Chapter 1
Surgical Anatomy of the Abdominal Wall

Derya Bingöl, Ozay Ozkaya Mutlu, and Osman Oymak

The objective of this chapter is to concentrate the attention of the reader on particular anatomical details of the abdominal wall, which are important for the surgical perspective.

As such, the abdomen constitutes the part of the body between the thorax and pelvis. The outline of the anterior abdominal wall is approximately hexagonal in shape. It is bounded superiorly by the arched costal margin, laterally by the midaxillary lines on either side bilaterally, and the anterior abdominal wall is in continuity, by the anterior half of the iliac crest, inguinal ligament, pubic crest, and pubic symphysis, inferiorly [1].

Externally, there are three basic anatomical landmarks in the abdominal area. These lines are demarking the grooves and eminences of the abdominal area. In order to mimic this ideal anatomy and to create a beautiful result, these structures are to be recreated (Fig. 1.1).

1.1 Linea Semilunaris

The linea semilunares can be seen as a pair of linear impressions in the skin that correspond with the lateral most edges of the rectus abdominis. It is formed by the

D. Bingöl, MD
Plastic, Reconstructive and Aesthetic Surgery Clinic, Medikal Park Hospital, Bursa, Turkey

O.O. Mutlu, MD
Plastic, Reconstructive and Aesthetic Surgery Clinic, Okmeydanı Training and Research Hospital, Istanbul, Turkey

O. Oymak (✉)
Oymak Plastic Surgery Clinic (OPC), Istanbul, Turkey
e-mail: osmanoymak@opc.com.tr

K.T. Tiryaki (ed.), *Inverse Abdominoplasty*, DOI 10.1007/978-3-319-39310-0_1

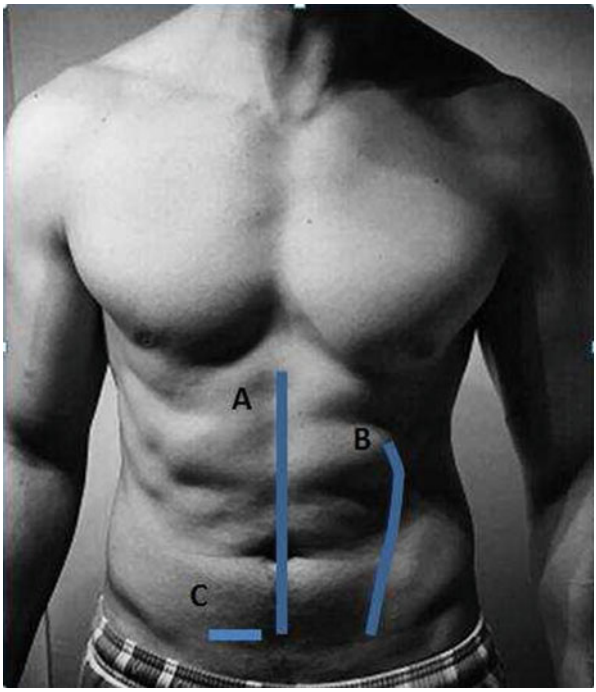

Fig. 1.1 *A* Linea alba *B* Linea semilunaris *C* Arcuate line

band of aponeuroses of the external oblique, the internal oblique, and transverse abdominal muscles [2].

1.2 Arcuate Line

The arcuate line is defined by the most inferior extension of the posterior rectus sheath, forming a crescent-shaped border. The arcuate line is generally located two fingerbreadths from the umbilicus to midway between the umbilicus and pubis. There are reports in the literature, however, that state the arcuate line is closer to 75 % of the distance between pubic crest to umbilicus or 1.8 cm superior to the anterior superior iliac spine [3]. It is not visible from the exterior [3].

1.3 Linea Alba

In the midline, a slight furrow extends from the xiphoid process above, to the pubic symphysis below, representing the linea alba in the abdominal wall. The fibres of the anterior and posterior sheaths of the rectus muscle interlace at the midline, forming the linea alba.

From the surgical anatomical perspective, the abdominal wall consists of various structural layers.

1.4 Layers of the Abdominal Wall

From the surgical anatomical perspective, the abdominal wall consists of various layers, namely, the skin, superficial fascia, fat, muscles, the transversalis fascia, and the parietal peritoneum.

1.4.1 Skin and Subcutaneous Tissue

This outmost layer consists of the skin, superficial fat layer, the fascia superficialis (Scarpa's fascia), and the deep fat layer.

1.4.1.1 Skin

Epidermis The epidermis is formed of five layers, and the epithelial cells transform itself into a keratin layer, which constantly peels off.

Dermis The deeper structure called the dermis has two layers with no threshold between them. They are:

- The *papillary* layer which is thinner and external
- The *reticular* layer which is deeper and denser

The skin covering the anterior abdominal wall is thin, in comparison with that of the back, and is relatively mobile over the underlying structural layers except at the umbilical region, where it is fixed. The thickness of the abdominal skin seems to augment when approaching the midline and especially around the umbilicus. Natural elastic traction lines of the skin (also known as skin tension lines or Kraissl's lines) of the anterior abdominal wall are disposed transversely. Above the level of the umbilicus, these tension lines extend mostly in a horizontal direction, while below this level, they continue along with a slight inferomedial oblique direction. Incisions made along, or parallel to, these lines tend to heal without much scarring, whereas incisions that cross these lines tend to result in wide or heaped-up scars [1].

