

Effectivity of laparoscopic inguinal hernia repair (TAPP) in daily clinical practice: early and long-term result

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Abstract

Introduction The aim of the study was to investigate the effectiveness of laparoscopic inguinal hernia repair in daily clinical practice.

Patients and methods All patients admitted to the hospital for surgery of an inguinal hernia during a 1-year period were prospectively documented and included in a follow-up study. The follow-up was performed at least 5 years after surgery and consisted of a clinical examination, ultrasound investigation and a questionnaire.

Results From January 2000 to January 2001 a total of 1208 inguinal hernias in 952 patients were consecutively operated by a total of 11 general surgeons in daily clinical routine. Of the patients, 98.02 % were operated on laparoscopically with the transabdominal preperitoneal patch plasty technique (TAPP) and 1.98 % had an open repair. The frequency of intraoperative and early postoperative complications was 2.8 %. The complication rate in the patients presenting a complex hernia was not higher than in patients with uncomplicated unilateral hernias. Life-threatening complications were seen in four patients (bowel lesion—0.4 %), but all four patients presented extensive adhesions in the abdominal cavity after previous abdominal surgery. The follow-up rate after 5 years was 85.3 %. After 5 years the recurrence rate was 0.4 % and

the rate of severe chronic pain 0.59 %. None of the patients took analgesics or had to change his occupation.

Conclusion Laparoscopic repair can be applied to all types of inguinal hernia as a daily routine procedure with low rates of recurrences and chronic pain. Limiting factor may be extensive adhesions after previous major surgery in the lower abdomen.

Keywords Inguinal hernia repair · Laparoscopic inguinal hernia repair · Laparoscopic hernioplasty · Laparoscopic herniorrhaphy · TAPP

Hernia repair with approximately 20 million procedures performed annually worldwide is the most frequent operation in general surgery. Because of this huge number of these interventions the quality of performance and patient recovery time which are dependent on the technique used have an impact on both the individual patient and the healthcare system of every country. It is amazing that despite more than 16,000 publications since the beginning of the last century, hernia repair has continued to be a vexing problem for surgeons across the world [1].

When closely studied [1], it seems the achievement of excellent long-term results with a low recurrence rate and avoidance of chronic groin pain remains difficult. The lack of consensus as to the optimum repair technique—laparoscopic or open, tissue repair or mesh—to insure a long-term durable result is also surprising [1]. Moreover, there is a remarkable lack of high-quality studies.

Many studies are carried out retrospectively, reporting on patient groups that are too small and highly selected, and the follow-up is carried out too soon or is not rigorous enough.

The study presented reports for the first time short- and long-term operative results achieved in clinical routine by

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the surgical team of a Department of General and Visceral Surgery of a middle-sized German hospital in a large, unselected patient group continuously operated on with a transabdominal preperitoneal patch plasty (TAPP) because of an inguinal hernia.

Methods

Study population, recruitment, study intervention and follow-up

All patients admitted during 1 year (2000) for surgery because of inguinal hernia disease in the Department of General and Visceral Surgery of the Marienhospital Stuttgart, Germany, were included in this prospective trial. The Marienhospital is a nonprofit institution with 780 beds. A total of 3500 patients requiring all kinds of general and visceral surgery are operated on annually in the department. The following procedures were carried out in the study year 2000: hernia repair 1450 (patients 1189), cholecystectomy 634, colorectal resection 367, thyroid resection 222, gastrectomy 45, hepatic resection 24, fundoplication 23, pancreatic resection 21, esophageal resection 21, other 954. In the operation program were involved: 1 chief surgeon, 5 senior residents, 4 residents, 7 trainees. In all patients admitted because of an inguinal hernia a laparoscopic approach in the TAPP technique was intended to perform.

In 1993 TAPP was introduced in the hospital and gradually this new technique was applied to all types of hernia and became the standard procedure with annually more than 1100 repairs. From the beginning all patients were documented prospectively and included in a follow-up. At regular intervals the data were analyzed, reported in meetings and publications [2–9] and the technique was improved accordingly. The patients were asked to come back for clinical follow-up at 4 weeks, 1, 3, 5 and 10 years after operation. Whereas it was possible for more than 90 % of the patients to be seen up to 1 year after surgery [7], afterward this percentage dropped dramatically. Therefore, in order to evaluate the long-term results more precisely the study presented here was designed, aiming at a complete clinical examination in patients at least 5 years after their operation and consisting of more than 1000 TAPP repairs which had been carried out continuously in an unselected group of inguinal hernia patients during the year 2000.

