



# Laparoscopic treatment of chronic pain following inguinal hernia repair: a narrative review of the literature

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**Abstract:** Approximately 5% of patients undergoing open hernia repair, and probably less after laparoscopic repair, will suffer from severe disabling chronic pain. The optimal strategy for surgical treatment of chronic pain following inguinal hernia repair is debatable and not evidence-based. Laparoscopic removal of mesh and/or retroperitoneal neurectomies have been performed in attempts to treat patients with chronic pain after inguinal hernia repair. The aim of this qualitative review is to analyze the evidence surrounding a laparoscopic approach to the surgical management of chronic pain following inguinal hernia repair. Only prospective studies including at least 10 patients operated with a laparoscopic technique were included. Non-English published studies were excluded. The MEDLINE database was searched and supplemented by screening the reference lists of included studies. Each study is presented separately. In total, six studies including 14–42 patients (n=189) reported outcomes with a postoperative follow-up of 3–57 months. Five studies analyzed clinical outcomes after laparoscopic triple or selective neurectomy and one study reported outcome following only laparoscopic mesh removal. The outcome variables were often poorly defined and inconsistent between studies. However, results were generally promising in respect of reduction in pain and increase in activity level. The definition of a successful postoperative outcome was lacking in most studies making it difficult to assert definitive conclusions. What is clear, is that a laparoscopic approach to managing postoperative pain after inguinal hernia repair is feasible but with some risks. More specifically, an extraperitoneal laparoscopic neurectomy may benefit patients suffering from severe chronic pain after inguinal hernia repair. The literature does not provide evidence supporting a universal laparoscopic approach to chronic pain following inguinal hernia repair. More large-scale high-quality studies are warranted before final conclusions can be made on the indication to offer a laparoscopic pain-operation and the long-term outcome.

**Keywords:** Hernia; inguinal; chronic pain; laparoscopy; treatment outcome; neurectomy

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## Introduction

Inguinal hernia repair is mostly performed using a mesh reinforcement with an open or laparoscopic approach (1). The use of mesh has dramatically reduced the risk of hernia recurrence (2) and the main clinical challenge has shifted

towards postoperative chronic pain. Approximately 5% of patients undergoing open hernia repair, probably less after laparoscopic repair, will suffer from severe disabling chronic pain (3). Inguinal hernia repair is one of the most common surgical procedures and thus, there is a high prevalence of patients with chronic pain necessitating an

optimal management strategy including surgical indication, approach and technique (3-6).

Although not evidence based, it is recommended that an open operation is performed when the pain-triggering operation (index operation) is an open inguinal hernia repair whereas a laparoscopic pain-operation is recommended for patients when the index operation is laparoscopic (7). Early results have suggested that a laparoscopic pain-operation also may be indicated in patients with no analgesic effect (failure) following an open pain-operation, although the evidence is weak and the results not uniform (8,9).

The aim of this qualitative review is to analyze the evidence surrounding a laparoscopic approach to the surgical management of chronic pain following inguinal hernia repair. To meet the aim, a literature search was performed using PubMed (up to August 2020). The pathophysiology for chronic pain following an inguinal hernia repair is first briefly summarized and technical aspects of the laparoscopic pain-operation technique are laid out. Available studies are presented with a focus on indication to operate, surgical strategy, and outcomes. We present the following article in accordance with the Narrative Review reporting checklist (available at <http://dx.doi.org/10.21037/ls-20-124>).

