PERITONEO-CUTANEOUS PERFORATORS IN DEEP INFERIOR EPIGASTRIC PERFORATOR FLAPS: A CADAVERIC DISSECTION AND COMPUTED TOMOGRAPHIC ANGIOGRAPHY STUDY


Background: Cutaneous perforators that do not originate from the deep inferior epigastric artery (DIEA) are rare, but may significantly affect operative outcome. Peritoneal-cutaneous perforators have been described as a source for augmenting the blood flow to a deep inferior epigastric perforator (DIEP) flap, however if unrecognized, may compromise flap survival. Methods: We reviewed 375 DIEA perforator (DIEP) flaps (325 with preoperative CTA and 50 cadaveric dissections) to investigate the incidence of this anomaly. Results: We detected this variation in 3/325 (1%) of DIEP flaps following preoperative computed tomography. In 1/50 (2%) of the cadaveric specimens, a peritoneal-cutaneous perforator was found and injected with lead oxide contrast. It was shown to fill the cutaneous veins of the majority of the lower abdominal integument. Conclusion: Peritoneal-cutaneous perforators are rare anatomical variations (4/375: 1.1%) that may have significant ramifications for surgery utilizing the vasculature of the abdominal wall. CTA was significantly able to detect this anomaly and aid operative planning. Preoperative CTA helps to safely identify individual vascular anatomy including rare variations. © 2008 Wiley-Liss, Inc. Microsurgery 29:124–127, 2009.

In 2007, Lasso et al. described "epiperitoneal" perforators emerging from under the posterior fascia of the rectus abdominis muscle.¹ They used these perforators to augment the blood flow to their deep inferior epigastric artery (DIEA) perforator (DIEP) flaps. If unrecognized, the raising of an abdominal wall flap on a single perforator that does not communicate with a sufficiently sizeable pedicle, such as the DIEA, may ultimately have dire consequences for survival of the flap.

With the increasing use of preoperative imaging, an increasing amount of anatomical information can be gathered than previously appreciated.²⁻⁵ A preoperative computed tomography angiogram (CTA) can visualize the location, size, and entire course of each perforator, while previously anatomical information was only gathered intraoperatively for those perforators included in the supply to the flap.⁵⁻⁶

After unexpectedly discovering a peritoneal-cutaneous perforator intraoperatively (see Fig. 1), we sought to determine the incidence of these perforators in our collective experience of DIEP flaps and cadaveric dissections of the abdominal wall.

METHODS

Clinical Studies

A clinical study comprising 325 preoperative computed tomographic angiography (CTA) imaging studies of consecutive DIEP flaps for breast reconstruction were reviewed for the incidence of peritoneo-cutaneous perforators. The CTAs were all performed at two institutions over a 30-month period from January 2006 to July 2008, utilizing a standardized protocol, as reported previously.⁴⁻⁷ All patients were female, recruited through the two senior authors (MWA and RA). The age range was 30–70.

In total, anatomical information was gathered for over 1,500 perforators.

Cadaveric Studies

Angiographic studies were performed using 50 fresh human cadaver abdominal walls. The age span was 62 to 93 years and body habitus was highly variable. All dissections were performed at the Jack Brockhoff Reconstructive Plastic Surgery Research Unit, Department of Anatomy and Cell Biology, The University of Melbourne, with institutional ethical approval obtained.

Radio-opaque contrast mixture was constituted in anticipation of angiographic studies, utilizing the technique described by Rees and Taylor (1986).⁵ This contrast mixture combined powdered lead-oxide and gelatin, in a 50°C water suspension. Each abdominal wall specimen was harvested from its respective cadaver. In all cases, dissection of the peritoneum and transversalis fas-
cia from the deep surface of the specimen was undertaken before angiographic studies. In 49 of the 50 specimens, the deep inferior epigastric arteries (DIEAs) were identified on the deep surface of the respective specimen, and each artery was cannulated. Each DIEA was injected with this mixture, until increasing resistance was felt (after a minimum of 30 ml lead oxide per artery). Specimens were left to cool at 4°C before any dissection being performed and plain radiography (angiography) was then performed.

In one specimen, a large (3 mm) vessel was identified on the deep surface, which was cannulated with a 20-gauge cannula, and injected directly with lead oxide contrast mixture. The DIEAs were not injected in this specimen. In this specimen, the DIEAs were injected with blue ink for photographic contrast.

