Chapter 9

Significance of Autologous Tissues in the Treatment of Complicated, Large, and Eventrated Abdominal Wall Hernias

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.68874

Abstract

Repair of complicated, large, or eventrated abdominal wall hernias poses a considerable challenge. Not infrequently, synthetic grafts implanted earlier become infected, entero- or subcutaneous fistulas appear, or emergency conditions like mechanical ileus or peritonitis develop. In such cases, direct closure of the abdominal wall with sutures or reinforcement with synthetic grafts is not recommended. Not many surgical techniques are capable of creating a low tension state. One is bridging of the abdominal wall defects; another is mobilization of the musculo-aponeurotic elements of the abdominal wall (components separation). In this chapter, the use of autologous double-layer dermal grafts and the technique of bilateral rectus muscle turnover allowing reconstruction of eventrated hernias in a tension-free way are discussed. In both procedures, only autologous tissues are used for reconstruction. With autologous dermal grafts, the rate of surgical complications is 4%, recurrence in the first 24 months is 11%, and the quality of life is significantly improved. With bilateral rectus muscle turnover, surgical complications occur at a rate of less than 2%, 24-month recurrence is 0%, and the quality of life is significantly improved. The technique of the interventions, their indications and contraindications, as well as their feasibility, advantages and disadvantages are described.

Keywords: infected and complicated abdominal wall hernia, eventrated hernia, autologous reconstruction, double layer dermal grafts, rectus turning over, recurrence, quality of life

1. Introduction

Repair of complicated, large, or eventrated abdominal wall hernias poses a considerable challenge for surgeons. Conditions characterized by the presence of an eventrated scar hernia and an extensive abdominal wall defect developed from an initially small ventral abdominal wall hernia are not infrequent in the surgical practice. Progression of incisional hernias in laparotomy scars may lead to a similar condition. Reconstruction of abdominal wall hernias accounts for 3–11% of all surgeries performed in general surgical wards, depending on the type and profile of the institute. Incisional hernias have a special significance in the surgical practice for two reasons: first, they develop as a consequence of an earlier intervention and have to be corrected, preferably in a definitive way, also satisfactory to the patient; second, abdominal wall hernias cannot always be resolved definitively despite all efforts. Scar hernias may recur for various reasons. They may be the consequence of inadequate surgical technique; in many cases, however, they are due to lack of compliance and discipline (strain exerted too early and not in a gradual fashion) on the patient's part. The question whether scar hernias are complications or natural corollaries of surgical interventions has been asked by several authors [1]. Whatever the reason, flat abdominal muscles lose their adherence partly or completely along the linea alba in the midline of the abdominal wall, and a progressive, well-defined, and well-known vicious circle is started. Since the reconstructed abdominal wall must resist, as much as possible, the intra-abdominal pressure—which often rises abruptly—as well as tension due to physical strain, reinforcement of the abdominal wall is a key factor in the surgery of abdominal wall hernias. Four kinds of techniques, each fundamentally different from the other, have evolved for the repair of abdominal wall hernias. The *first* is direct abdominal wall suture, with a synthetic mesh implanted in one of the following positions: epifascial (onlay), interfascial (inlay), or subfascial (sublay) [2, 3]. The *second* is the so-called components separation technique, in which closure of the defect is achieved by specific release of individual muscular components in the abdominal wall [4]. The *third* is laparoscopic abdominal wall reconstruction, in which a synthetic mesh is used to reinforce the abdominal wall [5]. The *fourth* technique involves bridging or replacement of the abdominal wall defect using synthetic or biological substances [6–8]. The common objectives of all these techniques are reducing the incidence of surgical complications, lowering recurrence rate, and improving the patients' quality of life.

Infected/compromised and eventrated abdominal wall hernias account for 1–8% of all (ventral and incisional) abdominal wall hernias in various institutes [9–10].

Treatment of complicated, large, or infected incisional hernias places a considerable burden on the patient, the hospital staff, the GP, as well as the social insurance [11–15].

The common objectives of all procedures performed in such cases are: (1) *elimination of contamination* in the abdominal wall environment; (2) *closure* of the abdominal wall *defect* with as little tension as possible; (3) maintenance of near-*normal intraabdominal pressure*; (4) *reduction* of postoperative surgical *complications*; (5) *reduction* of hernia *recurrence*; and last but not the least (6) *improvement of the quality of life*.

http://dx.doi.org/10.5772/intechopen.68874

1.1. Definition, terminology

The use of a unified and unequivocal terminology is essential in the surgery of abdominal wall hernias. The nomenclature follows the recommendations of the European Hernia Society (EHS) [16]. *Ventral abdominal wall hernias* are defined as abdominal wall defects of nonsurgical origin, through which intraabdominal tissues and organs leave the abdominal cavity and enter among subcutaneous tissues. Ventral hernias are located in an area bordered by the bilateral anterior axillary line, the costal arches, and the pubic bone. *Incisional abdominal wall hernias* are defined as abdominal wall defects developing in the scars of an earlier surgical intervention allowing tissues and organs to leave the abdominal cavity and enter among subcutaneous tissues. *Medial abdominal wall hernias* are defined as hernias between the medial margins of the bilateral rectus abdominis sheaths; they can be M1: xyphoidal, M2: epigastric, M3: umbilical, M4: infraumbilical, and M5: suprapubic hernias. *Lateral abdominal wall hernias* are defined as abdominal wall defects located lateral of the outer margin of the rectus abdominis sheath, with L1 being subcostal, L2: iliac, L3: lumbar, and L4: inguinal. In small abdominal wall hernia, the longest diameter of the abdominal wall defect is less than 2 cm. In medium-sized abdominal wall hernia, the longest diameter of the abdominal wall defect is between 4 and 10 cm. In large abdominal wall hernia, the shortest diameter of the abdominal wall defect is at least 10 cm. *Midline scar hernias* are defined as incisional hernias developed in the scars of median laparotomies. *Lateral scar hernias* are defined as incisional abdominal wall hernias located lateral of the rectus abdominis sheath. *Recurrent abdominal wall hernias* are defined as scar hernias that have been repaired at least once in an earlier surgery. They consist of two basic components: the abdominal wall defect and the hernia sac with the hernia contents. It should be borne in mind that an abdominal wall protuberance is not an abdominal wall hernia by definition. A *seroma* is a circumscribed, encapsulated pocket of interstitial noninfected fluid developing between the abdominal wall fascia and the subcutis in the operative area. A diffuse, unencapsulated collection of fluid is not to be interpreted as a seroma. An *enterocutaneous fistula* is an abnormal passage allowing chronic communication between two epithelial surfaces (e.g., the small or large intestine and the skin). A *subcutaneous fistula* is a chronic abnormal communication system connecting the abdominal wall superficial fascia and the implanted synthetic/biological material. *Graft* is a fixed synthetic or biological material without blood supply of its own implanted over, under, or among the abdominal wall fascia. *Flap* is a tissue with its own blood supply transferred from another area of the body to cover or replace the abdominal wall defect. *Synthetic grafts* are man-made substances (polyethylene, polypropylene, and teflon) used to reinforce the abdominal wall. *Xeno- and allografts* are specially prepared biological substances of animal (porcine, bovine) or human origin used for reinforcement and/or replacement of the abdominal wall in special cases. *Autografts* are tissues collected from the patient's own body, suitable for replacement and/or reinforcement of abdominal wall defects. A *superficial wound infection* is an inflammatory process at the site of the operation affecting exclusively the skin and the subcutaneous fatty tissue. A *deep wound infection* is an inflammatory process at the site of the operation affecting the skin, the subcutaneous fatty tissue, the abdominal wall fascia, the muscles, as well as the implanted mesh. The abdominal cavity is not affected by this process. *Wound dehiscence* is partial, clean, or clean-contaminated rupture of continuity affecting the skin and the subcutaneous tissue. *Centers for Disease Control and Prevention (CDCP) wound*

environment: classification of wounds by cleanliness into four categories. CDCP 1: clean, sterile; CDCP 2: clean but contaminated; CDCP 3: infected; CDCP 4: severely contaminated, necrotic. An *infected abdominal wall hernia* is defined as confirmed bacterial infection of the implanted synthetic graft or biological substance with simultaneous recurrence of the hernia. Earlier reconstructive surgery and recurring hernia are both assumed. *Compromised graft*: current or earlier bacterial infection of a synthetic graft. At best, it means a potentially contaminated environment (CDCP 2). The term *complicated* is used for incisional abdominal wall hernias which have recurred once or several times, featuring a compromised, or infected, synthetic graft and/or enterocutaneous fistula, with its hernia gate at least 10 cm in diameter. Abdominal wall incisional hernias with hernia sacs corresponding to at least 50% of the volume of the abdominal cavity, or chronically containing more than 50% of intraabdominal organs as defined by some authors [17], are called *eventrated*. The terms "loss of domain" and "loss of abdominal wall domain" are commonly used in the literature.

1.2. Aim of the chapter

1. Presentation of the technical details of reconstructive surgery using autologous double-layer dermal grafts in large recurrent infected abdominal wall hernias.
2. Discussion of short- and long-term outcomes and the results of quality of life studies following surgery with dermal grafts.
3. Computed tomographic (CT) examination of the musculoaponeurotic elements of the abdominal wall and discussion of its importance in the design of full midline giant abdominal wall hernia operations.
4. Presentation of the technical details of bilateral release and turnover of the rectus abdominis muscle and subsequent midline recreation, a surgical technique developed for the resolution of eventrated midline abdominal wall hernias.
5. Discussion of the short- and long-term outcomes of rectus turnover and changes in the quality of life following surgery.

2. Use of autologous double-layer dermal grafts in infected/recurrent large abdominal wall incisional hernias

2.1. Surgical technique

The intervention is performed under general intratracheal anesthesia in a state of complete muscle relaxation. A wide laurel-leave-shaped skin incision is made crosswise (never median!) between both spina iliaca anterior superior. The cutaneous-subcutaneous panniculus is removed (dermolipectomy), with the greater omentum carefully spared. The synthetic mesh implanted earlier is completely removed. The abdominal wall edges left behind should

be strictly intact. The hernia sac should be spared if possible. In the case of multiple hernia gates, individual intact abdominal wall bridges are not opened into each other.

2.1.1. Preparation of the dermal grafts

The retained panniculus is stretched in all directions, and the epidermis is completely removed (**Figures 1** and **2**). The next step is removal of the subcutaneous adipose tissue (**Figure 3**). The prepared dermal graft is stored in a 2:1 solution of H_2O_2-povidone iodine until being used. An adequately prepared dermal graft contains the reticular and vascular layers, as well as a small amount of adipose tissue, without epidermal elements, hair follicles, sebaceous, or sweat glands on its surface (**Figure 4**). The dermal graft is then cut to size in a way that its margins extend beyond the margins of the abdominal wall defect by at least 5 cm. On the basis of our own measurements, a dermal graft can be expanded to 130–135% of its original size when stretched.

