

Inguinal Hernias: A Current Review of an Old Problem

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ABSTRACT

The repair of groin hernias are amongst the most commonly performed procedures by the general surgeon today, with almost as many types of repairs as there are hernias.

Inguinal hernias account for 75% of all abdominal wall hernias with a lifetime risk of 27% in men and 3% in women¹. Repair techniques have evolved from open suture methods to mesh repairs done either open or laparoscopically, translating to improved patient care and decreasing complications associated with hernia repair.

This article is intended to provide an overview of the presentation and latest evidence based guidelines for the management of inguinal hernias.

Keywords: repair, groin hernia, technique

INTRODUCTION

An inguinal hernia is a protrusion of abdominal cavity contents through the inguinal canal. There are two types of inguinal hernia, direct and indirect, which are defined by their relationship to the inferior epigastric vessels. Direct inguinal hernias protrude medial to the inferior epigastric vessels when abdominal contents herniate through the external inguinal ring. Indirect inguinal hernias occur when abdominal contents protrude through the deep inguinal ring, lateral to the inferior epigastric vessels; this may be caused by failure of embryonic closure of the processus vaginalis.

Inguinal hernias may be congenital or acquired, with the latter the more common presentation. Essentially any risk factors that either increases intra-abdominal pressure or weakens the anterior abdominal wall may lead to the formation of an inguinal hernia.

Known risk factors associated with hernia occurrence are:

1. Smoking
2. Positive family history
3. Patent processus vaginalis
4. Collagen disease
5. Previous appendicectomy (open) and prostatectomy
6. Patients with ascites
7. Peritoneal dialysis
8. After long term heavy work
9. Chronic obstructive pulmonary disease (COPD)

It is interesting to note that occasional lifting, constipation and prostatism has not been proven to increase risk of inguinal hernias.²

CLINICAL PRESENTATION

Typically, patients may present complaining of either groin pain or swelling/lump. The presence of swelling/lump may be asymptomatic with respect to their activities of daily living.

If symptomatic, they may be either minimally symptomatic (intermittent discomfort/pain) or symptomatic with interference with their activities of daily living. Furthermore they may present with incarceration where the hernia is unable to be reduced into the abdominal cavity which may lead to strangulation or ileus.

Clinical examination should reveal a reducible lump in the groin with a positive cough impulse. It is important to identify patient with recurrent hernias as evidenced by previous groin incision/laparoscopic incisions. Previous lower abdominal scar must be noted as they may influence the approach to repair. Tenderness, signs of inflammation and irreducibility of the hernia may point to strangulation which will require urgent surgery.

Although classically taught to differentiate direct vs. indirect hernias, generally clinical examination has been shown to be inaccurate and does not usually influence management. It is more important to identify and differentiate femoral hernias from inguinal hernias as the former may require a more emergent repair.

DIFFERENTIAL DIAGNOSIS

Several differential diagnoses to be considered in the diagnosis of groin hernias depend on the presenting symptom.

If presenting with swelling in the groin:

- Incisional hernia
- Lymph gland enlargement
- Femoral artery aneurysm
- Saphena varix
- Soft tissue tumour

- Abscess
- Genital abnormalities such as ectopic testis

If presenting with pain without swelling:

- Adductor tendinitis
- Pubic osteitis
- Hip artrosis
- Bursitis Ileopectinea
- Low back pain
- Endometriosis

INVESTIGATIONS

Generally, patient who present with typical symptoms and signs of groin hernia do not require further imaging for confirmation. The diagnosis is clinical.

However, in cases where the diagnosis is unclear, the patient may benefit from ultrasound of the groin which is non invasive and dynamic. The specificity of ultrasound in relation to surgical exploration is 81-100%, its sensitivity is 33% and up to 100% in clinical diagnosis of a groin hernia.

MRI has a role in the diagnosis of groin hernia if the ultrasound done is non-diagnostic. MRI is especially useful for patients who present with pain that may be related to sports pathologies and for soft tissue differentiation of tumour or inflammation. Furthermore MRI allows for scanning to be done in any plane and dynamically during straining for further accuracy. Its sensitivity has been quoted to be about 94.5% and specificity about 96.3%.³

The role of CT is limited in the non acute setting even though it has a sensitivity of 83% and specificity of 67-83%. The role of CT may be useful in the rare case of involvement of the urinary bladder and for the evaluation of intra abdominal pathologies that may cause increased intra abdominal pressure causing hernia formation.²

Herniography has been touted as a safe, sensitive (100%) and specific (98-100%) in the diagnosis of the occult hernia. However in our local context it is not widely used secondary to its invasive nature

and risk of complications of 0-4.3%, including contrast allergy, intestinal perforation, abdominal wall haematoma and pain².

