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Step-by-step guide to safe removal of pre-peritoneal inguinal mesh

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Abstract

Background Inguinal hernia repairs are among the most common operations performed worldwide. An increasing number is performed minimally invasively with mesh placed pre-peritoneally. Some situations may require mesh removal. This can be complex and challenging. We share our technique to remove pre-peritoneal mesh using a minimally invasive approach.

Methods The multiple steps involved in robotic-assisted pre-peritoneal mesh removal are reviewed in detail, including preoperative planning, intraoperative positioning, review of anatomic landmarks, and systematic approach with technical tips to reduce complications.

Results We provide an attached narrated video guide with a written summary to outline pre-peritoneal inguinal mesh removal. The steps are applicable to both robotic-assisted and laparoscopic approaches. We present a video of the robotic-assisted approach. We prefer the robotic-assisted approach for most pre-peritoneal mesh removal based on results of our retrospective series of 26 patients undergoing 31 mesh removals. We noted that our robotic-assisted approach was more effective than the laparoscopic approach, with significantly less incidence of vascular injury (0 vs 5, $p < 0.05$) and less nerve (1 vs 4) and spermatic cord injuries (0 vs 1).

Conclusions As pre-peritoneal inguinal mesh implantation becomes more popular, surgeons may be seeing more patients with complications who may require mesh removal. We provide a detailed step-by-step approach with video to serve as a guide to surgeons who are planning for safe removal of pre-peritoneal inguinal hernia mesh.

Keywords Inguinal hernia · Mesh removal · Robotic · Laparoscopic · Chronic pain · CPIP

Inguinal hernia repairs are among the most common operations performed worldwide [1]. Implantation of mesh during inguinal hernia repair is standard procedure in the USA and has increased worldwide [1–3]. Since the introduction of minimally invasive techniques, laparoscopic and robotic-assisted inguinal hernia repair with pre-peritoneal mesh has slowly gained popularity [4, 5]. The proportion of all inguinal hernias approached laparoscopically varies across regions and individual practices. For example, rates of laparoscopic repair compared to all inguinal hernia repairs are 42% in Switzerland and Germany [6–8], whereas rates are lower (4%) in Great Britain [9]. In the USA, the proportion of laparoscopic inguinal repairs has slowly risen to 17% based on National Surgery Quality Improvement Program data [10, 11].

A variety of complications after hernia repair may require mesh removal as part of their treatment. These complications include mesh infection, mesh-related pain, meshoma, nerve entrapment, hernia recurrence, and other reasons for chronic post-ingunal herniorrhaphy pain (CPIP) [12, 13]. Mesh removal, however, can be complex and challenging, especially when found in the retromuscular pre-peritoneal space.

Published data about mesh explantation is sparse—mostly case reports and without technical guidance to the reader

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[12]. Guidelines addressing inguinal hernia mesh removal focus primarily on indications and clinical decision making but are limited in their depth and technical details [14]. The lack of publications about this procedure and our own experience as a referral center for hernia complications indicate that few surgeons perform mesh removal; even less are comfortable with removal of pre-peritoneal mesh.

Our goal in this descriptive technical article is to detail the preoperative planning and systematic operative approach to removal of pre-peritoneal inguinal mesh. Our aim is to serve as a guide to surgeons who may be faced with such a clinical situation. We describe our method for robotic-assisted pre-peritoneal inguinal mesh removal in this step-by-step guide and illustrative narrated video (see Video in supplementary material).

Methods

Preoperative considerations

Prior to attempting mesh removal, an understanding of the myopectineal orifice anatomy is crucial. When re-operating in the pre-peritoneal space, the anatomy will be distorted. This is one of the challenges of mesh removal.

A detailed history and physical focusing on symptomatology provides insight into the localization and characteristic of the patient's symptoms. These can include neuropathic or non-neuropathic symptoms related to meshoma, hernia recurrence, nerve entrapment and/or infection. The dermatome mapping technique is a useful tool in assessing the type and distribution of symptoms [15, 16].

Assessment of the patient's pain and discomfort will influence intraoperative decision making, especially if considering leaving mesh behind in the case of a difficult dissection. Alternatively, when the indication for mesh removal is due to a rare reaction to the implant itself, the aim of the operation should be complete mesh excision. During preoperative informed consent, a comprehensive discussion with the patient may include the feasibility of complete mesh removal and consequences of residual mesh.

