The Anatomical Basis of the Lumbar Artery Perforator Flap: A Cadaveric and Computer Tomography Angiogram Study

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Abstract

Background: Lumbar skin flaps based on cutaneous perforators arising from the lumbar artery have been described for coverage of lumbosacral defects and as free flaps for autologous breast reconstruction. Thus, the purpose of this study is to clarify anatomical aspects of the lumbar artery perforator flaps pertaining improvement in utility and design of this flap.

Methods: Five fresh human bodies were dissected and twenty three-dimensional computed tomographic (CT) angiographic previously used for the evaluation of the deep inferior epigastric perforator flap in patients that underwent breast reconstruction were evaluated. All cutaneous lumbar artery perforators were analyzed for total number, location, and external diameter.

Results: The number of perforators observed per side was 1.6±0.84 in the CT angiography and 3±1.05 in the cadaver study. Data from CT angiographies showed a mean diameter of the pedicle of 2.76±0.74 mm. This perforators were located at the mean distance from the midline (spinal process) of 76.56±6.97 mm, the mean length pedicle were 19.88±7.57 mm. Data from the cadaveric dissection study the mean diameter of the pedicle were 1.96±0.57 mm, the mean distance from the midline were 69.6±22.5 mm.

Conclusion: The lumbar artery perforator flap is based on a perforator that has a predictable location and presents a good caliber. Versatility of design of a pedicled flap as a propeller, bilobed or transposition flap based on this reliable perforator can be useful to reconstruct complex defects in the lumbar area. Preoperative planning with CT angiography is recommended to assess the location and caliber of the perforator allowing a better design of the flap.

Keywords: Lumbar artery perforator flap; Computed tomography; Cadaveric

Introduction

In 1987 a study by Taylor introduced the angiosome theory a seminal article in perforator flap surgery [1]. The advantages of perforator flaps are the ability to spare the underlying muscle; decreasing donor site functional deficit and likely pain. Since Wei [2]. Described the concept of free-style perforator flap every region of the body with matching color, texture and pliability is a potential area for harvesting a free-style perforator flap.

Oncological resections, trauma, pressure sores or congenital anomalies can causes defects on the lumbar area that need to be covered with flaps. Various flap have been proposed for the closure of posterior trunk defect [3-6]. latissimus dorsi, reverse latissimus dorsi, trapezius, levator scapulae, rhomboid, gluteal, transverse lumbosacral back flap, but they have whether donor site morbidity or a limited arc of rotation. Free flaps are also possible, but due to the paucity of recipient vessels in the posterior trunk area, make this a less reliable option. Therefore local or regional flaps are preferred due to shorter operating time and better tissue color and thickness match. Cutaneous perforators arising from the lumbar artery can be used for local propeller or perforator flap but currently, the available anatomical literature is insufficient to document the perforator location and vascular anatomy of the lumbar region to design and plan perforator-based flaps from the lumbar artery.

Therefore, the purpose of this study is to revisit, both radiologically and anatomically, the lumbar perforators and to evaluate their reliability for a lumbar artery perforator flap.
Material and Methods

The study was divided in two parts. In the first part a radiological evaluation of the lumbar area was performed. In the second part a cadaveric dissection study was undertaken.

Computed tomographic study

Twenty consecutive CT angiography, previously done for mapping of perforators of the deep inferior epigastric perforator flap used for breast reconstruction, were evaluated. All the CT angiographies were performed using a Somaton Sensation 16 machine (Siemens, Forchheim, Germany). A catheter was placed in the antecubital vein of one arm, and a bolus injection of 80 ml contrast medium (Omnipaque 300 mg/ml, GE Healthcare, Oslo, Norway) was administered through a power injector (Stellant Medrad, Indianola, USA) at 4 ml/s. The scanning delay was approximately 30s. Bolus tracking was done with the region of interest (ROI) on the aorta, just above the aortic bifurcation. Scanning was initiated approximately 10 s after the ROI reached 100 Hounsfield’s unit. The perforating vessels ≥1 mm were identified and tagged as septocutaneous (between erector spinae muscles and quadratus lumbarum) or musculocutaneous (through the quadratus lumborum muscle) and dissected till their corresponding source artery. All the perforators not coming from the lumbar artery and with a pedicle < 1 mm were excluded. The diameter of the pedicle, as the sum of the diameter of the artery, the vein and the nerve ≥1 mm was chosen because in smaller pedicles the artery would be smaller than 0.5 mm, potentially compromising and this could not supply the flap [7]. The distance from the midline, as mentioned before, and the diameter of the pedicle were taken.