INDICATIONS FOR REPAIR

Groin hernias are repaired if they cause significant symptoms (either of discomfort and/or pain), when complications occur or to prevent complications.

Yet not all inguinal hernias need repair. In patients with asymptomatic inguinal hernias, the chance of incarceration is low (estimated at 0.3-3% per year) and risk of postoperative complications higher especially in the elderly patient with significant comorbidities. Furthermore, the majority of patients with strangulation either did not know they had an inguinal hernia or had not seen a doctor for their hernia prior to presentation.

A recent RCT published in 2006 randomized 356 minimally symptomatic men (over 18 years old) to operation and 366 men to watchful waiting. Results showed that 23% of patients crossed over from watchful waiting to operation with only 1 acute incarceration without strangulation within 2 years and one incarceration with bowel obstruction within 4 years. (0.1% overall). It appears that it may be safe to delay hernia repair in the minimally symptomatic male patient until such time that he becomes symptomatic. However, patients need to be counseled that the risk of complications, although low, still exist with a watchful waiting strategy.

Patients who present with significant symptoms of pain/discomfort should be scheduled for elective surgery. The patient with irreducible hernia should also be operated earlier to prevent complications leading to strangulation although the current literature does not identify which patients with irreducible hernia have a higher risk of strangulation. Indeed in the current European hernia guidelines these recommendations are of expert consensus opinion only².

CONTRAINDICATIONS FOR REPAIR

For elective repair, there are few contraindications. Absolute contraindications to elective repair include pregnancy and active infection: after these conditions resolve, they may be considered for repair⁵.

Indeed, with the wide variety of surgical

and anesthetic options available, there are few contraindications to repair and relative contraindications need to be balanced against potential benefit individualized to the patient and the surgeon involved.

CURRENT EVIDENCE BASED MANAGEMENT

Once surgical treatment is decided, the operating surgeon has a variety of surgical techniques to choose from. The repair of the inguinal hernia consists of 3 major components:²

1. Dissection of the hernia sac from the spermatic cord structures
2. Reduction of the hernia sac contents and resection of reduction of the hernia sac
3. Repair and/or reinforcement of the fascial defect in the posterior wall of the inguinal canal

While 1-2 are common in almost all hernia repairs, the variation comes from the method chosen to deal with the resultant posterior wall and fascial defect.

Essentially repair methods can be considered under broad categories below:⁵

1. Open
 - a. Suture based: e.g. Bassini, McVay, Shouldice
 - b. Mesh based:
 - i. Anterior approach: Lichtenstein, "plug and patch", Hertra sutureless mesh (Trabucco)
 - ii. Posterior approach: Stoppa, Kugel
2. Laparoscopic
 - a. Total extraperitoneal (TEP): split mesh, rectangular mesh, preformed mesh, 3D mesh
 - b. Trans abdominal preperitoneal (TAPP)

Open suture based methods

Bassini first described his technique in 1884 and since then several other have followed with variations of the open suture method all bearing their name.

Of all the open suture based methods, the Shouldice

Table 1. General complications of hernia surgery.

	General Complication	Incidence	Management
1.	Haematoma	5.6 - 16 % Open 4.2 - 13.1% Endoscopic	Non operative management Evacuation only with large symptomatic haematomas
2.	Seroma	0.5% - 12.2% Higher rates with Endoscopic method	Generally will resolve within 6 - 8 weeks No clear evidence re: drainage, However may be done under local anaesthetic if persistent
3.	Wound Infection	1 - 3 % Open <1% Endoscopic	Mainly superficial infection Deep infection rare, surgical drainage and antibiotics usually suffice
4.	Urinary Retention	<3% with higher rates with GA/RA as compared to LA No significant difference between operative methods	Analgesia and early mobilisation May require short term urethral catheterisation
5.	Ischaemic Orchitis, Testicular Atrophy and Damage to the Ductus Deferens	0.7% both open/endoscopic techniques	Techniques suggested for prevention include minimising cord dissection, transaction of large hernia sac rather than completed dissection, care with excessive occlusion of internal ring Increased risk with recurrent hernia repair and dissection of cord beyond pubic tubercle
6.	Bladder Injury	Rare	Higher rates with TAPP technique. Predisposing factors include full bladder, exposure of retro pubic space and opening of the transversalis fascia/ peritoneum in direct hernias
7.	Intestinal Injury	Rare (higher in Endoscopic technique)	Recommended that patients with major lower open abdominal surgery and previous radiotherapy to pelvic organs do not undergo endoscopic inguinal hernia repair
8.	Vascular Injury	Rare (higher in Endoscopic technique)	Damage to inferior epigastric artery from dissecting trocars and Vares needle injury to major vessels form majority of causes. Open technique with direct visualisation for port insertion whenever possible is recommended.

