



Laparoscopic transabdominal preperitoneal (TAPP) hernia repair: surgical phases and complications

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Abstract

Background: This study aimed to determine the nature of complications after transabdominal preperitoneal (TAPP) hernia repair, and to evaluate possible links to intraoperative factors in an effort to reduce the incidence of complications.

Methods: The TAPP procedures for inguinal/femoral hernias performed between 1992 and 2004 at a single center were analyzed retrospectively. Complications were categorized according to severity and stage of the surgical procedure at which they occurred. Individual surgeon performances were examined to determine whether the rates of complications were related to surgeon experience.

Results: A total of 1,973 TAPP procedures were reviewed, and 81% of the patients completed 5 years of follow-up evaluation. The 74 complications (3.7%) reported were categorized as follows: 33 major (1.7%) versus 41 minor (2.0%), 66 hernia-related (3.4%) versus 8 laparoscopy-related (0.5%) complications, and 12 recurrences (0.6%). Risk factors for complications included inguinoscrotal hernia ($p \leq 0.001$), dissection/reduction of the sac ($p = 0.02$), and surgeon experience (< 50 TAPP procedures; odds ratio, 7.1; 95% confidence interval, 4.2–11.9).

Conclusions: Accuracy in dissection/reduction of the sac improves the outcome of TAPP hernia repair. This effect is related to the experience of the surgeon. Experience performing more than 75 procedures is required for optimal results.

Key words: Complications — Inguinal hernioplasty — Laparoscopy — Prevention — Surgical error — Transabdominal preperitoneal procedure

Surgery of the inguinal canal has improved in recent years, with various techniques introduced to reduce the incidence of recurrence and other complications. New methods for the repair of hernias have been explored, with the development of minimally invasive procedures such as laparoscopic techniques in the early 1990s.

Laparoscopy now represents a valid alternative to traditional open techniques, and many reports have demonstrated that this procedure is associated with a lower incidence of postoperative pain and permits more rapid recovery of normal physical activity than conventional procedures [1, 3, 8, 12–14, 19]. However, data concerning the recurrence of hernia still are controversial, with rates ranging from 0% to 15% for laparoscopic repair, as compared with rates of 0.1% to 4.9% reported for open techniques.

There remains a need for comprehensive definitions of complications associated with the laparoscopic technique. The limitations and complications of transabdominal preperitoneal (TAPP) hernia repair have been discussed extensively, but reports in the literature tend to focus on multicenter, retrospective studies, and to assess different techniques simultaneously [4–9, 11, 12, 15, 19]. The complication rates for TAPP were not higher than those reported for conventional repairs, but new and sometimes unique complications were seen. The data available show an incidence of complications ranging from 6.3% to 15.3% during the learning phase, which decreases to between 2.5% and 7.4% when performed by more experienced surgeons [4–9, 11, 12, 15, 19]. However, these findings are fragmented and do not provide a coherent basis for clear conclusions to be drawn.

There is a primary need for further definition of what is meant by “complications” (major or minor) with TAPP hernioplasty, and for further quantification of the true incidence of postoperative complications. Together, these two measures will help to determine whether any causal link exists between complications and intraoper-

ative error. They also will help to establish whether an association exists between procedural performance and experience of the surgeon. In turn, guidance for the prevention of complications can then be formulated.

Our experience is based on a homogeneous series of cases treated using the TAPP technique by a single surgical team working within standardized operating times. The patients had strictly scheduled follow-up evaluation, and all complications were recorded. Careful examination of the different complications (in relation to the technique itself, the type of hernia treated, and the experience of the surgeon) has enabled us to postulate causes for the complications and to propose criteria for their prevention. We summarize our findings and recommendations in this report.

