



# “P<sup>6</sup>LAND”: An Educational Tool for Free Flaps

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## Abstract

### Keywords

- microsurgery
- learning
- education
- free flaps
- flap
- surgery

**Background** Microsurgical education requires both technical skill and didactic knowledge. Learners are frequently asked to describe free flaps and their knowledge tested in clinical work and during exams.

**Methods** We have created an educational tool that will aid learners in remembering important information related to flaps.

**Results** “P<sup>6</sup>LAND” which divides and organizes information into three parts: Preoperative considerations, Pedicle, Position, LANDmarks, Plane of dissection, Protection and Postoperative considerations.

**Conclusion** The aim of this paper is to further describe this educational tool and to provide a compendium for the most common fasciocutaneous, muscle, perforator, and bone flaps based on the literature. This tool was also prevalidated among a group of learners.

Microsurgical education predominantly focuses on skill acquisition with numerous courses,<sup>1</sup> simulators, and nonbiological and biological models<sup>2–5</sup> described. There is little emphasis on the microsurgical literature regarding study techniques to better understand how to raise and inset flaps safely. There are several Web sites that help provide useful summaries,<sup>6</sup> seminal papers,<sup>7</sup> and excellent textbooks.<sup>8,9</sup> Many of these references can be overwhelming and do not provide a succinct and structured way to organize this large volume of information. In addition, there is a lack of structure to learn this information, specifically, a lack of flap study mnemonics. Study mnemonics are a useful way to organize large amounts of data. “P<sup>6</sup>LAND” divides information into three parts: preoperative, intraoperative, and postoperative considerations. This organization helps highlight the important aspects of raising flaps in a succinct way. The aim of this paper is to highlight the specifics of the mnemonic and

provide an appendix for the most common fasciocutaneous, muscle, perforator, and bone flaps. The mnemonic has been referred to as P<sup>6</sup>LAND: Preoperative, Position, Pedicle, LANDmarks, Plane, Protection, Postoperative.

The order of the mnemonic refers to the steps of the procedure. For example, preoperative workup must come first and includes any physical examination maneuvers or special investigations that needs to be completed before a surgical intervention may commence. The next five focus on important steps intraoperatively including the position of the patient, the main pedicle (and corresponding venous supply and nerve supply), landmarks of the flap (markings, and proximal and distal landmarks), the dissection plane, and anatomic structures to protect when operating. Finally, the postoperative phase refers to important tests, monitoring, or investigations to monitor the viability of the flap. Below, will be a more thorough discussion of each factor.

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## Preoperative Considerations

The preoperative workup includes any physical examination tools or special investigations that need to be completed before a surgical intervention may commence. Special tests (such as an Allen's test), use of Dopplers to mark out any perforators, and imaging (i.e., computed tomography) are some examples of preoperative considerations.

## Intraoperative Considerations

### Position

Position information describes the position of the patient intraoperatively. Most flaps can be procured with the patient in supine position. Variants include lateral decubitus (such as for scapular/parascapular, latissimus dorsi [LD] flaps), prone, or modifications of supine (e.g., "frog-legged" for the gracilis flap).

### Pedicle

Pedicle information relates to the artery, veins, and possible innervation of the flap. Pedicle information, first and foremost, describes the main arterial blood inflow and the main venous outflow.

### Landmarks

"Land" stands for landmarks of the flap, which include general markings, proximal, distal, and possible medial and lateral landmarks. This provides information related to the general anatomic boundaries of the flaps. For example, the proximal landmark of an anterolateral thigh flap (ALT) is the anterior superior iliac spine while the distal landmark is the lateral border of the patella.

### Plane

The plane describes the dissection plane such as suprafascial, subfascial, intramuscular, submuscular and can refer to compartments.

### Protection

Protection refers to structures that must be protected which may be encountered during the dissection. These structures include the pedicle itself as well as other neurovascular structures or areas that may result in complications. For example, in the LD flap procurement, the thoracolumbar fascia must be carefully preserved to prevent painful postoperative lumbar hernias.