2.1.2. Crucial steps of the procedure

The graft is placed in the abdominal cavity with its original surface facing outward. Two procedures may be used here, depending on the status of the greater omentum (intact or not). In case there is no greater omentum, the spared hernia sac and the peritoneum are circularly separated from the inner surface of the abdominal wall, corresponding to the size of the implanted graft. The hernia sac and the peritoneum are closed with 3/0 absorbable thread, and then the graft is placed over the closed peritoneum. The first graft complements the abdominal wall defect. The edges of the abdominal wall are fixed to the graft circularly using 3/0 nonpenetrating, knotty, nonabsorbable stitches (**Figure 5**).

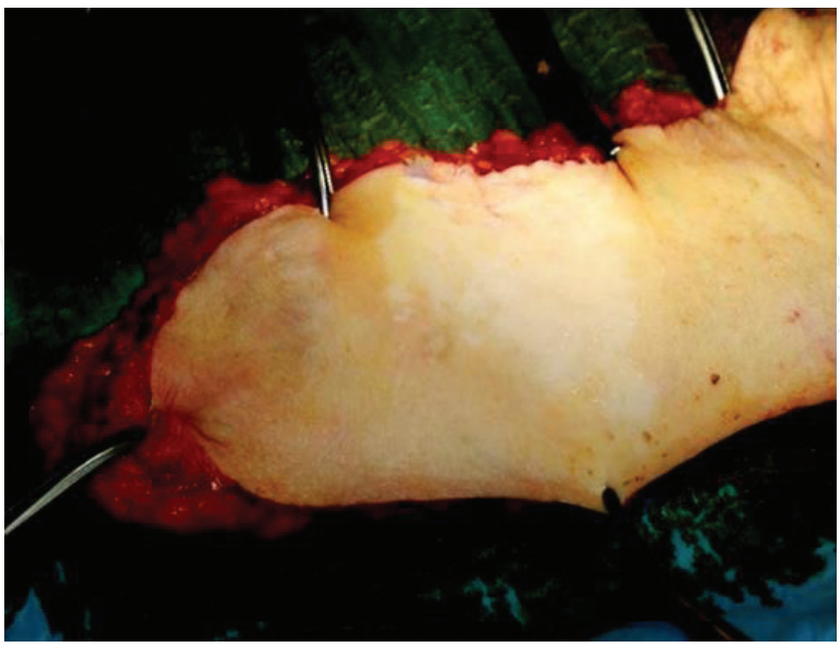

Figure 1. An appropriately stretched panniculus. The subcutis is not yet removed. The dermis is homogeneous without visible scars.

Figure 2. Removal of the epidermis. You can see removed epidermal elements on the blade. The blade is held tilted at approximately 30°. The lighter and darker sections of the dermis are clearly visible. The lighter section corresponds to the graft without the epidermis, while the darker section still contains the epidermis. The dermis must not be damaged during removal. Make sure that all epidermal elements are removed.

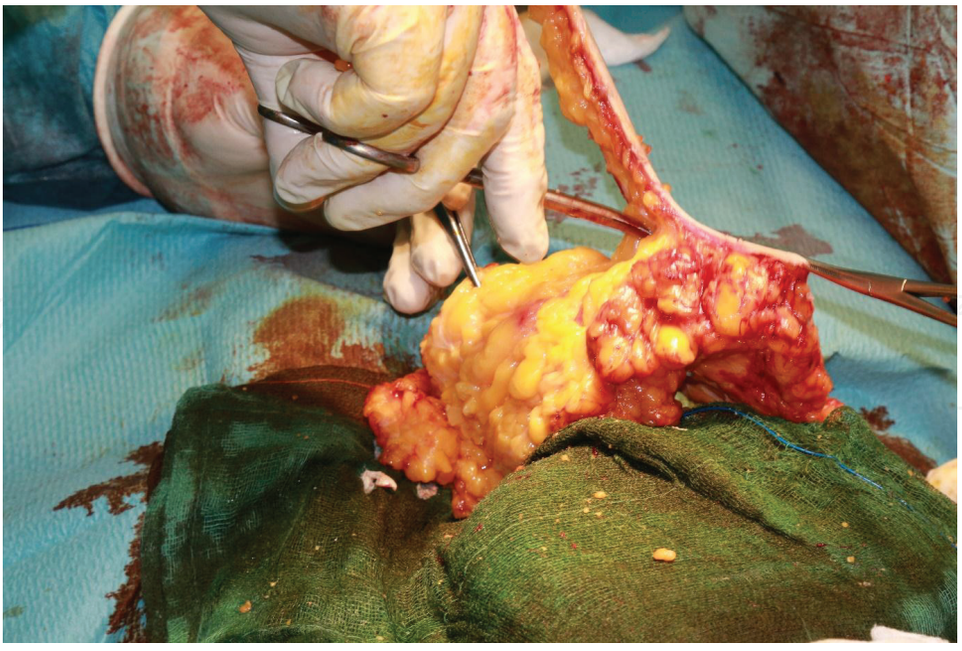

Figure 3. Removal of the adipose tissue. It is not necessary to remove the whole adipose tissue element. The numerous viable ADSCs in the adipose tissue (≈250,000–400,000 cells/5 ml homogenized adipose tissue) play an important role in the integration of the dermal graft.

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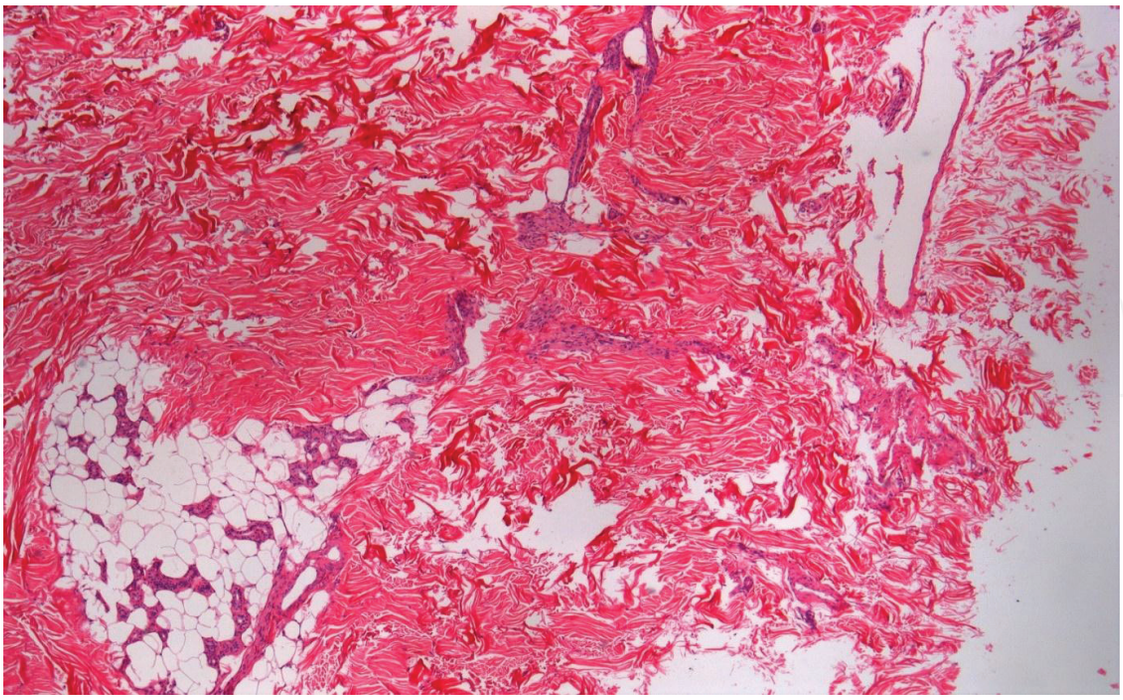

Figure 4. Histological picture of an adequately prepared dermal graft. There are no epidermal elements or signs of penetrating or partial dermal lesions. HE stain 100×.

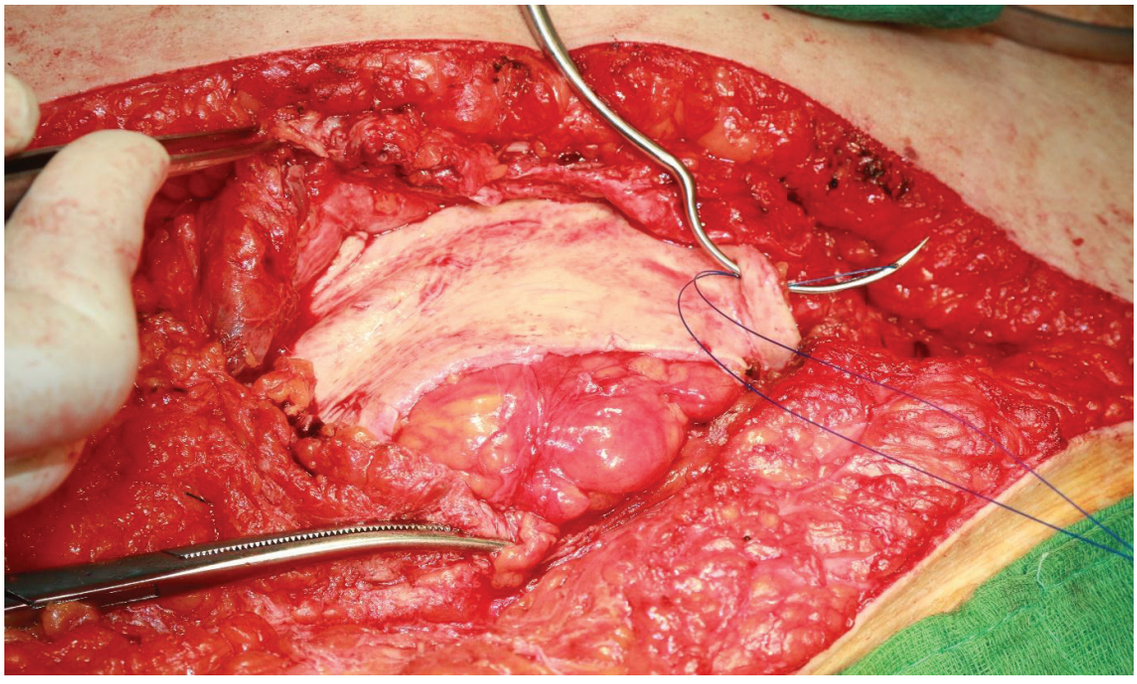

Figure 5. Placement of the first dermal graft. The inner graft is fixed with knotty, nonabsorbable 2/0 stitches with an overlapping margin of at least 5 cm. Intact abdominal wall edges must be constructed. These edges should then be fixed to the dermal graft with knotty, nonpenetrating stitches. There is no direct abdominal wall suture. The area of the abdominal wall defect is 168 cm^2. The placement of remote stitches is considerably easier when an instrument specifically designed for the purpose is used.