Materials and methods

Study design

This retrospective, single-center study analyzed surgery outcomes data collected from patients with inguinal hernias who underwent TAPP hernioplasty at the 1st Department of Surgery, Sesto San Giovanni (Milano), Italy, between March 1992 and March 2004. The same surgeon performed all the procedures during the period 1992–1994, when the TAPP technique was in its experimental phase. Two different surgeons performed the TAPP surgeries between 1995 and 1998, when the technique was being consolidated and standardized. Between 1999 and 2004, all members of the surgical team, consisting of five skilled surgeons, performed TAPP procedures. The three surgeons who entered the surgical team during the final period of analysis all were trained under the supervision of one of the two leading surgeons. There were no selection criteria for patient inclusion or exclusion. The type of intervention used for all the procedures was decided by the surgeon, with agreement from the patient. If patients did not choose TAPP, they underwent Lichtenstein's repair under local or spinal anesthesia. Final decisions on the procedure type were made by each patient.

Data collection and follow-up evaluation

The follow-up program consisted of postoperative clinical evaluation at 1 and 6 months, then once yearly for 5 years. All intraoperative and postoperative complications were recorded, even those that appeared clinically insignificant, so that their true importance could be assessed over time. Complications were classified as either major or minor according to their severity. In addition, complications associated with the laparoscopic technique were classified as laparoscopic, and those that occurred during hernia repair exclusively were categorized as hernial. Finally, the number and type of complications for each surgeon were compiled, and these data were compared with the number of TAPP procedures performed.

Standardized TAPP methodology

In view of our assumption that postoperative complications are the result of intraoperative error, we did not limit our investigation to examination of intraoperative complications. To determine possible criteria for prevention, we analyzed the different surgical phases involved in the TAPP procedure and considered the laparoscopic complications connected with each of the following intraoperative steps: introduction of the Veress needle, use of trocars (including introduction and removal), and closure of the abdominal wall (fascial and cutaneous layers). The remaining intraoperative steps (i.e., opening/detachment of the peritoneal wall, freeing of Cooper's ligament, preparation of the spermatic cord, and positioning of the prosthesis) were correlated with hernia repair (hernial) complications.

Table 1. Baseline characteristics of patients and hernias treated

Characteristic	
Patients (<i>n</i>)	1,694
Age: years (range)	52.5 ± 9.8 (18–90)
Male/female	8/1
Hernia: <i>n</i> (%)	1,973
Unilateral	1,415 (83.5)
Bilateral	279 (16.4)
Elective surgery	1,683 (99.2)
Emergency surgery	13 (0.8)
Primary hernia: <i>n</i> (%)	1,725 (87.5)
Oblique external	1,083 (62.8)
Oblique internal	105 (6.0)
Direct	473 (27.4)
Crural	44 (2.5)
Femoral	20 (1.1)
Inguinoscrotal hernia	60 (3.5)
Incarcerated hernia	28 (1.6)
Recurrent hernia: <i>n</i> (%)	248 (12.5)
Oblique external	86 (34.7)
Oblique internal	48 (19.3)
Direct	99 (40.0)
Crural	9 (3.6)
Femoral	6 (2.4)
Inguino-scrotal hernia	23 (9.3)
Incarcerated hernia	15 (0.6)

Statistical analysis

Findings regarding the patients treated and their subsequent follow-up evaluation were collected and stored in a Microsoft Access database. Statistical analysis of the findings obtained was performed using the chi-square test in Microsoft Excel. Findings were considered statistically significant if *p* values were less than 0.05.

Results

Data set characteristics

Baseline patient characteristics along with main features of the hernias treated are reported in Table 1, and the number of TAPP procedures performed per year between 1992 and 2004 are shown in Fig. 1.

Of the patients with recurrent hernia, 25 were originally treated in our center and 200 had their operations in other surgery units. All these patients underwent an open repair technique for the primary hernia.

Follow-up evaluation was completed by 81% of the patients (*n* = 1,373), whereas 2% of the treated patients (*n* = 34) were lost to follow-up evaluation. The remaining 17% of the patients (*n* = 288) presented incomplete follow-up evaluations. The mean follow-up period was 53 ± 9.3 months.