technique has been shown to be the best with recurrence rates of 0.7-1.7% in specialized centers. In the Shouldice technique, the posterior wall of the inguinal canal and the internal ring were repaired by means of suture in several layers with continuous non-soluble monofilament suture. However it is important to note that the Shouldice technique done in general surgical practice have poorer results with long term recurrence rates between 1.7-15%⁶.

Indeed the criticism of the suture based repair is the application of tension over the repair site. This may result in ischemia, causing pain, necrosis and ultimately tearing of sutures and recurrence of the hernia².

Open mesh based methods

The principle behind the open mesh method is the tension free reinforcement of the fascial defect in the posterior wall. This may be done via 2 fundamentally different methods of either blocking the defect with a plug or reinforcement with a flat mesh of non-absorbable material e.g. polypropylene.

By far the Lichtenstein technique, introduced in 1984, has been the best studied and the method of choice in the open mesh technique. The technique, in brief, involves positioning the mesh between the internal oblique muscle and the aponeurosis of the external oblique and suturing to the inguinal ligament with a 2cm medial overlap of the pubic tubercle.

This technique's popularity has been largely attributed to its reproducibility with minimal perioperative morbidity, low recurrence rates in the long term and ability to be performed under local anaesthesia as a day surgery².

The most well known of the open posterior approach mesh repair is the Stoppa technique. This involves the dissection of the preperitoneal plane via an abdominal incision to expose the myopectineal orifice of Fruchaud with the insertion of a large mesh covering all the orifices. This method can be considered a precursor to the laparoscopic mesh repair that we have today and is still the procedure of choice in complex hernias⁷.

Another technique described is the open preperitoneal mesh placement of the Kugel

patch with short-term results comparable to the Lichtenstein technique⁸

Laparoscopic methods

The laparoscopic inguinal hernia repair was first performed by Ger and colleagues⁹ in 1982 with the simple closure of the internal ring with a stapler. Arregui then reported his trans-abdominal preperitoneal (TAPP) technique in 1991. This involved the incision of the peritoneum to reveal the myopectineal orifices, the hernia sacs dissected out and reconstitution of the peritoneum after placement of a large prosthesis to cover the hernia defects. However the need to transverse the abdomen cavity to reach the preperitoneal space has led to concerns about potential visceral injury and adhesions.

This led to the evolution of the totally extraperitoneal (TEP) technique. In TEP the access to the preperitoneal space is achieved with a dissecting balloon, a laparoscope or blunt dissection without entry into the peritoneal cavity. A mesh prosthesis is inserted into the preperitoneal space and the pneumopreperitoneum is evacuated under direct vision. Variations in technique generally exist in fixation methods (Tacks, no tacks, Fibrin glue) and mesh configuration (Wrapped around cord, 3D mesh)¹⁰.

Evidence based decision making: What to do for who?

Unilateral hernias

1. Mesh or no mesh?

Results from a systematic review of RCTs by the Cochrane collaboration/EU Hernia trialist Collaboration in 2002 and 2003 showed strong evidence that fewer hernias recur after mesh repair than following non mesh repair. Furthermore the chance of chronic pain is reduced with mesh repair².

Following that, 3 RCTs comparing Shouldice and Lichtenstein techniques showed that recurrences were clearly higher in the Shouldice technique.^{11,12,13}

In the authors own analysis done as part of the European Hernia Society guidelines (EHS)², they performed an additional meta-analysis comparing the Shouldice repair with different mesh techniques in all trials with follow-up of more than 3 years. Their results show that mesh technique is superior

regarding recurrence but not at the expense of more pain.

2. If mesh, what mesh is best?

While the use of mesh in hernia repair is relatively well established in the literature, the type of mesh to be used is still a matter of debate.

