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CLINICAL ARTICLE

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Double gastroepiploic vascularized lymph node tranfers to middle and distal limb for the treatment of lymphedema

Pedro Ciudad, MD, PhD[1,2] | Oscar J. Manrique, MD[3] | Shivprasad Date, MD[1] | Mouchammed Agko, MD[1] | John Jaime Perez Coca, MD, PhD[4] | Wei-Ling Chang, BS[1] | Federico Lo Torto, MD[1] | Fabio Nicoli, MD[1] | Michelle Maruccia, MD[1] | Javier López Mendoza, MD[5] | Hung-Chi Chen, MD, PhD, FACS[1]

[1]Department of Plastic and Reconstructive Surgery, China Medical University Hospital, Taichung, Taiwan

[2]Department of Biological Science and Technology, China Medical University, Taichung, Taiwan

[3]Division of Plastic and Reconstructive Surgery, Mayo Clinic, Rochester, Minnesota

[4]Institute of Biotechnology, National Chung Hsing University, Taichung, Taiwan, Republic of China

[5]Hand and Microsurgery Clinic, Hospital Ángeles del Pedregal Ciudad de México, México

Correspondence
Pedro Ciudad, MD, PhD, Department of Plastic Surgery, China Medical University Hospital, 2 Yuh-Der Road, Taichung 40447, Taiwan.
Email: pciudad@hotmail.com

Abstract

Background: Vascularized lymph node (VLN) transfer for lymphedema treatment has shown promising results. Optimal donor and recipient sites remain a matter of debate. We describe the technique and outcomes of a laparoscopically harvested extended gastroepiploic VLN flap with two levels of inset.

Patients and Methods: Between 2014 and 2015, four-patients with upper limb breast cancer-related lymphedema and three-patients with lower limb pelvic cancer-related lymphedema who underwent VLN transfers were included. After harvest, the gastroepiploic VLN flap was divided into two halves that were separately inset at the level of elbow and wrist (upper limb) or knee and ankle (lower limb). The mean patient age was 53.1 years (range, 42–65 years).

Results: The average flap size after division was 6.3 cm in length (range, 5–7 cm) and 3.4 cm in width (range, 3–4 cm). The mean pedicle length was 3.2 cm (range, 2.5–4 cm). All flaps survived completely. No donor or recepient site complication was noted. At a mean follow-up of 9.7 months (range, 8–11 months), the mean circumference reduction rate was 43.7 ± 2.5% along the entire limb ($P < 0.05$). No episode of infection was noted postoperatively.

Conclusions: Double gastroepiploic VLN transfers to middle and distal limb are a safe approach with very promising results. This technique may be used to improve clinical outcomes by enhancing the lymphatic drainage of the entire affected limb in a uniform fashion. In addition, the laparoscopic harvest can provide decreased donor site morbidity with a faster recovery.

1 | INTRODUCTION

The most common microsurgical techniques used for the treatment of extremety lymphedema include lymphaticovenular anastomosis (LVA; Boccardo, Casabona, DeCian, Friedman, Murelli, Puglisi, … Campisi, 2014; Campisi, Boccardo, Zilli, Maccio, & Napoli, 2001; Chang, Suami, and Skoracki, 2013; Yamamoto, Chen, Yamamoto, Yoshimatsu, Tashiro and Koshima, 2015) and vascularized lymph node (VLN) transfer (Barreiro, Baptista, Kasai, Dos Anjos, Busnardo, Modolin, & Ferreira, 2014; Becker, Vasile, Levine, Batista, Studinger, Chen, & Riquet, 2012; Ciudad, Kiranantawat, Sapountzis, Sze-Wei Yeo, Nicoli, Maruccia, … Chen, 2015; Ciudad, Maruccia, Socas, Lee, Chung, Constantinescu, … Chen, in press; Cheng, Huang, Nguyen, Saint-Cyr, Zenn, Tan & Lee, 2012; Ito & Suami, 2014; Lin, Ali, Chen, Wallace, Chang, Chen & Cheng, 2009; Raju & Chang, 2015; Sapountzis, Singhal, Rashid, Ciudad, Meo, & Chen, 2013; Silva & Chang, 2016). In the last decade, the use of VLN transfer has gained interest, as it has been shown to be an