Complications

There were 74 complications associated with 1,973 hernias (3.7% incidence): 33 (1.7%) classified as major complications and 41 (2.0%) classified as minor complications (Table 2). Complications classified as hernial (i.e., directly linked to the hernia repair) totaled 65 (3.3%), and there were 9 (0.4%) laparoscopic complications. A total of 16 complications (19.3%) were recorded

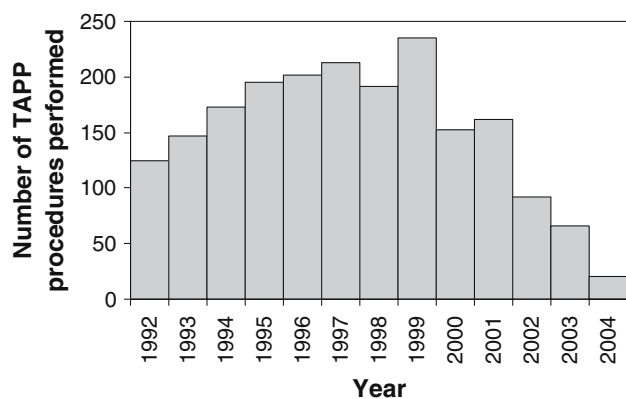


Fig. 1. Number of transabdominal preperitoneal (TAPP) procedures performed per year between 1992 and 2004.

Table 2. Complications recorded in the overall analysis

Complication type	<i>n</i>	% Patients ^a
Major complications		
Total	33	1.7
Persistent pain/paresthesia (> 6 months)	10	0.5
Trocar-site incisional hernia ^b	7	0.3
Hematoma (> 20 ml)	3	0.1
Seroma (> 20 ml)	3	0.1
Hemoperitoneum	2	0.1
Orchiditis	2	0.1
Injury to the deferens	2	0.1
Intestinal occlusion	1	<0.1
Prosthetic infection	1	<0.1
Bladder lesion	1	<0.1
Microperforation of the sigma	1	<0.1
Minor complications		
Total	41	2.1
Seroma (< 20 ml)	21	1.1
Transient pain/paresthesia	8	0.4
Hematoma (< 20 ml)	6	0.3
Intraoperative epigastric lesions	6	0.3

^a Relative to the total number of hernia cases (*n* = 1,975)

^b Laparoscopically correlated complications

from 83 procedures performed on inguinoscrotal hernias ($p < 0.001$). Of these, 9 (10.8%) were classified as major ($p < 0.001$), and 7 (8.4%) were categorized as minor ($p < 0.001$). The rate for the complications classified as major and minor still is statistically significant for the group of inguinoscrotal hernias, as compared with the rate for the noninguinoscrotal group (Table 3).

There were no statistically significant differences in the incidences of complications between primary hernias and recurrent hernias, or between hernias treated with emergency surgery and those treated with elective procedures. Similarly, the relatively higher incidence of complications occurring during the early years of the technique (1992–1996) was found not to be statistically significant, as compared with the overall incidence across the observation period (1992–2004), or with the incidence in later years (2000–2004).

The number of TAPP procedures performed by each surgeon between 1999 and 2004 is reported in Fig. 2. The distribution of complications according to the learning phase for each surgical team member is dis-

Table 3. Complications recorded for inguinoscrotal hernia procedures

Complication type	<i>n</i>	% Patients ^a
Major complications^b		
Total	9	10.8
Orchiditis	2	2.4
Seroma (> 20 ml)	2	2.4
Persistent pain/paresthesia	2	2.4
Hemoperitoneum	1	1.2
Microperforation of the sigma	1	1.2
Intestinal occlusion	1	1.2
Minor complications^c		
Total	7	8.4
Seroma (< 20 ml)	4	4.8
Hematoma (< 20 ml)	2	2.4
Transient pain/paresthesia	1	1.2

^a Relative to total number of hernia cases (*n* = 83)