1.4.1.2 Superficial Fat Layer (Superficial Adipose Tissue)

Superficial fat, just under the dermis, is formed of large fat lobes encased between fibrous septa in a honeycomb-like structure and presents nearly constant characteristics throughout. These septa (retinacula cutis superficialis or Camper`s fascia)

Fig. 1.2 Retinacula cutis superficialis or Camper's fascia

Fig. 1.3 The attachments of Camper's fascia to the skin above the umbilicus can occasionally create a deep horizontal line

appear well defined. They are mostly oriented perpendicular to the surface and are mechanically strong, anchoring the dermis to the deeper planes (Fig. 1.2).

Stronger attachments to the dermis in the midline and above the umbilicus have been reported [4]. This is the reason why liposuction performed above the umbilicus and close to the midline is more prone to result in irregularities. The attachments of

the retinacula cutis superficialis to the skin at 5–7 cm above the umbilicus can occasionally be stronger than usual and create a deep horizontal line. This deformity cannot be corrected by classical or scarpa-saving undermining – more superficial interventions are necessary (Fig. 1.3).

Things to Remember

- In order to mimic this ideal anatomy and to create a beautiful result, the superficial landmarks are to be recreated.
- Liposuction performed above the umbilicus and close to the midline is more prone to irregularities.
- On rare occasions particularly above the umbilicus, the retinacula cutis superficialis' attachments to the skin may be stronger than usual and create a deep horizontal line.
- This deformity cannot be corrected by classical or scarpa-saving undermining – more superficial interventions are necessary.

1.4.1.3 Fascia Superficialis (Scarpa's Fascia)

The superficial fascia comprises two distinct layers: an outer, adipose layer lying subjacent to the dermis and an inner fibroelastic layer termed Scarpa's fascia, the membranous layer of superficial fascia [1]. The fibrous layer with a membranous appearance –the fascia superficialis – is continuous and well organized. It separates the superficial and deep adipose tissues (Fig. 1.4).

This layer can be followed as a dissection plane from the thorax to the inguinal ligament. It does not appear uniform in thickness. Being a well-defined white layer in the lower abdomen, thickening toward the inguinal ligament where a multilayered structure of multidirectional collagen bundles is perceptible. The Scarpa's fascia loses consistency in the upper abdomen, where it can be identified as a much thinner translucid collagen layer through which adipose tissue can be seen [4]. This membrane, which is strongly fused medially to the linea alba and caudally to the

Fig. 1.4 Scarpa's fascia

inguinal ligament and the osseous prominence of the iliac crest, cranially continues into the thorax. The membranous layer (Scarpa's fascia) is an important structure, which is strong enough to diminish the tension of sutures when identified and sutured in continuity during closure of the abdominal flap [5].

1.4.1.4 Deep Fat Layer (Deep Adipose Tissue, DAT)

Deep adipose tissue appears very different from the superficial adipose tissue, as its fat lobes are smaller, flatter, and less well defined (Fig. 1.5). This adipose layer shows significant variations in terms of thickness between different areas. Towards the points, at which the membranous layer of the subcutaneous tissue adheres to salient structures (e.g., the inguinal ligament, bony prominences, linea alba), they become thinner and tend to progressively reduce the fat component. However, the network of collagen fibres (retinacula cutis profunda) become stronger and more tightly packed and connects the deep aspect of the membranous layer to the deep fascia.

In the deep adipose layer, the fibrous septa are predominantly obliquely and horizontally oriented (retinacula cutis profunda) and connect the membranous layer (Scarpa's fascia) to the fascia of the rectus abdominis or external oblique muscle [4]. The membranous layers DAT and SAT create a sliding system that absorb the mechanical stimulations applied to the skin or that are generated by muscular contractions.

In this way the subcutaneous tissue ensures autonomy between the skin and the muscles. If any scarring creates adhesion between the skin, membranous layer, and deep fascia, every muscular contraction could also affect the skin, activating the cutaneous receptors – also vice versa: every stimulation of the skin could be transmitted to the underlying structures. This may explain the importance of the correct layered reconstruction of the subcutaneous tissue in avoiding complications after closure of the abdominal surgery wounds [4].

Things to Remember

1. A trilaminar structure is always present at the abdominal subcutis.
2. Over the rectus abdominis muscle, there is a thicker region, and the difference is mainly attributable to the superficial compartment.
3. The deep fat compartment has a minor contribution to the overall thickness, which is less than 25 % of the total thickness.
4. The superficial fat compartment is more susceptible to increase in thickness in obesity compared with the deep compartment.
5. The Scarpa's fascia is always present and does not become vestigial with increased adiposity [6].

