Abdominal Wall Surgery

26

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Background

In their daily working activities, plastic surgeons frequently face issues related to the abdominal wall region.

The abdomen, symbol of both motherhood and eroticism, is one of the most important anatomical subunits of the body. This explains the significant psychological impact related to abdominal wall diseases.

Abdominal wall defects may represent a challenging issue, and plastic surgery involvement in abdominal wall reconstruction becomes necessary especially in complex cases where routine techniques are not adequate or sufficient.

26.1 Introduction

Abdominal wall defects can be either congenital or acquired.

Congenital umbilical and inguinal hernias are usually repaired in infancy or childhood.

On the other hand, most of the acquired defects arise from postpartum changes, traumas, tumors, radiation necrosis, or complications of previous abdominal surgeries, leading to high costs for the healthcare system, related to high rates of recurrence and reoperation. Besides being a cosmetic problem, abdominal wall defects have a strong negative functional impact on patients' quality of life. The majority of these patients also have significant comorbidities like tabagism, diabetes mellitus, chronic obstructive pulmonary disease (COPD), coronary artery disease (CAD), poor nutritional status, immunosuppression, chronic corticosteroid use, and obesity. Such risk factors need to be reduced before surgery, in order to have the greatest chances of success and to reduce the risk of bacterial contamination, infection, and failure of the whole reconstructive process. Diagnosis is made on physical examination and supported by abdominal computed tomography (CT) or magnetic resonance imaging (MRI), which confirms the extent and location of the abdominal wall defect and gives information on the integrity of musculofascial structures involved. A proper integration of clinical and radiological evaluations helps the surgeon to define the best preoperative planning, especially if the patient has undergone previous surgeries. The anterior abdominal wall assists in protection of viscera, postural stabilization, and maintenance of intra-abdominal pressure. The latter function is central to the voluntary control of coughing, micturition, and defecation. Consequently, loss of continuity of abdominal

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wall structures or full-thickness defects may significantly affect these functions. The goals of abdominal wall reconstruction are to treat any abdominal open wounds, providing a complete soft-tissue coverage, to restore and reinforce fascial integrity, to protect abdominal viscera, to restore function, and to prevent hernias according to the "like-with-like" principle of reconstructive surgery [1]. The decision to perform an immediate or a delayed reconstruction must be taken after having considered the patient's comorbidities and clinical condition, the etiology and type of the defect, and the infective status of the wound. If possible, an immediate reconstruction is always preferable, due to the benefits that this kind of approach brings from a psychological and medical point of view. When that is impossible, an adequate abdominal coverage is performed to provide temporary closure; in such conditions, vacuum-assisted closure therapy reduces bacterial colonization and aids in keeping the wound clean by improving vascularization and minimizing wound inflammation.

Acquired abdominal wall defects represent the focus of this chapter.

26.2 Surgical Anatomy

A thorough understanding of the anatomy of the abdominal wall is essential when planning reconstruction. The abdominal wall is defined as the part of the trunk that is bounded laterally by the right and left mid-axillary lines; superiorly by the costoxiphoid margins; and inferiorly by the pubic crest, the inguinal ligaments, and anterior halves of the iliac crests. The anterolateral abdominal wall is made up of several layers, which from the outside to the inside are represented by the skin, subcutaneous tissue of variable thickness with its fasciae, three fascia layers and five paired symmetrical muscles, transversalis fascia, and parietal peritoneum.

26.2.1 Anatomy of the Integument

The skin envelope is related to body habitus and is certainly more prone to undergo drastic changes due to massive weight gain and/or loss, pregnancies, physical activity, age, abdominal surgeries, or genetic conformation. The skin is mobile compared to the musculoaponeurotic plane below.

On the abdominal wall, the minimum skin tension lines, or Langer lines, are oriented in a horizontal or oblique direction, thus defining the best direction for surgical incisions. Between these lines, which can be real skin folds, we can identify the suprapubic fold (site of Pfannenstiel incision) and the infraumbilical fold, which unites the two anterosuperior iliac spines, approximately in the middle of the navel-pubis line.

The quality of the skin differs depending on the subunits of the abdomen: the subcutaneous tissue below the umbilicus is more represented, giving this region a softer and more relaxed texture, compared to the supra-umbilical region. In men, the adipose plane tends to thicken subumbilically and laterally at the hip level.

In women, fat distribution is commonly located at the sub-umbilical level and in the periumbilical region. This distribution determines the so-called "round abdomen" appearance. It is important to check the quality of the skin, the presence and the distribution of abdominal scars, and the existence of stretch marks. The abdomen is divided into four quadrants and nine regions; in the region above the umbilicus, the Camper fascia and Scarpa fascia are usually adherent to each other and form a single layer. They split below the umbilicus, forming:

- Camper fascia, a thick fibrofatty tissue layer that extends from the xiphoid process and the lateral costal margins to the inguinal ligament bilaterally, and it continues inferiorly past the inguinal ligament as the subcutaneous fat of the thigh. It lies deep in the skin, but superficial to the Scarpa's fascia, and it is composed by a three-dimensional architecture of fibrous septae, which provides support for the adipose tissue.
- Scarpa fascia is a thin and more membranous layer, loosely connected to the aponeurosis of the obliquus externus abdominis by areolar tissue, but closely adhered in the middle line to the linea alba and to the symphysis pubis, and is prolonged on to the dorsum of the penis, forming the fundiform ligament [2].

26.2.2 Anatomy of the Myofascial System

The muscles of the abdominal wall can be divided into two groups: the anterolateral muscles and the posterior muscles.

The former is composed by five paired muscles:

- Rectus abdominis
- Pyramidalis
- External oblique
- Internal oblique
- Transversus abdominis

All of them have corresponding layers of investing fascia (Fig. 26.1).

Rectus abdominis and pyramidalis muscles are located anteriorly; each rectus joins the midline to form the linea alba, an important landmark during abdominal surgery: wider in its upper part, it undergoes alterations following the increase in intra-abdominal volume in case of pregnancy, obesity, or ascites. Rectus muscles running vertically from the xiphoid process and costal cartilages of V–VI–VII ribs to the pubic symphysis. Their lateral borders create a surface known as the linea semilunaris. There are also three tendon inscriptions that form three transversal grooves, interrupting the muscle fibers.

The pyramidalis muscles are not functional and are found in 80% of the population. It is a triangular-shaped muscle with its base on the pubic bone.

External oblique is configured as the largest and most superficial muscle in the abdominal wall, which originates from the cartilage of the lower VII ribs and runs obliquely from superior/lateral to inferior/medial and inserts on to the iliac crest and pubic tubercle.

Internal oblique lies deep in the external oblique; smaller and thinner, it originates from the inguinal ligament, iliac crest, and lumbodorsal fascia; its fibers course perpendicular to the external oblique from inferior/lateral to superior/medial and inserts to the cartilage of the lower five ribs. At this inferior portion, it joins the aponeurosis of the transversus abdominis muscle to create the conjoined tendon.