The follow-up consisted of three parts: clinical examination, ultrasound and questionnaire. The study was mainly done by a young surgeon not involved in the operation program. He was assisted by a surgeon (second author) very experienced in ultrasound diagnostics and who had been 15 years in surgery already. In questionable cases the chief surgeon or a senior resident was consulted.

The dynamic ultrasound examination of the inguinal region was performed by using the abdominal press with the valsalva maneuver. We used a linear ultrasound head from 8 to 12 MHz. The patient was normally in supine position, for more details sometimes in upright position. The examination of the inguinal region was conducted in transversal, then in longitudinal and finally in diagonal sections. The transversal and longitudinal examination started at the level of the lacuna vasorum to detect femoral hernias. The following scanning of the inguinal area was carried out from lateral to medial and from medial to lateral parallel to the inguinal ligament up to the level of the iliac spine. The criteria for recurrence were as follows: (1) a clear detection of a hernia defect and (2) while performing the valsalva maneuver the visualization of a protruding hernia sac. All 4 recurrences were detected and treated in our institution again, but one was diagnosed 4 weeks after TAPP, one after 6 months and two not before the follow-up at 5 years. In all four recurrences there was a concordance between ultrasound recurrences and clinical recurrences.

The patients visited at home had no ultrasound examination, but in the cases the GP was consulted an ultrasound examination was done. When visiting the patient at home the young surgeon was accompanied by the second author.

In cases where the patient had moved to a different address the public registration office was asked for the new address. Twenty-six patients were visited at their homes, and 14 patients were requested to visit their general practitioner for the examination.

The assessment of postoperative physical restrictions was done using a validated Activity Assessment Score (AAS) published by McCarthy [10]. The intensity of chronic pain was classified according to Fujita [11], which means: mild pain VAS 1–3, moderate pain VAS 4–6 and severe pain VAS 7–10.

In detail, in the questionnaire for evaluating the AAS the patient was asked for: localization of pain, activities during which the pain occurs (sitting, walking, getting up, climbing stairs), frequency of pain, intensity of pain (VAS), analgetics consumption, foreign body feeling, restriction of physical activities and feeling of numbness in the inguinal region.

Technique TAPP

All operations were carried out under general anesthesia; a urinary catheter was not inserted routinely. The surgical technique for TAPP was highly standardized and published previously [3, 5, 7–9]. The Veress needle was used for creation of the pneumoperitoneum (observing strict adherence to the safety tests acc. to Semm). In cases after periumbilical surgery the open technique was used. In 2000

three reusable trocars with blunt conical tips were used (10 mm at the umbilicus with 30° optic, 12 mm right lateral medio-clavicular level of umbilicus and 5 mm left lateral level umbilicus). Opening of the peritoneum was started in the region of the spina iliaca ant. sup. and continued about 3–4 cm above all possible hernia openings to the ligamentum umbilicalis medialis, which does not have to be transected. A complete anatomical dissection of the pelvic floor was carried out to guarantee a flat and wrinkle-free placement of the mesh. The extent of dissection reached medially 1–2 cm beyond the symphysis pubis to the contralateral side, cranially 3–4 cm above the transversalis arch or any direct defect, laterally to the spina iliaca ant. sup., and caudally at least 4–5 cm below the ileo-pubic tract at the level of the psoas muscle and 2–3 cm below Cooper's ligament at the level of the superior arch of the pubic bone (parietalization). The abdominal wall was dissected all along the anatomical landmarks (epigastric vessels, rectus muscle, transversalis fascia, pubic bone) but not too close to the peritoneal flap, thus avoiding peritoneal tears or a lesion to the urinary bladder. Into the resulting preperitoneal space a polypropylene mesh (Prolene, 120 g/m²), 10 × 15 cm, without any cutting or slit, was flat and wrinkle-free implanted. The mesh was fixed with 6 staples (EMS, J&J), two at Cooper's ligament, two at the rectus muscle medial to the epigastric vessels and two at the transverse fascia lateral to the epigastric vessels and high above the ileo-pubic tract with strict avoidance of clips in the area caudal to the ileo-pubic tract. As the last step the peritoneum was closed with an absorbable running suture (PDS, J&J). Mobilization and oral nutrition were started immediately after operation. Ultrasound examination was done routinely before discharge. The patients were discharged home between 2 and 3 days after the operation.

