Deep inferior epigastric lymph node basin: Analysis of novel donor site for vascularized lymph node transfer among 10 consecutive patients

Oscar Ochoa MD FACS | Michael Metzner MD | Constantine Theoharis MD | Minas Chrysopoulo MD FACS | Steven Pisano MD | Chet Nastala MD FACS | Peter Ledoux MD | Gary Arishita MD | Ramon Garza III MD | Ted Snider MD

1 Plastic Reconstructive and Microsurgical Associates (PRMA), San Antonio, Texas
2 Department of Surgery, UT Health, San Antonio, Texas
3 South Texas Pathology Associates, San Antonio, Texas

Correspondence
Oscar Ochoa, 9635 Huebner Road, San Antonio, TX 78240.
Email: dr.ochoa@prmaplasticsurgery.com

Abstract

Introduction: Breast cancer-related extremity lymphedema is a potentially devastating condition. Vascularized lymph node transfer (VLNT) has shown benefit in lymphedema treatment. Due to concerns over potential iatrogenic complications, various donor sites have been described. The current study aims at defining the deep inferior epigastric lymph node basin as a novel donor site for VLNT.

Methods: A retrospective study was performed on patients undergoing routine abdominal-based breast reconstruction. Resection of all perivascular adipose and lymphatic tissue surrounding the proximal deep inferior epigastric pedicle was performed at the time of pedicle dissection and submitted for Pathologic evaluation. Patient demographics and pertinent medical/surgical history was obtained from medical records.

Results: Specimens were obtained from 10 consecutive patients. Seven patients underwent bilateral reconstruction for a total of 17 specimens obtained. Mean patient age and BMI were 48 years ± 9.4 and 27 ± 4.2, respectively. Fourteen out of 17 (82%) specimens contained viable lymph nodes displaying a thin fibrous connective tissue capsule overlying an unremarkable subcapsular sinus with a cortex and paracortex containing germinal centers composed of B lymphocytes, tangible body macrophages, and T-cells. The medullary sinus space displayed a fatty unremarkable hilum. The mean number and size of lymph nodes were 2.6 ± 1.2 nodes/specimen and 3.67 mm ± 2.3, respectively. All patients experienced an uneventful postoperative course without evidence any of compromised flap viability.

Conclusion: Lacking previous description, the deep inferior epigastric lymph node basin is a readily accessible donor site with significant anatomic advantages for potential VLNT during autologous breast reconstruction.

1 | INTRODUCTION

Breast cancer-related upper extremity lymphedema is a devastating potential ramification of lymphatic disruption caused by axillary lymph node staging and/or management of lymph node metastasis. Disruption of afferent lymphatic flow leads to pressure-driven accumulation of protein-rich fluid within the interstitial spaces leading to extremity swelling and irreversible fibrosis (Warren, Brorson, Borud, & Slavin, 2007). Reported incidence of upper extremity lymphedema following axillary lymph node dissection ranges between 12 and 49% (Kwan et al., 2002; Petrek, Senie, Peters, & Rosen, 2001). Although the introduction of sentinel lymph node biopsy techniques have decreased the incidence of upper extremity lymphedema, reported risk remains between 3.5 and 11% (DiSipio, Rye, Newman, & Hayes, 2013; Lumachi et al., 2009; McLaughlin et al., 2008).

Treatments for lymphedema range from conservative decongestive therapy, which includes exercise, compression garments, and manual lymph drainage to the growing field of microsurgical management including vascularized lymph node transfers (VLNT). VLNTs are based on the concept of implantation of healthy lymph node tissue into...
extremities where the lymphatic system has been disrupted, or where the lymph nodes are absent secondary to surgical intervention. The mechanism of how VLNTs function in reducing extremity lymphedema is still debated, but 3 primary theories that have been proposed: (1) release of obstructive scar tissue at recipient sites, (2) hydrostatic “pumping” where the lymph node acts as a pump via arterial inflow and venous outflow, and (3) lymphangiogenesis through growth factors such as VEGF-C produced by the healthy transplanted lymph node tissue (Chang & Kim, 2010; Cheng et al., 2014; Ito & Suami, 2014; Patel, Lin, & Cheng, 2015; Vilkanen, Visuri, Sulo, Saarikko, & Hartila, 2015). Despite an ill-defined mechanism of action, VLNTs have shown some promising results in the treatment of lymphedema (Nguyen et al., 2017).