In the next step, the second graft is cut to size with its margins extending beyond the margins of the abdominal wall by approximately 2 cm. The graft is placed with its original surface facing inward. This way, the original epidermal surfaces face each other. Like the first one, the second graft is fixed to the abdominal wall fascia with nonabsorbable knotty stitches, in a nonfully stretched state (**Figure 6**). The outer dermal graft can also be applied perforated (**Figure 7**). The surgical area is rinsed with a 2:1 solution of H_2O_2-povidone iodine, with two or three suction drains left behind. The subcutis is "anchored" to the abdominal wall fascia with 8–10 absorbable stitches. The wound must be closed tension-free, using double-layer nonabsorbable subcutaneous and knotty or intracutaneous skin sutures (**Figure 8**).

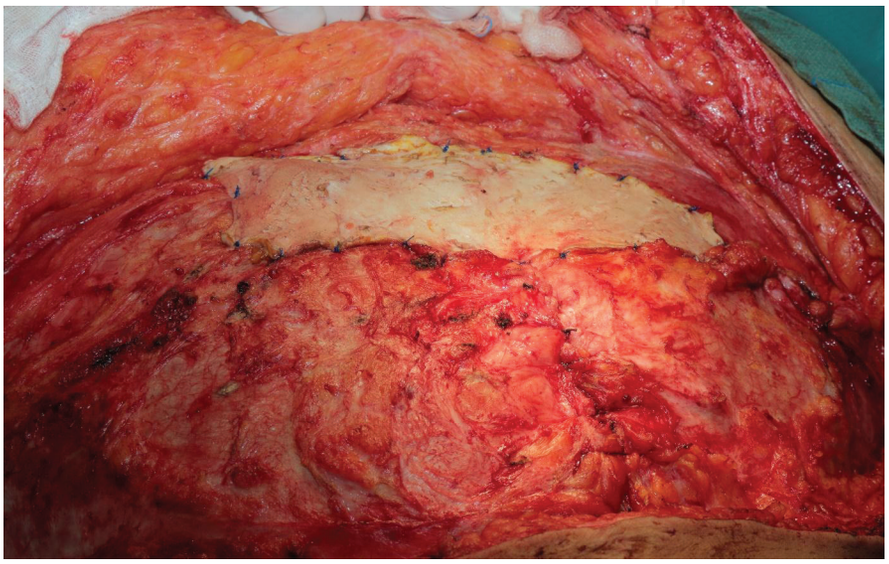

Figure 6. The second dermal graft (two pieces) in a fixed state. The hernia had an extension of 178 cm^2. The knotty stitches used for fixing are clearly visible. The original dermal surface looks inward.

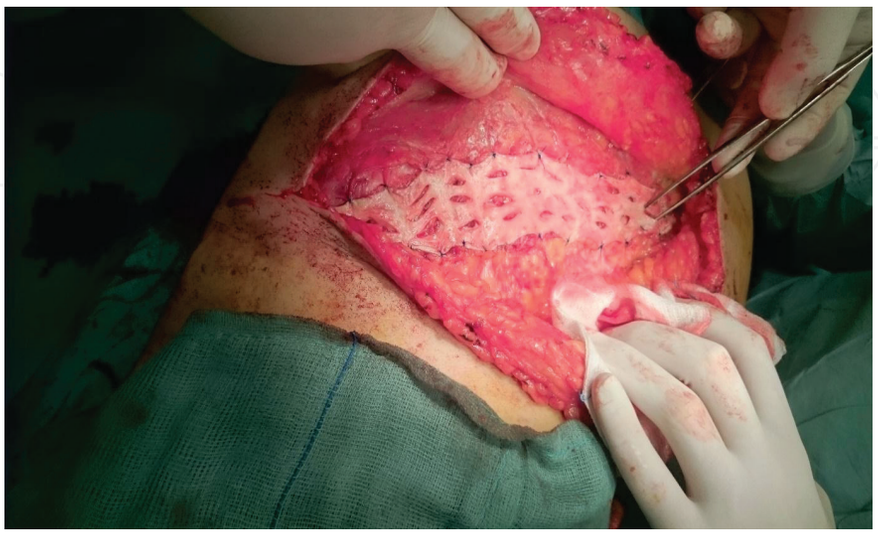

Figure 7. Reconstruction of L_1 recurrent infected abdominal wall hernia using a double-layer dermal graft. The outer graft is perforated as seen. Integration is probably faster with perforated grafts.

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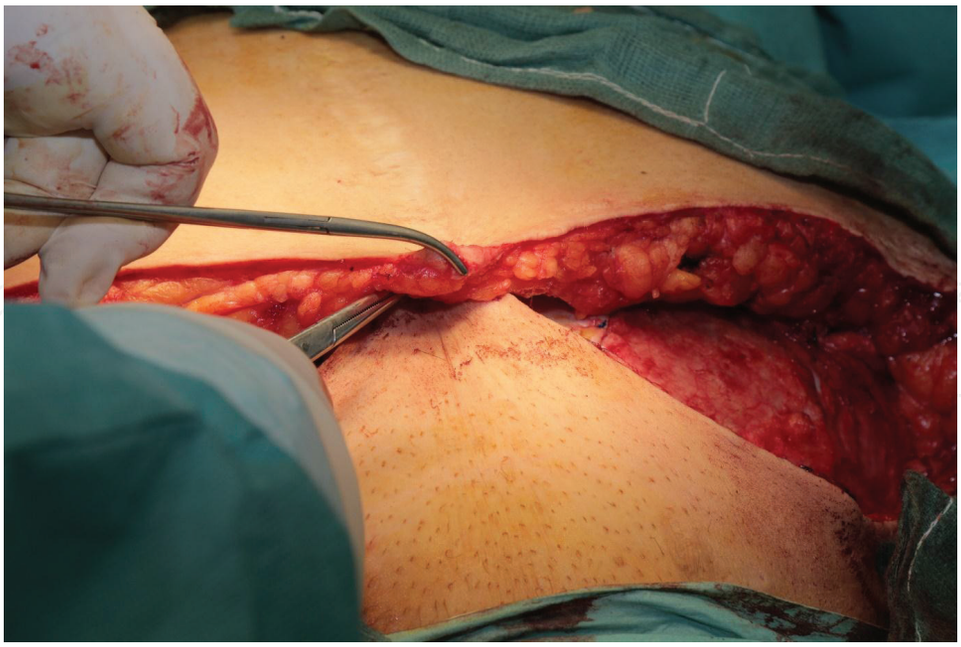

Figure 8. The wound must be closed tension-free. To achieve this, the skin-subcutis must be mobilized to the required extent. The sufficiently thick adipose tissue layer, a key factor in the integration of the second graft, is clearly visible. The adipose tissue should be protected as much as possible during surgery. It should be raised with a wet wipe, without using sharp, traumatizing hooks. Any worn-out adipose tissue particles are removed at closure.

2.1.3. Complications, recurrence and quality of life following abdominal wall reconstructions with autologous double-layer dermal grafts

Reconstructions with autologous double-layer dermal grafts are not free from complications. Hematomas (2.5%), superficial wound infections (3%), and deep wound infections (2.5%) are the most frequent complications in the early postoperative stage. In the late postoperative period, diffuse fluid build-up is the most common complication (17%). These fluid collections, however, are not circumscribed real seromas and can be successfully treated by percutaneous or ultrasound-guided puncture. Genuine subcutaneous seromas are very rare and require surgical exploration. Deep infection in the surgical area may lead to the formation of subcutaneous fistulas (2.5%), which must be removed surgically as they are not likely to resolve spontaneously. Inadequate preparation of the dermal grafts (epidermal elements, such as sebaceous glands or hair follicles, left on the surface) may also lead to complications. An adequately prepared dermal graft should contain nothing but the stratum reticularis and the stratum vascularis of the dermis, with a minimum amount of subcutaneous fatty tissue islands, but without *any* epidermal structures. Dermal grafts have no blood supply of their own. The grafts serve as a kind of connective tissue "scaffolding" for integration and remodeling. Neovascularization starts partly from the subcutaneous adipose tissue and partly from the greater omentum. The process takes 4–5 weeks. Adipose-derived stem cells (ADSCs), present in large quantities in the fatty tissue, play an important role in angiogenesis and connective tissue remodeling (**Figure 9**). Without remodeling and integration, the hernia will recur. Recurrence is invariably preceded by the dermal graft becoming lax, followed by recurrence of the hernia. Abdominal wall laxity occurs in 10–15% of the cases after such operations. Laxity develops in the first 12 months, and recurrences occur in the first 2 years.

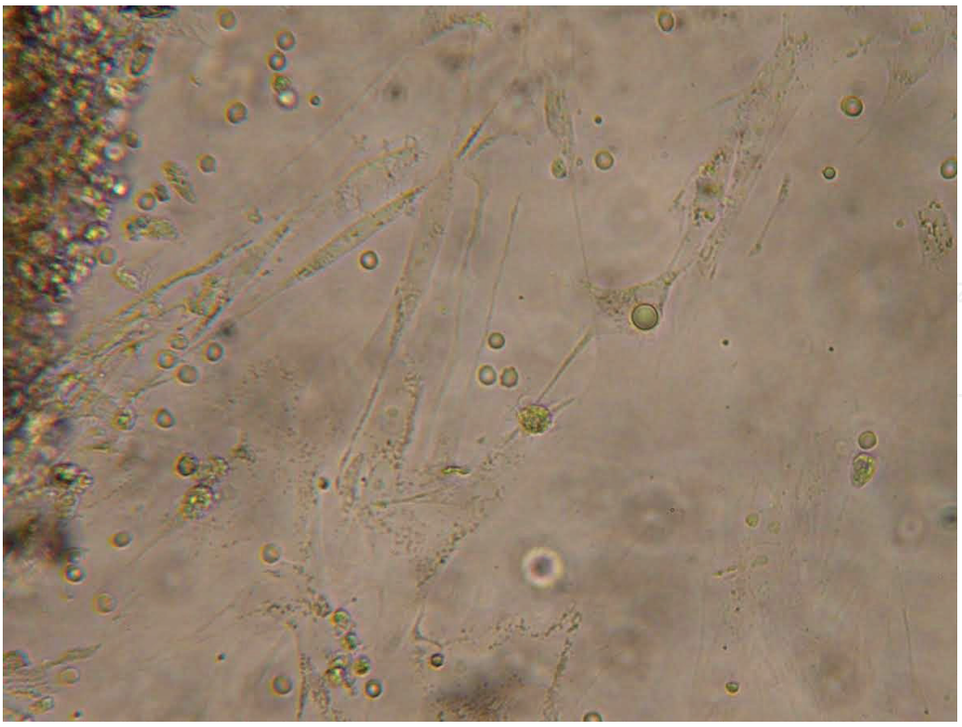

Figure 9. ADSC *in vitro* culture can be seen in the picture. The cells are derived from the abdominal subcutaneous adipose tissue harvested during dermal graft reconstructive surgery. The cells have vital role in the integration and restructuring of autologous dermal grafts. ADSC cells are the elongated rice-grain forms in the picture. (No stain, native photograph of the cell culture, 300×, the author's own research, photogpaphed by Máté Rózsahegyi).

