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REVIEW

Open transversus abdominis release in incisional hernia repair: technical limits and solutions

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Abstract

Introduction Incisional hernias with a defect width of more than10 cm are considered complex. The European Hernia Society guidelines recommend that such hernias should only be repaired by surgeons with experience of component separation. The standard component separation technique now is posterior component separation with transversus abdominis release (PCSTAR). Questions are raised about the limits of this technique.

Methods A literature search of publications on PCSTAR was performed for any references to the limits of this technique in open incisional hernia repair. We found 26 publications relevant to answer this research questions.

Results The standard PCSTAR can generally be used for a defect width of up to 15–17 cm. For defects greater than 17 cm problems must be expected with procedural tasks involving closure of the posterior layer and anterior fascia. No data are available in the literature on the bridging rate for the posterior layer. However, our own experiences show that gaps (holes) occur in the very thin peritoneum/fascia transversalis during dissection and these must be carefully closed. Furthermore, bridging with an absorbable synthetic mesh is needed not so rarely. Closure of the anterior fascia is successful in 81.0–97.2% of cases. In addition to a further mesh for anterior fascial closure, the hernia sac bound with multiple, accordion-like stitches can also be used.

Summary For a defect width greater than 17 cm, the limits of PCSTAR become increasingly evident and can be overcome through special technical solutions for closure of the posterior layer and the anterior fascia.

Keywords Incisional hernia · Transversus abdominis release · TAR · Posterior bridging · Posterior component separation

Introduction

In a Delphi consensus an incisional hernia defect width of more than 10 cm was thought to be a decisive influencing factor for the complexity of repair [1].

According to the European Hernia Society guidelines for midline incisional hernia repair, fascial closure without myofascial release is no longer possible for a defect width greater than 10 cm [2]. Therefore, the guidelines' group recommends that incisional hernias with a defect width greater than 10 cm should only be repaired by surgeons with experience of the component separation technique [2].

The anterior component separation (ACS) technique was publicized by Ramirez in 1990 and rapidly became widespread in the USA [3, 4]. The relatively high rate of wound complications soon became apparent as a drawback of this technique [4].

The ACS recurrence rate was between 9% and 18% [4]. As an alternative to the ACS, Novitsky next introduced in 2012 posterior component separation with transversus abdominis release (PCSTAR) [5].

A recent meta-analysis of 19 studies with 3412 patients demonstrated that, while open PCSTAR was associated with fewer wound complications than open ACS, at 6.11% versus 4.27%, it had a somewhat higher recurrence rate [4]. One likely explanation for this may be that anterior fascial closure was not possible in 8.46% of all component separation cases in this meta-analysis, but this was significantly more often the case in PCSTAR [4]. Accordingly,

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bridging had to performed more often in PCSTAR [4]. Besides, closure of the posterior layer was not always possible in open PCSTAR [5].

Based on the available literature, this paper now aims to identify how often closure of the posterior layer and anterior fascia was not possible in open PCSTAR and, accordingly, how often bridging was needed. Before describing the bridging technique used for the posterior layer and anterior fascia, the standard PCSTAR technique must be explained.

The open PCSTAR standard technique [5–12]

A number of procedural tasks must be performed to assure complication-free PCSTAR (Table 1) [6].

- Midline laparotomy

A generous midline incision should be made from above to below the hernia defect [11]. The base for the location for initial abdominal entry is influenced by physical examination and a CT scan [11]. Poorly healed midline scars or ulcerated skin should be excised by an elliptical midline incision [11]. If the hernia sac is located directly under the skin, special care must be taken when opening the abdomen as small bowel loops may be fixed in the hernia sac [11].

- Adhesiolysis

After gaining access to the abdominal cavity, visceral adhesions to the anterior abdominal wall are freed [10]. Interloop adhesions are ignored unless the patient has clinical symptoms of bowel obstruction [10]. Foreign bodies, e.g. previous mesh, tackers or sutures, are removed to prevent infections or chronic pain [10].

Table 1 Procedural tasks in open transversus abdominis release

- Midline laparotomy
- Adhesiolysis
- Rectus release and retrorectus dissection
- Superior and inferior dissection
- Exposure and division of transversus abdominis muscle
- Closure of posterior layer
- Mesh placement and fixation
- Anterior fascial closure
- Skin closure

- Rectus release and retrorectus dissection

For rectus release and retrorectal dissection the posterior rectus sheath is incised approximately 0.5–1 cm from the medial edge of the rectus muscle [8]. The retromuscular plane must be developed laterally until the neurovascular bundles can be seen just medial to the linea semilunaris [8]. It is important to identify and preserve the perforating neurovascular bundles to the rectus muscle [8]. Therefore, mainly blunt dissection should be used. After identifying the neurovascular bundles, incision of the posterior layer of the rectus sheaths can be continued in cranial and caudal directions. Here, it is important to ensure that the posterior layer of the rectus sheaths is divided as far medially as possible in order to preserve as much of the posterior layer of the rectus sheaths as possible for reconstruction of the posterior layer [11].