### Pathophysiological aspects

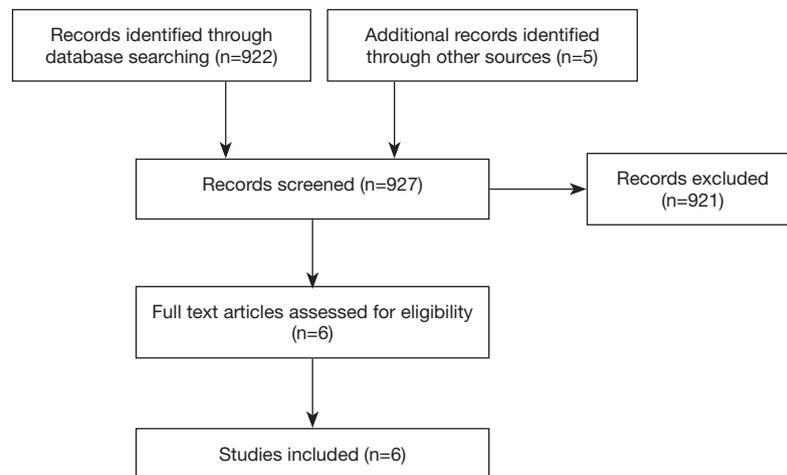
Chronic pain following inguinal hernia repair is predominantly neuropathic in origin (nerve damage by surgical trauma, traction and compression) but nociceptive pain mechanisms are often also involved (inflammation, scar tissue, meshoma and mechanical stiffness, compression of the spermatic cord) (5,10-12). The inguinal nerves of greatest concern are the iliohypogastric, ilioinguinal, and genitofemoral nerves (11,13). Patients often present with both neuropathic and nociceptive clinical pain complaints making differentiation between pain mechanisms difficult (7). Clinically, it is generally accepted that neuropathic pain is characteristically burning, electric, knife-stabbing, tingling and/or prickling and can be accompanied by radiation of pain, numbness and/or dysesthesia (14). Nociceptive pain is characteristically throbbing, dull, aching and/or pounding, and generally not radiating (15). Neuropathic pain may be clinically diagnosed using validated questionnaires ( $\approx 80\%$  sensitivity and specificity) (16) supported by Quantitative Sensory Testing (QST) and dermatosensory mapping (17-20). QST is a technique to diagnose peripheral nervous system disorder ranging from a meticulous and time consuming

battery of technical tests to a simple pinprick or pressure algometry test (7,21) and has also been reported as outcome in otherwise clinical outcome studies (8,17,18,20) although its' association with postoperative outcome is dubious (8,17,18,20,22).

### Laparoscopic surgical technique and anatomical considerations

For a laparoscopic extraperitoneal neurectomy, the patient is placed in the lateral decubitus position with the side of the groin pain up. The operating table is flexed to open the space between the iliac crest and costal margin. The first incision is a 12 mm transverse incision in the midaxillary line 4 cm proximal to the iliac crest. From this incision, the external oblique fascia is incised, and the muscle layers (external oblique, internal oblique and transversus abdominis) divided in order to reach the retroperitoneum. A dissecting balloon is placed and inflated which mobilizes the peritoneum in the avascular plane and exposes the retroperitoneal plane. The balloon is replaced with a 12 mm trocar and CO<sub>2</sub> is used to insufflate to 15 mmHg. A 5 mm port is placed 2 cm medially. The anatomical landmarks are now the fat pad, the quadratus lumborum and psoas muscles, and the costal nerve at the T12 costal margin. The first step is to sweep the fat pad medially to expose the quadratus lumborum and psoas muscles. Now the common trunk of the ilioinguinal and iliohypogastric nerves can be located running across the quadratus lumborum and through the rim (or nearby) between the quadratus and psoas muscles, respectively, and can be resected at this location, but preferably as distal as possible to minimize the risk of laxity of the flank muscles (8). The common trunk of the genitofemoral nerve can be identified penetrating the middle part of psoas muscle at various heights. The lateral cutaneous femoral nerve can be identified lateral to the psoas muscle crossing the iliac muscle below the iliac crest and the femoral nerve can be found lateral and deep to the psoas muscle. However, the anatomy is relatively subject to variation (19).