## Postoperative Considerations

Finally postoperative describes the care including flap checks (timing, assessment), need for a stepdown bed, and any other monitoring (i.e., donor site). It also refers to the position of the patient to prevent pressure at the pedicle or donor. For example, for the supraclavicular flap, the recommendation is to decrease pedicle strain by ensuring the neck is in a semiflexed position. Alternatively, after a deep inferior epigastric perforator (DIEP) harvest, the patient sits in a flexed position to prevent undue tension or pressure on the abdominal donor and incision.

**Table 1** P<sup>6</sup>LAND mnemonic details

Considerations		
Preoperative	Special tests (Allen's test, Doppler), imaging (i.e., computed tomography angiogram)	
Intraoperative	Position	Patient position
	Pedicle	Involving arteries/veins (and number) $\pm$ nerves
	Landmarks	Markings
		Proximal
		Distal
	Plane	Dissection plane
	Protection	Of neurovascular and anatomic structures during dissection
Postoperative		Flap checks, stepdown, monitoring devices, drains, positioning of patient

Please see ► **Table 1**: P<sup>6</sup>LAND mnemonic details for a concise summary. Also, see **Appendix A**: Flap mnemonic examples, for use of this mnemonic in common free flaps.

## Prevalidation of P<sup>6</sup>LAND

We have attempted validation of this mnemonic with trainees. Residents from levels 2 to 5 and fellows were included in the validation process. We randomized 40 learners into "control" and "experimental" groups with training levels considered during randomization. Both groups were asked to provide information on five most common free flaps: (1) DIEP, (2) LD, (3) ALT, (4) fibula, (5) radial free forearm flap. The "experimental" group was shown the P<sup>6</sup>LAND mnemonic. Trainees were asked to then provide information that they would typically give to examiners when asked about each flap. They were timed during the process. The trainees in the control group scored  $33.8 \pm 10.2\%$  when describing key information regarding the flaps including but not limited to pedicle, preoperative assessment, and protection of key structures, whereas the trainees in the experimental group scored  $72.9 \pm 10.2\%$ . The control group took approximately 10 minutes to discuss five free flaps, whereas the experimental group took approximately 14 minutes.

## Conclusion

In conclusion, this mnemonic, P<sup>6</sup>LAND, represents a good educational tool for trainees and residents to help in remembering key points when discussing flaps. The aim of this work was to create a mnemonic that makes logical sense and follows the natural sequence of flap procurement. This would prove to be helpful not only when learning these flaps but also when discussed in formal exams. It provides an organized way that ultimately will allow them to remember

the key points when assessing patients and performing these procedures both efficiently and safely. We believe that this manuscript is additive to the plastic surgery education literature. Much of our tools rely on memorization with the amount of information available for flaps being quite daunting. This mnemonic is helpful to distill this information therefore making it a useful adjunct.

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#### Conflict of Interest

None declared.

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**Appendix A:** Flap mnemonic examples

## Table of contents

Flap type	Anatomic location	Flap
Fasciocutaneous	Scalp	Temporoparietal fascia
	Trunk	Scapular
		Parascapular
		Groin
	Upper extremity	Deltpectoral
		Supraclavicular
		Lateral arm
Muscle	Trunk	Latissimus dorsi
		Pectoralis major
		Rectus abdominis
	Lower extremity	Gluteus maximus
		Gracilis
		Gastrocnemius
Bone	Trunk	Iliac crest
	Lower extremity	Fibula
Perforator	Trunk	Superficial inferior epigastric artery
		Thoracodorsal artery perforator
		Deep inferior epigastric perforator
	Upper extremity	Free radial forearm
	Lower extremity	Superior gluteal artery perforator
		Inferior gluteal artery perforator
		Tensor fascia lata
		Anterolateral thigh flap
		Anteromedial thigh flap

