Endothelial integrity of ultrasonically skeletonized internal thoracic artery: morphological analysis with scanning electron microscopy

Masaru Yoshikai\textsuperscript{a,*}, Tsuyoshi Ito\textsuperscript{b}, Keiji Kamohara\textsuperscript{a}, Junji Yunoki\textsuperscript{a}

\textsuperscript{a}Department of Cardiovascular Surgery, Shin-Koga Hospital, 120 Tenjin-cho, Kurume, Fukuoka 830-8577, Japan
\textsuperscript{b}Department of Thoracic and Cardiovascular Surgery, Saga Medical School, Saga, Japan

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Abstract

Objective: The skeletonized internal thoracic artery (ITA) has several advantages over a pedicled one in coronary artery bypass grafting (CABG). An ultrasonic scalpel makes ITA skeletonization easy and speedy, however, the ultrasonic energy that is transmitted to the artery itself can occasionally injure the endothelium. Therefore, the endothelial integrity of the ultrasonically skeletonized ITA is a major concern related to this technique. The purpose of this study is to assess the endothelial integrity of the ultrasonically skeletonized ITA. Methods: We skeletonized the left ITA with an ultrasonic scalpel in nine patients who underwent CABG, and thereafter the terminal portion of this artery was subjected to a morphological study. The endothelial integrity of this artery was morphologically assessed using scanning electron microscopy, and the results were compared to that of the left ITA skeletonized with fine scissors. Results: All ITA specimens showed a completely confluent endothelium, and no endothelial injury was observed by the scanning electron microscopic study. Conclusions: The skeletonization of the ITA with an ultrasonic scalpel had no deleterious effect on the endothelium. This morphological study confirmed the safety and the reliability of this technique, and we therefore recommend its clinical use in the skeletonization of the ITA for CABG.

1. Introduction

The internal thoracic artery (ITA) has an excellent long-term patency rate, and it has been the most reliable graft material used in coronary artery bypass grafting (CABG). An injury to the ITA endothelium can activate a coagulation cascade, which can result in thrombus formation [1] thus leading to early graft failure. Moreover, the damage to the endothelium can also promote the atherosclerotic process [2], thus eventually leading to the long-term development of graft stenosis or occlusion. Therefore, a technique, which does not cause any mechanical damage to the endothelium, should be utilized when harvesting the ITA. The ITA may be used as a pedicle or a skeletonized conduit, and the skeletonization of this artery has been shown to maximize its benefits in clinical use [3]. An ultrasonic scalpel (Harmonic Scalpel; Ethicon Endo-Surgery, Cincinnati, OH) allows ITA skeletonization to be easily and quickly performed. In addition, its clinical usefulness has also been reported [4,5]. When performing this technique, maximal attention should be paid to not allow the ultrasonic scalpel to come in contact with the ITA, however, the direct transmission of ultrasonic energy on the ITA itself may sometimes accidentally or instantaneously occur, and such endothelial injury of the ITA thus remains a major concern. In this study, we used scanning electron microscopy (SEM) to morphologically evaluate the endothelial integrity of the ultrasonically skeletonized ITAs and herein present our results.

2. Material and methods

Left ITAs harvested from ten consecutive patients undergoing elective CABG were the subject of this study. In nine patients, the ITA was skeletonized using an ultrasonic scalpel. In one patient, only the terminal portion of the ITA was skeletonized with scissors as a control. Informed consent was obtained from all patients...
participating in this study, and this study was approved by our institutional ethics committee on human research.

2.1. Operative technique

After performing a standard median sternotomy, the left ITA was harvested in a skeletonized fashion using an ultrasonic scalpel. We used a dissecting hook type blade (Harmonic Scalpel, dissecting hook type; Ethicon Endo-Surgery, Cincinnati, OH) and set the output of the ultrasonic scalpel at level 2. Higami et al. previously described these procedures in detail [4]. In brief, after a longitudinal incision on the endothoracic fascia about 1 cm medial to the ITA, the medial satellite vein is then swept away from the ITA by moving an ultrasonic scalpel quickly (‘quick touch’ method). The fatty tissue around the ITA is easily removed in this way. Next, the branches of the ITA are exposed and visualized. Next, by placing the tip of the blade on the branch at least 1 mm away from the ITA itself for 3–4 s, we are thus able to divide the branch by protein coagulation (‘close coagulation’ method). During skeletonization, care should be taken that the ultrasonic scalpel does not come in contact with the ITA for more than 0.2 s. In this way the ITA is fully skeletonized from its origin to 1 cm beyond the bifurcation. After the administration of heparin, the terminal portion of the ITA just proximal to the bifurcation is cut over an area measuring 1 cm in length, and then it is subjected to an SEM study to evaluate its endothelial integrity. One ITA skeletonized with scissors was also submitted to an SEM study as a control.

