ENDOSCOPIC INGUINAL HERNIA REPAIR

MTT Knook

Cover:

Bridges of Rotterdam, CJ van Steensel, 1996.

The publication of this thesis was financially supported by

Tyco Healthcare BV,
B. Braun Medical BV,
Medeco BV,
Bard Benelux BV,
Johnson & Johnson Medical BV

ISBN: 90-9016066-3

Printed by:
Pasmans BV, Den Haag.

ENDOSCOPIC INGUINAL HERNIA REPAIR

ENDOSCOPISCHE LIESBREUKCHIRURGIE

Proefschrift

ter verkrijging van de graad van doctor aan de Erasmus Universiteit Rotterdam
op gezag van de Rector Magnificus
Prof.dr.ir. J.H. van Bemmel

en volgens besluit van het College voor Promoties

De openbare verdediging zal plaatsvinden op
woensdag 25 september 2002
om 15:45 uur

door

Maria Theresia Theodora Knook

geboren te Roosendaal en Nispen, 21 augustus 1966

Promotie commissie

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voor mijn ouders

aan Aline en Philippe

Endoscopic Inguinal Hernia Repair

Contents

Chapter 1

General introduction

Inguinal hernias are among the oldest surgical challenges, having been recognized by the Egyptians in 1500 BC and Hippocrates in 400 BC. Celsus in 40 AD described Roman surgical practice, including manual hernia reduction for strangulated hernia, truss for reducible hernia and surgery only for pain. The operation was performed via a scrotal incision and the wound was left open for secondary healing to increase scarring. Scar tissue was considered optimal reinforcement of the weak abdominal wall [5,23,24]. In the middle Ages, Guy de Chauliac contributed to the advance of hernia surgery by distinguishing femoral from inguinal hernias. Caspar Stromayr (1559) was the first to write a textbook on hernia repair, the Practica coposia. During the Renaissance, inguinal hernia anatomy was studied by cadaveric dissection. Sir Percival Pott was one of the first to suggest the congenital origin of hernias. He described the pathophysiology of a strangulated inguinal hernia in 1757 [5,23,24].

The nineteenth century brought anesthesia, hemostasis and antisepsis, setting off modern hernia surgery [5,23,24]. Two surgeons, Marcy born in the USA in 1871 and Eduardo Bassini from Italy, born in 1884, contributed significantly to the development of inguinal hernia surgery during the nineteenth century. Both surgeons described the inguinal anatomy in detail. The transversalis fascia, the transverse and oblique abdominal muscles and the external oblique aponeurosis, which, together constitute the inguinal canal, were described in detail by Marcy and Bassini. Their hernia repair techniques made use of these tissues to repair the defect.
Eduardo Bassini, who is considered to be the the father of modern hernia surgery, was the first to perform a true herniorraphy with reconstruction of the inguinal floor *(fig.1)*. Bassini [5,31] used the anterior approach to the inguinal hernia. He reduced the indirect hernia after freeing it from the inguinal cord structures while the direct hernia was reduced without resection after opening the transveralis fascia. The repair of the inguinal canal involved suturing of the conjoined tendon of the transverse abdominal muscle and the internal oblique muscles together with the transversalis fascia down to the inguinal ligament. Several variations of this technique have evolved since then.

Hackenbruch used the external oblique aponeurosis in the reinforcement of the posterior wall leaving the funiculus in subcuteous position. *McVay (fig.2)* sutured the transverse muscle and the transversalis fascia to Coopers ligament and the femoral sheath. *Shouldice (fig.3)* performed a four layer overlapping reconstruction of the transversalis fascia, the internal oblique muscle and the external oblique aponeurosis using a running steel suture [24,27]. *Maloney* performed a darnplasty. In general, these repairs had a high recurrence rate, up to 25% [27]. In a review of eleven retrospective studies on Bassini repair, Bendavid reported recurrence rates after primary inguinal hernia repair varying from 2.9% to 25%. Eight retrospective studies on the Mc Vay repair reported recurrence rates from 1.5% to 15.5% [2]. Only specialized centres have much lower recurrence rates. The Shouldice Clinic has reported a remarkably low recurrence rate of 0.6 % for more than 6000 hernias with a minimum follow-up of 10 years [14].
Lichtenstein (fig.4) suggested a tension free repair of the posterior wall of the inguinal canal by inserting a prosthetic mesh extraperitoneally to create a new inguinal floor [18]. Reports by Lichtenstein involving more than 6000 patients have shown a recurrence rate of 0.7% [17]. However, as this follow-up involved a questionnaire instead of physical examination, the true recurrence rate could be underestimated.

Hernia recurrence is a major socio-economic problem. In the Netherlands, annually 33,500 inguinal hernia repairs are performed among 16 million people. Of these operations, 5175 (15.5%) involve recurrent inguinal hernias [27]. The high incidence of recurrence after inguinal hernia repair has been the incentive for surgeons to continue exploring other techniques for hernia repair. Considering the large number of patients with inguinal hernias, improvement in hernia surgery may have major medical and socio-economic consequences. The costs of sick leave after inguinal hernia repair, averaging 6 weeks, add up to 35 million guilders or 17 million euro per year, assuming that 50% of inguinal hernia patients are part of the working population with an average salary of 40,000 guilders a year [13].

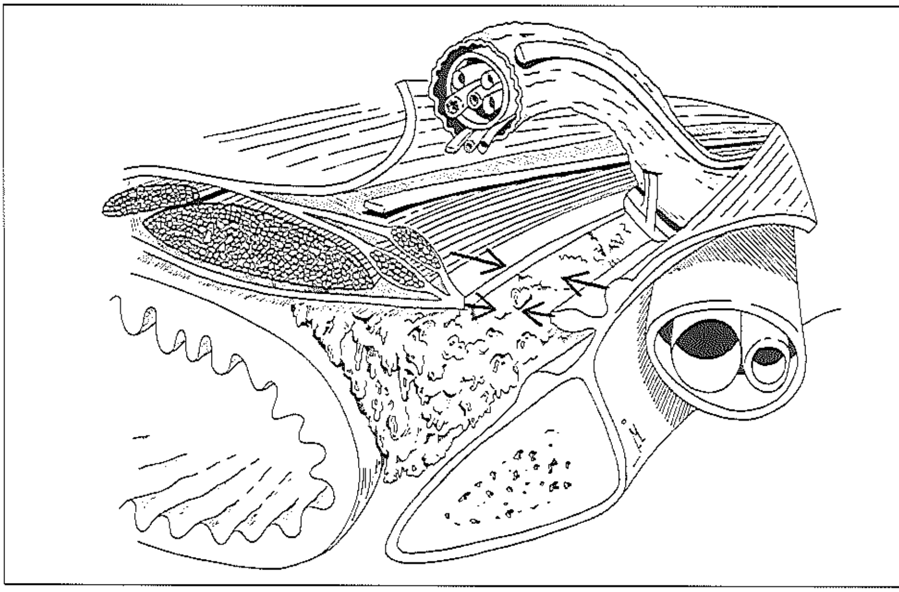

Figure 1. Bassini repair.

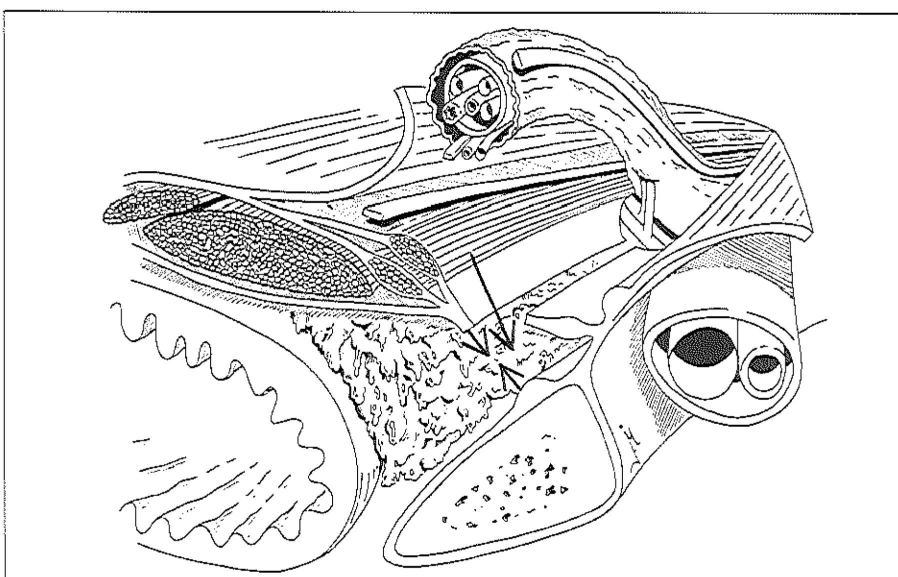

Figure 2. Mc Vay repair.

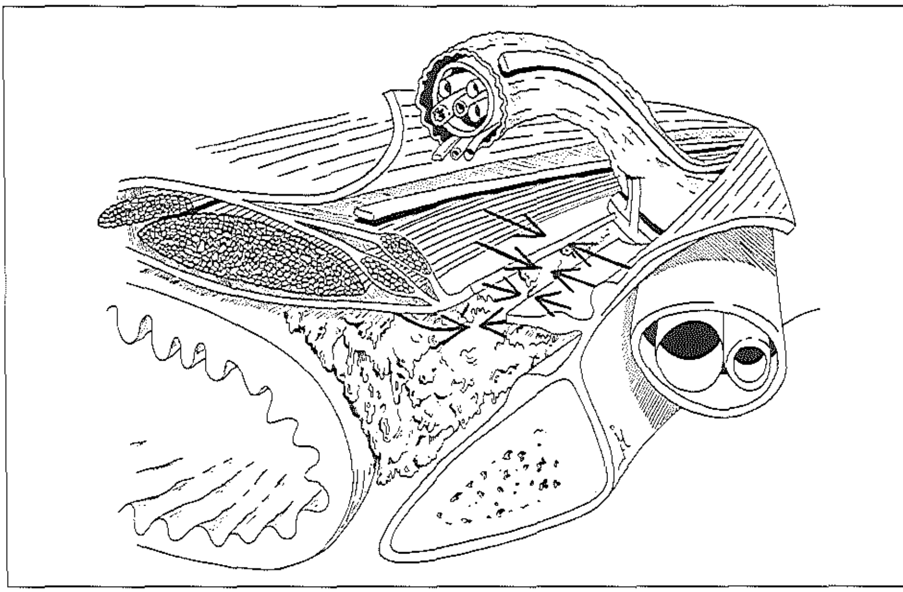

Figure 3. Shouldice repair.

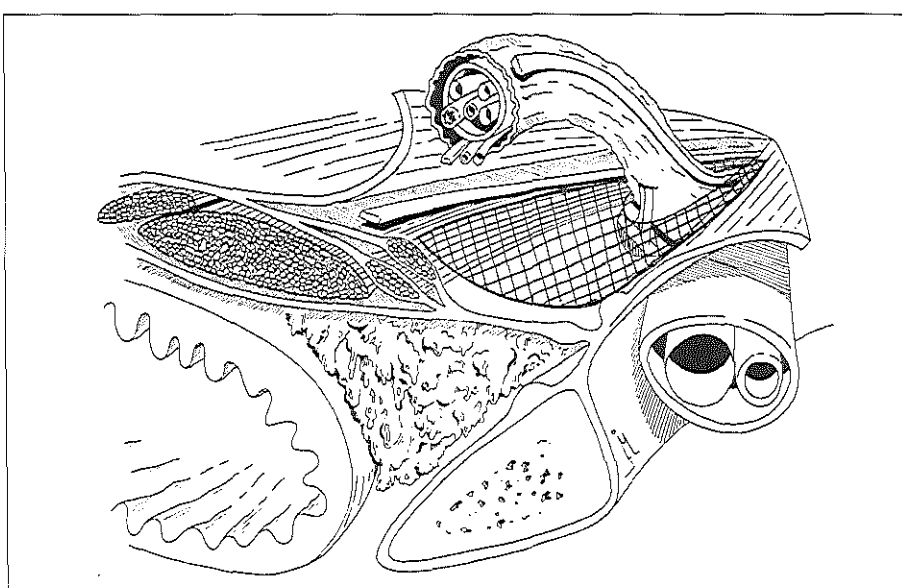

Figure 4. Lichtenstein repair.

In an attempt to decrease recurrence rates, prosthetic materials were introduced in hernia surgery. Until then, all inguinal hernia repairs were performed by approximation of aponeurotic and muscular tissue which created tension predisposing to recurrences. The advantage of the use of a mesh in inguinal hernia repair is the creation of a tension-free repair.

There are several techniques of conventional tension-free mesh repairs.

The *Lichtenstein* repair is performed via an anterior approach to the inguinal canal. The hernial sac is reduced and the defect in the inguinal wall is secured by positioning the prosthetic material in an onlay fashion. The oval tailored prosthesis is fixed to the inguinal ligament laterally and the aponeurosis of the internal obligue muscle medially. At the internal annulus, a slit is made in the mesh for passage of the inguinal cord [5]. *Figure 5* shows the preperitoneal view of the mesh position in Lichtenstein repair.

The *Rives* procedure is performed via an anterior incision; the preperitoneal space is then entered by opening the transversalis fascia. After reducing the hernial sac, the mesh is positioned preperitoneally and fixed to the Cooper ligament and the rectus abdominus muscle medially [5,28].

The Wantz repair is similar to the Rives repair since the mesh is positioned preperitoneally; it is however fixed to the abdominal wall.

The *Stoppa* procedure is performed via a preperitoneal approach using a lower midline incision; the hernia is then reduced and the mesh is positioned to cover the defect with adequate margins [5].

Ugahary developed a mesh technique in which a preperitoneal repair is performed via a muscle-splitting incision cranial to the inguinal area [30].

After the introduction of endoscopic surgery in daily surgical practice, this technique was also applied to inguinal hernia repair. The aims were to lower recurrence rates, improve postoperative recovery and promote earlier return to work. At first, these repairs were performed without prosthetic materials. In 1982, Ger performed the first endoscopic inguinal hernia repair via a transabdominal approach which involved reduction of the indirect hernia and closure of the internal ring [12]. Prosthetic material was then introduced in endoscopic repair and a variety of endoscopic techniques was developed. Fitzgibbons classified these different endoscopic repairs [7].

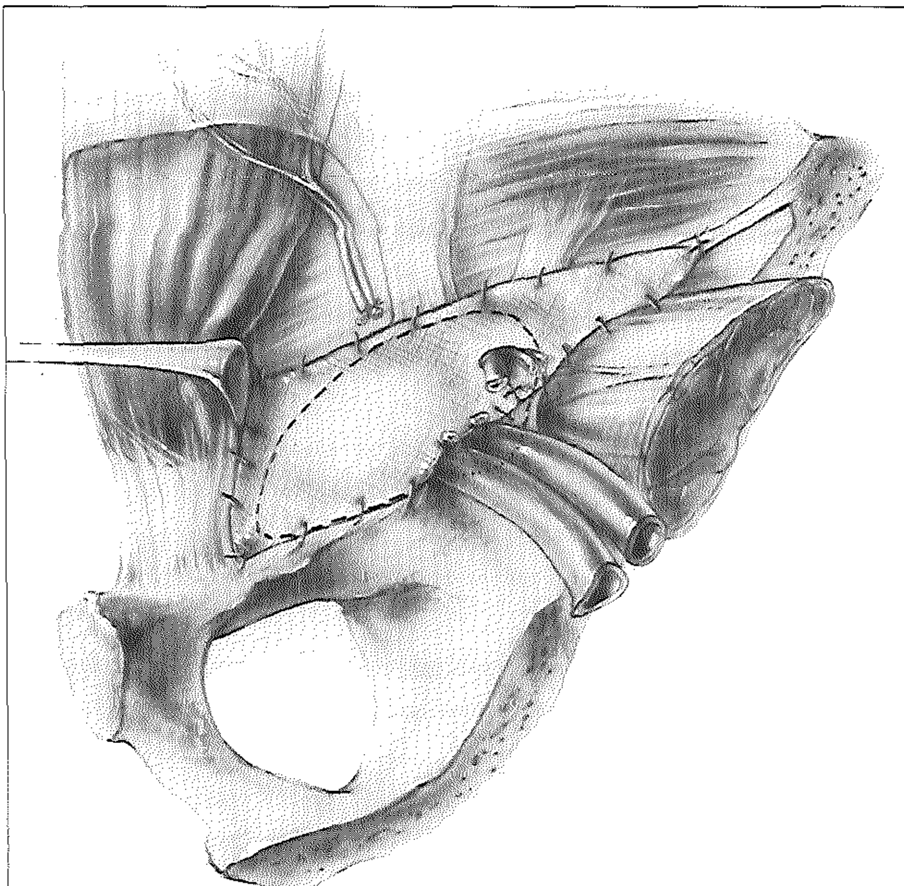

Figure 5. Mesh position as in Lichtenstein repair.

Classification of Endoscopic Hernia Repairs:

The IntraPeritoneal Onlay Mesh technique (IPOM) (fig.6.1)

The intraperitoneal onlay mesh (IPOM) technique is a technique in which a prosthetic mesh is placed transperitoneally on the parietal peritoneum, covering the hernial orifice. The major concern of this technique, however, is placement of mesh such that it is exposed to the bowel, which can result in enterocutaneous fistulae or bowel obstruction due to adhesions [5].

The Plug and Patch Technique

The plug and patch method is based on the tension-free concept generally accepted in inguinal hernia repair and was introduced by Schultz and Corbitt in 1990 [3]

Via a transabdominal approach, a plug is positioned in the hernial defect and the defect is further covered by the mesh prosthesis. To prevent the mesh from sliding into the defect, the plug, which is formed by folding a sheet of mesh, is placed in the defect to carry the covering mesh. In this technique the meshes used were 5 x 5 cms. However, this method leads to early recurrences because the mesh size is too small [3].

The TransAbdominal PrePeritoneal procedure (TAPP) (fig.6.2)

The plug and patch procedure caused a palpable mass in the inguinal region in a majority of patients. Since the plugs were used to prevent the mesh from slipping through the abdominal defect, enlarging the mesh (providing a larger overlap) would probably have prevented this problem. With this idea in mind the transabdominal preperitoneal procedure was introduced [5].

In the transabdominal preperitoneal procedure (TAPP) the peritoneum is incised along a horizontal line cranially to the hernia. In this procedure cranial and caudal flaps are created by dissecting the peritoneum away from the transversalis fascia, Cooper's ligament, the vas and gonadal vessels. The hernia is reduced and a 10 x 15 cm mesh is positioned over the direct, indirect and femoral hernia areas. The peritoneum is closed over the mesh.

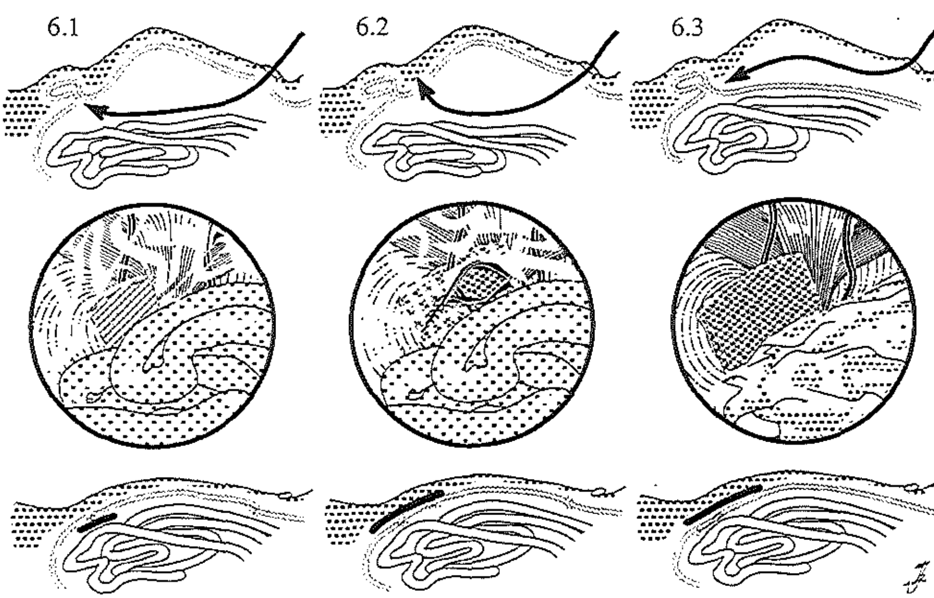

Figure 6.1-6.3:

Figure 6.1: Intraperitoneal Onlay Mesh (IPOM) Technique

Figure 6.2: Transabdominal Preperitoneal (TAPP) Technique

Figure 6.3: Total Extraperitoneal (TEP) Technique

The total extraperitoneal procedure (TEP) (fig.6.3)

In the total extraperitoneal procedure (TEP), the peritoneal cavity is not entered but a preperitoneal space is selectively developed through a subumbilical incision. The preperitoneal space can be created by blunt dissection through insufflation of a balloon, or by using a finger or laparoscope *(fig.7.1-7.2)*. The preperitoneal space is maintained by carbon-dioxide insufflation creating a pneumopreperitoneum *(fig. 7.3)*. After sufficient preperitoneal dissection and reduction of the hernial sac from the medial orifice or the inguinal canal, the mesh prosthesis (10 x 15 cm or 15 x 15 cm) is positioned over the hernial defect *(fig.8)*. Fixation of the mesh occurs by intra-abdominal pressure [5]. Nowadays, the most prevalent endoscopic procedures for inguinal hernia repair are the transabdominal preperitoneal and total extraperitoneal repairs.

The question remains which technique is preferable for inguinal hernia repair: conventional or endoscopic, with autologous material or a prosthesis. Multiple studies have been reported, all supporting different methods of inguinal hernia repair. Since the advent of endoscopic techniques, many studies have been published all reporting a lower recurrence rate and faster return to work. Retrospective studies of endoscopic hernia repair published before initiation of this thesis generally described the results of different endoscopic techniques *(Plug and Patch, TAPP and TEP)* within one group of patients [8,9,11]. Other investigations of endoscopic inguinal hernia repair reported results for variable group of primary, recurrent and bilateral hernias [8,9,11,22,25,31] (Table1). Furthermore, in randomized studies different endoscopic mesh repairs were compared to conventional methods without mesh [6,20], conventional mesh repairs [33,34,35], or a mixture of mesh and non-mesh techniques [21] (Table 2).

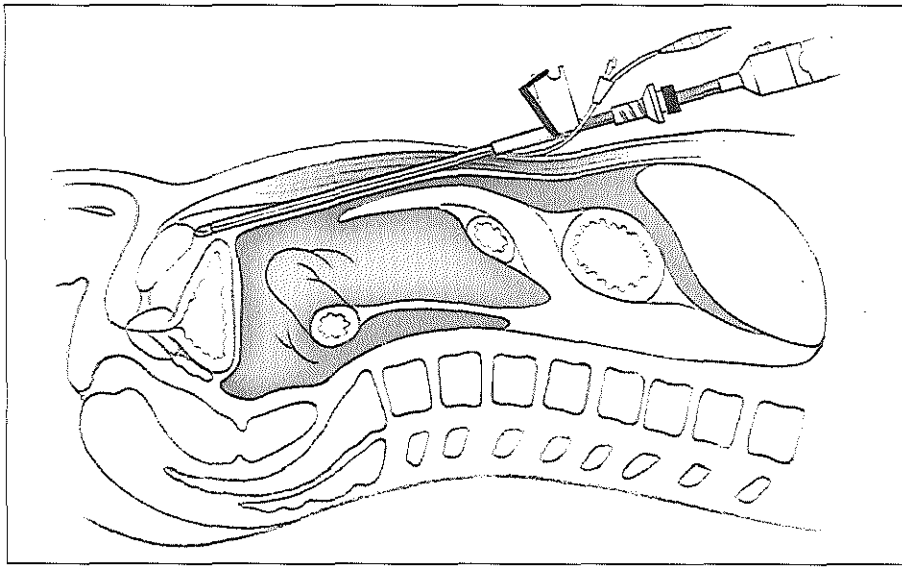

Figure 7.1: Balloon trocar positioning in the extraperitoneal space in TEP hernia repair.

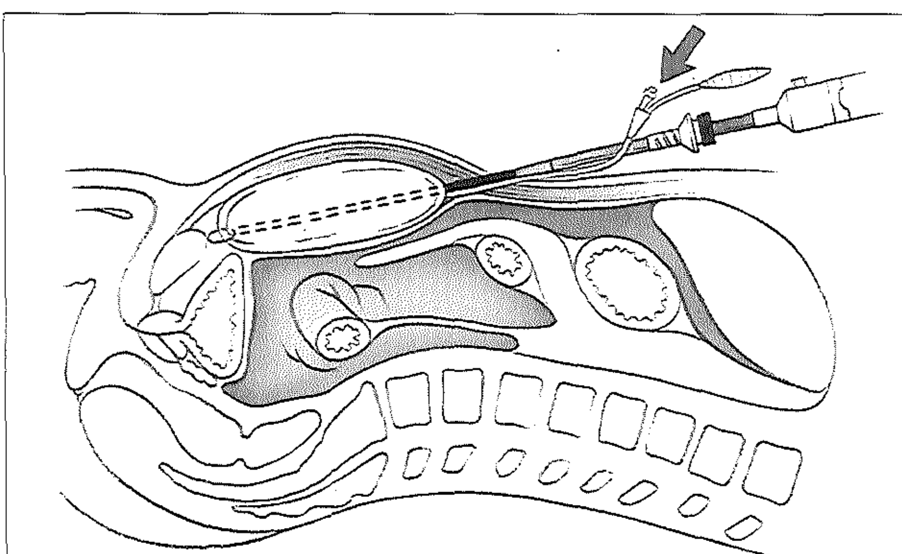

Figure 7.2: Balloon trocar insufflation in the preperitoneal space in TEP hernia repair.

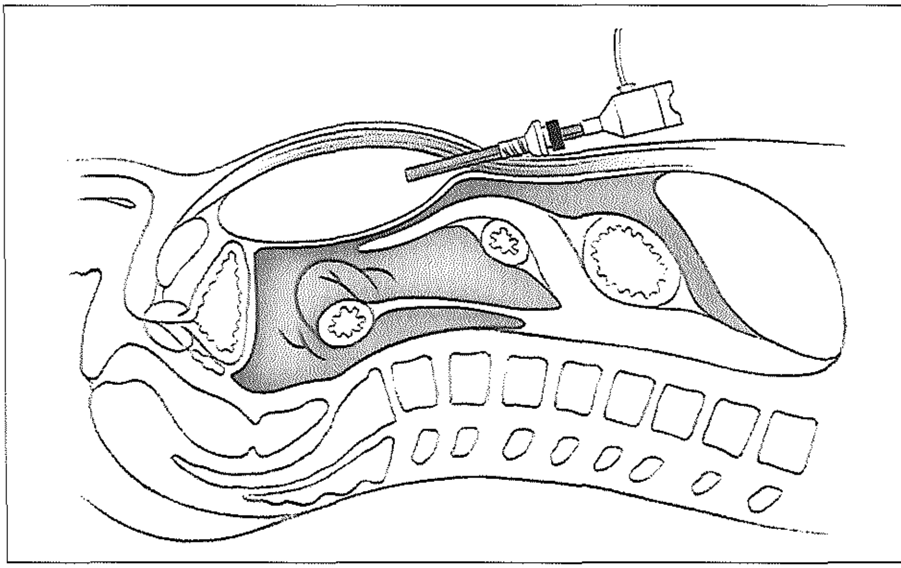

Figure 7.3: Insufflation of the preperitoneal space in TEP hernia repair.

