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Reconstructive

Modified Preparatory Intravascular Stenting Technique in Super-microsurgical Lymphaticovenular Anastomosis for the Treatment of Lymphedema

Takashi Nuri, MD, PhD
Akinori Asaka, MD
Yuki Otsuki, MD, PhD
Koichi Ueda, MD, PhD

Summary: Clinical studies have reported that lymphaticovenular anastomosis (LVA) is more effective for early-stage lymphedema. However, the diameter of lymphatic vessels in early-stage lymphedema is thin (only about 0.3 mm). In this article, we report a modified preparatory intravascular stenting technique (PIST) for LVA with smaller lymphatic vessels and present the results of its application for the treatment of secondary lymphedema. In this technique, a 9-0 nylon thread is inserted into the target lymphatic vessel. Then, the thread is pulled until its tip has entered the lymphatic vessel. After that, the thread is allowed to proceed into the lumen by pushing it. Finally, with the nylon in place, the lymphatic vessel is transected and the lumen is secured. In this report, we investigated the surgical time for LVA between 10 patients who underwent LVA with modified PIST (group A) and another group of 10 patients who underwent LVA without the technique (group B). Lymphatic lumen was secured at all sites where indocyanine green lymphangiography confirmed lymphatic flow. The average outer diameter of lymphatic vessels in group A and B were 0.36 mm and 0.53 mm, respectively. The average surgical time for LVA in group A was 136 minutes, which was significantly shorter than the 187 minutes in group B. Our results indicated that modified PIST can help secure the lymphatic lumen even when the lymphatic vessels are thin. As a result, this technique can significantly reduce the surgical time for this procedure.
(Plast Reconstr Surg Glob Open 2023; 11:e5308; doi: 10.1097/GOX.0000000000005308; Published online 4 October 2023.)

INTRODUCTION

Lymphaticovenular anastomosis (LVA) has gained popularity, and clinical studies have reported that this treatment is more effective for early-stage lymphedema. For a successful LVA, the intimal connections between blood vessels and lymphatic vessels must be sutured securely. However, the diameter of lymphatic vessels in early-stage lymphedema is thin (only about 0.3 mm), and LVA is still a demanding technique. One of the major stumbling blocks is the low visibility of the lumen after lymphatic transection.

In 2012, the authors reported a preparatory intravascular stenting technique (PIST) that helps secure the lymphatic lumen.[1] Although this technique is effective in advanced cases with dilated lymphatic vessels, the nylon thread may not pass through the lumen in early-stage lymphedema because of the characteristically thinner lymphatic vessels.

In this article, we report a modified PIST on smaller lymphatic vessels, and present the results of its application for the treatment of secondary lymphedema.

From the Department of Plastic and Reconstructive Surgery, Osaka Medical and Pharmaceutical University, Osaka, Japan.

Received for publication May 9, 2023; accepted August 21, 2023.

Presented at the 66th Annual meeting of Japan Society of Plastic and Reconstructive Surgery, Nagasaki, Japan, April 25, 2023.

DOI: 10.1097/GOX.0000000000005308

METHODS

Surgical Technique

In this technique, a 9-0 nylon thread is used. It is inserted into the target lymphatic vessel as far as it will go. After the needle is separated from the thread, the thread is slowly pulled until its tip has entered the lymphatic vessel. After that, the thread is gradually pulled

Disclosure statements are at the end of this article, following the correspondence information.

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and pushed until it can be pushed without any resistance. When the tip of the thread reaches the lymphatic lumen, there is no longer any resistance to the pushing of the thread, and it proceeds into the lumen (Fig. 1). (**See Video 1 [online],** which displays progressive modified PIST being performed on a 0.3-mm outer diameter lymphatic vessel and retrograde modified PIST on a 0.2-mm outer diameter lymphatic vessel. In each video, the right side toward the figure shows the distal side of the lymphatic vessels.) Finally, with the nylon in place, the lymphatic vessel is transected and the lumen is secured. The nylon thread can be used as a stent by inserting it into the vein to stabilize the anastomosis.

Evaluation of the Effect of Modified PIST

Under the approval of Osaka Medical and Pharmaceutical University institutional review board (No. 2022-165), we evaluated the effectivity of modified PIST by comparing the surgical time between two groups of patients with secondary lower limb lymphedema who underwent LVA in Osaka Medical and Pharmaceutical University. Between April 2021 and November 2022, 65 patients underwent LVA. Ten patients each were randomly selected with the same surgeon, the same number of anastomoses, and the same International Society of Lymphedema Staging of Lymphedema Score from those who underwent LVA with and without modified PIST. Group A consists of 10 patients who underwent LVA using modified PIST. Group B consists of another 10 patients who underwent LVA without the technique. The same surgeons performed LVAs after having 5 years of experience.