Since the first described use of polypropylene prosthetics in inguinal hernia repair by Usher in late 1950s (14), the types of prosthetics available has been bewildering. The variability in terms of classification of lightweight vs. heavyweight, pore size and the myriad raw materials used for meshes make direct comparisons between meshes difficult.

Generally mesh prosthetics can be considered based on its characteristics¹⁵. They may be synthetic non absorbable, coated non absorbable, partially absorbable or biologic. Furthermore, they can be considered based on their material density ("weight") porosity and strength.

The flat synthetic non-absorbable polypropylene mesh is the best-studied mesh with the longest experience and most articles in the literature. It is the mesh of choice of most surgeons in open inguinal hernia repairs. The monofilament nature of the mesh also reduces the chance of incurable chronic sinus formation or fistula, which can happen in patients complicated by deep infection.

Weight reduced, macroporous (<1000 um) oligofilament prosthetics seem to shrink less, induce less scar formation and inflammatory reaction therefore causing less long term discomfort and foreign body sensation when used in open hernia repairs. However this must be balanced against increased risk of hernia recurrences especially if they are not adequately fixed or overlapping as suggested in recent literature².

A recent review article suggest that indeed the selection of the appropriate mesh prosthetics should be based on the sound understanding of properties of the mesh selected, the technique used and for the appropriate clinical scenario¹⁵. Perhaps the answer then is not a "best mesh" for all inguinal hernia repairs but the right mesh for the right technique in the right patient.

3. Open mesh or laparoscopic mesh?

Several recent meta-analysis of RCTs^{16,17} done

including a recent systemic review¹⁸ showed several benefits of laparoscopic mesh repair over open. These include:

1. Less wound infection
2. Less haematoma
3. Less chronic pain/numbness
4. Earlier return to normal activities or work
5. Shorter hospital stay

Benefits of the Lichtenstein repair however included:

1. Shorter operation time
2. Lower incidence of seroma
3. Lower recurrences

This benefit of lower recurrences however is debated as most of the recurrences in the laparoscopic group were strongly influenced by the Veteran Affairs (VA) Multicenter trial¹⁹ where the minimum sized mesh was 7.6x15cm, which some experts feel may have been undersized. When this trial was excluded, there was no difference between open and endoscopic surgery.

Clear benefit of Lichtenstein repair however is observed in patients who have large scrotal irreducible inguinal hernias, after pelvic irradiation or major lower abdominal surgery or who are not able to undergo general anaesthesia.

Complications were higher in the laparoscopic group—particularly of rare but serious complications of major vascular and visceral (bladder) injuries.

4. If open mesh repair, what anaesthetic method is best?

Open hernia repair may be performed under general, regional or local anaesthesia. In contrast, in local centres, all laparoscopic hernia surgery is done under general anaesthesia.

The type of anaesthesia used for open hernia repair is important because many postoperative side effects and prolonged hospital stay are often related to effects of anaesthesia.

Local anesthesia has been shown to be superior to general/regional anaesthesia in terms of less postoperative pain, less anesthesia related complaints, less micturition difficulties with faster discharge and short-term recovery. However, this may not be suitable for patients who are very young, anxious, morbidly obese and complex or complicated hernias. Furthermore, surgeons need to be familiar with the infiltration technique. Indeed most of the dissatisfaction with local anaesthesia involved intraoperative pain experienced by the patient.

General anaesthesia provides the surgeon with optimal operating conditions with patient immobility and muscle relaxation. Currently, general anaesthesia with short acting agents combined with local infiltration of analgesics is considered safe and fully compatible with day surgery. However this may be complicated by risk of airway complications, cardiovascular instability, nausea/vomiting and urinary complications, which may prolong hospital stay.

Nevertheless, general anaesthesia is a valid alternative to local anaesthesia especially when used in combination with local anaesthesia.

Regional anaesthesia may be administered either with spinal or epidural techniques. This is viable options especially when the patient has significant risk of general anaesthesia and not suitable for local anaesthesia.

However, in the latest EHS guidelines there is level 1b evidence to suggest that regional anaesthesia, especially when using high dose and/or long acting agents, has no documented benefits in open hernia repair, increases the risk of urinary retention and should be avoided².