Results

CT angiography scans demonstrate 1.5±0.72 perforators bigger in size of 2 mm on the right side and 1.7±0.86 good perforators on the left side (Figure 1). No significant differences between the two sides were noted. Based on cadaveric dissections ≥0.7 perforators on the right side and ≥1.4 good perforators on the left side were dissected, as for the CT angiography scan study there were non-significant differences between the two sides (Figure 2). The anatomical features and location of the perforators are displayed in (Table 1 and 2).

The course of the perforator originated from the lumbar artery which arises, as the intercostal arteries, directly from the aorta, at the level of the lumbar body (Figure 3). All pairs move posterior behind the iliopectineus muscle and then between the erector spinae and the quadratus lumborum muscles, or in front of the quadratus lumborum (only the fourth lumbar artery). Laterally to the erector spinae muscles and quadratus lumborum) or musculocutaneous from the inferior aspect of the last rib to the superior aspect of the iliac crest, and proceeded to midline. The perforating vessels ≥1 mm were identified and tagged as septocutaneous (between erector spinae muscles and quadratus lumbarum) or musculocutaneous (through the quadratus lumborum muscle) and dissected till their corresponding source artery. All the perforators not coming from the lumbar artery and with a pedicle < 1 mm were excluded. The diameter of the pedicle, as the sum of the diameter of the artery, the vein and the nerve ≥1 mm was chosen because in smaller pedicles the artery would be smaller than 0.5 mm, potentially compromising and this could not supply the flap [7]. The distance from the midline, as mentioned before, and the diameter of the pedicle were taken.

Table 1: Location and Anatomical features of the perforators in the CT Angiography Study.

<table>
<thead>
<tr>
<th>CT Angio</th>
<th>Right Side</th>
<th>Left Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of the pedicle Mean ± SD</td>
<td>2.67 ± 0.74 mm</td>
<td>2.85 ± 0.74 mm</td>
</tr>
<tr>
<td>Range</td>
<td>2.0-4.5 mm</td>
<td>2.0-4.33 mm</td>
</tr>
<tr>
<td>Distance from the midline Mean ± SD</td>
<td>76.67 ± 6.74 mm</td>
<td>74.79 ± 6.78 mm</td>
</tr>
<tr>
<td>Range</td>
<td>65-91.9 mm</td>
<td>61-100 mm</td>
</tr>
<tr>
<td>Length of the pedicle Mean ± SD</td>
<td>20.91 ± 7.53 mm</td>
<td>19.07 ± 7.62 mm</td>
</tr>
<tr>
<td>Range</td>
<td>13-37 mm</td>
<td>13-32 mm</td>
</tr>
</tbody>
</table>
Table 2: Location and Anatomical features of the perforators in the Cadaveric Dissection Study.

<table>
<thead>
<tr>
<th>Cadaveric Dissection Study</th>
<th>Right Side</th>
<th>Left Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diamter of the pedicle Mean ± SD</td>
<td>1.93 ± 0.62 mm</td>
<td>2.16 ± 0.53 mm</td>
</tr>
<tr>
<td>Range</td>
<td>1.0 mm</td>
<td>1.5-3 mm</td>
</tr>
<tr>
<td>Distance from the midline Mean ± SD</td>
<td>77.71 ± 8.87 mm</td>
<td>59.66 ± 2.21 mm</td>
</tr>
<tr>
<td>Range</td>
<td>57-105 mm</td>
<td>28-94 mm</td>
</tr>
<tr>
<td>Incidence of specimen with a muscolocutaneous course</td>
<td>40 %</td>
<td>66 %</td>
</tr>
<tr>
<td>Incidence of specimen with a septocutaneous course</td>
<td>60 %</td>
<td>34 %</td>
</tr>
</tbody>
</table>

Discussion

Acquired or congenital defects of the lumbar area are usually the result of trauma, oncological resection or pressure sores. Secondary intention healing or skin grafts are a reliable option to close defects in this area but a flap is absolutely a better option of proven efficacy. Various methods have been proposed for the closure of posterior trunk defects: latissimus dorsi, reverse latissimus dorsi, trapezius, levator scapulae, rhomboïd, gluteal, transverse lumbosacral back flap, but they have presented with whether donor site morbidity or a limited arc of rotation. Free flaps are also possible but the paucity of vessels in the posterior trunk area make this a less reliable option and local or regional flaps are preferred due to shorter operating time and better tissue color and thickness match. Cutaneous perforators arising from the lumbar artery can be used for local propellor or perforator flap but currently, the available anatomical literature inadequately documents the vascular anatomy of the lumbar perforator artery.