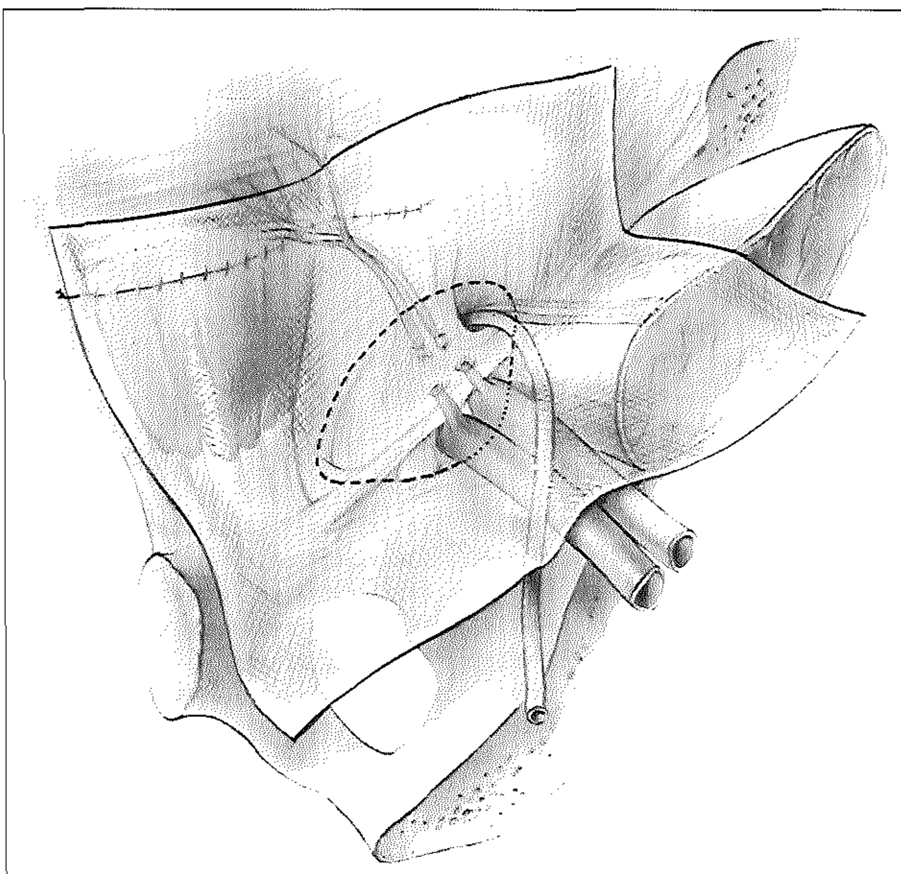

Figure 8: Adequate mesh positioning as in preperitoneal hernia repair.

Table 1

Retrospective studies on endoscopic inguinal hernia repair [8,9,10,11,22,25,31].

Author	No of Patients Type of hernias	Techniques	Follow up (Months)	Physical Examination
Felix, 1995	81 R/B	TAPP / TEP	1 - 28	?
Fitzgibbons, 1995	686 P/B/R	IPOM/TAPP/TEP	15 -	?
Panton, 1994	79 P/B/R	TAPP	1 - 12	?
Sandblicher, 1996	192 R/B	TAPP	9 - 31	?
Vanclooster, 1996	976 P/B/R	TEP	6 - 79	?
Topal, 1997	403 P/B/R	TEP	12	?
Ferzli, 1998	400 P/B/R	TEP	Mean 38	?
Leibl, 1998	2700 P/R	TAPP	Med 20	?

Author	Complications %	Return to work or daily activities (days)	Recurrence %
Felix, 1995	?	7	1
Fitzgibbons, 1995	17	?	4.5
Panton, 1994	10	?	0
Sandblicher, 1996	9	14	0.5
Vanclooster, 1996	8.4	?	0.1
Topal, 1997	3.6	?	0.3
Ferzli, 1998	4.8	?	1.7
Leibl, 1998	4.6	?	1

P: Primary, B: Bilateral, R: Recurrent

Table 2

Randomized Trials:

TEP or TAPP, versus Open Mesh Repairs or Non-Mesh repairs.

Author	Patients	Techniques	Follow up (Months)
Wilson, 1995	242	TAPP / Open Mesh	?
Wright, 1996	120	Endoscopic /Open Mesh and Non-mesh	?
Wellwood, 1998	400	TAPP / Open Mesh	?
Dirksen, 1998	175	TAPP / Open NonMesh	15-36
Liem, 1997	1051	TEP / Open NonMesh	12-24

Author	Complications No	Return to work Endoscopic versus Open Repair	Recurrences %
Wilson, 1995	23 / 36	10 / 21 (p<0.001)	?
Wright, 1996	15 / 46	?	?
Wellwood, 1998	313 / 396	?	0 / 0
Dirksen, 1998	5 / 0	14 / 21	8 / 25
Liem, 1997	95 / 105	10 / 21	3,4 / 6

TAPP: TransAbdominal PrePeritoneal

TEP: Totally ExtraPeritoneal

In our opinion, the results of these reports cannot be extrapolated to the repair of one specific group of inguinal hernias (primary/bilateral/recurrent) using a single endoscopic technique. Therefore, in our studies, the results of only the TEP hernia repair were analyzed for separate groups of primary hernias, recurrent hernias after conventional repair, and bilateral hernias. The results of the TAPP repair of recurrent hernias after endoscopic repair were also analyzed separately. Furthermore, in most published series, follow-up is short and physical examination is not mentioned [8,9,11,22,25,31](Table1). However, physical examination is crucial in the follow-up of hernia repair. Since primary, recurrent and bilateral inguinal hernias have different characteristics, they should be analyzed separately in order to obtain a clear idea of the results of endoscopic hernia repair for these specific groups.

This thesis has three main objectives.

***First*:** to investigate the applicability and results of endoscopic repair of various inguinal hernias.
***Second*:** to optimize total extra-peritoneal repair by analysis of the causes of recurrence and determination of the optimal mesh size for endoscopic inguinal hernia repair.
***Third*:** to assess the application of endoscopic inguinal hernia repair in the Netherlands.

Therefore, a survey of four groups of hernia repairs was performed at the Reinier de Graaf Hospital, Delft, the Netherlands, and the Ikazia Hospital, Rotterdam, the Netherlands. The four groups of hernias consisted of primary hernias, recurrent hernias after conventional repairs, bilateral hernias and recurrent hernias after endoscopic inguinal hernia repairs.
Furthermore, the question of which mesh size is adequate for endoscopic inguinal hernia repair had to be answered. A porcine model was created to perform

measurements to relate size of hernial defects, mesh size and protrusion of the mesh upon exposure to different gas pressures.

To asses the current attitude towards endoscopic inguinal hernia, a questionnaire was sent to all Dutch registered surgeons to investigate the implementation of endoscopic inguinal hernia repair in the Netherlands.

A literature review was performed to determine the complication rates of endoscopic and open inguinal hernia repair.

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Chapter 2

Anatomy of the inguinal area and its implications for endoscopic inguinal hernia repair

MTT Knook, JF Lange, GJ Kleinrensink, HJ Bonjer

2.1 Introduction

Knowledge of anatomy is the key to successful surgery. Perhaps there is no other disease in the field of general surgery for which successful repair is so dependent upon proper understanding of complex anatomy as the inguinal hernia. Whereas general surgeons are more familiar with the anatomy of the inguinal region from the anterior approach, the posterior view of the inguinal area is less well-known [2]. The difference between an anterior and a posterior approach is defined by the different structures which need to be identified to perform an adequate repair.

Anterior view of the inguinal region *(fig.1A)*

In the anterior approach, the aponeurosis of the external oblique muscle, the spermatic cord, the inguinal ligament, the pubic bone, the transversalis fascia, the internal oblique muscle, as well as the ilioinguinal, later genitofemoral, and cutaneous branches of the iliohypogastric nerve can be identified [14].

Posterior (endoscopic) view of the inguinal region *(fig.1B)*

The endoscopic posterior approach can be divided into the transabdominal preperitoneal approach (TAPP) and the total preperitoneal approach (TEP), which differ in hernia identification [13]. With respect to the transabdominal preperitoneal approach, a direct or indirect hernia can be identified immediately *(fig.3)*, whereas in the total preperitoneal approach the hernia is only encountered after dissection of the preperitoneal space [13].

When performing dissection in endoscopic hernia repair, surgeons must seek carefully for anatomic landmarks to prevent damage to regional nerves and vessels. Several authors have studied the inguinal anatomy and described its consequences for endoscopic inguinal hernia repair (2,3,4,5,6,7,8). This chapter aims to provide an overview of the implications of local anatomy on endoscopic inguinal hernia repair.

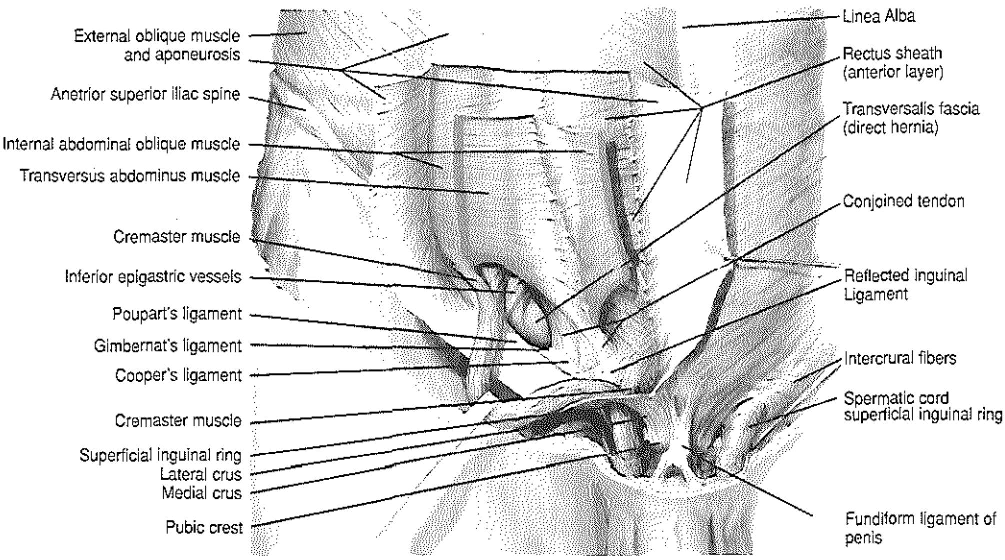

Figure 1A: Anterior view of the inguinal region.

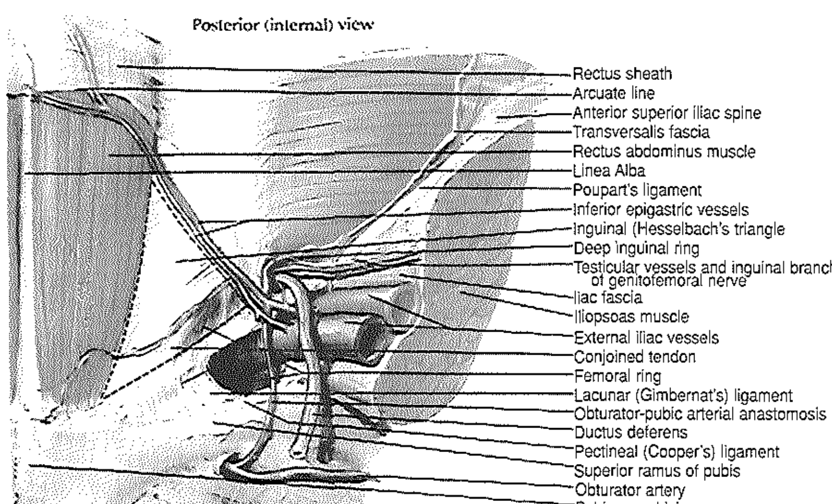

Figure 1B: Posterior view of the inguinal region.

2.2 Transabdominal view of the groin.

In *TAPP* hernia repair, after entering the peritoneal cavity, the inguinal area can be observed through the overlying intact peritoneum. In this phase, *five* different anatomical landmarks can be identified: *(fig.2A)*

the *median umbilical ligament which contains the obliterated urachus,*
the *medial umbilical fold overlying the obliterated umbilical artery,*
the *lateral umbilical fold due to the epigastric inferior artery and veins,*
the *vas deferens, accompanied by*
the *gonadal artery and vein.*

In TAPP inguinal hernia repair, the hernia can be observed as a protrusion in the anterior abdominal wall and one can differentiate directly between an indirect, a direct and a femoral hernia *(fig.3)*.

On entering the peritoneal cavity for TAPP inguinal hernia repair, the *medial umbilical fold* is the most prominent structure encountered. It is the initial landmark that must be recognized before incision of the peritoneum. The medial umbilical fold is the medial boundary of the peritoneal dissection. Dissection more medialwards to this ligament carries the risk of injury to the bladder. This *medial umbilical fold* must not be mistaken for the *median umbilical ligament* which is located in the midline and is a remnant of the urachus.

If the *medial umbilical fold* appears to lie more lateralwards than expected, being near to or overlying the lateral fold, it must be anticipated that this can lead to bladder injury, as the lateral edge of the bladder lies just medial to the *medial umbilical fold [4,5]*.

Farther lateral to the *medial umbilical folds are* the *paired lateral umbilical folds* which are formed by the *inferior epigastric vessels* as they course along the anterior abdominal wall. The *inferior epigastric arteries and veins* run medialwards to the *internal inguinal*

ring. These vessels are easily visualized in a lean patient. In obese patients, however, these vessels can be obscured by a thicker preperitoneal fat layer.
The *testicular artery and vein* enter the *internal spermatic ring* on its posterior aspect. The lateral hernial sac is always anterior to the testicular vessels and the vas deferens. The *vas deferens* can be observed joining the *spermatic vessels* just prior to entering the *internal spermatic ring*. From this point, the vas deferens can be traced medially during its retroperitoneal course as it curves over the pelvic brim before disappearing behind the bladder. It is always associated with the artery to the vas, which may be helpful in visualizing this structure [5].
Since the spermatic vessels and the vas deferens approach the internal inguinal ring from different directions, these structures form the apex of an imaginary triangle called the *'Triangle of Doom'* in which the external iliac artery and vein lie at a deeper level *(fig. 1B)*.

2.3 Preperitoneal view of the inguinal region

The five structures described above can all be visualized in a transabdominal view with the peritoneum still intact. After opening the peritoneum or when performing a *TEP* endoscopic inguinal hernia repair, these structures can be visualized in the preperitoneal space *(fig.2B)*.

2.3.1 Blood vessels

The major vessels encountered in the *preperitoneal space* are the *external iliac artery and vein*. As discussed above, the triangular area, the so-called 'Triangle of Doom', between the spermatic vessels and the vas contains the external iliac artery and vein. Dissection should be avoided or be performed carefully in this area so as not to severe these vessels. In addition suturing and stapling, if thought necessary, should be restricted to the area lateral and medial to this triangle [3,4].

Two major arterial branches, the *inferior epigastric* and the *deep circumflex iliac arteries* and their accompanying veins originate from or drain into the external iliac vessels. The *inferior epigastric artery* furthermore gives off two small branches, the *cremasteric artery* and the *pubic artery*.

Some individuals have an aberrant obturator artery originating from the pubic artery, forming an anastomosis directly with an obturator artery from the normal internal iliac source. In such cases, a 'Corona Mortis' is formed by the internal iliac, the obturator, the aberrant obturator, the inferior epigastric and the external iliac arteries. When dissecting near the pubic bone this aberrant obturator artery is at risk for damage. If the aberrant obturator is severed both ends may bleed profusely [3,4]. Lateral to the internal inguinal ring are the deep circumflex iliac vessels branching from the external iliac vessels.

2.3.2 Lymphatic vessels

Lymph nodes and *lymph channels* follow the course of the main blood vessels. *Lymph nodes* medial to the external iliac vein can disguise the presence of iliopubic or aberrant obturator vessels. Furthermore they can conceal the presence of nerves just lateral to the external iliac vessels. Dissection of these lymph-nodes should not be performed since underlying vessels or nerves can be severed, and it is not necessary for reduction of the inguinal hernia.

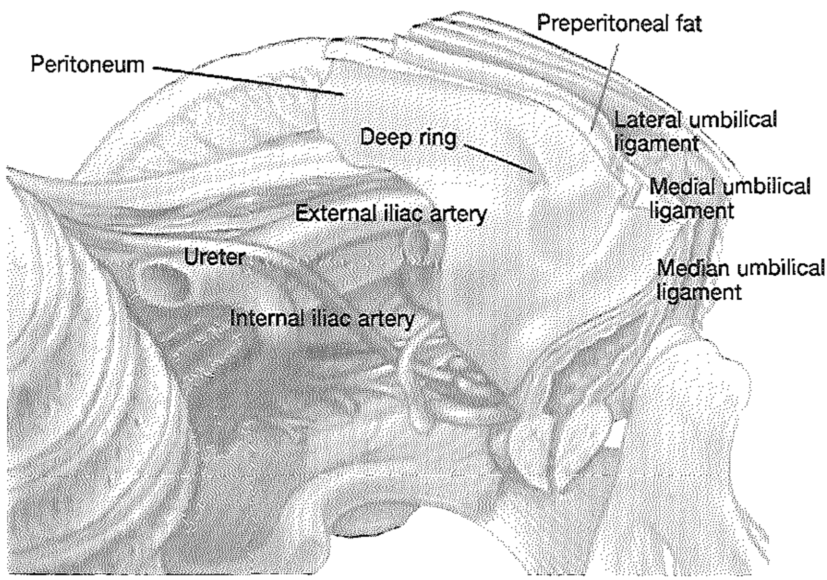

Figure 2A: Anatomical landmarks with overlying peritoneum in TAPP hernia repair.

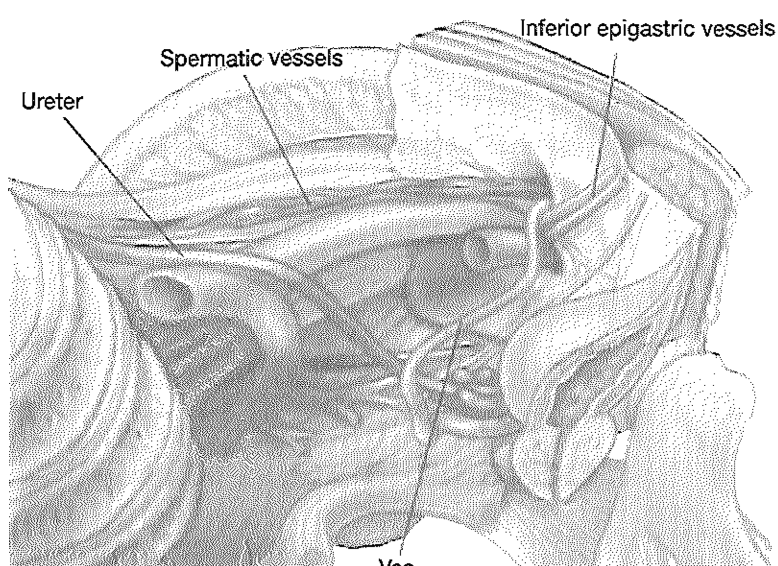

Figure 2B: Anatomical landmarks without overlying peritoneum in TEP hernia repair.

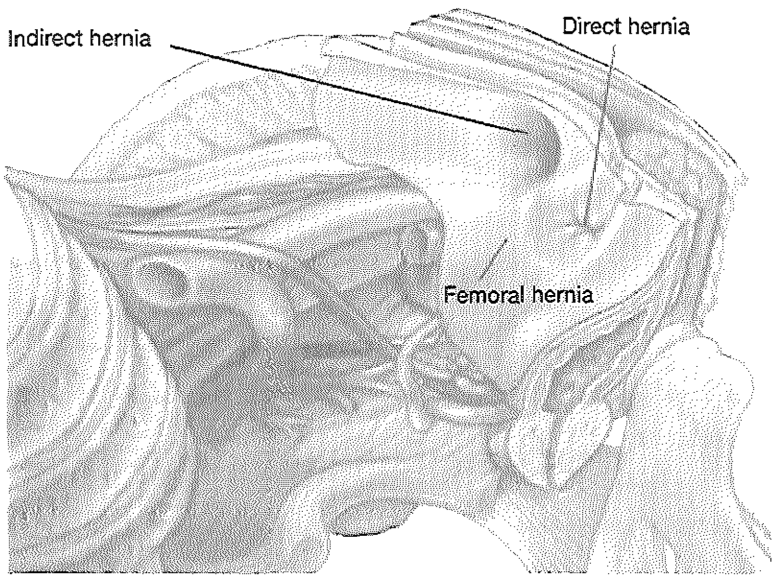

Figure 3: Direct, indirect and femoral hernia visualized with intact peritoneum as in TAPP hernia repair.

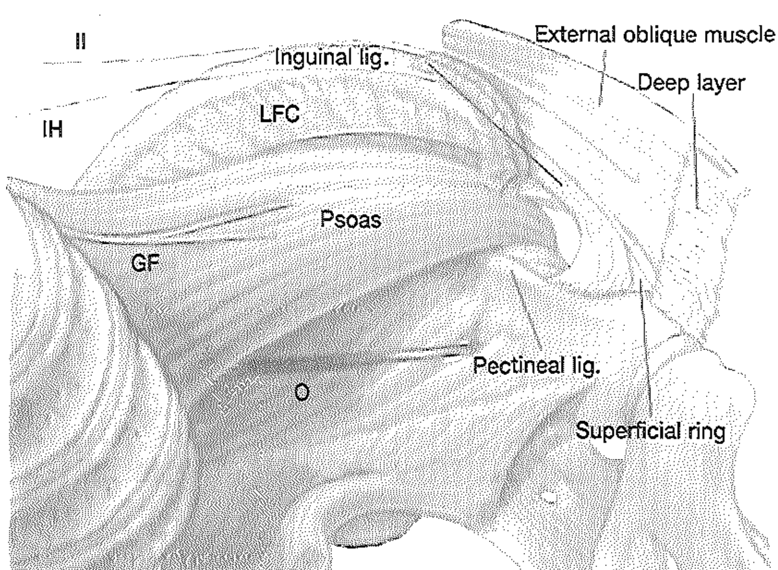

Figure 4: Nerves of the inguinal region.

2.3.3 Nerves (fig.4)

The *femoral nerve* is located in the groove between the psoas major and the iliac muscles, just lateral to the external iliac artery and posterior to the iliac fascia. Other nerves recognizable in the inguinal region are the *lateral cutaneous femoral (LFC) nerve*, the *genitofemoral (GF) nerve, and the anterior branch of the femoral nerve*. The *lateral cutaneous femoral nerve* runs just lateral to the femoral nerve. The *genitofemoral nerve* runs through the psoas muscle in a course medial to this muscle. It usually divides into the *genital* and *femoral* branches near the deep inguinal ring. The *anterior femoral cutaneous nerve* runs just lateral to the femoral branch of the *genitofemoral nerve[11]*.

Aniballi et al. [1] described the 'Triangle of Pain'. This triangle is bounded by the internal spermatic vessels inferiorly and the iliopubic tract ventero-laterally. Staples placed in this area may injure the femoral branch of the genitofemoral nerve, the lateral femoral cutaneous nerve and the femoral nerve. The previously mentioned Triangle of Doom should also be approached with respect. It houses the *genital branch of the genitofemoral nerve*. This genital branch passes through the triangle to the inguinal canal, where it runs adjacent to the spermatic cord. It enters the inguinal region through the internal inguinal ring.

2.4 The proper preperitoneal space

The objectives of endoscopic preperitoneal hernia repair are twofold:

1) Safe identification and repositioning of the hernia sac.
2) Positioning of a mesh prosthesis in Bogros' and Retzius' spaces (see below), with ample (>3 cm) overlap over the hernia defect.

These objectives can only be accomplished safely with integrity of neuromuscular structures if dissection is performed in the proper peritoneal plane [1,9]. Without proper understanding of the relationships in this space, dissection of the hernia sac can erroneously be attempted just posterior to the rectus muscle and thus, in many cases, anterior to the inferior epigastric vessels. Under these circumstances these vessels are often ligated to ameliorate exposure. It must be undrestood that between the rectus muscle and the peritoneum there is a complex multilayered fibrous structure, which at least partially must be transected to enter the proper preperitoneal space. This fascia-like structure, representing the roof of the space, consists (ventral to dorsal) of the following three structures *(fig.5)*.

1) The anterior lamina of the transversalis fascia (ALTF), just posterior to the rectus muscle.
2) The posterior lamina of the transversalis fascia (PLTF).
3) Preperitoneal fascia

In 1804 Sir Astley Cooper described the transversalis fascia as being composed of two layers: the anterior and posterior laminae of transversalis fascia [12].

The ALTF blends with the aponeurosis of the transversalis muscle to form the floor of the inguinal canal, often erroneously calld the transversalis fascia in daily surgical practice. In TEP repair the anterior lamina is left intact, representing the ceiling of the proper preperitoneal space from which the inferior epigastric vessels are suspended.

The PLTF, located between the arcuate line and the pubic bone dorsal to the rectus muscle, is perforated by the inferior epigastric vessels and must be incised to enter the preperitoneal space *(fig.6)*. The inferior epigastric vessels are sandwiched between ALTF and PLTF. Lateral to the inferior epigastric vessels the two laminae fuse. Usually the PLTF is opened by a fully expanded balloon, introduced horizontally between the ALTF and the PLTF. If the balloon is insufficiently inflated, the strong PLTF will resist [10]. The same phenomenon occurs when the balloon is partially located in the rectus sheath, cranial to the arcuate line. Under these circumstances identification and isolation of an indirect hernia sac becomes extremely difficult since the sac together with the spermatic cord or round ligament is obscured by the PLTF and fixed by it to the abdominal wall. As a consequence neurovascular structures are easily severed. Sometimes the PLTF is thought to be the continuation of the posterior rectus fascia caudal to the arcuate line, also known as the vesico-umbilical fascia.

The preperitoneal fascia, like the PLTF, originates from the arcuate line but inserts on the bladder. The insertion on the bladder probably explains why the preperitoneal fascia, in contrast to the PLTF, stays intact after balloon insufflation. The preperitoneal fascia is represented by an areolar layer of fibrous tissue, blended laterally with the posterior lamina of transversalis fascia.

The proper preperitoneal space, located between PLTF ventrally and the preperitoneal fascia dorsally, extends caudalwards to Retzius' space and in the lateral direction to Bogros'space.

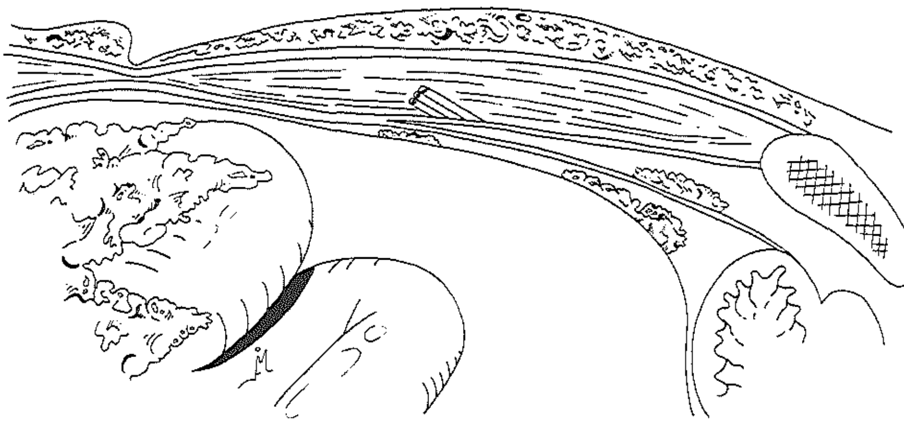

Figure 5: Posterior lamina of the transversalis fascia intact.

