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Microvascular Patch Graft Angioplasty of the Common Carotid Arteries in Rats

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ABSTRACT

AIM: To provide a training model for microvascular patch graft angioplasty of the common carotid arteries (CCAs) in rats.

MATERIAL and METHODS: Using male Sprague-Dawley rats (n=20), an oval-shaped arterial patch 3 mm in length and 1.2 mm in width was prepared from a segment of left CCA, and a linear longitudinal arteriotomy 3 mm in length was made along the anterior aspect of the right CCA, then the arterial patch graft was anastomosed to the right CCA with 10-0 sutures in an interrupted fashion. Patency was assessed immediately and 30 minutes after the procedure.

RESULTS: All microvascular patch graft angioplasties of the rat common carotid arteries were successful, and all the patency rates immediately after the operation and thirty minutes after the restoration of blood flow were 100%.

CONCLUSION: The training model for microvascular patch angioplasty with rat CCAs can serve as a training tool for mastering the procedure, and this technique could provide an alternative strategy for the surgical repair of microvascular aneurysms and microvascular vessel injuries.

KEYWORDS: Patch graft, Angioplasty, Training, Rat, Common carotid artery

ABBREVIATIONS: MCA: Middle cerebral artery, **CCA:** Common carotid artery

INTRODUCTION

In addition to classical end-to-end, end-to-side and side-to-side microvascular anastomosis, microvascular patch graft angioplasty is one of the most important revascularization techniques in cerebrovascular neurosurgery. Different patch grafts from the superficial temporary artery and radial artery, among others, have been successfully used to treat middle cerebral artery (MCA) aneurysms, vertebral artery aneurysms and intraoperative MCA injuries (13,14,19). Therefore, it is necessary for surgeons to develop the microvascular patch graft angioplasty technique in the laboratory before performing it in a real human body. The authors report a training model for microvascular patch graft angioplasty of the common carotid arteries (CCAs) in rats.

MATERIAL and METHODS

The study was approved by the Institutional Review Board, and the animal care complied with the Guide for the Care and Use of Laboratory Animals. All procedures were performed by the first author under 10x or 16x magnification with a microscope (Zeiss, OPMI Pico). Twenty male Sprague-Dawley rats weighing 200-250 g were used. After the rats were anaesthetized intraperitoneally with pentobarbital (50 mg/kg), a midline linear cervical incision was made, and the CCA on both sides was carefully dissected. The left CCA was ligated to harvest a segment of the artery (Figure 1A). A longitudinal incision was made to unfold the segment (Figure 1B), an oval-shaped arterial patch 3 mm in length and 1.2 mm in width was prepared, which was carried out by meticulously

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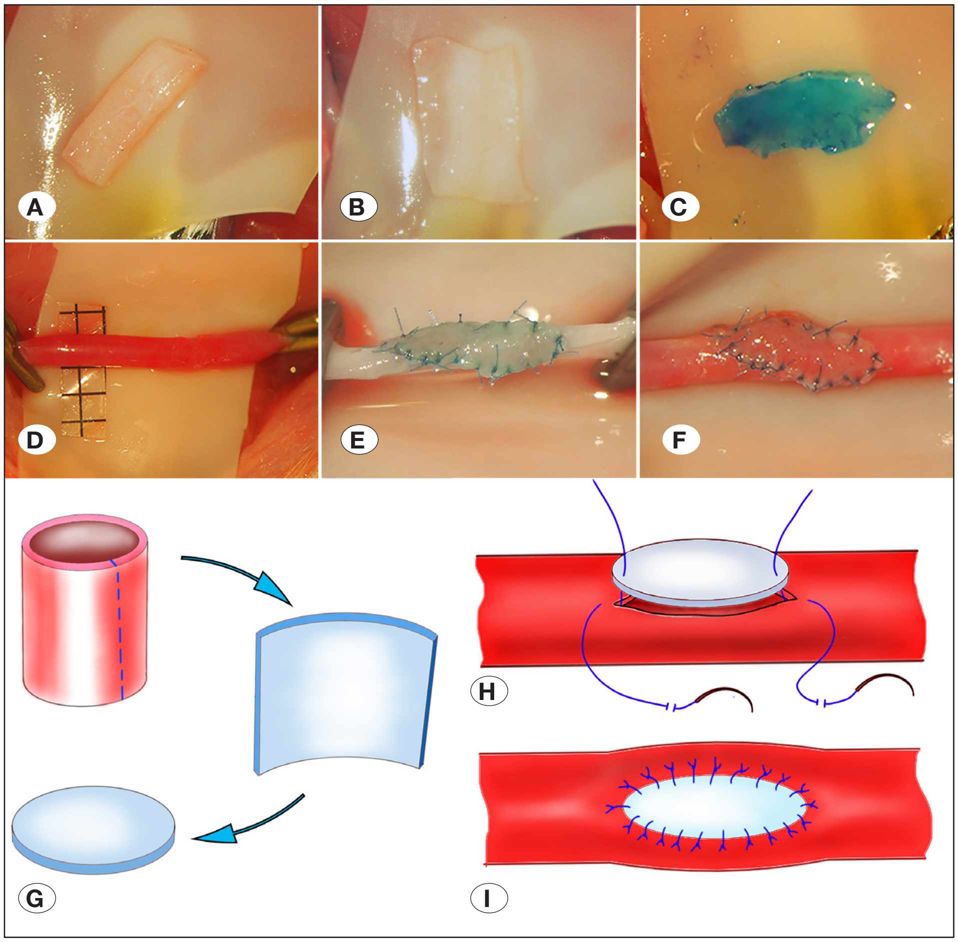