A total of 11 surgeons were involved in the hernia program, among them were the chief surgeon, three senior residents, three residents and four trainees.

Outcomes

Primary outcome

The primary outcome of the trial was recurrence of a hernia within 5 years after the repair.

Secondary outcomes

The secondary outcome was chronic pain.

Tertiary outcomes

Tertiary outcomes were intra- and postoperative complications. All the data were registered prospectively. The

operating surgeon had to fill in a special documentation sheet immediately after the operation. A study assistant entered these data together with the early postoperative complications into a database. Long-term complications were assessed at the 4-week, 1-year and 3-year visits.

Statistical analysis

Data were processed using medians and ranges. Pearson's Chi-squared test was applied for statistical analysis. $P < 0.05$ was considered significant.

Results

Baseline characteristics of the patients

Between January 2000 and January 2001, a total of 952 patients were operated on because of an inguinal hernia (Fig. 1). Twenty-four patients (1.98 % of all hernias) were operated on using an open technique. The reasons for choosing the open technique were as follows: In 15 patients a Shouldice repair was carried out because of young age ($n = 9$; 18–21 years), because of high risk for general anesthesia ($n = 1$), because the patient did not wish to have the mesh ($n = 1$) and because of extensive adhesions found in laparoscopy ($n = 4$). In six patients a Lichtenstein procedure was carried out because of history of major abdominal surgery ($n = 3$), high risk for general anesthesia ($n = 2$), extensive adhesions found in laparoscopy ($n = 1$). In three patients a Stoppa/Rives operation was performed because of extensive adhesions found in laparoscopy

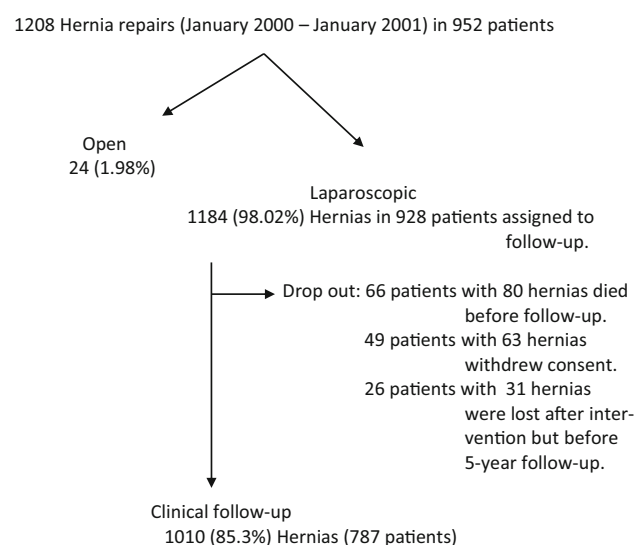


Fig. 1 Flowchart of patients screened for long-term follow-up (5 years)

Table 1 Baseline characteristics of the patients

TAPP repair Characteristic	787 patients (1010 hernias)
Age (year)	60 (17–92)
Sex (%)	
Male	91
Female	9
BMI	25 (14.2–38)
Hernia (%)	
Unilateral	71.66
Bilateral	28.34
Primary	88.12
Recurrent	11.88
Hernia type (Nyhus) (%)	
II	26.73
IIIa	30.20
IIIb	22.67
IIIc	1.49
IV	11.88
Combined defects	7.03
Scrotal	6.3
Irreducible	3.96
Strangulated	1.09
ASA class (%)	
I	26.1
II	61.3
III	11.5
IV	1.1

($n = 1$), history of both transabdominal prostate resection and fourth recurrence ($n = 1$), and in one case simultaneous with repair of a large incisional hernia.

