Hernia (2022) 26:1121–1130
https://doi.org/10.1007/s10029-022-02595-w

ORIGINAL ARTICLE

Retrospective analysis of open preperitoneal mesh repair of complex inguinal hernias

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Received: 10 September 2021 / Accepted: 1 March 2022 / Published online: 5 April 2022
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Abstract

Purpose The open posterior approach in the form of either a Stoppa or Wantz operation may be a good alternative technique particularly in the repair of complex inguinal hernias. The term "complex inguinal hernia" designates hernias with a combination of arduous features including large hernia defects, large to giant hernia sacs, multiple recurrences, and bilaterality. In this retrospective analysis, we investigated our results of open posterior repair in view of its feasibility in patients with complex inguinoscrotal hernias.

Methods From a series of 845 inguinal hernia patients, we retrospectively reviewed the records of 60 patients with complex inguinal hernias whom were directed to open preperitoneal repair by either a Stoppa or Wantz procedure.

Results More than 80% of cases were males with large to giant inguinoscrotal hernias. One half of patients had bilateral hernias, and one fourth had recurrent hernias. Early postoperative complications occurred in almost half of patients; however, most of them were minor. The most important early complication in this series was the full recurrences we encountered in the very next morning in two patients. Eighty-three percent of patients left hospital in the first 2 days averaging 1.8 days of hospital stay. The mesh:defect area ratio is <7 in recurrent hernias while it is >9 in nonrecurrent cases.

Conclusion The open posterior approach to complex inguinal hernias facilitated both handling and repair of difficult hernias. It was very well tolerated by the patients, and yielded favorable postoperative results. We think the open posterior repair may be a method of choice in the repair of complex inguinal hernias.

Keywords Complex inguinal hernia · Giant inguinoscrotal hernia · Recurrent inguinal hernia · Bilateral inguinal hernia · Open posterior repair · MDAR

Introduction

Treatment of an inguinal hernia (IH) can be challenging for the surgeon if it comprises unconventional features. Although not designated universally, the term "complex inguinal hernia" represents a hernia holding one or more abnormal properties including a large hernia defect, a large to giant hernia sac with or without incarceration or strangulation, and a single or multiple recurrent hernia after anterior and posterior repair attempts [1–3]. European Hernia Society (EHS) has classified the inguinal hernias by the size and types of the defects. The size of the hernia orifice is registered as 1, 2 or 3 if it is as wide as to insert one, two or three fingers into it. For the anatomic localization, the indirect and direct defects are designated as L: lateral and M: medial, and F stands for a femoral hernia. IHs with large fascial defects (> 3 finger-width), namely M3 or L3 of EHS classification, may be difficult hernias regarding restoration of the anatomical structure and functions of the groin [4, 5]. Scrotal extension of the hernia sac (especially if irreducible) represents a major challenge for the surgeons [5]. Repair of these hernias by a posterior preperitoneal approach, either by an open or laparoscopic technique, has long been advocated by many as a feasible method [3–7].

Campanelli et al. [8, 9] proposed an anatomoclinical classification of recurrent IHs. In their R3 subgroup, the authors assimilated recurrent groin hernias with large defects, multirecurrent hernias, non-reducible hernias, recurrences with

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contralateral primary or recurrent hernias, recurrences compromised by patient-related comorbidities, and femoral hernias. As well emphasized, surgeons must analyze the reasons of previous recurrences, types of repairs and patients' characteristics, and must customize the operation accordingly [7, 8, 10].

A simple reduction of a longtime large hernia may entail morbidity and even mortality associated with loss of domain and increased intraabdominal pressure (IAP) [1, 11, 12]. To avoid abdominal hypertension, some preoperative and intraoperative methods must accompany the hernia repair. There are multiple techniques utilized in the repair of large to giant inguinoscrotal hernias; however, some produced inconsistent results or were difficult to do if not in expert hands [3, 6, 13, 14]. In such large hernias, it seems likely that an open posterior approach with wide preperitoneal dissection and large mesh placement would be the most preventive method against high risk of recurrence [6, 14–17].

In this retrospective analysis, we investigated our results of open posterior repair in patients with complex inguinoscrotal hernias. Our primary endpoints were postoperative complications and length of stay (LOS) in the early period, and recurrence rate at 2 years.

