Observational Study

Medicine

OPEN

Comparison of perioperative outcomes between endoscope-assisted technique and handheld acoustic Doppler for perforator identification in fasciocutaneous flaps

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Abstract

The endoscopic technique has been utilized to harvest muscle flaps and detect perforators of fasciocutaneous flaps. This study aimed to compare the perioperative outcomes between the endoscope-assisted technique and handheld acoustic Doppler for perforator identification in fasciocutaneous flaps.

This retrospective case-control study included patients who underwent fasciocutaneous flap reconstruction for traumatic soft tissue defects. In the case group, perforator identification was assisted by the endoscope-assisted technique. In the control group, age- and sex-matched patients received handheld acoustic Doppler to detect perforators. Perioperative outcomes, flap characteristics, and postoperative complications were compared.

There were 12 patients in the case group and 12 in the control group. Compared with the control group, the case group had a significantly shorter length of donor-site wounds (9 cm vs 12 cm, $P=.023$) and a significantly smaller proportion of patients receiving skin grafting at the donor sites (0% vs 41.7%, $P=.037$). The case group had a longer operative time, but the difference was not statistically significant (180 minutes vs 150 minutes, $P=.367$). The amount of blood loss, the time length of postoperative drainage, and complications did not significantly differ between the 2 groups.

The endoscope-assisted technique for perforator identification of fasciocutaneous flaps provided less donor-site morbidity and a significantly shorter length of donor-site wounds than the conventional handheld acoustic Doppler, which suggests that this technique could be a valuable alternative when a precise design is indicated.

Keywords: endoscopy, perforator flap, reconstructive surgical procedures, soft tissue injuries

1. Introduction

Endoscopic surgery has been widely utilized in reconstructive surgery. Many studies have clearly described the use of the endoscopic technique to harvest muscle flaps.[1–3] In a case report in 2012, Katsuragi-Tomioka et al[4] was the first to apply the endoscopic technique to assist in harvesting fasciocutaneous flaps. Subsequently, Huang et al[5] demonstrated the feasibility of the endoscope-assisted method in identifying perforators of fasciocutaneous flaps for 9 consecutive patients. Both Katsuragi-Tomioka et al[4] and Huang et al[5] commented that the endoscope-assisted method could provide a precise flap design and reduce the sacrifice of donor sites because the perforator was directly localized by endoscopic vision.

As the survival of a patient with a perforator flap profoundly depends on a reliable perforator, numerous tools have been used to identify them. Currently, the handheld acoustic Doppler is the most available modality.[6] To evaluate the clinical effectiveness of the endoscope-assisted method, this study compared the perioperative outcomes of fasciocutaneous flap reconstruction using an endoscope-assisted method for perforator identification with those using a traditional handheld acoustic Doppler.

2. Materials and methods

2.1. Subjects

This retrospective case-control study was ethically approved by the Institutional Review Board of National Yang-Ming University Hospital. The inclusion criteria for the case group

Editor: Johannes Mayr.

Ethical approval: This is a retrospective study, for this type of study formal consent is not required.

Informed consent: This article does not contain any studies with human participants performed by any of the authors.

No funding was received for this research.

The authors declare that they have no conflict of interest.

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Medicine (2018) 97:22(e10849)

Received: 6 February 2018 / Accepted: 1 May 2018

http://dx.doi.org/10.1097/MD.0000000000010849

were: patients who underwent fasciocutaneous flaps reconstruction for traumatic soft tissue defect with tendon or bone exposure during the period from January 2012 to December 2016; those in which perforator identification was assisted by the endoscopic technique. Patients with peripheral arterial occlusive disease or severe infections were excluded.

The inclusion criteria for the control group were age- and sex-matched patients of the case group; patients who underwent fasciocutaneous flap reconstruction for traumatic soft tissue defect with tendon or bone exposure during the period from January 2010 to December 2011; those in which perforator identification was assisted by traditional handheld acoustic Doppler. Patients with peripheral arterial occlusive disease or severe infections were excluded.

2.2. Surgical technique

Details of the endoscopic technique have been described in the previous report.[5] Briefly, in the beginning, the temporary designed flap was marked on the skin. One 5-mm trocar was then inserted through a 1-cm endoscopic incision (Fig. 1A). After creating a virtual cavity by insufflating CO_2 with a pressure of 12 mmHg, a 5-mm 30-degree angled endoscopic camera, micro-dissectors, and retractors were inserted. Under endoscopy, the fascia was dissected directly in the subfascial plane and a perforator was identified (Fig. 1B). The exact location of the perforator was marked on the skin and the fasciocutaneous flap was designed (Fig. 1C). After harvesting the perforator, with preservation of its perforator pedicle, flap advancement was performed and the skin defect of the donor site was closed (Fig. 1D).

