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SURGICAL ENDOSCOPY
and Other Interventional Techniques

Open or endoscopic total extraperitoneal inguinal hernia repair? A systematic review

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Abstract
Background: Although a large number of surgeons currently perform endoscopic hernia surgery using a total extraperitoneal (TEP) approach, reviews published to date are based mainly on trials that compare laparoscopic transabdominal preperitoneal (TAPP) repair with various types of open inguinal hernia repair.
Methods: A qualitative analysis of randomized trials comparing TEP with open mesh or sutured repair.
Results: In this review, 4,231 patients were included in 23 trials. In 10 of 15 trials, TEP repair was associated with longer surgery time than open repair. A shorter postoperative hospital stay after TEP repair than after open repair was reported in 6 of 11 trials. In 8 of 9 trials, the time until return to work was significantly shorter after TEP repair. Hospital costs were significantly higher for TEP than for open repair in all four trials that included an economic evaluation. Most trials (n = 14) reported no differences in subsequent recurrence rates between TEP and open repair.
Conclusions: The findings showed that endoscopic TEP repair is associated with longer surgery time, shorter postoperative hospital stay, earlier return to work, and recurrence rates similar to those for open inguinal hernia repair. The procedure involves greater expenses for hospitals, but appears to be cost effective from a societal perspective. The TEP technique is a serious option for mesh repair of primary hernias.

Key words: Endoscopic total extraperitoneal hernia repair — TEP

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Inguinal hernia repair is one of the most common surgical procedures. In the United States alone, more than 700,000 of these procedures are performed each year, incurring approximately 3.5 billion dollars of hospital costs [1]. Optimizing surgical technique to improve short-term outcome and reduce the rate of recurrence is therefore of great value to health care.

Over the past 20 years, several hernia repair techniques have been introduced [2–4]. Reducing the rate of recurrence has been the main incentive for the development of these new techniques. The introduction of the Lichtenstein tension-free hernioplasty, which uses a mesh to reinforce the abdominal wall, has decreased recurrence rates greatly [5]. Another advantage of the Lichtenstein hernia repair is that it is a relatively straightforward and easy-to-learn procedure requiring minimal dissection that can be performed using local anesthesia. In addition, because the technique is tension free, it is associated with significantly less postoperative pain and discomfort than conventional open repair [6].

Since the introduction of laparoscopic inguinal hernia repair, most of the ongoing discussion has focused on the choice between open or endoscopic surgery. Endoscopic inguinal hernia repair is associated with shorter recovery periods, earlier return to daily activities and work, and fewer postoperative complications [7]. Some authors suggest that endoscopic repair of recurrent hernia is easier because it is performed in virgin tissue.

On the other hand, endoscopic hernia repair requires special skills to overcome limitations inherent to this type of surgery such as loss of depth perception, limited range of motion, and reduced tactile feedback. As a consequence, endoscopic hernia repair has a significant learning curve [8] and is associated with longer operating times [9]. Furthermore, some serious complications during laparoscopic transabdominal preperitoneal (TAPP) mesh repair have been reported [10–13], some even resulting in the death of a patient [11, 13]. Some authors propose that

these complications may have been avoided if an endoscopic extraperitoneal approach had been used [11].

Neumayer et al. [14] compared a mixed design of total extraperitoneal (TEP) and laparoscopic TAPP repair with anterior open inguinal repair according to the Lichtenstein method. Randomized clinical trials comparing only TEP repair with open repair are scarce. Although many surgeons have now adopted the TEP repair, reviews and metaanalyses published to date are based primarily on comparisons between both laparoscopic and endoscopic repair with open inguinal hernia repair [15]. In light of this, a systematic review was performed to examine all published and nonpublished randomized controlled trials comparing TEP with open mesh and suture repair.

Materials and methods

Randomized trials comparing TEP with open mesh or suture repair were included in this review. Studies that included both TEP and TAPP were not included. Relevant randomized controlled trials were identified through a systematic search of Pubmed, Medline, Embase, and Cochrane using the keywords "TEP" and "randomized controlled trial." Studies published as abstracts and presented at scientific meetings also were included in the review to minimize bias.

A total of 23 randomized trials comparing TEP repair with open hernioplasty were identified. In some cases, different outcomes for the same trial were published in separate articles. Therefore, a total number of 29 publications had to be analyzed [16–44]. Of the 23 trials included in this review, 18 were reported as full articles and 5 as abstracts only. Most trials compared TEP with one method of open repair. In seven trials, TEP was compared with two or more open types of inguinal hernia repair (Table 1).

Because of heterogeneity between studies (Table 1), it was not possible to pool the data. The divergences in trial designs were too great, and not all data needed to perform a quantitative statistical analysis were available. Therefore, we performed only a qualitative analysis. The current review focuses on operating time, hospital stay, return to work, major complications, recurrence rates, and costs of TEP, as compared with suture repair. Statistical significance was defined as a p value less than 0.05.