A total of 1184 hernias (98.02 %) in 928 patients were operated exclusively in TAPP technique and were assigned to follow-up. In 787 patients (84.8 %) presenting a total of 1010 hernias (85.3 %) it was possible to perform a clinical examination 6 years (range 5–7 years) after the operation. These patients constitute the study group.

Table 1 shows the baseline characteristics of the patients completed the follow-up. All types of inguinal hernia inclusive of the complex and emergency cases are represented as well as cases of patients with an increased risk for general anesthesia (ASA III 11.5 %).

In Table 2 characteristics of the surgical procedure are shown. A total of 11 surgeons were involved in the TAPP program. Twenty-two patients had a history of previous preperitoneal surgery, and in 9 patients additional interventions were carried out.

Table 2 Characteristics of the repair procedure

TAPP repair Variable	787 patients (1010 hernias)
Surgeon, level of experience	
Resident (%)	80.79
Trainee (%)	19.21
Operation time (min)	42 (15–175)
Coexisting local conditions	
Previous transabdominal	
Prostate resection [n (%)]	12 (1.5 %)
Previous preperitoneal	
Mesh implantation [n (%)]	10 (1.27 %)
Synchronous operations	
Cholecystectomy [n (%)]	7 (0.89 %)
Sigmoid resection [n (%)]	1 (0.127 %)
Appendectomy [n (%)]	1 (0.127 %)

Table 3 Intraoperative and early postoperative complications

TAPP Variable	1010 hernia repairs
Intraoperative complications	
Bowel lesion [n (%)]	4 (0.4 %)
Urinary bladder lesion [n (%)]	1 (0.1 %)
Injury to epigastric vessel [n (%)]	1 (0.1 %)
Injury to testicular vessel [n (%)]	1 (0.1 %)
Conversion [n (%)]	3 (0.3 %)
Postoperative complications	
Urinary retention [n (%)]	7 (0.7 %)
Mesh infection [n (%)]	2 (0.2 %)
Seroma (revision) [n (%)]	2 (0.2 %)
Testicular swelling [n (%)]	2 (0.2 %)
Epididymitis [n (%)]	1 (0.1 %)
Ileus [n (%)]	1 (0.1 %)
Bleeding [n (%)]	1 (0.1 %)
Infected seroma [n (%)]	1 (0.1 %)
Urinary tract infection [n (%)]	1 (0.1 %)
Reoperation	
Laparoscopic [n (%)]	3 (0.3 %)
Laparotomy [n (%)]	2 (0.2 %)

Complication

Intraoperative and early postoperative complications are demonstrated in Table 3. TAPP was completed in 99.75 % of cases; in two patients it was converted to an open repair

because of severe adhesions in the lower abdominal cavity detected with laparoscopy and in one patient because of a small bowel lesion occurring during insertion of the optic trocar (see below). In the intraoperative and early postoperative phases some 28 complications (2.8 %) were observed. Two bowel injuries were caused when dealing with extensive adhesions of small bowel loops with the groin which had arisen in one case after perforated appendicitis and in the other patient after major colorectal surgery. Both patients had to be reoperated by laparotomy because of local peritonitis or abscess formation. Two bowel lesions were caused by trocar insertion although an open access (Hasson) had been chosen. In both of these patients the lesion was detected immediately and closed by suture, but in one case the TAPP procedure was carried out fully, and in the other the surgery was converted to open. In both patients the subsequent course was uncomplicated. The lesion of the urinary bladder occurred in a patient showing extensive tense scar tissue in the spatium of Retzius after previous transabdominal prostate resection. The lesion was immediately recognized and closed by suture; the latter course was uneventful. One of the two mesh infections was seen in the patient mentioned above with the small bowel lesion and the other developed in a 93-year-old man, in whom a fistula between the urinary bladder and the skin after long-term supra-pubic catheter had been severed during TAPP. Although the opening to the bladder was oversewn, apparently a contamination of the mesh had occurred. The ileus (small bowel) was caused by a gap possibly left open or reopened after suture closure of the peritoneum. Six days after TAPP this patient was reoperated using laparoscopy, the incarcerated bowel was reduced, and the gap closed with suture. The further course was normal. The two other laparoscopic revisions were done in two cases on the second postoperative day: in one patient because of a bleeding caused by an injury to an umbilical vessel, and in the second case to cut a suture with which intraoperatively the supra-pubic urinary catheter had been fixed. In three patients conversion to an open repair was necessary because of extensive intra-abdominal adhesions obstructing the access to the groin.