Predisposing factors include smoking, diabetes mellitus (DM), chronic obstructive pulmonary disease (COPD), negligence of the use of elastic trusses, and physical activity too intensive or started too early following surgery (**Table 1**). The rate of recurrence can be reduced provided the patients wear the hook-and-loop elastic truss for long enough and in the right way, properly fitted. Medium or heavy physical load should be avoided during this period. Patients are recommended to follow a regimen of light meals several times a day, avoid foods that cause bloating, and lose weight. If the hernia recurs, further dermal graft reconstruction is usually no longer feasible, as grafts of the required quality and quantity are no longer available after the previous operation. In such cases, components separation, rectus muscle turnover, reinforcement with a synthetic or biological graft, or reconstruction using pedicled or free musculoaponeurotic flaps may be considered.

In case the surgical intervention is performed in a complicated CDCP 2–3 (infected synthetic mesh, enterocutaneous, or subcutaneous fistulas) or CDCP 4 (peritonitis, necrotic abdominal wall) environment, the patient should receive antibiotics. The recommended regimen is i.v. amoxicillin-clavulanic acid 1.2 g three times a day for 5 days (or i.v. cephalosporin 2 g once a day or i.v. clindamycin 600 mg three times a day in case of hypersensitivity to penicillin) and i.v. metronidazole 15 mg/kg/day. No antibiotic is required for surgeries in CDCP 1 environment, unless the operation lasts longer than 180 minutes [18, 19]. To prevent deep venous thrombosis and pulmonary embolism, subcutaneous enoxaparin 0.6–0.8 ml once a day should be administered prophylactically for 3 weeks from the second postoperative day. Mobilization should

Recurrence after double-layer dermal graft reconstructions															
	Gender	**Age**	**BMI (kg/m²)**	**DM**	**COPD**	**Smoking**	**Omentum**	**Peritoneum closure**	**Fluid accumulation**	**Time to laxity (month)**	**Time to recurrence (month)**	**Previous reconstructions (n)**	**Previous fitula formation**	**Physical activity**	**Elastic bandage with Velcro***
1	Female	54	36.9	+	+	+	_	_	+	3	13	3	+	+	2
2	Female	47	37.5	_	+	+	_	_	+	5	17	2	+	+	2
3	Female	63	41.9	+	+	+	_	_	+	6	19	2	+	+	3
4	Male	57	27.5	_	+	+		_	+	_	21	3	+	+	Continuous

Notes: One patient had M_1, two patients had M_3, and one patient had M_4 hernia. The size of the abdominal wall defects was 275, 103, 78, and 153 cm^2 (mean: 152.3 cm^2), in order of magnitude. There is no significant difference between the mean size of the abdominal wall defects of all patients (145.9 cm^2) and the mean size of recurrent hernias (0.657, ns, Student's t-test). Recurrence was more frequent in women, all the patients were severely overweight, and all of them were active smokers. In none of the cases could the hernia sac be spared and a peritoneal layer created. None of the patients had the greater omentum. Abdominal wall reconstructions at the same site have been performed twice or three times earlier. Surgery was performed in a CDCP 3 environment in all patients. At the time of recurrence (12–24 months after surgery) all patients were physically active and only one of them wore an elastic truss

Abbr: DM: diabetes mellitus, BMI: body mass index, COPD: chronic pulmonary obstructive disease. *: how long he/she wore the elastic bandage?

Table 1. Data of recurrent abdominal wall hernias following reconstructive surgery with double-layer dermal grafts.

start on day 2 following the operation, assisted by a physiotherapist, with loading applied in a stepwise fashion. First, the patient is allowed to sit up from a supine position, and then stand up with help in the beginning. Gradual mobilization without the risk of overexertion is one of the most important postoperative rules to be observed in these cases. Postoperative pain gradually subsides (measured on a 10-point numerical rating scale, RNS). On day 1 following surgery, the mean score of pain intensity was 5.9 ± 1.7, which decreased to 3.4 ± 0.76 by day 5. Ninety percent of the patients reported that the intensity of pain was significantly lower following surgery with dermal grafts compared to earlier abdominal wall reconstruction(s), and 100% would prefer reconstruction with dermal grafts if allowed to choose.

With regard to the quality of life, 30 months after the operation, 84% of the patients are satisfied with the result of the intervention and their load capacity. They have had no significant difficulty sitting or standing up from a supine position since the third postoperative month and more than 82% of the patients would opt for dermal graft surgery as opposed to earlier interventions. Recurrences generally occur at months 12–24. Return to presurgery activities should be gradual. In the first 4 weeks, the patients are allowed nothing but light strolls while wearing their elastic trusses; they must avoid carrying any load. In the second 4-week period, light physical load is permitted: the patients may lift loads of 2–7 kg, walk or stroll, or go for a light swim. At weeks 9–12, they may return to their earlier activities but should wear the elastic truss during the day. Cycling is allowed. To protect the reconstructed abdominal wall and prevent it from becoming lax again, the patients should continue wearing the truss in case of major physical strain (**Table 2**). Subcutaneous or enterocutaneous fistulas are

Quality of life statistical data								
Month	**1**	**3**	**6**	**9**	**12**	**18**	**24**	**30**
Avg. satisfactory score (1–3)	2.2 ± 0.31	2.3 ± 0.38	2.6 ± 0.13	2.7 ± 0.31	2.4 ± 0.52	2.4 ± 0.1	2.1 ± 0.23	2.3 ± 0.42
Avg. pain score (1–10)	5.3 ± 0.51	4.2 ± 0.30	3.9 ± 0.44	4.1 ± 0.10	3.0 ± 0.19	2.3 ± 0.28	3.2 ± 0.2	2.8 ± 0.46
Which procedure would you choose if you decided now? (1–2)	1.0 ± 0.0	1.0 ± 0.0	1.2 ± 0.2	1.4 ± 0.21	1.35 ± 0.43	1.45 ± 0.23	1.37 ± 0.21	1.47 ± 0.54
Do you wear the elastic bandage regularly? (1–2)	1.0 ± 0.0	1.0 ± 0.0	1.2 ± 0.11	1.25 ± 0.36	1.19 ± 0.45	1.67 ± 0.67	2.0 ± 0.0	2.0 ± 0.0
How difficult to sit up? (1–3)	1.78	1.9	2.36	2.53	2.73	2.83	2.73	2.76
How difficult to stand up? (1–3)	1.59	1.77	2.36	2.5	2.62	2.58	2.56	2.65
Have the daily routine been affected by the procedure? (1–2)	1.8	1.9	1.9	1.9	1.8	1.6	1.7	1.7

Abbr: Avg: average.

Table 2. Changes in quality of life between months 1 and 30 following surgery.

http://dx.doi.org/10.5772/intechopen.68874

invariably eliminated by adequately performed surgery, a fact appreciated by patients much more than the repair of the recurrent hernia itself. The use of double-layer dermal grafts improves the quality of life in both the early and the late postoperative periods. Since the intraabdominal pressure is low following the interventions (12.1 ± 2.3, 11.3 ± 3.1, 9.5 ± 1.3 8.7 ± 2.2, and 7.2 ± 1.9 mmHg on days 1–5 after surgery), pain is less intense, making mobilization significantly easier and more successful. Patients should be checked every 6, then every 12 months in the first 2 years; follow-up visits should include physical examination in supine and standing position, as well as abdominal ultrasonography.

3. Bilateral rectus abdominis muscle release, turning-over and recreation of the midline gap in the cases of eventrated loss of abdominal wall domain hernias

Complete lack of the midline, with the bilateral rectus abdominis muscles moved further away from each other, leading to medial abdominal wall hernia and eventration, is a well-known phenomenon following serial intraabdominal surgeries (**Figures 10** and **11**).

Following open abdomen treatment or intraabdominal serial surgeries, the medial section of the abdominal wall usually heals *per secundam intentionem* between the medial margins of the dynamically lateralizing rectus abdominis muscles [20, 21]. This state makes the patients disabled not only in an aesthetic sense but also functionally. The procedure consists in a tension-free

Figure 10. Eventrated, loss of abdominal wall domain, complicated hernia having recurred four times. The skin shows signs of contact dermatitis and fistula ducts. The fistulas started from the level of the infected synthetic mesh. The BMI is 57.1 kg/m^2. Primarily, the 62-year-old male patient underwent surgery for necrotizing pancreatitis and extensive retroperitoneal necrosis. The area of the abdominal defect, 19 cm wide at its largest extension, was 676 cm^2. The medial margin of the rectus abdominis muscle was located at the medioclavicular line. The main complaint in such cases, apart from the aesthetic aspect, is the abdominal wall's lack of loading capacity. The incision line is precisely marked out on the operating table, right before the operation.

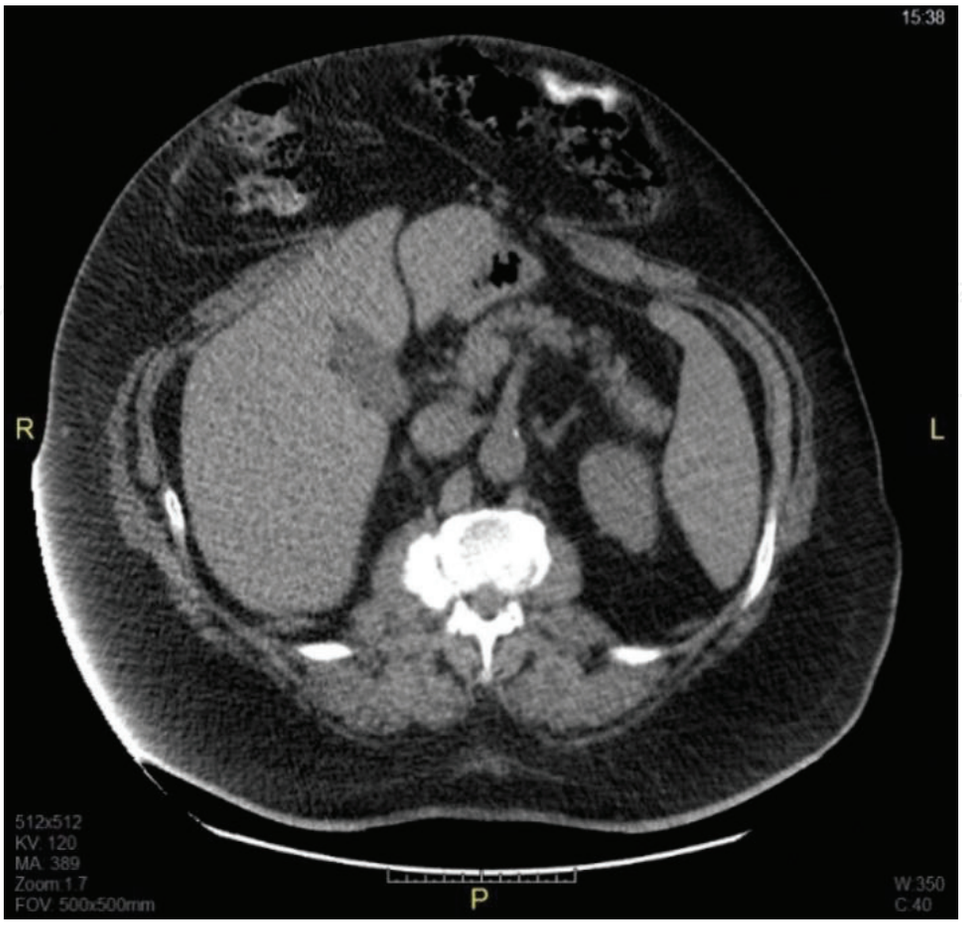

Figure 11. Changes in the size of the midline gap and the combined width of the bilateral rectus muscles in cm. As can be seen clearly, the two lines intersect at month 12 and the combined width of the turned-over bilateral rectus muscles can cover the gap until about month 18.

recreation of the *midline* and the linea alba, lateral release of both *rectus abdominis muscles* from the posterior fascia of the rectus sheath, their *turning-over* at a degree of 180° toward the midline, with blood supply to the muscles retained. Only the spared hernia sac and the intact bilateral rectus abdominis muscles are used for the reconstruction.