Following the neurectomy, the patient can be repositioned to supine and the mesh can be removed with a transabdominal approach similar to TAPP if necessary. Mesh removal is performed by dividing the peritoneum at the superior border of the mesh, separating the bladder from the mesh to open the space of Retzius, then freeing the peritoneum from the inferior edge of the mesh. The mesh is then separated from the anterior abdominal wall



**Figure 1** Flow-chart detailing study selection.

with sharp and electrocautery dissection paying attention to the epigastric and femoral vessels. Preservation of the gonadal vessels and vas deferens is attempted in males but may not be possible. A total mesh removal is the goal but for safety reasons only partial mesh removal may be possible (20,23).

## Methods

The current review is a narrative critical appraisal of the literature. A literature search was conducted in the MEDLINE database and supplemented by screening the reference lists of included studies (Figure 1). Only prospective studies including at least 10 patients operated with a laparoscopic technique were included. Thus, non-randomized, uncontrolled and observational studies were also included. Reviews and non-English published studies were excluded. The search string included the following words: (Neurectomy) AND (Hernia) and yielded a total of 922 hits. Two authors independently selected the relevant articles. Articles were screened based on study titles (56 results) and abstracts from these were extracted. After applying inclusion and exclusion criteria on the abstracts, a total of six studies were eligible and full texts were extracted (Figure 1).

The same two authors collected data from each article. Specific outcomes were not predefined, and all outcomes were extracted. All relevant outcome measures are described independently. Other extracted variables were inclusion criteria, exclusion criteria, number of included patients, indication to operate, aim of the study, type of index repair, inclusion period, follow-up and surgical complications.

## Results

The study results are briefly summarized in Table 1. In total, six studies including 14–42 patients (n=189) have reported outcomes after 3–57 months postoperatively (8,9,19,23–25). Five studies analyzed clinical outcomes after laparoscopic triple or selective neurectomy for chronic pain (8,9,19,24,25) and one study reported outcome following laparoscopic mesh removal (23).

### *Laparoscopic retroperitoneal triple neurectomy*

Chen *et al.* (19) included 20 patients with neuropathic pain diagnosed with nerve blocks in the first pioneering study reporting results after laparoscopic retroperitoneal triple neurectomy. The authors did not provide detailed information on the classification of neuropathic pain. It was a prospective study based on 119 consecutive referred patients. Indication to operate required a minimum of 6 months groin pain, but specific indication to offer a pain-operation was not defined. Index operations were TEP (nine patients), TAPP (one patient), open preperitoneal bilayer hernia system (four patients), open mesh repair (four patients), plug repair (one patient) and open non-mesh repair (one patient). Data from the specific operations were pooled for a compiled analysis. Exclusion criteria were ASA score > III, primary orchialgia, non-neuropathic pain, hernia recurrence, pain unrelated to prior surgery, meshoma pain, prior retroperitoneal surgery, pain outside the area innervated by the three nerves, multifocal pain syndrome and histologically confirmed prior triple neurectomy.

**Table 1** Uncontrolled prospective studies of outcomes after laparoscopic pain-operations for chronic pain after inguinal hernia repairs (index repair)