One of the most common VLNT donor sites for lymph node harvest is the inguinal lymph node basin based off the superficial circumflex iliac vessels or superficial inferior epigastric pedicle. The inguinal lymph node basin could be used as an independent flap or, due to its favorable location, as a composite flap through incorporation of the lymph node harvest with an abdominal-based autologous flap for simultaneous breast reconstruction and surgical treatment of lymphedema (Becker, Assouad, Riquet, & Hidden, 2006; Nguyen, Chang, Suami, & Chang, 2015; Saaristo et al., 2012). However, concerns for potential iatrogenic lymphedema of the lower extremity following inguinal lymph node harvest (Pons, Masia, Loschi, Nardulli, & Duch, 2014; Vignes, Blanchard, Yannoutos, & Arnaud, 2013) has led to the exploration of alternative donor sites for VLNT. Alternative donor sites in clinical use include axillary/lateral thoracic, submental, supraclavicular, and omental flaps (Ciudad et al., 2017; Garza, Skoraki, Hock, & Povoski, 2017; Nguyen et al., 2015; Oi & Chang, 2017; Patel et al., 2014; Scaglietti et al., 2018).

Unfortunately, each of the donor sites described are associated with potential morbidity and variable complexity. Without a previous description in the literature as a potential source for VLNT, this study characterizes the deep inferior epigastric lymph node basin.

2 | METHODS

A retrospective study of prospectively recorded data was conducted after institutional review board approval (UT Health, San Antonio, TX) among 10 consecutive breast cancer patients that underwent deep inferior epigastric perforator (DIEP) flap reconstruction by the first author (O.O.) from March to August 2017. Among study patients, the perivascular tissue attached to and completely encasing the proximal deep inferior epigastric vessels was excised as an independent incidental procedure. Patient preoperative demographics including medical and surgical history were obtained from medical records and recorded appropriately. Patients with a history of stage IV breast cancer, recent viral illness or abdominal wall soft tissue infection, as well as, other known malignancies were excluded.

2.1 | Surgical Technique

At the time of breast reconstruction, standard DIEP flap design using the infraumbilical abdominal wall tissue was undertaken. Flap elevation and perforator selection was executed in standard fashion for each hemi-abdomen (Clemens & Nahabedian, 2011). After perforator selection, the ipsilateral anterior rectus sheath was incised vertically along the caudal and lateral aspect. The incised edges of the rectus sheath were reflected medially and laterally exposing the caudal rectus abdominis muscle. The lateral edge of the caudal rectus abdominis muscle was identified and exposed from the pedicle origin off the external iliac vessels to the bifurcation of the medial and lateral branches of the deep inferior epigastric pedicle (Figure 2).

Once exposed, the deep inferior epigastric pedicle proximal to the bifurcation was skeletonized of all perivascular adipose and lymphatic tissue until reaching the pedicle origin off the external iliac vessels under loupe magnification. Of note, vascular perforators, originating from the medial and/or lateral pedicle branches, supplying the adipocutaneous substance of the DIEP flap are located far more distally and unrelated to the LN basin discussed herein surrounding the proximal pedicle. The pedicle perivascular tissue corresponding to each DIEP flap dissected was excised and submitted for pathologic evaluation to determine number and dimension of viable lymph nodes.

3 | RESULTS

Ten consecutive patients underwent breast reconstruction with DIEP flaps and were included in the current study. Mean patient age was $48.1 \pm 9.4$ years with an average BMI of $27.6 \pm 4.2$. Seven out of 10 (70%) patients reported at least one previous abdominal surgery.
Bilateral breast reconstruction with DIEP flaps was performed in 7 patients while 3 patients underwent unilateral reconstruction for a total of 17 flaps dissected with corresponding perivascular specimens obtained for analysis.