LVA was performed at four sites (dorsal foot, two sites in the lower legs, and above the knee) for patients who underwent LVA under general anesthesia. For patients who preferred local anesthesia, two LVAs were performed at sites where linear descriptions were confirmed by ICG lymphography. Surgical time was defined as the time from the start of the initial incision to skin closure.

Takeaways

Question: How can we accurately perform lymphaticovenular anastomosis (LVA) even in a small lymphatic vessels seen in the early stages of lymphedema?

Findings: To accurately perform LVA even in small lymphatic vessels seen in the early stages of lymphedema, researchers used a modified preparatory intravascular stenting technique to secure the lymphatic lumen at all sites where lymphatic flow was confirmed by indocyanine green lymphangiography. This technique significantly reduced surgical time for LVA.

Meaning: Our results indicated that modified preparatory intravascular stenting technique can help secure the lymphatic lumen, even when the lymphatic vessels are thin, and help perform LVA quickly.

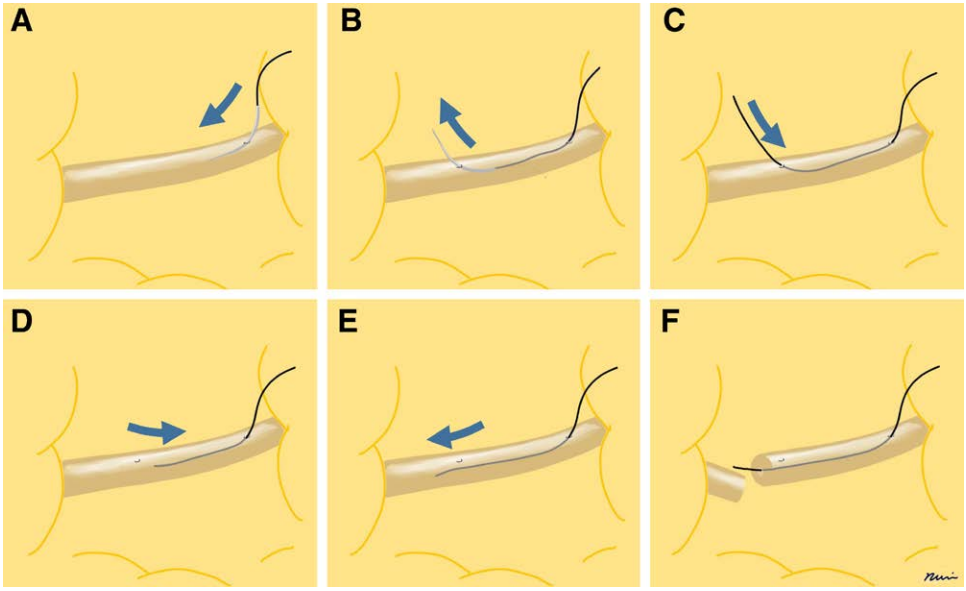

Fig. 1. Schematic diagram of modified PIST: The left side toward the figure shows the distal side of the lymphatic vessels (the brown arrows indicate the direction of lymphatic flow). A–B, The 9-0 nylon is inserted into the lymph vessel. The needle is penetrated as long as possible before penetrating out of the lymphatic vessels. C–D, Then the thread is slowly pulled until the tip of the thread has entered the lymphatic vessel. E, After that, the thread is gradually pulled, being pulled and pushed. When the tip of the thread reaches the lymphatic lumen, there is no longer any resistance to the pushing of the thread and it proceeds into the lumen. F, The inserted nylon thread is kept in place, and the lymphatic vessel is cut distal to the puncture point (The red arrow indicates the puncture point). The lumen is secured by pushing the thread out the end of the resected lymphatic vessel, and the nylon can be used as the guide stent.