Results

The 23 trials analyzed in the current review included a total of 4,231 patients. The follow-up periods ranged from 0 to 48 months.

Operating time

Data on the duration of surgery were compared in 15 of the trials. The TEP repair required significantly more time than the open methods of inguinal hernia repair in 10 of the trials. One trial reported a shorter operating time for TEP repair than for Lichtenstein hernioplasty. For three trials, no significant differences were found. Bilgin et al. [19] mentioned operating times, but did not state whether the differences observed were statistically significant (Table 2).

Hospital stay

In-hospital stay was mentioned in available data on 11 trials. Significant differences in favor of TEP repair were found in six trials. Heikkinen et al. [16] found a longer hospital stay after TEP repair than after Lichtenstein tension-free hernioplasty (6.25 vs 4.75 h; $p < 0.001$). In two trials, no differences between groups were found, and in one study, p values were omitted (Table 3).

Major complications

Only one major complication, a bowel obstruction, was reported among the patients undergoing TEP repair within the framework of a randomized trial [17]. Among the patients undergoing open surgery, no major complications occurred during or after the surgical procedure.

Return to work

In nine trials, return to work was compared between TEP and open repair. In eight of these trials, TEP repair was associated with significantly fewer workdays lost than open repair (Table 4).

Recurrence rates

Recurrence rates were reported in 15 trials. Liem et al. [41] reported a significantly lower rate of recurrence after TEP than after various methods of open mesh and open nonmesh repair ($p = 0.006$). In the remaining 14 trials, no significant differences were found (Table 5).

Costs

An economic evaluation was performed in only four trials [16, 17, 36, 40]. In the trial by Heikkinen et al. [16], hospital costs were significantly higher for TEP endoscopic repair than for Lichtenstein repair ($1239 vs $782; $p < 0.001$). Total costs, defined as direct and indirect costs caused by absence from work, were however higher with open repair ($3,912 vs $4,661 for TEP vs Lichtenstein, respectively; $p = 0.02$). The cost-effectiveness analysis by Andersson et al. [17] showed similar results, namely, higher direct costs for TEP than for Lichtenstein repair ($2,085 vs $1,480; $p < 0.001$), but no difference in total costs, including costs of sick leave ($4,408 vs $4,757; $p = 0.21$). In the study by Liem [40], TEP repair was found to involve higher hospital costs: Dfl 2,417.24 ($1,309.13) vs Dfl 1,384.91 ($750.05). However, societal costs were lower for endoscopic repair, resulting in total costs that were only Dfl 251.50 ($136.21) higher for TEP repair. Fleming et al. [36] reported nearly 40% higher costs for TEP repair than for Shouldice, mainly caused by the high costs of laparoscopic equipment and disposables.

Discussion

Laparoscopic hernia surgery has been criticized because of its complexity, high costs, risk of major

Table 1. Details on articles and abstracts regarding randomized controlled trials comparing TEP with open repair

Reference	Type of open repair	Follow-up (months)	No analysed
TEP vs open mesh			
Heikkinen et al. [16]	Lichtenstein	10 (median)	45
Andersson et al. [17]	Lichtenstein	12(97%)	168
Merello et al. ¶ [18]	Lichtenstein	"short"	120
Bilgin et al. ¶ [19]	PPOR	12/15 (median)*	60
Lal et al. [20]	Lichtenstein	13 (mean)	50
Payne et al. ¶ [21]	Lichtenstein	20 (median)	100
Colak et al. [22]	Lichtenstein	12/11 (mean)*	134
Bostanci et al. [23]	Stoppa	15 (mean)	64
Champault et al. [24]	Stoppa	20 (mean)	100
Champault et al. [25]	Stoppa	20 (mean)	100
Suter et al. [26]	Stoppa	—	39
Suter et al. [27]	Stoppa	—	39
Khoury et al. [28]	Mesh-plug	17 (median)	292
Bringman et al. [29]	Lichtenstein, Mesh-plug	20 (98%)	294
Wright et al. [30]	Lichtenstein, Stoppa	0.25	120
Wright et al. [31]	Lichtenstein, Stoppa	0.25	64
Simmermacher et al. [32]	Ugahary	—	162
TEP vs open non-mesh			
Nathanson et al. ¶ [33]	Shouldice	24 (mean)	184
Bessell et al. [34]	Shouldice, darn	7.3 (mean)	113
Decker et al. [35]	Shouldice	—	30
Fleming et al. [36]	Shouldice	16 (86% median)	231
Champault et al. [37]	Shouldice	12.3 (mean)	181
TEP vs open mixed			
Liem et al. [38]	Procedure of choice	20 (median)	994
Liem et al. [39]	Procedure of choice	1.5	105
Liem et al. [40]	Procedure of choice	20 (median)	237
Liem et al. [41]	Procedure of choice	44 (median)	994
Champault et al. [42]	Shouldice, Stoppa	48 (79% mean)	461
Wright et al. [43]	Lichtenstein, Stoppa & others	60 (mean)	300
Vatansev et al. [44]	Lichtenstein, Bassini, Nyhus	0.25	84