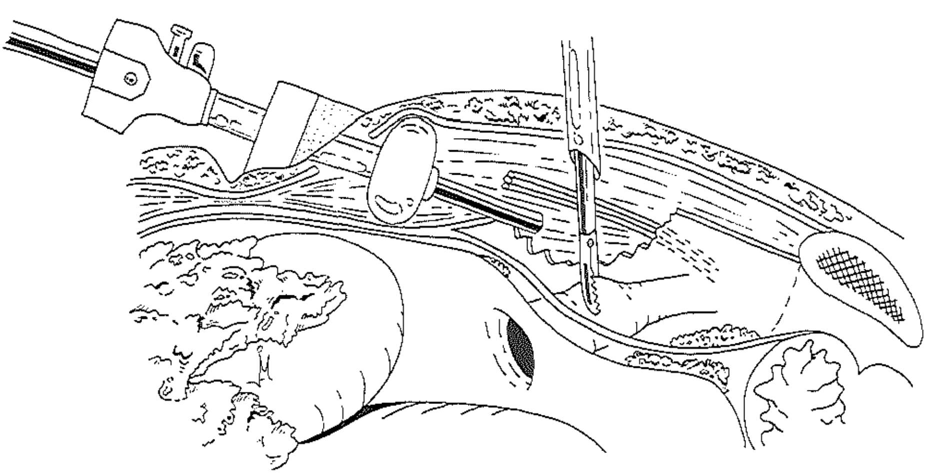

Figure 6: Posterior lamina of the transversalis fascia incised.

Retzius' space is located between the bladder and the pubic bone. It must be freed of adhesions for positioning of the caudal rim of the mesh prosthesis. Especially in older patients the venous plexus of the bladder is at risk during dissection of Retzius' space. Bogros'space is located between the abdominal wall and the ilio-psoas muscles, lateral to the external iliac vessels. It should be opened completely for positioning of the lateral rim of the mesh, adequately covering the hernia defect. Bogros' space is entered after opening the transversalis fascia, just lateral to the inferior epigastric vessels at the point of fusion of the ALTF and the PLTF, which is ventral to an indirect hernia sac.

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Chapter 3

Endoscopic totally extra-peritoneal repair of primary and recurrent inguinal hernias

MTT Knook, WF Weidema, LPS Stassen, CJ van Steensel.

Surgical Endoscopy (1999) 13: (5): 507-511

Abstract

Introduction: In most reports different techniques for combinations of primary and recurrent hernias have been described. Aim of this study was to investigate and compare results of endoscopic total extra-peritoneal repair (TEP) of primary and recurrent inguinal hernias separately.

Methods: From January 1993 to July 1995, 221 patients with an unilateral inguinal hernia (186 primary and 35 recurrent) underwent TEP repair. Follow-up, including physical examination, was performed at regular (three-month) intervals.

Results: Mean operation time was 37.6 minutes. Minor per-operative complications occurred in 23 cases. Conversion was required for 16 patients (7.2%). Postoperative complications were reported for 11.7% of the patients. Hospital stay was short. Mean follow-up was 40.4 months. Recurrence rate was 3.2% for primary hernias and 20% for recurrent hernias.

Conclusions: The preliminary success of TEP for primary inguinal hernia repair, as previously reported, is confirmed; the high recurrence rate after endoscopic repair of recurrent hernias needs discussion.

Introduction

Surgeons who treat primary inguinal hernias may be confronted with a disappointing number of recurrences. Specialized centers have reported excellent results after conventional repair. However, they are not easily equaled by others [8,10,18]. The repair of recurrent inguinal hernias is even more difficult due to the obscured anatomy and poor tissue quality [6,14]. Once a hernia has recurred after conventional herniorraphy the result of every successive conventional repair will be worse, with a recurrence rate of 23 to 33% [14,21,27].

Promising reports on endoscopic hernia repair have been published [18,4,5,16,26]; however follow-up has been short in these studies. When compared to the transabdominal preperitoneal procedure (TAPP) the total extra-peritoneal (TEP) procedure seems to have a lower potential for intra-peritoneal complications; TEP repair may therefore be the procedure of choice in most situations [3,5,9,19,22]. To investigate the technical feasibility, the complication rate and the morbidity of this procedure, a retrospective analysis was performed. Specifically, the recurrence rate for the TEP procedure for primary and recurrent inguinal hernias was determined. In our opinion primary and recurrent inguinal hernias have different characteristics; therefore to obtain a clear idea of the results of endoscopic hernia repair for these specific groups, primary and recurrent hernias were analyzed separately.

Materials and methods

Patients who underwent TEP repair for a unilateral primary or recurrent inguinal hernia at the Reinier de Graaf Hospital in Delft, the Netherlands, were included in this study. One hundred and eighty-six patients had a primary inguinal hernia and 35 a recurrent hernia. In all cases of a recurrent hernia, the hernia had occurred after prior conventional repair without the use of prosthetic material. All patients were declared fit for general anesthesia and none had an infection of the abdominal wall. The operations were performed by two staff surgeons, experienced in endoscopic surgery. A standardized procedure for TEP hernia repair was followed in all cases. The essentials of this technique, which was described previously by Liem et al. [13], are: general anesthesia, total extra-peritoneal dissection, and positioning of a 10 x 15 cm polypropylene mesh prosthesis. The prosthesis is anchored to the abdominal wall by intra-abdominal pressure alone; in other words, staples or stitches are not used for fixation of the mesh.

Patients were allowed to leave the hospital as soon as they felt up to it as long as postoperative complications needing clinical care had not occurred.

Patients were seen postoperatively at regular 3-month intervals in the first year and then annually by staff surgeons. All data on each group, i.e. primary and recurrent hernias, were registered separately. Initial data and data recorded during regular follow-up were collected from patient files. Localization of the primary hernia was classified according to Nyhus [17]. In case of a recurrent hernia the localization found during the operation was registered. Operation time was defined as the time from the first incision to the last suture. Peroperative complications (diffuse hemorrhage or bleeding from an epigastric vessel, injury to the vas deferens, technical defects of instruments, peritoneal defects), postoperative complications (hematoma of the abdominal wall, seroma, paresthesia, wound infection, urine retention) and conversion of the total extra-peritoneal procedure to a transabdominal laparoscopic or a conventional procedure were noted. Length of hospital stay (number of days in the hospital after surgery) and morbidity (number of days needed for recovery before returning to work or full daily activities) were assessed. Data collection was completed with data from the routine follow-up, including physical examination. For the present study all patients received a questionnaire and were asked to report to the outpatient department. Patients who did not react to our mailing were then approached by telephone. Patients who were lost to follow-up had moved outside the Netherlands or died. All other patients responded to our mailing or telephone request. At this final check-up, recurrence of the hernia was evaluated by a thorough physical examination.

Results

Primary inguinal hernia:

From January 1993 to July 1995, 186 patients (174 male and 12 female) were operated upon. Their age at surgery ranged from 20 to 90 years *(Table 1)*. Predisposing factors for hernia occurrence (heavy weight bearing, chronic constipation, urinary obstruction, chronic cough) were present in 38 of 186 patients. Hernia localization was classified according to Nyhus [17], *(Table 2)*. The mean operation time was 37 minutes. Peroperative and postoperative complications are shown in *Table 3*. Peroperative complications, which were minor, occurred in 16 patients (8.6%). Only once did injury of the epigastric vessels lead to preperitoneal bleeding. The vessels were clipped and the hematoma was evacuated. Peritoneal tears occurred during dissection in eleven cases (5.9%); in four cases a peritoneal dissection balloon (PDB) had been used. Conversion to another procedure was necessary in twelve cases (6.4 %). Conversion due to CO_2 leakage into the abdominal cavity, leading to reduction of the preperitoneal space and therefore to difficult dissection, occurred in eight patients. In three patients conversion was necessary for technical reasons and once due to bleeding which hampered visibility. Nine times the switch to a trans-abdominal procedure (TAPP) was successful; three times a conventional anterior approach was used, twice prosthetic material was needed.

Postoperative complications included a hematoma of the abdominal wall in five patients (2.7%), paresthesia of the inguinal-femoral region in four patients (2.2%), and seroma in three patients (1.6%). Except for two hematomas that required fine needle aspiration, these complications disappeared spontaneously. Urine retention which was seen in four cases (2.2%) was treated by temporary catheterization of the bladder. In one patient a hydrocele developed, due to a retained hernial sac; it was corrected surgically one year after primary repair *(Table 3)*. Mean hospital stay was 1.2 days. Patients returned to work or full daily activities after a mean period of 4.7 days *(Table 4)*. Mean follow-up was 40 months *(Table 4)*. Six patients were lost to follow-up, two had moved outside the country and four had died. Their data at the last follow-up have been included in this study. Six patients exhibited a recurrence. Two of these patients had done a lot of heavy weight bearing before operation but not afterwards. Of these six recurrences, four developed within the first year of surgery, the other two in the second year. These recurrences were among the first thirty cases of the surgeons. In three of these cases a large postoperative hematoma or seroma occurred after the primary repair. Three cases of recurrence were repaired surgically. In all three cases a direct recurrence was diagnosed during the operation. The mesh had shifted laterally, allowing the new direct hernia to develop. Repair was performed by an endoscopic trans-abdominal procedure (TAPP) without recurrence to date. Patients with a recurrent hernia that was not repaired did not suffer complaints due to this hernia and were therefore not interested in an intervention.

Recurrent inguinal hernia:
Between January 1993 and July 1995, 35 patients with a recurrent unilateral inguinal hernia after prior conventional herniorraphy were treated by the TEP technique. All patients were male, their age ranged from 25 to 89 years *(Table 1)*. Predisposing factors for hernia occurrence (heavy weight bearing, chronic constipation, urinary obstruction, chronic cough) were present in 14 of 35 patients. In total 25 patients had undergone one previous repair, eight patient's two previous repairs, one patient three previous repairs, and one patient four previous repairs. The localization of a recurrent hernia (Nyhus IV) was described according to findings during the operation *(Table 2)*. The mean operation time was 41 minutes. Only minor per-operative complications were encountered. Peritoneal tears occurred during preperitoneal dissection in 11 patients; in six of these cases a peritoneal dissection balloon (PDB) had been used. Preperitoneal bleeding occurred in two patients due to injury to an epigastric vessel *(Table 3)*. The epigastric vessel was clipped and the hematoma was evacuated successfully. In four cases the TEP procedure could not be continued due to peritoneal tears and intra-abdominal gas leakage. In all four procedures the surgeon switched to a TAPP procedure.

Postoperative complications included a hematoma of the abdominal wall in five patients and paresthesia of the inguinal-femoral region in two *(Table 3)*. All recovered spontaneously. The mean hospital stay was 1.3 days. Patients returned to work or full daily activities on the average after 4.2 days *(Table 4)*.

Only one patient was lost to follow-up due to death of unrelated origin. After a mean follow-up of 43 months, seven patients were found to have a recurrence. Only one of these patients had done some heavy weight bearing before operation but not thereafter. Five of these recurrences occurred within the first year of surgery. The other two occurred in the beginning of the second year. Reintervention took place in three of these seven cases. In all three patients the mesh had moved laterally, allowing a new direct hernia to develop. Repair of these recurrent hernias was performed with a TAPP procedure without recurrence to date. The four patients who did not undergo repair did not have complaints due to this hernia and were not motivated to undergo intervention.

Table 1.

Characteristics of 221 patients who underwent endoscopic total extra-peritoneal repair of an inguinal hernia.

	Primary Hernia	Recurrent Hernia
Number of patients	186	35
Male : Female	174 : 12	35 : 0
Age:	Median: 54	Median: 66
	Range: 20-90	Range: 25-89

Table 2.

Nyhus Classification, 221 patients with an inguinal hernia.

Nyhus classification	Primary Hernia	Nyhus classification [17]	Recurrent Hernia
NII (Indirect)	88	NIV (Indirect)	10
NIIIA (Direct)	30	NIV (Direct)	13
NIIIB (Combined)	54	NIV (Combined)	6
NIIIC (Femoral)	5	Unclassified	6

Table 3.

Endoscopic total extra-peritoneal repair of inguinal hernias.

Complications amongst 221 patients.

	Primary Hernias		Recurrent Hernias		Total	
	N	%	N	%	N	%
Peroperative complications:						
Peritoneal tears	11	5.9	11	31	22	9.9
Bleeding	10	5.3	2	5.7	12	5.4
Postoperative complications:	N	%	N	%	N	%
Hematoma	5	2.7	5	14	10	4.5
Paresthesia	4	2.2	2	5.7	8	3.6
Seroma	3	1.6	0		3	1.4
Urine retention	4	2.2	0		4	1.8
Hydrocele	1	0.5	0		1	0.5

N = Number of patients with this complication.

% = Number expressed as percentage of all the patients with a primary or recurrent hernia and the total number of patients.

Table 4.

Endoscopic TEP repair of an inguinal hernia

Hospital stay, return to work and follow-up time for 221 patients

	Primary Hernia		**Recurrent Hernia**	
Hospital stay (days):	Median:	1	Median:	1
	Range:	1-5	Range:	1-3
Return to work (days):	Median:	3	Median:	3
	Range:	1-30	Range:	1-14
Follow-up time (months):	Median:	42	Median:	43
	Range:	22-55	Range:	27-55

Discussion

Laparoscopic repair is gaining popularity for the treatment of inguinal hernias. This is due to promising early reports of rapid recuperation and a low recurrence rate after short follow-up
[4,5,16,18,26]. Both the use of prosthetic mesh to create a tension-free repair and the endoscopic technique itself are responsible for these results. Some conventional techniques have led to promising results in specialized centers but could not be equalled in other series. The results of conventional techniques for recurrent hernia repair are even more disappointing. Studies of endoscopic hernia repair, until now, generally describe the results of different techniques within one group of patients [4,6,7]. Other reports on endoscopic inguinal hernia repair describe results of hernia repair in a variable group of hernias, in which primary, recurrent hernias and bilateral hernias are combined [4,5,6,7,18,24,26].

In our opinion the results of these reports cannot be extrapolated to the repair of only one specific group of inguinal hernias using a single laparoscopic technique.

In most series follow-up is short, and physical examination is not mentioned. However physical examination is crucial in the follow-up of hernia repair. Many recurrences tend to be asymptomatic and cannot be adequately deduced from questionnaires or telephone interviews [8,12].

Since the beginning of endoscopic hernia surgery a variety of endoscopic techniques has been used. The complications of the intra-peritoneal onlay mesh technique (IPOM) and the trans-abdominal preperitoneal procedure (TAPP) appeared to be attributable to adhesion of the bowel to the intra-abdominally positioned mesh or to parts of the mesh exposed after inadequate closure of the peritoneum as well as to injury of the intra-abdominal organs [5,19,25]. The total extra-peritoneal procedure (TEP) seems to reduce these risks and is therefore our technique-of-first-choice in most situations [3,5,9,19,22,26].

In our study of TEP repair for unilateral primary hernias and recurrent hernias after conventional repair, the occurrence of per-operative and postoperative complications was low and comparable to other reports on endoscopic hernia repair [4,5,6,7,18,22,24]. The operation time for the two groups is comparable and not longer than for conventional repair. Conversion to another procedure involved the TAPP procedure in the majority of cases, thereby maintaining the advantages of laparoscopic surgery. When it was not possible to continue endoscopically, this was due to problems with anesthesia (muscle relaxation) or technical problems.

The previously reported positive results of a short hospital stay and rapid recuperation were confirmed for both primary and recurrent hernia repair. If the patient remained at home longer after hernia repair, then he or she was usually stimulated by others to do so. The fear of overdoing things is still present among both patients and general practitioners [13,20].

The low recurrence rate of 3.2% found for the primary hernia group is also in accordance with previous reports. Four of the six recurrences occurred in patients who were operated upon during the early phase of our experience with the TEP procedure (among the first 30 patients of each surgeon). The 'learning curve' may play a role here [13]. Four of these recurrences developed within the first year of surgery. This is in accordance with the suggestion that recurrences after endoscopic repair are mainly due to technical errors and therefore occur early. However, we consider our mean follow-up of 40.4 months only the start of a decent surveillance. Further study must confirm the present promising results.

In contrast, the recurrence rate of 20% (seven out of 35 repairs) for recurrent inguinal hernia repair is rather disappointing. Comparable studies have not yet been published which makes it difficult to draw any conclusions. The question is what the cause of this high recurrence rate might be. Patient related factors leading to higher recurrence rates do not seem to be of influence, although more patients with for instance heavy weight bearing were seen in the recurrences group. The known causes of recurrence after endoscopic repair of a primary inguinal hernia might lead to an explanation for the failure of endoscopic repair of a recurrent hernia [2,20,25]. Although it is possible that the initial hernia was not repaired adequately, recurrences are mainly due to insufficient mesh size, inadequate mesh positioning, and mesh migration [20].

Although the existence of a 'learning curve' [11,13] for this procedure might be considered, both surgeons had passed through this period and had achieved positive results with low recurrence rates for primary inguinal hernia repair using the same technique.

For all three patients who underwent reintervention a direct recurrence after the initial endoscopic repair could be diagnosed during the subsequent operation. The mesh had moved laterally allowing a new direct hernia to develop. Mesh migration may have been facilitated by postoperative hematoma or seroma formation, although only minor postoperative hematomas and seromas were seen in these patients, which to our opinion makes this a less likely possibility. The problem could lie in the fact that the mesh is not fixed. If a hernia consists of a large abdominal wall defect or tissue of poor quality, which is often the case in recurrent inguinal hernias, not fixating the mesh might sooner result in inadequate covering of the inguinal floor, than for a primary inguinal hernia. [1,19,25]. However, when stapling a mesh different problems can be encountered. Far fewer surgeons are familiar with the inguinal anatomy as seen in the posterior or preperitoneal approach than in the anterior approach. This knowledge is important as this approach poses risks to specific nerves and vessels. Staples from the symphysis pubis to the anterior superior iliac spine jeopardize all lumbar plexus nerves (Genital branch of the genito-femoral nerve, ilio-inguinal nerve, lateral femoro-cutaneous nerve, Femoral branch of the genitor-femoral nerve)[18,23,25].

A thorough understanding of the anatomy of these nerves can prevent stapling in the areas of danger and reduce the incidence of this related complication. Because of the inconstancy and unpredictability of the course of these nerves deep to the iliopubic tract and the iliopsoas fascia this area should be avoided when placing staples or sutures lateral to the internal ring [18,25].

Knowledge of the inguinal anatomy is also essential in preventing damage to the vessels of the inguinal area. Medially, the iliopubic and aberrant obturator vessels can be lacerated in the area of the femoral ring and the pectineal ligament. Also the external iliac artery and vein located in the so-called Triangle of Doom (area between the epigastric vessels and the vas deferens) are in danger [15].

When a preference for stapling exists over the use of a larger mesh size; stapling to the Cooper ligament, or a margin of several centimeters of the abdominal wall more cranially are a relatively save alternative. Nevertheless complications as osteitis of the pubic bone may occur and the obturator branch of the epigastric artery, which runs in craniocaudal direction over the inner side of the superior pubic arch, may be damaged easily when stapling inferiorly [15]. Furthermore it may be advisable to use tackers instead of staples hereby reducing the chance of entrapment of nerves.

Considering the above mentioned we still prefer enlarging the mesh size over taking the risks known for mesh stapling.

Conclusions

At our hospital the results of endoscopic TEP repair of primary or recurrent inguinal hernias confirm the rapid recuperation mentioned in earlier reports.

Our series of patients with unilateral primary inguinal hernias confirms the feasibility, low complication rate and low recurrence rate reported for this specific technique. Most recurrences are seen early, both in time elapsed postoperatively and relative to the surgeons' experience. This implies that technical errors may be a cause of recurrence. If this is true better results can be expected in the future.

A disappointing recurrence rate was found for the TEP repair of recurrent inguinal hernias after conventional herniorraphy. After considering the possible causes of this result we think the explanation can be found in the poor tissue quality of the recurrent hernia, resulting in larger defects and general failure of the abdominal wall. A mesh size which suffices for primary inguinal hernia repair is probably not sufficient for recurrent hernia repair. Since our preference is to avoid fixation of the mesh, a larger mesh prosthesis for TEP repair of recurrent inguinal hernias must be investigated in the future.

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Chapter 4

Endoscopic totally extra-peritoneal repair of bilateral inguinal hernias

MTT Knook, WF Weidema, LPS Stassen, RU Boelhouwer, CJ van Steensel.

British Journal of Surgery (1999) 86: (10): 1312-1316

Abstract

Introduction: Recurrence rates of bilateral inguinal hernia repair with a giant prosthesis (Stoppa procedure) are low. Endoscopic total extra-peritoneal bilateral inguinal hernia repair with a giant prosthesis combines the low recurrence rate of the 'Stoppa repair' and the advantages of minimal invasive surgery. The aim of this retrospective study was to investigate whether extra-peritoneal bilateral inguinal hernia repair could be performed by the minimal invasive, totally extra-peritoneal approach.

Methods: From February 1993 to January 1998, 98 patients with bilateral inguinal hernias underwent surgery. A polypropylene 30 x 10 cm rectangular mesh or a 30 x 10/15 cm 'slip-mesh' was used. Follow-up, including a physical examination of 96 % of patients was performed.

Results: The median operative time was 60 minutes, mostly minor intra-operative complications occurred. Conversion was required for two patients. Apart from one patient with a necrotic fasciitis who died from respiratory failure, only minor postoperative complications (10%) occurred. Median hospital stay was 1 day (range 1-21). Median recuperation time was 5 days (range 1-22). Median follow-up (96%) was 32 months (range 7-57); there were six recurrences (17.6%) in the 10 x 30 cm mesh group (34 hernias in 17 patients) and two (1.2%) in the 30 x 10/15 cm mesh group (162 hernias in 81 patients).

Conclusions: The endoscopic approach for the Stoppa procedure for bilateral inguinal hernia repair is a reliable method with minor complications. It ensures a short recuperation time and the recurrence rate is low due to adequate overlap of the hernial defect when a 'slip-mesh' is used.

Introduction

Some studies have reported an increased morbidity following bilateral inguinal hernia repair compared to unilateral hernia repair [1,2]; other authors deny higher morbidity for bilateral inguinal hernia repair when a tension-free repair is performed [3,4,5]. In view of the disadvantages of sequential unilateral hernia repair, such as higher total expenses and more sick leave, simultaneous repair is to be preferred [1,4,5,6,7]. From the standpoint of morbidity an endoscopic technique for bilateral inguinal hernia repair should be attractive since it is known to cause less postoperative pain and ensures more rapid recovery compared to conventional hernia repair [1,2,8,9,10]. Furthermore the recurrence rate for conventional hernia repair without mesh prosthesis remains high [11]. The prosthetic repair of bilateral inguinal hernias by the preperitoneal approach, as described by Stoppa and Warlaumont, has reduced recurrence rates significantly [1,12,13].

Endoscopic totally extra-peritoneal bilateral inguinal hernia repair with a giant prosthesis combines the low recurrence rate of the 'Stoppa' prosthetic repair of groin hernias and the advantages of minimal invasive surgery [4,10,14,15,16].

Patients and methods

Ninety-eight patients with bilateral inguinal hernias at physical examination who were fit for general anesthesia and did not have an infection of the abdominal wall underwent surgery. Peroperative hernia classification was performed as proposed by Nyhus [12]. All operations were performed by three staff surgeons, experienced in endoscopic surgery. The procedure used was standardized for all cases. The essential steps of total extra-peritoneal repair have been described by Liem et al. [17].

For the first 17 large mesh cases of this study a 10 x 30 cm polypropylene prosthesis (prolene®) was used. However, we had the impression that a relatively large number of medial recurrences occurred due to insufficient overlap of the medial orifice when using the 10 x 30 cm prosthesis; therefore, we changed to a 10/15 x 30 cm 'slip-mesh' polypropylene prosthesis for the subsequent 81 cases. The 'slip-mesh' (*fig 1*) is a tailored mesh of 15 x 30 cm. The 'slip' is pulled into a position which results in better coverage of the area of the direct hernias.

When intra-operative complications would lead to the need for conversion to another endoscopic or an open technique, the procedure was chosen by the operating surgeon.

Postoperatively patients were mobilized directly and were allowed to leave the hospital as soon as they felt up to it as long as postoperative complications requiring clinical care had not occurred.

The first 54 patients were seen postoperatively at regular 3-month intervals during the first year and then annually by the authors. The other patients (43) were seen one week postoperatively and when no problems occurred further follow-up was done on demand. For the present study initial data and data recorded during follow-up were collected from patient records. Surgery time was defined as the time from the first incision to the last suture. Intra-operative complications (diffuse hemorrhage or bleeding from an epigastric vessel, peritoneal defects), postoperative complications (large haematomas of the abdominal wall, seroma, paresthesia, wound infection, urine retention, mesh infection, pneumopericardium) and conversion of the total extra-peritoneal to an endoscopic transabdominal or open procedure were noted. Length of hospital stay (number of days in the hospital after surgery), recuperation time (number of days needed for recovery before returning to work or full daily activities) and recurrence of a hernia were assessed. To complete this study with up-to-date recurrence rates, all patients were approached by mail or telephone and asked to report to the outpatient department to have a physical examination. Appointments were made at two fixed dates at which all (96%) patients had a thorough physical examination performed by a staff surgeon and a senior resident (both authors of this manuscript). At this final check-up, initial data missing from patient records were collected and recurrence of the hernia was evaluated by means of a thorough physical examination.

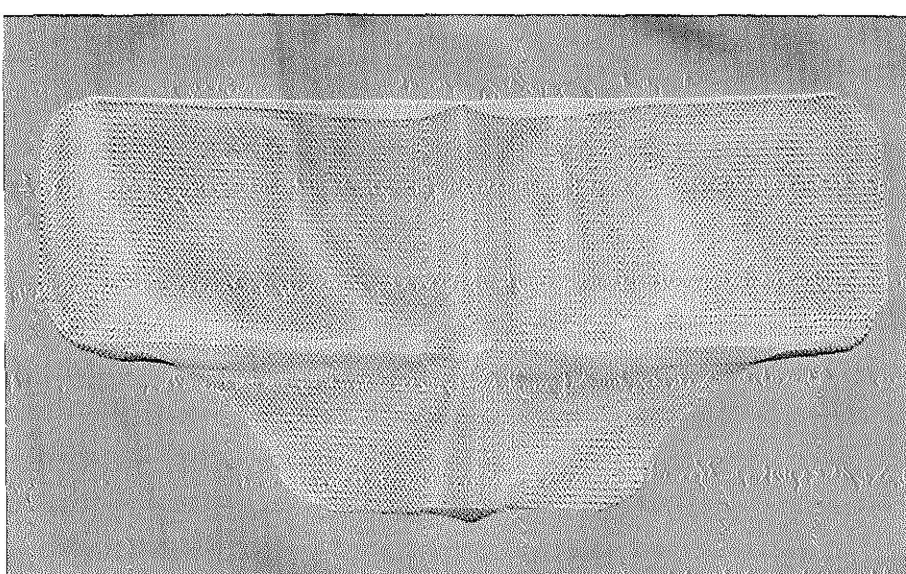

Figure 1. Slip-mesh for endoscopic bilateral inguinal hernia repair.

Results

From February 1993, to January 1998, 98 patients (96 male and 2 female) were operated upon. Their age at surgery ranged from 27 to 86 years (median 60). Hernia localization, classified according to Nyhus, is given in *Table 1*. In 75 patients a primary bilateral inguinal hernia was diagnosed. In 14 patients the hernia was primary on one side and recurrent on the other side and in another nine patients the hernia was recurrent on both sides. The recurrent hernias had all developed after prior conventional hernia repair without the use of prosthetic material. For dissection a peritoneal dissection balloon (PDB) was used in 80 cases, leading to peritoneal tears during dissection in 14 cases (17%). In the other 18 patients dissection was performed with the endoscope leading to peritoneal tears in all instances (100%). The median operative time was 60 minutes (range 20-120).

Intra- and postoperative complications are summarized in *Table 2*. In one patient the epigastric vessels were injured necessitating the use of clips to stop the bleeding. In 30 of 32 patients with minor peritoneal tears the peritoneal defect was closed with a Polydioxanone-S® (PDS) running suture or endoloop. Twice this was not possible: in one case dissection difficulties due to leakage of gas into the abdominal cavity made it necessary to convert the procedure to a transabdominal preperitoneal (TAPP) repair with 10 x 15 cm prosthesis on each side; in the other case the procedure was continued using the open Stoppa approach.