- Superior and inferior dissection

The plane is completed superiorly to the retroxyphoidal/retrosternal space and inferiorly to the space of Retzius [10].

"The insertion of the posterior rectus sheath with the xiphoid can be incised" [12]. "This provides access to the fatty triangle and extends cephalad in a substernal plane" [12].

If the defect extends close to the xiphoid and therefore greater mesh overlap is needed, the peritoneum can be resected from the central tendon of the diaphragm [12].

Below the arcuate line the posterior rectus sheath is composed of only peritoneum and fascia transversalis [11]. A confluent space is developed through medial division of the posterior layer of both rectus sheaths to the arcuate line and blunt dissection in the space of Retzius [11], exposing the symphysis and Cooper's ligament [11]. The deep inferior epigastric vessels coursing on the dorsum of the rectus muscles must be spared [11].

- Exposure and division of transversus abdominis muscle

If midline restoration is not possible at this stage without creating undue tension and/or there is not enough mesh overlap, transversus abdominis release (PCSTAR) must be carried out [11]. PCSTAR can be conducted using a top-down or bottom-up approach [11]. PCSTAR starts with incision of the posterior rectus sheath around 0.5-1 cm medial to the neurovascular bundles and exposure of the medial extensions of the transversus abdominis muscles (top-down approach) [10]. It is best to begin this step in the upper third of the abdomen because here the transversus abdominis muscle is strongest [10]. While sparing the peritoneum/fascia transversalis beneath the transversus abdominis muscle (TAM), continue division of the muscle

in cranial and caudal directions [10]. Dissect the fibers of the TAM from the underlying complex composed of peritoneum and fascia transversalis [11]. "Below the arcuate line peritoneum and transversalis fascia are extremely thin and therefore diligence must be exercised during the inferior dissection to avoid injury" [10]. Blunt dissection can be used for further opening of the avascular retromuscular space between the TAM and peritoneum/fascia transversalis [10]. The plane between TAM and peritoneum/fascia transversalis must be opened cranially to the diaphragm, caudally to the myopectineal orifice and laterally to the psoas muscle [10]. Such a wide opening of the pre-peritoneal/pre-fascia transversalis plane permits the use of very large meshes with corresponding overlap [10]. With the bottom-up approach, entry to the layer between the TAM and peritoneum/fascia transversalis is at the level of the arcuate line.

- Closure of posterior layer

The next step is reconstruction of the posterior layer, composed of the posterior rectus sheath, peritoneum and fascia transversalis [9]. This is done with a running, slowly absorbable suture [9–11]. If TAR is carried out correctly, tension-free closure of the posterior layer should generally be possible [11]. If this is not the case, repeat lateral dissection may be needed [11]. All defects in the posterior layer must be carefully closed to prevent intestinal prolapse into the space between the peritoneum/fascia transversalis and polypropylene mesh [11].

- Mesh placement and fixation

The decisive advantage conferred by PCSTAR is the ability to use meshes measuring between 30 × 30 cm and 50 × 50 cm thanks to the creation of a very large mesh bed. Diamond-shaped meshes are often used, thus extending the cranial-caudal dimension [11]. A second mesh can be placed if there is insufficient overlap, especially in the upper portion under the costal arches [11].

Mesh fixation is a controversial topic [11]. Advocates of non-fixation of meshes are of the view that the wide overlap of the meshes together with the intra-abdominal pressure provide for adequate mesh fixation between the abdominal wall layers [11]. An alternative, minimally invasive fixation technique is the use of fibrin glue for fixation of the mesh to the posterior rectus sheath [11]. The most invasive fixation technique is the use of transfascial sutures for mesh fixation to the TAM [11]. This presents a risk of chronic pain.

- Anterior fascial closure

According to Novitsky [8], the medialized anterior rectus sheaths can then be approximated using either running or interrupted slowly absorbable monofilament sutures to restore the linea alba (Fig. 1). Reconstruction of the linea alba is also reported by Jones [9], Kushner [10], Siegel [11] and Gibreel [12].

- Skin closure

Attenuated and far redundant skin and soft tissue should be excised [8]. Closed-suction drains are placed on the mesh [8].