We recommend very carefully reviewing a preoperative cross-sectional image, such as computed tomography (CT) scan or magnetic resonance (MR) imaging. Three-dimensional imaging helps provide a roadmap to one's dissection. It may identify aberrant anatomy or challenges. We prefer MR, as it can best differentiate between the mesh itself and adhesions to surrounding structures with the benefit of sparing ionizing radiation exposure [17]. Specific radiologic characteristics to look for are distortion of the bladder by the mesh and lack of fatty plane between the mesh and the external iliac vessels. Both findings may hint that dissection may be challenging, and there will be adhesions or even

erosion of mesh to these structures. In males, there may be findings of dilated spermatic veins or stenosis of the vas deferens. These may suggest erosion of the mesh into the spermatic cord contents. Consultation with a radiologist is especially helpful in these situations.

Operative approach

We present our technique for robotic-assisted approach to pre-peritoneal mesh removal (see Video in supplementary material). Most of these techniques are applicable to a laparoscopic approach as well. We advocate against the open approach for pre-peritoneal mesh removal if minimally invasive techniques are available.

Positioning

The patient is positioned supine, with both arms padded and tucked. The face is protected from risk of injury from the robotic arms. The *da Vinci* (Intuitive Surgical, Inc, Sunnyvale, CA) S/Si is docked between the patient's legs for bilateral inguinal mesh removal or side-docked from the contralateral side for unilateral inguinal mesh removal. The *da Vinci* Xi may be docked from any side.

We routinely place a urinary catheter. This decompresses the bladder to reduce its risk of injury. Also, in the case of mesh adhesion or erosion into the bladder the catheter can be instilled to distend the bladder and aid in its identification. In males, we routinely sterilely prep the scrotum into the operative field. This allows for manual traction on the testicle intraoperatively, as needed, to help identify the spermatic cord. This maneuver can be helpful to reduce risk of inadvertent injury to the spermatic cord, which is often intimately involved with the mesh in its pre-peritoneal course.

Port placement

We use a 4-port technique (Fig. 1). Pneumoperitoneum is obtained using a Veress needle through the umbilicus. With the *da Vinci* Xi, after successful insufflation of the abdomen, an umbilical 8-mm robotic trocar is placed (12 mm for the *da Vinci* S/Si). We recommend a 16-cm length "bariatric" trocar for this camera port in patients that are not thin. Additional 8-mm ports are placed in the left and right abdomen, 8 cm (approximately 1 handbreadth) from the umbilicus and in-line with the umbilicus. The fourth port is a 12-mm Assistant's port placed 8 cm laterally to the 8 mm port, ipsilateral to the affected side from which the mesh will be removed so that retraction can be performed. This is preferably placed contralateral to the side the robot is docked, to make room for the surgical Assistant. Skiving the 12-mm Assistant's trocar through the abdominal wall can reduce risk of port-site incisional hernia. A similar technique can be

Fig. 1 Four-port technique with a lateral 12-mm Assistant's port (arrow) on the contralateral side to the robot, ipsilateral to the mesh being removed. Assistant's port is used for retraction, mesh insertion and removal

used laparoscopically, with three 5-mm trocars of surgeon's choice and a lateral-most 12-mm trocar.

Operative steps

An initial intraperitoneal survey is performed to identify anatomic landmarks (Fig. 2). This includes the external iliac vessels, inferior epigastric vessels and the mesh that can often be visualized adherent to the peritoneum. Start the peritoneal dissection medial to the anterior superior iliac spine, and extend transversely, staying along the superior edge of the mesh. We recommend using robotic scissors with
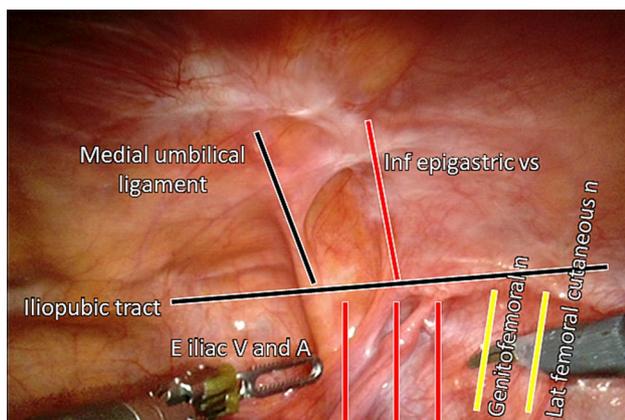