Postoperative complications occurred in 10 % of the patients, most of which were minor. Small haematomas, which resolved spontaneously, accounted for another 11% of the 'postoperative complications'. Mild paresthesia of the medial thigh in two patients was probably due to injury of the ilio-inguinal nerve; at three months it had completely disappeared in both patients. The seromas needed fine needle aspiration and the cystitis was treated with antibiotics. One mesh infection was successfully treated by ultrasound-guided drainage and the administration of intravenous antibiotics; at follow-up no signs of ongoing infection were present. The other patient with a mesh infection suffered a dramatic necrotizing fasciitis which, although cured by an extensive abdominal resection, led to his death due to ARDS and pulmonary insufficiency.

Median hospital stay was one day (mean 2, range 1-21). The patient with the infected mesh which was treated successfully and the patient who underwent dilatation of the urethral stricture were hospitalized for 14 and 21 days, respectively. The patient who died of ARDS due to necrotizing fasciitis was in the hospital for 21 days. The 30-days hospital mortality thus was 1%. One patient with an elevated temperature of unknown origin was hospitalized for analysis for two weeks until the temperature resolved spontaneously. Patients returned to work or full daily activities after a median period of 5 days (mean 7, range 1-22).

Ninety-four of 98 patients responded to the postal questionnaire and, in some cases, subsequent telephone request; therefore follow-up with a physical examination was accomplished in 96%. Median follow-up was 32 months (mean 30, range 7-57).

Eight recurrences were diagnosed in seven patients. In six patients a unilateral recurrent inguinal hernia was seen at physical examination. In one patient a bilateral recurrent hernia was diagnosed. Five patients had noticed bulging; the other two patients were asymptomatic. Six of these recurrences occurred within the first year of surgery for a primary inguinal hernia. Six of the patients with a recurrence belonged to the group of 17 patients (34 hernias, i.e. recurrence rate: 17.6%) who received the 10 x 30 cm rectangular prosthesis. Of the 81 patients (162 hernias) with a 10/15 x 30 cm slip prosthesis, two (1.2%) suffered a recurrence. Reintervention was performed in five cases (six hernias) by means of a transabdominal preperitoneal procedure (TAPP). This reintervention allowed us to investigate the cause of the recurrence. In all cases the recurrent hernia was located medially, and thus was probably due to insufficient overlap of the defect by the rectangular mesh or inadequate positioning of the slip-mesh. The two fully asymptomatic patients preferred to postpone the operation until complaints developed.

Table 1.

Classification according to Nyhus of 98 patients with a bilateral inguinal hernia.

Nyhus classification		Nyhus classification [12]		Nyhus classification	
II, II	20	IIIA, IIIA	19	IIIB, IIIB	9
II, IIIA	11	IIIA, IIIB	10	IIIB, IV	3
II, IIIB	6	IIIA, IV	8	IV, IV	9
II, IV	3				

NII: Indirect hernia, NIIIA: Direct hernia, NIIIB: Combined hernia, NIV: Recurrent hernia

Table 2.

Endoscopic total extra-peritoneal repair of bilateral inguinal hernia. Complications among 98 patients.

Peroperative complications:			**Postoperative complications:**		
	N	%		N	%
Peritoneal tears	32	33.0%	Hematoma	11	11.2%
Conversion*	2	2.0%	Mesh infection	1	0.9%
Epigastric vessel	1	1.0%	Urine retention#	2	1.8%
laceration			Pneumopericardium	1	0.9%
			Seroma	1	1.0%
*TAPP repair	1	1.0%	Cystitis	2	1.8%
*Open Stoppa	1	1.0%	Temperature c.c.i	1	0.9%
			Paraesthesia	2	1.8%
			Death	1	0.9%

N = Number of patients with this complication.

% = Number expressed as percentage of all the patients with a bilateral inguinal hernia

[#] *Once in a patient with a preexisting urethral stricture*

Discussion

Both the use of a prosthetic mesh to create a tension-free repair and the endoscopic technique have gained popularity in inguinal hernia surgery [3,4,9]. Stoppa and others have used the preperitoneal sub umbilical approach to the retro-fascial space since 1969. Advantages of this approach were the ease of separation of the retro-fascial cellular space, direct access to the posterior inguinal structures; clear understanding of the hernial lesions, and clear exposure of the musculopectineal opening. Furthermore, in their opinion, the retrofascial space is a natural site for prostheses to reinforce the transversalis fascia.

Although several promising reports on endoscopic inguinal hernia repair have been published [2,8,18,19], reports on endoscopic bilateral inguinal hernia repair are scarce [4,10]. As a rule these bilateral procedures are small in number and are described as part of a study on endoscopic unilateral inguinal hernia repair [8,12,18,20]. The technique most often used for these bilateral hernias is the transabdominal preperitoneal (TAPP) technique with two meshes of 10 x 15 cm or one single large mesh [7]. The total extra-peritoneal (TEP) procedure however is the preferred technique in most situations, as it is less difficult to position a large mesh [18,21,22].

The choice of a single large prosthesis might reduce the problem of mesh migration and the risk of insufficient overlap of the medial defect [10,14, 21]. It is important to cover the areas of both indirect and direct (potential) hernias of the inguinal floor in all cases to reduce hernia recurrence [21]. In this study on bilateral inguinal hernia repair we adopted the "Stoppa" procedure which was transformed into an endoscopic approach. Stoppa and Warlaumont report a recurrence rate of 1.4% using their technique. In their opinion the recurrences that did occur were due to insufficient mesh size or shape since the recurrences passed through the insufficient fascia under the lower edge. We encountered the same problem using the rectangular mesh and therefore switched to the 'slip-mesh' prosthesis which resulted in lower recurrence rates (1.2%).

In the present study of TEP repair of bilateral inguinal hernias the occurrence of intra-operative and postoperative complications was comparable to that of other reports on endoscopic inguinal hernia repair [8,9,18, 21,22]. Nevertheless, two serious complications did occur. Although one of these patients did not suffer any late problems from this complication (mesh infection), the second patient died of respiratory failure during treatment of necrotizing fasciitis in the Intensive care unit. For this reason selective indications for repair with prostheses (no abdominal wall infections, no active other infections), irrespective of the procedure, and careful attention to the prevention of septic complications of both conventional and endoscopic repairs are essential [13]. Antibiotics were not administered in these patients as we consider these mesh-infections a coincidence in this subgroup of patients as mesh infections have not occurred at all in the (> 1000) other hernia repairs performed by the authors.

Operative time was comparable to or even shorter than that in conventional surgery.

The short hospital stay and rapid recuperation in this group are comparable to earlier reports [2,4,14]. Simultaneous repair of bilateral hernias which, according to some authors is controversial in the event of open inguinal hernia repair, does not lead to extra hospitalization or longer recuperation when the endoscopic approach is applied [4,14,16]. The wide range in the length of hospital stay and the time needed for recuperation was due to the extended clinical treatment of a mesh infection in one patient, the surgical treatment of urethral stricture in another patient, and the conversion to an open repair in two patients.

Essential in a study like this is the physical examination of patients at final follow-up. True recurrence rates can be obscured when follow-up is short or when follow-up is based solely on written or verbal correspondence [6,16]. Many recurrences are not noticed by the patient and will therefore not be reported in questionnaires or during interviews by telephone [4,9,11,16].

The recurrence rate was high for the 17 patients (34 hernias) in which a rectangular mesh was used (17.6%). In four of these six patients reintervention took place. All of these recurrences were found to be medial recurrences. Probably the rectangular shape of this prosthesis does not give adequate coverage of the medial defects. As we switched to the 'slip-mesh' which ensures a more complete overlap of the medial defects the recurrence rate dropped to 1.2% [14]. This recurrence rate is most probably still due to inadequate dissection or inadequate positioning of the mesh: the prosthesis was not found in the correct position medially at reintervention for the recurrent hernia. Adequate dissection and mesh positioning when using an adequate mesh size should further decrease recurrence rates.

The results of this procedure as shown are promising. It should however be emphasized that a relatively long learning curve [17] is to be expected since both the introduction and the positioning of the mesh prosthesis are quite difficult.

Although this procedure is feasible the question remains as to whether it is also reasonable. Increased costs of the procedure are often mentioned as a negative feature. The decreased costs due to shorter sick leave and less re-admission due to hernia recurrences may compensate for the higher costs of the endoscopic procedure.

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Chapter 5

Laparoscopic repair of recurrent inguinal hernias after endoscopic herniorrhaphy

MTT Knook, WF Weidema, LPS Stassen , CJ van Steensel

Surgical Endoscopy (1999) 13: (11): 1145-1147

Abstract

Introduction: Although the recurrence rate for endoscopic herniorraphy is low (0-3%) the question remains whether these recurrences should be corrected laparoscopically or by the conventional method. Aim of this study was to investigate whether these recurrences can be repaired by means of the laparoscopic approach with acceptable complication and recurrence rates.

Methods: From October 1992, to December 1997, 34 patients with recurrent inguinal hernias at physical examination underwent surgery. All recurrences had occurred after endoscopic inguinal hernia repair with mesh prostheses. The recurrences were repaired endoscopically using a transabdominal approach. A new polypropylene mesh with a size depending on the diameter of the defect was used.

Results: Mean surgery time was 69 min. There were no conversions to the anterior approach. After a mean follow-up of 35 months no recurrences had been diagnosed.

Conclusions: The transabdominal preperitoneal approach is a reliable technique for recurrent inguinal hernia repair after previous endoscopic herniorrhaphy.

Introduction

Laparoscopic repair has gained acceptance for the treatment of inguinal hernias. This is due to promising early reports, after a short follow-up, of rapid recuperation and a low recurrence rate. Laparoscopic inguinal hernia repair combines the advantage of mesh insertion (tension free repair) with the rapid rehabilitation offered by laparoscopy [3,4,12,13,19].

Not withstanding these promising reports recurrent inguinal hernias occurred after endoscopic inguinal hernia repair, although far less frequently than after conventional repair [15,18].

The subsequent question is how to treat these recurrent inguinal hernias. Is there still a place for laparoscopic surgery or should we turn to conventional methods? The authors, having confidence in the laparoscopic technique, adopted the transabdominal approach for the repair of recurrent inguinal hernias after prior endoscopic repair. Laparoscopic repair of these recurrent hernias made it possible to determine the reasons for the recurrence and to compare our findings with those reported in the literature. A retrospective analysis was performed to investigate the technical feasibility, the complication rate and morbidity of this procedure. Furthermore, the recurrence rate was studied. The possible mechanism of these recurrences is discussed and modification of the authors' technique of primary endoscopic hernia repair is described. With this knowledge future hernia repair can be perfected.

Materials and methods

Patients who underwent TAPP (transabdominal preperitoneal) repair for a unilateral recurrent inguinal hernia after prior endoscopic hernia repair were included in this study. Thirty-four patients, one female and 33 male, were operated on. All operations were performed at the Reinier de Graaf Hospital in Delft or the Ikazia Hospital in Rotterdam, The Netherlands. All patients were declared fit for general anesthesia and none had an infection of the abdominal wall. The operations were performed by staff surgeons, experienced in endoscopic surgery. A standardized procedure for TAPP hernia repair was followed in all cases. The essentials of this technique are: general anesthesia, transabdominal approach, opening of the peritoneum above the hernial defect, preperitoneal dissection and exposure of the original mesh, reduction of the recurrent inguinal hernia, positioning of polypropylene mesh prosthesis over the original mesh ensuring adequate positioning of the new mesh over the hernial defect, and closure of the peritoneum. The prosthesis is anchored to the abdominal wall by intra-abdominal pressure, when necessary staples were used for fixation of the mesh.
Patients were allowed to leave the hospital as soon as they felt up to it as long as postoperative complications requiring clinical care had not occurred.
Patients were examined postoperatively at regular 3-month intervals in the first year and then annually by staff surgeons. Initial data were collected from patient files. Localization of the recurrent hernia as found during the operation was registered. Surgery time was defined as the time from the first incision to the last suture. Data such as per-operative and postoperative complications (hematoma of the abdominal wall, seroma, paresthesia, wound infection, urine retention) and conversion of the transabdominal preperitoneal procedure to a conventional procedure were noted. Length of hospitalization (number of days in the hospital after surgery) and morbidity (number of days needed for recovery before returning to work or full daily activities) were assessed. Data collection was completed with recent data from the routine follow-up, including physical examination.

Patients (30 of 34), who had not visited the outpatient department recently, received a questionnaire and were asked to report to the outpatient department. Patients who did not react to our mailing (2) were then approached by telephone. All patients responded to our mailing or telephone request. For all patients recurrence of the inguinal hernia was evaluated by a thorough physical examination.

Results

From October, 1992, to December 1997, 34 patients (33 males and one female) were operated on. Their age at surgery ranged from 39 to 77 years. Predisposing factors for the hernia (heavy weight-bearing, chronic constipation, urinary obstruction, chronic cough, or blowing instruments) were present in 7 of 34 cases. The original endoscopic hernia repair procedure and original hernia type in these 34 patients are given in Table 1. Localization of the recurrent hernia (Nyhus IV) was determined during dissection. In 22 cases a medial recurrent hernia was found. In these cases the original mesh probably did not cover the defect sufficiently on the medial side since the hernia passed the mesh medially. Another possibility is that the mesh moved laterally during or after desufflation. In seven patients an indirect recurrent hernia was found. In these patients the primary hernial sac was probably not fully dissected or the mesh was too small, since the recurrent hernia was found to protrude under the original mesh prosthesis. In 5 patients combinations of these types were seen *(Table1)*.

The mean surgery time was 69 minutes. Peroperative complications occurred in 2 patients (5.9%). Once the vas deferens was damaged and had to be clipped. In another patient it was not possible to close the peritoneum over the mesh so it was left partially uncovered. Conversion to another procedure was never necessary. Postoperative complications included hematoma of the abdominal wall, which disappeared spontaneously, in six patients. Paresthesia of the inguinal-femoral region did not occur in this series nor did we see any seromas. Urine retention occurred in one patient.

Mean hospital stay was 1.5 days (Range 1-3). Patients returned to work or full daily activities after a mean period of 6 days (Range 2-14). Mean follow-up was 35 months. All patients were available for follow-up. As yet no recurrences have been seen.

Table 1.

Transabdominal pre-peritoneal repair of a recurrent inguinal hernia, after endoscopic repair.

Original operation, hernia type, and localization of recurrence for 34 patients.

Endoscopic repair at original operation	**N**	**Type of hernia at original operation**	**N**	**Localization of recurrence**	**N**
TAPP	9	Nyhus II (indirect)	6	Indirect	7
TEP *	9	Nyhus IIIA (direct)	8	Direct	22
Patch and Plug	13	Nyhus IIIB (combined)	17	Combined	5
Endoscopic Stoppa **	3	Nyhus IV (prior conventional repair)	3		

* TEP for unilateral hernias.

** TEP for bilateral hernias using giant mesh prosthesis.

Discussion

Total extraperitoneal endoscopic inguinal hernia repair, as mentioned before, yields excellent results with consistently low rates of recurrence in reported series performed by experienced surgeons [5,6,8,10,12]. Nevertheless recurrent inguinal hernias do occur [2,8,15,17,18]. Identification of the causes of recurrence after endoscopic hernia repair is crucial for the future treatment of all inguinal hernias, either primary or recurrent. A number of possible reasons for recurrence have been mentioned and discussed by different authors experienced in endoscopic inguinal hernia surgery [2,8,11,15,18,17]. The prevailing opinion is that recurrences are due to technical errors. Factors leading to recurrences include the surgeon's experience, inadequate dissection, missed hernias, insufficient size of the prosthesis, and insufficient overlap of the prosthesis over the hernial defect, improper fixation, folding or twisting of the prosthesis, and mesh lifting secondary to hematoma formation [2,6,11,14,15,17]. A central aspect in all of these cases is the surgeon's experience. It is obvious that many technical errors can be avoided if we know how to prevent them. It has been shown that most recurrences can be found among the surgeon's early cases of endoscopic hernia repair [8,9,11,17]. Incomplete dissection and missed hernias lead to early recurrences because the hernia was not repaired adequately. Often cited as a mechanism for recurrence is the inadequate size of the prosthesis, so that not all the defect is covered and overlap is insufficient [6,11,14,15]. In the 22 cases of a medial recurrent hernia the mesh probably did not cover the defect sufficiently on the medial side since the hernia passed the mesh medially [2]. Of these 22 patients 13 had a recurrence after previous patch and plug repair in which smaller mesh prosthesis (5 x 5, 6 x 8) was used [7]. In the other nine cases a TAPP or a TEP procedure was used. We think that the mesh was too small with respect to the hernial defect in the first thirteen cases. During a TAPP it is sometimes difficult to create enough room to position the prosthesis correctly which probably led to medial recurrence due to insufficient overlap on this side. In the TEP procedure incorrect positioning is the most probable cause of medial recurrence. On the other hand the mesh could have moved laterally during desufflation if it is not kept in place [11]. After desufflation, when a hematoma or a seroma forms, floating of the mesh could lead to mesh movement. Elevation of the intra-abdominal pressure might lead to protrusion of the mesh into the hernial defect.

In seven patients an indirect recurrent hernia was found. In these cases the primary hernia was probably not fully dissected or the mesh was too small because the recurrent hernia was found to have slipped under the mesh prosthesis into the abdominal wall defect. In the 5 combined recurrences combinations of these must be the explanation.

All recurrent hernias occurred in patients from the early period of the authors' experience with endoscopic hernia repair, illustrating the presence of a learning curve and inadequacies of the original technique.

Discussions on 'to staple or not to staple' remain heated. The advantages include the lower risk of mesh migration, the disadvantages include nerve entrapment, vessel laceration and pain of the abdominal wall [1,8,14,18]. Since we prefer not to use staples for mesh fixation we advocate the use of larger mesh prosthesis [8]. Not enough is known about how much overlap is essential to prohibit hernia recurrence. The basic requirement is prosthesis large enough to cover and adequately overlap all potential hernia sites in the myopectineal orifice. It is thought that all defects should be overlapped by at least 2 cm if the mesh is stapled and 3 cm if it is left unstapled. A 15 x 15 cm prosthesis should therefore be adequate to prevent recurrent hernias, assuming proper positioning and complete dissection have taken place [5,11]. If despite these precautions a recurrent hernia does occur a second repair has to be performed.

In the present study the results of a second endoscopic hernia repair are evaluated. The authors preferred the transabdominal approach since dissection difficulties in the preperitoneal space due to the primary repair were anticipated. Although more lacerations of the intra- abdominal structures during the TAPP compared to the TEP are reported in the literature [4,14,15], the transabdominal procedure did not give rise to any complications in the present group of patients. The mean surgery time was longer than for repair without previous mesh placement due to the necessary dissection of the peritoneum from the prosthesis and closure of the peritoneum after mesh placement. Peroperative and postoperative complications did not occur more frequently than after primary endoscopic repair [4,6,8,10,12]. Rapid recuperation was experienced by almost all patients. And most important, no recurrences have been seen at physical examination after a relatively long follow-up period. These results strengthen our belief in the importance of endoscopic inguinal hernia repair in contemporary surgery. As time passes and techniques become perfected the recurrent hernia may become an ancient phenomenon.

Conclusions

Laparoscopic repair of recurrent hernias after primary endoscopic herniorrhaphy made it possible to study the likely causes of recurrence. Peroperative analysis suggests that the recurrences correlate predominantly with the surgeons' experience and the mesh size. Application of this knowledge for future hernia repair can lead to perfection of the procedure.

The question of whether there is a place for laparoscopic surgery in the treatment of recurrent inguinal hernias after endoscopic herniorrhaphy has been answered. The procedures were performed with few complications and without any need for conversion. Furthermore, probably due to incorporation of the lessons learned from earlier repairs, we saw no re-recurrences at medium term follow-up. The transabdominal preperitoneal approach is a reliable technique for recurrent inguinal hernia repair after previous endoscopic herniorrhaphy.

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Chapter 6

Optimal mesh size for endoscopic inguinal hernia repair. *A porcine model.*

MTT Knook, AC van Rosmalen, BE Yoder, GJ Kleinrensink, CJ Snijders, CWN Looman and CJ van Steensel

Surgical Endoscopy (2001) 15: (12) 1471-1477

Abstract

Introduction: Although the recurrence rate for endoscopic herniorraphy is low (0-3%), it can still be improved. In addition to using an expert technique that will minimize the risk of recurrence, it is essential that the mesh be large enough to cover the hernial defect adequately. To gain an impression of the adequate mesh size of such repairs, we performed an experimental study in a porcine model.

Methods: To mimic inguinal hernial defects, circular holes of different diameters were cut in pigs abdominal walls after lifting the peritoneum from the transverse fascia. The pig abdominal walls were positioned in a hermetically sealed chamber in which air pressure was applied to replicate intra-abdominal pressure. Measurements were obtained to relate protrusion of the mesh to three variables: intra-abdominal pressure, defect size, and mesh overlap over the defect after positioning the mesh between the abdominal wall and the peritoneum.

Results: Mesh protrusion increased as defect size and intra-abdominal pressure increased. Mesh protrusion decreased as overlap of the mesh over the defect increased. Protrusion was found to level off when the mesh overlapped the defect by 3 cm and adequate positioning of the mesh was maintained.

Conclusions: Recurrences after endoscopic inguinal hernia repair due to inadequate mesh size and mesh protrusion might be decreased when the mesh overlaps the defect by $\geq$ 3 cm.

Introduction

When performed by experienced surgeons, total extra-peritoneal (TEP) endoscopic inguinal hernia repair has been shown to yield excellent results with consistently low rates of recurrence [3,6,8,9,10]. Nevertheless, recurrent inguinal hernias do occur [2,9,12,14,17]. A number of possible reasons for these recurrences have been discussed by various authors experienced in endoscopic inguinal hernia surgery [2,9,11,12,14,17]. The prevailing opinion is that they are due to technical errors, such as inadequate dissection, missed hernias, improper mesh fixation, and folding or twisting of the prosthesis. Another frequently cited cause is inadequate size of the prosthesis, such that the defect is not adequately covered and overlap is insufficient [2,6,11,12,13,14].

In cases of insufficient overlap, elevation of the intra-abdominal pressure - for instance, during exercise - can lead to protrusion of the mesh into the hernial defect and subsequently, if the mesh is too small, to hernia recurrence. When all other causes of recurrence have been eliminated, the basic requirement is a prosthesis large enough to cover and adequately overlap all potential hernia sites in the myopectineal orifice [16,18]. This condition raises an obvious question "what is the adequate mesh size for inguinal hernia repair?" To gain an impression of the optimal mesh size in relation to defect size, we performed an experimental study in a porcine model. Measurements were obtained to relate protrusion of the mesh to three variables: intra-abdominal pressure, defect size, and mesh overlap over the defect.

Materials and methods

Measurement model (fig.1)

The measurement device consists of:

- A cylindrical chamber consisting of a PVC cylinder (diameter 20 cm, height 15 cm).
- A circular Perspex plate at each end.
- Truss rods surrounding the PVC cylinder. The rods seal the chamber hermetically by compressing the top and bottom circular Perspex plates so that air pressure can be applied without any danger of leakage. An O-ring is used to make an extra air-tight seal of the bottom and top plate to the cylindrical chamber.
- A hole of 7 cm in diameter in the bottom Perspex plate with an adapter to mimic different defect sizes.
- Adaptors with holes of decreasing diameter (1 – 6 cm) could be placed in the 7-cm hole in the bottom piece to mimic defects from 1 to 6 cm in diameter.
- An air hose valve on top of the cylinder is used to supply air pressure, which mimics intra-abdominal pressure.
- A manometer (mmHg) was mounted so that the exact air pressure in the cylindrical chamber could be recorded (50-250 mmHg, in steps of 50 mmHg).
- A Sony® digital gauge DG 50S and a Sony® magnescale LY-101 were used to measure and record mesh protrusion.

Range in defect sizes used in the experiment

For the sake of convenience in this model we decided to use circular defects and circular meshes so that we could determine the minimal adequate mesh size more precisely. The maximum diameter of the defect size was 6 cm (range 1 to 6 cm).

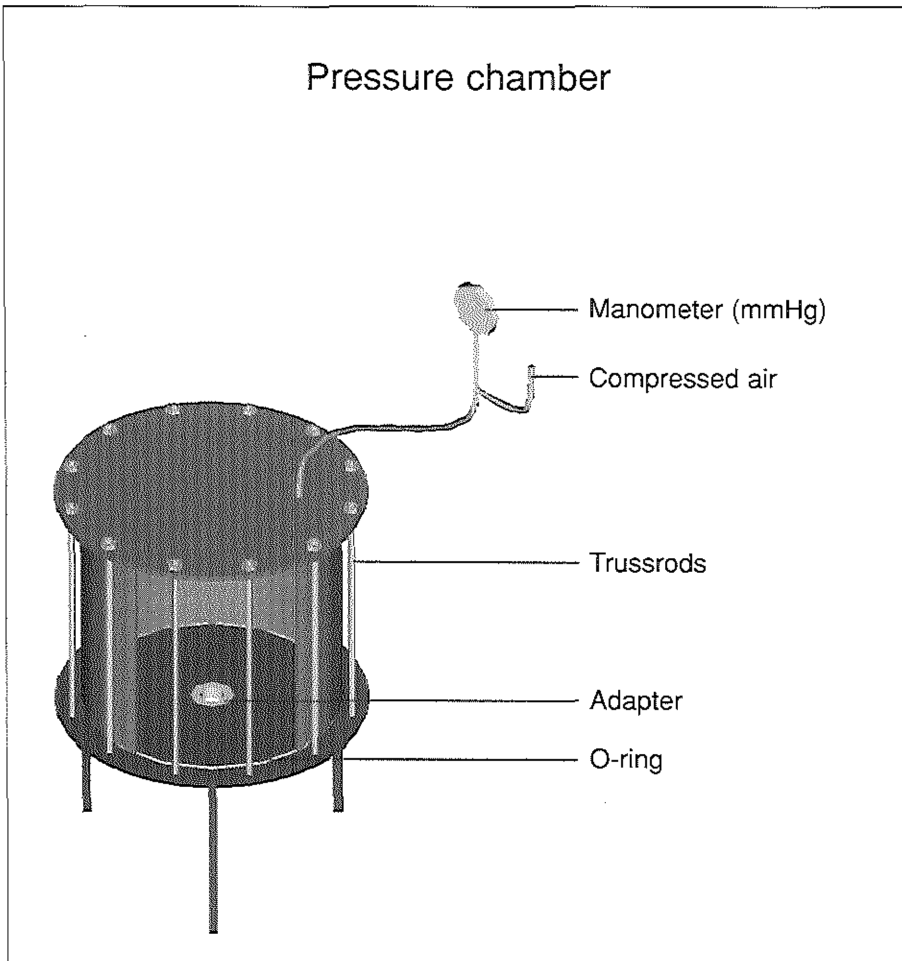


Figure 1. Measurement chamber.

Range of intra-abdominal pressures used in the experiment

Intra-rectal pressure provides a good estimate of intra-abdominal pressure [15]. Therefore, intra-abdominal pressures were estimated using measurements of intra-rectal pressure. Reported maximal physiological limits of intra-abdominal pressure range from 113 mmHg at valsava maneuver to 277 mmHg during weight lifting in male athletes [1,7]. In addition, 10 healthy human volunteers were asked to cough and perform the valsalva maneuver to mimic pressure elevations in daily life; the highest intra-rectal pressure monitored was 250 mmHg, range 140 - 250 mmHg (in an athletic person).

From these data, we concluded that an intra-abdominal pressure range of 50 mmHg to 250 mmHg adequately represents everyday intra-abdominal pressures in inguinal hernia patients.

Abdominal wall model

Six porcine abdominal walls were used to replicate the human abdomen. The abdominal walls were frozen and stored at - 40°C. When needed for the experiment, they were defrosted at 4°C and moistened at room temperature.

To prepare the abdominal wall for measurement, the peritoneum was carefully dissected from the transversalis fascia; then circular defects of increasing diameters (1cm, 2cm, 3cm, 4cm, 5cm, and 6cm) were cut into the muscular part of the abdominal wall. Skin and subcutaneous tissue were left in place.

Mesh prosthesis

Prolene circular meshes of increasing sizes (diameter range 3 - 16 cm) were used to cover the defects. They were positioned between the peritoneum and the abdominal wall.