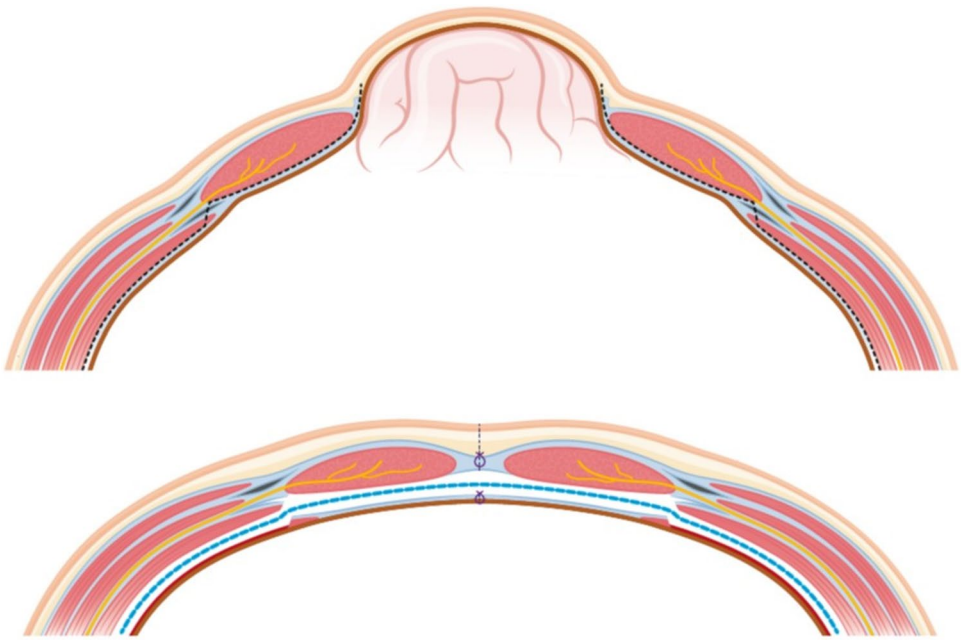

Fig. 1 Complete reconstruction of the abdominal wall with retromuscular placement of very large meshes and closure of the posterior layer and the anterior fascia (Standard PCSTAR)

Defect widths and areas in patients with open transversus abdominis release [4, 8, 13–16]

Even the recently published European Hernia Society guidelines for midline incisional hernia do not contain a well-founded indication for open PCSTAR [2]. They only recommend that incisional hernias with a defect width greater than 10 cm should only be repaired by surgeons with experience of the component separation technique [2].

A literature search was then carried out to identify for which defect widths and defect areas surgeons had indicated PCSTAR. This revealed that the mean or median defect widths were between 15.0–17.0 cm with a range of 9–36 cm (Table 2). The mean defect areas were 384–606 cm^2. This clearly shows that patients treated with PCSTAR had defect widths and defect areas significantly greater than those recommended in the European Hernia Society guidelines.

Bridging the posterior layer [5, 7, 8, 10, 11, 17–22]

For large defects and following previous operations it was not possible to achieve closure of the posterior layer in a relevant proportion of cases despite sufficient TAR dissection. While this problem is reported in the literature and technical solutions are recommended, no frequency rates are given. The posterior layer is composed of the posterior rectus sheath, peritoneum and fascia transversalis. Since the posterior layer outside the posterior rectus sheath is composed of only peritoneum and fascia transversalis, smaller or larger gaps may easily occur during dissection. The smaller gaps must be carefully closed with a suture to prevent intestinal prolapse through the gaps into the space between the posterior layer and polypropylene mesh. Larger defects and lack of tension-free approximation of the two posterior layers require defect closure by bridging the posterior layers (Table 3). There are numerous references to such an approach in the literature (Fig. 2).

The use of the greater omentum usually makes little sense since it will often have undergone scarring following

Table 2 Defect widths and areas in patients with open transversus abdominis release

Author	Year	Defect width	Defect area	Number of TARs (n)
Novitsky [8]	2016	15.2 cm (range 9–36 cm)	606 cm^2 (180–1280 cm^2) (mean, range)	428
Hodgkinson [13]	2018	–	457.42 $cm^2 \pm 158.74$ cm^2 (mean, SD)	281
Wegdam [14]	2019	–	509 cm^2 (235–606 cm^2) (mean, range)	646
Oprea [4]	2023	–	346.29 ± 160.08 cm^2 (mean, SD)	1703
Zolin [15]	2023	15.0 cm (12–19 cm) (median, range)	–	1203
Christopher [16]	2023	17.0 cm (range 15–24)	384 cm^2 (205–471 cm^2) (mean, range)	–

Table 3 Techniques to bridge gaps in the posterior layer in open transversus abdominis release

Author	Year	Techniques to bridge gaps in the posterior layer
Carbonell [17]	2008	Absorbable mesh
Krpata [18]	2012	Greater omentum, synthetic polyglactin mesh (Vicryl)
Novitsky [8]	2016	Portions of the hernia sac, biologic mesh, absorbable mesh
Novitsky [5]	2012	Portions of the hernia sac, absorbable mesh
Winder [19]	2018	Absorbable synthetic polyglactin mesh (Vicryl)
Robin-Lersundi [20]	2018	Absorbable mesh (Bio A), hernia sac (Vicryl)
Siegal [11]	2019	Greater omentum, hernia sac, polyglycolic acid mesh (Vicryl), biologic mesh, coated 4-hydroxybutyrate mesh (Phasix ST)
Alkhatib [21]	2020	Rapidly absorbable synthetic mesh (Polyglactin 910—Vicryl)
Zolin [7]	2020	Greater omentum, hernia sac, absorbable synthetic mesh (Polyglactin 910—Vicryl)
Punjani [22]	2021	Synthetic absorbable mesh, composite mesh
Kushner [10]	2021	Greater omentum, absorbable microporous mesh, tissue separating mesh