Fig. 1.5 Deep adipose tissue appears very different from the superficial adipose tissue, as its fat lobes are smaller, flatter, and less well defined

1.5 Musculofascial System of the Abdomen

The abdominal wall consists of five paired muscles: three flat muscles and two vertical muscles. The three flat muscles are the external oblique, internal oblique, and the transversus abdominis. The two vertical muscles are the rectus abdominis and pyramidalis. The three-layered structure, combined with extensive aponeuroses, works in a synkinetic fashion. Fusion of the fascial layers of these muscles forms three distinct fascial lines: the linea alba and two semilunar lines. The linea alba is formed by the fusion of both rectus sheaths at the midline, while the semilunar lines are formed by the union of the internal oblique, transversus abdominis, and external oblique as they join the rectus sheath (Fig. 1.6).

The abdominal muscular anatomy is well known with one vertical muscle anteriorly and three large lateral muscles overlying each other inversely. The vertical rectus muscle is divided by the linea alba.

1.5.1 Linea Alba

The linea alba is the rest of the embryonic ventral suture made up of three distinct aponeurotic layers originating from three lateral abdominal muscles, migrating to the midline, encircling the rectus abdominis muscle and fusing in the midline. It is a three-dimensional composition of tendon fibres from abdominal wall muscles. The cranial aspect is attached to the xiphoid process of the sternum, while caudally, it inserts at the pubic symphysis. This strong attachment to the sternum prevents any hyperextension of the vertebral structures. Also, the midline insertions of these fibres play a significant role in stabilizing the abdominal wall [2, 7].

According to the orientation of the collagen fibres, the linea alba is organized into three laminae: the anterior, the middle, and the posterior laminas. Substantial amounts of elastic fibres are in all the laminae at all levels of the linea alba. The elastic fibres

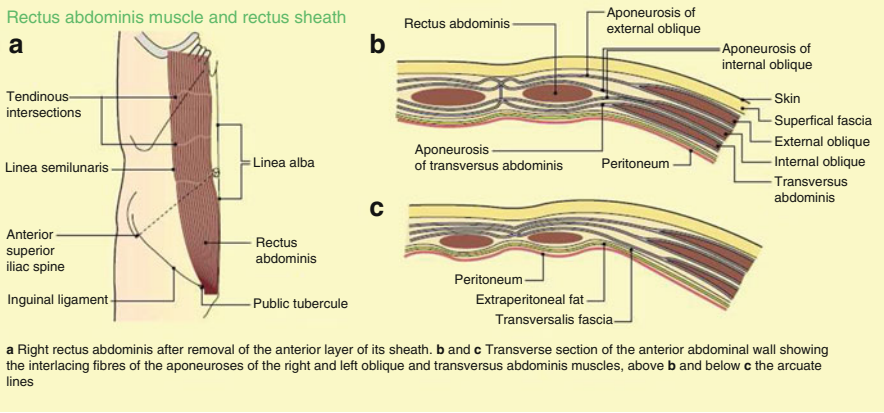

Fig. 1.6 Musculofascial system of the abdomen. (**a**) Right rectus abdominis after removal of the anterior layer of its sheath. (**b**, **c**) Transverse sections of the anterior abdominal wall showing the interlacing fibres of the aponeuroses of the right and left oblique and transversus abdominis muscles, above (**b**) and below (**c**) the arcuate lines (Source: Moore [19])

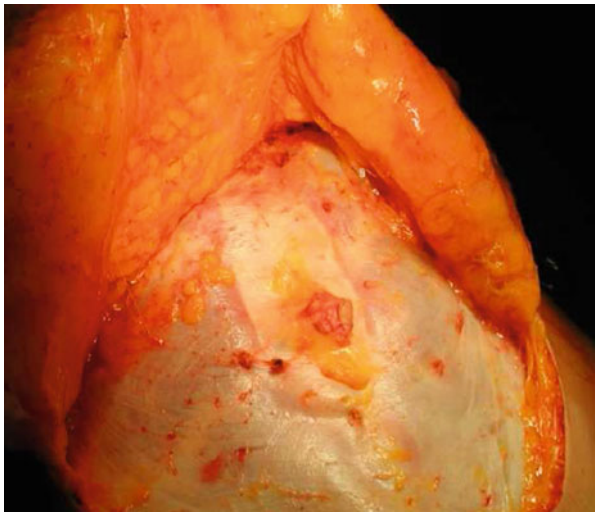

Fig. 1.7 The dehiscence of the linea alba

are, however, more concentrated in the anterior lamina, followed by the posterior lamina, while the middle lamina contains the least [8]. Higher concentrations of elastic fibres in the caudal, anterior, and lateral parts of the linea alba may be an adaptation to more forces in these areas as a consequence of the erectness of the trunk.

Below the umbilicus, the linea alba is weaker due to the absence of the third layers coming from the rectus muscles. During post-pregnancy the upper part is the most affected [8]. With age the linea alba dehisces, reaching 10 mm at 45 years of age and 15 mm after 45 years [7] (Figs. 1.7 and 1.8).