Patients and methods

By definition, we have considered an inguinal hernia a "complex inguinal hernia" if it contained any two or more of the following constituents, namely (1) an M3-L3 inguinal defect [4], (2) an R3 recurrence [8], (3) a large inguinoscrotal sac (> 1L) [18], (4) any bilateral hernia with complex findings on either or both sides. We retrospectively reviewed the records of a total of 845 inguinal hernia patients for a period of 6 years from January 1, 2012 to December 31, 2017. One hundred and seven patients had complex hernia findings, and had been repaired by one of TIPP, TAPP, TEP or Stoppa/Wantz procedures. Of those, 69 cases were directed to open preperitoneal repair, namely the Stoppa and Wantz operations, for their hernias exhibiting significant "complex hernia" findings.

Preoperative preparation

Due to unfavorable factors related to hernia and the patient, those patients were meticulously prepared for surgery. The past IH repairs and lower abdominal operations were recorded. The local conditions in the inguinal region, and reducibility of inguinoscrotal hernias were examined. If the hernia sac size was larger than a liter, the contents and loss of domain was evaluated on a CT. The volume of the sac was calculated by the formula $4/3 \cdot \pi \cdot r^3$. We introduced a Foley catheter into the bladder at the beginning of the procedure to be removed next morning.

Operative technique

We preferred general anesthesia for open posterior repairs; however, we had to continue with spinal anesthesia in some patients with cardiopulmonary risks. We performed open preperitoneal repairs of Stoppa and Wantz in the original techniques only with slight modifications [19, 20]. Since 1995, we used a standard 8–10 cm low midline abdominal incision in bilateral and some unilateral hernias with previous posterior repairs [21]. Otherwise, we utilized a high inguinal transverse incision for a unilateral Wantz repair. With either incision, we focused our attention on passing behind the transversalis fascia to reach to the wide cleavable preperitoneal space, from where we dissected the spaces of Retzius and Bogros. During this cleavage, the spermatic cord is carefully elevated from the iliofemoral vascular pedicle, and the hernia sac was separated from the elements of the cord. We reduced the hernia sac together with its content, and opened frequently to evaluate intestinal viability or resect a bulky omentum when necessary. The cord lipoma and any other hernia from the Fruchaud's myopectineal orifice (MPO) were also reduced. Then we retracted the hernia and peritoneal sacs away from the ilioinguinal region to examine the MPO visually and by hand to check the type(s) and width(s) of the original and concomitant defects. This maneuver formed the basis of selecting the appropriate mesh type and size. We always dissected the preperitoneal space as wide as possible. The peritoneum as a sac was separated away from the abdominal and pelvic walls, and its dissection was extended posterosuperiorly over the iliac vessels and laterally over iliopsoas muscle and ureter much farther than that of a laparoscopic approach. We parietalized the vas deferens and vascular pedicle to find their triangular spread, and released them further from the peritoneal sac for approximately 12 cm more. This extensive parietalization of cord elements enabled placement of a large prosthesis. For specific to complex hernias, we preferred to use the largest possible piece of mesh in its special trapezoid design as depicted by Wantz [20]. Alike from Stoppa's original GPRVS (giant prosthetic reinforcement of the visceral sac) technique, we utilized two separate rectangle pieces of mesh instead of one whole chevron mesh for bilateral hernias. Before placement of every mesh, we cut a triangle alongside the lateral edge starting from the inferolateral corner to a point two to four centimeters medial to the superolateral corner. This trimming brought the mesh into a shape of right-angled trapezoid which helped its anterosuperior leaf accommodate better in preperitoneal space of lower abdominal wall. We trimmed another very small diagonal piece from the inferomedial corner of it to keep the mesh

from touching the prostate. We placed the mesh in position in a concave form. Its spine extended from a point two centimeters contralateral to mid-symphysis pubis medially along the iliopubic tract over MPO to iliac crest laterally. The anterosuperior leaf rose up to linea semicircularis so that it also effectively reinforced the incision. The posteroinferior leaf, covering both the MPO and obturator fossa, well extended in all directions behind the peritoneal sac. The dimensions of the polypropylene mesh varied from the smallest 15 × 17 cm to 26 × 30 the largest. We calculated the area of the mesh in each patient. Using Wolloscheck and Konerding's [22] average male and female MPO dimensions defined in human cadavers, we found our series' average MPO dimensions. We considered MPO an ellipse, and calculated the average MPO area utilizing the π.a.b formula where a and b were the long and short radii of the MPO. We defined the average MPO area in our series as 44.0 cm^2. By dividing the mesh area by this constant MPO area, we further determined in each case the mesh:defect area ratio (MDAR) as proposed by Tulloh and de Beaux [23].