5. Laparoscopic mesh – TEP or TAPP?

Although operating in the same preperitoneal plane, the access to the plane is different comparing TEP versus TAPP and hence the complications. TAPP had a higher proportion of major vascular and visceral injuries compared with TEP and open surgery (0.65% vs. 0-0.17%). Furthermore TAPP may cause more intra abdominal adhesions leading to intestinal obstruction in a small number of cases².

A specific meta-analysis comparing TAPP versus TEP stated that there was insufficient data to allow

conclusions to be drawn but suggest that TAPP is associated with higher rate of port site hernias and visceral injuries although TEP was associated with higher number of conversions¹⁷.

6. Once mesh in place for TEP, do we need fixation?

Studies of laparoscopic hernia recurrences have shown that medial or lateral recurrences are caused by rolling up of the mesh thus prompting some authors to use mesh fixation either with sutures or tacks^{20, 21}. However, the use of tacks has been associated with postoperative pain and nerve injury particularly to the femoral branch of the genitofemoral nerve and lateral femoral cutaneous nerve.

In recent times there has been a move away from mesh fixation in laparoscopic TEP. A large retrospective study had shown no significant increase in recurrences and furthermore less pain at 4 weeks, shorter hospital stay, lower rates of urinary retention and seroma formation and earlier return to normal activities²².

A recent meta-analysis of outcomes of staple fixation vs. non fixation of mesh by Tam et al however did not demonstrate any significant difference in post operative pain. The study did however demonstrate a significant decrease operative cost and reduced operative time and inpatient stay with no significant difference in complications and recurrences²³.

Bilateral hernias

In bilateral hernias limited data exist comparing open vs. laparoscopic mesh repair. Data suggest that there is no significant difference with recurrences and persisting pain between the 2 methods. However laparoscopic methods (TAPP/TEP) may offer reduced time to return to normal activities compared with open mesh repair.

Recurrent hernias

In general, recurrent hernias would benefit from another plane of dissection from the initial method of repair. Thus if the initial repair was done laparoscopically (where dissection was done in the preperitoneal plane), recurrences would be better done handled via the open anterior method e.g. Lichtenstein technique.

This is also true vice versa where recurrences from previous anterior approach would benefit from repair via the posterior preperitoneal method.

Evidence points to reduced perioperative complications, post operative pain, analgesia requirements and time to return to normal activities with laparoscopic approach (both TEP/TAPP) compared with repeat open anterior approach (Lichtenstein) in recurrent inguinal hernias²⁴. Further evidence comparing TAPP versus Lichtenstein showed less postoperative pain and shorter sick leave for the laparoscopic group with comparable recurrences and chronic pain²⁵.

Groin hernias in females

Women account for 8-9% of all inguinal and femoral hernia operations performed². In large epidemiological studies, female herniorrhaphy have higher reoperation rates, with 40% of them because a femoral recurrence is found.

Thus it is recommended that every effort should be made to exclude femoral hernias in ladies and that laparoscopic surgery should be considered for them as this approach is able to cover the inguinal and femoral orifices simultaneously.

COMPLICATIONS OF INGUINAL HERNIA REPAIR

Complications can be considered as general complications as well as complications specific to endoscopic surgery².

Specific complications of endoscopic surgery:

1. Pneumatic complications
 - a. High insufflation pressures can lead to pneumomediastinum, pneumothorax and subcutaneous emphysema
2. Carbon dioxide insufflation complications
 - a. This can lead to hypercapnia, acidosis and haemodynamic changes
3. Trocar insertion
 - a. Trocar hernias may occur (0.06-0.4%) and insertion complications as mentioned previously under general complications.

Chronic pain management

Ongoing debate in world literature in recent times has focused on the cause and management of chronic pain post herniorrhaphy.

Chronic pain can be defined as pain that persist after the normal healing process as occurred, typically 3 months post surgery²⁷. The true incidence of chronic pain however has been difficult to document. This is partly because of differing definitions of chronic pain, most patients are not seen for follow up consistently for longer than 3 months, those that have pain do not present back to the primary surgeon and even fewer get referrals to a pain specialist for further treatment.

Current literature document rates of chronic pain post herniorrhaphy of between 14%-54% with up to 21% of patients functionally impaired in work or leisure activities²⁸. Overall rates of moderate to severe chronic pain were experienced by 10-12% of patients. Up to 1% of patients may eventually be referred to a pain specialist post open repair compared to 0.4% after laparoscopic repair²⁹.