Fig. 2 An initial intraperitoneal survey identifies anatomic landmarks, right side. This includes the external iliac vessels ("E iliac v and a"), inferior epigastric vessels (Inf epigastric vs), genitofemoral nerve (Genitofemoral n), lateral femoral cutaneous nerve (Lat femoral cutaneous n), and the mesh that can often be visualized adherent to the peritoneum. Other critical anatomy can be predicted based on these initial landmarks

monopolar energy in the dominant hand. In the non-dominant hand, we prefer to use a bipolar grasper, such as the fenestrated bipolar forceps. The Prograsp forceps have the most strength and is best at handling stiff or heavy mesh, but it lacks the benefits of bipolar cautery. The next generation grasper will have the ability to provide cautery and stronger grip. We will likely switch to option that in the future.

Once the superior mesh edge has been encountered, the first desired plane of dissection starts between the mesh and the transversalis fascia. Keep the mesh adherent to the peritoneum; this layer will be separated later during the operation. Carry the dissection along the superior mesh edge starting from the superolateral edge and progressing medially past the inferior epigastric vessels and inferiorly toward the lateral iliopubic tract (Fig. 3).

The mesh can often be dissected off the inferior epigastric vessels without vascular injury. If there is bleeding, clipping (with a laparoscopic or robotic clip applier) or bipolar cautery of these vessels may be necessary.

Halt before getting too close to the iliopubic tract, as progressing too far inferiorly at this point may risk injury to the spermatic cord and genitofemoral and lateral femorocutaneous nerves.

Next, from the superomedial mesh edge, dissect the mesh inferiorly towards Cooper's ligament (Fig. 4). Staying close to the mesh will reduce risk of bladder injury. Few other structures are at risk of injury here.

Once the mesh is freed from the abdominal wall superiorly, laterally and medially, the most challenging portion of the mesh removal ensues, i.e., removal of the mesh off the spermatic cord in males, the external iliac vessels and the genitofemoral nerve. Significant caution should be exercised as these structures may be shifted from mesh adhesion. In

Fig. 3 Medial edge of the right inguinal mesh is seen retracted inferomedially exposing the inferior (inf) epigastric vessels. The dissection is first carried from the superolateral mesh edge progressing medially past the inferior epigastric vessels and inferiorly toward the iliopubic tract
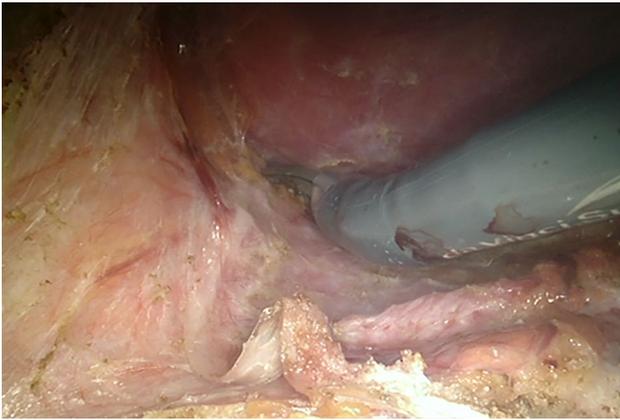
Fig. 4 Right inguinal mesh dissection is next approached medially and inferiorly toward Cooper's ligament (tip of instrument) while staying close to the mesh to reduce risk of bladder injury

females, we routinely sacrifice the round ligament using bipolar electrocautery.

