is the core principle of all electrosurgery devices:

\[ \text{energy} = 2 \times (\text{current/cross-sectional area}) \times \text{resistance} \times \text{time} \]

Low cautery requires a longer time to produce dissectible energy, during which time it creates an unpredictably high temperature, which causes ITA injury. The time needed for preparation of the ITA with low cautery was significantly longer in our study, which confirms this.

Finally, tissue around the ITA consists of endothoracic fascia, fatty tissue and intercostal muscle, which have different impedances to electrical current. Fatty tissue requires higher threshold energy to be dissected in comparison with muscle due to its higher resistance to electric current.

Instead of blunt dissection, cauterying for a more extended time may cause burn depth of the ITA pedicle. Moreover, at a higher power of cautery (40W), it was possible to divide the ITA branches by direct contact with a 3–5-mm distance from the ITA main trunk without clips. This technique can provide optimal haemostasis. Placing haemostatic clips onto the stumps of the ITA branches after the ITA is completely dissected also eliminates the risk of contact injury.

Our study result was inconsistent with other studies with MEC, in that both indicated that there was endothelial damage. The question of whether endothelial injury regresses later or causes stenosis or occlusion is not known. In our study, the absence of stenosis or occlusion may be explained by the fact that the endothelial injury detected by histopathological investigation was too trivial to trigger the endothelial coagulation cascade, or the injury could spontaneously have lessened over time. But further investigation and long-term follow ups are necessary to confirm this theory.

This study has some limitations. It included only a limited number of patients. The histopathological observation at the distal end of the ITA may not be consistent with the integrity of the entire length of ITA. Therefore, it was not possible to prove it in vivo. Finally, since there is no globally recognised scoring or grading system of ITA endothelial injury, the severity of ITA endothelial injury could not be graded in detail. Further investigation and long-term patency are required before widespread use of this technique.

Conclusion

Low cautery power (20W) may not be safe for harvesting pedicular ITA. Morphological integrity of the ITA endothelium was better preserved with 40W output, and it also enabled the operator to harvest faster. Endothelial injury caused by the MEC below 40W did not have any adverse effect on ITA free flow and one-year patency.

References

5. Bilgen F, Yapici MF, Serbetçioğlu A, Tarhan IA, Coruh T, Ozler A.


