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ORIGINAL ARTICLE

Single-access laparoscopic primary and incisional prosthetic hernia repair: first 50 patients

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Abstract
Background Primary and incisional hernia can be repaired by multitrocar laparoscopy. Single-access laparoscopy (SAL) recently gained interest to decrease the invasiveness and to reduce the abdominal trauma, besides improved cosmetic results. The authors report first 50 patients who consulted for primary and incisional hernia and treated by SAL prosthetic repair.
Patients and methods Between December 2009 and March 2012, 50 patients (24 females, 26 males) were submitted to SAL for primary (23) and incisional hernia (27). Mean age was 49.1 ± 15.1 years (17–75), and mean body mass index 29.7 ± 5.7 kg/m^2 (19–44.1). A total of 26 primary and 30 incisional hernias were treated. The technique consisted in implied the use of an 11-mm trocar for 10-mm scope, curved reusable instruments without trocars, and dualface prosthesis fixed by tacks without transfascial closures.
Results No conversion to open surgery nor addition of one or more trocars was necessary. Mean perioperative hernia sizes were 7.0 ± 5.0 cm (2–24) in length and 6.0 ± 3.4 cm (1–16) in width, for a surface of 55.0 ± 64.6 cm^2 (2.8–268.2). Mean prosthesis size used was 188.1 ± 113.4 cm^2 (56.2–505.6). Mean laparoscopic time was 60.2 ± 32.8 min (26–153), and mean final scar length was 21.2 ± 4.5 mm (13–35). Mean hospital stay was 2.2 ± 1.2 days (1–8). Perioperative complications were registered in 4 patients and minor early complications in 13 patients of each group. After a mean follow-up of 16.1 ± 8.8 months (4–34), 2 late complications were observed in one patient of each group.
Conclusion Primary and incisional hernia can safely be treated by SAL prosthetic repair, but a learning curve is unavoidable. Thanks to this approach, in patients with primary hernia, only a small scar is finally visible, and in patients who proved to be prone to develop incisional hernia, the number of fascial incisions can be reduced.

Keywords Single-access · Single-incision · Single-port · Single-site · Umbilical hernia · Ventral hernia · Incisional hernia · Laparoscopy

Introduction

Primary hernia, including umbilical hernia, is the most often acquired in adult with an overall incidence of approximately 5–6 % of all abdominal wall hernias [1]. Typical predispositions are the rise of the intra-abdominal pressure in cases of extreme obesity, history of multiple pregnancies, chronic bronchopneumonia, and ascites.

Incisional hernia, which is a failure of the abdominal wall fascia to heal properly after surgery, is a common complication that affects over 10 % of patients undergoing a laparotomy [2]. Risk of incisional hernia formation after laparotomy depends on the type and urgency of the surgical procedure performed [3, 4]. It is associated with various

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factors like obesity, steroid use, vascular disease, chronic bronchopneumonia, previous abdominal operations, intra-abdominal infection, and postoperative septic complications [3–5].

With the advent of minimal invasive techniques, laparoscopy has been introduced for the treatment of primary or incisional hernia both after open and laparoscopic surgery. Laparoscopy offers a risk of perioperative complications similar to or inferior to that of open surgery, with decreased wound infection rates [6], and a trend toward decreased hemorrhagic complications and mesh infections [7]. It seems to have clear advantages over open surgery for reasons of less postoperative pain, decreased hospital stay, faster return to normal activity, and better cosmesis [8–14]. Thanks to the enhanced visualization, it provides a complete view of the entire defect, including smaller defects that have not always been appreciated clinically, and allows tacking of the mesh to healthy tissue.

Different laparoscopic techniques have been described such as intraperitoneal onlay mesh (IPOM) placement without closures [15] or with transcutaneous transfascial closure of defect [16]. The prosthesis can be fixed to the abdominal wall through absorbable or non-absorbable tacks, double-crown technique (involving two circles of tacks), transfixant sutures or not, and glue [17, 18].

Although laparoscopic repair has been reported to have superior outcomes in terms of incisional hernia recurrence than open surgery [19, 20], the risk of trocar site hernia (TSH) after laparoscopy remains present. In a review by Helgstrand et al. [21], the incidence of TSH was reported to be between 0 and 5.2 %; one-third appeared within 30 days from surgery, 1/3 between 30 days and 2 years, and 1/3 remained unknown. TSH, frequently associated with female gender and high age, was related to the size of the trocars, with a distribution of 4 % after 5-mm trocar and 96 % after 10–12-mm trocars.