^b $p < 0.001$ vs incidence in the all-hernia group

^c $p < 0.001$ vs incidence in the all-hernia group

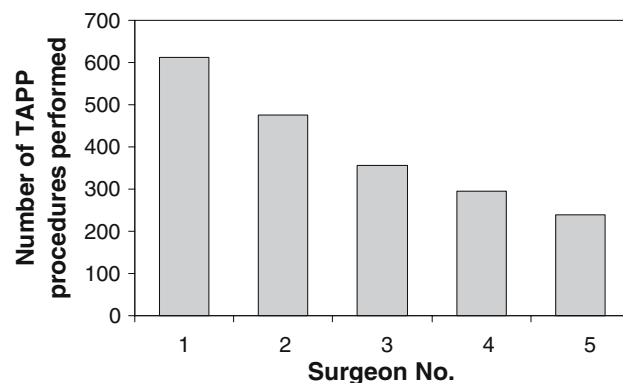


Fig. 2. Number of transabdominal preperitoneal (TAPP) procedures performed by each surgeon of the surgical team.

played in Table 4. The two leading surgeons who defined and standardized the TAPP technique are indexed as surgeons 1 and 2. The other surgeons who joined in the final study period are referred to as surgeons 3, 4, and 5. Most of the events were reported in the early learning phase: 61 complications within the first 50 TAPP procedures conducted versus 13 complications for procedures thereafter. During the first 25 TAPP procedures performed (i.e., early learning phase), the complication rates of surgeons 1 (36%) and 2 (32%) differed from those of surgeons 3 (28%), 4 (24%), and 5 (28%), but the difference did not reach statistical significance. Notably, this difference became less evident in the subsequent learning phases. Analysis of these data indicated that the performance of 50 TAPP procedures represents the key cutoff in the surgeon learning curve because the odds ratio for the complications decreased from 7.1 to 0.9 (95% confidence interval, 4.2–11.9).

From the panel of major complications, the incidence of seroma, in particular was found to be correlated with the size of the hernia (the significantly higher incidence of seroma was associated with inguinoscrotal hernias [6 cases, 7.2%]) and with recurrent hernia. No trocar-site infection of the surgical wound was observed at our center. The complications considered within the

Table 4. Distribution of complications according to the learning phase for each surgical team member

TAPPs performed	Complications					Total complications <i>n</i> (%)	Odds ratio (95% CI)	Chi ² (<i>p</i> value)
	Surgeon 1 <i>n</i> (%)	Surgeon 2 <i>n</i> (%)	Surgeon 3 <i>n</i> (%)	Surgeon 4 <i>n</i> (%)	Surgeon 5 <i>n</i> (%)			
0–25	9 (36)	8 (32)	7 (28)	6 (24)	7 (28)	37 (29)	14.8 (9.0–4.1)	0.00
26–50	5 (20)	5 (20)	4 (16)	5 (20)	5 (20)	24 (19)	7.1 (4.2–11.9)	0.00
51–100	0 (0)	1 (0.4)	0 (0)	0 (0)	1 (0.4)	2 (0.8)	0.9 (0.2–4.1)	0.01
> 100	4 (0.7)	3 (0.8)	2 (0.7)	1 (0.5)	1 (0.7)	11 (0.7)	0.5 (0.0–1.2)	0.00

TAPP, transabdominal preperitoneal; CI, confidence interval

context of the standardized procedural staging and the actions taken (laparoscopic and hernia repair correlated) are summarized in Table 5.

There were 12 cases (0.6%) of recurrence related to procedures in our unit. Eight of these cases followed laparoscopic repair of a primary hernia (0.5%), and four occurred after laparoscopic repair of a recurrent hernia (1.6%). There was a statistically significant reduction in the incidence of recurrences over the years due to standardization of the technique and a greater number of surgeons performing the procedures: 10 cases of recurrence (83.3%) up to the year 2000 versus 2 cases of recurrence (16.7%) between 2000 and 2004.

Discussion

Laparoscopic TAPP hernia repair 12 years after its introduction is a well-defined surgical procedure that offers significant advantages to patients. Assessment of this technique must take into account procedure-correlated complications and their mechanism of onset across the surgical phases. Together with technical features, the outcome of TAPP hernia repair is associated with the experience of the surgeon (i.e., complications decrease as surgical experience increases). The combination of technical features and surgical experience may provide an improved measure by which to gauge the TAPP procedure in terms of feasibility and safety, and may offer an insight into intraoperative and postoperative errors that could predispose a patient to clinical complications.