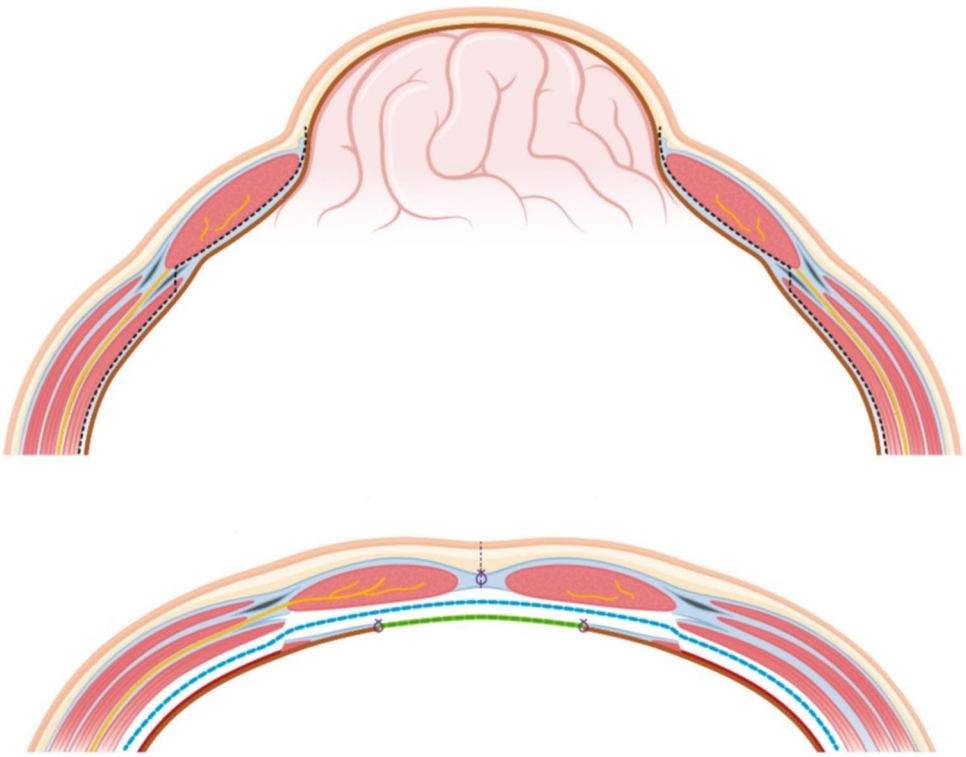

Fig. 2 Bridging the posterior layer with absorbable synthetic meshes

previous operation and does not lend itself to bridging the defect. The use of the hernia sac for bridging presupposes that the hernia sac is resected at the hernia border and anterior layer of the rectus sheath in order to be sufficiently mobile. This may mean that viable scar tissue is sacrificed for repair of the anterior fascia. It also means that the hernia sac will no longer be available for anterior fascial closure.

Absorbable synthetic meshes are more suitable for bridging gaps in the posterior layer.

Meshes made of polyglactin 910 (Vicryl), polyglycolic acid and trimethylene carbonate (BioA) and coated 4-hydroxybutyrate (Phasix ST) are available to that effect.

The meshes differ in terms of their absorption time. After 56–70 days Vicryl is completely absorbed, BioA after 6–7 months and Phasix ST after 18 months. There are also reports on the use of a coated polypropylene mesh (composite mesh) [22]. In the literature there is only one series with 36 patients for whom it was not possible to achieve tension-free closure of the posterior layer during PCSTAR [19]. The defect was therefore bridged with an absorbable synthetic, polyglactin 910, mesh. In this series the median defect width was 25 cm with a range of 8–35 cm [19]. If one compares the defect width with the data from Table 1, it is clear that the defects in this series were markedly larger. Hence, by extending the peritoneal abdomen through bridging with an absorbable synthetic mesh, the indication for PCSTAR can be expanded. Another benefit of this technique is that the hernia sac remains connected with the anterior layer of the rectus sheath and is available for closure of the anterior fascia.

In the series by Winder et al. [19], 5 of 39 (13.9%) patients had wound complications. Five patients experienced a recurrence (13.9%) over a median of 27 months. The authors concluded that the use of an absorbable synthetic mesh did not lead to more perioperative complications. The recurrence rate is also acceptable.

