A New Suturing Device for Small Arteries

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SUMMARY

Endoscope-assisted surgery and robot-assisted surgery are not common in cardiac surgery, particularly coronary artery bypass grafting, because of the complex nature of the procedures. We developed a new suturing device that allows for easy performance of such cardiac surgeries in comparison with conventional suturing methods. A total of 63 rabbits were used in this study. The right carotid artery was bypassed using the same side of the jugular vein under endoscopic guidance. Of these, 48 rabbits were operated on using the new devices and 15 rabbits were operated on using conventional polypropylene sutures. The proximal suturing time was 16.6 ± 5.3 minutes in the group that underwent surgery using the new device (group D) and 22.8 ± 7.6 minutes in the control group (group C; \( P < 0.05 \)). The distal suture time was 16.3 ± 4.2 minutes in group D and 22.8 ± 6.0 minutes in group C \( (P < 0.05) \). The operation time was 113.0 ± 15.8 minutes in group D and 136.7 ± 20.6 minutes in group C \( (P < 0.05) \). Graft flow was 19.9 ± 12.8 mL/minute in group D and 12.1 ± 11.3 mL/minute in group C \( (P < 0.05) \). Thus, the operation time and the suture time differed significantly between the groups. This device provides advantages in endoscopic surgery compared to the conventional suture method. (Int Heart J 2016; 57: 323-326)

Key words: Minimally invasive cardiac surgery, Coronary artery bypass graft, Endoscopic surgery

Currently, endoscope-assisted surgery and robot-assisted surgery are commonly used. These surgical methods have recently been applied to cardiac surgery, but are not often conducted in this field owing to the complexity of cardiac surgery, particularly coronary artery bypass graft (CABG). We have developed a new suturing device for small arteries with the purpose of allowing for easier suturing in a small area under endoscopic guidance than with conventional suturing methods. Itoda, et al\(^1\) have already demonstrated the efficacy and safety of this new device in open surgery. Herein, we evaluated the efficacy of this new device in endoscope-assisted surgery using a rabbit endoscopic model of artery bypass grafting.

METHODS

Device design: The device has a simple structure where the anchoring mechanism is connected with the free end of a commercially available polypropylene suture (Figure 1). The anchoring mechanism (prototype version: height, 0.9 mm; width, 0.5 mm; depth, 0.5 mm) was developed using biocompatible stainless steel (SUS316L) and was manufactured with laser processing. After a usual running suture, a surgeon led the suture thread into the channel of the anchoring mechanism, which was then compressed with the needle holder using standard force to provide a rigid connection between the suture thread and the anchoring mechanism; this completed the anastomosis. Using this device made it possible to avoid the tangled ligation procedure. Figure 2 shows the procedure involved in the anastomosis using the device. Before initiating the experiments, a few improvements were made to the device to make it suitable for endoscopic use (the improved version). A slight angle was introduced in the anchoring mechanism, which allowed for easier entry of the suture thread into the device channel than with the prototype version. The length of the suture thread in the prototype device was 20 cm. We shortened the suture thread to 5 cm in the improved version. Thus, the device enabled better handling ability under an endoscope-assisted surgery.

Experiment:

Experimental protocol Institutional guidelines for the care and use of laboratory animals were followed. All experiments were performed in accordance with the Guide for the Care and Use of Laboratory Animals published by the United States National Institute of Health. The protocol was approved by the Institutional Animal Care and Use Committee of the University of Tokyo.

Method Male New Zealand white rabbits were purchased for this study. All rabbits were anesthetized with an intramuscular...
injection of ketamine and xylazine combined. During this operation, approximately 6 mL/minute oxygen was administered, and spontaneous breathing was maintained. Next, 2.5 mL of xylocaine was administered as local anesthesia after which a 3-cm median cervical incision was made. The right carotid artery and jugular vein were exposed. A 2-cm segment of the jugular vein was cut and used as the free graft.

**Anastomosis:** In this study, 48 rabbits were operated on using the new device (group D), and 15 rabbits were operated on using a conventional polypropylene suture (8-0 Prolene® ETHICON, Johnson & Johnson, Tokyo), which served as the control group (group C). The proximal and distal sections of the carotid artery were clumped together using forceps. First, a proximal anastomosis was created. Next, the carotid artery was cut and an approximately 3-mm long and a 1.25- or 1.50-mm diameter coronary shunt (Medtronic Japan Co., Ltd., Tokyo) was inserted. Stay sutures were created at the proximal and distal ends of the anastomosis site. The suture was made outside to inside for the carotid artery and inside to outside for the graft at each side. In addition, a triple ligation was performed at each side in group C. Subsequently, the endoscopic procedure was initiated. The surgical field was covered with the upper compartment of the endoscopic surgery training box (EndoWork Pro II, Kyoto Kagaku Co., Ltd., Kyoto, Japan). A flexible rigid scope (VISERAEELITE®, Olympus Co., Ltd., Tokyo) was inserted via ports located at the top of the box, thus creating an endoscopic surgical environment (Figure 3). During the endoscopic anastomosis, a ValveGate™ PRO (GEISTER Medizintechnik GmbH, Tuttlingen, Germany) needle holder and forceps were used.