In the early years of this study, we were prone to use lighter mesh types (Ultrapro, Ethicon, Germany) (Dynamesh Cicat, FEG Textiltechnik, Germany) (Duzey Light,Duzey Medikal, Turkey); however, we preferred heavy mesh (Prolene, Ethicon, Germany) (Duzey PPM, Duzey Medikal, Turkey) more recently. We fixed the mesh in position mostly by two tacks (Protack, Covidien, USA) on the Cooper's ligament. In M3/L3 hernias, we put a third tack superior to pubic tubercle and rarely a fourth one on Cooper's ligament close to iliofemoral vessels. We did not fix the mesh in any other location.

If a hernia was irreducible, we initially cut anteriorly the iliopubic tract and inguinal ligament. With appropriate effort, a majority of large inguinoscrotal hernias could be milked into the abdomen. For those still irreducible, we further incised scrotum to free the sac from adhesions, and manipulate it bimanually as described by Campanelli [15]. In these cases, to facilitate reduction we opened the hernia sac, performed an omentectomy and drained sequestrated fluid. We performed orchiectomy when necessary. We were careful during the reduction of giant hernias in virtue of postoperative increased IAP. In the early years, we used to prepare the IH patient so that we could perform an anterior component separation by dividing bilaterally the external oblique aponeurosis through two separate small transverse abdominal incisions on the sides. More recently, we prepared our patients so that we could perform, when necessary, a transversus abdominis release (TAR), a procedure which is a natural continuum of preperitoneal ilioinguinal dissection. If we decided to add a TAR procedure, we outdid this wide dissection in both Bogros spaces upwards beneath and lateral to linea semicircularis to actually unite with the incoming lateral dissection of the TAR procedure. This maneuver facilitated the further steps of TAR considerably. We extended the midline skin incision upwards for another 8–10 cm, incised the rectus sheaths bilaterally, and past behind of the rectus muscles. Close to the lateral edge of the rectus sheaths, we incised the sheaths during which we preserved the perforating nerves and blood vessels. As we cut piecemeal the transversus abdominis muscles, we met with the previously dissected preperitoneal space. The superior level of TAR varied according to IH sac size and degree of loss of domain.

Postoperative care and follow-up

To monitor for early potential complications, some patients were admitted to the intensive care unit (ICU). After extubation, we followed their vital signs, oxygen saturation, and urinary output and blood gases for any sign of cardiopulmonary intolerance. The IAP via urinary catheter was measured in some patients with large hernias. When it was consistent that the patient breaths well and maintains a good level of oxygenation and perfusion, we transferred him or her to a normal bed. We let oral intake by two to six hours postoperatively, and encouraged ambulation as early and frequently as possible. We took off most of the IV lines, urinary catheters and suction drains next morning. If the patient stood up straight and walked with little aid, and reported no problems regarding micturition and defecation, we discharged the patient in the first postoperative day. We hospitalized for longer when the patient's clinical condition necessitated. The length of stay (LOS) and postoperative complications were recorded during our routine follow-ups at 1 week, 1 month, 3 months, and 1 year. Our Hernia Working Group routinely called them on the telephone at 2 years to complete the records as previously described by Eisenberg et al. [24]. Complications within the first month of surgery were defined as early complications and those beyond as late. Early surgical site occurrences (SSO) such as wound infections, seromas, hematomas and orchitis were recorded.

Statistical analysis

We utilized SPSS 22 statistics software for all statistical analyses. Descriptive statistics are given as *n* (%) and mean ± standard deviation for categorical and numerical variables, respectively. The Mann–Whitney *U* test was used to compare whether there is a difference in the dependent variable for two independent groups. The $p < 0.05$ value was accepted to determine the statistical significance for all statistical tests.

Results

We further excluded nine cases due to missing data, and carried out this retrospective study on the records of 60 patients who exhibited "complex inguinal hernia" findings and therefore had their hernias repaired by open preperitoneal approach. The majority of cases were males (85%) with an average age of 59 ± 15 (27–86). The two-thirds of patients were obese, and the average BMI was 32 ± 5 kg/m^2 (22–45) (Table 1). Half of the cases underwent surgery under general anesthesia, while others were done under spinal. The midline infraumbilical incision was utilized in two thirds of patients.