With regard to the technical aspect, we prefer to deemphasize the analysis of the complications correlated with the laparoscopic technique (i.e., complications that occurred during the use of the Veress needle, use of trocars, and closure of the abdominal wall) because these are phases common to other laparoscopic procedures (e.g., colecystectomy, appendectomy). Although these elements are clinically relevant, they do not specifically contribute to the analysis of the TAPP procedure, and our findings are supportive of other such data reported in the literature [4, 17, 18].

Of greater interest is the analysis of the following complications that occurred during the hernia repair phases:

1. *Incision and detachment of the peritoneal wall:* This process exposes the epigastric vessels to risk of injury (1.3%) [15]. These vessels should therefore always be clearly identified, although hemostasis is easily performed in the event of errors. Vesical injury is another complication associated with this step, which can be averted by avoiding incisions larger than 8 cm on the peritoneal wall, never cutting beyond the medial edge of the residual umbilical artery, and identifying the vesical cupula.
2. *Dissection of Cooper's ligament:* Cases of hematoma in Bogros's prevesical space and of vesical lesions have been reported previously [10, 15]. Blunt dissection, avoiding iliac vessels (laterally) and the bladder (medially), and the scrupulous use of hemostasis can help to avert this complication.
3. *Dissection/reduction of the sac:* This appears to be the surgical phase most closely associated with intraoperative and postoperative complications (both major and minor). Visceral lesions, injury to the deferential artery, orchiditis, lesions of the deferens, and seromas all are seen [2, 8, 10, 15]. According to our findings, the incidence of these complications depends more on the traction maneuvers performed than on the size of the primary hernia. Dissection and full removal of the sac can help to avoid such complications when reduction proves arduous. This is even more evident for inguinoscrotal hernias, as discussed later.
4. *Preparation of the spermatic cord:* Potential injuries include vascular lesions of the spermatic cord [8, 15, 19], lesions of the deferens, and lesions of the iliac vessels. It is good practice always to lift up the plane beneath the spermatic cord and to proceed with dissection cautiously.
5. *Placement of the prosthesis:* Recurrence, the principal complication linked with this phase, occurs either due to the limited size of the prosthesis or because of its rotation caused by the yielding of one or two principal points of anchorage (laterally to the spermatic cord elements and medially to Cooper's ligament). Bleeding at the level of Cooper's ligament is not uncommon, and often is caused by the application of clips (positioned somewhat haphazardly) to secure

Table 5. Complications among all hernia procedures split by stages in the standardized transabdominal preperitoneal (TAPP) procedure (laparoscopically correlated stages vs hernia repair stages)

Laparoscopically correlated stages	Stage of procedure	Complication	Incidence <i>n</i> (%)
Laparoscopically correlated stages	1. Use of the Veress needle	Lesion of the viscera	0 (0)
		Lesion of the lower epigastric vessels	0 (0)
	2. Use of trocars	Lesion of the periumbilical artery	0 (0)
		Lesion of the lower epigastric vessels	3 (0.2) ^a
	3. Closure of the abdominal wall	Lesion of the periumbilical artery	1 (0.1)
		Cases of trocar-site incisional hernia	7 (0.2)
		Hematoma (< 20 ml)	4 (0.2)
		Lesions of the epigastric vessels	4 (0.2)
	Hernia repair correlated stages	1. Incision/detachment of the peritoneal wall	0 (0)
		2. Dissection of Cooper's ligament	3 (0.2)
Hernia repair correlated stages	1. Incision/detachment of the peritoneal wall	Hematomas > 20 ml (bleeding in Bogros's space)	3 (0.2)
		Lesion of the bladder	1 (0.1)
	2. Dissection/reduction of the sac	Hematomas < 20 ml	2 (0.1)
		Microperforation of the sigma	1 (0.05)
	3. Dissection/reduction of the sac	Lesion of the deferens	1 (0.05)
		Orchiditis	2 (0.1)
		Seromas > 20 ml	3 (0.2)
		Seromas < 20 ml	21 (1.1)
	4. Preparation of the spermatic cord	Prosthetic infection	0 (0)
		Lesion of the deferens	1 (0.1)
5. Placement of the prosthesis	Ischemic lesion of the spermatic cord	0 (0)	
	Lesion of the iliac vessels	0 (0)	
	Cases of persistent pain/paresthesia	10 (0.5)	
	Cases of transient pain/paresthesia	8 (0.4)	
6. Closure of the peritoneal wall	Prosthetic infection ^c	1 (0.1)	
	Recurrence	12 (0.6)	
	Postoperative occlusion	1 (0.1)	