Fourteen out of 17 study perivascular specimens (82%) contained viable lymph nodes after histologic evaluation. The deep inferior epigastric lymph nodes described herein were located along the corresponding pedicle, 6–8 cm from the pedicle origin in the preperitoneal space just proximal to its usual bifurcation (or trifurcation) into medial and lateral branches. The medial and lateral branches continue distally into their corresponding intramuscular portions, ultimately terminating in perforators entering the adipocutaneous substance of the DIEP. Each individual node displayed a thin fibrous connective tissue capsule overlying an unremarkable subcapsular sinus in association with a cortex containing follicles with germinal centers composed predominantly of B lymphocytes with occasional tingible-body macrophages. The paracortex was composed predominantly of T cells. The medullary sinus space displayed a fatty unremarkable hilum.

FIGURE 2 Intraoperative photo of deep inferior epigastric pedicle and lymph node basin isolation. The deep inferior epigastric pedicle and attached lymph node basin (over a moist 4 × 4 sponge) was dissected from the surrounding preperitoneal tissue.

Bilateral breast reconstruction with DIEP flaps was performed in 7 patients while 3 patients underwent unilateral reconstruction for a total of 17 flaps dissected with corresponding perivascular specimens obtained for analysis.

Fourteen out of 17 study perivascular specimens (82%) contained viable lymph nodes after histologic evaluation. The deep inferior epigastric lymph nodes described herein were located along the corresponding pedicle, 6–8 cm from the pedicle origin in the preperitoneal space just proximal to its usual bifurcation (or trifurcation) into medial and lateral branches. The medial and lateral branches continue distally into their corresponding intramuscular portions, ultimately terminating in perforators entering the adipocutaneous substance of the DIEP.

Each individual node displayed a thin fibrous connective tissue capsule overlying an unremarkable subcapsular sinus in association with a cortex containing follicles with germinal centers composed predominantly of B lymphocytes with occasional tingible-body macrophages. The paracortex was composed predominantly of T cells. The medullary sinus space displayed a fatty unremarkable hilum.

FIGURE 3 Photomicrograph (100×) of deep inferior epigastric lymph node (stained with Hematoxylin and eosin) showed a thin fibrous connective tissue capsule overlying an unremarkable subcapsular sinus in association with a cortex that contained follicles with germinal centers composed predominantly of B lymphocytes with occasional tingible-body macrophages. The paracortex was composed predominantly of T cells. The medullary sinus space displayed a fatty unremarkable hilum.

Life (Ahmed, Prizment, Lazovich, Schmitz, & Folsom, 2008; Morgan, Franks, & Moffatt, 2005). As a surgical treatment for extremity lymphedema, vascularized lymph node transfer (VLNT) has shown promising results (Basta, Gao, & Wu, 2014; Becker et al., 2006). VLNT for breast cancer-related upper extremity lymphedema can be performed in conjunction with an abdominal-based free flap for breast reconstruction (Becker et al., 2006; Nguyen et al., 2015; Saaristo et al., 2012) or as a solitary free flap to the axilla (Becker et al., 2012; Vignes et al., 2013) or other more distal extremity recipient sites (Cheng et al., 2013; Gharb et al., 2011; Lin et al., 2009).

In an effort to minimize iatrogenic donor site morbidity associated with lymph node harvest, various lymph node donor sites have been described and are in clinical use (Ciudad et al., 2017; Garza et al., 2017; Nguyen et al., 2015; Oi & Chang, 2017; Patel et al., 2014; Scaglioni et al., 2018). Currently, the superficial inguinal lymph node basin based off the superficial inferior epigastric or superficial circumflex iliac vessels is the most common donor site used for VLNT (Patel et al., 2014). However, due to concerns over potential development of secondary lymphedema of the lower extremity (Vignes et al., 2013), investigation into alternative potential donor sites continues.