Complete anterior fascial closure [4, 8, 13, 14, 21–23]

In the literature the rate of complete anterior fascial closure in open PCSTAR was between 81.0% and 98.0% (Table 4). In a recent meta-analysis the rate of complete anterior fascial closure was 90.5% [4]. As such, one can assume that in around 90% of cases anterior defect closure is possible. At the start of the learning curve the closure rate is more likely to be 80%, rising with more experience to around 90%. The data by Punjani et al. [22] show that the learning curve for PCSTAR is long. For 100 PCSTAR repairs carried out, the complete anterior fascial closure rate was 81.0%. By contrast, the first person to describe PCSTAR reported for 428 PCSTARs a complete anterior fascial closure rate of 97.2% [8]. But even after 1203 PCSTARs, the complete anterior fascial closure rate may be 92%. It therefore appears realistic

Table 4 Complete anterior fascial closure—restoration of the linea alba

Author	Year	Complete anterior fascial closure (%)	Bridged repair (%)	Number of TARs (n)
Posielski [23]	2015	90.5	9.5	32
Novitsky [8]	2016	97.2	2.8	428
Hodgkinson [13]	2018	96.9	3.1	281
Wegdam [14]	2019	98.0	2.0	646
Alkhatib [21]	2020	90.0	10.0	1314
Punjani [22]	2021	81.0	19.0	100
Oprea [4]	2023	90.5	9.5	1703
Zolin [15]	2023	92.0	8.0	1203

that in around 10% of all PCSTARs complete closure of the anterior fascia is not possible.

Bridged repair of anterior fascia

If bridged repair of the anterior fascia is needed, this can be achieved in very different ways (Table 5). Novitsky et al. [8] described bridging with two rotational flaps consisting of hernia sac and skin and subcutaneous tissue coverage. Jons et al. [9] recommended a heavier weight polypropylene mesh and the use of the hernia sac from the contralateral side (Fig. 3).

Garcia-Urena et al. [24] described the fixation of the mesh at the borders of the anterior rectus sheath, leaving a bridge that is usually covered with remnant of the hernia sac or fibrous tissue.

The group around Rosen [21] published a series of 96 patients, in whom anterior fascial re-approximation was not feasible and a bridged repair was required. Only the skin and subcutaneous tissue were re-approximated to cover the mesh [21]. The defect size in this subgroup of patients was 26.0 ± 8.0 cm. At a mean follow-up of 20 ± 10 months a recurrence rate of 46% was reported [21].

Zolin et al. [7] described a technique to close the anterior fascia as much as possible without creating undue tension to minimize the size of the bridged region.

Kusher et al. [10] used a piece of bridging synthetic mesh and sutured the borders to the existing anterior fascia.

Punjani et al. [22] sutured the anterior fascia, which could not be closed, to the underlaying mesh with non-absorbable sutures.

Miguel-Mendez et al. [25] bridged the anterior fascia with a mesh.

Our own experience based on a 1-year period from 12/2022 to 11/2023

In the 1-year period from 01/12/2022 to 30/11/2023, 98 patients with incisional hernia underwent surgical repair in our hospital. For 51 of these patients surgical repair was performed using the PCSTAR technique. The hernias repaired were $n = 31$ medial, $n = 16$ lateral and $n = 9$ parastomal incisional hernias. PCSTAR repair was carried out in open technique for $n = 26$ patients, in laparoscopic technique for $n = 21$ patients, and in robotic technique for $n = 9$ patients. Anterior bridging had to be performed in $n = 1$ (4.7%) of the open PCSTAR medial incisional hernia repairs. For

Table 5 Bridged repair of the anterior fascia in open transversus abdominis release

Author	Year	n	Defect localization	Defect area	Defect width	Technique
Novitsky [8]	2016	12	Anterior fascia	–	–	Soft-tissue coverage over the mesh (2 rotational flaps, skin and subcutaneous tissue coverage)
Jones [9]	2016	–	Anterior fascia	–	–	A heavier weight mesh should be considered. The hernia sac from the contralateral side is ideally used
Garcia-Urena [24]	2019	47	Anterior fascia	–	–	Borders of the anterior rectus sheath are fixed to the mesh, leaving a bridge that is usually covered with remnant of hernia sac or fibrous tissue
Alkhatib [21]	2020	96	Anterior fascia	–	26.0 ± 8.0 cm	Bridging with skin and subcutaneous tissue coverage
Zolin [7]	2020	–	Anterior fascia	–	–	If anterior fascial closure is not possible, as much of the anterior fascia is closed without creating undue tension, attempting to minimize the size of the bridged region
Kushner [10]	2021	–	Anterior fascia	–	–	A piece of bridging synthetic mesh can be used and the edges sutured to the existing anterior fascia
Punjani [22]	2021	–	Anterior fascia	–	–	Anterior defects, which could not be safely approximated, are stabilized by suturing them in an interrupted fashion to underlaying mesh with non-absorbable sutures
Miguel-Mendez [25]	2021	–	Anterior fascia	–	–	The anterior layer is bridged with the mesh when complete anterior closure cannot be achieved