Figure 1: The microvascular patch angioplasty of CCAs in rat **(A-F)** and the schematic illustrations **(G-I)**. After a segment of left CCA was harvested **(A)**, a longitudinal incision was made to unfold the artery **(B)**, an oval-shaped arterial patch 3 mm in length and 1.2 mm in width was prepared **(C, G)**. Then the right CCA was temporarily clipped **(D)**, a linear longitudinal arteriotomy 3 mm in length was made, and the microvascular patch angioplasty was performed in an interrupted suturing technique **(E, H, I)**, then blood flood was restored after the removal of the clips **(F)**. (Scale bar = 1 mm).

cutting the excessive tissue from the unfolded segment with microscissors on a piece of rubber dam to help unfold it, and blue dye was used to help visualize the segment (Figure 1C, G). Then, the right CCA was temporarily clipped (Figure 1D), a linear longitudinal arteriotomy 3 mm in length was made along the anterior aspect of the exposed segment, and the lumens of the vessels were irrigated with heparinized saline (100 units/mL). The adventitia around the arteriotomies was carefully removed, and the arterial patch graft was anastomosed to the right CCA with nonabsorbable monofilament polypropylene blue 10-0 sutures (W2790, 13 cm in length, 3.8 mm, 3/8 circle taper point, BV 75-3, Ethicon) in an interrupted fashion (Figure 1E, HI). After microvascular patch graft angioplasty was completed, the temporary clips were removed to restore blood flow in the right CCA (Figure 1F). Patency was assessed immediately and 30 minutes after the procedure through direct observation and Acland's test under a microscope, which was carried out by milking the right CCA with two microforceps to empty it and refill it with blood flow (20).

RESULTS

In the study, the diameter of the CCA was between 1 mm and 1.2 mm. In all rats, microvascular patch graft angioplasty of the rat CCA was successfully performed, and the patency rate immediately after the operation and thirty minutes after the restoration of blood flow was 100%.

DISCUSSION

Microvascular patch graft angioplasty is one of the most important revascularization techniques in vascular surgery and is commonly used in carotid endarterectomy or coronary artery revascularization. In cerebrovascular neurosurgery, different microvascular patch grafts from the superficial temporary artery and radial artery, among others, have been successfully used to treat MCA aneurysms, vertebral artery aneurysms and intraoperative MCA injuries (13,14,19). It is recommended that every microvascular technique be fully mastered in a microsurgical laboratory before application in real human procedures.

Microvascular training using silicone tubes, chicken wings and thighs, human and bovine placenta, cadaveric brains and living animal models (such as rats and mice) has been previously reported (5,8,10,15,20). Human cadaveric heads can be used to perfectly mimic microvascular surgeries in the corresponding cerebrovascular anatomical situations, but the mechanical characteristics of fixed brain tissue and vessels are obviously different from those of living animals (15). Although experiments on both human cadaveric heads and living animal models must be performed in microsurgical laboratories under strict ethical approval, living animal vessels can effectively simulate microvascular surgery in humans in terms of texture, hepatic qualities, pulsation and coagulation physiology, which make them indispensable in cerebrovascular training (12,20).