3.1. Significance of preoperative computed tomography to perform the rectus muscle turning-over procedure

The evolution of abdominal wall hernias (including dynamics, time course, and changes in the size of the bilateral rectus muscle) after intraabdominal serial surgeries and/or open abdomen treatment follows a typical course [22]. The combined width of the bilateral rectus muscles is sufficient to cover the midline abdominal wall defect in a tension-free way, but performance of the intervention has an "optimal" time interval (**Table 3** and **Figure 12**). Detailed and precise evaluation of the musculoaponeurotic elements of the abdominal wall is essential before reconstructive surgery with the rectus muscles. Feasibility of the intervention must be assessed by CT/MR imaging prior to surgery. The bilateral rectus muscles will be able to cover the complete midline abdominal wall defect free of tension if their *combined* width is nearly the same.

	T_0	T_3	T_6	T_{12}	T_{18}	T_{24}
Avg. midline gap (cm)	3.94	5.57	9.2	14.1	16.3	19.7
Avg. rectus sheath thickness (cm)	1.38	1.28	1.24	1.2	1.09	0.98
Righ rectus sheath width Th-XI, (cm)	7.36	7.27	7.08	6.89	6.7	6.49
Left rectus sheath width Th-XI (cm)	7.46	7.34	7.25	6.99	6.55	6.23
Righ rectus sheath width L-II (cm)	7.72	7.7	7.36	7.12	7.01	6.93
Left rectus sheath width L-II (cm)	7.8	7.85	7.43	7.2	7	6.85
Righ rectus sheath width L-IV (cm)	5.16	5.02	4.89	4.83	4.69	4.57
Left rectus sheath width L-IV (cm)	5.27	5.13	4.87	4.83	4.68	4.63

Abbr: Avg: average, $T_{(0–24)}$: $Time_{(month)}$, Th: Thoracal, L: Lumbar.

Table 3. Mean sizes of the rectus muscle and of the abdominal wall defect at various time points. Width of the rectus sheath was measured at three altitudes, as the rectus muscle width is not the same at various altitudes, featuring characteristic anatomical morphologies.

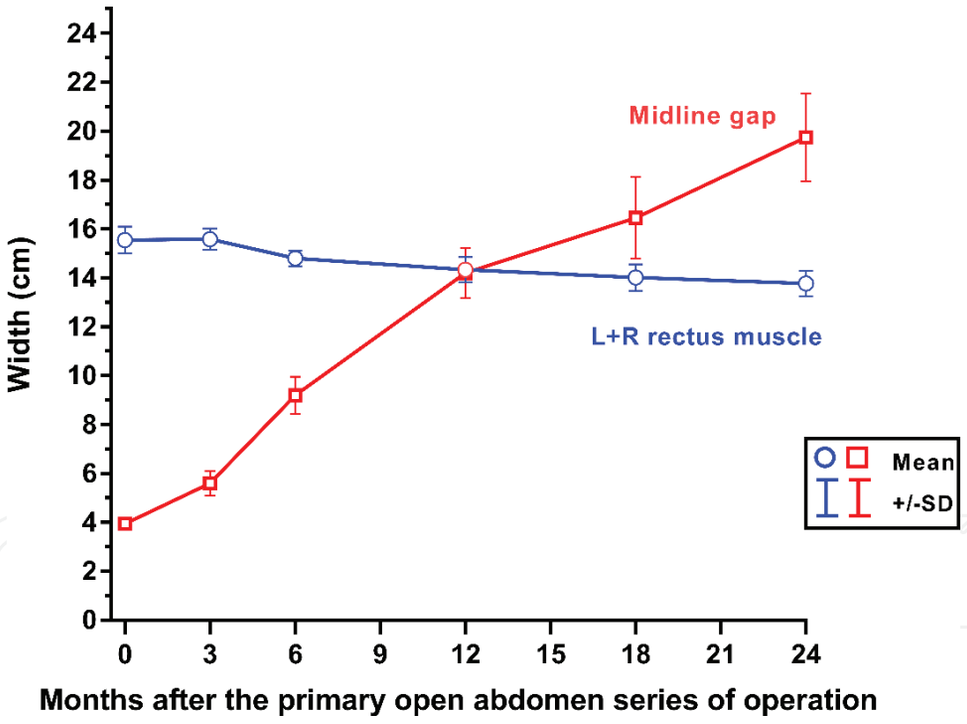

Figure 12. Characteristic CT image of an eventrated, loss of abdominal wall domain. The edge of the liver also reaches into the hernia sac. The bilateral intact rectus muscles (combined width 17.3 cm) and the midline abdominal wall defect (16.15 cm wide) are clearly visible. The size of the abdominal wall defect was 529 cm^2.

3.2. Surgical technique

The operation is performed under general anesthesia in a state of complete muscular relaxation. Preoperative antibiotic prophylaxis is not necessary [18, 19]. Following a full median

or transverse skin incision, the intact hernia sac is not removed, only in case it is severely damaged. The choice of a median or transverse incision depends on the quality of the midline skin. In the case of relatively intact skin in the midline, the transverse "bay-leaf" form excision between the two iliac crest is superior to median incision. The aim is to spare as much as possible of the hernia sac, which will be the inner layer of the recreated abdominal wall. The next step is identification of the lateral margin of the bilateral rectus abdominis muscle. After this, the anterior rectus muscle fascia is incised from the origin to the adhesion of the muscle, to reveal the rectus abdominis muscle (**Figure 13**).

Starting from its lateral margin, the full length of the muscle, except its 2-cm medial margin, is prepared off the posterior wall fascia. During mobilization, at least three minor perforant segmental arteries and veins are revealed; each of them is dissected and tied up. The origin of the muscle is separated from the seventh and eighth rib cartilages. The medial half of the muscular origin (processus xiphoideus, fifth and sixth rib cartilages) is left intact. The arteria epigastrica superior and inferior vessels are carefully spared. Release of the lateral half of the muscular adhesion from the symphysis is also performed. The arteria and vena epigastrica inferior vessels are spared. The released muscle is turned over in the direction of the midline at a degree of 180° (**Figure 14**).

The abdominal wall defect is reconstructed in the following way: the spared hernia sac is precisely cut to size and closed in the midline with 3/0 absorbable monofilament running stitches (**Figure 15**). The released rectus muscle is turned over medially at a degree of 180°. The fascia (originally anterior, becoming posterior when the muscle is turned over) is closed with 3/0 absorbable, monofilament running stitches at a distance of 1 cm from each other (**Figure 16**). The rectus muscles laid next to each other are closed in the midline with 3/0 absorbable,

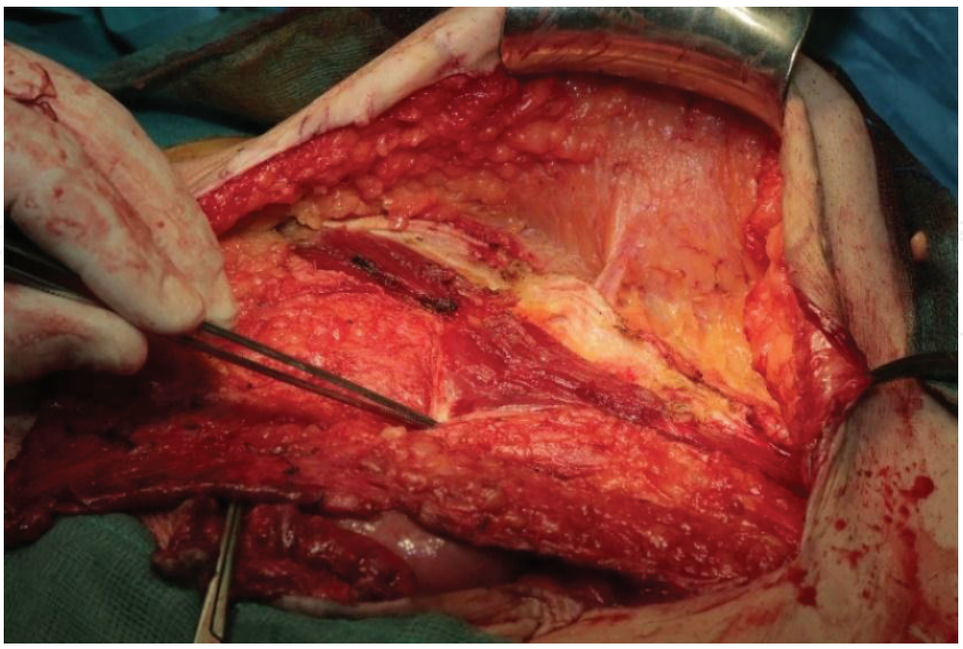

Figure 13. First step of rectus muscle release. The rectus fascia is incised full length 1 cm of the lateral margin of the muscle in a medial direction and the rectus abdominis muscle is revealed.

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Figure 14. The left-side rectus muscle can be seen properly released and turned over medially. The right hand holds the turned-over, good-quality muscle, which has good blood supply. The forceps indicate the width of the rectus muscle, 1.32 cm thick and 7.24 cm wide.