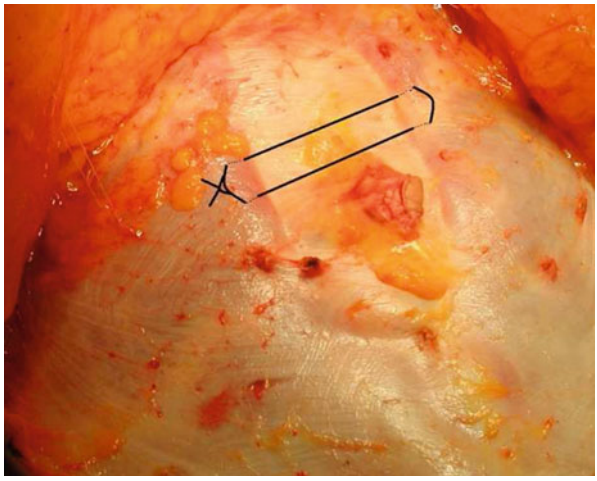

Fig. 1.8 Any suture on the abdominal muscle fascia must be placed perpendicular to the linea alba for a better hold

1.5.2 Rectus Muscle

The rectus is a long, strap-like vertical muscle lying on either side of the midline. The upper part is attached to the external part of the costal cartilages and the xiphoid process, and it ends in the lower abdomen, with insertions into the pubis and symphysis. Superiorly, the rectus is wide at 15 cm, broad, and thin, gradually becoming narrow (7 cm) and thick inferiorly. Segmentation of each rectus muscle occurs through tendinous intersections that attach the rectus muscle with the anterior layer of the rectus sheath. In 80 % of people, there is a small triangular muscle, called the pyramidalis, located anterior to the inferior part of the rectus. This muscle assists in tensing the linea alba.

It is interesting to note that the number of intersections of this muscle appears to have decreased through evolutional history: 12 in horses, 6 in gorillas, and 4 in men [7]. This shows the decreased need of the reinforcement in erected position. The rectus sheath has contributions from all three abdominal muscles' aponeuroses inferior to the umbilicus. The anterior sheath superior to the umbilicus is composed only of aponeuroses from the external and internal abdominal muscles. The transversalis aponeurosis does not assist with the formation of the anterior sheath at this level (Fig. 1.9).

In effect, the internal oblique aponeurosis splits, allowing one layer to pass anteriorly and another one posteriorly to the rectus muscle. The anterior layer will then join with the external oblique aponeurosis to form the anterior wall of the rectus sheath. The anterior sheath can be considered a composite of all three aponeurotic layers at a variable level below the umbilicus. The posterior sheath can be similarly described in relation to the umbilicus. Superior to the umbilicus, the posterior sheath consists of contributions from both the aponeuroses of the internal oblique and the transversus abdominis. Inferior to the umbilicus, the external

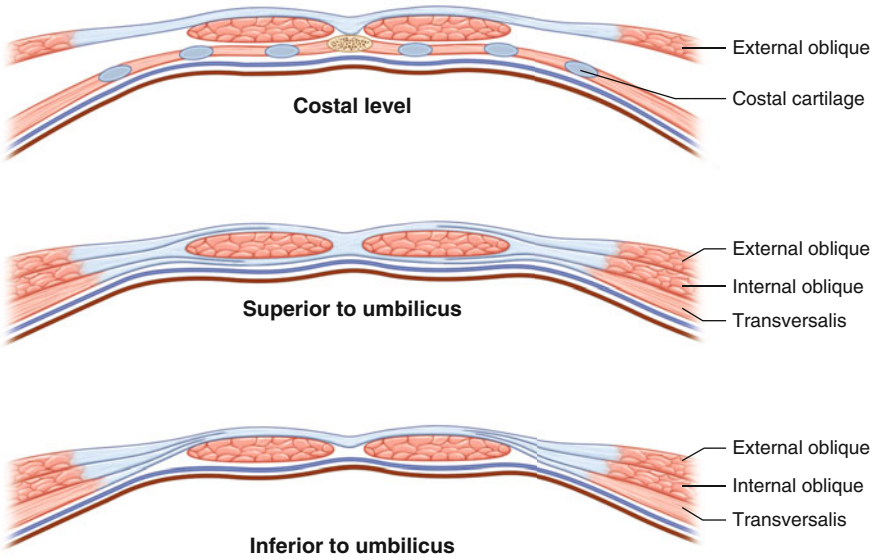

Fig. 1.9 The axial anatomy of linea alba and fascial system at different levels

abdominal aponeurosis does not contribute to the formation of the posterior rectus sheath.

The arcuate line is defined by the most inferior extension of the posterior sheath forming a crescent-shaped border. In the midline, fibres of the anterior and posterior sheaths interlace forming the linea alba. It is now understood that mechanical forces acting here contribute to the formation of epigastric hernias [9].

The ratio of collagen types I and III in the composition of the aponeurosis is a genetic condition, and there is also a change in this in relation to age. With age, the ratio of type I to type III changes in favour of type III which is less elastic and has less capacity to absorb water. Thus, it could be claimed that the aponeurosis becomes weaker and vulnerable with age.

Another factor that may play a role in the correction of the musculoaponeurotic layer is the level of collagen deposits in muscles. Deposits of collagen within the muscles (types I, III, IV, and V) are located in the epimysium, perimysium, and endomysium [10].