2.2. Preparation for scanning electron microscopy

ITA cylinders were cut longitudinally and then were immediately washed gently with a physiologic solution, and immersed in 2.5% glutaraldehyde for 24 h. All samples were washed in cacodylate buffer, postfixed in 1% osmium tetroxide (OsO₄), and thereafter were further dehydrated in ascending concentrations of ethyl alcohol, and dried in CO₂ at a critical point. After drying, all samples were mounted on specimen stubs using colloidal silver and coated with gold using argon, and finally were observed by SEM (Nippon Denshi JSM-25S11).

One pathologist examined all specimens and described the endothelial integrity according to the score system proposed by Fischlein et al. [6] using the following criteria: (1) completely confluent endothelium; (2) partially confluent endothelium; (3) loosely netted endothelium; (4) islands of endothelium; and (5) no endothelium.

3. Results

Fig. 1 showed the endothelium of the ITA skeletonized with scissors as a control. As we expected, no endothelial injury was observed in this specimen. Nine ultrasonically skeletonized ITAs also showed a completely smooth confluent endothelial lining (Fig. 2). All nine specimens had a completely preserved endothelium without any endothelial cell loss, and all were scored as grade 1 by the scoring system described above.
4. Discussion

In the present study, we morphologically assessed the endothelial integrity of the ultrasonically skeletonized ITA using SEM, and were able to confirm that using this technique to skeletonize the ITA does not cause any injury to the endothelial cell lining.

The skeletonization of the ITA has been reported to have several advantages over harvesting the ITA as a pedicle. Skeletonization allows us to obtain a longer ITA [7], which means that a more proximal thick portion of the ITA can be used for anastomosis, and the ITA can then also reach more distal coronary artery branches. A sequential bypass graft is easier to perform with the skeletonized ITA. It also preserves the blood supply to the sternum, thus allowing for more rapid healing and a decreased risk of wound infection [3,8], while also preserving the pulmonary function [9]. The skeletonized ITA also has a greater free blood flow with no need for preserving the pulmonary function [9]. The skeletonized ITA over its full length. In general, the terminal portion of the ITA has a thinner vessel wall than the proximal portion, so the results of this study can be extrapolated to the full length of the ITA. Another study limitation concerns the methodology of this study. We evaluated the endothelial cell integrity of the ITA only in a morphological study using SEM. The morphologically intact endothelium seems to have normal endothelial cell function, however, further examinations concerning the endothelial cell function are called for.

In the present study, we skeletonized the ITAs using an ultrasonic scalpel according to the method developed by Higami et al. [4]. This technique does not apply any coagulated branches could tolerate pressure up to 350 mmHg. Whether or not the ultrasonic energy conveyed to the ITA can cause the endothelial cell injury remains a major concern, so we therefore designed this study to assess the endothelial integrity of the ITA.

In the present study, we skeletonized the ITAs using an ultrasonic scalpel and compared the endothelial cell integrity using the SEM. Their results showed that an ultrasonic scalpel preserved the endothelium better than the high-frequency electrocautery in the pedicled fashion and compared the endothelial cell integrity using the SEM. Their results showed that an ultrasonic scalpel preserved the endothelium better than the high-frequency electrocautery when these two tools were applied less than 5 mm close to the ITA. Moreover, they reported that an ultrasonic scalpel applied directly on the ITA for 1 s could cause injury to the endothelial cells. Lamm’s method for applying an ultrasonic scalpel to harvest the ITAs was clearly different from the method developed by Higami et al. [4]. In the present study we were extremely careful not to touch the ITA itself with the ultrasonic scalpel, and to apply the scalpel on the side branches 1 mm away from the ITA when dividing them. None of the nine ITAs skeletonized with an ultrasonic scalpel showed any endothelial cell injury in the SEM study. This finding confirmed the preservation of the endothelial cell lining of the ultrasonically skeletonized ITAs at the cell level, and it also supported the histopathological findings reported by Higami et al. [11]. We concluded that the skeletonization of the ITA with an ultrasonic scalpel caused no deleterious injury on the endothelium, while the instantaneous transmission of ultrasonic energy on the adventitia of the ITA had no negative effect on the endothelium.

5. Study limitation

In the present study we only investigated the terminal portion of the ITAs by the SEM study and did not examine the ITA over its full length. In general, the terminal portion of the ITA has a thinner vessel wall than the proximal portion, so the results of this study can be extrapolated to the full length of the ITA. Another study limitation concerns the methodology of this study. We evaluated the endothelial cell integrity of the ITA only in a morphological study using SEM. The morphologically intact endothelium seems to preserve normal endothelial cell function, however, further examinations concerning the endothelial cell function are called for.

6. Conclusions

The skeletonization of the ITAs using an ultrasonic scalpel was found to preserve the endothelial cell integrity if extreme care is taken to avoid the ultrasonic scalpel from coming in contact with the ITA itself. This technique is safe and does not cause vessel dissection, and we therefore recommend its clinical use in the skeletonization of the ITA.

References