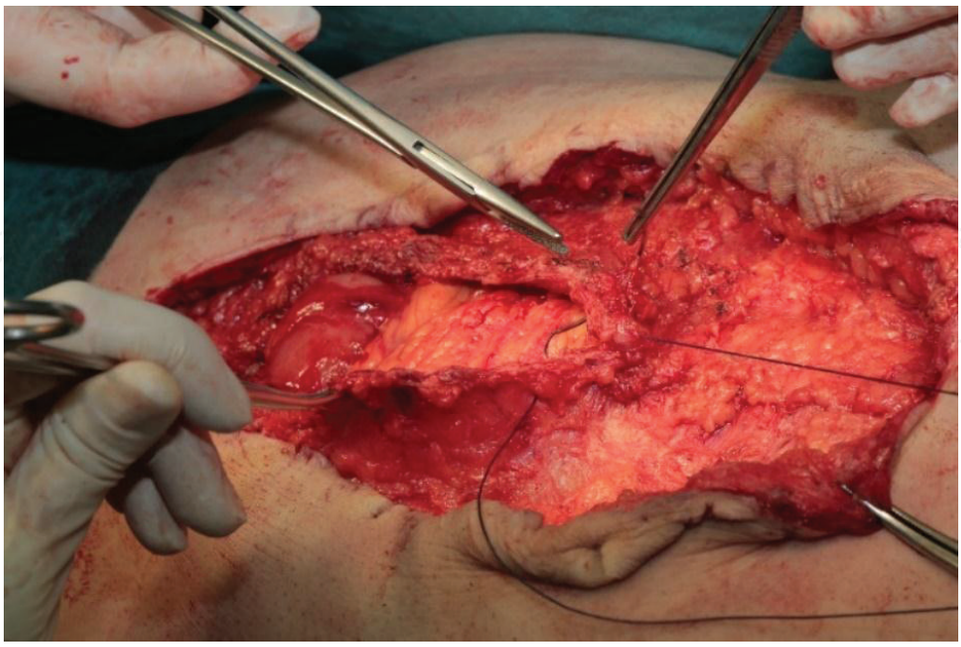

Figure 15. First step of midline recreation, closure of the peritoneum. After closing the peritoneum, the posterior (anterior before the turnover) fascia of the rectus sheath is closed.

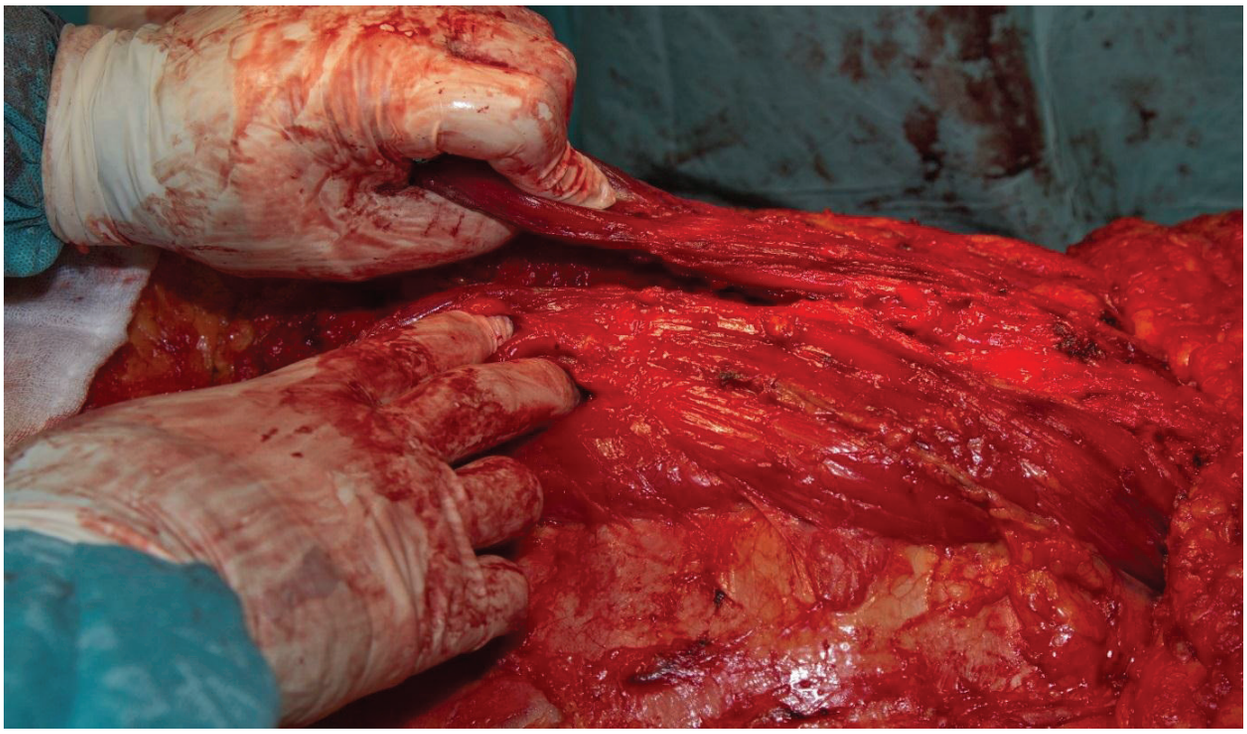

Figure 16. Last step of midline recreation. The two rectus muscles of good quality and blood supply are turned facing each other and are tension-free. The closure is performed using knotty stitches along the full length of the muscle.

monofilament knotty stitches placed at a distance of 2 cm from each other. Laterally, the fascia of the obliquus externus and internus muscles is sewn to the posterior wall fascia with running 3/0 absorbable monofilament stitches (**Figure 17**). Three suction drains are left behind in the operative area, one in the midline and one each with lateral outlets (**Figure 18**). Before skin closure, the subcutis is fixed to the fascia with 8–10 absorbable, knotty 3/0 subcutaneous anchor stitches. The midline is closed with 3/0 interrupted subcutaneous stitches and 2/0 interrupted nonabsorbable monofilament skin stitches. After the operation, *before extubation*, an adjustable elastic abdominal wall bandage must be placed on the abdominal wall.

3.3. Complications, recurrence, and quality of life following rectus muscle turning-over procedure

The rate of surgical complications in the early postoperative stage following rectus muscle turnover is less than 2%. Superficial wound infections and wound dehiscence requiring local treatment are the most frequent complications. Normally, there is no need for antibiotic administration. Deep wound infection occurs in less than 1% of the patients. In such cases, empiric antibiotic therapy (i.v. amoxicillin-clavulanic acid 1.2 g three times daily or, in the case of hypersensitivity to penicillin, i.v. clindamycin 300 mg three times daily for 5 days) or antibiogram-based targeted antibiotic administration is required, in addition to open wound treatment. Subcutaneous fluid accumulation, which can be successfully controlled by percutaneous tapping, develops in less than 10% of the cases. Genuine seromas are very rare. In the early postoperative stage, necrosis of the turned-over rectus muscle may theoretically occur.

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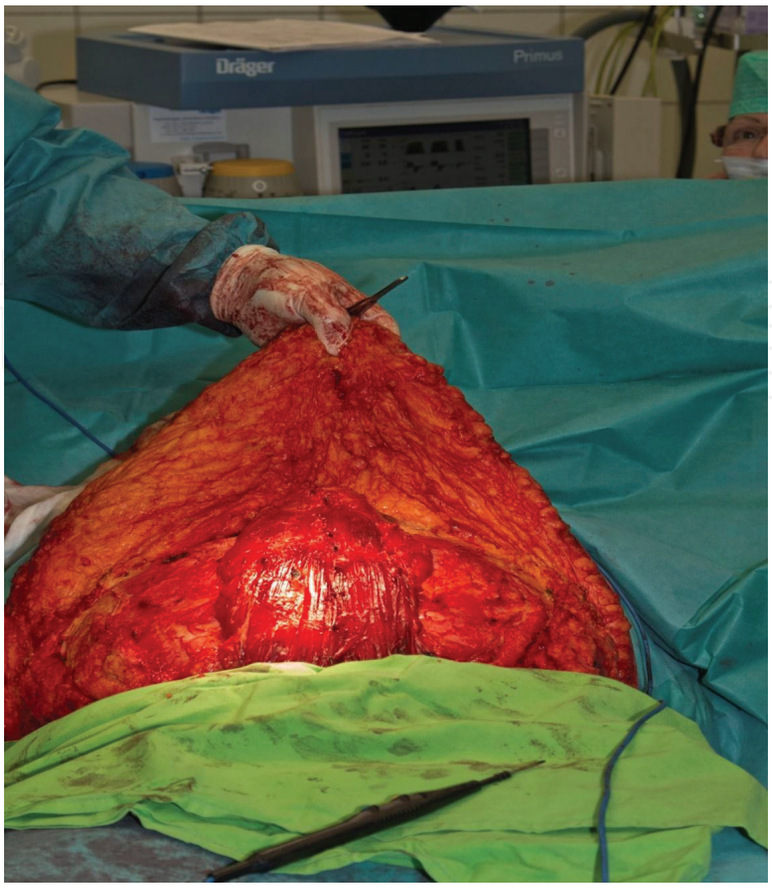

Figure 17. The intervention is complete. The muscle covers the midline and is in a fully closed, turned-over position. Blood supply to the muscle is maintained, it has the proper colour, nonlivid. The bilateral lateral segments, original sites of the rectus muscles, can be seen clearly. The posterior wall of the rectus sheath and the medial margin of the externus abdominis muscle are also clearly visible.

Figure 18. The reconstructed abdominal wall. Three drains are left behind, draining the medial and lateral areas.

It happens when blood supply to the muscle stops during turning-over. Prevention is paramount: the arteria epigastrica superior and inferior vessels must be spared applying extreme caution. Should the vessels be damaged, reconstruction should preferably be performed by a vascular surgeon. A circumscribed dark purple discoloration may develop on the surface of the turned-over muscle during surgery; it does not require any intervention and causes no complications.