The current study characterizes a newly described lymph node basin that, surprisingly, has escaped description in the literature despite routine exposure during abdominal-based free flap breast reconstruction through dissection of the proximal deep inferior epigastric vascular pedicle. Lymphatic drainage of the anterior abdominal wall is dependent on superficial and deep lymphatic systems. The superficial lymphatic vessels drain the infraumbilical abdominal wall soft tissues above the deep muscular fascia into the superficial inguinal lymph node basin. In contrast, the deep lymphatic vessels of the infraumbilical abdominal wall are associated with the abdominal wall musculature (Hunstad & Repta, 2009) and fascia and follow the deep inferior epigastric vessels (Felmerer, Muehlfelder, Berens von...
In a cadaveric anatomic study performed by Felmerer et al., authors injected the abdominal fascia with lymphatically collected Turnbull’s blue dye and were able to document the presence of lymphatic vessels connected by ladder-like channels along the deep inferior epigastric pedicle (Felmerer et al., 2002). The deep inferior epigastric lymph nodes characterized in this study are positioned along these previously reported lymphatic vessels surrounding the proximal vascular pedicle and form a component of the deep lymphatic system draining the anterior abdominal wall.

Viable lymph nodes located along the perivascular tissue encasing the deep inferior epigastric pedicle were found in 14 out of 17 study specimens (82%), 6–8 cm from its origin off the external iliac vessels and just proximal to the normal bifurcation of medial and lateral branches (Figure 4). As a potential source for VLNT, the viability of the deep inferior epigastric lymph nodes described in this study is based on the histologic findings associated with normal viable lymphatic tissue staining patterns and architecture. In addition, continued lymph node perfusion and viability after harvest along with the deep inferior epigastric pedicle is suggested by intraoperative indocyanine green angiographic imaging obtained after pedicle and lymph node basin dissection verifying proof of concept with perfusion of the lymph node basin while attached solely to the deep inferior epigastric pedicle (Figure 5). Due to its location, not surprisingly, harvesting of the deep inferior epigastric lymph node basin was not associated with any complications in this study.

The deep inferior epigastric lymph node basin characteristics reported in this study are comparable to other donor sites in clinical use. Consistent with previous studies characterizing other lymph node basins for VLNT, lymph node quantity within deep inferior epigastric lymph node basin specimens (mean 2.6 nodes/specimen) is similar compared to inguinal (Patel et al., 2014; Zeltzer et al., 2017), submental (Patel et al., 2014), thoracodorsal and supraclavicular donor sites (Gerety et al., 2016). Viable lymph nodes were identified in 14 out of 17 specimens (82.3%) collected in the current study. In comparison to the most popular donor site for VLNT, Zeltzer et al. reported the presence of a viable lymph node unit in only 84% of inguinal lymph node samples (Zeltzer et al., 2017). The ideal volume of transferred lymphatic tissue for effective lymphedema treatment has yet to be determined and is an area of active research. The mean diameter of histologically defined lymph nodes in the current study specimens was 3.67 mm. Interestingly, although a minimum lymph node volume has been suggested previously (Zeltzer et al., 2017), omental flaps have shown effective long-term improvements in extremity lymphedema through lymphoreticular bodies despite lacking true lymph nodes (Nguyen et al., 2017).

Conceptually, the ideal lymph node donor site characteristics should include functional lymph nodes with consistent vascular

### TABLE 1: Patient population and lymph node basin characteristics

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>BMI</th>
<th>Prior abdominal surgeries (#)</th>
<th>Laterality of reconstruction</th>
<th>Specimen side</th>
<th>Lymph node number</th>
<th>Individual lymph node size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>54</td>
<td>25</td>
<td>1</td>
<td>Bilateral</td>
<td>Right</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>41</td>
<td>29</td>
<td>1</td>
<td>Unilateral</td>
<td>Right</td>
<td>3</td>
<td>3.8</td>
</tr>
<tr>
<td>3</td>
<td>53</td>
<td>27</td>
<td>0</td>
<td>Bilateral</td>
<td>Right</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>61</td>
<td>22</td>
<td>0</td>
<td>Bilateral</td>
<td>Right</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>61</td>
<td>24</td>
<td>2</td>
<td>Unilateral</td>
<td>Right</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>36</td>
<td>28</td>
<td>2</td>
<td>Bilateral</td>
<td>Right</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>42</td>
<td>30</td>
<td>0</td>
<td>Bilateral</td>
<td>Right</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td>42</td>
<td>25</td>
<td>1</td>
<td>Bilateral</td>
<td>Right</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>53</td>
<td>29</td>
<td>3</td>
<td>Bilateral</td>
<td>Right</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>38</td>
<td>37</td>
<td>4</td>
<td>Unilateral</td>
<td>Left</td>
<td>1</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Deep Inferior Epigastric Lymph Node Basin](image.png)