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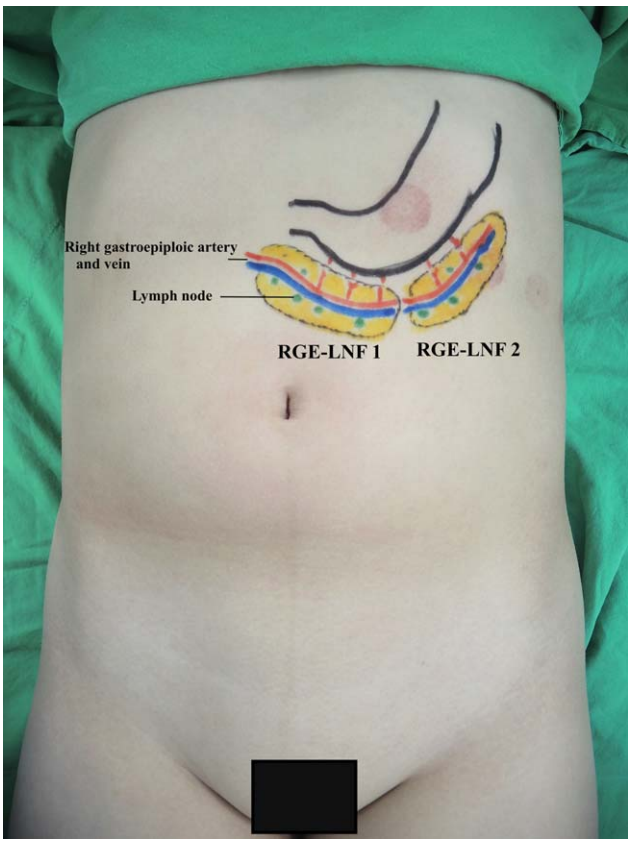

FIGURE 1 Design of the extended gastroepiploic VLN flap

effective way to reduce limb volumes, decrease episodes of cellullitis and improve quality of life (Cheng et al., 2012; Ciudad et al., 2015; Dionyssiou, Demiri, Tsimponis, Sarafis, Mpalaris, Tatsidou & Arsos, in press; Ito & Suami, 2014; Raju & Chang, 2015; Silva & Chang, 2016).

Various donor sites have been described for the harvest of VLN flaps. Several clinical series describing use of groin, submental, supraclavicular, lateral thoracic, and right gastroepiploic lymph node flaps in the treatment of limb lymphedema have been published (Barreiro et al., 2014; Cheng et al., 2012; Ciudad et al., 2015; Lin et al., 2009; Sapountzis et al., 2013). While there are concerns regarding donor site lymphedema following VLN flap harvest (Azuma, Yamamoto, & Koshima, 2013; Dayan, Dayan, & Smith, 2015; Ito & Suami, 2014; Massey & Gupta, 2015; Pons, Masia, Loschi, Nardulli, & Duch, 2014; Sulo, Hartiala, Viitanen, Mäki, Seppänen & Saarikko, 2015; Vignes, Blanchard, Yannoutsos, & Arrault, 2013; Viitanen, Mäki, Seppänen, Suominen & Saaristo, 2012), there is an ongoing debate regarding the most appropriate anatomic site for flap inset.

Our group has previoulsy reported the right gastroepiploic VLN flap (Ciudad et al., 2015; in press). Over the last several years, we have employed it as the workhorse flap for the treatment of extremity lymphedema. Furthermore, in order to obtain a larger number of lymph nodes (compared to our previous study; Ciudad et al., in press) and to enhance lymphatic drainage, while reducing donor site morbidity, we decided to re-design the flap and its inset (Figure 1).

The aim of this article is to describe our experience using an extended gastroepiploic VLN flap divided into two for double VLN transfers to the middle and distal aspect of the affected limb (AL) in one stage-procedure. We describe surgical pearls and report the clinical outcomes of this novel approach to the microsurgical treatment of upper and lower extremity lymphedema.

2 | PATIENTS AND METHODS

An institutional board-approved review of a prospectively collected database on patients undergoing VLN transfer at the China Medical University Hospital in Taichung/Taiwan was undertaken. Patients with upper or lower extremity International Society of Lymphology (ISL) stage II or III lymphedema, who underwent the laparoscopically harvested extended gastroepiploic VLN transfer between August 2014 and January 2015,were included in this study. Four patients presented with upper limb lymphedema after treatment for breast cancer and three patients with lower limb lymphedema following hysterectomy and radiotherapy for gynecological cancer. The patients average age was 53.1 years (range, 42–65 years). Diagnosis was made based on past medical history, clinical examination, and lymphoscintigraphy using Technetium 99 m. Patients were staged according to the ISL classification (International Society of Lymphology, 2003). In addition, these patients received at least 6 months of unsuccessful preoperative medical conservative treatment. Patients with prior history of abdominal surgery were excluded. Demographic data, flap harvest time, total operative time, length of hospital stay, clinical outcomes, and complications were recorded (Table 1).