**Fasciocutaneous****Scalp****Temporoparietal fascia flap**

Preoperative (preop)	Doppler superficial temporal artery (STA)	
Position	Supine, gel donut, head turned away	
Pedicle	STA and vein N: auriculotemporal nerve	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Pitanguy's line</li> <li>• Preauricular incision extending cephalad toward vertex for 12 cm with Y-extension</li> <li>• Boundaries between zygomatic arch and temporal fusion line (within temporal fossa)</li> </ul>
	Proximal	Zygomatic arch
	Distal	Temporal fusion line
Plane	Subsuperficial temporal fascia, supra/subdeep temporal fascia	
Protection	Frontal branch, auriculotemporal n, middle temporal branch; alopecia (minimal cautery use); bony prominences—padding	
Postoperative (postop)	No direct pressure Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>10,11</sup>**Trunk****Scapular**

Preop	Doppler pedicle	
Position	Lateral decubitus (with sandbag)/prone	
Pedicle	Circumflex scapular artery (and vein)—transverse branch N: none	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Triangular space:               <ul style="list-style-type: none"> <li>- 1st line: midpoint of scapular spine to tip of scapula</li> <li>- 2nd line: at upper 2/5th of line 1, to lateral border of scapula</li> </ul> </li> <li>• Center axis on axis (transverse flap): laterally between axilla and lateral scapular border, medially midway between medial border of scapula and midline</li> <li>• Pinch test for primary closure</li> </ul>
	Proximal	Midline/scapular spine (midway between medial border of scapula and midline)
	Distal	Posterior axillary line/midback (laterally between axilla and lateral scapular border)
Plane	Subfascial plane toward triangular space (medial to lateral)	
Protection	<ul style="list-style-type: none"> <li>• Bony prominences—padding</li> <li>• Prone—globe protection, gel rolls, pillow under ankles, foam around face, arms abducted &lt; 90 degrees and externally rotated on arm boards above head</li> </ul>	
Postop	No direct pressure on flap Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>12–14</sup>



## Parascapular

Preop	Doppler pedicle	
Position	Lateral decubitus (with sandbag)/prone	
Pedicle	Circumflex scapular artery (and vein)—vertical branch N: none	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Triangular space localization landmarks               <ul style="list-style-type: none"> <li>- 1st line: midpoint of scapular spine to tip of scapula</li> <li>- 2nd line: at upper 2/5th of line 1, to lateral border of scapula</li> </ul> </li> <li>• Center skin on axis; superiorly just inferior to triangular space, inferiorly midway between tip of scapula and posterior superior iliac spine (PSIS) (oblique line)</li> <li>• Pinch test for primary closure</li> </ul>
	Proximal	Superiorly just inferior to triangular space
	Distal	Inferiorly midway between tip of scapula and PSIS (oblique line)
Plane	Subfascial plane distal to proximal	
Protection	<ul style="list-style-type: none"> <li>• Bony prominences—padding</li> <li>• Prone—globe protection, gel rolls, pillow under ankles, foam around face, arms abducted &lt; 90 degrees and externally rotated on arm boards above head</li> </ul>	
Postop	No direct pressure Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>12–14</sup>

## Groin

Preop	Femoral artery pulse, Doppler	
Position	Supine with sandbag under hip	
Pedicle	Superficial circumflex iliac artery (and vein) N: none	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Line: 2.5 cm inferior and parallel to line from pubic tubercle to anterior superior iliac spine (ASIS)</li> <li>• Flap: centered over line, 2.5 cm above and 5 cm below inguinal ligament (1/3rd above and 2/3rd below)</li> </ul>
	Proximal	Lateral (ASIS)
	Distal	Medial border of sartorius
Plane	Suprafascial plane to lateral border of sartorius then subfascial plane to medial border of sartorius	
Protection	Femoral vessels, lateral femoral cutaneous nerve	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>15–18</sup>