Table 4 shows the long-term results. In two of the six patients suffering from a chronic seroma an anterior revision with excision of the seroma capsule was done. The remaining four were treated conservatively. In one patient 16 months after TAPP a hydrocele resection was performed. A fourth anterior revision with partial mesh explantation was performed in the case of the above-mentioned 93-year-old patient who had an infection of the mesh.

Recurrence

A total of four recurrences were observed. The primary operation in one of these patients had been performed

Table 4 Long-term results

TAPP repair/clinical examination Variable	1010 hernia repairs
Persistent seroma [<i>n</i> (%)]	6 (0.6 %)
Nerve deficiency [<i>n</i> (%)]	3 (0.3 %)
N. cut. fem. lat. [<i>n</i> (%)]	2 (0.2 %)
Ramus genitalis [<i>n</i> (%)]	1 (0.1 %)
Reoperation	
Open, anterior [<i>n</i> (%)]	4 (0.4 %)
Chronic seroma/hydrocele [<i>n</i> (%)]	3 (0.3 %)
Mesh infection [<i>n</i> (%)]	1 (0.1 %)
Recurrence [<i>n</i> (%)]	4 (0.4 %)
Chronic pain [<i>n</i> (%)]	44 (4.35 %)
Mild (VAS 1–3) [<i>n</i> (%)]	28 (2.77 %)
Moderate (VAS 4–6) [<i>n</i> (%)]	10 (0.99 %)
Severe (VAS 7–10) [<i>n</i> (%)]	6 (0.59 %)
Trocar hernia (umbilical) [<i>n</i> (%)]	32 (3.17 %)
Operative repair [<i>n</i> (%)]	8 (0.79 %)
Contralateral hernia after 5 years (related to no. of patients operated on because of an unilateral hernia) [<i>n</i> (%)]	78 (13.8 %)

because of a left-sided recurrence after a laparoscopic repair 2 years before. Additionally, it was known that in the patient's history there had been a previous transabdominal prostate resection. In the operation the patient presented a huge medial gap which was covered by two 10 × 15 cm meshes overlapping each other. Despite the presence of these two meshes, he returned, a few months later, with a recurrent hernia. During laparoscopy the recurrence was seen laterally and caudally of the previously implanted two meshes. Furthermore, diagnostic laparoscopy showed also a recurrent hernia on the right side after previous open repair. This time the whole groin was covered by a 21 × 26 cm large composite mesh. The previously implanted meshes were left in place. At follow-up after 5 years the patient was feeling well without any signs of recurrence.

In a second patient the primary operation was done because of a bilateral hernia (right side: Nyhus II and Nyhus IIIa; left side: Nyhus II). At the 5-year follow-up a recurrence was detected on the left side without any complaints. Up to now no reoperation had been carried out; thus, the reason for the recurrence remains unclear.

The same is true with the third patient. The primary operation in this patient was also done because of a bilateral hernia, on both sides Nyhus IIIa. At the 5-year follow-up a recurrence on the right side was suspected and confirmed by computer tomography. Since the patient had no complaints he was not willing to undergo a reoperation.

The operation in the fourth patient had been performed because of a fourth recurrence of a right-sided hernia

(Nyhuis IVb) after both open and laparoscopic repairs. Already 4 weeks after TAPP a recurrence was detected and 5 months later repaired. Intraoperatively, a huge lateral gap (10 cm) was found with the previous mesh pushed into the sac. The reoperation lasted more than 4 h; the defect was covered by three meshes, 15 × 15 cm each. At follow-up 1 year later the patient had no complaints and presented no signs of a re-recurrence.