2.1 | Surgical technique

A supraumbilical 12 mm trocar was placed to obtain pneumoperitoneum followed by two 5 mm trocars in the right and left upper quadrants (Figure 2). The patient was then placed in a reverse Trendelenburg position to drop the omentum and help visualize the origin of the right gastroepiploic vessels. An experienced laparoscopic surgeon performed the harvest of the gastroepiploic VLN flap with the guidance of the plastic surgery team. The dissection was done using a 5-mm LigaSure Dolphin Tip Laparoscopic sealer/divider dissector (Covidien-Medtronic, Minneapolis, MN). A small omental window was created between the stomach and the transverse colon at the planned distal end of the gastroepiploic VLN flap. Meticulous dissection was first undertaken towards the origin of the right gastroepiploic artery and then in the opposite direction along the poximal greater curvature. The left gastroepiploic vessels were then identified and carefully ligated. Using sharp and blunt dissection, the right gastroepiploic artery and vein were exposed and individually ligated. This allowed a harvest of a flap ~15 cm in length and 3–4 cm in width. Special attention was exercised to prevent devascularization of the flap or injury to the stomach and/or transverse colon (Supporting Information Video 1).

Once the flap was harvested, it was retrieved from the abdominal cavity and placed on a side table for preparation with the aid of the microscope or magnifying loupes. The course of the gastroepiploic vessels was identified and careful dissection was performed at the center of the flap to divide the flap into two equal size lymph node flaps

TABLE 1 Patients who underwent double gastroepiploic VLN tranfers to middle and distal limb for the treatment of lymphedema

Patient	Age (Years)	Diagnosis	Affected Limb	ISL Stage	Duration of symptoms (months)	Flap Harvest Time (min)	Flap dimensions		Pedicle length		Recipient vessels		Flap division time (min)	Total operating time (min)	Flap survival	Complications		Length of stay (days)	Follow up (months)	Circumference reduction rate (%)					Episodes of infection	
							(cm)	(cm)	(cm)	(cm)	Distally	Proximal				Donor site	Recipient site			AE/AK	BE/BK	AW/AA	H/F	Total	Pre-op (per year)	Post-op (follow-up)
1	42	Left breast cancer	Left upper limb	III	30	30	5.0 × 3.5	6.0 × 4.0	4	3.5	RAB-CV	AURA BV	8	240	Yes	No	No	7	8	36	35	45	44	40	2	0
2	58	Right breast cancer	Right upper limb	III	25	41	7.0 × 3.5	5.0 × 3.0	3	2.5	RA-CV	AURA BV	9	265	Yes	No	No	7	11	35	37	49	51	43	1	0
3	62	Right breast cancer	Right upper limb	III	35	39	6.0 × 3.5	6.0 × 4.0	4	3	RAB-CV	AURA BV	10	225	Yes	No	No	6	10	36	33	44	50	40.8	2	0
4	50	Left breast cancer	Left upper limb	III	36	30	6.0 × 3.5	5.0 × 3.0	4	2.5	RAB-CV	AURA BV	9	200	Yes	No	No	7	8	37	33	50	48	42	1	0
5	44	Right ovarian cancer	Right lower limb	III	41	46	6.5 × 3.0	7.0 × 3.0	3	3	MPA-MPV	MSA -GSV	8	260	Yes	No	No	7	10	44	45	53	51	48.25	3	0
6	65	Right ovarian cancer	Right lower limb	III	16	32	6.0 × 3.5	5.0 × 4.0	4	2.5	MPA-MPV	MSA -GSV	9	225	Yes	No	No	7	10	42	46	45	50	45.75	1	0
7	51	Left ovarian cancer	Left lower limb	III	21	41	6.0 × 3.0	6.0 × 4.0	4	2.5	MPA-MPV	MSA - GSV	8	250	Yes	No	No	6	11	44	39	44	48	43.8	2	0
TOTAL AV (%)	53.1				29.1	37.0	6.3 x 3.4		3.2				8.7	237.9						39.1	38.3	47.1	48.9	43.7	1.71	0.0
TOTAL SD																				4.0	5.4	3.5	2.5	2.5	0.76	0.0
p-value																				0.0004[a]	0.0002[a]	0.0011[a]	0.0006[a]	0.0004[a]	0.00071[a]	

ISL: International Society of Lymphology; RAB: radial artery branch (dorsal); CV: cephalic vein; AURA: anterior ulnar recurrent artery; BV: basilic vein (branch); MPA: medial plantar artery; MPV: medial plantar vein; MSA: medial sural artery; GSV: greater saphenous vein (branch); AE: above elbow; BE: below elbow; AW: above wrist; H: hand; AK: above knee, BK: below knee, AA: above ankle, F: foot, AV (%): average percentage reduction of lymphedema; SD: standard deviation.