**FIGURE 4** Schematic of deep inferior epigastric lymph node basin with abdominal flap reflected medially. Lymph node basin was located along the proximal deep inferior epigastric pedicle between the bifurcation of the medial and lateral branches and origin from external iliac vessels.
anatomy allowing uncomplicated and efficient dissection located in an adjacent or easily accessible operative field with negligible or absent donor site morbidity. The deep inferior epigastric lymph node basin described in this study meets all above characteristics specifically when utilized in conjunction with an abdominal-based breast reconstruction such as a DIEP or muscle-sparing TRAM flap for simultaneous breast reconstruction and VLNT. In bilateral breast reconstruction cases, flap vascular anastomosis would be required to vessels in the axilla, such as the thoracodorsal vessels, in order to inset the lymph node cluster in the native axillary LN bed. In this setting, lymph node basin location along the abdominal flap vascular pedicle carries significant advantages regarding optimization of continued lymph node function after flap transfer. Specifically, the standard paired vascular free flap anastomoses, not only provide abdominal flap perfusion and venous outflow, but also simultaneously supply the lymph node basin. This characteristic overcomes some important limitations associated with inguinal VLNT. When performed in conjunction with breast reconstruction, arterial inflow to the inguinal lymph node basin is dependent on random perfusion through the abdominal flap. Inguinal lymph node perfusion in this circumstance is unpredictable (Saaristo et al., 2012) and may be additionally compromised if lower abdominal (i.e., Pfannenstiel) incisions are present. In contrast, the deep inferior epigastric lymph node basin is axially perfused through small un-named branches directly from the deep inferior epigastric pedicle. This has been shown in the current study through indocyanine green angiographic imaging. When performing inguinal VLNT in conjunction with breast reconstruction, Saaristo et al. describes assessing lymph node perfusion clinically and performing an additional arterial anastomosis to the retrograde thoracodorsal artery if perfusion is inadequate through the abdominal flap (Saaristo et al., 2012). Parallel to arterial perfusion, venous outflow of the deep inferior epigastric lymph node basin is provided through the deep inferior epigastric vein. This configuration allows lymph node basin venous outflow through a single venous anastomosis. With simultaneous inguinal VLNT and abdominal-based breast reconstruction, an additional lymph node venous anastomosis is invariably required for proper lymphatic decompression through lymphovenous shunting (Cheng et al., 2013; Lin et al., 2009). Additional vascular anastomoses associated with inguinal VLNT can, not only be technically challenging, but also increase operative time (Saaristo et al., 2012).

Alternatively, treatment of upper extremity lymphedema and unilateral breast reconstruction could be accomplished using the contralateral DIEP flap pedicle for lymph node harvesting for axillary nodal reconstitution while maintaining preferred usage of the internal mammary vessels for ipsilateral pedicle anastomosis. While this may facilitate optimal flap positioning, venous outflow to the deep inferior epigastric lymph node basin on the contralateral pedicle may be suboptimal and possibly require an additional venous anastomosis for proper lymphovenous shunting.

As the first to describe the deep inferior epigastric lymph node basin, the current anatomic study has important limitations to consider. The relatively small sample size (17 specimens) could be expanded to include a greater number of patients to further characterize this novel lymph node basin. More importantly, the current study is lacking clinical data to demonstrate efficacy regarding improvements in upper extremity lymphedema. Given the number and size of the lymph nodes present within this lymph node station as reported by the current study in comparison to other donor sites in clinical use, there is no theoretic reason to dismiss the deep inferior epigastric lymph node basin as a viable donor site for VLNT. Furthermore, utilization of the axillary (thoracodorsal) vessels for anastomosis in bilateral cases may result in suboptimal lateral positioning of the flap substance compared to cases where the internal mammary vessels are utilized as the recipient vessels. The benefits gained by elimination of donor site morbidity and ensured perfusion of the lymph node basin based on its location in relation to the pedicle are worth noting making this technique an additional potential option in the armamentarium of the reconstructive surgeon.