Chronic pain

Five years after TAPP six patients (0.59 %) complained of severe chronic pain, but none of these patients needed analgetic treatment and only one experienced some restrictions of his physical activities. The pain occurred in one patient only when he gained body weight, in one patient once a week during sexual activity, in two patients after major physical strain, in one patients when weather changes, and in one patient once in 6 months only without any known reason. Among the patients complaining moderate chronic pain three reported pain when weather changes, one when feeling stressed, one with pressure on the groin, the other five occasionally without a special cause being given. Three complained of restriction of some physical activities, but none needed any analgetics.

Out of the patients with mild chronic pain only four had the feeling of some limitation of their physical activities but none needed a painkiller. Statistical analysis showed that young patients and smokers complained significantly more often about chronic pain (χ^2 $p = 0.0003$ resp. 0.0356). There was no correlation with sex, BMI, length of history, hernia type or level of experience of the surgeon.

However, only one of the 6 patients complaining about severe pain at 5-year follow-up reported about some pain at the 4-week examination and the other 5 had not complained about any pain or discomfort in the groin.

Trocar hernias

All of the 32 trocar hernias occurred at the umbilicus where the 10-mm optic trocar had been inserted. Patients with the highest BMI (25 percentile) or with the lowest BMI (25 percentile) developed significantly more often a trocar hernia compared to patients with a normal BMI ($p < 0.001$). There was no correlation with age, sex, length of history, smoking, hernia type, duration of operation or level of experience of the surgeon.

Contralateral hernias, developed between operation and follow-up

Among the patients who were operated on primarily due to a unilateral hernia, at the follow-up it was found that 78

(13.8 %) had developed a hernia on the contralateral side. Most of these hernias were not observed until more than 5 years after the primary operation (median 69.5 months; range 7–88 months).

Discussion

This study demonstrates that laparoscopic hernia repair in the transabdominal preperitoneal patch plasty (TAPP) technique is applicable to all types of inguinal hernia, even to the most complex ones. Furthermore, the study shows that general surgeons including the trainees in general surgery can learn and perform TAPP safely as a daily routine procedure with low rates of recurrences and chronic pain. However, the preconditions for satisfactory results are to use a highly standardized and quality-controlled technique, a well-structured training program and careful supervision of trainees. The trainees were supervised up to the point they reached resident level (specialist in general surgery), in the rule at least after 6 years education in surgery. After introduction of TAPP in 1993 by the chief surgeon firstly he trained and supervised the senior residents and the senior residents trained the residents and the trainees. Teaching and learning as it is used in our department has been published by Bökeler et al. [12]. Using this systematic training and supervision the results of trainees and residents are not significantly different except for operation time.

Preperitoneal mesh repair in inguinal hernia surgery works according to the physical principle of Pascal [13]. Thus, following this principle the main key to the prevention of a recurrence is the size of the mesh in relation to the size of the defect. A large RCT reported a recurrence rate of about 10 % 2 years after laparoscopic repair, but re-evaluation of the data showed that in the patients with a recurrence a significantly smaller mesh had been implanted [14, 15]. Guidelines recommend a mesh size of at least 10 × 15 cm [16, 17]. However, in patients showing a hernia opening with a diameter of ≥ 4 cm implantation of an even larger mesh, e.g., 12 × 17 cm, is advised.

Fixation of the mesh especially in large direct defects may help but cannot compensate for insufficient mesh size [17]. In the year 2000 when the presented study was done this relationship was not yet fully understood and might be the reason for the occurrence of a recurrence in the three of our cases. The second key to preventing recurrent hernia is related to the extent of dissection of the groin. Along the anatomical structures the whole pelvic floor must be dissected to be clear of fatty layers, only then it is possible to smooth the mesh flat and without any wrinkles directly to the structures of the abdominal wall—rectus muscle, transversales arch, pubic bone, femoral vessels and psoas

muscle [17]. The peritoneum must be peeled from these structures up to 4–5 cm below the ileo-pubic tract (paritalization) because the mesh must not roll up when closing the peritoneal opening. Following these rules in laparoscopic hernia repair as outlined in our study it is possible to achieve recurrence rates which are in a range lower than the rates reported for open mesh repairs are [14, 18–20].