At this point, we begin separation of the peritoneum off the mesh. We advise taking the extra effort to preserve the peritoneum during this process as a transabdominal pre-peritoneal (TAPP) mesh repair can be subsequently accomplished if indicated (Fig. 5). The peritoneal dissection off the mesh is primarily done to help better identify the anatomy and visualize critical structures before pursuing mesh removal off the cord, vessels and nerves. An atraumatic laparoscopic grasper through the lateral Assistant's port can provide valuable counter-traction as the mesh and peritoneum are peeled off each other. With the robot, this can be a lateral robotic Assistant's arm if there is no other assistant available. By separating the mesh from the peritoneum, virgin territory below the inferior mesh edge can be exposed, allowing for better visualization during circumferential dissection
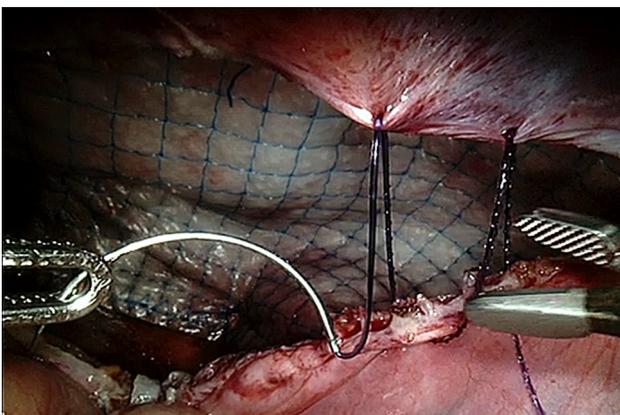
(Fig. 6). Follow the critical structures from the virgin retroperitoneal space in toward the mesh-adhered space. This path can help reduce the risk of inadvertent neurovascular injury.

The mesh need not be removed en bloc. At times, piecemeal removal of the mesh can help reduce the bulk of the mesh and facilitate its manipulation. If the dissection proves too difficult or unsafe, such as over the external iliac vessels, mesh may be left behind. Note the one exception: it is important to attempt complete mesh removal if the indication for mesh removal is for the rare case of systemic severe allergic reaction to the implant itself.

Results

We have been performing minimally invasive inguinal mesh removal for over 16 years. Removal of pre-peritoneal mesh is more complex and challenging than anteriorly placed mesh. We began with laparoscopic mesh removal. We have since converted to a robotic-assisted approach after analyzing our early outcomes [18]. Based on our retrospective analysis of 26 patients undergoing 31 mesh removals, our robotic approach resulted in significantly lower incidence of vascular injury (0 vs 5, $p < 0.05$) to the epigastric vessels or external iliac vein. We also experienced less nerve injuries (1 vs 4) and less spermatic cord injuries (0 vs 1) compared to our laparoscopic mesh removal technique (Table 1). The nerve injuries all presented with postoperative genital branch neuralgia. The spermatic cord injury was an unplanned vasectomy. There were no testicular complications, such as ischemia.
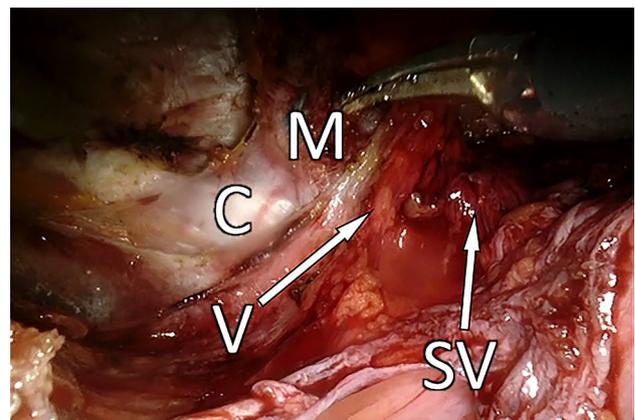

Fig. 5 We advise taking the extra effort to preserve the peritoneum as a TAPP mesh repair can be subsequently performed, if indicated. Seen here is peritoneal closure after hybrid mesh repair

Fig. 6 With the right inguinal mesh (M) retracted superiorly, the peritoneum is dissected off the mesh. Note that Cooper's ligament (C) has already been exposed medially. This allows an approach towards the spermatic cord and external iliac vessels from known virgin territory inferior and posterior to the inferior mesh edge. Elements of the spermatic cord are visualized, including the vas deferens (V) and spermatic vessels (SV)

Table 1 Retrospective analysis of laparoscopic versus robotic mesh removal, $N = 26$ [18]

	Laparoscopic	Robotic	p value
N	17	9	
Age (years)	48	49	NS
Sex—male (%)	65%	67%	NS
BMI (kg/m²)	25.7	28.4	NS
Primary reason for mesh removal			
Chronic pain	12 (71%)	7 (78%)	NS
Recurrence	5 (29%)	2 (22%)	NS
Vascular injury	5 (29%)	0	< 0.05
Clipped epigastric vessels	4 (24%)	0	
External iliac vessel injury	1 (6%)	0	
Nerve injury[a]	4 (24%)	1 (11%)	NS
Spermatic cord injury[b]	1 (6%)	0	NS
Length of hospital stay (days) (range)	0 (0–9)	0 (0–3)	NS

BMI body mass index, *NS* not significant

[a]All were genital branch of genitofemoral nerve, presenting with postoperative neuralgia

[b]No testicular complications

A narrated video of the mesh removal technique, performed robotically, can be viewed in video in supplementary material.