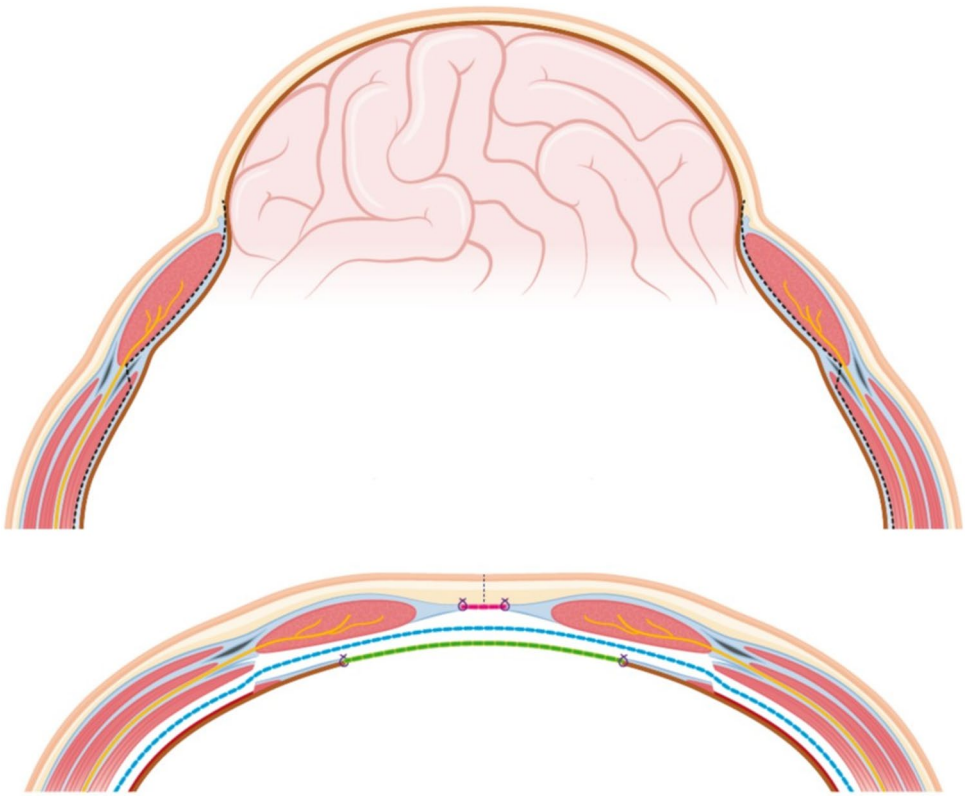

Fig. 3 Bridged repair of the posterior layer and anterior fascia for very large medial incisional hernias

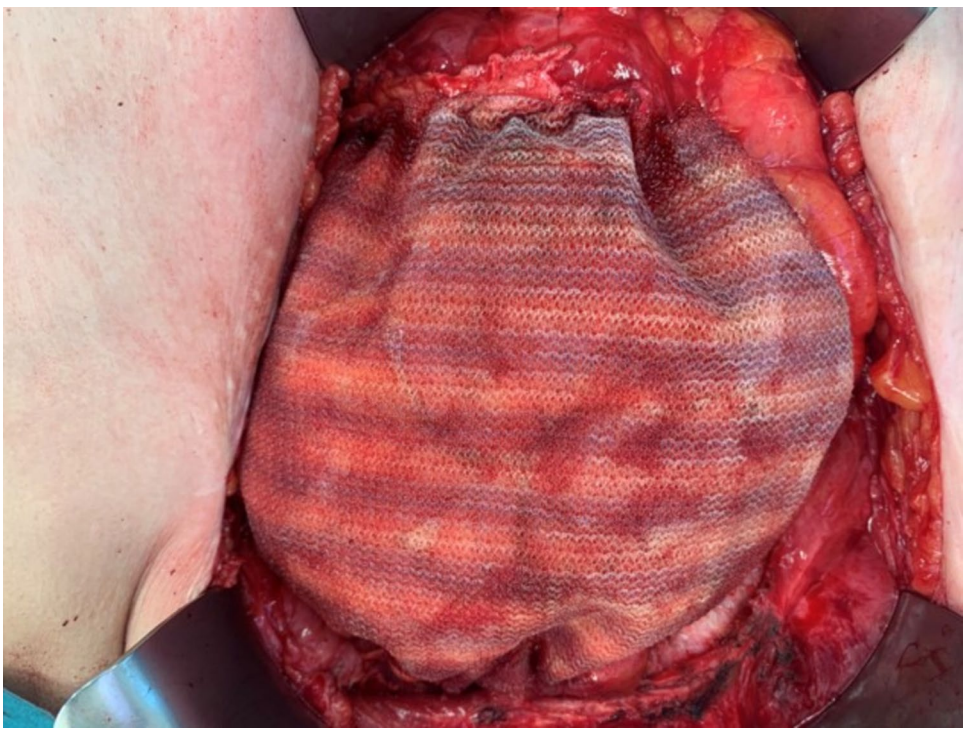

Fig. 4 Reconstruction of the posterior layer with a slowly absorbable mesh made of coated 4-hydroxibutyrate (Phasix ST)