Porcine model measurements procedure

After installation of the cylindrical measurement chamber and preparation of the pig abdominal wall, an appropriate circular defect was cut out of the porcine abdominal wall to match the diameter of the adaptor defect (1, 2, 3, 4, 5 or 6 cm) and the mesh was positioned over the defect (overlap 1, 2, 3, 4 or 5 cm). The peritoneum was moistened before each measurement and thereafter positioned over the mesh to cover it completely. The porcine abdominal wall was then positioned to cover the defect in the Perspex bottom plate of the measurement chamber; the defect in the abdominal wall matched the defect size of the adapter. The gauge was placed under the chamber, through the defect, to touch the mesh (or, in the measurements without a mesh, the transversalis fascia) as calibrated at zero protrusion. Air was supplied through the air pressure valve in increasing pressures ranging from 50 mmHg to 250 mmHg in 50 mmHg increments. Finally, measurements were made to relate protrusion (of the transversalis fascia or the mesh) to the following three variables: intra-abdominal pressure, defect size, and mesh overlap. Mesh overlap is defined as the diameter of the mesh minus the diameter of the defect divided by two.

Six porcine abdominal walls were used to perform measurements of defect sizes of 1 to 6 cm. Three measurements were made for each defect size. To minimize the effect of inter- porcine variables, each of the porcine abdominal walls was used for measurements for three different defect sizes. Thereafter, the mean values for each series of three measurements per defect size were used for further evaluation.

Statistical analysis

A statistical analysis was performed to assess:

1. The importance of the use of a mesh after correction of an inguinal hernia.
2. The effect of intra-abdominal pressure, defect size, and mesh overlap on the protrusion of the mesh in the defect.

To do so we fitted linear models on the natural logarithm of the measured protrusion. The effects were assessed using t-tests and F-tests. In addition, 95% confidence intervals (CI) were calculated. If the 95%-CI did not include 0, the p-value was smaller than 0.05, and the effect was considered statistically significant.

Results

First, protrusion of the transversalis fascia and peritoneum was measured without a mesh covering the defect. Protrusion increases as air pressure increases. The protrusion also increases at the same air pressure as the defect size increases. *Figure 2* shows how the protrusion increased with increasing air pressure as also with an increasing defect diameter (1-6 cm). Further experiments were performed with a prolene mesh with increasing overlap (1-5 cm). Protrusion again increases as air pressure increases but the protrusion is less as mesh overlap increases. *Figure 3* shows the increase of protrusion as air pressure increases at each defect size, protrusion is shown to be less at greater mesh overlap.

It is shown that protrusion decreases as mesh overlap increases, and that protrusion is less at smaller defect diameters. *Figure 4* shows the protrusion at 50-250 mmHg air pressure focused on the effect of mesh overlap. It appears that the protrusion is similar when mesh overlap was more than 3 cm for all defect sizes. Furthermore, for small defect size (1 or 2 cm), mesh overlap of more than 2 cm resulted in similar protrusions.

Statistical analysis

The statistical analysis showed that the protrusion was 2.2 times as large when no mesh was used compared to when a mesh was used (corrected for defect size and air pressure; 95% CI 2.0-2.3). The effects of air pressure and defect size (Fig 2-4) were evident and highly statistically significant. The mean decrease of protrusion was 8.5% per centimeter mesh overlap (95%-CI 7.6% - 9.4%) after correction for defect size and air pressure. However, the effect of mesh size overlap diminished at larger mesh sizes and was larger with higher pressures. Protrusion stays more or less similar when mesh overlap is more than 2 cm for the smaller defect sizes and more than 3 cm for all defect sizes.

In *Table 1* the decrease of protrusion is shown in percentage of decrease per cm more mesh overlap for every defect size at 250 mmHg air pressure. It shows that in the lower range of defect sizes, the most important decrease of protrusion occurs up to 2 cm mesh overlap, whereas in the higher range of defect sizes this occurs at 3 cm mesh overlap.

Table 1.
Decrease of protrusion per centimeter of mesh overlap for every defect size at 250 mmHg air pressure

	Defect size											
Overlap	1 cm	%	2 cm	%	3 cm	%	4 cm	%	5 cm	%	6 cm	%
0 cm	1,1		2,6		4,1		4,0		4,6		4,8	
		54,2		***47,3***		***48,3***		***34,1***		***24,9***		***23,5***
1 cm	0,5		1,4		2,1		2,7		3,5		3,7	
		16,3		***21,7***		***17,5***		***14,7***		***19,1***		***11,7***
2 cm	0,4		1,1		1,8		2,3		2,8		3,2	
		7,3		***8,3***		***4,0***		***10,6***		***10,7***		***6,5***
3 cm	0,4		1,1		1,7		2,0		2,5		3,0	
		5,3		***3,8***		***3,0***		***2,5***		***6,4***		***3,6***
4 cm	0,4		1,0		1,6		2,0		2,3		2,9	
		2,8		***2,9***		***1,8***		***2,0***		***5,1***		***3,1***
5 cm	0,4		1,0		1,6		1,9		2,2		2,8	

Figure 2 A: *Protrusion as a function of air pressure at increasing defect size (no mesh).*

Air pressure in mmHg

	50	100	150	200	250
1 cm	0,6	0,8	0,9	1,0	1,1
2 cm	1,7	2,0	2,1	2,4	2,6
3 cm	2,4	3,2	3,6	3,8	4,1
4 cm	3,1	3,7	3,7	3,9	4,0
5 cm	3,4	3,8	4,0	4,2	4,6
6 cm	3,6	3,9	4,5	4,6	4,8

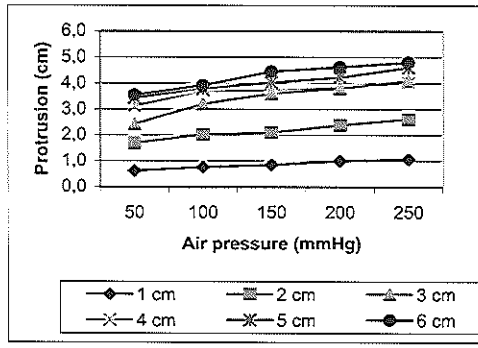


Figure 2 B: *Protrusion as a function of defect size at increasing air pressures (no mesh).*

Air pressure in mmHg

	50	100	150	200	250
1 cm	0,6	0,8	0,9	1,0	1,1
2 cm	1,7	2,0	2,1	2,4	2,6
3 cm	2,4	3,2	3,6	3,8	4,1
4 cm	3,1	3,7	3,7	3,9	4,0
5 cm	3,4	3,8	4,0	4,2	4,6
6 cm	3,6	3,9	4,5	4,6	4,8

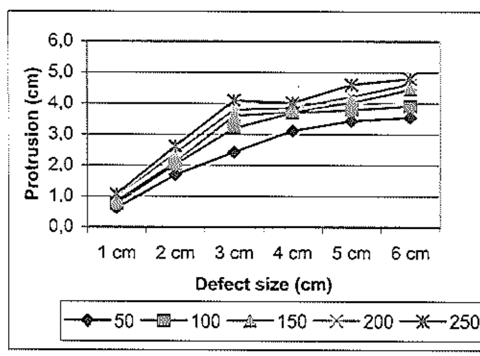


Figure 3 A: *Protrusion as a function of air pressure at increasing defect size. Mesh overlap 1 cm.*

Air pressure in mmHg

	50	100	150	200	250
1 cm	0	0,3	0,4	0,4	0,5
2 cm	0,7	0,9	1,1	1,2	1,4
3 cm	1,4	1,7	1,9	2,0	2,1
4 cm	1,6	2,1	2,4	2,5	2,7
5 cm	2,3	2,6	2,9	3,2	3,5
6 cm	2,4	3,0	3,2	3,5	3,7

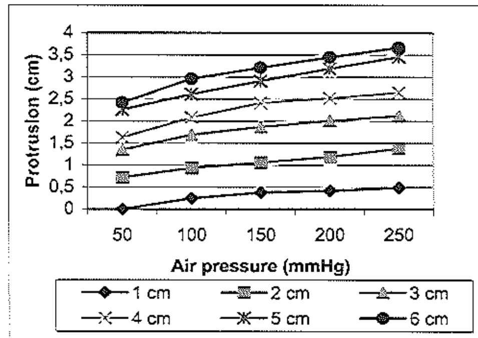


Figure 3 B: *Protrusion as a function of air pressure at increasing defect size. Mesh overlap 2 cm.*

Air pressure in mmHg

	50	100	150	200	250
1 cm	0	0,2	0,4	0,4	0,4
2 cm	0,6	0,8	0,9	1,0	1,1
3 cm	1,2	1,5	1,8	1,9	2,0
4 cm	1,4	1,8	2,0	2,3	2,3
5 cm	2,0	2,4	2,7	2,9	2,8
6 cm	2,3	2,7	3,0	3,2	3,2

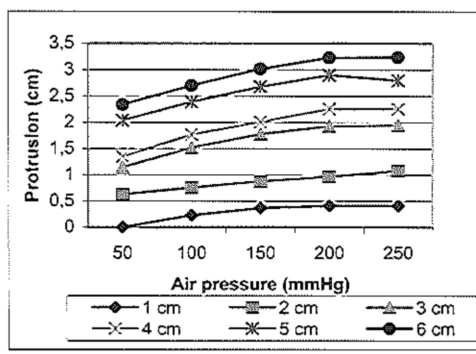


Figure 3 C: *Protrusion as a function of air pressure at increasing defect size. Mesh overlap 3 cm.*

Air pressure in mmHg

	50	100	150	200	250
1 cm	0	0,3	0,3	0,4	0,4
2 cm	0,5	0,7	0,8	0,9	1,1
3 cm	0,9	1,2	1,4	1,6	1,7
4 cm	1,2	1,6	1,9	1,8	2,0
5 cm	1,6	2,1	2,3	2,3	2,5
6 cm	1,8	2,3	2,8	3,1	3,0

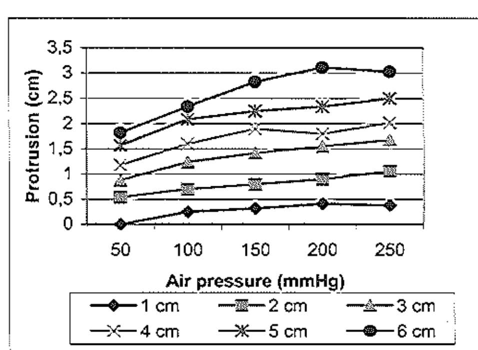


Figure 3 D: *Protrusion as a function of air pressure at increasing defect size. Mesh overlap 4 cm.*

Air pressure in mmHg

	50	100	150	200	250
1 cm	0	0,2	0,3	0,4	0,4
2 cm	0,5	0,7	0,8	0,9	1,0
3 cm	0,8	1,1	1,3	1,5	1,6
4 cm	1,1	1,6	1,8	1,9	2,0
5 cm	1,5	2,0	2,1	2,3	2,3
6 cm	1,6	2,3	2,6	2,9	2,9

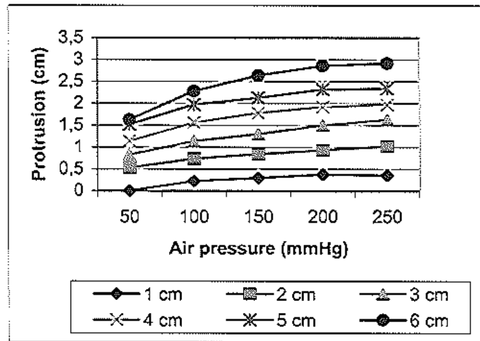


Figure 3 E: *Protrusion as a function of air pressure at increasing defect size. Mesh overlap 5 cm.*

Air pressure in mmHg

	50	100	150	200	250
1 cm	0	0,2	0,2	0,2	0,4
2 cm	0,5	0,7	0,8	0,9	1,0
3 cm	0,8	1,1	1,3	1,4	1,6
4 cm	1,1	1,5	1,6	1,8	1,9
5 cm	1,5	1,8	2,0	2,2	2,2
6 cm	1,6	2,2	2,6	2,8	2,8

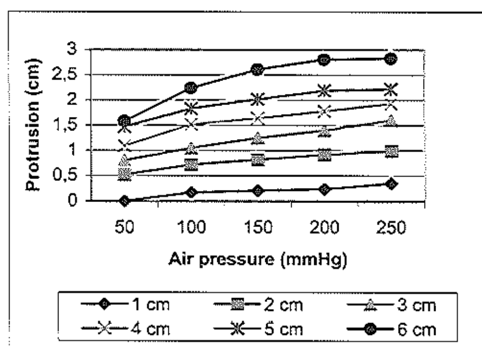


Figure 4 A: *Protrusion as a function of mesh overlap at increasing defect sizes.*

Air pressure 50 mmHg

	1 cm	2 cm	3 cm	4 cm	5 cm	6 cm
0 cm	0,6	1,7	2,4	3,1	3,4	3,6
1 cm	0	0,7	1,4	1,6	2,3	2,4
2 cm	0	0,6	1,2	1,4	2,0	2,3
3 cm	0	0,5	0,9	1,2	1,6	1,8
4 cm	0	0,5	0,8	1,1	1,5	1,6
5 cm	0	0,5	0,8	1,1	1,5	1,6

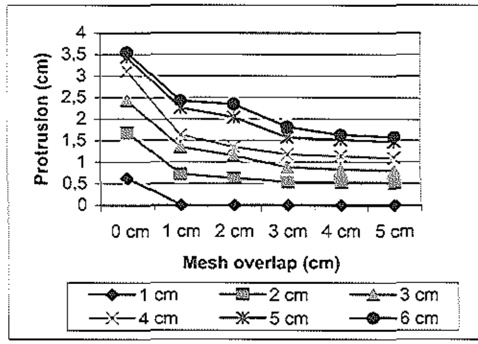


Figure 4 B: *Protrusion as a function of mesh overlap at increasing defect sizes.*

Air pressure 100 mmHg

	1 cm	2 cm	3 cm	4 cm	5 cm	6 cm
0 cm	0,76	2,03	3,2	3,7	3,79	3,92
1 cm	0,25	0,94	1,69	2,08	2,61	2,96
2 cm	0,23	0,76	1,52	1,77	2,39	2,56
3 cm	0,25	0,7	1,24	1,6	2,09	2,34
4 cm	0,23	0,74	1,14	1,56	1,97	2,28
5 cm	0,17	0,72	1,05	1,52	1,83	2,24

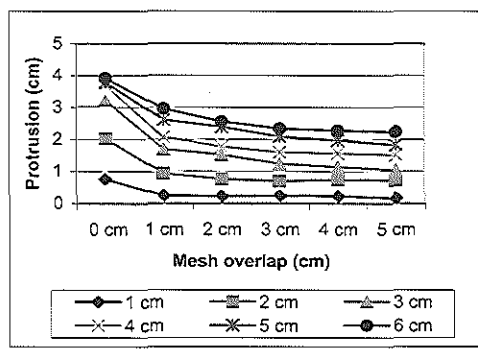


Figure 4 C: *Protrusion as a function of mesh overlap at increasing defect sizes.*

Air pressure 150 mmHg

	1 cm	2 cm	3 cm	4 cm	5 cm	6 cm
0	0,85	2,1	3,6	3,73	4,03	4,45
1	0,38	1,06	1,87	2,41	2,91	3,21
2	0,37	0,88	1,78	2,01	2,68	3,02
3	0,32	0,8	1,42	1,9	2,25	2,83
4	0,3	0,84	1,3	1,78	2,13	2,64
5	0,21	0,82	1,25	1,64	2,02	2,61

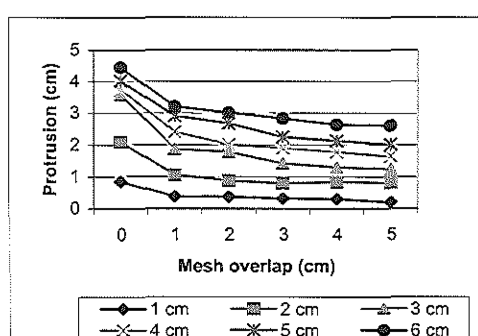


Figure 4 D: *Protrusion as a function of mesh overlap at increasing defect sizes.*

Air pressure 200 mmHg

	1 cm	2 cm	3 cm	4 cm	5 cm	6 cm
0	1	2,39	3,8	3,85	4,22	4,62
1	0,42	1,19	2,01	2,52	3,19	3,45
2	0,41	0,97	1,93	2,26	2,9	3,23
3	0,41	0,9	1,55	1,8	2,34	3,11
4	0,38	0,93	1,5	1,92	2,32	2,86
5	0,24	0,92	1,4	1,78	2,19	2,81

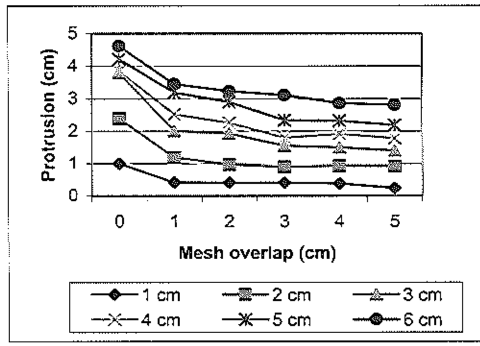


Figure 4 E: *Protrusion as a function of mesh overlap at increasing defect sizes.*

Air pressure 250 mmHg

	1 cm	2 cm	3 cm	4 cm	5 cm	6 cm
0	1,07	2,62	4,1	4,02	4,61	4,8
1	0,49	1,38	2,12	2,65	3,46	3,67
2	0,49	1,08	2,03	2,36	3,09	3,42
3	0,47	0,99	1,68	2,05	2,5	3,15
4	0,42	1,02	1,66	2,03	2,4	2,95
5	0,35	1,02	1,6	1,93	2,22	2,83

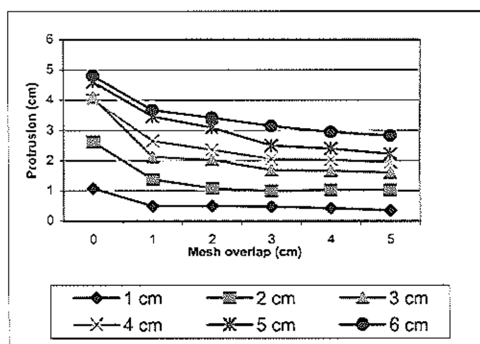


Figure 5 A: *Protrusion as a function of air pressure. Defect size 3 cm.*

Air pressure in mmHg

	50	100	150	200	250
0 cm	2,4	3,2	3,6	3,8	4,1
1 cm	1,4	1,7	1,9	2,0	2,1
2 cm	1,2	1,5	1,8	1,9	1,8
3 cm	0,9	1,2	1,4	1,6	1,7
4 cm	0,8	1,1	1,3	1,5	1,7
5 cm	0,8	1,1	1,3	1,4	1,6

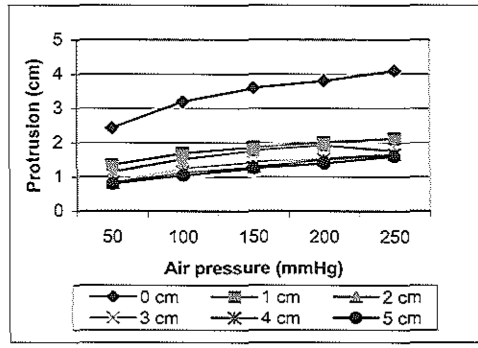
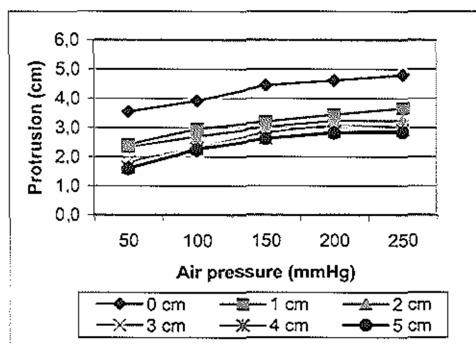


Figure 5 B: *Protrusion as a function of air pressure. Defect size 6 cm.*

Air pressure in mmHg

	50	100	150	200	250
0 cm	3,6	3,9	4,5	4,6	4,8
1 cm	2,4	3,0	3,2	3,5	3,7
2 cm	2,3	2,7	3,0	3,2	3,2
3 cm	1,8	2,3	2,8	3,1	3,0
4 cm	1,6	2,3	2,6	2,9	2,9
5 cm	1,6	2,2	2,6	2,8	2,8



Discussion

Endoscopic repair is gaining popularity in the treatment of inguinal hernias. This is due to promising early reports of rapid recuperation and a low recurrence rate after short follow-up [4,5,8]. Both the use of prosthetic mesh to create a tension-free repair and the endoscopic technique itself are responsible for these results. When recurrences do occur, the size of the prosthesis is often a cause of the recurrence [2,6,11,12,13,14]. An inadequately sized prosthesis which does not cover all defects and does not provide sufficient overlap, allows a new hernia to pass through the abdominal wall defect [2,6,11,12,13,14]. Furthermore a small prosthesis placed over an isolated defect may lead to recurrence because of subsequent enlargement of the defect or shrinkage of the prosthesis [11]. A prosthesis placed over an isolated defect ignores the possible weakness of the entire inguinal region, and a future recurrence might occur at another site due to inadequate coverage of potential hernia defects. All hernias pass through the inguinal wall at the musculopectineal opening. The size of this musculopectineal opening varies according to the structure of the muscular triangle [16,18]. In this area the transversalis fascia represents the only resistant layer of the abdominal wall. A piece of synthetic mesh easily reinforces this area of weak transversalis fascia and assures perfect and permanent tightness of the deep inguinal layer. Therefore, the prosthesis should cover the entire myopectineal orifice. The prosthesis must extend beyond the weak inguinal area in all directions so that it is pushed by intra-abdominal pressure against the abdominal wall and quickly becomes attached by growth of connective tissue through the mesh [16].

Elevation of the intra-abdominal pressure during exercise might lead to protrusion of a mesh into the hernial defect; when the mesh is too small, a hernia recurrence might subsequently occur. Those activities that act to increase intra-abdominal pressure and favor hernia formation, including coughing and heavy weight lifting, will probably not affect preperitoneal prosthetic repair when an adequate mesh size is chosen. Determination of adequate mesh size is therefore of great importance. According to

Lowham et al. overlap of 2 cm of the mesh over the defect is adequate when the mesh is stapled. However, when the mesh is not stapled an overlap of 3 cm is necessary. This would result in a mesh size of 10-15 x 10-15 cm [11]. It is not clear however how the authors determined this adequate mesh size.

To show the relationship between the degree of protrusion and the intra-abdominal pressure, measurements were performed at increasing air pressures in which defect sizes and mesh overlap were varied. One measurement series without a mesh was performed to visualize the effect of the presence of a mesh on protrusion *(fig.2)*. The difference in protrusion when no mesh is used when compared to the protrusion in presence of a mesh shows that the mesh has an evident reinforcing effect on the abdominal wall at the hernia site. Furthermore it was shown in this experiment that when using a mesh, the increasing air pressure (in vivo: intra-abdominal pressure) leads to increasing protrusion of the mesh. This increase in protrusion increases as defect size increases *(fig.4)*. Therefore a larger mesh is needed to adequately cover defects with increasing diameters. The increase in protrusion however is less as mesh overlap increases *(fig.3,4,5)*. Thus the increase of protrusion decreases as mesh overlap increases. At a certain mesh overlap the defect is adequately covered and increase of mesh overlap does not lead to a significant effect on the level of protrusion.

The most important contribution of increasing mesh size to the decrease in protrusion takes place at the lower range of mesh overlap (1–3 cm) hereafter there is an evident diminishing effect of the enlargement of the meshes most clearly shown at the larger defect sizes. At a defect size of 1 cm to 3 cm a diminishing effect of the enlargement of the meshes appears after 2 cm mesh overlap whereas at a defect size of 4 to 6 cm this diminishing effect appears after 3 cm mesh overlap *(fig. 4)*.

The results of this porcine study give an indication of an adequate mesh size for inguinal hernia repair. Of course several assumptions have been made to be able to perform this in vitro study. We do not know what kind of effect freezing and thawing of the pigs' abdominal walls have on the mesh protrusion in this model. Furthermore, in this model it is not possible to appreciate the effect of the presence of fibrin (the body's own 'glue') which might provide some initial stability. As meshes get incorporated into the tissue when ingrowth occurs it is possible that protrusion decreases in time due to fixation of the mesh as a cause of this tissue ingrowth. Realizing the imperfection of this model and keeping the incompleteness of an in vitro experiment in mind, interesting conclusions can be drawn considering mesh size in inguinal hernia repair

Conclusions

The success of endoscopic hernia repair depends on the surgeon's expertise in repairing the inguinal hernia. Furthermore an adequate mesh size to cover all potential hernia sites is needed. The results of this porcine study give an indication of an adequate mesh size for inguinal hernia repair. Independent of the defect size (in this model up to 6 cm) the use of a mesh prosthesis with more than 3 cm overlap results in only minimal further protrusion into the hernia defect. Extrapolating this outcome to clinical practice might lead to decreased recurrence rates in inguinal hernia repair. However, clinical studies have to prove this assumption by showing a decrease of recurrence rates using this mesh size.

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Chapter 7

Complications of conventional and endoscopic inguinal hernia surgery

MTT Knook and HJ Bonjer

"Nothing so prevents the occurrence of complications as one's awareness and the fear of them".

R. Bendavid.

Groin Hernia Surgery. Surgical Clinics of North America. 1998.

Introduction

Endoscopic repair of inguinal hernias was introduced into daily surgical practice in the early 90's. One of the great differences between endoscopic and conventional inguinal hernia surgery is the surgical approach. In endoscopic surgery, the inguinal canal is left intact, and the posterior aspects of the groin are exposed either by preperitoneal or transperitoneal access. Conventional inguinal hernia surgery entails opening the inguinal canal and identification of the anatomical elements of the groin on the anterior side. Due to the lack of preperitoneal inguinal procedures in conventional surgery, knowledge of and instruction in preperitoneal anatomy was limited until recently. The use of endoscopic techniques and a preperitoneal approach to the posterior anatomy of the groin are novelties to inguinal hernia surgery. New developments are known to be associated with complications due to the lack of experience of those who are performing innovative surgery. Therefore, it is not surprising that some have suggested that endoscopic inguinal hernia surgery is associated with more complications than conventional open inguinal hernia surgery.

This review attempts to document and relate complications of conventional and endoscopic inguinal hernia surgery to surgical experience and technology.

Peroperative surgical complications

Surgical complications can occur in both open and endoscopic inguinal hernia repair. Some complications are procedure-related but most of them occur in both techniques. Known complications of open inguinal hernia repair are hemorrhage, nerve injury, disturbance of testicular blood supply, injury of the vas deferens, injury to the intestine or urinary bladder, and femoral vein stenosis [49]. All of these complications, except for femoral vein stenosis, can also occur in endoscopic inguinal hernia repair. Procedure-related complications of endoscopic surgery, although rare, are most frequently bowel perforations or vessel lacerations which occur during trocar placement [7,8,17,21,28,29,47,55,62,63,64,76]. The reported incidence of major vascular lesions (iliac arteries or veins, aorta, vena cava) ranges between 0.06 and 0.14% for laparoscopic procedures [28,29,62,64,76]. Visceral injury (predominantly bowel injury) is reported to occur in 0.12 to 0.2% of the laparoscopic procedures [8,29,64].

Vascular injury in open and endoscopic inguinal hernia repair

Vascular injury is relatively rare in open inguinal hernia repair. Only one randomized controlled trial reported an incidence of vascular injury of 2 % for open hernia repair [37]. The femoral vein may be constricted by sutures placed during the course of open hernia repair, particularly the non-mesh techniques such as Coopers' ligament repair (McVay) [9,46,48,49]. Furthermore sutures may be placed through the iliac artery or vein when the internal orifice is narrowed after a hernioplasty [67].

Only two articles have reported figures for vascular or visceral injury in endoscopic inguinal hernia repair, ranging from 0.08 to 1% [57,63]. These injuries all occurred during transabdominal endoscopic hernia repair.