With age, there is also an increase in the total number of fibres, which causes the muscles to become less flexible and pliable. This may increase resistance to mobilization of the muscles during the correction of abdominal deformities. Furthermore, it is important to stress that there is a relationship between the size of the musculoaponeurotic deformity and skin excess on the abdomen [4, 10].

Collagen fibres of the rectus fascia after leaving the line alba to medial go with an angle which varies and tends, with age, to end in a horizontal line.

1.5.3 Pyramidalis Muscle

The pyramidalis is a small triangular muscle located anterior to the inferior aspect of rectus abdominis that is absent in about 20 % of the population. The pyramidalis originates from the pubis inferior to the insertion of the rectus abdominis and inserts into the linea alba inferior to the umbilicus to assist in stabilization of the abdominal wall [2].

1.5.4 External Oblique Muscle

This is the most superficial lateral muscle and the largest and thickest of the three flat muscles of the abdomen. The muscle arises from the lowermost eight ribs posteriorly to interdigitate with both the serratus anterior and latissimus dorsi muscles and courses inferior-medially, attaching by means of its aponeurosis centrally at the linea alba. Inferiorly, the external oblique aponeurosis folds back upon itself and forms the inguinal ligament between the anterior superior iliac spine and the pubic tubercle [11].

1.5.5 Internal Oblique Muscle

The internal oblique muscle originates from the anterior portion of iliac crest, lateral half to two-thirds of inguinal ligament, and posterior aponeurosis of the transversus abdominis muscle. The fibres run superiorly–anteriorly at right angles to the external oblique and insert on the cartilages of the lower four ribs [11].

These muscle fibres are differently oriented in the upper and lower parts. The Spiegel line is at the transition of the muscular and aponeurotic parts of the muscle. This weak line can cause lateral hernias [7]. If required, lateral tightening must be done at this line and at the internal oblique level. The aponeurotic part fuses with the opposed muscle aponeurosis in the middle to form the linea alba. This fusion is absent in the lower quarter of the linea alba.

1.5.6 Transversalis Muscle (Transversus Abdominis)

The muscle transversalis is the deepest muscle with horizontally oriented fibres and has a very important role to play in expiration. These muscles arise from the inner surface of the 7th–12th costal cartilages, the iliac crest, and the lateral third of the inguinal ligament. These fibres course medially to the lateral border of the rectus

muscle. The end of the muscle fibres and the beginning of aponeurosis is called the linea semilunaris. The aponeurosis fuses to the posterior rectus fascia [4] (Fig. 1.10).

Things to Remember

- Linea alba strongly attaches to the sternum to prevent any hyperextension of the vertebral structures.
- With age the linea alba dehisces, reaching 10 mm at 45 years of age and 15 mm after 45 years.
- With age, the ratio of type I to type III changes in favour of type III which is less elastic and has less capacity to absorb water. Thus, it could be claimed that the aponeurosis becomes weaker and vulnerable with age.
- With age, there is also an increase in the total number of fibres, which causes the muscles to become less flexible and pliable. This may increase resistance to mobilization of the muscles during the correction of abdominal deformities.
- The Spiegel line is at the transition of the muscular and aponeurotic parts of the muscle. This weak line can cause lateral hernias.

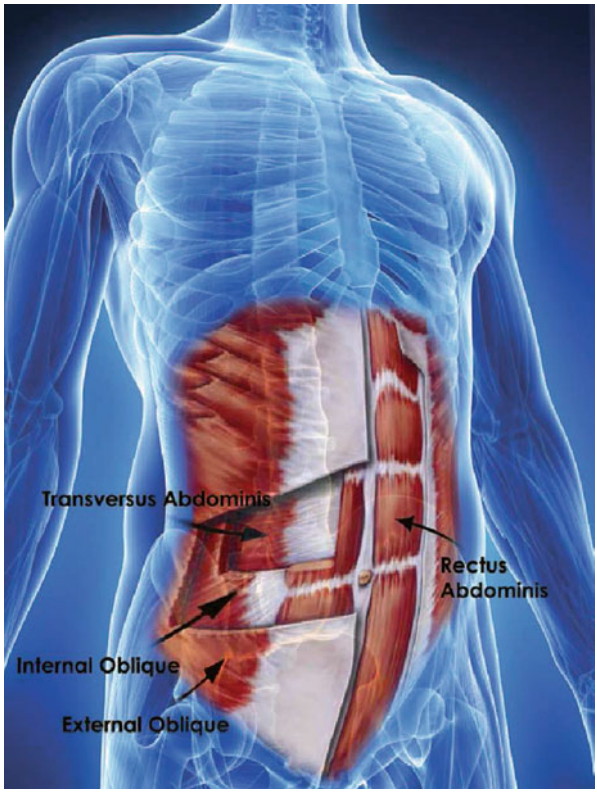

Fig. 1.10 Anterior and lateral abdominal muscles (Pulikkottil et al. [20])

1.6 Abdominal Blood Supply

Three major arterial branches supply blood to either side of the anterior abdominal wall which includes two branches of the external iliac artery and a branch of the internal thoracic artery. The inferior epigastric artery which is a branch of the external iliac artery travels within the transversalis fascia until it reaches the arcuate line where it pierces the rectus sheath. The second branch of the external iliac artery, the deep circumflex iliac artery, runs parallel to the inguinal ligament between the transversus abdominis and internal oblique muscles. The superior epigastric artery, the terminal branch of the internal thoracic artery, enters the rectus sheath superiorly [9] (Fig. 1.11).