Transverus abdominis is the deepest of the three anterolateral wall muscles with transversely running fibers and originates from the lower six costal cartilages, lumbar vertebrae, iliac crests, and iliopsoas fascia and inserts into the conjoint tendon, xiphoid process, linea alba, and pubic crest [3].

Tranversalis fascia is the thin aponeurotic membrane of the anterolateral abdominal wall which lies between the inner surface of the transversus abdominis muscle and peritoneum. It forms part of the general layer of fascia lining the abdominal wall and is directly continuous with the iliac and pelvic fasciae.

The parietal peritoneum is a continuous membrane which is made up of simple squamous epithelial cells called mesothelium.

The three fascial components of the lateral abdominal wall (the external oblique, internal oblique, and transverse abdominis) come together medially to form the anterior and posterior rectus sheath; each aponeurosis is bilaminar. Above the arcuate line, the anterior rectus sheath is composed of both leaves of the aponeurosis of external oblique and the anterior leaf of the aponeurosis of internal oblique fused together. The posterior rectus sheath is composed of the posterior leaf of the aponeurosis of internal oblique and both leaves of the aponeurosis of transversus abdominis. At the midline, fibers from each layer decussate to the opposite side of the sheath forming the so-called linea alba. Below the arcuate line, the three aponeurotic layers form the anterior rectus sheath [4]. Also, this is the point where the inferior epigastric vessels perforate the rectus abdominis to vascularize the skin.

The posterior abdominal wall is essential for postural stability, as well as lower limb movements, and acts as a barrier for the retroperitoneal organs. The muscles that form the posterior abdominal wall are:

- Quadratus lumborum
- Psoas major
- Psoas minor
- Iliacus

Key Points

The rectus muscle presents an anterior and posterior sheet for most of its length: the anterior sheet is formed by the aponeuroses of the external oblique and the anterior leaf of the aponeurosis of internal oblique, whereas the posterior is formed by the posterior leaf of the internal oblique and the aponeuroses of the transversus abdominis. Midway between the umbilicus and the pubic symphysis, all the aponeuroses move to the anterior sheet. At this point, the posterior sheet becomes thinner leaving the rectus abdominis in direct contact with the transversalis fascia. This demarcation point is called the arcuate line.

26.2.3 Anatomy of Vessels, Nerves, and Lymphatics

The vascular supply to the abdomen can be subdivided into three zones (Huger's zones I, II, and III) based upon regional anatomy as described by Huger (Fig. 26.2) [5]. The first zone corresponds to the middle part of the abdomen and is vascularized by the perforating branches of the superior epigastric artery and inferior epigastric artery, which anastomose within the rectus muscle fascia. The second zone corresponds to the hypogastrium and is nourished by the superficial circumflex artery, the superficial epigastric artery, and some perforating branches from the proximal segment of the inferior epigastric artery. The third zone includes the lateral areas of the abdomen and is supplied by the perforating branches

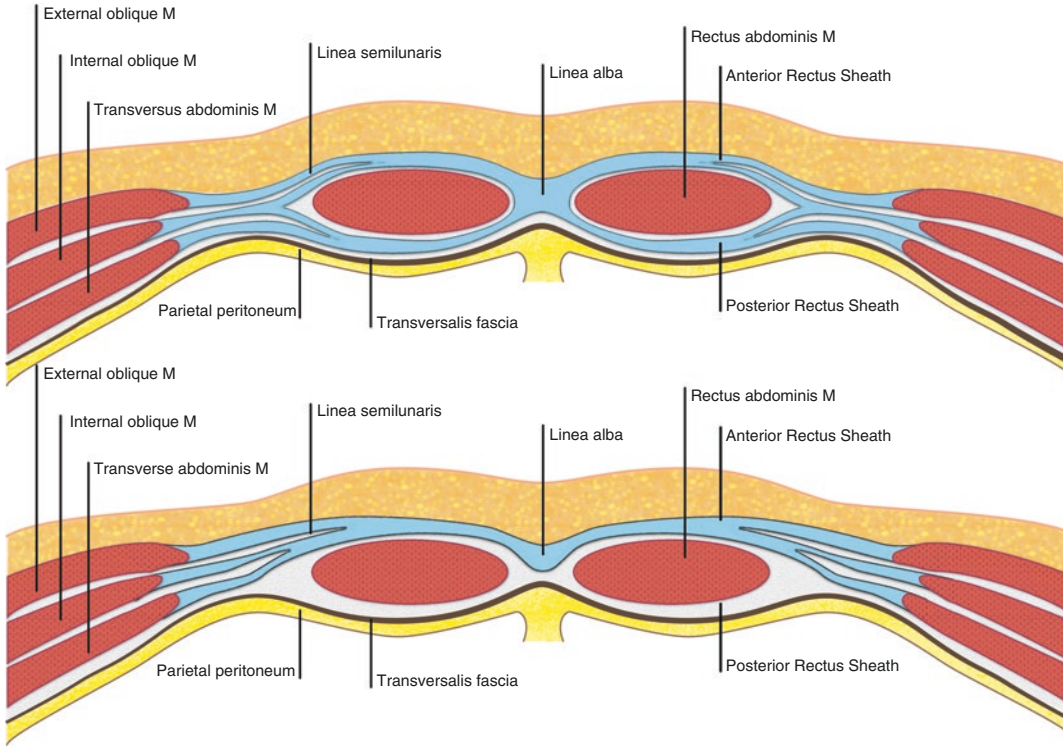

Fig. 26.1 Myofascial abdominal wall anatomy. Difference between above and below arcuate line. (Illustration by Federico Di Crescenzo)

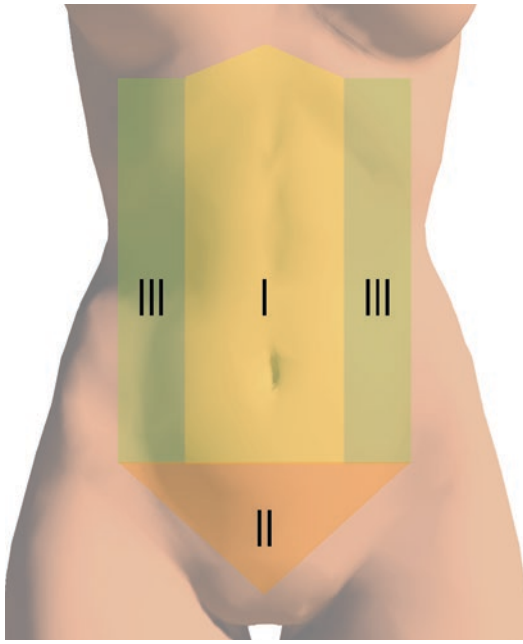

Fig. 26.2 Vascular zones of the abdominal wall (Huger's zones). (Illustration by Federico Di Crescenzo)

from the diaphragmatic, intercostal, and lumbar arteries. The third zone is responsible for the vascularization of the lateral cutaneous flaps advanced caudally during abdominoplasty procedures; when such branches are spared, there is no increased risk of marginal skin necrosis [6].