Of 60, 10 cases had normal size hernias (< 1 L). A total of 39 cases (65.0%) had "large" hernias with sizes between one and two liters. Eleven patients (18%) had scrotal hernias even larger than two liters. We defined these as "giant" inguinoscrotal hernias. Of these 11 giant hernias, seven were between 2 and 3 L, three were bigger than 3 L, and the remaining one was as large as 4 L. While standing up, six of them extended below mid inner thigh level (Trakarnsagna's Type I) and two descended further down nearing suprapatellar level (Trakarnsagna's Type II) [25]. None of giant hernias reached the level of the knee. Most of the large inguinoscrotal hernias associated with large inguinal defects exceeding the width of three fingers (M3, 3 cases/L3, 44 cases). Thirty-two patients (53.3%) had bilateral hernias, and by "complex hernia" definition, 26 of them had a large hernia and six had an R3 recurrence on either side. The third integral group of complex inguinal hernias comprised 15 (25%) cases with R3 recurrent hernias. Of these, seven cases had multiply recurrent hernias, six cases had bilateral hernias, and two cases had recurrent hernias with large defects. Most of the fascia defects in recurrent cases were typically fibrotic rings permitting two fingers to pass. The average (median) defect size in 15 recurrent cases were 2.6 ± 0.7 fingers while it was measured 3.4 ± 0.7 fingers in the 45 primary complex hernias ($p < 0.001$). The two of seven multiply recurrent cases had had previous TAPP repairs. One of them was suffering chronic inguinal pain, in whom we removed parts of the previous mesh and unscrewed a dozen of metallic tacks.

The sac reduction was difficult in 25 patients (41.6%) (Table 2). This explains why we eventually divided the inguinal ligament in 11 cases (18.3%), and further incised the scrotum for bimanual reduction of the sac in three cases (5.0%). In irreducible large hernias, alike from many smaller-size hernia repairs in which reduction is little or no problem, the reduction required bimanual handling and dissection of the whole sac both from preperitoneal and scrotal aspects. The sacs of incarcerated hernias were usually edematous and inflamed, and showed adhesions to surrounding tissues including the spermatic cord. The reduction of the sac in such cases often necessitated its dissection from the scrotum and spermatic cord. Knowing that the dissection of the spermatic cord elements from the sac plus their high parietalization in the extraperitoneal space may cause minute injuries to the veins of pampiniform plexus; we paid utmost care during these dissections

Table 1 The baseline parameters of 60 patients with complex inguinal hernias

	N	%
Gender		
Male	51	85.0
Female	9	15.0
BMI (kg/m^2)		
> 40	3	5.0
30–40	34	56.7
< 30	23	38.3
Hernia location		
Unilateral	28	46.7
Bilateral	32	53.3
Hernia type		
Primary	45	75.0
Recurrent	15	25.0
Hernia sac size		
Normal (< 1 L)	10	16.7
Large (1–2 L)	39	65.0
Giant (≥ 2 L)	11	18.3
ASA		
1	23	38.3
2	24	40.0
3	11	18.3
4	2	3.3
Anesthesia		
General	28	46.7
Spinal	32	53.3
Intensive care unit		
Yes	6	10.0
No	54	90.0
Hospital stay (day)		
1	26	43.3
2	24	40.0
3	6	10.0
4	3	5.0
5	1	1.7
Smoking		
Yes	26	43.3
No	34	56.7
Systemic disease[a]		
Yes	37	61.7
No	23	38.3

[a]Diabetes mellitus and hypertension

Table 2 Intra- and postoperative findings and results

	N	%
Incision		
Midline	38	63.3
Transverse	22	36.7
Sac reduction		
Easy	35	58.3
Difficult	25	41.7
Inguinal ligament incision		
Yes	11	18.3
No	49	81.7
Scrotal incision		
Yes	3	5.0
No	57	95.0
Orchiectomy		
Yes	4	6.7
No	56	93.3
Bowel resection		
Yes	0	0.0
No	60	100.0
Omentectomy		
Yes	16	26.7
No	44	73.3
Component separation (TAR)[a]		
Yes	2	3.3
No	58	96.7
Early postoperative complications		
Yes	33	55.0
No	27	45.0
Late postoperative complications		
Yes	4	6.7
No	56	93.3
Readmissions @ 30 days		
Yes	3	5.0
No	57	95.0
Recurrences @ 2 years		
Yes	3	5.0
No	57	95.0
Reoperation		
Yes	2	3.3
No	58	96.7

[a]*TAR* transversus abdominis release

to avoid any injury to these delicate vessels. If reduction of the sac content was already accomplished at this stage, we transected the sac in some cases at a level rather distally, and left distal part untouched to prevent any further injury. We did four (6.7%) orchiectomies, of which three were for marked injury to testicular vasculature and one was for its undescended atrophic nature and fusion to the neck of the sac. Of note, besides the original hernia, we discovered on the same side concomitant hernias from the myopectineal orifice in 21 cases (35.0%), being either medial or lateral hernias in 18 and femoral hernias in three.