Study	No	Index repair	Inclusion period	Follow-up (mo)	Outcome	Complications
Triple neurectomy	Chen	20 TAPP, TEP, open (+/- mesh)	2012	3	Reduced NRS pain scores (not defined) ( $P < 0.001$ ); reduced narcotic dependence (not defined) in 95% of the patients; improved activity level (not defined) in 100% of the patients	Diaphragm lesion, n=1
	Moore	62 TAPP, TEP, open (+/- mesh)	2012–2015	57	Reduced NRS pain scores (not defined) in 80% of the patients ( $P < 0.001$ ); reduced narcotic dependence (not defined) in 92% of the patients; improved activity level (not defined) in 94% of the patients	Diaphragm lesion, n=1; skin hypersensitivity, n=5; abdominal flank laxity, n=4
	Pedersen	33 TAPP, open mesh	2015–2016	3	Reduced pain-related functional impairment scores ( $P < 0.001$ ); clinically relevant improvement in functional impairment in 61%; reduced fraction of patient from moderate/severe to mild/no pain in 58% of patients ( $P < 0.001$ )	Diaphragm lesion, n=1
Elective neurectomy	Giger	39 TAPP, TEP, open (+/- mesh), appendectomy, Pfannenstiel, orchiectomy, lumbotomy	1997–2007	12	Reduced fraction of patient from moderate/severe to mild/no pain at rest in 90% of patients ( $P < 0.001$ ); reduced fraction of patient from moderate/severe to mild/no pain limiting daily activities in 85% of patients ( $P < 0.001$ ); reduced fraction of patient from moderate/severe to mild/no occupational disability in 80% of patients ( $P < 0.001$ )	Diaphragm lesion, n=1
	Moreno-Egea	16 Open mesh, appendectomy, Spigelian hernia	2012–2014	24	Reduced pain (not defined) in 94% of the patients	iatrogenic nerve lesion, n=1
Mesh removal	Slooter	14 TAPP, TEP	2011–2017	8	Reduced NRS pain scores (not defined) ( $P < 0.01$ ); more than 50% reduction in NRS pain scores in 64% of patients; excellent/good patient satisfaction in 71%	Bladder lesion, n=1

Unless stated otherwise pre- vs. postoperative changes were not statistically tested for significance and pain registrations were defined. Index repair, chronic pain-triggering inguinal hernia repair; TAPP, transabdominal preperitoneal repair; TEP, total extraperitoneal repair; NRS, numeric rating scale; mo, months.

Before the pain-operation, patients were evaluated by a dedicated pain specialist team. Multimodal pharmacological treatment, behavioral interventions and peripheral nerve block was standard. All patients were subjected to imaging (ultrasound-, CT- or MR-scans). Pre- and postoperative dermatosensory mapping was used to assess involvement of the inguinal nerves and to confirm a successful triple neurectomy. Mean duration of follow-up was five months (range: 3–9 months). The authors reported a significant reduction in NRS from 7.8 to 1.9 ( $P < 0.001$ ). Unfortunately, the NRS was not defined and detailed information on registration conditions (pain while coughing, from supine to standing, etc.) were not provided. Narcotic dependence (not defined) was decreased in 19 of the 20 patients (95%). Subjective reported activity levels (not defined) were improved in all patients (100%). Pre- vs. postoperative pain-dependent physical activity and narcotic dependence were not statistically tested for significance. Whether the pre- vs. postoperative outcome changes were clinically relevant was not noted. Complications were not pre-study defined and the authors reported only one intraoperative complication (diaphragm injury; laparoscopically sutured with no sequelae). Despite only including 20 patients, this pioneering study demonstrated feasibility and safety and the results indicated the potential analgesic effects of a laparoscopic retroperitoneal triple neurectomy in patients with chronic neuropathic pain. However, the small sample size, the lack of information of indication to operate, the vaguely defined outcome variables, and the short follow-up, makes the study results subject to bias and questions the external validity of the findings.

Moore *et al.* (8) conducted a prospective study by adding another 42 patients to the 20 patients described above (19) and thus compiling data from a total of 62 patients for reanalysis. Follow-up was an average 57 months (range: 3–90 months). In this study, the additional 42 patients were classified as suffering from neuropathic pain {determined by clinical history, positive Tinel's sign [percussion of a nerve to elicit a pins and needles sensation (26)] and dermatosensory mapping} and patients with nociceptive pain were excluded. In total, 567 patients were evaluated and 505 were excluded (mainly due to non-neuropathic pain, low pain severity and meshoma pain). Index operations were TEP (23 patients), TAPP (3 patients), open mesh repair (17 patients), plug and patch repair (8 patients), open preperitoneal bilayer hernia system (5 patients), plug repair (2 patients) and open non-mesh repair (4 patients). The main objective was to demonstrate the durability of