## Upper extremity

## Deltopectoral

Preop	Not applicable (N/A)	
Position	Supine	
Pedicle	1st to 3rd (2nd most dominant) perforating branches of the internal mammary artery (and veins) N: 2nd–4th intercostal nerves	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Mark: sternum, infraclavicular line, deltopectoral groove, anterior axillary line, and nipple</li> <li>• Boundaries between sternum to anterior axillary line               <ul style="list-style-type: none"> <li>- Superiorly from infraclavicular line to 4th intercostal space (above nipple)</li> </ul> </li> <li>• Narrower the pedicle = more arc of rotation</li> </ul>
	Proximal	Deltopectoral groove/anterior axillary line
	Distal	Sternum/infraclavicular line (to 4th intercostal space above nipple) supraclavicular
Plane	Subfascial (lateral to medial)	
Protection	Cephalic vein	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor) No direct pressure	

Sources: Adapted from.<sup>19–23</sup>

## Supraclavicular

Preop	Doppler, computed tomography angiogram (CTA)	
Position	Supine with bolster under shoulders, head to contralateral side	
Pedicle	Supraclavicular artery (with venae comitantes) N: supraclavicular nerve branches	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Triangle: inferiorly by clavicle, medially by posterior border of SCM, laterally by external jugular vein (origin of supraclavicular artery)</li> <li>• Skin island: elliptical/fusiform design over supraclavicular and shoulder/upper arm</li> <li>• Pinch test for primary closure</li> </ul>
	Proximal	Infraclavicular/base of neck
	Distal	Mid-deltoid
Plane	Subfascial	
Protection	Spinal accessory nerve and supraclavicular nerves	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor) ± drain/s Position to decrease pedicle strain (i.e., semiflexed neck position)	

Sources: Adapted from.<sup>24–26</sup>

Abbreviation: SCM, sternocleidomastoid.



**Lateral arm**

Preop	Doppler, tourniquet	
Position	Supine or lateral decubitus	
Pedicle	Posterior radial collateral artery (venous system: superficial—cephalic vein; deep—venae comitantes) N: posterior brachial cutaneous and posterior antebrachial cutaneous	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Line between deltoid insertion and lateral epicondyle</li> <li>• Skin pedicle: centered over the axis <math>\pm</math> cephalic vein if possible</li> <li>• Pinch test for primary closure</li> </ul>
	Proximal	Deltoid insertion
	Distal	Lateral epicondyle of humerus
Plane	Subfascial dissection	
Protection	Radial nerve, cephalic vein	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor) Posterior elbow splint	

Sources: Adapted from.<sup>27–29</sup>**Muscle****Trunk****Latissimus dorsi**

Preop	N/A	
Position	Lateral decubitus (sterile mayo stand with pillow and free arm draped)	
Pedicle	Thoracodorsal artery and vein; n: thoracodorsal nerve	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Mark posterior axillary line, posterior iliac crest, dorsal midline, scapula tip, T7 (uppermost medial origin), superior and lateral borders of muscle</li> <li>• Skin paddle design: transverse, vertical or oblique</li> <li>• Most inferior limit is 8 cm from PSIS</li> </ul>
	Proximal	Axillae
	Distal	PSIS/dorsal midline
	Medial	Posterior midline
	Lateral	Posterior axillary line
Plane	Supramuscular and submuscular	
Protection	Thoracolumbar fascia (thoracolumbar hernia) Bony prominences (gel pads), axillary roll, pillow between knees	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor) Drain/s in back donor	

Sources: Adapted from.<sup>30–35</sup>

**Pectoralis major**

Preop	N/A	
Position	Supine with shoulder bump, arms at sides	
Pedicle	Thoracoacromial artery and vein N: lateral + medial pectoral n	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Mark axis, sternal border, clavicle, anterior axillary line, 6th intercostal space (lower border of pectoralis major), template of deltopectoral flap (to preserve as salvage)</li> <li>• Mark skin paddle:               <ul style="list-style-type: none"> <li>- Females: horizontal line in IMF</li> <li>- Males: designed medial to NAC in males</li> </ul> </li> <li>• Boundaries of skin &gt; any skin overlying muscle</li> </ul>
	Proximal	Clavicle/lateral border of sternum
	Distal	Sternocostal head
Plane	Supramuscular plane, submuscular plane	
Protection	Internal mammary artery perforators	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor) Drains	

Sources: Adapted from.<sup>36</sup>

Abbreviations: IMF, Inframammary Fold; NAC, nipple areolar complex.