The posterior intercostal arteries (which accompany the intercostal nerves) supply the three-ply muscles in the lateral part of the anterior abdominal wall and in this function are reinforced by the lumbar arteries, which are branches of the abdominal aorta [1].

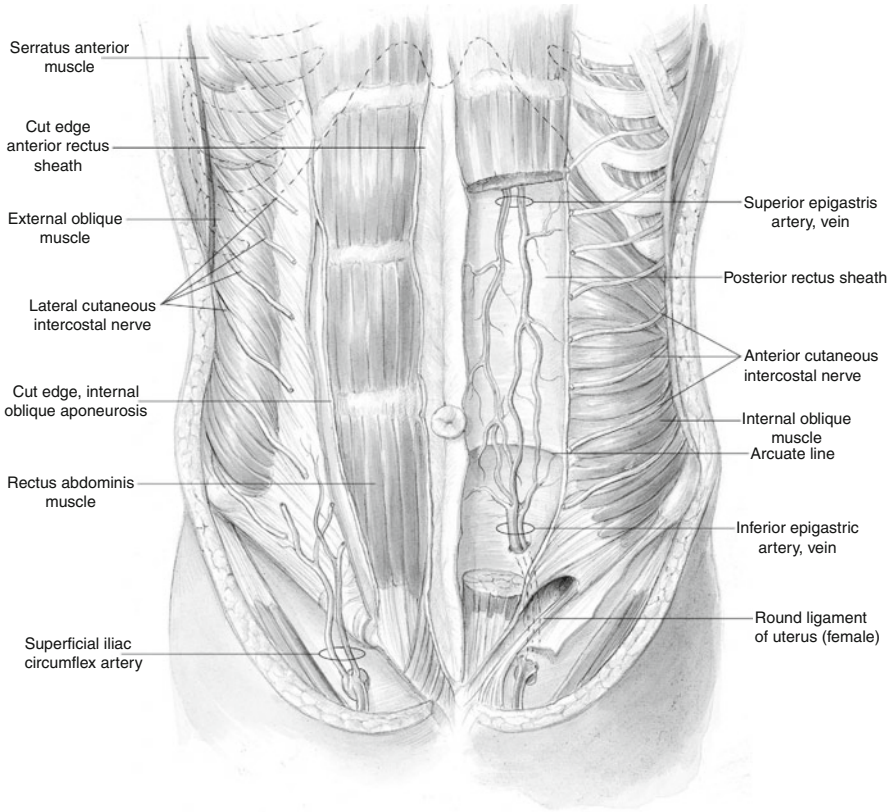

Fig. 1.11 Blood supply – anterior abdominal wall (Ahluwalia et al. [9])

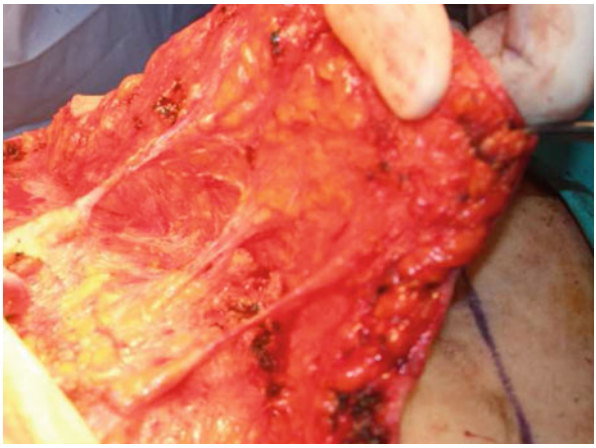

Fig. 1.12 Perforator arteries from rectus muscle (sub-umbilical level)

The rectus abdominis has a dual blood supply. The upper half of the muscle is supplied by the superior epigastric artery (a branch of the internal thoracic artery). The artery enters the rectus abdominis alongside the xiphisternal junction with its companion veins. The lower half of the rectus abdominis is supplied by the deep inferior epigastric artery, a branch of the external iliac artery. Myocutaneous rotation flaps may be fashioned using either the upper or lower halves of the rectus abdominis muscle [1].

The abdominal wall receives its blood supply from direct cutaneous vessels and musculocutaneous perforating vessels [12]. The wall of the arteries perforating the rectus muscle contains more elastic fibres than average. This allows these vessels to keep their perfusion capacity between two gliding tissues: the rectus sheath and deep adipose tissue (Fig. 1.12).

If torn by blunt dissection, these arteries can escape into the rectus fascia and cause intramuscular bleeding, which can lead to long-term pain after abdominoplasty. In obese patients the distribution of these arteries is severely altered.

The deep perforator arteries supply the deep adipose tissues. Superficial adipose tissue is supplied by the arteries from the superficial arterial system. Late lipolyses occurring after abdominoplasty can be explained by the total undermining of the flap from the deep muscular perforated arteries and partial necrosis in the deep fatty tissues [7].