Discussion

CPIP is defined as postoperative pain lasting 3 or more months after inguinal hernia repair [12, 19]. It is reported following 12% of inguinal hernia operations with mesh [20] and can occur regardless of mesh use, technique or approach [21]. In those repairs performed with mesh, some may require mesh removal to help address the pain. Since laparoscopic and robotic-assisted inguinal hernia repairs with mesh have gained popularity, one would expect a demand for the need to remove their pre-peritoneally placed mesh in the case of CPIP.

While open mesh removal is an established technique, it is a complex and challenging procedure and should be performed by experienced surgeons for best outcomes [22]. Our practice is a referral center for hernia complications, and mesh removal is among the specialized procedures we perform. Based on our own experience as well as our interaction with surgeon and patient communities, we find that most general surgeons do not offer inguinal mesh removal. Among those that do offer mesh removal, most perform it via open approach.

We strongly advocate the minimally invasive approach for removal of pre-peritoneal mesh, when that expertise is available. This approach can be even more challenging and risky than the open approach for anteriorly placed mesh, but it has been shown to be feasible, safe and effective [6]. Sensing the growing demand for pre-peritoneal mesh removal, we share our systematic approach that we have honed over the span of 16 years. The impetus for this step-by-step guide with video (see Video in supplementary material) is to promote safe pre-peritoneal mesh removal, as there is little to no technical guidance available for the surgeon.

In our practice, we started with a laparoscopic approach and evolved toward a robotic approach for most of our pre-peritoneal mesh removals. We have previously shared that early in our robotic experience, we immediately noticed less morbidity and superior early outcomes compared to doing our laparoscopic approach (Table 1) [18]. This is the basis for which we prefer the robotic-assisted approach for pre-peritoneal mesh removal in our practice. We feel that the robotic approach allowed us to have enhanced visualization of the critical structures such as the vessels and spermatic cord contents and their intimate contact with the mesh, thus avoiding their injury as the mesh is being dissected free from them.

While mesh removal is the focus of our video manuscript, it is important to appreciate that mesh removal is not the most important part of the patient's treatment. CPIP is a complex clinical situation that demands a lot of time devoted to gathering a detailed history, careful examination and preoperative assessment to be successfully treated. The decision for mesh removal should be tailored to each patient's needs [12]; similarly, the decision for neurectomy and type of hernia repair as the independent effect of mesh removal is difficult to determine [12, 23, 24]. In our practice, we perform selective neurectomy based on the patient's clinical and surgical findings.

The surgical evaluation and successful treatment of CPIP can make a dramatic improvement in a patient's quality of life. We hope this detailed step-by-step guide can help promote surgeon interest and improve their expertise in minimally invasive approach toward safe removal of pre-peritoneal inguinal mesh.

Compliance with ethical standards

References

1. Bay-Nielsen M, Kehlet H, Strand L, Malmstrøm J, Andersen FH, Wara P, Juul P, Callesen T (2001) Quality assessment of 26,304

herniorrhaphies in Denmark: a prospective nationwide study. Lancet 358(9288):1124–1128

2. Rutkow IM (2003) Demographic and socioeconomic aspects of hernia repair in the United States in 2003. Surg Clin North Am 83(5):1045–1051 (**v–vi**)

3. Kouhia S, Vironen J, Hakala T, Paajanen H (2015) Open mesh repair for inguinal hernia is safer than laparoscopic repair or open non-mesh repair: a nationwide registry study of complications. World J Surg 39(8):1878–1884

4. Winslow ER, Quasebarth M, Brunt LM (2004) Perioperative outcomes and complications of open vs laparoscopic extraperitoneal inguinal hernia repair in a mature surgical practice. Surg Endosc 18(2):221–227

5. Rutkow IM (1998) Epidemiologic, economic, and sociologic aspects of hernia surgery in the United States in the 1990s. Surg Clin North Am 78(6):941–951 (**v-vi**)