Risk factors for development of chronic pain include:

1. Female gender
2. Younger age
3. Preoperative pain
4. Severe pain immediate postoperatively
5. Preoperative chronic pain syndromes e.g. irritable bowel syndromes, headaches and back pain
6. Failure of identification of the inguinal nerves during operation (ilioinguinal/iliohypogastric/genitofemoral)

Techniques to prevent chronic pain development include:

1. Careful identification of inguinal nerves during operation
2. Use of lightweight/materials reduced/large pore (>1000-um) where possible to reduce long term discomfort
3. Use of endoscopic approach where technically feasible

Management of chronic pain post herniorrhaphy is complex and would often benefit from referral to a multidisciplinary pain clinic.

There are currently no randomized studies on the treatment of chronic pain after hernia surgery.

In the initial assessment, non-hernia related groin pain should be ruled out.

Subsequently, chronic post herniorrhaphy groin pain may be divided into neuropathic and non-neuropathic pain. Non-neuropathic pain may relate to mesh irritation/bulky mesh, hernia recurrence and excessive scar formation which should be 1st considered. Neuropathic pain may be due to nerve entrapment by sutures or staples. There may be also be neuroma formation with partial or complete transection of the involved nerve.

Treatment spectrum includes oral analgesics, regional nerve blocks, pulsed radiofrequency techniques as well as surgical intervention. Most surgeons will consider operative intervention as a last resort.

Surgical intervention techniques include laparoscopic exploration and removal of tacks (when fixation used in laparoscopic repair) and triple neurectomy with possible removal of mesh. Indeed triple neurectomy in one series of 225 patients with chronic pain reported a success rate of 80% complete resolution of pain. However this operative should be attempted only by experienced hernia surgeons as failed reoperation often add significant distress and worsened symptoms for these patients.

CONCLUSION

Despite more than 200 years of experience, the optimal surgical approach to inguinal hernia remains controversial. More than 100 randomized studies have attempted to establish the most efficient and effective treatment technique.

The answer perhaps is to tailor the technique to the patient and the local expertise available. Each patient is different and the experienced surgeon with the best understanding of current evidence and skills has the best chance for good outcome in the chosen hernia repair method for the patient.

REFERENCES

1. Kingsnorth A, LeBlanc K. Hernias: inguinal and incisional. *Lancet* 2003; 362:1561-71.
2. Simons MP, Aufenacker T, Bay-Nielsen M, Bouillot JL, Campanelli G, Conze J, et al. European Hernia Society guidelines on the treatment of inguinal hernia in adult patients. *Hernia*. 2009; 13(4):343-403.
3. Van den Berg JC, de Valois JC, Go PM, Rosenbusch G. Detection of groin hernia with physical examination, ultrasound and MRI compared with laparoscopic findings. *Invest Radiol*. 1999; 34(12):739-43.
4. Fitzgibbons RJ Jr, Giobbie-Hurder A, Gibbs JO, Dunlop DD, Reda DJ, McCarthy M Jr, et al. Watchful waiting vs. repair of inguinal hernia in minimally symptomatic men: a randomized clinical trial. *JAMA*. 2006; 295(3): 285-292.
5. Khaitan L, McKernan JB. Groin hernia. In : *Current Surgical Therapy: Ninth edition* by John L. Cameron.
6. Simons MP, Kleijnen J, van Geldere D, Hoitsma HF, Obertop H. Role of the Shouldice technique in inguinal hernia repair: a systemic review of controlled trials and a meta-analysis. *Br J Surg*. 1996; 83(6):734-38.
7. Beets GL, van Geldere D, Baeten CG, Go PM. Long term results of giant prosthetic reinforcement of the visceral sac for complex recurrent inguinal hernia. *Br J Surg*. 1996; 83(2): 203-06.
8. Dogru O, Girgin M, Bulbuler N, Cetinkaya X, Aygen E, Camci C. Comparison of Kugel and Lichtenstein operations for inguinal hernia repair: results of a prospective randomized study. *World J Surg*. 2006; 30(3):346-50.
9. Ger R, Monroe K, Duviver R, Mishrick A. Management of indirect inguinal hernia by laparoscopic closure of the neck of the sac. *Am J Surg*. 1990;159:370-3.
10. Gould J. Laparoscopic versus open inguinal hernia repair. *Surg Clin N Am*. 2008; 88: 1073-1081.
11. Butters M, Redecke J, Koninger J. Long term results of a randomized clinical trial of Shouldice, Lichtenstein and transabdominal preperitoneal hernia repairs. *Br J Surg*. 2007; 94:562-565.
12. Nordin P, Bartelmess P, Jansson C, Svensson C, Edlund G. Randomized trial of Lichtenstein versus Shouldice hernia repair in general surgical practice. *Br J Surg*. 2002; 89:45-49.
13. Van Veen RN, Wijsmuller AR, Vrijland WW, Hop WC, Lange JF, Jeekel J. Long-term follow-up of a randomized clinical trial of non-mesh versus mesh repair of primary inguinal hernia. *Br J Surg*. 2007; 94:506-510.
14. Usher FC. Further observations on the use of Marlex mesh: a new technique for the repair of inguinal hernias. *Am Surg*. 1959; 25:792-5.
15. Earle DB, Mark LA. Prosthetic materials in inguinal hernia repair: How do I choose? *Surg Clin N Am*. 2008; 88:179-201.
16. McCormack K, Wake B, Perez J, Fraser C, Cook J, McIntosh E, et al. Laparoscopic surgery for inguinal hernia repair: systemic review of effectiveness and economic evaluation. *Health Technol Assess*. 2005; 9:1-203;iii-iv
17. Schmedt CG, Sauerland S, Bittner R. Comparison of endoscopic procedures vs Lichtenstein and other open mesh techniques for inguinal hernia repair: a meta-analysis of randomized controlled trials. *Surg Endosc*. 2005; 19:188-99.
18. Kuhry E, van Veen RN, Langeveld HR, Steyerberg EW, Jeekel J, Bonjer HJ. Open or endoscopic total extraperitoneal inguinal hernia repair? A systemic review. *Surg Endosc*. 2007; 21:161-166.
19. Neumayer LA, Giobbie-Hurder A, Jonasson O, Fitzgibbons R Jr, Dunlop D, Gibbs J, Reda D, Henderson W; Veterans Affairs Cooperative Studies Program 456 Investigators.