The venous drainage of the abdominal wall superior to the umbilicus is via the internal mammary, intercostal, and long thoracic veins: these veins ultimately drain into the superior vena cava. Inferior to the umbilicus, the venous drainage is via the superficial epigastric, circumflex iliac, and pudendal veins, eventually draining to the groin in the saphenofemoral junction and, ultimately, to the inferior vena cava.

The lymphatic vessels of the abdominal wall are organized according to two systems, one superficial and the other one deep. The superficial one is in the soft tissue above the deep muscular fascia, and it accompanies the subcutaneous blood vessels below the dermis. Vessels from the infra-umbilical skin run with the superficial epigastric vessels and drain into the superficial inguinal nodes; the supra-umbilical region is drained by axillary and parasternal nodes. The deep lymphatic system is associated with the abdominal wall musculature: these vessels parallel the deeper arteries; lymphatics in the upper part of the abdominal wall run with the superior epigastric vessels to parasternal nodes, while those in the lower abdominal wall run with the deep circumflex iliac and inferior epigastric arteries to external iliac nodes.

Sensory and motor innervation to the muscles comes from the intercostal and subcostal nerves, from T7 to L1, for the rectus abdominis muscle, as well as from the iliohypogastric nerve for the external oblique muscle or the ilioinguinal nerve for the internal oblique muscle. The iliohypogastric nerves provide sensation to the anterior abdominal wall in the suprapubic region.

Key Points

Vascularization of the abdominal wall must always be kept in mind when approaching both reconstructive and aesthetic surgery procedures to minimize complications. In patients with previous abdominal scars and associated comorbidities, wide undermining should be avoided, and as many perforators as possible should be spared.

26.3 Classification of the Abdominal Wall Defects

Abdominal wall defects can be classified in congenital or acquired based on their pathogenesis and may be asymptomatic or symptomatic (Tab1). Such defects may produce a wide variety of clinical issues ranging from minor cosmetic impairment to major destructive conditions (Table 26.1).

26.3.1 Congenital Defects

Congenital defects are due to an incomplete closure of the abdominal wall during embryogenesis, including omphalocele, umbilical hernia, gastroschisis, and bladder exstrophy; nowadays,

Table 26.1 Classification of abdominal wall defects

Abdominal wall defects		
	Acquired	
Congenital	Partial defects	Full-thickness defects
Gastroschisis	Diastasis recti	Traumatic defects
Omphalocele	Hernias (umbilical, lateral, inguinal)	Oncological resection
Bladder exstrophy	Postoperative or incisional hernia	
Umbilical hernia		

they are usually diagnosed in the context of a routine ultrasound during pregnancy.

26.3.1.1 Omphalocele

Omphalocele is the protrusion of the abdominal viscera through a median defect in the abdominal wall at the base of the navel. The prevalence of omphalocele is approximately 2–3 cases per 10,000 births [7]. The herniated contents are covered by a membranous sac contiguous with umbilical cord and can become necrotic after birth. The size of the defect can be small, up to 5 cm, also called "minor," or more than 5 cm, called "major," and the sac may contain bowel loops, small or large intestine, stomach, bladder, ovary, or liver. In infants with omphalocele, the incidence of other congenital anomalies, such as bowel atresia, chromosomal abnormalities, and cardiac and renal anomalies, is very high.

26.3.1.2 Gastroschisis

Gastroschisis is the protrusion of abdominal wall contents through a defect in the abdominal wall that is not in the midline, but usually to the right of the umbilicus, with no covering membrane or sac. The incidence of gastroschisis is about 0.5–4.5 cases per 10,000 living births [8–10]. The cause of this defect is still unknown. This condition is not generally associated with other major congenital or chromosomal anomalies. Gastroschisis is often classified into simple (isolated defect) and complex (associated with bowel-related complications: intestinal atresia, perforation, stenosis, or volvulus) [8, 10].

26.3.1.3 Bladder Exstrophy

Bladder exstrophy represents a failure of the anterior bladder wall to close normally, due to a lack of muscular or connective tissue. The reported incidence is 0.25–0.5 in 10,000 births and is more common in males at a ratio of 2:1 [9]. The disease can be diagnosed by a prenatal ultrasound, which highlights the absence or non-visualization of the bladder, which is open to the abdominal wall. Other findings include external genitalia malformation, represented by a small penis with anteriorly displaced scrotum. Also, in females, besides a widening of the iliac crests, a bifid clitoris and uterine and vaginal anomalies can be identified [11]. Differential diagnosis must be with an empty bladder: in this case, the scan can be repeated in 15-min intervals.

26.3.1.4 Umbilical Hernia

The umbilical hernia in the baby results from an incomplete closure of the fascia of the umbilical ring at the time of reintegration in the abdominal cavity of the intestinal loop; therefore, intraabdominal contents may protrude. The skin coverage is not missing. The incidence is very high at birth: it is estimated at 10–30% of all white children at birth, decreasing to 2–10% at 1 year of age, with boys and girls affected equally, but it tends to close spontaneously in the first 2 years of life, after separation of the umbilical cord. Umbilical hernia is more common in black infants than in whites. It is usually asymptomatic [12].

26.3.2 Acquired Defects

The acquired defects can be divided into:

1. Partial abdominal defects
2. Full-thickness defects

26.3.2.1 Partial Defects

Diastasis Recti

Diastasis recti is not a true abdominal wall fascial defect, but a common condition characterized by the separation of the two rectus abdominis

muscles along the linea alba, resulting in abdominal protrusion that is often associated with a negative body image, musculoskeletal pain, and occasionally urogynecological symptoms. This separation results in a gap, defined as inter-recti distance (Fig. 26.3). The condition may appear in newborns, in men, or in patients with prior abdominal surgery, but it is more commonly found in women; during pregnancies, the geometry of the abdominal muscles changes, and uterine growth leads to an elongation of the abdominal muscles and a change in the angle of the muscles' attachment. This leads to a stretching and flaccidity of the linea alba which may result in the enlargement of the distance between the medial borders of the muscles, with subsequent loss of their straightforward course. Most studies have agreed that the minimum inter-recti distance to designate a diastasis is 22 mm [13]. The diagnosis of diastasis recti is based on the patient's history and physical examination, confirmed by ultrasonographic study, computer tomography (CT), or magnetic resonance imaging (RMI). An umbilical hernia is often associated with diastasis recti due to the progressive laxity of the midline fascia.