RESULTS

Clinical Studies

In our experience of 325 DIEP flaps with preoperative computed tomographic imaging, three peritoneo-cutaneous perforators were identified (1%). All three perforators were periumbilical perforators, located within 4 cm of the umbilicus. The course of the perforators could be seen to traverse the extraperitoneal fat, posterior rectus sheath, rectus abdominis muscle, and cutaneous fat. The perforators were seen to have no communication with the DIEA (see Fig. 2). In all cases, the perforator was highlighted and the skin marked preoperatively to warn the surgeon and prevent its use in supplying the flap.

Figure 1. Intraoperative photograph demonstrating a peritoneal-cutaneous perforator. Blue arrow demonstrates perforation of the posterior rectus sheath by this perforator.

Figure 2. Computed tomographic angiogram (CTA) axial maximum intensity projection (MIP) reconstruction, demonstrating a 1.5-mm medial row perforator supplying the abdominal wall integument. It can be seen to traverse the medial edge of rectus abdominis and originate from an intra-abdominal vessel. Blue arrow demonstrates perforation of the posterior rectus sheath by this perforator.

Figure 3. Photograph of the deep surface of a cadaveric anterior abdominal wall. An intra-abdominal perforator (black arrow) has been injected with lead oxide mixture (orange color). The deep inferior epigastric veins (DIEV) and superficial inferior epigastric veins (SIEV) have been tied off with suture material. The deep inferior epigastric arteries have been injected with blue ink for photographic contrast.
**Cadaveric Studies**

Out of a total of 50 cadaveric dissections, one peritoneal-cutaneous perforator was detected. This large (3 mm) peritoneal-cutaneous vessel was injected directly with lead oxide contrast mixture, without any other veins or arteries cannulated or injected (see Fig. 3). The DIEAs were injected with blue ink for photographic contrast. Upon plain film radiography, the angiogram was shown to be a true venogram, demonstrating that the perforator filled the superficial inferior epigastric vein (SIEV) on the left side and the deep inferior epigastric vein (DIEV) on the left and right side (see Fig. 4). This vessel thus represented a peritoneal-cutaneous perforator draining a significant amount of the superficial tissues of the anterior abdominal wall.

**DISCUSSION**

Peritoneo-cutaneous perforators have been described rarely in the literature, and the incidence of this anomaly has not been previously investigated. The importance of these vessels lies with the dire consequences that may ensue if unrecognized during the raising of a DIEP flap, or alternatively these vessels can be used to augment the blood flow to a DIEP flap. Our clinical and cadaveric studies have demonstrated an incidence of 4/375 (1.1%) for peritoneal-cutaneous perforators. The increasing use of DIEP flaps worldwide is likely to provide the number of cases where this anomaly will become clinically relevant.

In our series, we found that the use of preoperative CTA detected this anomaly and aided flap planning. While we are not aware of any described flap failures that occurred as a result of this anomaly, as perforator flaps are increasingly being considered as the gold standard in breast reconstruction, any technique to improve the speed, outcomes, and safety of these procedures should be encouraged. It is likely that even more anatomical variations and relationships will become evident with the more widespread use and refinement of imaging techniques.

Peritoneo-cutaneous perforators may be considered as representing an abnormality of vasculogenesis. While it has been long held that the umbilicus receives blood vessels from intra-abdominally, it is conceivable that the periumbilical perforators that originate intra-abdominally represent a developmental abnormality whereby umbilical vessels have developed a more extensive pattern of supply.

Previous attempts in improving outcomes for DIEP flaps have largely focused on operative technique and postoperative course modification, however preoperative planning is being increasingly recognized as an essential element of DIEP flap surgery. Adequate imaging can aid patient selection, plan the operative technique, reduce operating time, and improve operative outcomes.

The use of multislice CT angiography has recently been discovered as a powerful planning tool for DIEP flap surgery. Recent cadaveric studies have shown that the branching pattern on CT tomography is strongly correlated to the location and intramuscular course of perforators, from the main DIEA trunk to the point of the penetrating rectus sheath. As the speed, efficacy, and above all safety of these procedures is increased, they will undoubtedly be performed in more and more centers across the world, and an increasingly accurate knowledge of the vascular anatomy will become paramount for safe and efficient operating.

**CONCLUSION**

Cutaneous perforators that do not originate from the DIEA are rare (1.1% of cases), but have the possibility to significantly affect operative outcome. We support the routine use of preoperative CTA to safely identify individual vascular anatomy and to study the vascular anatomy of perforator flaps.

**REFERENCES**