[a]$P < .05$.

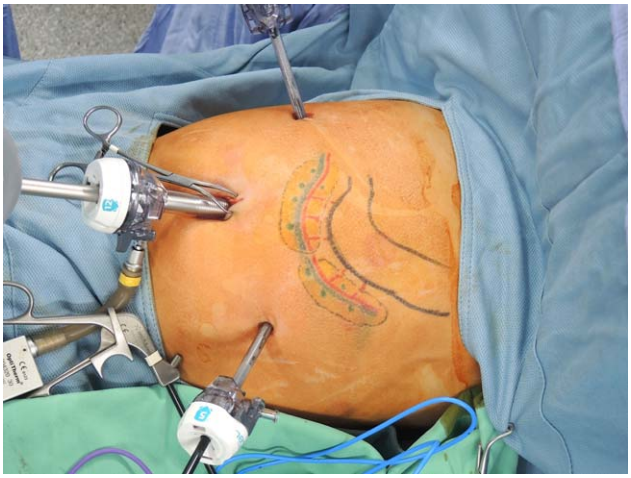

FIGURE 2 Pneumoperitoneum was established by an open Hasson technique followed by placement of a blunt 12 mm trocar in the midline 2 cm above the umbilicus and two operating 5 mm trocars on the right and left upper quadrants lateral to the rectus sheath

(Figure 3). All vascular and lymphatic vessels were carefully ligated during this division (Supporting Information Video 2).

The flaps were then inset at two different levels for each extremity. In the upper extremity, the wrist was intially explored looking for either the dorsal branch of the radial artery for end-to-end anastomosis or the radial artery itself for end-to-side anastomosis. The second inset was at the level of the cubital fossa using the anterior ulnar recurrent artery and the basilic vein or its branch (Figure 4A). The flap inset for the lower extremity was done at the medial aspect of the ankle using the medial plantar vessels and at the popliteal fossa using the medial sural artery and venae comitantes or the greater saphenous vein as recipient vessels. (Figure 4B) The recipient sites at the middle of the limb were closed primarily, whereas in the distal limb, a split thickness skin graft was usually placed to avoid compression.

Flap monitoring was done clinically and with the help of a hand-held doppler. Patients were monitored postoperatively for 2 days in a surgical intensive care unit. They were then transferred to a regular floor and were discharged by the end of first postoperative week.

FIGURE 3 Microscope aided back table preparation of the flap with division at the center yielded two symmetric flaps. (V: vein, A: artery, LN: lymph node)

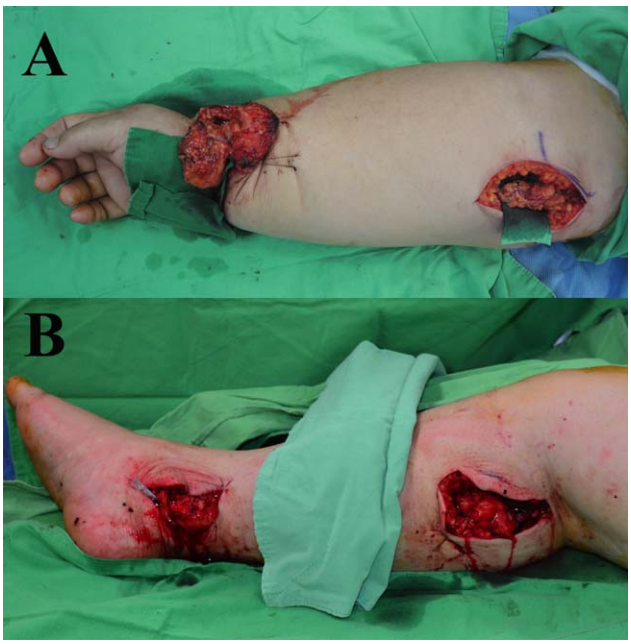

FIGURE 4 Double level inset at the middle and distal aspect of extremity. (A) Patient with upper extremity lymphedema. (B) Patient with lower extremity lymphedema

The circumference of the edematous and normal upper/lower limbs were measured at the following levels: 10 cm above the elbow (AE) or knee (AK), 10 cm below the elbow (BE) or knee (BK), 10 cm above the wrist (AW) or ankle (AA), and at the midhand (*H*) or midfoot (*F*). Serial measurements of the extremity circumference and photographs were used for objective clinical assessment. The percentage of improvement was defined as "reduction rate" comparing the AL to the healthy limb (HL) using the following equation: Circumference reduction rate (%) = [1 – (postoperative AL – HL)/(preoperative AL – HL)] ×100. Lymphoscintigraphy was performed preoperatively and at 6–8 months postoperatively. A computerized tomography (CT) scan of the extremity was performed to evaluate viability of the flaps 3 months postoperatively.