Hernia

A hernia is defined as a bowel coming out of the cavity that normally contains it, through an orifice or area of weakness. According to the European Hernia Society, we can classify abdominal wall hernia in medial and lateral. Medial hernias include umbilical and epigastric hernias, whereas lateral hernias involve Spigelian and lumbar hernias [14]. For the development of a hernia, two conditions must occur: a predisposing condition, due to malformations, congenital weakness, or a thinning of the abdominal wall caused by pregnancy, old age, or constitutional thinness, and a triggering condition, caused by an increase in intra-abdominal pressure related to coughing, obesity, or overexertion.

An *umbilical hernia* is a ventral hernia located at or near the umbilicus. The European Hernia Society classification for abdominal wall hernias defines the umbilical hernia as a hernia located from 3 cm above to 3 cm below the umbilicus. It

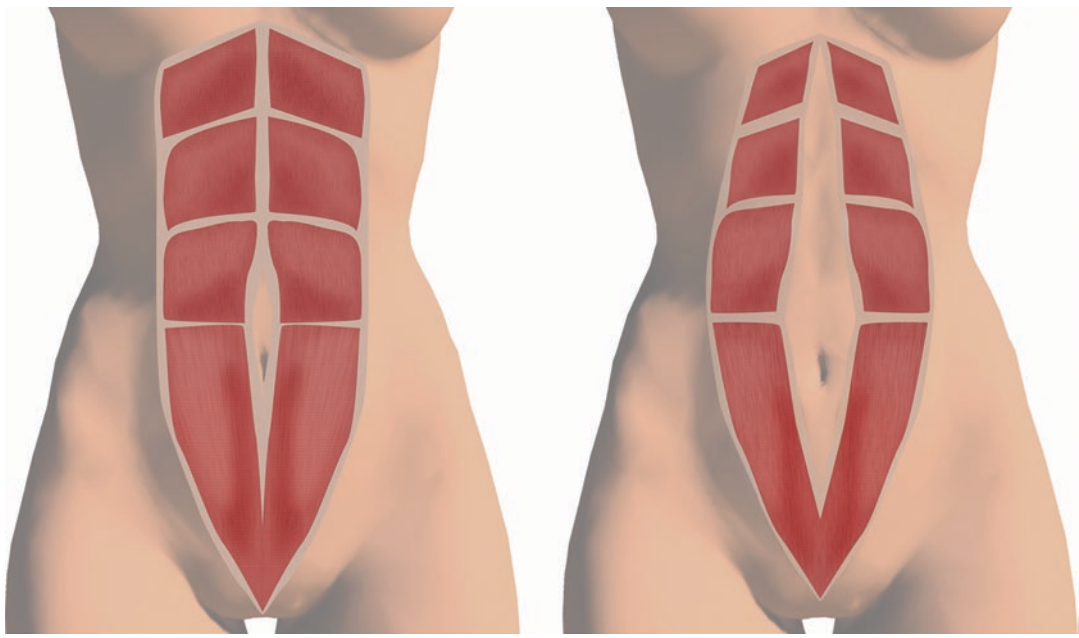

Fig. 26.3 On the left, normal anatomy of the rectus abdominis muscles and the linea alba. On the right, diastasis recti with increase of the inter-recti distance. (Illustration by Federico Di Crescenzo)

is the second most common type of hernia in adults following inguinal hernia. It accounts for 6–14% of all abdominal wall hernias in adults [15]. Unlike in children, the adult umbilical hernia has no tendency to spontaneous regression and must always be operated, considering the high risk of incarceration related to it. Narrow-neck hernias are at greater risk for incarceration and strangulation of bowel, whereas large-neck hernias are less likely to cause bowel trauma. The navel is the scar located in the center of the xiphopubic line and consists of a fibrous ring covered by the pre-peritoneal tissue and by the peritoneum; this represents a locus minoris resistentiae. In adulthood, it measures 2–3 mm, but it can be wider in predisposed patients. Abdominal distension is a risk factor for umbilical hernias; this is the reason why they are more frequently found in multipares, in cirrhotic patients, and in the obese. Diagnosis is clinical and is easier in normal-weight or underweight patients when an umbilical bulging appears during the Valsalva maneuver. Umbilical hernias are generally asymptomatic, becoming symptomatic in case of strangulation or incarceration. When diagnosis is doubtful or when it is indicated to study the accompanying diastasis, ultrasound or CT exams are useful.

Epigastric hernia occurs when an area of weakness in the abdominal wall allows pre-peritoneal fat to push through; these kinds of hernias are typically small. They occur in the area between the navel and the breastbone. These hernias typically do not cause symptoms, but the patients may experience pain in the upper abdomen. It is important for the surgeon to know that some patients develop more than one epigastric hernia at a time.

Lateral hernias include Spigelian hernias, which might appear on the semilunar line at the level of the external margin of the rectus abdominis muscle; this line extends from the anterior margin of the IX costal cartilage to the pubis. They are usually found below the umbilical level due to dehiscence of the transversus aponeurosis and internal oblique muscle which appear to be weaker in the vicinity of the semilunaris line.

Lumbar hernias come out through one or both areas of least resistance in the posterolateral supra-iliac region: the superficial lumbar Petit's triangle and the quadrilateral area of Grynfeltt. Petit, in 1738, described one of the first cases of complicated lumbar hernia which appeared in a triangle bounded by the iliac crest, the external oblique muscle, and the latissimus dorsi muscle (named from him the Petit's triangle). On the other hand, the space described in 1866 by Grynfeltt is bordered by latissimus dorsi muscle at the level of the XII rib, the posterior margin of internal oblique muscle, and the serratus muscle. The area of greatest weakness is represented by the aponeurosis of the transverse muscle, due to the passage of three muscular nerve pedicles. Such "costo-iliac" hernias can vary between 2 and 20 cm in diameter. Other abdominal wall hernias are represented by inguinal and crural hernias.

Inguinal hernia can be classified as:

- External or indirect oblique hernias, also called "lateral hernias"; they are the most frequent, involving peritoneal sac, which is externalized through the lateral inguinal dimple, lateral to the epigastric vessels. Usually, the sac is intra-funicular and corresponds to the persistence of the peritoneo-vaginal duct. It develops like a "glove finger" inside the fibro-cremasteric sheath and follows the way of the funiculus.
- Direct hernias, also called "medial": they exteriorize from the dimple medial inguinal, medial to the epigastric vessels. Usually, the sac is wider than long and spheroidal and corresponds to a prolonged relaxation of the transversalis fascia a level of the medial inguinal dimple. Sometimes the sack externalizes through a limited orifice and takes a diverticular aspect.
- Internal oblique hernias are located at the level of the internal inguinal dimple, medial to the umbilical artery, and are externalized at the inner corner of the inguinal duct. They are exceptional.