In microvascular training, rats are the most commonly used animals, and rat CCAs are the most frequently used arteries because of their similarity in size to many human cerebral vessels (16). Models for classical end-to-end, end-to-side, and side-to-side anastomosis using rat CCAs have been previously reported (11,17,18). However, few studies have reported rat microvascular patch graft angioplasty training models. Cuevas and Gutierrez Diaz (6) described a microvascular patch graft angioplasty model using a strip of the saphenous vein from Wistar rats as a patch graft. The saphenous vein patch graft was sutured to a 5-8 mm longitudinal arteriotomy of the right CCA using 10-0 interrupted sutures. In Cuevas's model, in addition to the incision to expose the recipient artery, another incision was needed to harvest the patch graft, and the venous patch graft was mismatched to the recipient artery, making it unsuitable for arterial repair. In the present study, the surgical approach was simple, and only a single midline cervical incision was sufficient to expose both the matched donor and recipient arteries. Bai et al. (2) reported a rat aorta and inferior vena cava angioplasty model in which a bovine pericardial patch 3 mm x 1.5 mm x 0.6 mm in size was sutured to a 3-mm venotomy or arteriotomy in the inferior vena cava or abdominal aorta of a Wistar rat using 10-0 nylon sutures with a continuous or interrupted suturing technique, achieving 100% patency in all groups 7 days after the procedure. Several different types of patch grafts using the same angioplasty model have been reported by Bai and other authors, including porcine pericardial patches, polyester patches, and autologous jugular vein and carotid artery patches (3,4,9). In their studies, the patch grafts used were almost the same size as ours, but they chose the rat inferior vena cava or abdominal aorta as the recipient vessel, both of which are greater than 2 mm in diameter. In Cuevas' study and the current paper, the CCA, with a diameter of approximately 1 mm, was used as the recipient artery. Microvascular training using vessels with smaller diameters requires a higher level of microsurgical skill than training using vessels with larger diameters, but all of these models could be used to complement each other to mimic microvascular patch graft angioplasty in vessels with different diameters.

It has been reported that arterial patches retain their natural characteristics in arterial environments, while synthetic and other autologous tissue patches heal by acquisition of the vascular identity determined by the environment into which they are implanted, suggesting some plasticity of these patch grafts (3,4,9). However, autologous tissue remains the gold standard for vessel closure (3), and the most ideal patch graft should be identical to the recipient vessel in terms of thickness, texture, and consistency, among other characteristics. In cerebrovascular surgery, superficial temporal artery and radial artery patch grafts have been successfully used for cerebral arterial patch angioplasty (13,14,19). Angioplasty using thin-walled patch grafts risks aneurysm formation, and some authors have successfully performed microvascular angioplasty using adventitia and venous patch grafts to create aneurysmal models (1,7). Thus, a matched arterial patch graft is more suitable in the treatment of aneurysms or arterial injuries. In this study, both the patch graft and recipient artery were from the CCAs of the same animal, and the arterial patch graft was perfectly matched to the recipient artery; thus, aneurysm formation was less likely if the procedure was performed properly. During the procedure, great care should be taken to avoid causing injury to the endothelial layer or bringing the adventitia into the lumen; otherwise, a thrombus may form. Although microvascular patch graft angioplasty is different from classical end-to-end, end-to-side and side-to-side anastomosis, the microvascular anastomotic principle is the same, and the microvascular patch graft angioplasty technique could be learned through sufficient, deliberate practice in microsurgical laboratories. We suggest that surgeons continue to practice microvascular patch angioplasty with other microvessels and different patch grafts to mimic different surgical situations after mastering the technique in the model, as we described; additionally, a continuous suturing technique may also be used in the procedure.

There are some limitations to our study. The left CCA was ligated, and the right CCA was temporarily clipped during the procedure, which may lead to cerebral hypoperfusion; however, we found that this had no obvious side effects in the training model used in the study.

CONCLUSION

The training model for microvascular patch angioplasty with rat CCAs can serve as a training tool for mastering the procedure, and this technique could provide an alternative strategy for the surgical repair of microvascular aneurysms and microvascular vessel injuries.

AUTHORSHIP CONTRIBUTION

Study conception and design: ZX, JW

Data collection: ZX, JW

Analysis and interpretation of results: ZX, JW

Draft manuscript preparation: ZX, JW

Critical revision of the article: ZX, JW

Other (study supervision, fundings, materials, etc...): ZX, JW

All authors (ZX, JW) reviewed the results and approved the final version of the manuscript.

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