Under endoscopic guidance, a left side (far side) running suture was performed from the proximal to distal direction outside to inside for the carotid artery and inside to outside for the graft using the proximal side of the stay suture (Figure 4A). Thereafter, compression and connection was established in group D, and septuple to octuple ligations were performed in group C. A right side (near side) running suture was then performed from the distal to proximal direction outside to inside for the graft and inside to outside for the carotid artery using the other side of the stay suture (Figure 4B). Connections and ligations were carried out similarly for the right side. After anastomosis of the proximal side, that of the distal was performed similarly as for the proximal side. Subsequently, the forceps that were used to clump the artery were removed, and hemostasis was obtained. Next, the segment between those anastomoses was ligated and cut (Figure 5). After administering 2.5 mL of xylocaine as local anesthesia, the wound was closed.

**Endpoint:** The following endpoints were evaluated in all 63 rabbits; 1) Anastomosis time: This was defined as the duration for performing the suture from the beginning of the left side (far side) to the end of the right side (near side). 2) Operation time: This was defined as the time from the beginning of the median incision to the end of wound closure. 3) Graft flow in the acute phase: Soon after the anastomosis, graft flow was evaluated with a VeriQ (Nippon BXI Inc., Tokyo).

**Statistical analysis:** The mean ± standard deviation of anastomosis time, operation duration, and graft flow was calculated.
using Microsoft Excel (Microsoft Inc., WA, USA). Differences between the groups were analyzed using Student’s t-test with JMP (SAS Institute Inc., NC, USA).

**Results**

**Anastomosis time:** Figure 6A shows the anastomosis time. The mean proximal anastomosis time was 16.6 ± 5.3 minutes for group D and 22.8 ± 7.6 minutes for group C ($P < 0.05$),
and the distal anastomosis time was 16.3 ± 4.2 minutes for group D and 22.8 ± 6.0 minutes for group C (P < 0.05). Thus, in both cases, a significant difference was observed between the two groups.

**Operation time:** Figure 6B shows the operation time. The mean operation time was 113.0 ± 15.8 minutes for group D and 136.7 ± 20.6 minutes for group C (P < 0.05). A significant difference was observed between the groups.

**Graft flow in the acute phase:** Figure 6C shows the graft flow in the acute phase. The mean flow was 19.9 ± 12.8 mL/minute for group D and 12.1 ± 11.3 mL/minute for group C (P < 0.05). A significant difference was observed between the groups.

**Discussion**

The rabbit carotid artery bypass model has often been used for the evaluation of anastomosis, and several kinds of suture methods have thus been developed. For example, Caiati, *et al.*\(^2\) reported the efficacy of a vascular clip. In their study, 26 New Zealand White rabbits underwent interposition of jugular vein grafts in the left carotid artery. However, there were no differences in the peak velocity, vascular cell proliferation, or intimal changes. Puca, *et al.*\(^3\) reported the use of minimally occlusive laser vascular anastomosis. In their study, 40 New Zealand White rabbits underwent two end-to-end anastomoses between the jugular vein graft and the ipsilateral carotid artery. This technique reduces the duration of clamping for the recipient artery.

Itoda, *et al.*\(^1\) reported the efficacy and safety of the new suturing device that we developed. Rabbit carotid artery bypass using the jugular vein was performed using open surgery. However, there were no significant differences in suturing duration, graft patency, and blood flow. No particular histopathological changes related to the device were observed. However, Itoda, *et al.* conducted experiments using open surgery, and so, this study focused on performing endoscopic surgery using the new device.

In the present study, endoscopic techniques were partially used, but the duration of the operation and suture differed significantly between the groups. One possible reason is that using the device avoids tangled ligation. Conventional ligation in endoscopic surgery is difficult. In contrast, the device requires only a simple maneuver to anchor the suture thread. Therefore, the device provides more advantages in endoscopic surgery. Another possible reason is that using this device is easier than performing a conventional suture. Moreover, 2 stay sutures were carried out, after which the endoscopic procedure was initiated. In conventional sutures, the suture thread on the side opposite the needle tends to hinder the suturing procedure even if it is anchored with forceps. In contrast, the device has no suture thread on the opposite side.

We believe this device will provide even more advantages in the CABG model. The parachute technique is commonly used in CABG, and the technique requires no stay sutures. Thus, the device is stabilized during anastomosis and allows one to easily carry out the anastomosis in comparison with the conventional suture method. The graft flow in the acute phase also showed a significant difference. The reason for this may be that conventional sutures tend to unintentionally involve a tight ligation. However, the device offers less risk because of the simplicity of the anchoring process.

**Conclusion:** Our results demonstrate the advantages of the new device in endoscopic surgery compared to the conventional suture method. Before designing any clinical trials though, the utility of the device must be evaluated with a larger animal endoscopic model of CABG.

**References**


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