^a Two minor and one major complication^b Patient had undergone prostatectomy^c Patient affected by human immunodeficiency virus (HIV) infection

the prosthesis medially. Preventive hemostasis with a bipolar electrocoagulator may be worthwhile when some vessels cross over Cooper's ligament. Numerous reports in the literature have highlighted controversy over the issue of postoperative pain, which is characterized according to site, severity, and duration [3, 8, 16]. Postoperative pain can be minor and of a somatic nature, occurring in the lower homolateral abdominal quadrant or in the hemiscrotum. However, some patients experience much more severe postoperative pain of a neurogenous type and over prolonged periods, caused by compression of the genital or femoral branch of the genitofemoral or the lateral femorocutaneous nerve. A much larger, roughly trapezoidal "pain zone" proposed recently [16] is bounded medially by the vascular elements of the spermatic cord and laterally by the upper anterior iliac spine, with a superior boundary 1 to 2 cm above the ileopubic tract. More than one author has suggested that this entire area should remain "off limits" to the application of metal clips. Finally, prosthetic infection also can appear as a late complication related to prosthesis placement [11, 20]. This has occurred in one (HIV-positive) patient of ours.

6. *Closure of the peritoneal wall:* This final stage can provoke intestinal occlusion related to development of adhesions between the intestine and areas of exposed mesh, which occur when the peritoneal suture gives way [5, 15]. The prevalence of intestinal occlusion after TAPP is higher than with the open techniques because the peritoneum is violated to a greater extent [2, 5]. A significant protective measure against this is the interposition of the peritoneum, which minimizes the contact between the prosthesis and the visceral structures.

Besides the influence of factors associated with intraoperative error at the different methodologic steps outlined, our data demonstrate that the surgical indication can have a clear influence on the occurrence of intraoperative and postoperative complications. For instance, inguinoscrotal hernias show a significantly higher rate of complications such as seromas, postoperative pain, bleeding, injury to the deferens, and orchiditis. In our experience, the choice to refrain from reducing large, often incarcerated hernial sacs, which involves dissection of the strangulated cingulum and dissection/removal of the sac, allows fewer dissection/traction maneuvers on the sac itself and the spermatic cord elements. As a consequence, there is a drastic reduction in the incidence of complications. In our opinion, this precaution helps to ensure safe performance of TAPP for inguinoscrotal hernias, and is supported in the literature [7].

However, analysis of our data indicates that surgical skill is in fact the crucial aspect governing the outcome of the TAPP procedure. Knowledge of the standardized methodology must be gained by long-term specialist training and well-structured experience. For experienced

surgeons, we identified 50 TAPP procedures as the cutoff in the learning curve for an acceptable complication rate. However, we consider that at least 75 TAPP procedures are required to complete a series of high-performance results. Training must be given under the supervision of a skilled surgeon for at least the first 50 procedures, and must provide hernia repairs of increasing difficulty and dimension. It would be very informative to record intraoperative performance on videotape or CD-ROM for discussion of the procedure afterward to highlight the most critical steps. For surgeons without any prior experience of laparoscopy, a cutoff limit of 75 TAPP procedures should be considered, and it is strongly advised that laparoscopic training be initiated with less demanding procedures such as colecystectomy.

In summary, the TAPP procedure is a specialist technique of hernia repair that can offer distinct advantages when performed by a skilled, well-trained surgeon in a highly specialized center. Standardization of the methodology shows that dissection/reduction of the sac requires considerable accuracy, particularly in the case of large hernias. Hence, this represents a key step in complication prevention.

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