The umbilicus receives blood flow from the surrounding subdermal plexus. In addition, there are three distinct additional sources: the right and left deep inferior epigastric arteries, the ligamentum teres, and the median umbilical ligament. The deep inferior epigastric artery is the dominant blood supplier to the umbilicus.

The umbilicus is more at risk during abdominoplasty performed on a morbidly obese individual because it is elongated and the vascular anatomy is potentially distorted. Shortening the umbilicus by resecting the distal portion may be advantageous in preserving the viability of the umbilicus in these situations [13].

1.7 Lymphatic System of the Abdomen

The lymphatic channels reside within the sub-scarpal fat layer superficial to the anterior rectus sheath. Soft tissue lymphatics above the umbilicus drain to axillary lymph nodes, while those below the umbilicus drain to the superficial inguinal lymph nodes. It has been reported that preservation of the subfascial lymphatic system diminishes the accumulation of serious post-abdominoplasty fluid and the need for drains. There are many publications discussing the advantages of this technique [6–8, 10, 14–17].

1.8 Abdominal Nerves

Cutaneous innervation of the abdominal wall is consistent with the segmental dermatomal pattern. The anterior and lateral cutaneous branches of the ventral rami of the 7th–12th intercostal nerves and the ventral rami of the first and second lumbar nerves have important sensory and motor functions [9] (Fig. 1.13).

1.8.1 Thoracoabdominal Nerves

The lateral cutaneous branches of intercostal and subcostal nerves supply sensation to the lateral portion of the abdomen. The anterior branches of the intercostal and subcostal nerves supply sensation to the midline abdomen.

These nerves are deep structures. Taking small amounts of fat from a periumbilical area is permitted by superficial local anaesthetics, but in the long-term, patients complain about pain in this area. It is advised to deeply inject the anaesthetics into the fascia to obtain long-term comfort. This is because terminal nerves from the iliohypogastric and ilioinguinal nerves are also supplying the periumbilical area.

1.8.2 Iliohypogastric Nerve (T12, L1)

Iliohypogastric nerve innervates the skin and soft tissue over the iliac crest and lateral thigh. Nerve entrapment during the rectus anterior sheath plication has been reported. Persistent lower abdominal wall pain occurring postoperatively, despite negative gastrointestinal and/or gynecologic pathology, should alert the surgeon to the possibility of iliohypogastric or ilioinguinal nerve entrapment. Diagnosis can be made if there is subsequent relief after nerve block and treatment consists of

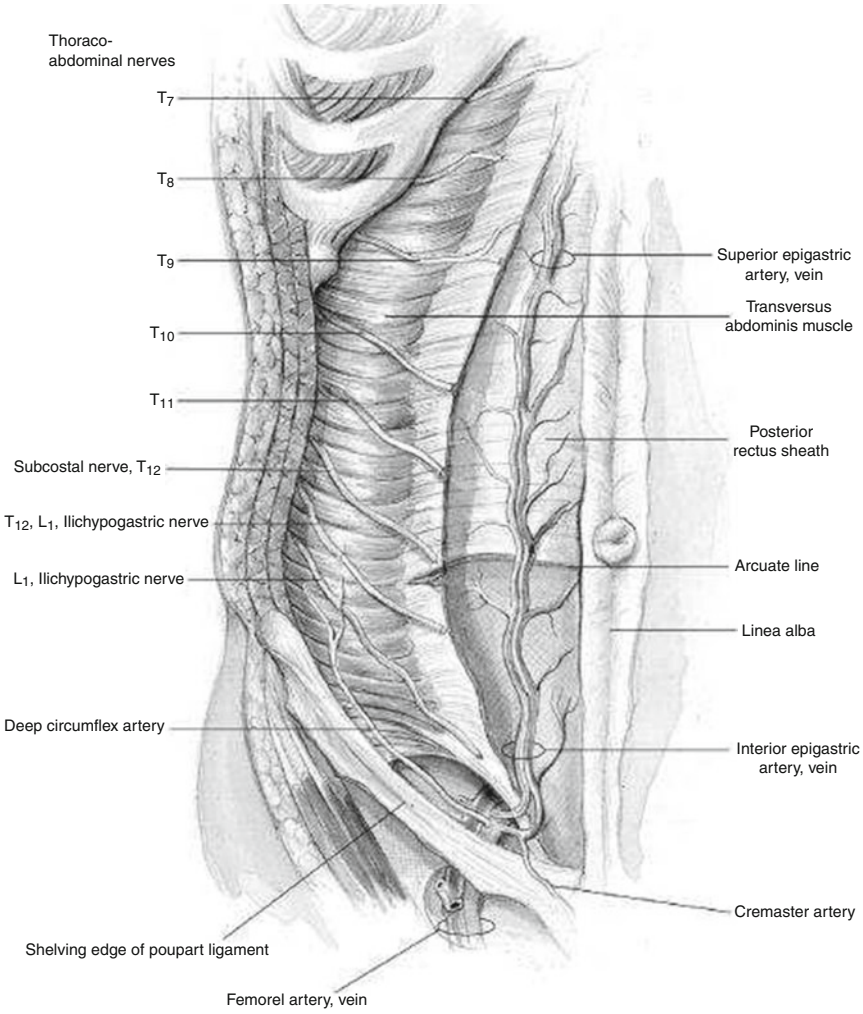

Fig. 1.13 Nerve supply of the anterior abdominal wall (Ahluwalia et al. [9])

performing a neurectomy at the level of the retroperitoneum to avoid recurrent painful neuromas [18].