analgesic effectiveness after neurectomy over time. The treatment algorithm and indication to operate was identical with the previous study from the research group (19), but in this study the authors only included patients with NRS pain of more than six (again, NRS was not explained in detail) and a positive Tinel's sign. Well-defined exclusion criteria were used [similar to the Chen *et al.* study (19)]. The authors found a significant reduction in NRS pain scores from 8.6 to 1.1 ( $P < 0.001$ ). Thirteen patients (21%) had complete pain resolution, 37 patients (60%) had significant resolution (NRS  $< 4$ ) and 9 patients (15%) had a decrease in pain to tolerable levels (NRS  $< 7$ ). In 3 patients (5%) pain intensity was unchanged after the operation and no patients experienced a worsening of pain. In total, 14 patients (23%) still complained of pain classified as nociceptive after the operation but information on pain intensity was not provided. Narcotic dependence (not defined) was decreased in 57 patients (92%) and subjectively reported activity level (not defined) increased in 58 patients (94%). Activity and narcotic dependence were not statistically tested for significance and it was unclear whether these improvements were clinically relevant. As described above, there was a diaphragm injury in one patient (2%). Twenty patients (32%) reported hypersensitivity in the distribution of neurectomy after the operation which persisted in five patients (8%). Transient lateral abdominal laxity was reported in 19 patients (31%), but 4 patients (6%) experienced lasting muscle weakness limiting physical activity throughout the 5-year study period. The authors did not define laxity or how it was diagnosed. Moreover, the study can be criticized for pooling patient results from an earlier study (19). The strength of the study was the long follow-up time of several years and the most important message was that pain scores remained unchanged on a low level and that pain scores corresponded to individual patient outcomes. Unfortunately, the authors failed to statistically correct for repeated registrations along the timeline for the study time but all P values during the seven test periods were below 0.001. Importantly, the authors honestly reported a relatively high number of patients with hypersensitivity and laxity of the abdominal oblique muscles of approximately 30%, although the majority of these complications were transient.

Pedersen *et al.* (9) conducted a prospective study of 66 patients with both nociceptive and neuropathic pain (clinical history). Of these 66 patients, 33 received a laparoscopic triple neurectomy. In total, 240 patients were examined and 174 were excluded. Reasons for exclusions

were according to the pre-study defined criteria but not systematically registered. A modified step-up algorithm inspired by an international consensus algorithm (7) was used: patients whose initial inguinal hernia repair was an open Lichtenstein's repair were subjected to an open triple neurectomy with mesh removal and patients whose initial hernia repair was TAPP were subjected to a laparoscopic triple neurectomy. Furthermore, patients who did not benefit from an open triple neurectomy (all after an index Lichtenstein repair) was subsequently subjected to a laparoscopic triple neurectomy. Data from patients undergoing an open pain-operation was not compared with data from patients undergoing a laparoscopic repair. Indication to operate was well-defined and patients were not offered and operation unless reporting pain for at least six months. To be a candidate for an operation it was required that groin pain, ejaculatory pain or pain-related social activity disruption was moderate or severe during the last week. Exclusion criteria were not attempting multi-modal analgesic treatment for at least 3 months, preoperative chronic pain syndrome not related to the inguinal intervention, non-compliant patient, alcohol or recreational drug abuse, <18 years of age. The primary outcome was pain-related functional impairment measured by a validated questionnaire [Activity Assessment Scale (AAS) (27)], where an improvement of  $\geq 25\%$  was regarded as clinically significant. A total of 21 patients underwent only a laparoscopic triple neurectomy and 12 underwent first an open triple neurectomy with total mesh removal and subsequently a laparoscopic triple neurectomy. Follow-up was a median three months (range: 3–12 months). In the first group of 21 laparoscopic patients (in total 33 as described above), 16 patients (76%) were clinically relevant improved and five (24%) were no different. The total AAS score changed from 60 to 17 ( $P < 0.001$ ). In the second group of 12 patients (of the 33 laparoscopic patients), only four (33%) were clinically relevant improved and eight (67%) were no different and the total AAS score changed from 53 to 39 ( $P = 0.15$ ). Further, 19 patients (58%) went from moderate/severe pain to mild/no pain measured by NRS ( $P < 0.001$ ). One patient with a history of right-sided pneumothorax and bleb-surgery experienced an intraoperative diaphragm injury and was excluded. The neurectomy was not performed in this patient and the patient was referred to a specialized anesthesiologic pain team. The study showed that extensive preoperative investigation (nerve blocks, imaging, preoperative evaluation and treatment by pain teams, etc.) might not be necessary