The operation does not require antibiotic administration, except when reconstruction of the eventrated abdominal wall hernia is performed as an emergency for mechanical ileus or peritonitis. To prevent deep venous thrombosis or pulmonary embolism, the patients are given s.c. enoxaparin prophylactically in a dose of 0.4–0.8 ml once daily, depending on body weight, for 3 weeks. On the first 5 days following the operation, the mean scores of pain intensity on the NRS scale were 6.9 ± 2.4, 6.1 ± 1.64, 6.2 ± 0.99, 5.5 ± 1.1, and 4.7 ± 0.67. Intraabdominal pressure gradually falls during the first 5 postoperative days (13.5 ± 2.5, 12.9 ± 1.7, 10,.2 ± 2.6, 10.1 ± 0.3, and 8.2 ± 2.4 mmHg). Abdominal wall laxity following reconstructions with the rectus muscle develops in 2% of the cases; recurrence of the abdominal wall hernia, however, was not observed during a mean follow-up of 24 months (**Figure 19**). Elimination of eventrated hernias leads to a marked improvement in the quality of life. There is a significant difference in the quality of life when the periods before and after the surgery are compared. By the evidence of a quality of life test performed after the first 30 days, the

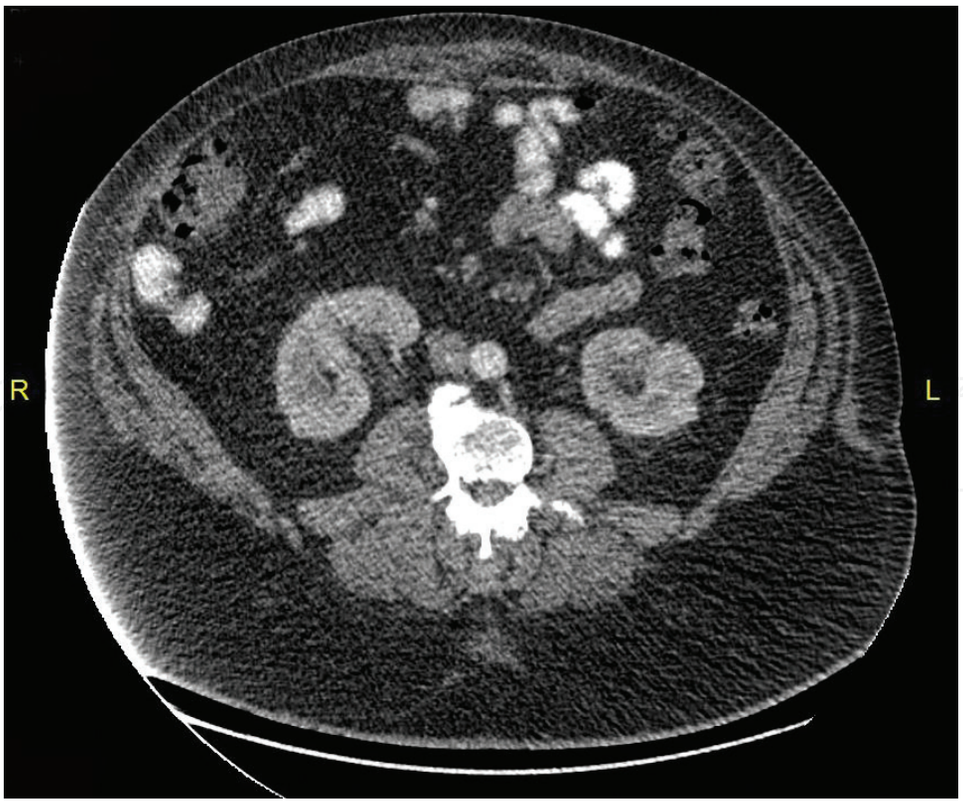

Figure 19. CT image taken one year after the intervention. There is no recurrence. The rectus muscle is hypertrophic, a phenomenon typically occurring in all patients. Its cause is unknown.

patients were completely satisfied with the outcome of the surgery (satisfactory score: 6.0 ± 0.0) (**Figure 20**). In our study, the mean QoL score (measured by the Ferrans-Power quality of life test adapted to the study) [23] was 23.3 ± 13.59 before the reconstructive surgery, which increased to 46.7 ± 6.38 by day 30 following the intervention. The difference was statistically significant, $P = 0.0013$, Student's unpaired t-test. The mean QoL scores at months 6, 12, 18, 24, and 30 were 47.1 ± 4.2, 45.2 ± 5.3, 48.0 ± 2.9, 47.4 ± 4.5, and 46.4 ± 4.8; the differences were not significant (p: ns, Student's unpaired t-test).

3.4. How and when to apply the rectus muscle release and turning-over procedure? Terms of application

CT morphometric analyses suggest that availability and intact state of the bilateral rectus muscle confirmed by CT is a fundamental criterion of applicability. Indication or contraindication of the procedure must be based on the assessment of the size of the abdominal wall defect and the condition of the bilateral rectus muscle at its full length. Patients with COPD or having a high body mass index (BMI) will particularly benefit from the procedure, as there is no risk of significant increase in intraabdominal pressure following surgery. Due to the complex nature of the procedure and the fact that applicability must be determined (on the basis of physical examination and evaluation of the CT images) preoperatively, the intervention should be indicated and performed by an experienced surgeon. Maintaining blood supply to the rectus muscle is the most critical element of the procedure. Release of the muscle from the lateral direction leads

Figure 20. Three months after the rectus muscle turning-over surgery. The BMI is 56.3 kg/m^2. The patient had an eventrated, giant hernia with four earlier recurrences and an abdominal wall defect of 621 cm^2.

to denervation of its lateral (becoming medial after the turnover) parts [24]. Although the outcome of abdominal wall reconstruction is not affected by denervation, patients should wear an adjustable elastic truss for at least 3 months following surgery to prevent midline laxity. After this period, they are still advised to wear their elastic abdominal wall bandage with Velcro™ when doing activities involving medium or more intensive physical strain. The function of the turned-over rectus muscle is retained. From month 3, sitting up and standing up no longer cause difficulty for the patient.

4. Rectus sheath anterior fascia release for large (not eventrated) midline incisional hernias

Autologous tissues can also be used for the reconstruction of large midline (noneventrated) hernias. If the width of the midline defect is not larger than 6–8 cm in a relaxed, supine position (which corresponds to the width of a unilateral rectus muscle, see **Table 3**), the midline can be reconstructed free of tension by release of the anterior fascia of the bilateral rectus muscle. In such cases, release and turnover of the muscle are not necessary (**Figure 21**).

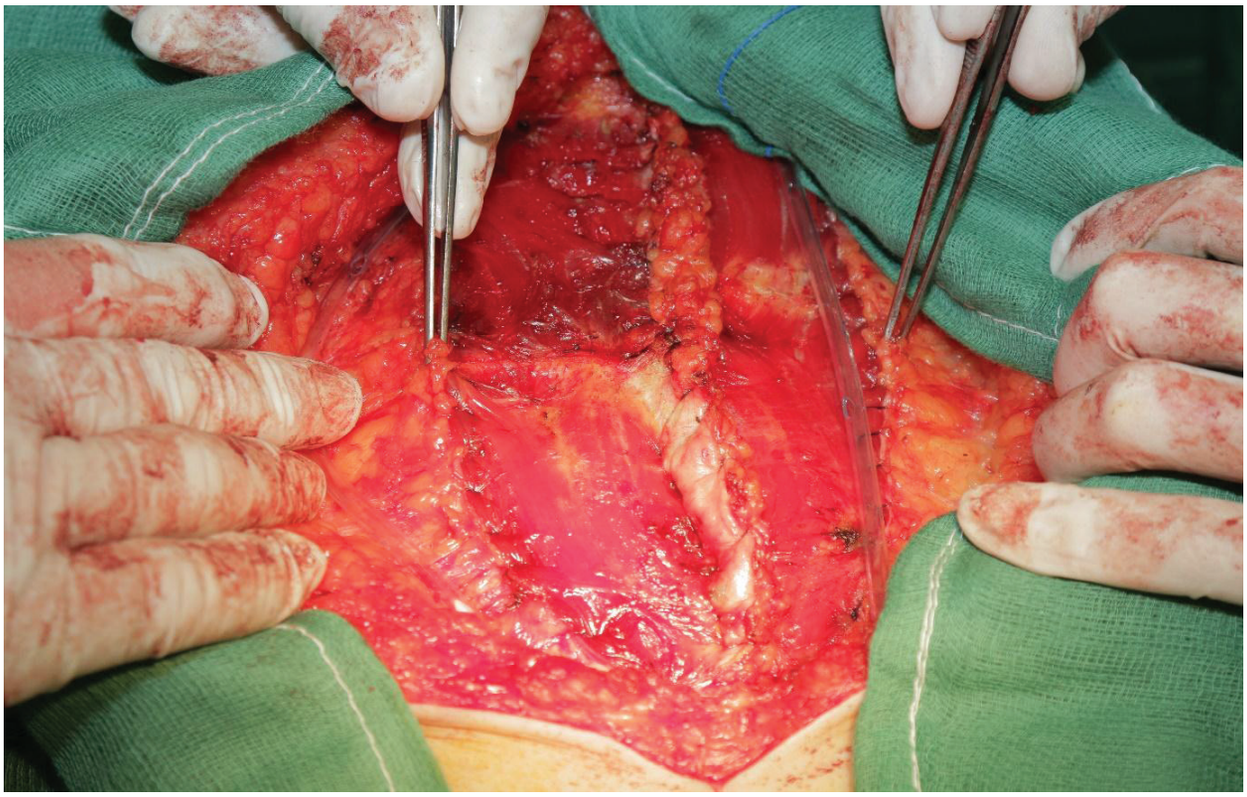

Figure 21. The anterior fascia is released from the anterior surface of both rectus sheaths. The forceps indicate the lateral margin of the sheath. The muscle is untouched. The midline defect was 6.5 cm wide and 17 cm long, its area was 110.5 cm^2. The midline could be closed free of tension. There was no need for synthetic mesh implantation. The fascia plates turned over the midline and closed in the middle are clearly visible.

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4.1. Surgical technique

Following a full median incision, the midline is carefully prepared. The hernia sac is spared and used for reconstruction of the peritoneal surface of the midline. The anterior fascia of the rectus sheath is incised full length along the lateral margin of the rectus sheath and prepared off the rectus muscle. The fascia plate is turned over toward the midline and fixed to the edge of the abdominal wall on the other side using 3/0 nonabsorbable running monofilament stitches. The same is repeated with the fascia plate of the other side so as to close the midline defect in two layers. Two drains are inserted. The adjustable elastic bandage is already applied on the operating table, before extubation.

4.2. How and when to use the rectus anterior sheath fascia turnover?

Rectus anterior sheath turnover was described by da Silva as early as 1979 [25–28]. Several modifications of the procedure are known. The procedure presented here is a tension-free modification of the original technique. The important difference is that it is used only when the midline abdominal wall defect is not wider than the width of a unilateral rectus muscle (about 6–8 cm), confirmed by abdominal CT prior to the intervention. If the defect is wider than the width of a unilateral rectus muscle, the rectus fascia turnover (the so-called "open-book" technique) is not recommended. Similarly, it is not recommended for repair of smaller abdominal wall incisional hernias, as these types of hernia can be successfully treated by less complicated procedures.

One of the advantages of the technique is tension-free reconstruction. Furthermore, less than 2% of the patients develop midline protuberance, provided the precise indication is observed. The recurrence rate is less than 3%. Subcutaneous fluid build-up (4–8%) and superficial wound infection (5%) are the most common complications. As with the other procedures, patients should wear an elastic truss for at least 3 months after surgery. Although minor or medium physical load is permitted, patients are advised to avoid heavy physical exertion even after this period. Should they perform any hard physical activity, patients must always wear an elastic truss.