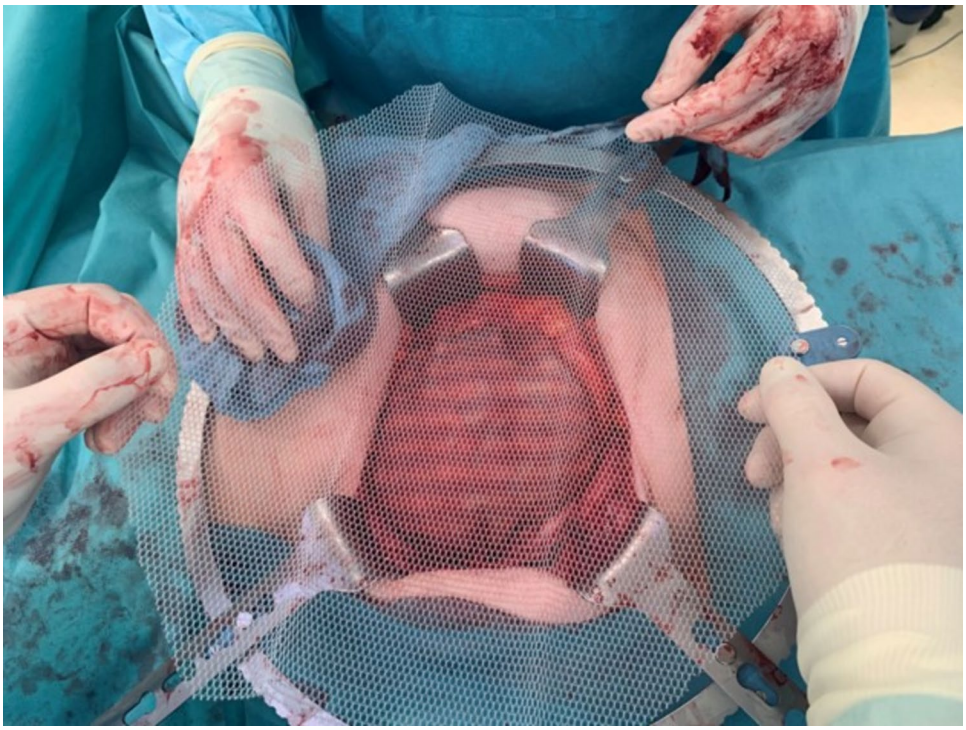

Fig. 5 Placement of a very large polypropylene mesh (45 × 30 cm) after bridging the posterior layer

reconstruction of the posterior layer, either a larger gap in the peritoneum/fascia transversalis had to be closed with a mesh or complete bridging with a slowly absorbable mesh had to be carried out in 33.3% of cases (Figs. 4 and 5).

Discussion

This analysis of data from the literature demonstrates that incisional hernias with a defect width of 15–17 cm can be repaired with an open PCSTAR standard technique (Fig. 6), while achieving adequate results. According to Grover [6] conduct of standard PCSTAR is divided into 9 procedural tasks (midline laparotomy, adhesiolysis, rectus release and retrorectus dissection, superior and inferior dissection,

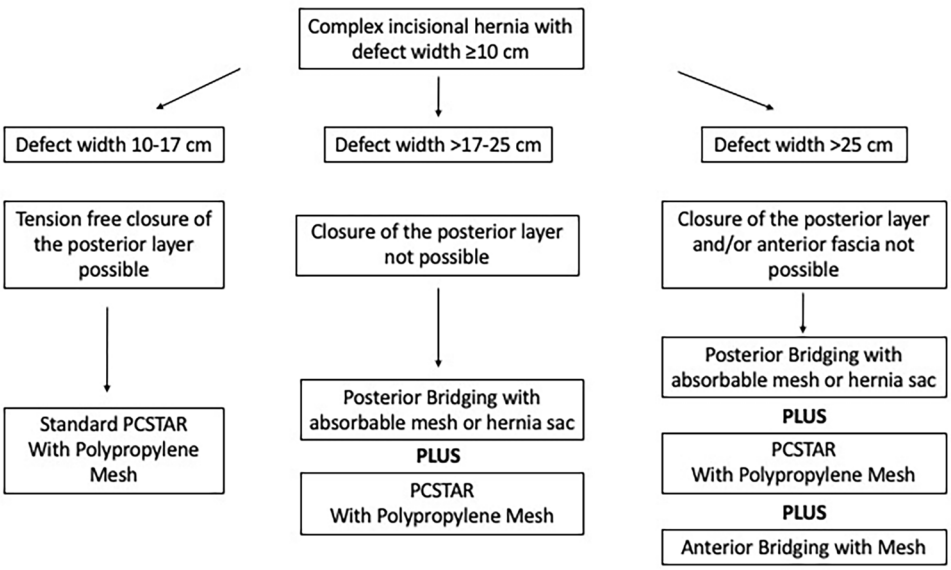

Fig. 6 Differential treatment of complex incisional hernias with open posterior component separation with transversus abdominis release (PCSTAR) depending on the defect width

exposure and division of transversus abdominis muscle, closure of posterior layer, mesh placement and fixation, anterior fascial closure, skin closure), each of which should be executed with the greatest precision to achieve good outcomes. This makes open PCSTAR a complex surgical technique. As the defect width of the incisional hernia increases beyond 17 cm, it will be more difficult to perform standard PCSTAR. The most likely limiting substeps of PCSTAR are reconstruction of the posterior layer and anterior fascial closure (Fig. 6).