prior to offering a neurectomy. The evidence was further strengthened by the use of a validated questionnaire. This study suffers from a low sample size and short follow-up. Further, the authors grouped the patients with a failed open neurectomy and the patients without any prior neurectomy into one group, which could make the results unreliable, especially since outcomes from a laparoscopic neurectomy after a failed open neurectomy has not previously been described. As in the studies above and below peri- and postoperative complications were not pre-study defined. For instance, postoperative laxity in the pain-operated groin was not registered.

### *Laparoscopic selective neurectomy*

Giger *et al.* (24) conducted a prospective study of 39 patients with neuropathic pain (clinical history, a positive Tinel's sign and nerve blocks). The authors included patients with a wide variety of prior surgical procedures (open non-mesh repair, open mesh repair, TEP, Cesarean section (Pfannenstiel's incision), open appendectomy, orchiectomy, and lumbotomy). Indication to offer an operation was severe pain (not further defined) for at least three months. The authors used nerve blocks to discriminate between the three nerves involved. Thus, patients were only included, if they had pain remission from the nerve block. Imaging (ultrasound-, CT or MR-scan) was used selectively to exclude differential diagnosis. A total of 71 patients were evaluated and 32 were excluded (due to differential diagnosis and suspected involvement of only the ilioinguinal or iliohypogastric nerves). The exclusion criteria were not well-defined. Follow-up was 12 months (no details on range). Twenty seven patients (90%, nine patients did not experience moderate/severe pain at rest before the surgery) improved from moderate/severe to no/mild pain at rest ( $P < 0.001$ ), 33 patients (85%) improved from moderate/severe to no/mild pain limiting daily activities ( $P < 0.001$ ), 36 patients (92%) improved from moderate/severe to no/mild pain after walking 30 steps ( $P < 0.001$ ) and 16 patients (80%, retired patients excluded) improved from partial/complete to no occupational disability ( $P < 0.001$ ). There was one (3%) intraoperative complication (diaphragm injury; laparoscopically sutured with no sequelae). Whether the pre- vs. postoperative outcome changes were clinically relevant was not noted. This study showed that a selective resection of the genitofemoral and ilioinguinal nerves is effective at reducing both pain at rest and pain limiting daily and physical function. Further, it also takes occupational

disability into account, showing that a neurectomy also has economic and societal benefits. The study is the only to examine a laparoscopic extraperitoneal selective neurectomy. The use of nerve blocks to examine which nerves are affected is not based on evidence. In fact, nerve blocks have been shown to not predict a positive outcome after a neurectomy (28). As the above-mentioned studies, the small sample size is likely to introduce severe bias and type I and type II statistical errors.