5. Discussion

The presence of large, infected, or eventrated abdominal wall hernias is an intolerable condition for patients. Complicated, recurrent, and/or infected incisional hernias and eventrated giant abdominal wall hernias are considered to be the consequence of earlier surgical interventions [29]. We fully agree with Kohler et al. [2], who claim (when discussing the question whether complicated incisional hernias are a natural corollary or a surgical complication) that surgical technique and accuracy of abdominal wall closure are key factors in the development of these conditions. There are two other factors playing a role: these are the presence of *predisposing* factors, a phenomenon extensively researched, and the patients themselves, to the extent they comply with the instructions they are given following surgery [30]. The reason

why ventral and incisional hernias are increasingly researched is their increasing incidence and the growing costs involved. In the USA, approximately 3.5 billion dollars are spent on the treatment of abdominal wall hernias each year [31]. Although prevention of recurrences and complications should be a major consideration at the very first intervention when doing reconstructive surgery in patients with abdominal wall hernia, the fact is that 20–37% of ventral hernias and 40–64% of incisional hernias recur and the number of complications increases with each intervention [32]. Infection of the synthetic material implanted during an earlier surgery (or surgeries) is the most significant complication [33]. The cost of hospitalization is doubled and, furthermore, there is a 6-time increase in the cost of dressing changes when the operative area and/or the mesh become infected [34]. We can agree with Sanchez, who claims that the treatment of infected/compromised grafts varies from case to case, with the mesh either spared or not in the end. Predisposing factors for mesh infection include a high BMI (≥25 kg/m^2), DM, COPD, infection of the site of an earlier operation, prolonged duration of surgery, opening of an intestine, and presence of enterocutaneous fistulas. The implanted mesh is removed in ≈5% of the cases, infection being the most common reason (69%) [35]. When repairing a recurrent and/or compromised incisional hernia, the surgeon usually faces two major problems: (1) the surgical environment is infected (CDCP 3–4) or contaminated (CDCP 2); (2) the abdominal wall defect is too extensive and cannot be closed free of tension. In such cases, most surgeons are understandably reluctant to implant another synthetic graft [36]. In cases requiring extensive abdominal wall replacement, the use of biological allo- and xenografts and various autologous tissues is the preferred choice in reconstructive surgeries. Of biological grafts, human, porcine, and bovine ADMs have been used [37–41]. In the vast majority of the cases, there is no question about the resolution of small or medium-size abdominal wall hernias. However, when faced with a *large, eventrated, complicated*, or *incarcerated* hernia and an *infected* (CDCP 3–4*) environment*, the surgeon must adopt a fundamentally different strategy. To choose the most appropriate surgical technique, the surgeon must have precise information on the condition of the musculoaponeurotic elements in the abdominal wall. The best way to obtain such information is abdominal CT/MR imaging [22], allowing assessment of the position of individual abdominal wall components, size of the hernia gate(s), and the volume of the hernia contents. In the case of eventrated hernias, determination of the size of the hernia sac is essential. Another important factor is knowledge of the various surgical techniques, necessary for the selection of the procedure that imposes the least possible stress in a *specific case*. Evaluation of literary data shows that the use of autologous tissues is indispensable in the repair of complicated, eventrated, or giant abdominal wall hernias [42]. There are procedures, which can be applied in certain cases only, and their use would be a mistake in any other case.

Direct abdominal wall sutures should never be used in *elective* or *acute* surgery of large, eventrated, or complicated hernias. Implantation of synthetic materials for abdominal wall reinforcement (but not replacement) is an option for elective surgeries in a CDCP 1–2 environment. Implantation of a synthetic substance in a CDCP 3–4 environment is associated with a high incidence of surgical complications in the operative area (25–65%), as well as a high recurrence rate (30–70%); for this reason, use of synthetic materials is not recommended in such cases. The use of ADMs may be an alternative; however, the high cost of the procedure, coupled with a high recurrence rate, is a limitation to its use. Generally, there are several

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options in each case; it is important, however, that the one involving the least possible stress should be selected and applied. Of autologous tissues, the use of dermal grafts is associated with the least strain during and after surgery; this is followed by rectus muscle turnover and the various component separation techniques, and finally by reconstructions with free or pedicled flaps.

The most important consideration when using autologous dermal grafts is the availability of tissues of adequate size and quality for reconstruction. To cover a defect of 10 cm in diameter (an area of 78.5 cm^2), the area of the dermal graft should be at least 220 cm^2. The 30–35% expansion capacity of a properly prepared graft should also be taken into account. All this means that grafts of adequate size and quality can only be obtained from obese patients. Prepared dermal grafts should not contain any epidermal elements or scar tissue.

Double-layer dermal grafts are preferred in cases of large medial or lateral incisional hernias having recurred at least once, in which a synthetic mesh was implanted during an earlier reconstructive surgery and CDCP 2–3 environment, compromised graft, deep wound infection, or subcutaneous and/or enterocutaneous fistulas developed in the postoperative period. In a CDCP 1 environment, this is the preferred choice if the hernia is large and a direct abdominal wall suture would lead to a significant increase in intraabdominal pressure. The procedure has obvious advantages in obese patients, where grafts are usually available in sufficient quantities, making synthetic grafts unnecessary. In patients with BMIs higher than 25 kg/m^2, the quantity and quality of dermal grafts are sufficient for the reconstruction of large hernias [43]. In patients with DM or COPD, conditions associated with a higher risk for recurrence and infection of the operative area, the use of autologous grafts is preferred to direct sutures or synthetic grafts. Perforated double-layer dermal grafts can successfully be used in CDCP 4 environments. Their advantages include faster integration and a significantly lower risk of infection at the site of operation. However, this procedure cannot be used in patients in whom dermal grafts of appropriate quantity and quality are not available. There are data, although limited, on the use of double-layer dermal grafts in CDCP 4 environments and in the case of extensive abdominal wall necrosis. Large abdominal wall defects can be repaired relatively quickly and cost-effectively without implanting synthetic or allo- or xenografts and without significant early postoperative tension even in CDCP 4 environments [44].

A precondition of bilateral rectus muscle turnover is the intact state of the bilateral rectus muscle confirmed by CT. A CT examination prior to surgery allows assessment of the size of the abdominal wall defect and the state of the bilateral rectus muscle, and serves as basis for the indication or contraindication of the intervention. In patients with COPD or having a high BMI, the procedure is clearly preferred, as there is no risk of increased intraabdominal pressure following surgery. Maintaining blood supply to the rectus muscle from the epigastric vessels is essential. In case of injury, the artery must be reconstructed. Maintaining blood supply to the rectus muscle is the most critical element of the intervention. Although release of the muscle from the medial direction leads to partial muscle denervation, the outcome of abdominal wall reconstruction is not affected and the turned-over muscle retains its function. To prevent the development of abdominal wall bulking, patients should wear an adjustable elastic abdominal wall binding with Velcro for at least 3 months following surgery and also later when exposed to physical load.

The procedure of bilateral rectus muscle release and turnover is used to reconstruct eventrations and midline abdominal wall defects developed after open abdomen treatments, retroperitoneal, and/or intraabdominal serial operations. The technique is also suitable for resolution of midline, recurrent, or neglected, primary medial giant abdominal wall hernias. The intervention can successfully be performed in patients with incarcerated eventrated hernias or in CDCP 3–4 environments. It is crucial that in case the rectus muscle was damaged or intersected during an earlier surgery, or the patient underwent transverse laparotomy (involving transverse intersection of the rectus muscle) earlier, the intervention cannot be performed. The width of the midline abdominal wall defect and the combined width of the bilateral rectus muscles along their full length must be carefully assessed. If the values "correspond" to each other, the intervention can be indicated from a morphological-anatomical point of view.

6. Conclusion

The statements related to the surgical procedures discussed in this chapter are summarized as follows:

1. Double-layer homogeneous dermal grafts can successfully be used in *large hernias* in *CDCP* 2–3 surgical environments. Quality of life significantly improves following surgery. If used accurately, the technique is capable of eliminating abdominal wall fistulas. The incidence of early and late complications is low. The recurrence rate is approximately 11%. The fact that grafts of sufficient quantity and quality can only be collected from overweight (BMI ≥ 25 kg/m^2) patients is a drawback of the procedure.
2. *In recurrent infected abdominal* wall hernias, *the infected synthetic mesh* should be *removed* completely. Partial removal fails to provide a permanent solution in most cases. In case the hernia has not recurred but the graft is infected, vacuum assisted closure (VAC) may be attempted. VAC is not recommended when recurrence and mesh infection occur simultaneously.
3. Double-layer dermal grafts can also be used in *CDCP* 4 surgical environments, provided that the outer graft is implanted perforated. *Perforated outer* grafts contribute to faster integration and remodeling.
4. The *greater omentum* and the *subcutaneous* adipose tissue are important factors in the integration of grafts. *Maximum caution* should be applied to *spare* them during surgery.
5. Patients should wear an adjustable *elastic truss* for 3 months following the intervention, even at night in the first month. Noncompliance increases the risk of recurrence.
6. The intervention is not recommended in patients with *eventrated* hernia or *extensive abdominal wall defect*.
7. Rectus muscle turnover is a method suitable for closure of wide midline abdominal wall defects and eventrated midline hernias. Lateral eventrated and large hernias can be repaired by unilateral rectus muscle release and turnover in the *lateral* direction.

8. Patients should wear an *elastic truss* for 3 (or 4, depending on the degree of physical activity) months following surgery. When doing activities involving medium or heavy physical load, patients are advised to continue wearing the truss to protect the abdominal wall.
9. The intervention is followed by a significant improvement in the quality of life.
10. The hernia recurrence rate is low. So far, no recurrence has occurred.
11. The procedure is recommended for reconstruction of repeatedly recurring midline (M_1–M_5) giant eventrated abdominal wall hernias developing after *open abdomen treatments* or retroperitoneal *serial surgeries*.
12. The procedure is also suitable for *emergency* operations (incarcerated hernia or CDCP 3–4). Before using the technique in emergency cases, however, surgeons should gain experience in elective interventions.
13. Abdominal CT allowing assessment of the volume of the hernia, the size of the midline abdominal wall defect and morphometry of the bilateral rectus *muscle* should be performed prior to the operation. An intact bilateral rectus muscle is a precondition of the procedure.
14. *Only* autologous tissues are used for abdominal wall reconstruction in the procedures discussed in this chapter. The procedures are cost-effective.
15. *Primary prevention* (increasing the proportion of minimally invasive intraabdominal penetrations) and *secondary prevention* (*lege artis* closure of laparotomies, use of a truss, and avoidance of overexertion following surgery) of abdominal wall incisional hernias may significantly reduce the incidence of large and complicated hernias.
16. The use of autologous tissues is *unavoidable* in the reconstruction of large, eventrated, or complicated abdominal wall incisional hernias in elective as well as acute interventions. Their application must be carefully weighed in these cases. Reconstruction of complicated abdominal wall hernias must be preceded by careful evaluation of the available techniques and selection of the one which is the most effective and the least stressful for the patient.
17. The use of autologous tissues requires further research to improve existing techniques and outcomes.

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