Table 1. Patient Characteristics

Case	Gender	Age	ISL Stage	No. Anastomosis	Average of Outer Diameter of Lymph Vessel (mm)	Period from Initial Surgery (mo)	BMI	Time for LVA (min)
Group 1								
1	M	71	II	4	0.38	84	29	109
2	F	48	II	4	0.3	81	19	114
3	F	27	II	2	0.38	69	18	252
4	F	76	II	4	0.35	114	22	120
5	F	64	I	4	0.45	10	20	181
6	F	66	Late II	4	0.5	85	36	124
7	F	40	II	4	0.4	24	19	121
8	F	70	II	2	0.47	171	20	77
9	F	47	Late II	4	0.38	104	21	163
10	F	70	Late II	4	0.3	273	22	101
Average		57.9*		3.6*	0.39*	101.5*	22.5*	136†
Group 2								
1	F	66	Late II	4	0.35	136	22	258
2	F	38	II	4	0.4	189	24	141
3	F	60	II	4	0.53	47	23	134
4	F	59	II	4	0.48	55	17	146
5	M	72	II	4	0.28	189	24	135
6	F	41	I	4	0.75	22	19	171
7	F	79	III	2	0.48	64	38	214
8	F	59	III	2	0.53	137	51	185
9	F	73	II	4	0.75	247	18	182
10	F	80	II	4	0.75	480	24	201
Average		63		3.6	0.58	156.6	26.2	187

Group 1: patients who underwent LVA with modified PIST; group 2: patients who underwent LVA without modified PIST; ISL: International Society of Lymphedema staging of lymphedema; Time for LVA: Time from initial skin incision to end of skin suture; M, male; F, female.
*$P > 0.05$.
†$P < 0.05$.

RESULTS

In group A, nine patients were women and one was a man, with an average age of 57.9 years (27–71 years). In group B, nine were woman and one was a man, with an average age of 63 years (38–80 years; Table 1).

In group A, the average outer diameter of the lymphatic vessels was 0.39 mm (0.2–0.7mm). Among them, the modified PIST was used on 14 anastomoses in 10 cases. Of the 14 anastomoses, lymphatic lumen was secured at all sites, where ICG lymphangiography confirmed lymphatic flow (n = 13/14). The average outer diameter of these 14 lymphatic vessels was 0.36 mm (0.2–0.6 mm). In group B, the outer diameter of the lymphatic vessels was 0.53 mm (0.3–1.0 mm).

The average surgical times for LVA in group A and B were 136 minutes (77–252) and 187 minutes (134–258). Statistical analysis indicated that the surgical time of group A was significantly shorter than that of group B (Table 1).

DISCUSSION

Technical constraints that are often encountered in an LVA are (1) mismatch between the vein and lymphatic vessel calibers and (2) mismatch between the numbers of veins and lymphatic vessels.[2] Innovation techniques that have been reported to overcome these constraints can be divided into two categories: innovations in anastomotic technique and innovations in anastomotic configuration.[2–9]

In early-stage lymphedema, the lymphatic vessels are not dilated, and it is challenging to secure the lymphatic lumen. In our report, the average outer diameter of lymphatic vessels anastomosed using the modified PIST was 0.36 mm (0.2–0.6 mm). The problem is that when the lymphatic vessels are dissected, they are squashed and their lumen is obscured. It is preferable to stent the lymphatic vessels before dissecting them. For these stenting methods, 9-0 nylon is commonly used.[1,10] In the original PIST, a nylon was threaded through a lymphatic vessel using needle curvature. However, the small needle arch of microsurgical needles of approximately 6 mm limits the length of nylon, which can be retained in the lymphatic vessels. In the modified PIST, the thread is advanced into the lumen, and the nylon can be held longer in the thin lymphatic vessels. Although the thickness of the 9-0 nylon is 0.03 mm, the thickness of the needle is around 0.1mm. As a result, the needle hole is larger relative to the small lymphatic vessels, which may result in lymphatic fluid leakage and adverse effects on smooth muscle function. In the modified PIST, the tip of the thread is moved back into the distal side of the site where the needle entered. Lymphatic leakage through the hole can be avoided by dissecting the lymphatic vessels obliterating the entry point.

For experienced surgeons, the modified PIST may not always be necessary for LVA. On the other hand, it is expected to improve the accuracy of LVA for lymphatic vessels around 0.3 mm, in which the lumen is expected to collapse and become unidentifiable. Our results showed that the modified PIST can significantly shorten surgical time required to secure the lumen.

This study has limitations. More cases are necessary to eliminate selection bias. Although the number of anastomoses was unified between the two groups, a prospective

study measuring the time taken per anastomosis would give a more accurate evaluation of this technique.

Takashi Nuri, MD
Department of Plastic and Reconstructive Surgery
Osaka Medical and Pharmaceutical University
569-8686, 2-7, Daigaku-Machi, Takatsuki
Osaka, Japan
E-mail: takashi.nuri@ompu.ac.jp

DISCLOSURE

The authors have no financial interests to declare in relation to the content of this article.

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