**Rectus abdominis**

Preop	Doppler	
Position	Supine	
Pedicle	Superior and deep inferior epigastric arteries, corresponding veins Innervation: intercostal nerves (7–12th)	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Mark midline, xyphoid, costal margin, umbilicus, pubis, ASIS</li> <li>• Mark skin paddle:               <ul style="list-style-type: none"> <li>- TRAM: superior incision above umbilicus to include perforators                   <ol style="list-style-type: none"> <li>1. Pinch test: inferior incision marked</li> </ol> </li> <li>- VRAM: median straight line (leaving umbilicus in situ), curvilinear laterally, directly over muscle                   <ol style="list-style-type: none"> <li>2. Pinch test: for primary closure</li> <li>3. Center paddle over muscle (or laterally if diastasis)</li> </ol> </li> </ul> </li> </ul>
	Proximal	Inframammary fold/costal margin
	Distal	Pubis crease
Plane	<ul style="list-style-type: none"> <li>• Above arcuate line: only anterior sheath</li> <li>• Below arcuate line: only muscle harvested</li> </ul>	
Protection	Note any diastasis rectus, hernias, abdominal incisions	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor) Drains	

Sources: Adapted from.<sup>37–40</sup>

Abbreviations: TRAM, transverse rectus abdominis myocutaneous; VRAM, vertical rectus abdominis myocutaneous.

## Lower extremity

## Gluteus maximus

Preop	CTA, magnetic resonance angiography, Doppler	
Position	Prone, lateral decubitus, or jackknife	
Pedicle	Superior and inferior gluteal arteries and veins, first perforator of profunda femoris artery and venae comitantes N: inferior gluteal nerve	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Mark gluteal crease</li> <li>• Four lines: <ul style="list-style-type: none"> <li>- Line 1: PSIS—coccyx</li> <li>- Line 2: PSIS—ischial tuberosity</li> <li>- Line 3: PSIS—greater trochanter</li> <li>- Line 4: greater trochanter to midpoint Line 1 (PSIS—coccyx)</li> </ul> </li> <li>• SGA = junction of medial and middle 1/3rd of Line 3 (PSIS—troch)</li> <li>• IGA = intersection Line 2 (PSIS—ischial tub) and Line 4 (greater troch to mid Line 1)</li> <li>• Line 4: piriformis muscle</li> <li>• SGA perforators above piriformis and lateral to SGA &gt;&gt; major perforator in triangle lateral to SGA and between Lines 3 and 4</li> <li>• IGA perforators below piriformis and above gluteal crease</li> <li>• Skin paddle: designed as large V-Y design (if future readvancement needed) centered over perforators if possible/over muscle</li> <li>• Rotation: inferior-based rotation with pivot point at medial base of muscle</li> </ul>
	Proximal	Third from PSIS to trochanter
	Distal	Midline (gluteal cleft)
Plane	Supramuscular, submuscular	
Protection	Sciatic nerve, posterior femoral cutaneous nerve	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor) Drain	

Sources: Adapted from.<sup>41,42</sup>

Abbreviations: SGA, superior gluteal artery; IGA, inferior gluteal artery.