In 1978 Hill [5] described a transverse lumbosacral flap for the management of sacral defects with an apparent reliable proximal axial pattern, but he did not describe in detail the axial pattern and the dimension and moreover the flap has some disadvantages such limited arc of rotation and no primary closure of the donor site. Kroll and Rosenfeld [8] were the first to describe a perforator flap located in the lumbar area near the midline based on unnamed perforator. They presented 5 cases and suggested a new flap to manage lumbosacral defect reducing donor-site morbidity associated with traditional musculocutaneous flap. Ao et al. [9] in a series of 20 cases covered with perforator based flap reported the use of a perforator coming from the fourth lumbar artery. In 1999, Kato [10] as the first to provide a description of the lumbar artery perforator flap. In this article, a fluorescein injection cadaver study demonstrated that the skin territory supplied by the second lumbar artery alone was from the posterior midline to the lateral border of the rectus sheath. In their clinical series, they reported that with a single perforator a flap of 8 x 27 cm of size was safely harvested. Later on Roche et al. [11] described a pedicled flap based on single artery up to 12 x 24 cm for the management of a large lumbosacral defect. De Weerd [12] proposed a double lumbar perforator flap in a butterfly configuration to provide stable coverage, without impairing muscle function, with a low donor site morbidity and primary closure, of a large sacral defect. He reported also the preservation of the cutaneous nerve to provide sensibility to the flap. Later on, De Weerd et al. [13] proposed the lumbar artery perforator flap as an alternative for DIEP flap in breast reconstruction, with also the possibility of anastomosing the sensory nerve to the fourth intercostal nerve for a sensate flap [14]. In 2008, Arco described a case of a large lumbar defect covered with a lumbar artery perforator flap with a cranial lateral intercostal artery perforator flap and Hocaoglu et al. [15] reported the use of pre expanded free lumbar perforator flap for the anterior chest wall in pediatric patient reconstruction but with flap necrosis of 50%.

Despite many case reports there are few studies describing the radiological anatomy and the clinical reliability of lumbar perforator artery flap. Offman et al. [16] in 2005 in a series of 5 fresh cadavers injected with a lead oxide-gelatine studied the vascular anatomy of the lateral lumbar regions. A mean of 6±2 perforators was found in this study coming from the lumbar artery each side with a mean diameter 2.1±0.5 mm and a primary territory based on a single artery of 45±23 cm² with a potential territory of 210±90 cm², but there were no clinical correlations.

In 2009 Lui [17] studied the superior gluteal artery and the lumbar artery with the three dimensional angiography, by this system he calculated a mean area of vascular territory supplied by the lumbar artery was 30 cm² with a range from 14 cm² to 64 cm². In 2009 Kiil [18] was the first to use the computed tomographic angiography for the study of the lumbar vessel and the first to describe the fourth lumbar vessel as a good recipient vessel for a free flap reconstruction of the gluteal area. In our study, we found that CT angiography could detect sizable perforators (diameter of 2 mm) with a mean of 1.5±0.72 perforators on the right side and 1.7±0.86 perforators on the left side were, whereas more perforators where identified in the cadaveric dissection study 3±0.7 perforators on the right side and 3±1.4 perforators on the left side were dissected. We found all the perforators at an average distance from the midline of 78.67±6.74 mm in the right side and 74.79±6.78 mm in the left side. The length and the dimension of the pedicle were highly variable but it was always possible to find a perforator for harvesting a reliable flap.

In summary, the lumbar perforator flap has a reliable and constant vascular supply and potentially is a valuable alternative as a local flap to manage defects in the lumbar area or distally as a free flap. The CT angiography is a useful imaging tool for the preoperative assessment of the lumbar perforators above 2 mm, allowing the surgeon to easily find a good perforator for harvesting and design consequently the perforator based flap.

References