According to Stoppa [13] the force (hydrostatic pressure in the abdominal cavity) which had caused the hernia will stabilize the reconstruction after preperitoneal mesh implantation. Insofar, preperitoneal mesh implantation is an absolutely tension-free technique, contrasting with open mesh repair not only when the patient is resting but also under physical strain. Tension is one of the factors which may cause pain in inguinal hernia repair. Therefore, the patient with a preperitoneal mesh will experience less pain with ensuing more rapid recovery.

In 2000 it was standard in all patients to fix the mesh with tacks. But meanwhile experience shows that in most cases fixation is not necessary [21]. Moreover, tack/staple fixation may be dangerous and may cause pain, although it was possible to show that this is true during the early postoperative days only [22]. In the latter course generally mechanical fixation if done properly does not increase the rate of chronic pain.

In the presented study the number of patients suffering from chronic pain is favorably low when compared to the results reported for open inguinal hernia repair. In open mesh repair reported rates of chronic pain vary between 16 [23] and 54 % [24]. The data from the Danish Hernia Registry [25] show that after open repair chronic pain occurs in 22.9 % of the patients, although only with 3.9 % suffering from severe pain; however, this means five times more frequent in comparison with the data after TAPP presented in this study. But the total frequency of chronic pain of 4.35 % after 5 years reported in the presented study corresponds well with the data very recently published by Antoniou et al. [26]. Antoniou et al. found in their meta-analysis an occurrence of chronic pain after laparoscopic inguinal hernia repair of between 6.2 and 11.8 % in dependence of glue or tackler fixation of the mesh. But it may be interesting to know that only one of the 6 patients complaining about severe pain at 5-year follow-up had reported about some pain at the 4-week examination and the other 5 did not complain about any pain or discomfort in the groin, even not at the 1-year routine follow-up. This result emphasizes that for evaluation of chronic groin pain after inguinal hernia surgery a long follow-up time is necessary, at least longer than 1 year.

Less pain corresponds significantly with more rapid recovery, and the patients usually go back to work about 1 week earlier compared to the Lichtenstein patients [27].

With the advent of 5-mm optics giving a similar imaging compared to the 10-mm ones, there may be the possibility for further reduction in the size of the trocars in order to reduce both postoperative pain and frequency of trocar hernias. Currently, in the three trocar technique it is recommended to use a 5-mm trocar for the optic at the umbilicus, 5-mm working trocar for left medio-clavicular line, level of umbilicus, and 7-mm working trocar for right medio-clavicular line, level of umbilicus. The latter larger one is required to introduce the mesh, a swab if necessary, or the needle holder with suture material.

With the use of this technique a reduction in the rate of trocar hernias at the umbilicus seen in this study can be expected. However, the reduction in the trocar size may inhibit the use of the open access [28] to the abdominal cavity for creation of the pneumoperitoneum. But anyway, there is no clear evidence that the open access is superior to the closed (Veress needle) technique [17]. In the presented study both injuries to the small bowel occurred when using the open access. Both lesions were detected immediately and oversewn, with the result that the latter course of recovery was uncomplicated. The other two bowel lesions occurred during adhesiolysis of small bowel loops from the abdominal wall to get access to the groin. Assessed *ex post*, in these two cases the indication for TAPP was overstressed. Adhesions in the abdominal cavity are a limiting factor in laparoscopic surgery. In the case that during laparoscopy the surgeon will find extensive adhesions it may be better to convert to an open repair as it was done in the cases of the three patients reported above. The other complications observed in this study were rare and of minor importance. Remarkably in the patients presenting complex hernias—scrotal, hernia after preperitoneal surgery, irreducible and strangulated—the complication rates are not higher compared to the uncomplicated hernia types. Without any doubt these operations may be very difficult, but using a strictly standardized technique and once the learning curve is accomplished the complication rates are not essentially higher [29–32]. Strangulated hernia is an excellent indication for TAPP, after cutting the hernia ring reduction of the hernia content is quite easy; thereafter, the surgeon will have 30–60 min time to observe the bowel to recover. Thus, the frequency of bowel resection may be less when compared to open techniques [29].