## Gracilis

Preop	N/A	
Position	Supine frog-leg, lithotomy	
Pedicle	Medial circumflex femoral artery (with venae comitantes) N: obturator nerve, anterior femoral cutaneous nerve	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• ID adductor longus tendon</li> <li>• Mark axis, perforators, estimated pedicle entry, obturator nerve (2–3 cm proximal to pedicle and enters at 45 degrees angle), and skin paddle</li> <li>• Skin paddle boundaries: proximal 2/3rd of thigh, 2–3 cm on each side of muscle</li> <li>• Pinch for primary closure</li> <li>• TUG: skin paddle located transversely over perforators ~ 10 cm distal to pubic tubercle <ul style="list-style-type: none"> <li>- Placed slightly posterior to gracilis to capture the bulky tissue in gluteal region</li> <li>- o Anterior limit is femoral triangle</li> </ul> </li> </ul>
	Proximal	Medial tibial condyle
	Distal	Pubis
Plane	Subfascial	
Protection	Greater saphenous vein	
Postop	Drain	

Sources: Adapted from.<sup>43–45</sup>

Abbreviation: TUG, transverse upper gracilis

**Gastrocnemius**

Preop	Tourniquet	
Position	Supine with leg internally/externally rotated, lateral decubitus	
Pedicle	Medial and lateral sural arteries (w/venae comitantes) N: branches of the tibial nerve	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Direct access thru vertical incision 2 cm posterior to tibial border for medial, 2 cm posterior to fibula for lateral incision is in upper 1/3rd</li> <li>• Access thru existing wound</li> </ul>
	Proximal	<ul style="list-style-type: none"> <li>• Medial head: medial condyle of femur</li> <li>• Lateral head: lateral condyle of femur</li> </ul>
	Distal	Achilles tendon
Plane	Areolar plane, submuscular plane	
Protection	Lesser saphenous vein, sural nerve	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor) Elevation of lower extremity ± gentle compression dressings	

Sources: Adapted from.<sup>46–49</sup>**Bone****Trunk****Iliac crest (deep circumflex iliac artery flap)**

Preop	Doppler	
Position	Supine with bump below hip, hip slightly flexed	
Pedicle	Deep circumflex iliac artery and venae comitantes	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Markings of ASIS, inguinal ligament, femoral vessels, iliac crest, flap axis</li> <li>• Medial incision from lateral to femoral pulse to ASIS</li> <li>• Lateral incision over crest (or skin paddle)</li> <li>• Skin paddle boundaries 2/3rd above and 1/3rd below crest, from ASIS to posterior axillary line</li> </ul>
	Proximal	Medial incision over inguinal ligament—lateral to femoral pulse to ASIS
	Distal	Iliac crest/gluteus medius/tensor fascia lata
Plane	Suprafascial over external oblique	
Protection	Lateral femoral cutaneous, genitofemoral, ilioinguinal, and iliohypogastric nerves; external iliac vessels	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor) Activity modifications	

Sources: Adapted from.<sup>50,51</sup>

**Lower extremity****Fibula**

Preop	Tourniquet, CTA (especially in traumatic injuries)	
Position	Supine or lateral decubitus	
Pedicle	Peroneal artery, lateral inferior genicular artery, anterior tibial perforator, and venae comitantes N: superficial peroneal nerve	
Landmarks	Markings	
	Proximal	Head of fibula
	Distal	Lateral malleolus
Plane	Supraperiosteal, subperiosteal, intramuscular	
Protection	Compartments: lateral (common peroneal nerve, around neck of fibula), anterior compartment (anterior tibial artery), posterior (deep; peroneal artery); ankle stability (leave > 6 cm of bone proximal to lateral malleolus for ankle stability)	
Postop	Leg in splint, activity modifications, no direct pressure Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>52–54</sup>

Scapula—please see above

Sources: Adapted from.<sup>3–5</sup>**Perforator****Trunk****Superficial inferior epigastric artery**

Preop	CTA, Doppler	
Position	Supine	
Pedicle	Superficial inferior epigastric artery and venae comitantes N: segmental intercostals T10–T12	
Landmarks	Markings	
	Proximal	ASIS/pubis tubercle
	Distal	Umbilicus
Plane	Suprafascial to external oblique + internal oblique, deep to Scarpa's fascia	
Protection	Femoral vessels	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor) No full hip extension	