2.3. Handheld acoustic Doppler

A handheld acoustic Doppler sonography, LifeDop 150 (Summit Doppler Systems Inc., CO), was used to detect the arterial perforators preoperatively. At the preoperative examination,

Figure 1. A 58-year-old man underwent fasciocutaneous flap reconstruction for traumatic soft tissue defect at the left inguinal area using the endoscope-assisted technique for perforator identification. (A) Through a 1-cm endoscopic incision, standard endoscopic instruments were inserted to identify the perforators. After identifying the perforator, its exact location was marked on the skin and the flap was also designed; e: endoscopic incision. (B) Under endoscopy, the perforator was identified under direct vision; f: fascia; p: perforator; m: muscle. (C) The perforator was harvested with preservation of the perforator pedicle. (D) Fasciocutaneous flap advancement was performed and the skin defect of the donor site was closed directly. (E) Four months postoperatively, both the donor-site and recipient-site wounds and the fasciocutaneous flap healed well.

Figure 2. (A) A 59-year-old man had traumatic soft tissue defect with implant exposure at the right pre-tibia area. (B, C) A random flap was used for reconstruction of the soft tissue defect. The perforator of the flap was identified via a handheld acoustic Doppler scanner. The residual skin defect was healed by secondary intention. (D) The 3-month postoperative follow-up showed survived flap and healed wound.

each patient was placed in the same position for the operation. The procedures of Doppler scanning were previously described.[7,8] After finding the sites of the acoustically loudest signals, the locations of the perforating arteries were marked on the skin (Fig. 2).

2.4. Evaluation

In addition to baseline demographic characteristics, flap characteristics were recorded, including the length and size of the flaps, type of perforators, and donor sites. Perioperative data (i.e., the length of incision, operative time, blood loss) and postoperative complications were also analyzed. Postoperatively, all patients were requested to receive outpatient follow-ups for at least 3 months.

2.5. Statistical analysis

The continuous variables were presented as median (interquartile range) and the categorical variables were presented as count (percentage). Normality of variable distribution was evaluated by the Shapiro-Wilk test. However, because of the small sample size, we still used nonparametric methods to compare the characteristics between the 2 groups. The Mann–Whitney *U* test and Fisher Exact test were used for continuous variables and categorical variables, respectively. A 2-tailed $P<.05$ indicated statistical significance. All analyses were performed using IBM SPSS Statistics for Windows, Version 19.0 (IBM Corporation, Armonk, NY).

3. Results

A total of 24 patients who met the eligibility criteria were included in this study: 12 consecutive patients in the case group and 12 patients in the control group. There was no significant difference in age, sex, and body mass index between the 2 groups (Table 1). Regarding the flap characteristics, the case and control groups showed no significant difference in the flap length ($P=.430$), flap size ($P=.589$), the type of perforator ($P=.640$), and the distribution of donor sites ($P=.500$).

As presented in Table 1, the case group had a significantly shorter length of the donor-site wound than the control group (9 cm vs 12 cm, $P=.023$). The case group had a numerically longer operative time, but it did not achieve a statistical significance (180 minutes vs 150 minutes, $P=.367$). The amount of blood loss

Table 1

Demographic characteristics, flap characteristics, and surgical information of the case and control groups.

Variables	Case (n=12)	Control (n=12)	P
Age, y	59 (49–69)	58 (50–71)	.94
Gender*			1.00
Male	11 (91.7)	11 (91.7)	
Female	1 (8.3)	1 (8.3)	
Body mass index, kg/m^2	24.7 (21.8–28.7)	25.5 (22.2–28.1)	.93
Flap characteristics			
Length, cm	4 (2–7)	4 (1–8)	.43
Size, cm^2	12 (4–48)	14 (5–40)	.59
Type of perforator*			.64
Transmuscular flap	2 (16.7)	4 (33.3)	
Septocutaneous flap	10 (83.3)	8 (66.7)	
Donor site*			.50
Anterolateral thigh flap	2 (16.7)	4 (25.0)	
Fibular flap	9 (66.6)	6 (46.7)	
Medial gastrocnemius flap	1 (16.7)	2 (33.3)	
Surgical data			
Length of donor-site wound, cm	9 (7–12)	12 (9–14)	.02
Operative time, min	180 (130–155)	150 (125–165)	.37
Blood loss, mL	125 (90–170)	135 (95- 165)	.75
Period of postoperative drainage, d	7 (6–8)	8 (6–9)	.21
Complications*			
Donor site	0 (0)	2 (16.7)	.48
Recipient site	2 (16.7)	1 (8.3)	1.00
Period of follow-up, mo	4.4 (3.8–4.9)	4.9 (3.3–5.6)	.31

* Data were presented as median (interquartile range) or count (percentage).

and time length of postoperative drainage did not significantly differ between the 2 groups. Notably, all the donor sites of the case group were closed directly, but 5 patients received skin grafting at the donor sites (0% vs 41.7%, $P=.037$). The post hoc power analysis revealed that the statistical power was 81.2%.

In this study, no patient experienced flap failure. Two patients (in the control group) had dehiscence of the donor-site wounds, which healed well after frequent dressings. Three patients (2 in the case group and 1 in the control group) experienced infections of recipient-site wounds, which recovered after intravenous antibiotic treatment. Both groups had median periods of follow-up of >4 months (Table 1).