Crural hernias, also called "femoral," are rarer than inguinal and more frequent in females. Crural hernias do externalize through the sheath

of the femoral vessels, which extends the transversalis fascia to the thigh. This sheath is normally narrow around the femoral vessels, except at the level of the medial aspect of the femoral vein. It is at this level that common crural hernias develop. The sack pushes through the crural ring, below the crural arch, medial to the femoral vein.

Postoperative or Incisional Hernia

Incisional hernia is defined as the herniation below the cutaneous plane of abdominal viscera, through a previous laparotomy incision, representing a rather frequent complication of abdominal surgery. In most cases, it appears in the first year after surgery, representing a complication, and it is often a source of long-term morbidity. Based on anatomical and clinical criteria, incisional hernias can be distinguished in median and lateral hernias. The median ones, originating at the linea alba, are the most frequent, representing a 75–90% of the total; among the lateral hernias, less frequent than the median (10–25% of total), the subcostal and inguino-iliac ones are the most common, in most of the cases located, respectively, in the right hypochondrium, as consequence of biliary surgery, and right iliac fossa, following surgery for appendicular peritonitis or for gynecological pathologies [16]. Depending on the size of the hernia gate, they can also be categorized as follows: small hernias (<5 cm), intermediate hernias (5–10 cm), large hernias (>10 cm), and giant hernias (>20 cm). Incisional hernia is an evolutionary disease, and when it reaches a considerable size, it alters the physiological balance between abdominal muscle activity, abdominal pressure, and diaphragm activity causing the so-called laparocele disease with important muscular, respiratory, cardiocirculatory, and visceral alterations. More than the endoabdominal pressure is the lateral traction carried out on the linea alba by the contraction of the lateral muscles of the abdomen that contributes to an increase of the fascial gap. This explains the natural trend of most ventral hernias to progressively increase in dimensions, unless scarring sclerosis acts to consolidate the hernial port when it is still small. In mobile hernias, synchronous with the acts of breathing, the viscera are rhythmically pushed through the hernial gate out of the abdominal cavity, and the activity of the diaphragm is seriously compromised; the movements of the abdominal wall become irregular during the phases of breathing with subsequent worsening of the respiratory function. It is useful for surgical planning to perform instrumental examinations like a CT scan to investigate defect depth (full or partial thickness), the presence of both rectus abdominis muscles, and horizontal diameter between the rectus abdominis and perforators' anatomy.

26.3.2.2 Full-Thickness Defects

Traumatic Defects

Acquired or full-thickness defects generally result from different conditions like previous surgery, trauma, infections, and tumor resections. Massive abdominal wall defect is a challenge to any reconstructive surgeon. Defects due to any trauma are very difficult to manage due to associated injuries, infection, and non-availability of local tissues for reconstruction. Traumatic rupture of the abdominal wall is most commonly supraumbilical and is related to a concurrent intra-abdominal injury. Plastic surgery is usually called not for the management of acute penetrating abdominal injury but for the repair of subsequent loss of domain. Reconstructive surgeons may also be called to evaluate wounds that have been left temporarily open.

Oncological Defects

History of abdominal neoplasm may complicate the reconstructive course: chemotherapy may impede wound healing, and radiotherapy causes extensive tissue injury and may contribute to abdominal wall defects. Acute radiation injury poses several challenges: difficulty in distinguishing anatomical planes, extensive soft-tissue fibrosis, reduced tissue pliability, and prolonged healing time. The injury to a wound bed is manifested by stasis or occlusion of the small vessels and decreased tensile strength.

26.4 Surgical Treatment

A lack of abdominal wall integrity is often a cause of frustration for patients, having a huge impact on quality of life, social relationships, and physio-psychological well-being.

Plastic surgeons are called to restore proper abdominal wall structure and function when it is diminished or absent. It is very common that patients consulting plastic surgeons have already made multiple attempts at surgical closure of their abdominal wounds with no success.

Risk factors for failure of primary hernia repair include obesity, surgical-site infection, hernia size, hernia repair technique, patient demographics, smoking history, chronic respiratory disease, prolonged wound healing, and mesh failure. Obesity is also an independent risk factor for postoperative complications. Surgeons must bring the patient to surgery in the best possible conditions and must reduce all related risk factors before planning an operation, except for emergency situations [17]. In line with that, nutritional evaluation and counseling for obese patients are paramount, and weight loss surgery should be considered; smoking cessation is mandatory, and diabetes and cardiac and pulmonary status should be assessed and optimized.

Depending on the clinical situation and on the type of defect, a decision should be made on whether it is advisable to proceed with immediate or staged repair.

Immediate reconstruction is commonly preferred because it is more cost-effective and less time-consuming in stable patients; on the other hand, major surgery should be postponed in case of significant distension, inflammation, infection of the wound bed, or planned staged reconstruction.

26.4.1 Repair of Congenital Defects

In case of congenital defects repair postpartum, fetuses with *gastroschisis* will benefit from intravenous fluid resuscitation and wrapped herniated loops in warm saline as there is an increased risk for water and heat losses by evaporation. A surgical option for gastroschisis includes repositioning of the herniated bowel into the abdominal cavity, with closure of the abdominal wall like in primary reduction and repair. In such cases, there is a high risk of respiratory complications. The surgical procedure can also be postponed if the patient is unstable. In cases of complex gastroschisis, the repair is usually delayed, as anastomosis is impossible, having an inherent risk of infectious and cholestasis complications.

In cases of *omphalocele* with a small abdominal wall defect, primary closure is the preferred therapeutic procedure, while in cases of a larger defect, multiple surgeries may be required to repair it. Various agents such as povidone-iodine, sulfadiazine, neomycin, silver-impregnated dressings, neomycin, polymyxin, and bacitracin ointments have been reported to help with the formation of an eschar of the amnion sac. There are different surgical techniques for the cure of omphalocele that include serial reductions or closing the defect gradually after replacing the sac with a mesh.

Bladder exstrophy is detected with prenatal US, and the prognosis is quite favorable. The postnatal management includes early surgical procedure to close the anterior wall defect within the first 3 days after birth. If the surgical repair is performed later, there is a higher risk of urinary incontinence or uterine prolapse, infertility, and increased risk of bladder adenocarcinoma. Besides bladder closure, pediatric surgeons must also repair the epispadias simultaneously, or in a staged intervention, in order to offer an acceptable appearance and function of the external genitalia.

Repair of the *umbilical hernia* in infants is usually postponed due to a low rate of complications; furthermore, most umbilical defects will be corrected spontaneously within 2 years. The size of the hernial ring provides a useful indicator for spontaneous closure. Expectant management of asymptomatic umbilical hernias until the age of 4–5 is both a safe and standard procedure in many pediatric hospitals. Surgery is indicated for complications of the hernia which include incarceration, strangulation, or rupture. Fascial defects

with diameters less than 1.0 cm almost always heal spontaneously before 6 years of age and therefore rarely need surgical treatment. Fascial defects greater than 1.5 cm rarely heal spontaneously before age 6; such large defects should be surgically corrected prior to age 6 to prevent embarrassment in school [18]. Umbilical hernia repair is a day case surgery performed under general anesthesia; a semicircular periumbilical incision is usually made on the left margin of the umbilical ring allowing to proceed with a dissection of the peritoneal sac at the deep face of the skin of the navel. The aponeurotic margins of the umbilical ring are then identified and carefully prepared, bringing them closer together with transverse stitches with non-absorbable suture. Umbilicoplasty may be performed, especially for those with a large umbilical hernia, to improve cosmetic results.