Vascular injury occurred more frequently during other endoscopic procedures such as laparoscopic cholecystectomy, diagnostic laparoscopy, laparoscopic appendectomy and tubal sterilization with incidences of 0.06 to 0.2% [28,29,62,64,76]. It is therefore likely that these injuries also occur in endoscopic inguinal hernia repair. Trans-abdominal inguinal hernia repair, due to the invasion of the abdominal cavity, is more susceptible to trocar-related complications [57,64,71]. When the trocar is introduced blindly into the abdominal cavity, it can cause injury of the intra-abdominal structures [57,71]. In total extra-peritoneal hernia repair the trocar is positioned 'a vue' in the preperitoneal space; therefore injury of the intra-abdominal organs cannot occur in this fase. In total extra-peritoneal and trans-peritoneal dissection of the preperitoneal space, injury of the iliac vessels can occur when dissection of the hernial sac from the funiculus takes place, since the iliac artery and vein lie just behind the cord structures. Although injuries of the vena cava have been discussed by some authors, exact figures have not been given [24,75]. Laceration of the inferior epigastric vessels occurred in 0.07 % of repairs in a series of 1423 hernias, reported by Felix et al, due to improper trocar placement [24]. In our own series of 451 hernia repairs, vascular complications were not encountered, although the inferior epigastric vessels had to be clipped in a minority of cases because they were hanging from the abdominal wall (due to inadequate positioning of the dissection balloon) and obscured visibility during the repair [33,34,35].

Apart from laceration of the abdominal vessels during trocar placement in transabdominal endoscopic hernia repair, abdominal vessels can be lacerated during dissection in the preperitoneal area in total extra-peritoneal endoscopic inguinal hernia repair. If dissection of the inguinal areais not performed carefully, the iliopubic and aberrant obturator vessels can be lacerated in the area of the femoral ring and medial to Cooper's ligament. As mentioned above, in the area between the spermatic vessels and the spermatic duct, the external iliac artery and vein are in danger [44]. Knowledge of the anatomy of the inguinal area is essential to prevent damage to the vessels of the inguinal area since dissection close to these structures can then be avoided.

Bowel and bladder injury

Bowel injury is very uncommon in open hernia surgery and is usually related to emergency surgery for incarcerated hernias. Bladder injury, when encountered in open hernia repair, is usually restricted to hernia repairs in children [74].
In a survey to study the incidence of complications related to endoscopic herniorraphy in a total number of 3229 herniorraphies reported by Phillips [54], bowel injury was reported only once (0.03 %) and bladder injury twice (0.06 %). All three injuries occurred in a TAPP procedure. Felix [24] reported laceration of the bowel in two patients due to improper trocar placement, and laceration of the small bowel due to dissection of adhesions in a recurrent inguinal hernia once, both during TAPP approaches (0.6 %). In this series of a total of 1423 hernioplasties, no bowel injuries occurred during the TEP approach. Several other authors have reported an incidence of 0.12-0.2% visceral injuries during TAPP hernia repair [8,29,64].
Although the incidence of these complications seems to be low, one must always try to avoid them. When establishing the pneumoperitoneum, improper placement of a trocar can result in laceration of the colon. Small bowel injuries can occur in patients with adhesions due to previous abdominal operations. During dissection, insufficiently isolated instruments can cause perforations of the bowel due to damage induced by electrocautery [8].
The bladder is at risk in endoscopic inguinal hernia repair when a Verres needle is not positioned carefully or when careless dissection takes place as the Retzius' space is entered to create enough room to position the mesh adequately, especially after prostatectomy or irradiation therapy in this area. In both cases a full bladder predisposes to bladder injury. In TAPP hernia repair the bladder is also at risk when the peritoneum is opened medial to the medial umbilical fold.

Reducing the risk of trocar- related complications

When the intra-abdominal cavity is entered, as when performing a TAPP endoscopic inguinal hernia repair, the open 'Hasson' procedure for the placement of the sub-umbilical trocar is likely to reduce the possibility of these injuries [7,11,17,28,29,62,64,76]. Especially for patients with prior abdominal operations this approach is advocated. However, an open introduction is not a guarantee for an uneventful approach [7,64]. Other trocars should be inserted under direct vision [76]. Furthermore, when using cautery during dissection, one must always keep in mind the risk of current leakage leading to coagulation of tissue not directly visible due to the limited view through the endoscope. Unnoticed damage can be done to vital organs out of sight [8]. To prevent laceration of vessels in the abdominal wall upon insertion of trocars, laparoscopic trans-illumination provides a clue in patients of normal weight [55]. Of course, knowledge of the anatomy generally remains essential for preventing damage [3,12].

Peritoneal laceration

Peritoneal laceration is a 'complication' related to the total extra-peritoneal endoscopic procedure. Peritoneal laceration is not specifically discussed in reports on complications of endoscopic inguinal hernia repair, probably because it is not regarded as such. However, in daily practice this problem is encountered relatively frequently. Peritoneal laceration is specifically a problem of TEP inguinal hernia repair as the peritoneum can tear when the preperitoneal cavity is created. Preperitoneal dissection can be difficult, especially after appendectomy, in the repair of recurrent inguinal hernias, and midline laparotomies. Laceration of the peritoneum occurs easily and introduces a handicap in preperitoneal dissection due to the escape of the insufflated carbondioxide into the intra-abdominal cavity. In our own series of 417 TEP inguinal hernia repairs a total of 54 (14%) peritoneal lacerations was encountered [33,34]. These tears did not lead to any further complications. Larger tears can cause difficulties in further preperitoneal dissection due to gas leakage intra-abdominally. To eliminate this problem a Veres needle can be placed intra-abdominally to evacuate the gas. If possible tears should be closed to avoid adhesion of intra-abdominal organs to the mesh [77], small tears with an endoloop and large tears with a running suture.

Pneumatic complications in endoscopic inguinal hernia repair

Case reports have been written on the occurrence of pneumomediastinum, pneumothorax and subcutaneous emphysema in endoscopic inguinal hernia repair [10,25,54,68]. Although encountered frequently in daily practice, a pneumoscrotum was not mentioned in published reports, probably because it is not considered to be a complication but an operation-related phenomenon which resolves spontaneously.
A pneumothorax was identified as a complication of endoscopic herniorraphy in two patients with insufflation pressures of 15 mmHg and a surgical procedure of more than two hours by Ferzli et al. [25]. The pathogenesis of this complication was not described. It is however thought that the level of the insufflationpressure might influence the occurrence of pneumothorax. Subsequently, a prospective study was performed on the effect of reducing insufflation pressure to 10 mmHg instead of 15 mmHg. In 50 patients, an insufflation pressure of 10 mmHg did not lead to pneumothorax [25]. In endoscopic TAPP inguinal hernia repair a pneumothorax can occur when gas enters the thorax through congenital defects in the diaphragm. The CO_2 then ascends along the blood vessels towards the mediastinum, resulting in a pneumomediastinum or pneumopericardium. In TEP endoscopic inguinal hernia repair these pneumatic complications occur due to the continuity of the extra-peritoneal space with the thoracic cavity [56]. Browne et al. described possible mechanisms which may contribute to the occurrence of pneumatic complications in TEP hernia repair such as peritoneal laceration and leakage of gas around diaphragmatic hernias or displacement of gas retroperitoneally [2]. Furthermore, subcutaneous CO_2 emphysema can occur due to

improper placement of the Veress needle and leakage of CO_2 around the trocars [52]. These pneumatic complications all resolved spontaneously [2,25,52,56].
However, since an asymptomatic pneumothorax is also found in a small percentage of patients during routine check-up, the occurrence of a pneumothorax after endoscopic repair might just be a coincidence.

Complications related to the insufflation of carbon dioxide in endoscopic inguinal hernia repair

CO2 insufflation of the peritoneal cavity can result in hypercapnia, acidosis, and hemodynamic alterations [13]. Adverse hemodynamic effects arise mainly from hypercapnia and elevated intra-abdominal pressure caused by pneumoperitoneum [19,43,50,60,68]. Hypercapnia and acidosis are usually secondary to absorption of insufflated CO_2 into the vascular system or to ventilation perfusion mismatch during the procedure due to the elevated intra-abdominal pressure and atelectasis of alveoli in the inferior pulmonary lobes [50,60,68]. The physiologic effects of hypercapnia include autonomic stimulation of the cardiovascular system such as tachycardia and hypertension, followed by acidosis-mediated myocardial depression, vasodilatation and hypotension [43]. However, although these physiologic alterations can have a major impact on the cardiovascular and pulmonary-compromised individual, they are of minor concern in the otherwise healthy patient [32,43,45,50,60].

Postoperative complications

Nerve injury and pain

Nerve injury is in fact a complication that is caused peroperatively, leading to postoperative complaints. Postoperative neuralgia and meralgia paresthetica occur in both conventional and endoscopic inguinal hernia repairs.

In open inguinal hernia repair, neuralgia is usually due to injury to the ilio-inguinal nerve or the ilio-hypogastric nerve. Injury to these nerves can occur during incision of the external aponeurosis and the dissection of the spermatic cord. The incidence of pain reported after open herniorraphy varies from less than 2% to as high as 11 % [16,44].

In endoscopic hernia repairs, the lateral cutaneous femoral (LFC) nerve and the genitor-femoral (GF) nerve are at risk [1, Chapter 2, fig.4]. The lateral cutaneous nerve of the thigh is vulnerable during dissection or stapling at the lateral end of the inguinal ligament [1]. The incidence of pain reported after endoscopic herniorraphy varies from 1 % to 4 % [24,44,56,75]. Only occasionally do staples or tacks penetrate so deeply into the abdominal wall that they cause irritation of the ilio-inguinal or ilio-hypogastric nerves.

In a comparative study on complications and results of open and endoscopic inguinal hernia repairs, Wilson et al. reported an incidence of postoperative neuralgia of 7.4 % for Lichtenstein repairs, and 0.8 % for endoscopic repairs [78]. Eubanks et al. described five patients (2%) out of a series of 252 hernia repairs who experienced meralgia paresthetica that resulted from staple entrapment of the lateral femoral cutaneous nerve during endoscopic herniorraphy [22]. Seid et al. reported three patients (2%) out of a series of 145 endoscopic herniorraphies who developed nerve entrapment [63]. Most cases of neural injury or entrapment after endoscopic herniorraphy are transient and need no further treatment. However, in the case of persistent severe groin pain a re-endoscopy can be considered to remove the staples placed through the injured nerve [22,58,63].

It is often difficult to diagnose severe nerve injury after inguinal herniorraphy because transient anesthesia or pain in the distribution of these nerves is not an uncommon postoperative occurrence. Because the distribution of sensory nerves in the inguinal region overlaps, a specific entrapment syndrome may be difficult to recognize [59]. The laparoscopic repair with staple fixation of prosthetic mesh places all the nerves of the lumbar plexus at risk for entrapment. Fewer surgeons are familiar with the inguinal anatomy seen from the posterior or preperitoneal approach than from the anterior approach. This anatomical knowledge is, however, important because this approach poses risks to specific nerves and vessels. Inadequately positioned staples can injure the genital branch of the genitofemoral nerve, ilioinguinal nerve, lateral femorocutaneous nerve, and the femoral branch of the genitofemoral nerve [42,59,72]. Because of the erratic and unpredictable course of the nerves deep to the iliopubic tract and the iliopsoas fascia this area should be avoided when placing staples or sutures lateral to the internal ring [41,59]. Considering the possibility of nerve entrapment, it would be good practice to avoid stapling of the mesh. When stapling is however necessary, adequate knowledge of nerve anatomy prevents nerve entrapment. In a comparative study of two groups of 50 patients, one with stapled meshes and one with non-stapled meshes no difference in nerve entrapment or recurrence rate was found [26]. The incidence of neuralgia decreases dramatically as the surgeon becomes more familiar with the anatomy of the nerve supply to the groin when viewed endoscopically [27].

Infections

As well as in open hernia surgery, infections can also occur in endoscopic inguinal hernia repair. The presence of a mesh in endoscopic repairs contributes to the higher risk of infection compared to those repairs without the use of foreign materials.

Infections can vary from a mild wound infection (0.2%) without any consequences to a persistent mesh infection leading to mesh removal (0.1%) [27]. In open non-mesh repairs drainage of the wound usually results in cure of the infection. In endoscopic repairs however due to the presence of a mesh the infection can persist. In these cases the only cure of the infection is to remove the mesh. In our own series of 451 hernia repairs, 2 mesh infections occurred. One patient recovered uneventfully after drainage of the abscess, the other developed a fasciitis of the abdominal wall and later died of ARDS (acute respiratory distress syndrome) [34]. Mesh infections are a feared complication of open and endoscopic inguinal hernia repair. Although the incidence of mesh infections is low they can have major consequences when they do occur. A serious infection may lead to fasciitis and necrosis of the tissues and deep abscess formation [27, 34]. Only one randomized trial has been published on the use of antibiotics in mesh hernia repair, where a decrease in wound infections after the administration of a single dose of antibiotics was found [81].

Seromas

Seromas occur after open and endoscopic procedures. An incidence of 7.4% has been reported for endoscopic hernia repair vs. 1.6% for Lichtenstein repairs [78]. This difference in incidence can be explained by the more extensive preperitoneal dissection inherent in endoscopic inguinal hernia repair.

Damage to the lymphatic drainage system may lead to the occurrence of seromas. Extensive skeletonization of the spermatic cord and tissue dissection from the sac can result in the severance of lymphatic vessels. Seromas vary in size and may be large enough to simulate a recurrent inguinal hernia. Seromas usually resorb spontaneously. Therefore drainage does not seem necessary [27]. If a seroma persists however, drainage by aspiration can be undertaken 6 to 8 weeks postoperatively [26]. Aspiration of a persistent seroma is necessary in 0.1–1.8% of the cases [27]. Ultrasound or MRI can be used to distinguish a recurrent hernia from a seroma. Since ultrasound is investigator-dependent and therefore less reproducible, MRI seems to be the best method to distinguish a recurrent hernia from a seroma. MRI can reveal even small postoperative fluid collections after surgical repair and can demonstrate a succesfullaparoscopic herniorraphy by showing the proper position of the mesh in the absence of a hernia [6].

Hematomas

Hematomas have been reported to occur after open hernia surgery in 2.7–33% of cases, in endoscopic surgery this incidence is 2–3% [5,79]. Bleeding is rarely of an extent that requires drainage. If so, however, one could leave a small drain behind. In our opinion drainage introduces a risk of contamination and we prefer to reserve drains for specific indications (coagulopathies, excessive diffuse bleeding).

Bleeding in endoscopic inguinal hernia repair is due to the extensive preperitoneal dissection, needed to create enough space to position a mesh adequately, which causes a large wound. During endoscopy, the preperitoneal space is insufflated with CO2 gas at preperitoneal pressures varying from 10 to 15 mmHg. Bleeding of small vessels might be obscured at this time since the pressure compresses the veins. After desufflation of the preperitoneal space some bleeding from these vessels may occur, resulting in postoperative haematomas of varying sizes of.

In our own series of 451 hernia repairs (353 patients), 27 patients (37 hernia repairs, 8 % of the hernia repairs) presented with a inguinal hematoma in two cases (0.4%) evacuation of the hematoma by fine needle aspiration was necessary [33,34,35]. Differentiation according to the different types of repairs reveals that, of these patients, 11 (4%) had had a TEP hernia repair, 10 (20 hernias) a bilateral hernia repair (10%) and 6 a TAPP repair (17%) after a recurrent inguinal hernia [33,34,35].

Trocar site hernias and bowel obstruction related to endoscopic inguinal hernia surgery

Trocar hernias obviously only occur in endoscopic hernia repair. Trocar hernias have developed after inguinal hernia repair in a small number of cases, specifically after TAPP endoscopic inguinal hernia repair. The risk of herniation of abdominal contents through the trocar insertion sites depends on the trocar size. The 5 mm trocar sites are at low risk for the development of incisional hernias whereas herniation may occur via the 10 mm incisions. Adequate closure of the fascia of the larger (>5 mm) incisions will solve this problem [24,54]. In the survey reported by Phillips [54] on 3229 herniorraphies the incidence of trocar hernias was 0.06%, all in TAPP inguinal hernia repair. Felix [24] reported 6 trocar hernias in a total of 1423 hernia repairs (0.4%).
Bowel obstruction can occur due to adhesions formed between bowel and mesh prosthesis or herniation of the bowel through trocar sites or the peritoneal closure over the mesh in TAPP hernia repair. [20,40,41]. Small bowel obstruction occurred in 5 (0.2%) of the 3229 patients analyzed by Phillips, all in TAPP inguinal hernia repair [54]. Fitzgibbons reported two patients with small bowel obstruction out of a series of 686 patients (0.2%) both needing intervention [27]. Bowel obstruction was further reported by Tucker [75] in one patient (0.4%) and by Felix in one out of 1423 (0.07%) hernia repairs [24]. Bowel obstruction only occurs when the bowel comes in contact with mesh or an opening in the abdominal wall. Thus, these complications do not occur in total extraperitoneal endoscopic hernia repair, since the peritoneum is left intact. Bowel obstruction due to adhesions is a rare complication, which requires intervention.

Testicular atrophy and ischemic orchitis

Damage to the testicle can occur both in open and in endoscopic surgery. Ischemic orchitis, a postoperative inflammation of the testicle, usually manifests itself clinically (painful enlargement of the testicle to two to three times the normal size) within 24 to

72 hours following inguinal hernia repair. An ischemic orchitis may progress and result in testicular atrophy, a process that can take several months [59].

Arterial and venous flow in the testis is assured by many collateral vessels which protect the testis from ischemic injury [59]. Careful dissection and preservation of vessels is important to preserve these anastomoses during hernia repair. Testicular atrophy may occur after complete excision of a large scrotal hernia sac which involves extensive dissection of the cord distal to the pubic tubercle and disruption of the vascular anastomoses that occur between branches of the scrotal, pudendal and testicular arteries. In endoscopic hernia repair it is advisable to transect a large scrotal hernia sac and reduce only the preperitoneal sac, thus leaving the scrotal and testicular vascularization intact. The reported incidence of orchitis/epididimitis after endoscopic hernia repair is 0.9% [27].

Testicular atrophy can also occur as a result of intense venous congestion within the testicle secondary to thrombosis of the veins within the spermatic cord. The initiating trauma is also seen during dissection of the cord from the hernial sac. Tight closure of the internal inguinal ring may also contribute to this phenomenon. Therefore, this complication may be more common in open hernia surgery than in an endoscopic mesh repair [4].

Conclusions

When discussing complications of inguinal hernia surgery a line should be drawn between major complications and minor complications. Major complications are those requiring surgical intervention or those that result in disability, such as vessel and bowel injury, bladder injury, testicular ischemia or atrophy, nerve entrapment, mesh infection and recurrences. Minor complications are those that resolve spontaneously or require a short course of antibiotics or drainage such as seromas, hematomas and transient neuralgias. Most major complications tend to occur during the learning curve of the individual surgeon and thus lessen with experience time.

Injury of the intra-abdominal viscera can occur during introduction of the trocars into the abdominal cavity. In patients who have had previous abdominal surgery, the bowel is especially at risk due to adhesions with the abdominal wall. These injuries however can be avoided by using the open trocar placement technique.

The advantages of stapling include a reduction of the risk of mesh migration; the disadvantages include nerve entrapment, vessel laceration and pain in the abdominal wall.

Since stapling is a major cause of nerve injury in endoscopic inguinal hernia repair it might be advisable to avoid the use of staples. When an adequately sized prosthesis is positioned over the defect the prosthesis is held in place by the intra-abdominal pressure when adequate repair is performed. Using a larger mesh, which adequately covers the potential hernia sites, and is held in place by the intra-abdominal pressure, eliminates the necessity of stapling. When stapling is necessary, stapling to 'Coopers ligament' is a relatively safe option. Nevertheless complications such as osteitis of the pubic bone may occur and the obturator branch of the epigastric artery may be severed easily when stapling inferior to the pubic bone.

Thus, complications after endoscopic inguinal hernia repair occur. The risk however appears to be comparable to that of open hernioplasty. Endoscopy-related complications are introduced using the endoscopic approach. The incidence of these complications remains low and varies significantly with the approach chosen (TAPP or TEP) and the experience of the surgeon.

Table 1.

Complications of hernia surgery, in conventional, total extra-peritoneal and trans-abdominal hernia repair.

	Conventional %	TAPP %	TEP %	TEP/TAPP %
Visceral/Vascular [58,64]		0.08-0.1%		
Vascular [38]	2		0	
Epigastric vessels [24]		0.07		
Visceral [8,29,65]		0.12-0.2		
Bowel [24,55]	0	0.03-0. 6	0	
Bladder [55]	0	0.06	0	
Peritoneal laceration [33,34]	0	0	14	
Nerve injury [16,24,45,57,76,79]	2-11			1-4
Pneumothorax [10,25,53,55,69]	c.r.	c.r.	c.r.	
Pneumomediastinum [10,53,57]	c.r.	c.r.	c.r.	
Pneumopericardium [10, 53]	c.r.	c.r.	c.r.	
Hypercapnia [13, 51,61,69]	c.r.	c.r.	c.r.	
Trocar site hernias [24,55]	0	0.06-0.4	0	
Seromas [79]	1.6			7.4
Hematomas [5,33,34,35,80]	2.7-33			1.4-17
Bowel obstruction [24,27,55,76]	0	0.07-0.4	0	
Wound infections [27]	0.2	0	0	
Mesh infections [27,34]	0.1	0	0	
Testicular atrophy [27]	?			0.9

c.r. = case report

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Chapter 8

Impact of randomized trials on the application of endoscopic techniques for inguinal hernia repair in the Netherlands

MTT Knook, LPS Stassen, HJ Bonjer.

Surgical Endoscopy (2001) 15: (1): 55-58

Abstract

Introduction: One year after publication of a Dutch prospective trial randomizing patients with inguinal hernias to either endoscopic or open repair, a questionnaire was sent to all Dutch surgeons to evaluate the impact of this trial on the application of endoscopic inguinal hernia repair in the Netherlands.

Methods: All 780 registered Dutch surgeons were addressed. The performance of endoscopic inguinal hernia repair, the technique and the indications, involvement of surgical residents, motives for use of conventional techniques, and type of open repair were documented.

Results: Response rate was 100%. Endoscopic inguinal hernia repair was performed by 16% of Dutch surgeons. The total extra-peritoneal approach was the preferred endoscopic technique in 81%. Primary inguinal hernias were approached endoscopically by only 54% of these surgeons, and recurrent hernias by 92%. The technique of choice for open repair of primary hernias was the Shouldice repair. Recurrent inguinal hernias were predominantly repaired using the Lichtenstein technique.

Conclusions: Although randomized clinical trials have provided evidence that the endoscopic approach to inguinal hernias is preferable, only 1 out of 6 Dutch surgeons has adopted the endoscopic inguinal hernia repair. Improvement of training of both surgical residents and surgeons, and increasing awareness among medical doctors and patients about the benefits of endoscopic inguinal hernia repair are necessary to enhance the acceptance of this valuable technique for inguinal hernia repair.

Introduction

Inguinal hernia repair is the most frequently performed operation in general surgical practice in the Netherlands. Annually 33,500 inguinal hernia repairs (primary, recurrent and bilateral hernias), are performed among 16 million Dutch people [23]. Of these operations, 5175 (15.5%) involve recurrent inguinal hernias [23]. The high incidence of recurrence after inguinal hernia repair has been the incentive for surgeons to continue exploring better techniques of hernia repair. Considering the high number of patients with inguinal hernias, such improvements have major medical and socio-economical importance.

Tension free hernia repair has been shown to diminish the recurrence rate of inguinal hernias significantly. Lichtenstein in 1974 was the first to describe such a tension free repair; an open anterior approach with the use of a mesh prosthesis [12,13].

Mesh repair of inguinal hernias through a preperitoneal approach was first described by Stoppa et al. in 1984, and later by Wantz [24,25,28]. The first endoscopic trans-peritoneal inguinal hernia repair which involved closure of the hernia was performed by Ger et al. in 1982 in the United States [9]. The real breakthrough of endoscopic hernia repair, however, followed in the early 90's [1,2,3,4,5,21,22]. At that time, endoscopic trans-peritoneal hernia repair was introduced in the Netherlands by a small group of surgeons. In 1994 a randomized study, the COALA trial (COALA= **CO**nventional **A**nterior versus **LA**paroscopic hernia repair), was started in the Netherlands. The objectives of this study were to compare the results of totally extra-peritoneal endoscopic inguinal hernia repair with conventional techniques that were used at that time in Dutch surgical practice. The results of this randomized trial have shown that endoscopic totally extra-peritoneal inguinal hernia repair is superior to conventional methods. There were significant benefits concerning postoperative pain, recovery and recurrence rate of inguinal hernias [14,15,16].

The goal of the present survey was to asses the application of endoscopic inguinal hernia repair in the Netherlands one year after appearance of reports providing evidence of distinct benefits of endoscopic inguinal hernia repair.

Materials and methods

In 1998 a questionnaire on endoscopic inguinal hernia repair was sent to all registered Dutch surgeons. This questionnaire recorded the following data:

1) Category of hospital (university hospital, teaching hospital, non-teaching hospital).
2) Performance of endoscopic inguinal hernia repair.
3) Technique of endoscopic inguinal hernia repair used (totally extra-peritoneal / transabdominal preperitoneal)
4) Number of endoscopic hernia repairs performed annually per surgeon (N<10, 10<N<30, 30<N<50, 50<N<100, N>100).
5) Mesh size.
6) Mesh fixation (stitches, staples or tackers).
7) Selection of patients (primary, bilateral, recurrent hernias).
8) Integration of endoscopic inguinal hernia repair in surgical residency.
9) Reasons for not performing endoscopic inguinal hernia repair (not convinced of superiority of repair, long learning curve, financial, other).
10) Preferred conventional technique.

Surgeons who did not respond to this questionnaire within three months were later approached by telephone.

Results

The opinion of 780 Dutch surgeons was sought. Of all addressed surgeons, 424 (54%) returned the questionnaire within 3 months. The opinion of the remaining 356 surgeons was obtained by telephone, either personally (65 %), or through a representative of the partnership (35%).

The endoscopic technique for inguinal hernia repair in the Netherlands was used by 123 of 780 surgeons (16 %) (*fig.1A*). The surgeons were located in 63 of a total of 143 hospitals. These 63 hospitals were six university hospitals (6/8), seventeen teaching hospitals (17/33), and forty non-teaching hospitals (40/102). Thus endoscopic inguinal hernia repair was performed in 56% (23/41) of the university and teaching hospitals and in 40% (40/102) of the non-teaching hospitals. The number of endoscopic repairs performed annually by each surgeon was: less than 10 repairs by 20%, between 10 and 30 repairs by 39%, between 30 and 50 repairs by 17%, between 50 and 100 repairs by 20% and more than 100 by 4%. Endoscopic inguinal hernia repair was included in the educational program for surgical residents in 68% of the university and teaching hospitals performing endoscopic inguinal hernia repair. As endoscopic inguinal hernia repair was performed in 56% (23/41) of all university and teaching hospitals the performance of endoscopic hernia repair by surgical residents took place in 38% of all teaching hospitals (68% of 56%).

Eighty-one percent of surgeons who performed the endoscopic repair for inguinal hernias preferred the total extra-peritoneal procedure (*fig. 1B*). Almost all surgeons (93%) used a prosthesis of 10 x 15 cm, 4 % used a smaller mesh (7 x 10 < X < 12 x 15) and 3 % used a larger mesh (15 x 15 cm).

Of the surgeons who corrected inguinal hernias endoscopically 54% used this technique for primary hernias, and the vast majority, 92%, for recurrent inguinal hernias. (*fig. 1C,D*).