Moreno-Egea (25) conducted a prospective study of 16 patients with neuropathic pain (clinical history, validated neuropathic questionnaire, physical examination, nerve blocks and electromyography). The total number of referred patients was not reported. Follow-up was 24 months (range: 12–48 months). The purpose the study was to demonstrate feasibility using a transabdominal preperitoneal laparoscopic approach (access to the retroperitoneal space through the abdominal cavity after pneumoperitoneum). Patients were included if pain duration was at least six months. Exclusion criteria were ASA score > III, hernia recurrence or meshoma, non-neuropathic pain, pain unrelated to prior surgery, primary orchialgia, current malignant diseases, proven mental illness or refusal to give informed consent. The index operations were open mesh hernia repair (13 patients), laparoscopic appendectomy (two patients) and Spigelian hernioplasty (one patient; no information regarding mesh). The authors did not use a standardized predefined treatment algorithm and outcome variables were poorly defined based on a non-validated questionnaire. Eleven patients (69%) had complete pain relief, four patients (25%) had moderate or some pain relief and in one patient (6%) pain intensity was unchanged, however no statistical test was performed and it was not noted whether the pre- vs. postoperative outcome changes were clinically relevant. One patient (6%) developed hypoesthesia in the area innervated by the lateral femoral cutaneous nerve. No other complications were reported. It may be concluded that a laparoscopic retroperitoneal access via the abdominal cavity is feasible, yet the lack of detailed study information, poorly defined outcomes and the small sample size makes conclusion from the study difficult.

#### ***Laparoscopic mesh removal without neurectomy***

Slooter *et al.* (23) conducted a prospective feasibility study on 14 patients with nociceptive pain presumably associated with an implanted mesh. Only patients with a laparoscopically implanted mesh (TAPP or TEP)

were included. The diagnosis was based on clinical pain characteristics (see above, history, and physical examination). Neither indication to offer surgery or exclusion criteria were defined, and the total number of applicable patients was not reported. The purpose of the study was to demonstrate safety and feasibility and secondly to evaluate effectiveness evaluating pain on an NRS, patient satisfaction and a validated quality of life questionnaire (12-Item Short-Form Survey; SF-12). Follow-up was a median of eight months (range, 2–62 months). Of the 14 patients, two patients had only a partial mesh removal and two patients had a concurrent neurectomy of the genitofemoral nerve. The results were a significant reduction in NRS from eight to four ( $P < 0.01$ ) with nine patients (64%) experiencing more than 50% reduction in NRS. Two patients (14%) were pain-free postoperatively. Patient satisfaction was measured in a non-validated questionnaire (excellent, good, moderate or poor). Ten patients reported excellent/good satisfaction (71%), moderate in three patients (21%) and poor in one patient (7%). Quality of life was improved measured by the SF-12 questionnaire (no statistical test was performed). Whether the pre- vs. postoperative outcome changes were clinically relevant was not noted. One patient (7%) experienced a minor bladder lesion (laparoscopically sutured; no sequelae) and two patients (14%) developed hernia recurrences. In conclusion, the present study suggested that total and sometime only partial mesh is possible and may on the right indication be beneficial in selected patients. Evidence is however weak and based on only 14 patients with vaguely defined outcome variables.

#### **Discussion**

Final conclusions surrounding the clinical results of a laparoscopic pain-operation are difficult. The evidence is based on only six small non-controlled and highly heterogeneous studies totaling 189 patients. The studies did not use uniform outcome measures to define a successful outcome. A critical analysis of the literature reveals a paucity of data to help define the surgical indications and outcomes of treating postoperative chronic inguinal pain with a laparoscopic approach. Nevertheless, the available studies show that the procedure is feasible, but patients may be at risk of diaphragm injury, skin hypersensitivity, nerve damage, and flank laxity.

The indication to offer a laparoscopic pain-operation rather than an open pain-operation for chronic pain after an open inguinal hernia repair is controversial and not

evidence based. Due to the mixed inclusion of patients reviewed within these studies, the present analysis [a variety of open and laparoscopic index operations and even non-inguinal hernia repairs (8,19,24,25)] cannot conclude that a laparoscopic pain-operation is recommended only for a laparoscopic index operation and not for an open operation as suggested in the so far only international published consensus report (7). On the other hand, it may be common sense to recommend an open pain-operation for an open index repair due to its less invasive surgical nature [while the laparoscopic approach has a risk of potentially serious complications and long lasting nerve related complications such as nerve dermatome involvement and lasting flank laxity (Table 1)]. Additionally, the results after a laparoscopic pain-operation for an open index repair were far from impressive. Notably, these outcomes are based on a small sample size (9).