26.4.2 Repair of Acquired Defects

Acquired defects of the abdominal wall are categorized in partial defects, which involve the loss of either the skin and subcutaneous tissue or the myofascial tissue, and complete defects, involving the full-thickness loss of both superficial and musculofascial layers.

26.4.2.1 Repair of Partial Defects

Partial defects involving the *skin and subcutaneous tissues*, if smaller than 5 cm in size, are usually closed primarily; defects between 5 and 15 cm in size are closed either with local flaps (random flaps, perforator flaps) or a split tissue skin graft or can also be managed with a vacuum-assisted closure device. For defects greater than 15 cm in size, options include pedicled or free fasciocutaneous flaps or, alternatively, the use of random flaps, whose use can be optimized with tissue expansion processes, which aid in tissue advancement and donor site closure. Expansion of both sides of a defect improves the process of reconstruction. The disadvantage of this technique is that it is a staged and lengthy procedure, and there is also a possibility of exposure and infection of the tissue expander. The advantage is that reconstruction can be performed with well-vascularized, innervated, autologous tissue.

Partial *myofascial defects* are closed primarily whenever possible; the plication of the anterior and/or posterior rectus sheath is the most frequent procedure performed by plastic surgeons to correct deformities of the musculoaponeurotic layer involving the midline.

Diastasis Repair

The most common partial myofascial defect of the abdominal wall is rectus diastasis, which usually needs surgical repair with different techniques, either through an open or laparoscopic/endoscopic procedure.

Open approach is performed during conventional abdominoplasty or mini abdominoplasty procedure, depending on the patient's body shape and skin laxity: conventional abdominoplasty is generally more suitable when there is redundant skin excess and involves the transposition of the umbilicus which is detached from the skin but remains connected to its stalk; mini abdominoplasty is usually performed in young women, when the abdominal skin tissue is elastic and involves a complete detachment of the navel from its pedicle, which remains adherent to the surrounding skin. This procedure does not involve the excision of abundant skin and subcutaneous tissue. The concept of abdominoplasty surgery has remained constant over the years. The purpose is to improve the contour of the abdominal wall by means of rectus abdominis fascia plication and removal of excess skin and fat from the lower abdominal region. These benefits are achieved using a low-lying suprapubic incision that can be hidden under the bikini line; anterior rectus sheath plication extends from the xiphoid appendix down to the suprapubic area. Plication of the anterior rectus sheath is performed with a one- or two-layer synthetic, monofilament, non-absorbable polypropylene suture. It is not uncommon that some patients present persistent musculoaponeurotic flaccidity after correction of the diastasis. Therefore, when there is laxity in the flank and hypogastric area after plication of the anterior rectus sheath, plication of the external oblique aponeurosis is an interesting

adjunctive procedure that can be used to improve overall tension of the musculoaponeurotic layer and to valorize the fine contour of the abdomen in thinner patients (Fig. 26.4).

In case of severe laxity, the use of a resorbable or no resorbable mesh can be considered; this might be placed over the anterior or posterior rectus sheath and anchored interrupted by using an absorbable suture. Obtaining a complete coverage of the mesh with the anterior rectus sheath layer is advisable to avoid complications.

Hernia Repair

The treatment of all umbilical hernias in adults must be surgical, considering the risk of strangulation. It is performed under general anesthesia that allows dissection in optimal conditions on a curarized patient. There are different techniques available: simple closure, closure with local plasty, or prosthetic reinforcement by conventional or laparoscopic approach. The indication for a specific technique depends on the size of the hernia, skin conditions, and the surgeon's preference. Elliptical semi-circle skin incision is performed on the left side of the navel, which can be slightly prolonged on the midline above or below, and then the surgeon proceeds with sack isolation, disconnection from skin adhesions, and repositioning of its content into the abdominal cavity. When the tension is high after hernia correction, small fascial releasing incisions (1–1, 50 mm on each side) are suggested. To avoid hernia recurrence, a wall reinforcement with a prosthetic material is often necessary. This must be inserted deeply to limit the risk of infection, often between the peritoneum and posterior aponeurosis of the rectus sheath; a cleavage plane is generally present between peritoneum and muscle sheath. The laparoscopic approach is also performed under general anesthesia, with an empty bladder. The patient is placed in a supine position. The operation starts with the creation of the pneumoperitoneum. The trocar with optics is inserted lateral to the navel or in the suprapubic region. Two more 5 mm operating trocars are placed laterally; after exploring the peritoneal cavity, the sac is freed from its adhesions, using scissors and hook coagulator. If a prosthesis is

Fig. 26.4 Pre- and post-correction of a rectus diastasis and umbilical hernia with conventional abdominoplasty

needed to be inserted, it is shaped and introduced in the abdominal cavity both through the optic trocar and through an additional 10 mm trocar.

Postoperative or Incisional Hernia Repair

Ventral hernias are one of the most common abdominal wall defects faced by reconstructive surgeons, known for the high relapse rate and surgical complications. It is important to note that, despite advances in hernia repair techniques and technologies, recurrence following standard ventral herniorrhaphy remains unacceptably high. Evidence from the trial conducted by Luijendijk suggests that nearly one quarter of ventral hernias repaired with synthetic mesh recur within 3 years; this rate reaches 50% for primary repair alone. In addition, the risk of hernia recurrence increases with each additional operation: the length of time between reoperations was progressively shorter after each additional hernia repair [19]. Postoperative complications and recurrence are the two main issues in ventral hernia repair; infection is a common and significant postoperative occurrence that increases the risk of hernia recurrence. Use of prosthetic repair material is highly recommended in order to reinforce the repair of all incisional ventral hernias, whether the midline fascia can be re-approximated or not. Very small defects may be closed primarily along with reinforcing prosthetic repair material, potentially using a retrorectus repair. Most defects too large for primary repair can be closed with the component separation technique and reinforced with prosthetic repair material. In 1990, Ramirez published his work on local tissue transfer for the repair of ventral hernias [20]. Component separation technique involves suprafascial lateral dissection to the midaxillary line, followed by a fasciotomy through the external oblique aponeurosis and then lateral dissection in the plane between the external and internal oblique muscles up to the midaxillary line. This avoids damage to the neurovascular structures supplying the muscles, which travel in the plane between the internal oblique and the transversus abdominis. These maneuvers allow medial advancement of 3–5 cm in the epigastrium, 7–10 cm at the waistline/umbilical region, and 1–3 cm in the suprapubic area for a single side; therefore, a bilateral component separation can allow for closure of a 20-cm-wide fascial defect. Component separation creates a dynamic repair by using incisions that create fascial release to bring the rectus muscles together at the midline, thereby recreating an innervated, functional abdominal wall. When component separation is not feasible or is insufficient to completely reduce the defect, surgeons may consider bridging the defect with prosthetic repair material (Fig. 26.5).