In the era of open hernia surgery the existence of a bilateral hernia was underestimated. But improvements in ultrasound diagnostic [33] as well as laparoscopic observations have begun to prove that bilateral hernia is more frequent than previously suspected [34, 35]. The presented study shows that about 28 % of the patients were synchronously operated on because of a bilateral hernia, but during the 5-year follow-up an additional 13.8 % developed a hernia on the contralateral side; thus, bilateral

hernia may occur in more than 40 % of the patients. It is important to mention that before TAPP in all patients admitted for hernia surgery in our hospital a careful clinical and ultrasound examination of both sides is routinely carried out, but in none of these patients who developed a contralateral hernia during the follow-up a clinically occult hernia had been detected neither before TAPP nor intraoperatively by direct view. In the case a small asymptomatic contralateral hernia was detected during TAPP, it was fixed if the patient had given informed consent which was asked for routinely before TAPP in all patients.

However, although laparoscopy offers the possibility to repair both sides without additional trauma to the abdominal wall, preventive repair is not recommended [16]. Although in one study laparoscopic repair of bilateral hernia was performed without increasing the complication rates [36], a recently published large study from the German Hernia Registry demonstrated a significantly higher risk in comparison with a unilateral operation [37].

In summary, this study shows that TAPP can be performed by general surgeons as a daily routine procedure. Furthermore, this study proves that all types of hernia as well as patients presenting all types of body habit (BMI) or general condition (ASA I–III) can be safely operated by TAPP with low rates of recurrences or chronic pain. The presented data show that the laparoscopic technique may be advantageous when compared to the total extraperitoneal approach (TEP) and open surgery as well. TEP has limitations as in large scrotal hernias, recurrent hernias after previous preperitoneal mesh implantation and incarcerated/strangulated hernias, and for open surgery the literature shows that laparoscopic repair is superior with respect to less pain and more rapid recovery [23–25, 27].

However, the study has several limitations. The study is done in an urban area of a country with a well-developed healthcare system and patients who mostly come in early stages of their hernia disease to treatment and furthermore have a better access to modern treatment protocols in comparison with the rural areas in Africa or Asia. The larger and more complex the findings are, the greater the need for open surgery will be.

A second limitation is that the design is prospective observational but shows no direct comparison with open techniques. This is only possible when performing a randomized controlled trial (RCT). On the other hand, the clinical value of a RCT may be limited because usually highly selected patient groups are compared not reflecting the results in hernia surgery achieved by the total of the surgical community.

A third limiting factor for application of the laparoscopic technique to all patients might be the presence of

extensive adhesions after major surgery in the lower abdomen. In order to avoid the risks of adhesiolysis and especially possible bowel lesions the indication for laparoscopy in these patients should not be overstressed and an open technique may be preferred.

Reimbursement of the costs may be a further limiting problem even in the rich Western countries. The direct costs for the laparoscopic procedure may be similar to an open repair [38, 39], but the basic equipment (video tower) and a variety of special instruments and materials are necessary, which cost up to US\$100,000. Therefore, from an economic point of view in low-resource countries as well as in small surgical institutions with a low case load it may be difficult to afford this money.

Last limitation concerns the learning curve. Laparoscopic hernia repair is considered a difficult operation; thus, the surgeon may need to carry out about 250 procedures to complete the learning curve [14]. However, the length of learning curve is strictly dependent on both standardization of the technique and the educational program used. In institutions presenting a high case load, a strictly standardized technique and a structured educational program, the number of operations a fellow surgeon needs to gain proficiency may be much smaller and will not exceed 50 repairs [12]. Moreover, it is shown that the results of the surgeons in training are not worse compared to those of experienced hernia surgeons provided that adequate supervision is guaranteed [12].

Conclusions

In summary, for the first time the presented study shows in a large patient population consecutively operated on that laparoscopic inguinal hernia repair (TAPP) not only is suitable in selected patients who are operated on by specialized surgeons but can safely and effectively be performed by general surgeons as a daily routine procedure in nearly all patients coming for operation with an inguinal hernia, provided that the technique is highly standardized, the surgeons are well trained and supervised properly. The only limiting factors are large irreducible hernias, hernias in patients after previous major lower abdominal surgery or hernias in patients not fit for general anesthesia.

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Compliance with ethical standards

Disclosures Florian Muschalla, Jochen Schwarz and Reinhard Bitner have no conflicts of interest or financial ties to disclose.

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