Sources: Adapted from.<sup>55–57</sup>

**Thoracodorsal artery perforator**

Preop	Doppler, color Doppler ultrasonography, or CTA	
Position	Lateral decubitus with shoulder abduction and 90 degree of elbow flexion (axillary roll, pillow between knees, sterile mayo stand with pillow, and arm free draped)	
Pedicle	Thoracodorsal artery (descending/vertical branch) N: posterior rami of lateral cutaneous branches of intercostal nerves	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Standard latissimus dorsi landmarks</li> <li>• Line: starting 8 cm below axilla (vascular hilum of latissimus dorsi) to PSIS</li> <li>• Skin island: centered at ant border of latissimus dorsi</li> <li>• Pinch test: identify widest portion of skin paddle to close by primary closure</li> </ul>
	Proximal	Lateral border of inframammary fold
	Distal	Latissimus dorsi muscle
Plane	Suprafascial, subfascial	
Protection	Thoracodorsal nerve	
Postop	Flap checks (Doppler, color, cap refill, temp, turgor) No full abduction of shoulder	

Sources: Adapted from.<sup>58</sup>**Deep inferior epigastric perforator**

Preop	CTA of the abdomen, Doppler	
Position	Supine	
Pedicle	Deep inferior epigastric artery, two veins N: 10th–12th intercostal n cutaneous branch/s	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Mark superior incision above umbilicus to include perforators</li> <li>• Pinch test: inferior incision marked tentatively</li> </ul>
	Proximal	Superior portion of the umbilicus
	Distal	6–8 cm superior to the vaginal cleft
Plane	Subfascial/submuscular	
Protection	Superficial inferior epigastric artery/venae	
Postop	Position: flexion of trunk Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>59–65</sup>

## Upper extremity

## Free radial forearm

Preop	Allen's test, tourniquet	
Position	Supine	
Pedicle	Radial artery + vein (venae comitantes ×2, cephalic vein) ± lateral/medial antebrachial ± lateral/medial cutaneous nerves	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• 1 cm distal to antecubital fossa to scaphoid tubercle</li> <li>• Skin boundaries between antecubital fossa and wrist crease</li> <li>• Width up to 2/3rd of forearm circumference with 1/3rd lateral to radial artery to include cephalic vein</li> </ul>
	Proximal	Midforearm
	Distal	Wrist crease
	Ulnar	Flexor carpi radialis tendon
	Radial	Brachioradialis tendon
Plane	Suprafascial and subfascial	
Protection	Flexor carpi radialis and brachioradialis tendons and paratenon; dorsal branch of the radial nerve	
Postop	Splint (if osseocutaneous), split-thickness graft for donor coverage Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>66,67</sup>

## Lower extremity

## Superior gluteal artery perforator

Preop	Doppler	
Position	Prone/lateral decubitus	
Pedicle	Superior gluteal artery (and vein) N: inferior gluteal nerve	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Mark gluteal crease</li> <li>• Mark three lines: <ul style="list-style-type: none"> <li>- Line 1: PSIS—coccyx</li> <li>- Line 2: PSIS—greater trochanter</li> <li>- Line 3: greater trochanter to midpoint Line 1</li> </ul> </li> <li>• SGA = junction of medial and middle 1/3rd of Line 2</li> <li>• Piriformis muscle = Line 3</li> <li>• SGA perforators above piriformis and lateral to SGA, major perforator in triangle lateral to SGA and between Lines 3 and 4</li> <li>• Skin paddle: oriented obliquely in superolateral direction</li> <li>• Skin pinch for primary closure</li> </ul>
	Proximal	Trochanter
	Distal	Midline (gluteal cleft)
Plane	Subfascial	
Protection	Sciatic nerve, inferior gluteal vessels	
Postop	Drain Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>68</sup>