A neurectomy is suggested mainly for patients severely suffering from predominantly neuropathic chronic pain, whereas mesh removal hypothetically is reserved for patients suffering from nociceptive pain. Only one study used a strict predetermined treatment algorithm as described in detail above (9). In that study, 3/4 of patients had their pain-related functional impairment clinically improved comparable to results after open pain-operations (11,13,17,29-31). However, the authors also offered a laparoscopic neurectomy to patients with no analgesic effect (failure operation) from a prior open neurectomy. Only one third of these patients benefitted from the subsequent laparoscopic pain-operation suggesting that this strategy after open failure should be reserved for only selected patients. The majority of studies included patients with neuropathic pain (8,19,23-25), but there is also evidence supporting that mesh removal may reduce pain in patients with nociceptive pain (11,17,20,23). Thus, it is hypothesized that a neurectomy is targeting neuropathic pain. On the other hand, mesh removal is targeting nociceptive pain. As such, a mechanism-based approach may be recommended although not specifically addressed in the literature. However, it may be difficult to clinically discriminate between neuropathic and nociceptive pain characteristics (7) arguing for a combined laparoscopic neurectomy and mesh removal in patients after a laparoscopic index repair and an open pain-operation including neurectomy and mesh removal after an open index mesh repair although the optimal strategy is not supported by evidence.

There is a therapeutic imperative to treat patients suffering from severe disabling chronic pain. Chronic pain is a major public health issue with significant

economic consequences for society involving professional employment, family-life, economy and physical and mental health (32,33). An evidence based surgical strategy as an effective treatment is therefore paramount. Giger *et al.* (24) has already shown, that a laparoscopic neurectomy does not only improve pain, but also improves occupational disability, further underlining the need for more evidence and wider implementation of this technique.

The next step in benefiting this severely afflicted patient group must focus on using well-defined and uniform outcome measures. Future studies should focus not only on pain scores, but also take functional impairment and quality of life into consideration (9,34). Further, there are no preoperative predictors identified for long-term outcomes. Thus, large prospective registry studies are required to identify potential predictors of positive and negative results. Small studies focusing on preoperative nerve blocks, imaging, dysejaculation, preoperative pain intensity, age, BMI and removal of any single nerve were not able to predict outcomes (12,28). Randomized controlled trials (RCT) are warranted to compare open and laparoscopic neurectomy and a comparison of the effect of selective and triple neurectomies is yet to be conducted. Moreover, a large well-designed RCT on extraperitoneal laparoscopic neurectomy +/- mesh removal after a pain-triggering laparoscopic inguinal hernia repair will provide evidence for mesh removal in a laparoscopic pain-operation.

The current review and conclusions from the literature has limitations. The review was narrative in nature and not subject to the strict criteria of a systematic review. Therefore, there may be a high risk of interpretation and selection bias. The focus was on the surgical approach to treat chronic pain after inguinal hernia repair. Thus, alternatives such as pharmacological treatments were not explored. The included studies did not explore whether preoperative pain after the index inguinal hernia repair operation was associated with a positive or negative outcome (8,9,19,23-25). Some patients with chronic pain could have suffered from pain before the index operation and not all studies accounted clearly for this (23,24), however most studies excluded patients with pain prior to the index operation (8,9,19,25). Thus, alternatives to surgery should always be attempted first [including BOTOX infiltration at the trigger-point (35)] and indication to operate should be the final option (3).

In conclusion, extraperitoneal laparoscopic neurectomy is feasible on the right indication, with a potential to reduce chronic pain in patients suffering from severe chronic pain

after inguinal hernia repair. More large-scaled, high-quality studies are warranted before final conclusions can be made on the indication to offer a laparoscopic pain-operation and the long-term outcomes associated with it.

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