4. Discussion

In this study, the perioperative outcomes of the endoscope-assisted technique were similar to those of the traditional handheld acoustic Doppler. There were no significant differences regarding operative time, blood loss, period of postoperative drainage, and complications between the 2 methods. However, we observed a significantly shorter length of the donor-site wound and less donor-site morbidity in the patients receiving the endoscope-assisted technique for perforator identification of fasciocutaneous flaps.

The application of an endoscope-assisted method for fasciocutaneous flap reconstruction was first addressed by Katsuragi-Tomioka et al,[4] who demonstrated the technique in anterolateral thigh flap of a representative case. The author commented that the technique could reduce the sacrifice area of the donor site. This study observed that patients receiving the endoscope-assisted method had a significantly shorter length of the donor-site wound. Additionally, the donor sites of the case group were closed directly and free from any complications, even for the largest flap, sized 48 $(6 \times 8)\,cm^2$. However, in the control group, 5 patients received skin grafting at the donor sites and 2 patients had dehiscence of the donor-site wounds. Although the comparison of donor-site morbidities between the endoscope-assisted method and the handheld Doppler did not achieve a statistical significance, we agreed with Katsuragi-Tomioka et al[4] and believed that our results provided clinical proof for their comments.

The disadvantages of the endoscopic assisted method are similar to those of all the other endoscopic procedures. It is experience-dependent, more time-consuming, and costly. Our results revealed that the case group had a notably longer operative time than the control group, but the difference did not achieve a statistical significance. The difference occurred because the handheld Doppler can be used preoperatively, but the endoscopic technique cannot.[7,8] Some people criticized that the physical manipulation of endoscopy might potentially increase the risk of vessel injuries.[9] However, the endoscope-assisted technique is only used to identify the location of the perforators, not for dissecting or raising the flaps. We believe that the risk of vessel injuries in the endoscope-assisted technique is similar to that of the direct open exploration. As plastic surgeons become more familiar with the endoscopic technique, the limitations would be minimized gradually.

Since the survival of a flap depends on a reliable perforator, the anatomical variation of perforator characteristics is a challenge for flap surgery.[10,11] Although direct open exploration of a flap can bring the most accurate information of the perforator, the procedure also results in huge damage to the donor site. To obtain a reliable perforator and to minimize the morbidity of the donor site, numerous tools have been developed for preoperative perforator mapping; for example, the handheld acoustic Doppler,[6] Color Duplex ultrasound,[12] contrast-enhanced ultrasound,[13] computed tomography angiography,[14] and magnetic resonance angiography.[15] However, these tools have their own pros and cons.

The handheld Doppler has several advantages, as it is easy to learn, portable, and available in most hospitals.[6] However, it was observed that the reliability of the Doppler scanner depends on the size of vessels.[16] The background noises often decrease its specificity, and its sensitivity is too high to detect adequate arteries.[7,8,16,17] The Color Duplex sonographer has higher accuracy than acoustic Doppler, but it is more experience-dependent and its application is limited by tight fascia and tortuous arteries.[18]

The contrast-enhanced ultrasound,[13] computed tomography angiography,[14] and magnetic resonance angiography[15] have a much higher accuracy. In the study by Gao et al,[13] computed tomography angiography showed sensitive and reliable results of diagnosing and grading vascular stenosis of the pedicles of head and neck free flaps. A prospective study also revealed excellent performance of magnetic resonance angiography in evaluating vasculature of arteriovenous malformations of the head and neck.[15] However, these tools had some disadvantages regarding cost, contrast allergy, length of time, and radiation exposure.

Notably, the aforementioned tools have fundamentally different principles of the endoscope-assisted technique. The above tools detect arterial perforators in an indirect way and the endoscope-assisted technique identifies the perforators under direct vision, which is similar to direct open exploration. Therefore, this study did not aim to evaluate the accuracy of the endoscope-assisted technique because we believe that to compare the perioperative outcomes between the 2 methods with different principles can provide more clinical information than comparing the accuracy.

There are several limitations in this study. The first one came from the retrospective study design. Potential selection and report bias could not be avoided. Second, the sample size was small and multivariate analysis could not be performed. Third, all patients underwent operations performed by the same plastic surgeon, which decreases the external validity of this study. However, because all patients had the same surgeon, this might also be an advantage of equal conditions for all patients. Fourth, we only compared the endoscope-assisted technique with the handheld acoustic Doppler because the handheld Doppler is the most widely available tooled to identify the perforators. Comparisons with the other modalities, for example, Color Duplex sonographer or computed tomography angiography, deserve more investigations.[12,14] Last, we did not evaluate the long-term functional recovery of the flaps. Regarding the pathological process of wound healing, the inflammatory phase and fibroblast proliferation phase are completed approximately within 3 weeks. After 7 weeks, a wound will reach about 70% of the strength of the undamaged tissue.[19] In this study, the minimum follow-up period of 3 months was requested for all patients, and we believe it was enough to monitor flap survival.

5. Conclusion

In this study we observed that the endoscope-assisted technique for perforator identification in fasciocutaneous flap provided less donor-site morbidity and a significantly shorter length of the donor-site wound than the conventional handheld acoustic Doppler, which suggests that this technique could be a valuable alternative when a precise design is indicated.

Author contributions

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