6. Slooter GD, Zwaans WAR, Perquin CW, Roumen RMH, Scheltinga MRM (2018) Laparoscopic mesh removal for otherwise intractable inguinal pain following endoscopic hernia repair is feasible, safe and may be effective in selected patients. Surg Endosc 32(3):1613–1619

7. Tschuor C, Metzger J, Clavien PA, Vonlanthen R, Lehmann K (2015) Inguinal hernia repair in Switzerland. Hernia 19(5):741–745

8. Bittner R, Schwarz J (2012) Inguinal hernia repair: current surgical techniques. Langenbecks Arch Surg 397(2):271–282

9. Ravindran R, Bruce J, Debnath D, Poobalan A, King PM (2006) A United Kingdom survey of surgical technique and handling practice of inguinal canal structures during hernia surgery. Surgery 139(4):523–526

10. Saleh F, Okrainec A, D'souza N, Kwong J, Jackson TD (2014) Safety of laparoscopic and open approaches for repair of the unilateral primary inguinal hernia: an analysis of short-term outcomes. Am J Surg 208(2):195–201

11. Neumayer L, Giobbie-hurder A, Jonasson O, Fitzgibbons R Jr, Dunlop D, Gibbs J, Reda D, Henderson W (2004) Open mesh versus laparoscopic mesh repair of inguinal hernia. N Engl J Med 350(18):1819–1827

12. HerniaSurge Group (2018) International guidelines for groin hernia management. Hernia 22(1):1–165

13. Bjurström MF, Nicol AL, Amid PK, Chen DC (2014) Pain control following inguinal herniorrhaphy: current perspectives. J Pain Res 7:277–290

14. Cunningham LA, Ramshaw B (2016) Mesh removal for chronic pain: a review of laparoscopic and open techniques. In: Jacob BP, Chen DC, Ramshaw B, Towfigh S (eds) The SAGES manual of groin pain. Springer, Switzerland, pp 301–317

15. Alvarez R (2016) Dermatome mapping: preoperative and postoperative assessment. In: Jacob BP, Chen DC, Ramshaw B, Towfigh S (eds) The SAGES manual of groin pain. Springer, Switzerland, pp 277–292

16. Bjurström MF, Álvarez R, Nicol AL, Olmstead R, Amid PK, Chen DC (2017) Quantitative validation of sensory mapping in persistent post-herniorrhaphy inguinal pain patients undergoing triple neurectomy. Hernia 21(2):207–214

17. Langbach O, Holmedal SH, Grandal OJ, Røkke O (2016) Adhesions to mesh after ventral hernia mesh repair are detected by MRI but are not a cause of long term chronic abdominal pain. Gastroenterol Res Pract 2016:2631598

18. Zarrinkhoo E, Towfigh S (2016) Risks of laparoscopic versus robotic-assisted mesh removal after inguinal hernia repair. In: Annual meeting of the Society of American Gastrointestinal and Endoscopic Surgeons, Boston, MA, March 16–19

19. International Association for the Study of Pain, Subcommittee on Taxonomy (1986) Classification of chronic pain. Descriptions of chronic pain syndromes and definitions of pain terms. Pain 3(Suppl):S1–S226

20. Koning GG, Wetterslev J, Van laarhoven CJ, Keus F (2013) The totally extraperitoneal method versus Lichtenstein's technique for inguinal hernia repair: a systematic review with meta-analyses and trial sequential analyses of randomized clinical trials. PLoS ONE 8(1):e52599

21. Öberg S, Andresen K, Klausen TW, Rosenberg J (2018) Chronic pain after mesh versus non-mesh repair of inguinal hernias: a systematic review and a network meta-analysis of randomized controlled trials. Surgery 163(5):1151–1159

22. Lange JF, Kaufmann R, Wijsmuller AR, Pierie JP, Ploeg RJ, Chen DC, Amid PK (2015) An international consensus algorithm for management of chronic postoperative inguinal pain. Hernia 19(1):33–43

23. Valvekens E, Nijs Y, Miserez M (2015) Long-term outcome of surgical treatment of chronic postoperative groin pain: a word of caution. Hernia 19(4):587–594

24. Campanelli G, Bertocchi V, Cavalli M, Bombini G, Biondi A, Tentorio T, Sfeclan C, Canziani M (2013) Surgical treatment of chronic pain after inguinal hernia repair. Hernia 17(3):347–353