¶ Reported as abstract only
* TEP/open

Table 2. Operating time

Reference	Operating time		*p* value
	TEP	Open	
Heikkinen et al. [16]	67.5 (40–88)*	53(42–78)*	0.001
Andersson et al. [17]	81 ± 27°	59 ± 20°	< 0.001
Bilgin et al. [19]	69 (25–150)ˆ	85 (40–150)ˆ	not stated
Lal et al. [20]	75.7 ± 31.6°	54 ± 15°	< 0.001
Colak et al. [22]	49.67 ± 14.11°	56.67 ± 11.67°	0.002
Bostanci et al. [23]	58 (40–85)	35 (20–65)	< 0.05
Suter et al. [26, 27]	82 (50–135)ˆ	54 (35–86)ˆ	< 0.001
Khoury et al. [28]	31.5 (5–80)*	30.5 (10–70)*	NS
Bringman et al. [29]	50 (25–150)ˆ	36 (19–88;45 (24–100)ˆ¶	< 0.001‡
Wright et al. [30]	60 (53–72)*	45 (35–52)*	< 0.0001
Liem et al. [38]	45 (35–60)*	40 (30–45)*	< 0.001
Vatansev et al. [44]	58.6 ± 9.7°	54.7 ± 7.2; 51.9 ± 6.5; 59.4 ± 8.2°	NS
Decker et al. [35]	57.2 (38–78)ˆ	53.1 (33–71)ˆ	NS
Fleming et al. [36]	70 (30–145)*	56 (30–145)*	0.0001
Simmermacher et al. [32]	27ˆ	39ˆ	< 0.001

* median (range); ˆ mean (range); ° mean ± standard deviation
¶ Mesh-plug; Lichtenstein
‡ significant difference between TEP\Lichtenstein versus Mesh-plug Lichtenstein; Nyhus; Bassini

complications, and need for general anesthesia. The majority of randomized trials compare a laparoscopic TAPP repair with open methods of inguinal hernia repair. As a consequence, systematic reviews and metaanalyses published to date have been based primarily on a comparison between TAPP and open groin hernia repair. Because most surgeons have now adapted the endoscopic extraperitoneal approach, a review of all

Table 3. Hospital stay

Reference	Hospital stay		*p* value
	TEP	Open	
Heikkinen et al. [16]	6.25 h (5.25–21)*	4.75 h (1.75–45)*	< 0.001
Andersson et al. [17]	13.6 ± 6.9 h°	12.4 ± 6.3 h°	NS
Bilgin et al. [19]	1.3 days (1–4)^	3.2 days (1–7)^	not stated
Lal et al. [20]	1.48 days (1–2)^	1.40 days (1–2)^	NS
Colak et al. [22]	1.80 ± 0.65 days^	2.73 ± 1.62 days^	0.001
Champault et al. [24, 25]	3.2 days (1–6) ^	7.3 days (5–12)^	0.01
Suter et al. [26, 27]	2.2 (2–4)^	2.7 (2–4)^	0.02
Khoury et al. [28]	100% daycare	98% daycare	NS
Wright et al. [30]	1 day (0–1)*	2 days (1–2)*	< 0.0001
Liem et al. [38]	1 day (1–2)*	2 days (1–2)*	< 0.001
Fleming et al. [36]	68% daycare	48% daycare	0.0065

* median (range); ^ mean (range)
° mean ± standard deviation

Table 4. Return to work

Reference	Return to work		*p* value
	TEP	Open	
Heikkinen et al. [16]	12 (3–21)*	17 (4–31)*	0.01
Andersson et al. [17]	8 ± 5 °	11 ± 8°	0.003
Merello et al. [18]	11^	26^	not stated
Lal et al. [20]	12.8 ± 7.1°	19.3 ± 4.3°	< 0.001
Champault et al. [24, 25]	17 ± 11°	35 ± 14°	0.01
Khoury et al. [28]	8 (5–13)*	15 (11–21)*	< 0.01
Bringman et al. [29]	5 (0–30)*	7 (0–150); 7 (0–70)*¶	0.02‡
Liem et al. [38]	14 (7–21)*	21 (12–33)*	0.001
Fleming et al. [36]	14 (3–42)*	30 (7–84)*	0.0001

*median (range); ° mean ± standard deviation
¶ Mesh-plug; Lichtenstein
‡ Significant difference between TEP and Lichtenstein repair only