Tips and Tricks

Important things to consider for better outcomes in abdominal wall surgery:

- According to the multidisciplinary approach, a good anesthesiologist-surgeon relationship is critical to achieve the best possible results; it is important to avoid cough, nausea, vomiting, and abdominal contractions postoperatively.
- Wearing compression garments after surgery will improve the patient's recovery and will reduce the rate of postoperative seromas.
- When dermolipectomy is performed, tension-free sutures with layered abdominal closure are suggested, which transfer the tension to the superficial fascia system and not on the distal skin flaps, in order to reduce skin flap necrosis and hypertrophic scars.
- Get out of bed: moving around and walking in the days following surgery help in faster recovery while reducing thromboembolic complications.

Synthetic mesh is currently the most common repair material used for reinforcement of ventral hernias; however, despite significant advantages such as reduced recurrence rates, ease of use, and comparatively low cost, permanent synthetic mesh has certain drawbacks. These disadvantages include increased risk of visceral adhesions to the

Fig. 26.5 Recurrent incisional hernia operated with a combination of mesh placement and component separation technique (Ramirez), which allowed bilateral advancement of the muscular layers with complete coverage of the mesh

repair site, erosion into the bowel leading to formation of enterocutaneous fistulae and/or bowel obstruction, extrusion of the repair material, and infection. Following removal of an infected prosthesis, the surgeon is left with a contaminated field and a hernia deficit larger than the original that still requires repair material. Surgeons must consider the use of biologic repair materials in place of permanent synthetic mesh, because of their ability to support revascularization: these materials are more resistant to infection and do not require removal when exposed or infected; furthermore, the ability of certain biologic prostheses to support revascularization may contribute to clearance of a contaminated field. Biologic repair materials have been successfully used to repair large contaminated and/or irradiated abdominal wall defects in patients with cancer when placed directly over the bowel. The choice between synthetic and biologic repair material for many surgeons is often based on several considerations including cost, choice of technique, technical expertise, and the risk for postoperative complications. In open incisional hernia repair, prosthetic repair material may be placed to reinforce a primary repair or to bridge a remaining defect if reapproximating of the fascial edges is not possible. There are several techniques that have been described, according to the location of the prosthesis: this can be sutured superficial to the primary repair of fascial edges *(onlay*), within the myofascial layers (*sublay*), or beneath the fascia and exposed to intraperitoneal contents (*underlay*). Overlay placement, therefore, may be preferred for types of synthetic mesh that are associated with formation of bowel adhesions to minimize the risk that the mesh may erode into the abdominal compartment and become exposed to the viscera. Bridging may not generally be recommended except in cases where component separation is not feasible or is insufficient to bring the fascial edges together. There are also theoretical advantages to the placement of repair material as an underlay: when the material is placed deep into the abdominal musculature, increases in intra-abdominal pressure press the repair material into the defect and against the native tissue, rather than away from the defect. This technique also seems to have a lower recurrence rate.

Although recurrence rates following reinforced laparoscopic hernia repair are comparable

to those of open repair with reinforcement, there are several documented advantages of the laparoscopic approach, including smaller incisions, lower risk for complications, shorter hospital stay, and patient preference. However, seromas may be more common following laparoscopic hernia repair, due to the use of drains in the open approach, which are not generally placed in laparoscopic repairs. In addition, the limitations of laparoscopic repair include the inability to restore functional abdominal wall anatomy, to manage skin redundancy and the hernia sac.

Key Point

Ventral hernias are one of the most common abdominal wall defects faced by reconstructive surgeons.

Repair of giant incisional hernias can bring to an increase of intra-abdominal pressure and, sometimes, to abdominal compartment syndrome. Patient optimization is crucial for the success of the intervention.

Given the high risk of recurrences, the use of a prosthesis is mandatory and must be placed preferably between the muscular plane and the posterior rectus sheath. In our experience, biologic mesh is the first choice, given the lower infection rate.

26.4.2.2 Repair of Full-Thickness Defects

Traumatic Defects Repair

Traumatic accidents or, more commonly, oncological resection (soft tissue sarcoma) may result in large full thickness of the abdominal wall. In trauma patients, especially with loss of domain, delayed reconstructions are preferred. In such cases, every effort should be made to achieve primary fascial closure after adequate debridement of any poor-quality, attenuated, scarred, damaged, or nonviable musculofascial tissue. In this case, the wound is closed with a temporary cover and subsequently re-explored. A skin graft may be applied as a temporary measure until reconstruction can be performed. Vacuum-assisted closure devices are used in such cases; using this adjunctive tool, a sterile foam dressing is placed in the wound cavity with an evacuation tube which exits the wound to create an airtight seal, and sub-atmospheric pressure is applied to the foam dressing; this procedure ensures a complete sealing from the environment, a better vascularization of the wound bed, a decrease of bacterial colonization, an improvement of granulation tissue while reducing the size of the defect, and increased flap survival. Unstable or trauma patients with full-thickness defects require reconstruction of the different layers to restore muscular function and replace skin and fascial gaps. In such patients, a staged approach is preferred using a temporary vacuum-assisted closure device and, if needed and possible, a planned tissue expansion procedure. Tissue expansion can provide autogenous tissue to close skin and subcutaneous defects larger than 15 cm in size after initially achieving temporary closure. Reconstruction requires expansion on both sides of the defect. Despite being a lengthy, staged procedure, it provides well-vascularized innervated autologous tissue for reconstruction. Expansion is achieved between external and internal oblique or between internal oblique and transverses abdominis muscles. Tissue expansion also restores abdominal domain thus allowing easy reduction of visceral contents of the ventral hernia and prevents postoperative respiratory discomfort [21].