Statistical analysis was performed with Student's *t* test. Values of $P < .05$ were considered significant. All calculations were done using SPSS statistical software (Macintosh Version 21.0; IBM Corp., Armonk, NY).

3 | RESULTS

The average flap size after division was 6.3 cm (range, 5–7 cm) in length and 3.4 cm (range, 3–4 cm) in width. The mean pedicle length was 3.2 (range, 2.5–4 cm). The average time for flap harvest was 37 min (range, 30–46 min). The mean time for flap preparation and total operative time was 8.7 mins (range, 8–10 min), and 237.9 min (range, 200–265 min), respectively.

All flaps survived completely. No complications were found at the recepient site. Contrast enhanced CT scan at 3 months after surgery showed viability of all the flaps at the recipient site areas. During the period of follow-up, there were no reports of donor site lymphedema,

trocar site infection, port site hernias, intrabdominal bleeding, ileus, small or large bowel obstruction.

At a mean follow-up period of 9.7 (range, 8–11) months, the mean circumference reduction rate of the lymphedematous limb was 43.7 ± 2.5% (range, 33–50%) overall, 39.1 ± 4.0% (range, 35–44%) AE/AK, 38.3 ± 5.4% (range, 33–46%) BE/BK, 47.1 ± 3.5% (range, 44–50%) AW/AA, and 48.9 ± 2.5% (range, 44–51%) in the *H*/*F*. The application of the *t* test showed a significant circumference reduction rate at all the levels: AE/AK ($P = .0004$), BE/BK ($P = .0002$), AW/AA ($P = .0011$), and *H*/*F* ($P = .0006$).

The results of the paired sample *t* test conducted to evaluate the impact of double VLN transfers on reducing lymphedema associated infections showed that there was a statistically significant decrease ($P = .00071$).

Lymphoscintigraphy showed significant improvement in the lymphatic dranaige when compared with the preoperative scans, especially in the proximal part of the involved extremities. Length of hospital stay was 6.7 days (range 6–7 days). The results are shown in detail in Table 1.

4 | CASE REPORTS

Case 1

A 62-year-old female presented with ISL Stage III left lower extremity lymphedema and recurrent episodes of cellulitis over the AL after total hysterectomy, inguinal lymph node dissection, and post-operative radiotherapy. The patient had developed swelling of the lower limb 6 months after the surgery. After a trial with complex decongestive therapy with only minimal improvement, VLN transfer was offered to the patient (Figure 5A). Preoperative lymphoscintigraphy revealed lymphatic obstruction with delayed uptake of contrast over the left lower limb. An extended gastroepiploic VLN flap was harvested laparoscopically and was subsequently divided into two flaps, measuring 6 × 3 cm^2 and 6 × 4 cm^2 with a pedicle length of 4 and 2.5 cm, respetively. One of the flaps was anastomosed to the medial plantar artery and vein at the ankle level. The other flap was transferred to the popliteal fossa using the medial sural artery and a branch of the greater saphenous vein. No lymphatic anastomosis or other surgical procedure was performed. The total operative time was 250 min.

FIGURE 5 (A) Preoperative photograph of a patient with left lower extremity lymphedema who underwent double VLN transfers to middle and distal limb from an extended gastroepiploic VLN flap. (B) Postoperative photograph at 11 months of follow-up showed satisfactory clinical outcome with significant reduction noted at the proximal extremity

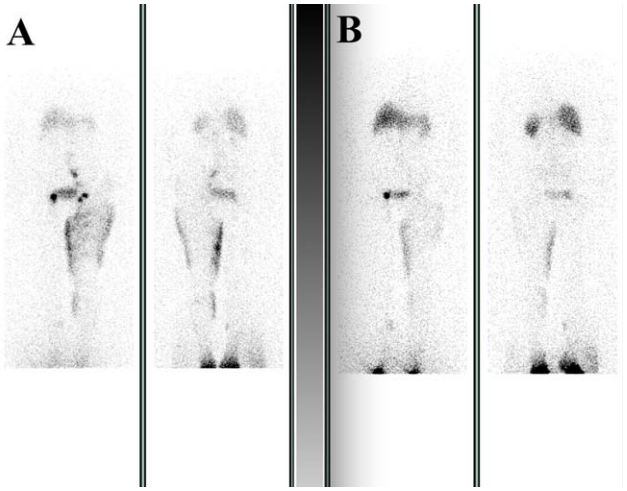

FIGURE 6 Preoperative (A) and postoperative (B) lymphoscintigraphy showed reduced dermal backflow at the proximal thigh