Table 5. Recurrences

Reference	Recurrences		*p* value
	TEP	Open	
Heikkinen et al. [16]	0/22	0/23	NS
Andersson et al. [17]	2/78	0/85	NS
Merello et al. [18]	0/60	0/60	NS
Bilgin et al. [19]	1/30	0/30	NS
Lal et al. [20]	0/25	0/25	NS
Colak et al. [22]	2/67	4/67	NS
Bostanci et al. [23]	0/32	0/32	NS
Champault et al. [24, 25]	3/51	1/49	NS
Suter et al. [26, 27]	1/20	0/19	NS
Khoury et al. [28]	3/150	4/152	NS
Bringman et al. [29]	2/92	2/104; 0/103¶	NS
Liem et al. [41]	21/487	43/507	0.006
Champault et al. [42]	7/107	8/64; 2/19‡	NS
Wright et al. [43]	3/149	3/151	NS
Fleming et al. [36]	2/93	5/106	NS

¶ Mesh-plug; Lichtenstein
‡ Shouldice; Stoppa

trials comparing TEP with open mesh and nonmesh repair was performed.

Most of the randomized trials in the current review reported longer surgery time for TEP than for open repair. Possible reasons for these prolonged operative times are the intricacy of the procedure and the need for general anesthesia.

A major drawback of the laparoscopic approach for inguinal hernia repair is the risk of major complications. The TEP procedure for hernia repair is performed within the preperitoneal space. The peritoneal space is avoided, presumably leading to a considerable reduction in the risk of major vascular complications, intestinal obstructions, and perforations.

In the current review, only one major complication was reported among the patients undergoing TEP hernia repair [17]. This patient experienced a small bowel obstruction 3 days after surgery. A loop of the small intestine had herniated through a peritoneal tear. These peritoneal defects occur in approximately 10% to 47% of endoscopic hernia repairs [38, 45, 46]. However, herniation occurs rarely and can be prevented by closing the peritoneal defect, for example, through the use of endoscopic stapling or pretied suture loop ligation [46].

Proponents of laparosopic inguinal hernia repair often refer to the shorter hospital stay and the earlier return to daily activities and work associated with this approach. Obviously, hospital stay and return to work are very important outcome measures given that many patients who undergo inguinal hernia repair are of working age. The majority of trials in the current review showed earlier hospital discharge and quicker return to work after TEP than after open hernia repair. In a systematic review by the Hernia Trialist Collaboration [47], which included mainly trials comparing TAPP with open procedures, no significant difference in length of hospital stay was observed between groups ($p = 0.50$). However, return to normal daily activities was found to be earlier after minimally invasive surgery ($p < 0.001$).

The economic benefits to society of reduced absence from work are clearly indicated by the differences in direct and total costs. Whereas in-hospital costs are significantly higher for TEP than for open hernia repair, no differences exist in total costs, including costs associated with workdays lost. Although endoscopic TEP hernia repair is more expensive for hospitals, it appears

Table 6. Qualitative analysis

Outcome	No of trials	Significant advantage*	
		TEP	Open
Duration of operation	15	10	1
Hospital stay	11	6	1
Return to work	9	7	1
Recurrences	15	1	0

* $p < 0.05$

to be cost effective for society as a whole. However, long-term recurrence rates and morbidity have not been included in the economic evaluations performed to date.

In a recent metaanalysis of randomized trials comparing open and laparoscopic inguinal hernia repair [7], a trend toward an increase in the relative probability of short-term hernia recurrence after laparoscopic repair was detected. However, this trend was found only for TAPP compared with open hernia repair and not for trials comparing TEP with open hernia repair. None of the differences observed were statistically significant.

In the current analysis of 23 trials comparing TEP repair with open mesh and sutured repairs, only one trial reported a significant difference in the number of recurrences [41]. Among 994 patients undergoing inguinal hernia repair, a lower recurrence rate after TEP than after open repair using various techniques was observed (21/507 vs 43/487; $p = 0.006$). None of the other trials showed any significant differences in recurrence rates between the different techniques. A possible reason for this is that these trials were not adequately powered to detect significant variances of this magnitude. Future large trials may show up such differences, which are not apparent in most of the studies analyzed in the current review.

Neumayer et al. [14] compared both the TAPP and TEP repair techniques with the open Lichtenstein method and concluded that the open technique is superior to the laparoscopic technique for mesh repair of primary hernias. Endoscopic TEP repair tends to be superior to TAPP repair, because of less morbidity as well as lower recurrence rates and complications [48, 49].

Endoscopic TEP repair seems to be associated with longer surgery time, shorter hospital stay, and earlier return to work than open inguinal hernia repair. (Table 6) Although TEP is associated with higher hospital costs, it does not seem to produce an increase in total expenses, including costs of sick leave. Recurrence rates after TEP repair seem to be comparable with, if not better than, rates after open methods of repair.

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