1.8.3 Ilioinguinal Nerve (L1)

The ilioinguinal nerve innervates lower abdominal skin. Coursing from the mons superiorly, these nerves are often divided bilaterally during caesarean sections, and many post-caesarean section patients have numbness of the lower abdominal skin. This may be an advantage for post-operative comfort.

1.8.4 Genitofemoral Nerve

This nerve exits the muscular fascia at the level of the inguinal ligament in the middle of its length. The surgeon shall preserve the lateral femoral cutaneous branch, which innervates the anterior thigh. The damage to this branch results in chronic numbness of the anterior thigh, which can be very annoying because of the difference between the sensitivity perception on the left and right sides [6].

Things to Remember

- Shortening the umbilicus by resecting the distal portion may be advantageous in preserving the viability of the umbilicus in these situations.
- Persistent lower abdominal wall pain occurring postoperatively, despite negative gastrointestinal and/or gynecologic pathology, should alert the surgeon to the possibility of iliohypogastric or ilioinguinal nerve entrapment.
- The surgeon shall preserve the lateral femoral cutaneous branch, which innervates the anterior thigh.

References

1. Mahadevan V. Anatomy of the anterior abdominal wall and groin. Surgery (Oxford). 2003;21(2):25–7.
2. Grevious MA, Cohen M, Shah SR, Rodriguez P. Structural and functional anatomy of the abdominal wall. Clin Plast Surg. 2006;33(2):169–79, v.
3. Cunningham SC, Rosson GD, Lee RH, et al. Localization of the arcuate line from surface anatomic landmarks: a cadaveric study. Ann Plast Surg. 2004;53(2):129–31.
4. Lancerotto L, Stecco C, Macchi V, et al. Layers of the abdominal wall: anatomical investigation of subcutaneous tissue and superficial fascia. Surg Radiol Anat. 2011;33(10):835–42.
5. Lockwood TE. Superficial fascial system (SFS) of the trunk and extremities: a new concept. Plast Reconstr Surg. 1991;87:1009–18.

6. Costa-Ferreira A, Rodrigues-Pereira P, Rebelo M, Vásconez LO, Amarante J. Morphometric study (macroscopic and microscopic) of the lower abdominal wall. Plast Reconstr Surg. 2014;134(6):1313–22.
7. Caix P. Anatomie de la paroi abdominal. Ann Chir Plast Esthet. 1999;44(4):289–311.
8. Rath AM, Attali P, Dumas JL, Goldlust D, Zhang J, Chevrel JP. The abdominal linea alba: an anatomic-radiologic and biomechanical study. Surg Radiol Anat. 1996;18:281.
9. Ahluwalia HS, Burger JP, Quinn TH. Anatomy of anterior abdominal wall. Operatives Tech In Plast Surg. 2004;6(3):147–55.
10. Monkhouse WS, Khalique A. Variations in the composition of the human rectus sheath: a study of the anterior abdominal wall. J Anat. 1986;145:61–6.
11. Moore KL, Dalley AF. Clinically oriented anatomy. 4th ed. Philadelphia: Lippincott Williams & Wilkins; 1999.
12. Nahai F, Brown RG, Vasconez LO. Blood supply to the abdominal wall as related to planning abdominal incisions. Am Surg. 1976;42(9):691–5.
13. Nahai F. Anatomical considerations in abdominoplasty. Clin Plast Surg. 2010;37(3):407–14.
14. Le Louarn C. Partial subfascial abdominoplasty. Aesthetic Plast Surg. 1996;20:123–7.
15. Costa-Ferreira A, Rebelo M, Va'sconez LO, Amarante J. Scarpa fascia preservation during abdominoplasty: a prospective study. Plast Reconstr Surg. 2010;125:1232–9.
16. Fang RC, Lin SJ, Mustoe TA. Abdominoplasty flap elevation in a more superficial plane: decreasing the need for drains. Plast Reconstr Surg. 2010;125:677–82.
17. Richter D. The scarpa lift, Paper presented at: 39th annual meeting of the German Society of plastic, reconstructive and aesthetic surgeons; Oct 2008; Germany.
18. Liszka TG, Dellon AL, Manson PN. Iliohypogastric nerve entrapment following abdominoplasty. Plast Reconstr Surg. 1994;93:181–4.
19. Moore KL. Clinically oriented anatomy. Baltimore: Williams & Wilkins; 1992.
20. Pulikkottil BJ, Pezeshk RA, Daniali LN, Bailey SH, Mapula S, Hoxworth RE. Lateral Abdominal Wall Defects: The Importance of Anatomy and Technique for a Successful Repair. Plast Reconstr Surg Glob Open. 2015;3:e481. doi:10.1097/GOX.0000000000000439.