In PCSTAR the posterior layer is formed from the complex, comprising the posterior layer of the rectus sheath, peritoneum and fascia transversalis. This complex is developed through blunt, more lateral dissection between the complex and transversus abdominis muscle. As the defect size increases, the peritoneum/fascia transversalis becomes thinner and thinner, retracting dorsally. This also means that the peritoneum/fascia transversalis becomes shorter and is also more difficult to dissect from the transversus abdominis muscle. Because the peritoneum/fascia transversalis is so thin, smaller, but also larger, defects occur during dissection. These must be closed carefully with either a suture or a mesh. If a mesh is used, this must be a mesh that allows contact with the bowel. This also applies if, for very large defects, reconstruction of the posterior layer is no longer possible and therefore bridging must be carried out. Absorbable synthetic meshes are recommended to that effect in the literature. By suturing these absorbable meshes into the defect of the posterior layer a "new abdominal cavity" is created in which the intestines can be accommodated again.

With this technique it is possible to achieve adequate reconstruction of the posterior layer even for very large defects. This also prevents onset of compartment syndrome because it pre-empts closure of the posterior layer under tension. Retromuscular placement of very large polypropylene meshes in the space between the bridged posterior layer and the transversus abdominis muscle will then be possible for durable reconstruction of the abdominal wall (Fig. 6).

Unfortunately, no information is provided in the literature so far on how often during reconstruction of the posterior layer large gaps in the peritoneum/fascia transversalis had to be closed through suturing an absorbable mesh or on how often bridging was needed. Based on our experience this is a common problem and the utmost care is needed when performing this procedure. If defects are left in the peritoneum/fascia transversalis, the small bowel can prolapse through the defects between the polypropylene mesh and peritoneum/fascia transversalis.

Likewise, anterior fascial closure represents a critical step of PCSTAR. Here, the aim is to restore the linea alba and return the muscles to their original position. The complete anterior fascial closure rate reported in the literature is 81.0–97.2%. In a series with 96 PCSTAR cases requiring bridge repair for incisional hernias with a defect width of 26 ± 8 cm, a recurrence rate of 46% was reported after 20 ± 10 months [21]. This means that bridge repair should be avoided whenever possible. Certain techniques, including the use of a second mesh sutured to the borders of the anterior fascia, are cited (Table 5) [7–10, 21, 22, 24, 25]. We allow the hernia sac to remain on the anterior layer of the rectus sheath and on the scarred hernia border until the end of the operation. Through dissection in the layer between peritoneum/fascia transversalis and the transversus abdominis muscle, the laterally displaced muscular abdominal wall can in some cases be repositioned medially. If direct closure of the anterior fascia with a suture is not possible, the preserved hernia sac can be used for defect closure. The hernia sac is bound on both sides with multiple accordion-like sutures and the linea alba is restored by means of the thus bound hernia sac. This technique can be modulated such that is does not create undue tension, giving rise to abdominal compartment syndrome. Redundant skin and hernia sac can be resected after anterior fascial closure. This technique largely succeeds in bringing the rectus muscles back to the restored linea alba. This means that the principle of retromuscular mesh placement can be largely reestablished. With that approach, the aim is to achieve for PCSTAR a lower recurrence rate than that seen in ACS [26].

In summary, it can be stated that, depending on the defect width, closure of the posterior layer and anterior fascia is a limiting factor of PCSTAR for incisional hernia repair. For defect widths of 17 cm and larger technical problems can arise during reconstruction of the posterior layer and anterior fascia. These are limits for the standard PCSTAR technique. For closure of the posterior layer problems can be solved through the use of absorbable synthetic meshes. For anterior fascial closure based on our experience the hernia sac, which is left on the anterior layer of the rectus sheath and on the scarred hernia ring and is bound with multiple, accordion-like stitches, can serve as a new linea alba. With these techniques, it is usually possible to overcome the problems caused by larger defects when performing PCSTAR.

Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on friendly request.

Declarations

Conflict of interest Prof. Dr. Köckerling reports grants to fund Herniamed from Johnson&Johnson, Norderstedt, Karl Storz, Tuttlingen, MenkeMed, Munich, DB Karlsruhe and personal fees from BD Karlsruhe. Dr. H. Riediger has nothing to disclose.

Ethical approval Only cases of routine hernia surgery were documented in the Herniamed Registry and all patients have signed a special informed consent declaration agreeing to participate. The Herniamed

Registry has ethical approval (BASEC No. 2016 - 00.123, 287/2017 BO2).

Human and animal rights This article does not contain any Study with animals performed by any of the authors.

Informed consent All patients with routine hernia surgery documented in Herniamed Registry have signed an informed consent declaration agreeing to participate.

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