**Inferior gluteal artery perforator**

Preop	Doppler	
Position	Prone/lateral decubitus	
Pedicle	Inferior gluteal artery (and vein) N: inferior gluteal nerve	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Mark gluteal crease</li> <li>• Mark four lines:               <ul style="list-style-type: none"> <li>- Line 1: PSIS—coccyx</li> <li>- Line 2: PSIS—ischial tuberosity</li> <li>- Line 3: PSIS—greater trochanter</li> <li>- Line 4: greater trochanter to midpoint Line 1 (PSIS—coccyx)</li> </ul> </li> <li>• IGA = intersection Line 2 (PSIS—ischial tuberosity) and Line 4 (greater trochanter to mid Line 1)</li> <li>• Piriformis muscle = Line 4</li> <li>• IGA perforators below piriformis and above gluteal crease.</li> <li>• Skin paddle: transverse paddle, 2 cm below gluteal crease; superior incision determined by pinch test and include perforators (1ry closure <math>\leq</math> 10 cm)</li> </ul>
	Proximal	Trochanter
	Distal	Midline (gluteal cleft)
Plane	Subfascial	
Protection	Sciatic nerve, superior gluteal vessels	
Postop	Drain Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>69</sup>**Tensor fascia lata**

Preop	Doppler	
Position	Supine	
Pedicle	Ascending or transverse branch lateral circumflex femoral artery and venae comitantes N: superior gluteal n, lateral cutaneous branch of T12 and lateral femoral cutaneous nerve of the thigh	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Mark: ASIS, lateral femoral condyle, axis, perforators</li> <li>• Skin paddle: ASIS to 10 cm proximal to knee; greater trochanter posteriorly to lateral edge of rectus femoris border medially               <ul style="list-style-type: none"> <li>-Leave distal 10 cm of Iliotibial tract to maintain knee stability.</li> </ul> </li> <li>• Pinch (&lt; 9 cm can close by primary intention)</li> </ul>
	Proximal	Greater trochanter
	Distal	Lateral condyle of tibia
Plane	Subfascial plane, submuscular plane	
Protection	Lateral femoral cutaneous nerve	
Postop	Hip flexion (if pedicled), drains Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>70–72</sup>

**Anterolateral thigh flap**

Preop	Doppler	
Position	Supine	
Pedicle	Descending branch of lateral circumflex femoral artery and vena comitantes N: lateral femoral cutaneous nerve	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Lines:               <ul style="list-style-type: none"> <li>-ASIS to superolateral patella</li> <li>-At midpoint, draw circle with 3 cm radius.</li> </ul> </li> <li>• Skin island: medial edge of rectus femoris to lateral edge of vastus lateralis               <ul style="list-style-type: none"> <li>- Proximally 10 cm inferior to ASIS and distally 7 cm superior to patella</li> </ul> </li> <li>• Pinch test: width of 10 cm can be taken for primary closure</li> </ul>
	Proximal	ASIS
	Distal	Superolateral border of the patella
Plane	Supra- or subfascial	
Protection	Intermuscular septum (between rectus femoris and vastus lateralis muscles) to protect vessels	
Postop	Skin graft for donor, drain/s Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>73,74</sup>**Anteromedial thigh flap**

Preop	Doppler	
Position	Supine	
Pedicle	Lateral circumflex femoral descending artery—septocutaneous branch	
Landmarks	Markings	<ul style="list-style-type: none"> <li>• Lines:               <ul style="list-style-type: none"> <li>-ASIS to superolateral patella</li> </ul> </li> <li>• Skin island: medial edge of rectus femoris to lateral edge of vastus lateralis               <ul style="list-style-type: none"> <li>- Proximally 10 cm inferior to ASIS and distally 7 cm superior to patella</li> </ul> </li> <li>• Pinch test: width of 10 cm can be taken for primary closure</li> </ul>
	Proximal	ASIS
	Distal	Superolateral border of the patella
Plane	Subfascial	
Protection	Great saphenous vein Saphenous nerve	
Postop	Drain/s Flap checks (Doppler, color, cap refill, temp, turgor)	

Sources: Adapted from.<sup>75–78</sup>