In our series, we needed to add a TAR procedure in two cases, both belonging to the group of giant hernias. One of them had a giant scrotal hernia measuring 4 L. In this case, we also resected a bulky omentum and drained a half liter of sequestered fluid from the sac which both contributed to TAR decompression. The second case of TAR procedure was one of the three patients with inguinoscrotal hernias measuring > 3 L. The remaining two cases with 3 L hernias did not necessitate a TAR procedure; however, omentectomies were done in both. Our results showed that we performed omentectomy in nine of 11 giant hernia cases, and in eight of 39 large hernia patients. We did not perform bowel resection in any of our patients. Neither of our two TAR patients developed any pulmonary insufficiency, and left ICU next morning.

We admitted six patients to ICU for the first postoperative night to monitor their cardiopulmonary functions. All six were obese males with large inguinal hernias. We observed transient atrial fibrillation in one, arterial hypertension in two, pronounced hyperglycemia in two, and profuse hemorrhagic drainage from the suction drain in a TAR patient. All of these conditions resolved after appropriate treatment, and no patient developed pulmonary insufficiency secondary to reduction of voluminous hernia contents. All six were taken to normal bed next morning. In the whole group of 60 complex IH patients, we observed major systemic complications in two patients. An elderly male patient developed aspiration pneumonia, and was given supportive treatment including supplemental oxygen, antibiotics, expectorants, and sent home on fourth day with a mini ventilator. Another male patient with a re-recurrent hernia after two successive Rutkow and Lichtenstein repairs (in whom we removed a bullet like retracted mesh plug) showed signs of exacerbated deep vein thrombosis of the ipsilateral leg. We continued his anticoagulant treatment in the postoperative period, and discharged home on the fifth day with recommendations including cessation of smoking, weight loss, wearing compression stockings, and effective ambulation. We documented some minor systemic complications in a total of 12 patients, all of which were treated appropriately (Table 3).

The open preperitoneal mesh repair of complex hernias were well tolerated by the patients, and their postoperative recoveries were usually uneventful. Most of the patients were discharged from hospital on the next (43.3%) or second day (40%) of the operation. The average and median (range) LOS were 1.8 and 2.0 days (1–5), respectively. A total of ten patients stayed in the hospital more than 2 days. The reasons of late discharge were due to postoperative complications in eight cases (aspiration pneumonia, deep vein thrombosis, persistent hemorrhagic wound drainage, difficult micturition

Table 3 The list of early and late complications after open preperitoneal mesh repair of 60 patients with complex inguinal hernias

	N	%
Early complications		
Systemic complications		
Major		
Aspiration pneumonia	1	1.7
Deep venous thrombosis	1	1.7
Minor		
Atrial fibrillation	1	1.7
Resistant hypertension	2	3.3
Hyperglycemia	2	3.3
Hemorrhagic drainage	1	1.7
Sinusitis	1	1.7
Headache	1	1.7
Dizziness	1	1.7
Nausea/bloating	2	3.3
Micturition disorders	5	8.3
Local complications		
Wound infection	2	3,3
Excessive pain	4	6.7
Minor scrotal problems	17	28.3
Edema, seroma	15	25.0
Hematoma	1	1.7
Hydrocele	1	1.7
Orchitis	3	5.0
Early recurrence	2	3.3
Late complications		
Chronic inguinal pain	3	5
Recurrence	1	1.7

and re-intubation, and early recurrence and reoperation) and other social reasons in the remaining two (travelling to a far destination, waiting to be picked up).

A total of 25 (41.7%) patients developed one or more local complications in the early postoperative period. Most of these complications were in the category of minor surgical site occurrences (SSO), in which the scrotal edema and seroma being the most frequent. The most important early complication in this series was the full recurrences we encountered in the very next morning in two patients. Both of them were heavy-built males with large scrotal hernias. One of them had had a hip disarticulation amputation on the side of his large and recurrent hernia. We thought technical failure in the first place and reoperated both patients immediately. We found in both cases that the meshes were pushed superiorly and rumpled by the reherniated peritoneal sac. In the first case, the mesh was partially and obliquely scrolled upwards from its inferomedial corner. In the latter, the upward scrolling was even more extensive. We also observed that we had used lightweight mesh with large pores in both cases, and they were rather small as related to patients' heavy body girths and large size defects (16×19 and 17×22). We, this time, laid 25×28 cm and 26×30 cm pieces of heavyweight mesh (Prolene, Ethicon, Germany) into the preperitoneal space. Their postoperative courses were uneventful, and they were discharged from hospital on days 3 and 4. Reportedly, they did not develop any recurrent hernia at 2 years. We recorded four late complications, of which three were chronic groin pain and one a recurrent hernia which developed in a 61-year old diabetic male who had had an L3 inguinoscrotal hernia with large volume. The patient reported that the recurrence is small, and he did not think of having a new operation. The average mesh size in our three recurrent cases was 292 cm^2. The nonrecurrent group comprising 57 plus our two immediately repaired cases had an average mesh area of 424 cm^2 ($p < 0.029$). We calculated the MDAR as 6.6 in recurrent cases and 9.6 in the nonrecurrent group ($p < 0.027$) (Table 4).