Oncological Defects Repair

Similar full-thickness defects are encountered after oncological resection of soft tissue sarcomas or skin metastasis from other cancer invading the abdominal wall. In such cases, immediate reconstruction is needed to provide urgent coverage of exposed viscera. We should support the use of mesh as a fascial repair in all oncologic cases. For moderate-size defects involving the lower abdominal wall and the inguinal region, local and/or locoregional pedicled flaps are used with success: in particular the gold standard coverage is provided by the use of tensor fascia lata flap and anterolateral

thigh flap with combination of fascia lata and muscle (vastus lateralis, rectus femoris) harvesting. In this scenario, the thigh donor site is ideal to provide an abundant source of vascularized fascia to perform fascial reconstruction; vascularized fascia lata was historically the mainstay for reconstructing contaminated fascial defects of the abdominal wall. In cases of prior radiation therapy, prior surgery, or excessive skin resection, vascularization may not be reliable, and a pedicled regional or free flap from the contralateral abdomen, thigh, or posterior trunk may be considered. Also, perforator flaps can be used with a similar purpose of skin resurfacing (deep inferior epigastric artery perforator flap, superficial circumflex iliac perforator flap), in combination with the use of a mesh; perforators are identified using a hand-held Doppler, and the flap is then meticulously raised ensuring no injuries to perforators under loupe magnification. For defects of significant size, especially extending in the upper abdominal quadrants, microsurgical transfer of free flaps from distant donor sites (anterolateral thigh flap, latissimus dorsi flap) is preferred to cover the exposed viscera and restore function: this is a more advanced technique, associated with long operating times, technically demanding and more prone to complications (Fig. 26.6). The procedure can be performed in a nonfunctional (if one or both rectus abdominis muscles are intact and functional) or functional way (if the motor function of the anterior abdominal wall is impaired) [17]. In such cases, the latissimus dorsi transfer is frequently indicated. The alternative in such extensive cases is abdominal wall transplantation. Composite allotransplantation of the abdominal wall involves harvesting full-thickness abdominal wall with the iliac or inferior epigastric vessels from a donor. Candidates for this reconstructive option should have exhausted all other options.

Key Point

It is advisable to perform an immediate reconstruction after oncological resection, when the wound is clean and local tissues are available and allow a proper reconstruction.

In traumatic defects, delayed reconstruction represents the best course of action; a temporary vacuum-assisted closure device is employed during stabilization of the patient in order to decrease the bacterial colonization, to define the real extent of the loss of substance, and to improve tissue vascularization.

An interdisciplinary approach plays a key role especially in full-thickness defects.

Take-Home Messages

- The abdominal wall is a functional unit: a comprehensive knowledge of the vascular and neural architecture is mandatory to successfully approach abdominal reconstruction.
- Elective defects such as rectus diastasis are frequently encountered and approached with a combined functional/aesthetic procedure: abdominoplasty/mini-abdominoplasty.
- Ventral hernia repair should be addressed with a combination of autologous and synthetic approaches to reduce complications.
- Component separation technique is the approach of choice for significant myofascial defects, especially in comorbid and obese patients.
- Oncological cases should be referred to microsurgical units with expertise in flap transplantation.

Pearls and Pitfalls

- Accurate planning of dermolipectomy patterns combined with rectus diastasis plication offers the best functional and aesthetic results.
- Reduce risk factors before surgery like tabagism, diabetes mellitus, chronic

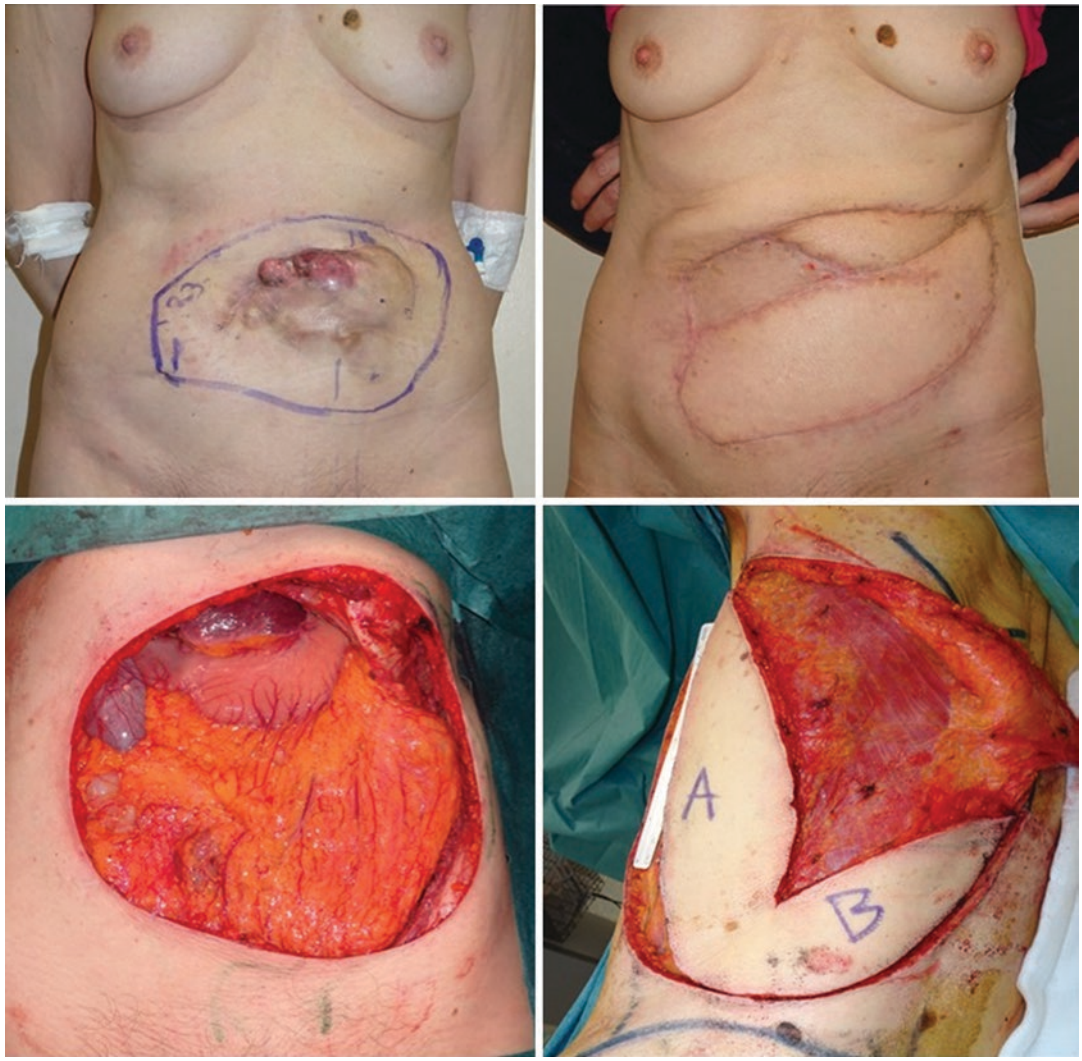

Fig. 26.6 Microsurgical abdominal wall reconstruction with a KISS LD free flap after wide resection of dermatofibrosarcoma protuberans

obstructive pulmonary disease (COPD), coronary artery disease (CAD), poor nutritional status, immunosuppression, and obesity in order to have the greatest chances of success.

- The use of prosthetics material is highly recommended in case of postoperative hernias, due to the high recurrence rate.
- The use of biologic meshes should be preferred to reduce the risk of bacterial contamination.

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