When a surgeon preferred a conventional technique for inguinal hernia repair the main reasons for this preference were: not convinced of the superior results of the endoscopic

technique (62%), associates already perform endoscopic inguinal hernia repair (35%), long learning curve (15%), direct costs of endoscopic repair were considered higher (12%), the surgeon was no longer a hernia surgeon due to super-specialisation (11%).
Of the surgeons who preferred a conventional technique for inguinal hernia repair, a minority preferred the Bassini repair for primary inguinal hernias (8%). The technique of choice for primary hernias was Shouldice repair (48%), and second, Lichtenstein repair (36%). A new mesh-repair which has been advocated by the Dutch surgeon Ugahary, an anterior preperitoneal approach through a small muscle-splitting incision in the lower lateral abdomen, was also gaining some acceptance (8%) [26]. Recurrent inguinal hernias were predominantly repaired using the Lichtenstein technique (52%). Second was the Shouldice technique (21%), and third the endoscopic repair (15%). The remaining 12% consisted of Wantz, Stoppa, and Ugahary repairs.

Figure 1A : Percentage of dutch surgeons performing endoscopic or open inguinal hernia repairs

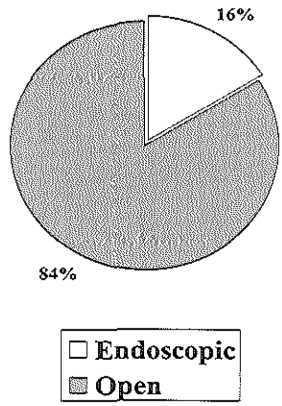


Figure 1B: Preference of endoscopic hernia repair technique amongst the 'Endoscopic surgeons' (16% Table 1)

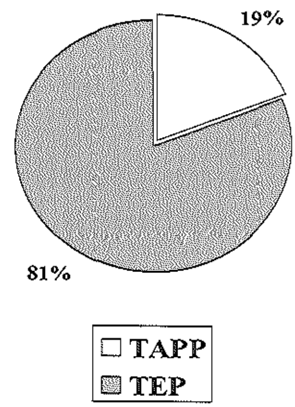


Figure 1C: Performance of endoscopic and open inguinal hernia repairs for primary inguinal hernia repair by 'endoscopic surgeons' (16% in Table 1)

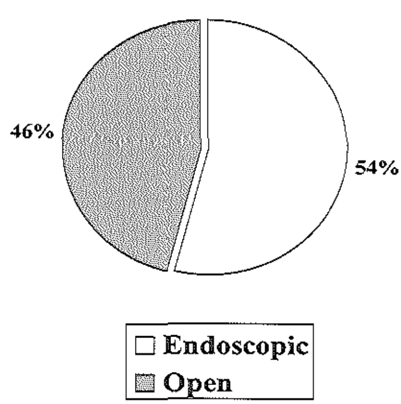
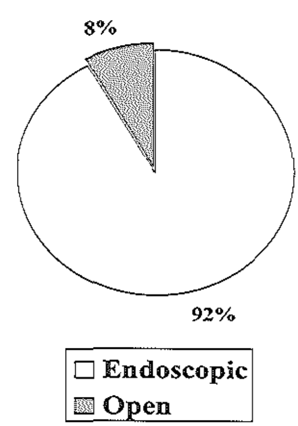


Figure 1D: Performance of endoscopic and open inguinal hernia repair for recurrent inguinal hernias by 'Endoscopic Surgeons' (16% in Table 1)



Discussion

At present, the Dutch national registration system (SIG) does not contain separate codes for endoscopic procedures [23]. Therefore, it is not possible to precisely assess the diffusion of endoscopic procedures in the Netherlands. Questionnaires are the only available means to provide this insight.

Our study revealed that endoscopic inguinal hernia repair was performed by 16 % of all Dutch surgeons in 1998. These surgeons represent 63 (44 %) of all 143 Dutch hospitals. It is difficult to put our results in perspective because comparable data are rare. Some perspective can be obtained from the questionnaires that were performed by Simons and co-workers [16,19]. They addressed all Dutch surgical residents in 1995 and 1997 in order to assess the application of the different techniques for inguinal hernia repair in Dutch *'training'* hospitals (university and other teaching hospitals). The response rates were 86 % and 90% respectively. The percentage of training hospitals in which endoscopic inguinal hernia repair is performed declined from 71 % of training hospitals in 1995 to 60 % in 1997. The results of our present study show that the percentage of training hospitals where endoscopic inguinal hernia repair is practiced has further decreased to 56 % in 1998.

Another trend is the increased popularity of the Shouldice and Lichtenstein techniques in recent years. Schoots [19,20] observed an increase of the use of Shouldice and Lichtenstein techniques as a first choice technique for primary hernia repair in training hospitals between 1995 and 1997 from 33% to 52% of training hospitals for the Shouldice repair and an increase from 8% to 25% of training hospitals for the Lichtenstein repair. The figures for *all* Dutch hospitals in 1998 (the present study) are 48% of training hospitals for the Shouldice repair and 36% of training hospitals for the Lichtenstein repair. *Table 1.*

The results of the Dutch COALA-trial have shown that endoscopic totally extra-peritoneal inguinal hernia repair is superior to conventional methods [14]. Although skepticism existed in the Netherlands on the true benefits of endoscopic inguinal hernia repair, we expected the results of this randomized trial to have led to greater acceptance and application of the technique in our country. Moreover some other randomized trials also have reported favorable results of endoscopic inguinal hernia repair [6,10,17,27,29,30]. The results of this questionnaire however suggest a diminishing performance of endoscopic inguinal hernia repair by the general surgeon, making it a procedure used mainly by specialized surgeons. Different factors might play a role in the hesitancy to apply this kind of hernia repair [17].

The shift towards conventional techniques and the slight decrease in popularity of the endoscopic repair might be inter-related. As the average Dutch surgeon only recently started to apply the best conventional techniques on a truly large scale, this may by many be considered as an adequate improvement of technique, and the change to the endoscopic technique too early. This is illustrated by the fact that 62% of the surgeons, who do not apply the endoscopic repair, stated that they were not convinced of the better results of the latter technique. Specifically surgeons with a great experience in conventional hernia repair are convinced that this technique is superior to an endoscopic technique in their hands and prefer to continue using this technique instead of having to pass a learning curve. Furthermore they see no benefit from endoscopic repairs concerning early rehabilitation as compared to other tension-free techniques as the Lichtenstein repair. This observation underlines the importance of randomized trials on endoscopic inguinal hernia repair versus either Shouldice or Lichtenstein repair [17,27].

The fact that endoscopic inguinal hernia repair is preferably performed using general anaesthesia might cause a hesitation among surgeons and patients who prefer regional or local anaesthesia [26]. Furthermore many doctors are still reluctant to accept endoscopic inguinal hernia repair as a day care procedure and therefore prefer a conventional repair which in their experience can be performed in day care [10]. The high degree of technical difficulty of endoscopic inguinal hernia repair was the main reason for the choice of conventional techniques by 15 % of the surveyed surgeons. This aspect stresses the necessity of ongoing education and creation of training facilities, not only for residents, but also for registered surgeons. According to Liem et al. [15] the learning curve flattens out after 30 endoscopic hernia repairs. Training possibilities and further application of this technique in surgical resident training programs can overcome the problem within a short time as herniorraphy is a very common procedure in the Netherlands.

Although reports of serious complications following laparoscopic inguinal hernia repair are published [7,18] complications of laparoscopic repair was not mentioned as a major reason for Dutch surgeons not to choose a laparoscopic approach in hernia repair. The rationale might be that the incidence of these complications is low, especially when only specific laparoscopy related complications (trocar hernia, bowel injury, vascular injury) are considered [7,18]. Other complications such as wound infections, hydroceles and nerve injury usually appear more frequently in open repairs [14,17].

Costs are also of concern in endoscopic inguinal hernia repair. The direct costs of endoscopic inguinal hernia repair are higher than those of conventional repairs, mostly due to the use of disposable instruments [17,28]. The indirect costs, however, are lower due to a shorter hospital stay and earlier return to work [10,11]. The higher in-hospital costs when laparoscopic inguinal hernia repair is performed are surpassed by the reduction in post-hospital community costs due to a marked reduction in loss of working days, leaving the endoscopic repair as a cheaper procedure than the conventional technique according to some authors [10,11]. It must be mentioned however that not all trials report a shorter hospital stay after laparoscopic inguinal hernia repair [28], specifically when repairs are performed under local anaesthesia. And as indirect costs are rather difficult to calculate a consensus that laparoscopic repair is cheaper overall is not reached among health economists. Furthermore, in the Netherlands the higher costs are billed to the hospital budget while the presumed lower indirect costs are to the advantage of the employer and social insurance companies. Up to now, no solution to this problem has been found.

Table 1.

Percentage of training hospitals which use the Shouldice or Lichtenstein techniques as technique of first choice for primary hernia repair.

	Shouldice	Lichtenstein
1995 Schoots IG et al. [20]	33%	8%
1997 Schoots IG et al. [20]	52%	25%
1998 Knook et al.	48%	36%

Conclusions

In conclusion, almost a decade after introduction of endoscopic inguinal hernia repair in the Netherlands, this technique is not as widely accepted as one would expect following the positive results of published trials. More scientific data seem to be required to convince the average surgeon of the benefits of this technique. Only when continuous effort is put into educating residents in endoscopic techniques, and when registered surgeons are given adequate training facilities, will this technique be disseminated further. This process will be facilitated when hospitals are compensated for their higher costs by the community that experiences a marked reduction in costs when this technique is applied. We feel that the present results of endoscopic hernia repair justify this wider dissemination.

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Chapter 9

General Discussion

Introduction

The most important goal in inguinal hernia repair is to use a technique which will not lead to recurrence. Furthermore the procedure has to be feasible and safe, preferably at low costs. Many surgeons have attempted to develop a repair that meets these conditions and several authors have published promising results of their series of inguinal hernia repairs. However, these results were often not reproducible at other institutions. Therefore, the choice of repairs in inguinal hernia surgery remains controversial. The solution to this controversy should come from randomized controlled trials. An important meta-analysis comparing open mesh versus non-mesh repair of inguinal hernias was performed by the European Hernia Trialist Collaboration. The aim was to perform a systematic review of published data comparing open tension-free repair with traditional open suturing methods [8]. From this meta-analysis it can be concluded that there was no difference in morbidity. Patients who had mesh repair seemed to return to normal activities faster than those in the non-mesh group but this difference was not significant ($P=0.34$). As far as the recurrence rates re concerned the use of prosthetic material diminished the recurrence rate significantly ($P<0.001$) [8].

Different procedures are available to perform a mesh repair of inguinal hernias. These procedures can be divided into three groups, according to the approach used by the surgeon. The three approaches are the open anterior approach, the open posterior approach, and the endoscopic posterior approach. The best known procedure in the open anterior approach is the Lichtenstein procedure, an example of the open posterior approach is the Stoppa procedure.

The endoscopic posterior approach is in fact a minimally invasive Stoppa or Wantz technique, combining the advantages of a preperitoneal repair and an endoscopic approach.

The first endoscopic technique in general surgery was the laparoscopic cholecystectomy in the late eighties [6]. Nowadays, this procedure is a common approach and endoscopic techniques are used for a variety of surgical procedures. Advantages of endoscopic procedures in general surgery are reduction of postoperative pain and faster recuperation compared to open techniques [32].

Endoscopic inguinal hernia repair was initiated in the early nineties. Starting with the patch and plug repairs, this technique evolved to the large mesh repairs of nowadays. The indications for endoscopic inguinal hernia repair are still controversial. Endoscopic enthusiasts perform this procedure for adults in all elective cases of reducible hernias when general anesthesia is possible. Others reserve the endoscopic repair for bilateral and recurrent hernias. Reluctance to apply endoscopic procedures for inguinal hernia repair is due to the assumed difficulty of the procedure, the fact that many surgeons are not convinced of the better results, the fear for complications, and the extra costs of the procedure [19].

Primary and recurrent hernias

In our study of TEP (Total Extraperitoneal Preperitoneal) repair for unilateral primary hernias and recurrent hernias after conventional repair, the occurrence of peroperative and postoperative complications was low [16]. The operation time for the two groups was comparable and was not longer than for conventional repairs [16,21]. Short hospital admission and early recovery were observed after both primary and recurrent hernia repair [16].

Concerning the recurrence rate, however, a difference was found between the recurrence rates for repairs of primary hernias (3.2%) and the recurrence rates for repairs of recurrent hernias after conventional repairs (20%) [16].

An explanation for the failure of endoscopic repair of a recurrent hernia lies in the known causes of recurrence after endoscopic repair of a primary hernia. Apart from inadequate hernia reduction, recurrences are mainly due to insufficient mesh size, inadequate mesh positioning, and mesh migration [5,27,35].

When compared to primary hernias, recurrent inguinal hernias frequently involve larger abdominal wall defects and tissue of poor quality surrounding this defect, especially when the previous repair of a hernia was performed by open non-mesh repair, due to the tension created on the abdominal wall. A mesh of the same size as used in primary hernia repairs appeared to be sufficient for the smaller hernial orifice but not for hernias with a larger defect, as in most recurrent hernias [16].

Recurrences after endoscopic inguinal hernia repair

The results of our analysis of recurrent hernias after previous endoscopic inguinal hernia repair confirmed the prevailing opinion that recurrences are due to technical errors such as inadequate hernia reduction, insufficient mesh size, inadequate mesh positioning, and mesh migration as mentioned above [18]. The key in all of these cases is the surgeon's experience. It has been shown that most recurrences can be found among the surgeon's early cases of endoscopic hernia repair [9,16,18,22,29]. Therefore, recurrence rates should drop as the experience of surgeons in endoscopic inguinal hernia repair increases and an adequate mesh size is used. To create an adequate mesh size, a mesh should either be tailored to the size of the hernia, or more practical, be large enough to prevent future recurrences or new hernias from a site other than the one repaired. This subject is discussed in detail in Chapter 6 [20].

Stapling of the mesh reduces the risk of mesh migration but induces the risk of nerve entrapment, vessel laceration and pain of the abdominal wall [2,16,26,35]. In order to avoid staples for mesh fixation we advocate the use of a larger mesh prosthesis [16].

Mesh size

An adequate mesh size is essential for succesfull endoscopic inguinal hernia repair. Since hernia defect sizes differ in individual cases and the exact measurement of a hernia defect is difficult it seems more practical to try to determine the adequate mesh size for all inguinal hernias. Furthermore, a prosthesis placed over a single defect ignores the possible weakness of the entire inguinal region, and a future recurrence might occur at another site due to inadequate coverage of potential hernia sites. Since all inguinal hernias pass through the inguinal wall at the musculo-pectineal opening this is the area that should be covered sufficiently by a mesh in inguinal hernia repair. This opening is usually larger than the existing defect. The size of the musculo-pectineal opening varies according to the structure of the muscular triangle [33,35].

According to Lowham et al. [9] an overlap over the defect of 2 cm is sufficient when the mesh is stapled and an overlap of 3 cm is sufficient when the mesh is not stapled, which would result in a square mesh size varying from 10 x 10 cm to 15 x 15 cm, according to the size of the defect and fixation of the mesh. It is not clear, however, how the authors determined this 'adequate' mesh size. Therefore, it is difficult to draw conclusions from these data.

The results of our 'optimal mesh size' porcine study, discussed in Chapter 6 [20] of this thesis, provide an indication of an adequate mesh size for inguinal hernia repair. Independent of the size of the defect, up to 6 cm in this model, the use of a mesh prosthesis with more than 3 cm overlap resulted in only minimal further protrusion into the hernia opening [20]. Therefore, we recommend a mesh size with a minimal overlap over the defect of 3 cm. When the myopectineal orifice measures less than 9 cm in diameter, which is usually the case, a mesh size of 15 x 15 cm is adequate.

Of course several assumptions were made in order to perform this in vitro study. Realizing the imperfection of this model and keeping the incompleteness of an in vitro experiment in mind, interesting conclusions can be drawn about mesh size in inguinal hernia repair [20].

Several studies have been published on the 'shrinkage of mesh' in hernia repair [1,4,14,15]. In a study by Klinge et al. on mesh shrinkage after implantation of the mesh in dogs, shrinkage of 50% was found [14]. Since mesh size is of undeniable importance in inguinal hernia repair, effects on the mesh such as shrinkage after implantation can theoretically result in insufficient covering of the hernia defect. Therefore, further research on this matter is necessary. Since less mesh shrinkage was reported by Klinge et al. [14,15] for meshes with diminished tissue response, material leading to adequate in-growth but minimal tissue response will probably be the mesh of choice.

Inguinal Hernia: open or endoscopic mesh repair?

Although consensus is emerging on the importance of mesh repair for inguinal hernia surgery, the discussion on the approach to the inguinal hernia is still ongoing. This discussion in fact focuses mainly on two methods of hernia repair, the anterior mesh repair or Lichtenstein repair, and the posterior endoscopic approach. Several randomized trials have been performed on this subject (Table 1.)

Table 1.

Randomized Trials on Endoscopic versus open groin hernia repair in trials with more than 100 patients.

Author	Patients	Techniques	Follow up (months)	Complications % Endosc / Open	Return to work Endosc / Open	Recurrences % Endosc / Open
				Serious*	mean	
Dirksen, 1998	175	TAPP / NonMesh	15-36	3.5 / 0		8 / 25
Liem, 1997	1051	TEP / NonMesh	12-24		14 / 21	3.4 / 6
Nathanson, 1996	184	TEP / NonMesh	Med 24		10 / 21	?
O'Dwyer, 1999	928	Mixed / Mixed	12	0.4 / 0.2		
Johansson, 1999	613	TAPP / NonMesh/ Mesh	12	0.3 / 0	14 / 17 / 17	2 / 2 / 5
Koninger, 1998	274	TAPP / NonMesh/ Mesh	Med 18		25 / 44 / 36	1 / 2 / 1
Paganini, 1998	108	TAPP / Mesh	25-31		15 / 14	3.8 / 0
Sarli, 1997	108	TAPP / Mesh	18-54		14 / 14	?
Zieren, 1998	240	TAPP / Mesh / NonMesh	Mean 25	1.6 / 0	3 / 11 / 4	0 / 0 / 0
Champault, 1997	100	TEP / Mesh	Mean 16		17 / 35	1.5 / 0.5
Payne, 1996	100	TEP / Mesh	Med 20		?	0.5 / 0
Lorenz, 2000	176	TAPP / NonMesh	24		27 / 34	1 / 0.5

*needing intervention

The European Hernia Trialists Collaboration performed a meta-analysis of randomized trials on the open hernia repair, mesh (predominantly Lichtenstein) and non-mesh, versus laparoscopic hernia repair [8]. From this analysis, it was concluded that complications were infrequent in both groups, patients with endoscopic repairs returned to work faster than those with open repairs, there was no difference in recurrence rate between patients with open mesh repairs and those with endoscopic repairs, and patient comfort was significantly better in the endoscopic group [8]. As mentioned by the author, this meta-analysis also had its limitations which mean that although rather convincing evidence is obtained from this work, definite results have to come from large randomized trials comparing the Lichtenstein repair to the total extraperitoneal endoscopic repair.

For this reason the Dutch 'LEVEL' Trial (Liesbreukcorrectie: Endoscopisch versus Lichtenstein) was started at the University Hospital Rotterdam, the Netherlands. Aim of this trial was to perform a prospective randomized study to compare the endoscopic inguinal hernia repair with the Lichtenstein hernia repair. Measures of outcome are complications, postoperative pain, recuperation time and cost-effectiveness. To assess postoperative pain and nausea, patients were asked to complete a questionnaire on a visual analogue scale preoperatively and 24hrs to 6 weeks postoperatively. A Medication Quantification Scale (MQS) was introduced to investigate drug use for pain relief. To assess physical performance, an 'exercise test' (sit ups and the straight leg raise) was performed preoperatively and 1 and 3 weeks postoperatively [23]. Quality of life was evaluated using the EuroQol questionnaire for quality of life, completed preoperatively and 4 weeks postoperatively. Recuperation or the resumption of normal daily activities was evaluated using an ADL (Activities of Daily Life) questionnaire. Costs of hernia repair were analyzed for two groups of patients, those retired and those employed. The costs themselves were divided into direct costs, (surgery-related/ direct postoperative period/ outpatient period) and indirect costs (decrease of productivity).

Trans Abdominal Preperitoneal (TAPP) or Total Extra-Peritoneal (TEP) hernia repair?

Since the beginning of endoscopic hernia surgery, a variety of endoscopic techniques has been used. At this moment, the most frequently performed procedures in endoscopic inguinal hernia repair are the Trans-Abdominal Pre-Peritoneal (TAPP) procedure and the Total Extra-Peritoneal (TEP) procedure. Complications such as bowel obstruction can occur in the intra-peritoneal onlay mesh technique (IPOM) due to adhesion of the bowel to the intra-abdominally positioned mesh. In TAPP repairs, adhesion developed to parts of the mesh left exposed after inadequate closure of the peritoneum can be encountered. A greater risk of injury of the intra-abdominal organs is that due to penetration of the abdominal cavity in TAPP hernia repair, especially after prior surgical procedures [9,27,35]. The total extra-peritoneal procedure (TEP) seems to reduce the risks for these complications and should therefore be the technique of choice [7,9,11,27,28].

However, the TEP procedure is not feasible for repair of recurrent hernias after conventional preperitoneal mesh procedures (Stoppa/Wantz/Ugahary), Lichtenstein repair or after endoscopic inguinal hernia repair. Scar tissue in the preperitoneal space created after these interventions makes entrance of the preperitoneal space by means of the TEP approach impossible. In these cases, a TAPP procedure can be performed in which case the mesh can be dissected from the surroundings, a new mesh can be positioned over the defect, and the peritoneum can be closed over the mesh [18].

Anesthesia

Laparoscopic herniorraphy has been criticized because of the need for general anesthesia, thus in the opinion of several authors, introducing unnecessary anesthesia-related complications such as nausea, vomiting, and aspiration. Regional anesthesia however also has specific disadvantages [25].

In general disadvantages of general anesthesia are intubation, introducing the risk of aspiration, tracheal or esophageal trauma, and myocardial ischemia in patients with coronary artery disease, respiratory depression, malignant hyperthermia and recall [25].

Disadvantages of regional anesthesia include increased time for block placement, pain produced by the administration of the block and failure to produce an adequate block. Pain produced by the administration of the block may result in myocardial ischemia in patients with coronary artery disease. A 10% to 17% incidence of block failure has been reported and inadequate anesthesia requires supplementation with inhalation or intravenous agents. Complications associated with spinal anesthesia include, hypotension bradycardia, nausea, post spinal headache, and urinary retention. Epidural complications may include hypotension, accidental subdural or subarachnoid injection, dural puncture and headache, neural damage, catheter complications, and, although very rare, permanent paralysis secondary to hematoma formation [25].

In our own series, all endoscopic hernia repairs were performed under general anesthesia. In a total of 350 hernia repairs, no anesthesia-related complications occurred [16,17,18]. However, if thought necessary, endoscopic inguinal hernia repair can be performed effectively under epidural anesthesia [3]. A comparison of the two techniques, general and epidural anesthesia led to the conclusion that epidural anesthesia is associated with a decrease in the incidence of postoperative pain and nausea ($p<0.05$). Epidural anesthesia is recommended as an effective alternative to general anesthesia for the performance of outpatient endoscopic inguinal hernia repair [30].

Since the Lichtenstein technique was originally performed under local anesthesia, this could be the procedure of choice when contraindications for general or epidural anesthesia exist. In the Netherlands, however, this technique is not routinely used. Exact numbers are not available.

Endoscopic repair has also been performed using local anesthesia. In 10 patients on average 30 cc lidocaine 1% was used [10]. In all patients the repair was performed successfully. In four of these cases a small amount of intravenous sedation was also given. Following this report, a prospective study was performed comparing general and local anesthesia for an extra-peritoneal approach of hernia repair. Ninety-two patients, with 107 groin hernias were included in this study. There was no significant difference in recurrence and complication rates in this comparison. It appears that blunt dissection of the preperitoneal space does not trigger pain and does not require lidocaine injection. The most painful area is the peritoneal reflection of the cord structure [10].

All the preceding reports discuss only the feasibility and complication rates of the different procedures and patient satisfaction. At present no literature is available on the suitability of the three methods of anesthesia for endoscopic inguinal hernia repair. However, patient satisfaction was determined [37] for the three different methods of anaesthesia (general, spinal and local anesthesia) for open inguinal herniorraphy. From this survey it was concluded that satisfaction ratings were equal among the three groups. Complication rates were highest in the spinal anesthesia group (urine retention).

In conclusion, the choice of the method of anesthesia for endoscopic inguinal hernia repair is not restricted. According to several reports epidural and local anesthesia are equally effective for endoscopic inguinal hernia repair as is general anesthesia. The procedure of choice for hernia repair and the anesthetic technique should be discussed with the patient in order to determine the appropriate technique for the individual patient.

Technical difficulty of the endoscopic procedure

In a study on the learning curve for inguinal hernia repair, Liem et al. reported a minimum of 30 endoscopic inguinal hernia repairs necessary per surgeon to be able to perform an adequate repair [22]. In our opinion this shows that the technical difficulty is surmountable. Of course, especially for an experienced open hernia repair surgeon the Lichtenstein technique is at first easier to perform, and for this reason may become his/her procedure of choice. Since the main contributions to success are the surgeons experience and the use of an adequately sized mesh prosthesis, any adequate mesh repair performed by a surgeon experienced in that repair meets these conditions.

Cost effectiveness

In the discussion on the cost-effectiveness of endoscopic inguinal hernia repair it is essential that direct (surgery-related) costs and indirect (economic) costs are combined [13]. As mentioned before [19], the direct costs of endoscopic inguinal hernia repair are higher than those of conventional repairs, mostly because disposable instruments are used. The indirect costs, however, are lower due to a shorter hospital stay and earlier return to work. In our opinion, based on results of early rehabilitation in our own series of endoscopic inguinal hernia repair, the higher in-hospital costs are surpassed by the reduction in post-hospital community costs when laparoscopic inguinal hernia repair is performed. This is due to a marked reduction in loss of working days, making endoscopic repair a cheaper procedure for the employer than the conventional technique [34]. Heikkinen et al performed a prospective randomized trial on outcome and cost of TEP hernioplasty and Lichtenstein repair among employed patients [11]. They demonstrated that the Lichtenstein operation is cheaper for the hospital, was that the total costs for the working patients are lower with the endoscopic technique because fewer working days are lost [11]. However, not all trials report a shorter hospital stay or faster return to work after endoscopic inguinal hernia repair. In the Netherlands the higher costs are part of the hospital budget while the presumed lower indirect costs are to the advantage of the employer and social insurance companies. Furthermore, since indirect costs are rather difficult to calculate, a consensus that laparoscopic repair is cheaper overall has not yet been reached among health economists. For now this problem must still be solved.

Future of inguinal hernia repair

In contrast to the explosive dissemination of the laparoscopic cholecystectomy, endoscopic inguinal hernia repair is still performed by a small group of surgeons in the Netherlands. The presumed technical difficulty, the 'need' for general anesthesia and the higher direct costs remain an obstacle to general adoption of endoscopic inguinal hernia repair [19]. The goal of inguinal hernia repair, however, as mentioned in the introduction to this chapter, is to perform a repair which is feasible, safe, and comfortable for the patient, and will certainly prevent a recurrence.

Since it has been proven that the use of a mesh in inguinal hernia repair reduces recurrence rates significantly [8,36], it is nowadays considered standard procedure. Furthermore, tension-free repair means earlier recuperation, and faster return to work. In fact any mesh procedure can be performed according to the expertise of the surgeon. However, for patients who probably should be operated upon under local anesthesia the Lichtenstein repair might be the procedure of choice. If, however, any hesitation exists on the use of a mesh prosthesis, the Shouldice repair appears to be the best non-mesh alternative [28].

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Summary and Conclusions

Summary

Chapter 1 is the general introduction of this thesis. The history of inguinal hernia repair and the evolution of surgical techniques for hernia repair from 1500 BC through the Middle Ages until present time are described. The introduction of anesthesia, hemostasis and antisepsis (Lister 1870) were essential steps to push inguinal hernia repair forward. Bassini, who is considered the father of modern hernia surgery, was the first to perform a true herniorraphy in 1884. Nowadays, in the majority of cases, conventional hernia repair is performed either without (e.g. Shouldice) or with (e.g. Lichtenstein) mesh implantation with excellent results in specialized hernia centers. In general practice, however, recurrence rates remained high after repair without a mesh. Endoscopic inguinal hernia repair was introduced in the early 1980's and has evolved into the totally extra-peritoneally (TEP) and transabdominal preperitoneal (TAPP) procedures as performed nowadays.