Postoperatively, in 3 months the AL became much lighter and softer. At 11 months of follow-up, the reduction rate of the limb circumference was 44, 39, 44, and 48% above the knee, below the knee, above the ankle, and at the foot, respectively (Figure 5B). Most importantly, antibiotics were suspended and no further episodes of infection were reported during this period. Compared with preoperative imaging (Figure 6A), postoperative lymphoscintigraphy showed that the double VLN transfers improved the lymphatic drainage of the AL uniformly and reduced the dermal backflow at the proximal thigh (Figure 6B).

Case 2

A 58-year-old woman developed breast cancer-related right upper extremity lymphedema after skin spearing mastectomy, axillary lymph node dissection and adjuvant chemo-radiotherapy. Upon presentation to our clinic two years after her breast cancer treatment, she was diagnosed with ISL Stage III lymphedema. Initially, the patient underwent complex decongestive therapy with minimal improvement in limb size or episodes of cellulitis (Figure 7A). Surgical treatment in the form of an extended gastroepiploic VLN transfer separated into two flaps for double level inset was offered. The flap was harvested laparoscopically in 41 min. After division, two flaps were fashioned, measuring 7 × 3.5 cm^2 and 5 × 3 cm^2 with pedicle lengths of 3 and 2.5 cm, respectively. One flap was placed at the wrist level using a branch of the radial artery and cephalic vein, while the other was positioned at the antecubital fossa using the anterior ulnar recurrent artery and a branch of the basilic vein. Postoperative follow-up at 11 months showed a

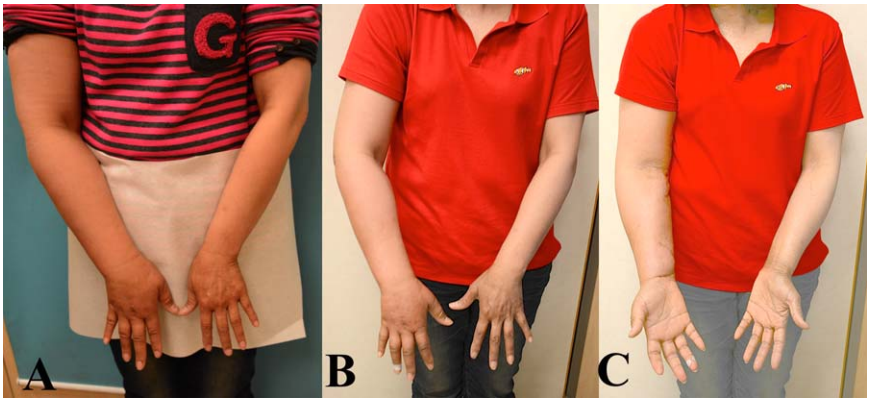

FIGURE 7 (A) Preoperative photograph of a patient with breast cancer-related upper limb lymphedema. (B) Postoperative follow-up photograph at 11-months showed significant improvement in circumference along the entire limb (dorsal view). (C) The two different levels of inset to the wrist and elbow can be identified by the scars (volar view)

circumference reduction of 35, 37, 49, and 51% at above elbow, below elbow, above wrist, and hand, respectively (Figure 7B,C). Moreover, no episodes of infection or complications were noted postoperatively.

5 | DISCUSSION

In the last decade, VLN transfer has gained popularity in the management of moderate to severe extremity lymphedema (Barreiro et al., 2014; Becker et al., 2012; Ciudad et al., 2015; Ciudad et al. in press; Cheng et al., 2012; Ito & Suami, 2014; Lin et al., 2009; Raju & Chang, 2015; Sapountzis et al., 2013; Silva & Chang, 2016). Several reports have documented a significant reduction in limb volume, improved extremity function/activities of daily living and an overall improvement in quality of life (Cheng et al., 2012; Ciudad et al., 2015; Dionyssiou et al., in press; Ito & Suami, 2014; Raju & Chang, 2015; Silva & Chang, 2016). In an attempt to find the ideal donor site, several VLN flaps have been described including groin, supraclavicular, submental, lateral thoracic area, and right gastroepiploic lymph node flap (Barreiro et al., 2014; Becker et al., 2012; Cheng et al., 2012; Ciudad et al., 2015; Lin et al., 2009).