Discussion

Unilateral or bilateral IHs with large fascial defects or large to giant hernia sacs, and those with single or multiple recurrences comprise the group of difficult hernias which inevitably cause serious complications if not managed properly [1–3]. The complexity of the IH may sometimes reach to an extreme level by varying combinations of the above-mentioned conditions. As such abnormal findings exist in an IH

Table 4 Comparison of the average mesh sizes and mesh:defect area ratios (MDAR) in recurrent and nonrecurrent patients after our open posterior repair of complex inguinal hernias [23]

Defect vs. mesh parameters	Recurrent (*N*:3)	Nonrecurrent (*N*:57 + 2)[a]	*p* value
Average mesh size (cm^2)	292.3 ± 54.6	424.4 ± 115.9	$p < 0.029$
Constant MPO area (cm^2)	44.0	44.0	
Average MDAR[b]	6.6 ± 1.2	9.6 ± 2.6	$p < 0.027$

The 44.0 cm^2 average myopectineal orifice (MPO) area in this series is a calculated constant

[a]Included 57 nonrecurrent plus the two "recurred and immediately re-repaired" cases

[b]MDAR mesh: defect area ratio

patient, the road to an uneventful convalescence must be paved with a personalized preoperative preparation, a meticulously designed definitive operation, and intensive postoperative care with appropriate follow-ups. For a regular IH, the gold standard for the repair would be either a Lichtenstein or a laparoscopic TEP/TAPP procedure. However, it is not easy, feasible or sometimes possible to fix a complex IH by an anterior approach if it is re-recurrent, irreducible or large. There are many published case reports in which anterior hernia procedures were not possible, and surgeons had to supplement with another open surgery technique to overcome the odd situation and accomplish the repair [1, 12, 26]. Although some experts excellently perform the repair of complex IH by laparoscopic means, it is not easy and sometimes possible to fix a complex hernia without supplementing with an open procedure [14]. Ertem et al. [18] defined that inguinoscrotal hernias with a volume below one liter can be repaired by laparoscopic means with standard laparoscopic experience. As the size of sac increases, some specific problems besides the volume may dictate selection of an open procedure.

Even with a large fascial defect, sometimes, it is not wide enough to reduce the herniated content, and necessitates surgical widening of the opening. In their novel "hug technique", Campanelli et al. [15] described the wide opening and interconnection of the inguinal region with preperitoneal space utilizing a long pararectus incision. This technique enables the sliding of the sac contents through the widely open neck region into the abdomen. This technique further continues with the placement of a 30×30 cm heavyweight mesh. The open posterior approach in such large to giant hernias provides surgeons with flexibility and ability during the dissection and reduction of the sac. Although nearly half of our patients showed some initial difficulty in sac reduction, we overcame this problem utilizing the facility of bimanual handling of the hernia sac from within the preperitoneal and scrotal spaces. Cutting inguinal ligament added paramount ease to reduction. Since the mesh ensures coverage of the cut inguinal ligament together with the myopectineal orifice, there is no need to fix it afterwards [15]. However, large hernias which have been incarcerated in the scrotum for a long time, fuse to adjacent structures due to inflammation and transient ischemic events, and become edematous that they cannot be reduced without additional measures. In such cases, incising the scrotum for further dissection of the sac may be necessary. Dissection, no matter if done through preperitoneal or transscrotal approach, causes inevitable injury to the testicular vessels. While surgeons are to take all measures to protect the testis and its vasculature, they must also inform patients preoperatively of the potential risks of orchitis and scrotal complications. This is because orchiectomy is more frequently needed in patients with a long history of giant IH. Another reason for orchiectomy is to prevent patients from the postoperative annoying symptoms of acute orchitis [12, 26]. Scrotal complications in the early postoperative period are unexpectedly high after repair of large to giant IHs. Important seromas and hematomas may occur despite suction drains being used [3, 12].