Chapter 2 describes the anatomy of the inguinal region with respect to endoscopic inguinal hernia repair techniques. It emphasizes the anatomical view encountered during preperitoneal approach. Furthermore, the 'dangers' of endoscopic inguinal hernia repair are discussed, and the essence of finding the proper preperitoneal plane in endoscopic inguinal hernia repair is addressed.

Chapter 3 presents our study of endoscopic total extraperitoneal repair of primary and recurrent inguinal hernias. This study involved 186 patients with primary hernias and 35 patients with recurrent hernias. The feasibility, low complication rate and low recurrence rate reported for this specific technique of TEP repair of primary inguinal hernias is shown. A disappointing recurrence rate, however, was found for the TEP repair of recurrent inguinal hernias after conventional herniorraphy. The causes of recurrences in endoscopic hernia repair are discussed and adjustments for future hernia repair are presented.

Chapter 4 presents the results of endoscopic totally extra-peritoneal repair of bilateral inguinal hernias. These operations were analyzed in 98 patients, seventeen of these had rectangular mesh repairs and 81 had 'slipmesh' repairs). The short hospital stay and rapid recuperation in this group are comparable to earlier reports. Simultaneous repair of bilateral hernias which, according to some authors is controversial in the event of open inguinal hernia repair, is not followed by longer hospitalization or delayed recuperation when the endoscopic approach is applied. A high recurrence rate was encountered in the rectangular mesh group due to insufficient mesh overlap at the medial hernia orifice area leading to medial recurrences. Afetr the introduction of the 'slipmesh' prosthesis the recurrence rate dropped to 1.2%.

Chapter 5 considers the laparoscopic repair of recurrent hernias after endoscopic herniorraphy. The question whether there is a place for laparoscopic surgery in the treatment of recurrent inguinal hernias after endoscopic herniorrhaphy is answered. The procedures were performed with few complications and without any need for conversion. Laparoscopic repair of recurrent hernias after primary endoscopic herniorrhaphy allowed study of causes of recurrence. Peroperative analysis suggests that the recurrences correlate predominantly with the surgeons' experience and the mesh size. Application of this knowledge for future hernia repair can improve the endoscopic procedure. The transabdominal preperitoneal approach appears a reliable technique for recurrent inguinal hernia repair after previous endoscopic herniorrhaphy.

Chapter 6 presents a study on the 'optimal mesh size' for endoscopic inguinal hernia repair, performed in a porcine model. To assess the adequate mesh size in relation to defect size, measurements were made to relate protrusion of the mesh to three variables: intra-abdominal pressure, defect size, and mesh overlap over the defect. In defect sizes up to 6 cm, the use of mesh prosthesis with an overlap of more than 3 cm results in no further decrease of protrusion into the hernia defect. Extrapolating this outcome to clinical practice potentially reduces recurrence rates in inguinal hernia repair. However, clinical studies will have to confirm this assumption by showing a decrease of recurrence rates using this mesh size.

Chapter 7 covers a review of complications in conventional and endoscopic inguinal hernia surgery. In this review, major and minor complications are considered separately. The incidence of major complications is particularly dependent on the expertise of the surgeon. Again, it is emphasized that the knowledge of anatomy greatly reduces the complication rate in endoscopic inguinal hernia surgery.

Chapter 8 presents a questionnaire on inguinal hernia repair, sent to all Dutch surgeons in 1998. This study revealed that endoscopic inguinal hernia repair was performed by only 16 % of all Dutch surgeons in 1998. The percentage of training hospitals in which endoscopic inguinal hernia repair is performed declined from 71 % of training hospitals in 1995 to 60 % in 1997 and further to 56 % in 1998. These results show a diminishing employment of endoscopic inguinal hernia repair by the general surgeon, making TEP repair a procedure used mainly by specialized surgeons. Surgeons not performing endoscopic inguinal hernia repairs were either not convinced of the superior results of the endoscopic technique (62%), or their associates already performed endoscopic inguinal hernia repairs (35%). Furthermore, there was a fear for a long learning curve (15%), direct costs of endoscopic repair were considered higher (12%), or the surgeon was no longer a hernia surgeon due to super specialization in another field of surgery (11%).

Chapter 9 is the general discussion of this thesis. It provides a review of the results of the studies described in chapters three through eight. It discusses the conditions for success in inguinal hernia repair such as surgeons' experience, knowledge of inguinal anatomy, and adequate mesh size. The specific advantages of open and endoscopic techniques in inguinal hernia repair are discussed. The current place of TEP and TAPP procedures in endoscopic inguinal hernia repair is addressed. Furthermore the author glances at the future of inguinal hernia repair.

Conclusions

1. Detailed knowledge of inguinal anatomy is necessary for correct endoscopic inguinal hernia repair.
2. Endoscopic (TEP) inguinal hernia repair is a feasible, safe, and efficient, technique for the elective repair of all inguinal hernias.
3. Adequate mesh cover of the medial hernia area is essential in the Stoppa bilateral inguinal hernia repair.
4. The TAPP approach is the procedure of choice for endoscopic repair of recurrences after prior endoscopic hernia repair.
5. The efficacy of the repair of an inguinal hernia is dependent on surgical experience and adequate mesh size.
6. A mesh should adequately overlap the myopectineal orifice to prevent all future hernias in this area.
7. The endoscopic inguinal hernia repair procedure lost popularity amongst Dutch surgeons due to the preference for open mesh repairs as they are considered easier to perform, cheaper and equally effective.

Samenvatting en Conclusies

Samenvatting

Hoofdstuk 1 is de introductie van dit proefschrift. Het beschrijft de geschiedenis van de liesbreukchirurgie en de ontwikkeling van verschillende technieken van 1500 AD, de middeleeuwen tot op de dag van vandaag. De ontwikkeling van anaesthesie, de techniek van hemostase and desinfectie (Lister 1870) was essentieel in de vooruitgang van de liesbreukchirurgie. Bassini, die beschouwd wordt als de vader van de moderne liesbreuk chirurgie, was de eerste die een liesbreukkanaalcorrectie uitvoerde (1884). Tegenwoordig wordt in de meerderheid der gevallen, met een conventionele liesbreuk correctie uitgevoerd volgens Shouldice (zonder prothese) of volgens Lichtenstein (met prothese), uitstekende resultaten bereikt in gespecialiseerde centra. In de algemene praktijk echter, bleven recidiefpercentages hoog bij technieken zonder mesh. De endoscopische liesbreukcorrectie werd in de vroege jaren '80 geïntroduceerd, en heeft zich ontwikkeld tot de totaal extraperitoneale (TEP) en transabdominale preperitoneale (TAPP) procedure zoals die tegenwoordig wordt uitgevoerd.

Hoofdstuk 2 beschrijft de anatomie van het liesgebied in verband met de endoscopische liesbreuk correctie technieken en benadrukt het anatomische inzicht hierbij. Verder worden de 'gevaren' van de endoscopische liesbreuk correctie belicht en wordt het belang van het vinden van het juiste preperitoneale vlak in de endoscopische liesbreuk correctie besproken.

In *Hoofdstuk 3* wordt een studie van het herstel van primaire en recidief liesbreuken beschreven. De resultaten van deze procedure werden bij 221 patienten (186 primair and 35 recidief breuken) geanalyseerd. Analyse van onze serie van 221 patienten met een primaire of recidief liesbreuk bevestigt zowel de uitvoerbaarheid, de lage complicatiefrequentie, als de lage recidiefpercentages beschreven van deze techniek. Een teleurstellend recidiefpercentage word echter gevonden bij de TEP liesbreuk correctie van recidief liesbreuken na eerder conventioneel herstel.

In dit artikel worden de oorzaken van het falen van de TEP liesbreukcorrectie voor deze groep van patienten besproken en derhalve aanpassingen voor toekomstig recidief liesbreuk herstel voorgesteld.

Hoofdstuk 4 presenteert de resultaten van de endoscopische liesbreuk correctie voor bilaterale breuken. De resultaten van deze correcties werden geanalyseerd bij 98 patienten (17 correcties met rechthoekige mat en 81 met 'slipvormige' mat). De korte opnameduur en het snelle postoperatieve herstel in deze groep zijn vergelijkbaar met die in eerdere publicaties. Gelijktijdig herstel van dubbelzijdige liesbreuken, wat volgens sommige auteurs controversieel is bij open liesbreuk herstel, leidt niet tot een langere opnameduur of een langere herstelperiode wanneer dit endoscopisch wordt verricht. Een hoog recidiefpercentage (17.6%) werd aangetroffen in de groep patienten (17) bij wie een rechthoekige mat werd gebruikt. Dit bleek te berusten op onvoldoende mat overlap voor de mediale breukpoort, leidend tot mediale recidieven. Bij gebruik van de "slipmat' daalde dit percentage tot 1.2%.

Hoofdstuk 5 bespreekt het laparoscopisch herstel van recidief liesbreuken na een endoscopische correctie. De vraag of er plaats is voor laparoscopische chirurgie bij de behandeling van recidief liesbreuken na een eerdere scopische interventie wordt hier beantwoord. De procedures werden met minimale complicaties, en zonder de noodzaak tot conversie uitgevoerd. Laparoscopisch herstel van recidief liesbreuken na een eerdere scopische correctie maakte het mogelijk om de oorzaken van het ontstaan van recidieven te bestuderen. Peroperatieve analyse sugereerde dat het ontstaan van recidieven correleert met de ervaring van de chirurg en de grootte van de mat. Toepassen van deze kennis zou de endoscopische liesbreuk chirurgie in de toekomst kunnen verbeteren. De TAPP liesbreuk correctie is een betrouwbare techniek voor recidief liesbreuk correcties na een eerder scopisch herstel.

Hoofdstuk 6 presenteert de resultaten van een studie naar de 'optimale mat grootte' voor endoscopisch liesbreuk herstel, uitgevoerd in een varkensmodel. Om een indruk te verkrijgen van de adequate matgrootte in verhouding tot defectgrootte, werden metingen verricht waarbij de protrusie van de mat werd gerelateerd aan drie variabelen: intra-abdominale druk, afmeting van het defect en overlap van de mat over het defect. Bij defect afmetingen tot 6 cm doorsnede leidde een mat met meer dan 3 cm overlap over het defect nauwelijks tot afname van de protrusie van de mat in het defect. Deze uitkomsten extrapolerend naar de chirurgische kliniek, zou betekenen dat lagere recidief percentages bij endoscopisch liesbreuk herstel bereikt kunnen worden. Bij het gebruik van deze matgrootte zou in klinisch onderzoek een geringer aantal recidieven moeten opleveren.

Hoofdstuk 7 geeft een overzicht van de complicaties van conventionele en endoscopische liesbreukchirurgie. Een verschil wordt gemaakt tussen ernstige en minder ernstige complicaties. Het voorkomen van ernstige complicaties is met name afhankelijk van de ervaring van de chirurg. Opnieuw wordt benadrukt dat kennis van de anatomie de kans op het onstaan van complicaties reduceert, zeker in de endoscopische liesbreukchirurgie.

Hoofdstuk 8 beschrijft de resultaten van een gehouden enquête in 1998 over endoscopische liesbreuk chirurgie, verzonden aan alle Nederlandse chirurgen. Deze studie liet zien dat in 1998 slechts 16% van de Nederlandse chirurgen de endoscopische liesbreuk correctie uitvoerde. Het percentage opleidingsziekenhuizen waar deze techniek uitgevoerd werd daalde van 71 % van de opleidingsziekenhuizen in 1995 naar 60 % in 1997 en verder naar 56 % van de opleidingsklinieken in 1998. Deze resultaten laten een daling zien van de verrichte endoscopische liesbreuk correcties door de algemeen chirurg, waarbij het een procedure lijkt te worden voor de gespecialiseerde chirurg. Chirurgen die geen endoscopische liesbreuk correcties doen zijn of niet overtuigd van de betere resultaten (62%), of deze procedure word door andere stafleden verricht (35%). Verder bestaat er een angst voor de 'learning curve' (15%). De procedure wordt als duurder beschouwd (12%), of de chirurg deed geen liesbreuk chirurgie meer t.g.v. specialisatie in een andere vorm van chirurgie (11%).

Hoofdstuk 9 is een algemene discussie betreffende dit proefschrift. Het geeft een overzicht van de studies beschreven in de hoofdstukken 3 tot en met 8. Het bespreekt de voorwaarden om tot succes te komen in de liesbreukchirurgie zoals de ervaring van de chirurg, de kennis van de anatomie van het liesgebied, en het gebruik van de juiste matgrootte. De specifieke voordelen van de open en endoscopische technieken in de liesbreukchirurgie worden genoemd evenals de plaats van de TEP en TAPP procedures binnen de liesbreukchirurgie. Vervolgens wordt een advies gegeven over de liesbreukchirurgie in de toekomst.

Conclusies

1. Uitgebreide kennis van de anatomie van het liesgebied is noodzakelijk voor het goed uitvoeren van een endoscopische liesbreuk operatie.
2. De TEP liesbreuk correctie is een veilige en efficiënte techniek voor de electieve behandeling van primaire, dubbelzijdige en recidief liesbreuken.
3. De 'slipmat' is essentieel bij de endoscopische dubbelzijdige liesbreukoperatie, waardoor de mediale breukpoort goed bedekt wordt.
4. De TAPP procedure is de techniek van keuze voor een endoscopisch herstel van recidief breuken indien een eerdere scopische correctie heeft plaatsgevonden.
5. Het resultaat van een liesbreukcorrectie hangt af van de ervaring van de chirurg met deze techniek, en de matgrootte die gebruikt wordt.
6. Een mat moet het potentiele breukgebied, de 'myopectineal orifice', goed afdekken om toekomstige breuken in dit gebied te kunnen voorkomen.
7. De endoscopische liesbreukoperatie heeft bij de Nederlandse chirurg aan populariteit verloren t.o.v. de open-mat-technieken, aangezien deze ingrepen eenvoudiger, even effectief en goedkoper lijken.

Illustrations:

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List of Abbreviations

TEP	Total Extra-peritoneal Preperitoneal
TAPP	Trans-Abdominal Pre-Peritoneal
IPOM	Intra-Peritoneal Onlay Mesh technique
ALTF	Anterior Lamina of the Transversalis Fascia
PLTF	Posterior Lamina of the Transversalis Fascia
LFC	Lateral Femoral Cutaneous
GF	GenitoFemoral
II	IlioInguinal
IH	IlioHypogastric
O	Obturator
COALA	COnventional Anterior versus LAparoscopic
LEVEL	Liesbreukcorrectie: Endoscopisch versus Lichtenstein
MQS	Medication Quantification Scale
ADL	Activities of Daily Life

Dankwoord

Graag wil ik iedereen bedanken die een bijdrage heeft geleverd aan de productie van dit proefschrift. Met name:

Mijn Promotor, Professor dr. HJ Bonjer,

Naast het streven om een proefschrift over endoscopische liesbreukchirurgie af te leveren was mijn tweede doel jouw eerste promovenda te zijn. Mede door jouw onaflatend enthousiasme voor mijn producties en de eeuwige bereidheid mij te steunen is dit gelukt.

Het stimuleren van jouw omgeving is je tweede natuur, ik prijs me dan ook gelukkig me een aantal jaren in jouw laparoscopische omgeving te hebben mogen begeven. Je vermogen om zowel een 'strenge' opleider als een goede kameraad te zijn bewonder ik zeer.

Het feit dat je in alle vroegte je Jaguar hebt gestart om met mij in de file naar Den Haag te gaan, om te helpen bij mijn eerste lap milt in het Medisch Centrum Haaglanden *(patient 140 kg)*, onderschrijft jouw betrokkenheid bij je (oud)-assistenten.

In mijn chirurgische toekomst zal ik mij blijven interesseren voor de endoscopie en de ontwikkelingen hierin. Ik hoop dat onze samenwerking altijd zal blijven bestaan.

Mijn Co-Promotor, Dr. CJ van Steensel,

In mijn tweede opleidingsjaar besloot ik dat het tijd werd voor wat wetenschap. Bij voorkeur moest dit leiden tot een proefschrift en dus aan de voorwaarden, interessant, overzichtelijk en uitvoerbaar, moest worden voldaan zodat het alleen op mijn eigen inzet stuk kon lopen. Dit aan jou voorleggend leverde het onomwonden antwoord op: de endoscopische liesbreuk chirurgie dus!

Lieve Kees, hoewel de aanzet tot dit boekje ons in het begin steeds dichter bij elkaar bracht was het in een gevorderder stadium vaak een opslokker van onze toch al niet al te overvloedige tijd samen. Ik heb genoten van ons gemeenschappelijk enthousiasme voor de laplies chirurgie en daarmee jouw onuitwisbare bijdrage aan mijn boek, hoewel je me

er ook vaak vanaf hebt gehouden voor de nooit te vergeten avondjes in onze favoriete kroeg "De Pui", met een whisky en een cola light.
Ik ben je erg dankbaar dat je altijd bereid bent te filosoferen over onze gezamelijke hobby, de algemene chirurgie, jij bent het overduidelijke voorbeeld van de positieve en stimulerende kanten van een partner in hetzelfde vak. Ik geniet steeds van jouw wat onconventionele karakter en met je brede interesse ben je een enorme verrijking in mijn bestaan.

Dr. WF Weidema,
Als 'baas' in het RdGG te Delft en als 'partner in crime' van Kees heb jij een onuitwisbare indruk op mij gemaakt. Je steekt niet onder stoelen of banken wat je van dingen vind, zowel chirurgisch als sociaal. Het heeft even wat tijd gekost voor dat ik dat heb leren waarderen maar doe dat nu zeer zeker. Je bent samen met Kees de drijvende kracht geweest in het begin van de endoscopische liesbreukchirurgie en daarmee mede de verstrekker van het patienten materiaal. Hiervoor, en voor de structurele commentaren op mijn artikeltjes evenals de stimulerende kracht van jouw enthousiasme voor mijn vorderingen, ben ik je erg dankbaar. Inderdaad, mijn cv is nu wat langer dan een A4-tje.

Dr. LPS Stassen,
Promotor en Copromotor ten spijt, zonder jou was dit boek er waarschijnlijk nooit gekomen! Vanaf het moment dat jij na het vertrek van de heren Weidema en van Steensel de honneurs van de endoscopische liesbreukchirurgie in het RdGG hebt waargenomen is onze samenwerking zeer vruchtvol gebleken. Je bent niet wars van monnikenwerk en hebt je mede ingezet voor de nacontroles van alle patienten en het verzamelen van gegevens van de enquetes. Met zeer opbouwende kritiek heb je mijn artikeltjes weten te perfectioneren, altijd de ruimte latend voor mijn eigen stijl. Zelfs toen ik in Marseille zat heb je via de e-mail een vinger aan de pols weten te houden, met het beste resultaat. Thanks!!

Prof. dr. HJ Bruining,
U bent de eerste geweest die er vertrouwen in had dat dit proefschrift er zou komen. Tijdens mijn sollicitatie gesprek voor de opleiding Heelkunde heeft u zich laten overtuigen dat ik tijdens mijn opleiding de wetenschap zou oppikken die in mijn curriculum ontbrak. Ik ben u erg dankbaar voor dit vertrouwen en blij dat ik het niet heb beschaamd. Op subtiele wijze heeft u het voor elkaar gekregen een heel bijzondere positie in mijn hart in te nemen, als opleider, met een heldere kijk op andere essenties van het leven. Bedankt voor uw input in mijn opleiding, maar ook voor de extra vrije dagen die ik kreeg om mijn motorrij-examen te halen. Ik ben er trots op dat u een bijdrage aan mijn stellingen wilde leveren.

Prof. dr. J Jeekel,
U bent de personificatie van de open liesbreukchirurgie, vele publicaties over dit onderwerp staan mede op uw naam. Gelukkig bent u ook een voorstander van het gebruik van een prothese bij het herstel van een liesbreuk. Ik wil u graag danken voor het opponeren tijdens mijn verdediging en hoop dat u eens uw eerste lap lies zult verrichten. Als hoofd van de afdeling chirurgie van het Dijkzigt heb ik u o.a. gewaardeerd om uw opvallende teamgeest die er mede toe kon leiden dat de hele afdeling tijdens de chirurgendagen op de tafels stond en het 'Dijkzigt Ski-Weekend' traditie is geworden. Hartelijk dank hiervoor!

Prof. dr. MA Cuesta-Valentin,
Als toonaangevend endoscopisch chirurg in Nederland heeft u altijd interesse getoond in de lap lies chirurgie. Helaas leiden butgettaire beperkingen ertoe dat u deze procedure *nog* niet in de VU kunt uitvoeren. Wie weet opent de nieuwe leerstoel perspectieven! Bedankt dat u in de commissie wilde plaatsnemen.

Prof. dr. OT Terpstra,
Ik waardeer het zeer dat u *(oud-Rotterdammer)* wilde plaatsnemen in mijn promotiecommissie.

Prof. dr. CJ Snijders,
Hartelijk dank voor uw biomechanische inzicht en uw bijdrage aan het 'optimal mesh size' varkens model. Bedankt dat u in de promotiecommissie wilde plaatsnemen.

Dr. J Himpens,
Ik voel mij vereerd dat u, als vooraanstaand Belgisch endoscopisch chirurg als deskundige in mijn promotiecommissie wilt plaatsnemen.
Hartelijk dank hiervoor!

Dr. RU Boelhouwer,
Roelof, bedankt voor je bijdrage aan de bilaterale endoscopische liesbreukchirurgie waardoor ik in de gelegenheid was dit onderwerp groter aan te pakken.

Dr. GJ Kleinrensink,
Gert Jan, met jouw anatomisch vernuft heb je dit hoofdstuk in mijn boekje weten te structureren. Ook was je een stuwende kracht achter het 'optimal mesh size' varkens model. Bedankt dat je deze mogelijkheid voor mij gecreerd hebt.

Annemarie van Rosmalen en Brent Emmerich Yoder,
Bedankt voor het uitvoeren van alle metingen in het varkens model, zonder jullie inspanningen hadden we nooit zo'n resultaat gehad. Fantastisch!!

CWN Looman en EW Steyerberg,
Zonder een statisticus is een promovenda nergens, jullie hebben dat ten ene male weer bewezen. Bedankt voor dit bewijs!

Mevr G Bieger-Smith,

Beste Gail, geweldig hoe snel je altijd het engels in mijn artikeltjes wist te corrigeren, tot aan de laatste spoedklus! Thanks!

Scarlet van Belle,

Jouw onaflatende bereidheid om via de e-mail ingestuurde diaseries bij te werken, weg te brengen en op te halen heeft mij veel sores bespaard. Ik ben je hier erg dankbaar voor!

Mede onderzoekers van de '*Bonjer Groep*',

Nicole Bouvy, Wietske Vrijland, Martijne van 't Riet, Phillippe Wittich, en Erik Hazebroek, bedankt voor het 'wij gevoel', de vriendschap, de interesse in elkaars projecten, de hulp bij dias en rattenproefjes en de steun bij voordrachten zowel in binnen als buitenland. It feels good to be one of you!

Dr. JF Lange Sr en Johan Lange Jr,

Dankzij het enthousiasme van sr en de tekentalenten van jr heb ik nu een boekje met fraaie en originele tekeningen van de traditionele liesbreukoperaties. Bedankt voor de bijdrage aan mijn anatomisch hoofdstuk, en de gezellige zondagochtendjes op de Schopenhauerweg.

Mijn ouders,

Pap en mam, beide totaal niet uit medische hoek maar met een inzet om deze te begrijpen die indrukwekkend is. Ik ben jullie erg dankbaar voor de stimulerende omgeving die ons gezin altijd is geweest. Onvoorwaardelijk hebben jullie mij gesteund in alle keuzes. Jullie bijdrage aan mijn succes is dan ook enorm.

Petra Bertelink,
Lieve Bertje, in 1984 hebben wij elkaar ontmoet op Hare Majesteits Eerste en is een onvoorwaardelijke vriendschap ontstaan. Nog steeds zijn we van elkaars dagelijkse leven op de hoogte en heb jij je als geen ander altijd betrokken gevoeld bij mijn hele carierre plan. Ik ben er trots op dat je tijdens mijn verdediging naast me staat.

Larissa Tseng,
Lieve Laris, samen hebben we een deel van onze Dijkzigt opleidingstijd doorgebracht waaraan ik onvergetelijke herinneringen heb. Je bent een heerlijke collega en een fantastische vriendin. Jouw betrokkenheid in de chirurgie en de patienten zorg wordt door weinigen gegevenaard. Ik heb je jaren geleden al gevraagd of je mijn paranimf wilde zijn als het zover was, en daar staan we dan. Ons volgende doel is jouw boekje!

Curriculum Vitae

Maria Theresia Theodora Knook is geboren op 21 augustus 1966 in Roosendaal en Nispen. In april 1973 werd zij in het Catharina Ziekenhuis te Eindhoven op conventionele wijze geopereerd aan een hernia inguinalis dextra. In 1984 behaalde zij haar middelbare school diploma (Atheneum β) aan het Bisschop Bekkers College te Eindhoven. In hetzelfde jaar startte zij na uitgeloot te zijn voor de studie geneeskunde aan haar propedeuse Biologie aan de Rijksuniversiteit, Leiden. Dankzij de sociale ondersteuning van de studentenvereniging 'Minerva' en haar huis 'de Hooimeyt' behaalde zij het propedeutisch examen in de Biologie in 1985. In 1985 kon echter gelukkig toch met de studie Geneeskunde worden gestart. In 1990 was zij in de gelegenheid om gedurende vier maanden te werken aan haar afstudeerproject 'Prevalence of Xeropthalmia in Whenchi, Ghana'. Een keuze-co-schap chirurgie werd met veel plezier doorlopen in het Ikazia Ziekenhuis, te Rotterdam (Opleider: Dr. HF Veen). Haar artsexamen behaalde zij vervolgens in september 1992. Van oktober 1992 tot januari 1994 werkte zij als AGNIO chirurgie in het Bronovo Ziekenhuis in Den Haag (Opleider: Dr. ABB van Rijn) waar haar chirurgische enthousiasme verder werd ontwikkeld. In februari 1994 kon zij aan haar opleiding tot algemeen chirurg beginnen in het Reinier de Graaf Gasthuis in Delft, de vijver van dit proefschrift (Opleiders: Dr. WBJ Jansen en D.r PW de Graaf). Het tweede gedeelte van de opleiding chirurgie volbracht zij in het Academisch Ziekenhuis Rotterdam, Dijkzigt, waar zowel haar endoscopische als endocriene chirurgische interesse werd gevoed (Opleiders: Prof.dr. HA Bruining en Prof.dr. HJ Bonjer). Dankzij de internationale contacten van haar opleiders was zij in de gelegenheid om in 1999 gedurende 3 maanden te participeren in het dagelijks werk op de afdeling endocriene chirurgie van l'Hopital d'Adultes de la Timone, in Marseille, Frankrijk (Prof.dr. JF Henry). Haar opleiding chirurgie werd afgerond op 1 februari 2000. Aangezien zij de thorax nog als een 'black box' beschouwde besloot zij zich verder te verdiepen in deze tak van sport binnen de algemene heelkunde. De vervolgopleiding longchirurgie volgde zij in maart 2000 tot juli 2000 op de afdeling cardiothoracale chirurgie van het Thoraxcentrum, Academisch Ziekenhuis Rotterdam Dijkzigt (Opleider: Prof.dr. AJJC Bogers) en vervolgens van juli 2000 tot juli 2001 op de afdeling cardiothoracale chirurgie van het St Antonius Ziekenhuis, Nieuwegein (Opleider: Dr.ir. HA van Swieten). Momenteel is zij als algemeen chirurg werkzaam in het Medisch Centrum Haaglanden, Den Haag, waar zij op 1 januari 2002 tot de maatschap Heelkunde is toegetreden.