One of the main concerns for VLN transfer is the potential for donor site morbidity. Even though the complication rate is low in published literature, several reports of iatrogenic lymphedema after VLN transfer have recently emerged (Massey & Gupta, 2015; Pons et al., 2014; Vignes et al., 2013). Marginal mandibular nerve injury, thoracodorsal nerve injury, upper or lower donor extremity lymphedema and visible scars are potential donor site morbidities with the use of the cutaneous VLN flaps.

The gastroepiploic VLN flap, which is based on the gastropepiploic vascular arcade along the greater curvature of the stomach, was described as an alternative option to avoid iatrogenic lymphedema (Ciudad et al., 2015, in press). The traditional open approach to omental flap harvest is prone to laparotomy-associated morbidities (Garderen Van, Wiggers & Van Geel, 1991). The laparoscopic approach, however, allows faster harvest with less donor-site morbidity (Salz, Stowers, Smith & Gadacz, 1993; Zaha & Inamine, 2010). Postoperative pain and therefore postoperative analgesia requirements are also decreased. In addition, the patient usually resumes food intake and ambulation the day after surgery (Zaha & Inamine, 2010). Nevertheless, complications such as injuries of the pedicle, partial graft necrosis, incisional hernia, peritonitis, injury to intra-abdominal organs, ileus or bowel obstruction, hemorrhage and wound infection have been reported in large series of laparoscopic omental flap harvest (Salz, Stowers, Smith, & Gadacz, 1993; Zaha & Inamine, 2010). In this study with a small series of patients, we did not encounter any donor site morbidity, either gastrointestinal complications, or intra-abdominal lymphedema, during the follow-up period. The length of hospital stay was relatively short (average of 6 days) and patients were able to return to their daily activities early. Admittedly, longer follow-up is required to identify any late complications such as bowel obstruction. However, it is important to highlight the limited extent of dissection during gastroepiploic VLN flap harvest as compared with total omental flap elevation. With the gastroepiploic VLN flap, only the omental tissue between the stomach and colon is harvested. This does not disturb the omental apron hanging from the transverse colon and allows retrieval of the flap through the supraumbilical trocar site without extending the incision. Thus, the reported donor site morbidity of the laparoscopic total omentum harvest does not necessarily apply to the laparoscopic harvest of the gastroepiploic VLN flap.

In cases of upper extremity lymphedema, the axilla, elbow and wrist have all been described as potential recipient sites for VLN trasnfer (Ciudad et al., 2015; Cheng et al., 2012; Ito & Suami, 2014; Lin et al., 2009; Raju & Chang, 2015). Similarly, for lower extremity lymphedema the options include the groin, knee, and ankle (Raju & Chang, 2015). The final choice of inset depends on the operating surgeon's view on the mechanism of VLN transfer (Ito & Suami, 2014; Raju & Chang, 2015). Distal sites like ankle and wrist are selected by those who believe in the "pumping" mechanism (Cheng, Huang, Wu, Yang, Lin, Henry, & Kolios, 2014). Others have suggested that a proximal "orthotopic" recipient site at the level of previous lymph node dissection is optimal after removal of scar tissue, as it simulates normal anatomy (Ito & Suami, 2014; Raju & Chang, 2015). A central location around the joint of the extremity (elbow or knee) is yet another

potential recipient site. In our experience, due to the effect of gravity the distal recipient site is certainly in a strategical position to collect the dependent lymphedema fluid. However, the proximal aspect of the limb is relatively far from the active VLN flap at the distal end. An additional second level of inset at the middle of the AL may afford improved lymphatic drainage of the proximal half of the limb. Being closer to the target area (proximal limb), the upper VLN exerts its local "sponge" effect more efficiently. At the same time, being at the most dependent portion of the proximal limb, it still collects the dependent lymphedema fluid.

We previously reported our experience with single (distal) inset of a laparoscopically harvested righ gastroepiploic VLN flap. Even though a direct comparison with our current data is not possible, the circumference reduction rates achieved at the distal aspect of the extremity are quite similar (BE/BK, AW/AA, and *H/F*). However, the improved circumference reduction rates at the proximal half of the limb (AE/AK) – 39.1 ± 4.0% in this study with double inset versus 24.4 ± 5.9% in the previous study with single inset (Ciudad et al., in press) – suggest a possible advantage of the double VLN transfers. In this study, there was a uniform reduction across the affected extremity ($P < .05$; Table 1). Moreover, no episode of lymphangitis or cellulitis was noted postoperatively and patients were able to maintain the uniform reduction in the limb size without the use of compression garments.