The early recurrences in two patients and their immediate reoperations have provided us with a new insight into building up a better surgical technique. The similar upward scrolling of the meshes giving passage to herniation underneath revealed us in the first place that the meshes were either too small or not properly and widely placed posterior to the MPO. It was our observation in this study that large hernias are associated with large defects, and frequently accompanied with concomitant hernias from the same MPO. Indeed, such complex IH cases may inherit a distinguished weakness in the region, and the MPO in such cases may be more prone to herniation and even to recurrences. Perhaps the surgeons should aim to cover the MPO with mesh with much wider overlap than what has been recommended usually. Other than general "large mesh" recommendations, there is no published study demonstrating how far the mesh should safely overlap the MPO in open posterior or laparoscopic repair of IHs. This specific "MPO failure" may well correspond with the gap of a primary or incisional ventral hernia. EHS classified the ventral incisional hernias by the transverse widths of the fascial gaps, i.e. a median incisional hernia at the umbilical level with an 8 cm transverse defect is an M3W2 hernia [27]. In his metaanalysis, LeBlanc [28] found that the risk for recurrence of incisional hernia decreased as the mesh overlapped the defect over 5 cm. Tulloh and de Beaux [23] brought into focus the mesh:defect area ratio (MDAR) as a predictor of recurrence after ventral hernia repair, and calculated an MDAR threshold of 16 to be exceeded. Similarly, Hauters et al. [29] confirmed the MDAR ratio as the most important predictive factor for recurrence, and reported a ratio of 13 as the threshold under which that technique cannot be recommended and 16 as the threshold over which the risk of recurrence is virtually nil. Interestingly, we calculated in our series an MDAR of < 7 for recurrent and > 9 for non-recurrent cases depicting a threshold around 8 ± 1.5. However, this issue needs to be researched further. Second, we found the meshes scrolled upwards while some tacks were still in place. This observation supported the fact that the lightweight meshes possess a low grip to the tissue which is an important factor that causes rapid deterioration of the repair upon dynamic intermittent strain like coughing [30]. The so-called "grip" varies widely related to meshes, tissues, and fixation used due to the different biomechanical properties of each component. Hollinsky et al. [31] researched the biomechanical properties of lightweight versus heavyweight meshes for laparoscopic inguinal hernia repair, and concluded

that, in terms of hernia recurrence, heavy meshes with greater flexural stiffness or well-fixed lightweight meshes that adequately overlap the hernia defect can be used for laparoscopic treatment of large inguinal hernias. In the remaining cases thereafter, we dissected the preperitoneal space even wider, and laid a heavyweight mesh as large as possible. The metaanalyses support our observation that the heavyweight mesh is superior to lightweight mesh in laparoendoscopic inguinal hernia repair [32, 33]. However, we still do not like to anchor the mesh laterally. When the patient returns to his or her normal life, any lateral tack, even put outside of the triangle of pain, would cause tension and pain during body movements. As we use a large heavyweight mesh and fix it properly at symphysis pubis and the Cooper's ligament, the free edges would help the mesh move in and become molded in the ilioinguinal concavity naturally and without tension.

The regular surgical repair of a longstanding giant inguinoscrotal hernia may precipitate development of abdominal compartment syndrome, if the contents are literally pushed back into the contracted abdominal cavity without taking any measure to restore the domain. Acute cardiopulmonary instability may develop and progress to immediate cardiac arrest [11, 34]. It is therefore mandatory to add at this stage to the procedure a number of decompressive measures to prevent the dangerous rise of the IAP. The preoperative progressive pneumoperitoneum (PPP) has been the most known technique used prophylactically in incisional and inguinal giant hernias [35, 36]. Historically, the intraabdominal debulking by various organ resections has been utilized as either a preventive or an emergency measure [37]. Botulinum toxin A (BTA) has been used intensively in recent years prior to the repair of giant ventral hernias. Zachary et al. [14] repaired two giant IH by eTEP after administration of both BTA and PPP. Tang et al. [38] successfully utilized same combination of BTA and PPP in the laparoscopic repair of giant IHs. Adding either an anterior or a posterior components separation technique to prevent dangerous increase in IAP is another measure taken during reduction of a large IH. The anterior components separation technique adapted from the repair of ventral hernias successfully reestablished the abdominal domain during repair of giant IHs [39, 40]. Large to giant IHs are yet to be counted among the indications of TAR. However, as can be explained by the Pascal Law, the IAP will inevitably rise as a voluminous hernia, no matter if ventral or inguinal, is forcefully reduced. Oprea et al. [41] demonstrated that posterior components separation with TAR effectively moderates the intraabdominal pressure and ventilation by increasing the abdominal cavity and improving the abdominal compliance. Miller and Reed [42] successfully treated a giant inguinoscrotal hernia by PPP and TAR. We think our two giant IH patients treated by the combination of Stoppa and TAR benefited from recreating the abdominal domain and increasing abdominal wall's flexibility. The more recent eTEP operations to fix ventral hernias combine dissection of these two planes [43, 44].