- Open mesh versus laparoscopic mesh repair of inguinal hernia. *N Engl J Med.* 2004; 350:1819-1827.
20. Deans GT, Wilson MS, Royston CM, Brough WA. Recurrent inguinal hernia after laparoscopic repair: possible cause and prevention. *Br J Surg.* 1995; 82:539-541.
21. Felix E, Scott S, Crafton B, Geis P, Duncan T, Sewell R, et al. Causes of recurrence after laparoscopic hernioplasty: a multicenter study. *Surg Endosc.* 1998; 12:226-231
22. Garg P, Rajagopal M, Varghese V, Ismail M. Laparoscopic total extraperitoneal inguinal hernia repair with nonfixation of the mesh for 1,692 hernias. *Surg Endosc.* 2009; 23:1241-1245.
23. Tam KW, Liang HH, Chai CY. Outcomes of Staple Fixation of Mesh Versus Non fixation in Laparoscopic Total Extraperitoneal Inguinal Repair: A Meta-Analysis of Randomized Controlled Trials. *World J Surg.* 2010 Aug 17. [Epub ahead of print]
24. Dedemadi G, Sgourakis G, Karaliotas C, Christofides T, Kouraklis G, Karaliotas C. Comparison of laparoscopic and open tension-free repair of recurrent inguinal hernias: a prospective randomized study. *Surg Endosc.* 2006; 20:1099-1104.
25. Eklung A, Rudberg C, Leijonmarck CE, Rasmussen I, Spangen L, Wickbom G, et al. Recurrent inguinal hernia: randomized multicenter trial comparing laparoscopic and Lichtenstein repair. *Surg Endosc.* 2007; 21:634-640.
26. Nilsson H, Stylianidis G, Haapamaki M, Nilsson E, Nordin P. Mortality after groin hernia surgery. *Ann Surg.* 2007; 245:656-660.
27. Ferzli GS, Edwards E, Al-Khoury G, Hardin R. Postherniorraphy groin pain and how to avoid it. *Surg Clin N Am.* 2008; 88:203-216.
28. Loos MJA, Roumen RMH, Scheltinga MRM. Classifying post herniorraphy pain syndromes following elective inguinal hernia repair. *World J Surg.* 2007; 31:1760-1765.
29. Hindmarch AC, Cheong E, Lewis MPN, et al. Attendance at a pain clinic with severe chronic pain after open and laparoscopic inguinal hernia repairs. *Br J Surg.* 2003; 90:1152-1154.