In the literature, there are only two case reports describing outcomes following double VLN transfers for the treatment of extremity lymphedema (Gómez Martín, Murillo, Maldonado, Cristóbal & Fernández-Cañamaque, 2014; Ito, Lin & Cheng, 2015). In the first study, a second VLN transfer to the same limb performed at a later stage was necessary to further improve clinical outcomes (limb size, skin quality). This supports the concept of double VLN transfers. In the second study, simultaneous autologous VLN trasnfers were performed from two separate donor sites. The advantage of our technique is that the two VLN transfers are performed simultaneously using a single donor site. This avoids potential complications of a second donor site and also reduces the flap harvest time. The flap preparation on the side table (division into two halves and preparation of the vessels) adds much less time (average 8.7 min) than a second flap harvest.

During double VLN transfers, there are several important considerations to take into account. When the second flap is inset in upper extremity cases, the anterior ulnar recurrent artery was chosen to preserve continuity of the major vessels. In lower extremity cases, the medial sural artery was the preferred recipient. For the latter, it is important to follow the vessel proximally in the popliteal fossa to identify either a bifurcation or a larger caliber, and therefore avoid vessel mismatch. This requires familiarity with local anatomy and a longer pedicle flap to reduce any tension during the microanastomosis. Another potential concern could be the additional recipient site. The VLN flap transfer to the middle of the limb implies an additional wound on the extremity. However, at this level usually an adequate size pocket can be created for the flap allowing primary closure of the wound. This is especially true for the lower extremity and easily applicable to VLN flaps of smaller size, such as the gastroepiploic VLN flap. To the contrary, the subcutaneous pockets created at the distal limb may not be able to cover the entire flap in some cases (5 patients), requiring skin grafts or local flaps for tension free closure. However, the aesthetic appearance of these sites can be improved at a second stage by removing the skin graft and microsurgical flap debulking without compromising the fine lymphatic channels (Ciudad, Yeo, Sapountzis, Lim, Nicoli, Maruccia, . . . & Chen, 2014).

This study is not without limitations. The main weakness of our article is the lack of lymphatic imaging techniques that could be performed at the time of harvest to confirm and identify in more detail the number of lymph nodes within each flap. However, the anatomy literature on perigastric lymph nodes has demonstrated presence of an abundant number of lymh nodes around the gastroepiploic vessels and along the greater curvature of the stomach (Borchard & Betz, 1991; Mitra Samar, 2001). Some of these nodes are not easily visible to the naked eye. During preparation of the flap under the microscope, we consistently identify visible and palpable lymph nodes on each half of the extended gastroepiploic flap. The omental tissue around the gastroepiploic vessels contains a well-vascularized, rich lymphatic network. By division of the flap into two, the amount of VLNs and lymphatic tissue transferred to a single limb is the same as with single inset. The only difference is the strategical positioning of this active lymphatic tissue by dividing into two and transferring it to two different levels.

The treatment of extremity lymphedema with VLN transfer is very promising. To reduce morbidity and improve final clinical outcomes, it is important to explore new ideas and techniques. In this limited case series, the overall results are very encouraging and the clinical utility of double VLN transfers from a single donor site harvest is presented. Currently, the gastroepiploic VLN flap is our flap of choice for VLN transfer in the treatment of extremity lymphedema due to its lymphatic properties (Morrison, 1906) and promising results (Ciudad et al., 2015; Ciudad, Manrique, Date, Sacak, Chang, Kiranantawat, . . . & Chen, 2017; Silva & Chang, 2016). We believe that patients with extremity lymphedema may benefit from double VLN transfers fashioned from a single extended gastroepiploic VLN flap divided into two. The double inset allows the underlying mechanism of the VLN transfer to take effect at the middle as well as distal region of the involved extremity.

6 | CONCLUSION

Double level VLN transfers to the middle and distal aspects of a limb using a single extended gastroepiploic VLN flap divided into two is a novel and safe approach to the treatment of extremity lymphedema with very promising results. This technique may be used to improve clinical outcomes by enhancing the lymphatic drainage of the affected limb at two different levels. In addition, the use of minimally invasive surgery techniques for flap harvest reduces donor site morbidity and allows a faster recovery. Nevertheless, larger prospective controlled studies directly comparing single level inset to double level inset in appropriately matched cohorts are necessary to confirm the validity of our conclusions on the efficacy of this technique.

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CONFLICT OF INTEREST

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article.

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