EHS recommends repair of a recurrent IH through undisturbed tissue planes. In case of a previous anterior repair, a TAPP or TEP should be used to repair the recurrence. Conversely, an anterior repair seems appropriate if a previous TAPP or TEP recurred [4]. A number of studies from expert centers proposed the use of relaparoscopic repair of recurrences after previous laparoscopic repair. Their findings indicate that there is a place for relaparoscopic surgery in the treatment of recurrent IHs [45, 46]. However, a TEP or TAPP procedure may not sometimes be a good choice even though it is done in expert hands [12]. Previous lower abdominal incisions, inability to open the space of Retzius, bleeding obscuring the operative field, and peritoneal violation leading to loss of working space may cause conversion to open preperitoneal repair [2]. Re-recurrent hernia operations are to be preferably performed in expert centers with an approach that is most comfortable to the surgeon [2, 16, 47]. In our series, 25% of patients were Campanelli's [8, 9] R3 recurrent IHs, of which half were multiply recurrent while the other half being bilateral, incarcerated or large in size. To our opinion, the open posterior repair may be chosen in such multiply recurrent cases for it gives surgeon the final opportunity to do the "most definitive repair of an intractably recurrent" IH. Our recurrent hernias showed favorable postoperative recovery, and only one recurred the next morning due to the technical failure we already mentioned above. We recorded no other recurrence in any of our R3 recurrent hernia cases at 2 years.

Complex inguinal hernias may be demanding to the patient and surgeon in various aspects. In such cases, the open posterior repair techniques, namely Stoppa and Wantz, comprise an effective all-purpose repair with good tolerance by the patients, and yield unexpectedly low recurrence rates. Only six of our cases necessitated ICU stay for the first night. Although SSO were frequent, 80% of our cases were well enough to leave the hospital in the first 2 days. Our average 1.8 day LOS is well corresponding with many other series [7, 14, 48]. We think our 5% recurrence rate at 2 years (1.7% if two technical failures not being counted) is also acceptable for such complex IHs [7, 10]. The patients with complex IHs, either primary or recurrent, may inherit a weakness in their MPO making it more vulnerable to herniation and recurrences. This issue needs to be investigated in future studies. However, our results gave us the impression that we may overcome this specific weakness and tendency of complex herniation by increasing the MDAR and grip factor of the mesh repair. In this retrospective series of complex IHs, it seems likely that there is an MDAR threshold of 8 to be exceeded to prevent recurrences.

In conclusion, we believe surgeons may benefit from categorizing some inguinal hernias with demanding properties under the topic of "complex inguinal hernias". Using this algorithm, surgeons may handle these hernias better, and avoid inappropriate techniques and maneuvers. This specific "open posterior repair operation" gives the surgeon the best opportunity to handle the complex inguinal hernia successfully. The reduction of the sac, accommodation of the abdominal cavity, and covering with mesh of the whole MPO with wide margins can be achieved with this technique. Because of the ease of the procedure, good tolerance by the patient and favorable postoperative results, we think open posterior repair method may be a good option in the repair of complex inguinal hernias.

Author contributions All authors contributed extensively to the work presented in this paper. Their roles are given below. Design of the work: ZM and KY. Acquisition of data: KY, MFG, AA and HO. Interpretation of data: ZM, KY, and IK. Drafting/critical revision: ZM, KY, and IK. Final approval: ZM.

Funding No specific funding was acquired for this study.

Availability of data and material Our data are available for reviewers.

Code availability Not applicable.

Declarations

Conflict of interest All of the authors declare that they have no conflict of interest.

Ethics approval This retrospective study was approved by the Council on Ethics in Human Research of Istinye University, Istanbul Turkey (June 29, 2021 21-64), and have therefore been performed in accordance with the Helsinki Declaration of 1975, as revised in 2008.

Informed consent The informed consent of hernia patients have been taken during hospitalization prior to their inclusion in the study.

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