In recent years, thanks to the new trend of single-incision/single-port laparoscopy, hernia defects can be repaired by a single-access laparoscopy (SAL), to decrease the invasiveness, reduce the abdominal trauma, and ensure the absence of multiple fascial incisions in patients who have shown to be prone to develop incisional hernia [22], besides improved cosmetic results. Moreover, the decreased incision size can reflect the lower wound infection rate and the reduced tissue trauma associated with SAL if compared with larger open incisions [23]. In addition, the risk to develop incisional hernia is lower [24].

Only a few reports on primary [25] and incisional [22, 26–30] hernia repair through SAL have been reported so far. The aim of this study was to show the feasibility, safety, and outcomes of the first 50 patients, who consulted for primary and incisional hernia and who were submitted to SAL prosthetic repair.

Patients and methods

Between December 2009 and March 2012, 50 patients (24 females, 26 males) were submitted to SAL for primary [23] and incisional hernia [27]. Inclusion criteria were patients with 1 or 2 abdominal wall hernias, a hernia defect inferior to 20 cm in length or width, and a body mass index (BMI) inferior to 45 kg/m^2. Exclusion criteria were contraindications to laparoscopy in general, no patient informed consent, and/or presence of previous prosthetic hernia repair.

Mean age was 49.9 ± 15.1 years (17–75), and mean body mass index was 29.7 ± 5.7 kg/m^2 (19–44.1). Hernia localization was classified according to the European Hernia Society classification [31]. Overall, 26 primary and 30 incisional hernias were treated. Primary hernias were umbilical [16], umbilical associated with recti muscles diastasis [2], and epigastric [8]; incisional hernias were defined as midline subxiphoidal [1], midline epigastric [4], midline umbilical [14], midline umbilical associated with recti muscles diastasis [2], midline infraumbilical [1], midline suprapubic [2], lateral right flank [2], lateral left flank [1], lateral right subcostal [1], and lateral left subcostal [2].

Among the patients with incisional hernia, 14 patients had previously undergone laparotomy and 15 patients presented TSH. All procedures were elective excepted for one (incarcerated incisional hernia). All patients signed an informed consent about the surgical procedure and risks associated with general laparoscopy and SAL.

General anesthesia was induced i.v. with 0.2 μg/kg sufentanil, 2 mg/kg propofol, and 0.6 mg/kg rocuronium. After tracheal intubation, anesthesia was maintained with 5–6 % desflurane. In case of crush induction, 2 mg/kg etomidate or propofol and 1 mg/kg succinylcholine were used i.v., and after the intubation, a 0.2 μg/kg sufentanil and 0.1 mg/kg rocuronium were administered. Two gram cefazolin was administered i.v. to all patients perioperatively.

Postoperatively, 1 g paracetamol was pushed for a WHO visual analog pain score (VAS) between 1 and 3, 100 mg tramadol for VAS between 4 and 8, and 1 mg piritramide for VAS between 9 and 10. VAS score was registered every 6 h postoperatively.

Operative time was divided between total and laparoscopic time. Total time was recorded between the skin incision and the completion of the fascial closure; laparoscopic time was considered between beginning of the pneumoperitoneum and removal of the instruments and trocar.

A prescription of 1 g paracetamol from 1 to 3 times per day was given at the discharge. The patients were interviewed at their first office visit for abdominal pain, based on the number of drugs daily used.

Statistical analysis

Patients' baseline continuous characteristics and continuous outcomes of intervention were described using mean as location parameter and standard deviation as dispersion parameter. The position of the distributions between the 2 groups (primary and incisional hernia) was compared using the non-parametric Wilcoxon rank test for independent samples. Rates of complications were compared using the Fisher's exact test.

For measuring postoperative pain, VAS scales (0–10) were proposed by the nurses to the patients at the following time points: 6, 12, 18, 24, 30, 36, 42, 48 h. We reported each time point separately and the mean VAS score using the available time points.

The use of analgesic drug after the discharge was reported as a cumulative dose taken by the patient in grams every 6 h and treated as a continuous variable.

All p values reported were two-tailed and we considered as significant result a comparison associated with a p value <0.05. We did not adjust our level of significance for multiplicity due to the exploratory nature of our comparisons.

Surgical technique

The patient was positioned supine with the arms alongside the body and the legs straight. The position of the team and the choice of the abdominal incision were dependent upon the localization of the hernia defect, adhering to the principle of laparoscopy, in which the surgeon's head aligns with the operative field and video monitor [32]. For example, if the primary hernia was on the midline and the incisional hernia was on the right abdominal quadrant, the team stood on the patient's left with the camera assistant to the surgeon's right, and the incision was performed in the left flank. If the hernia defect was on the left abdominal quadrant, the team stood on the patient's right, with the camera assistant to the surgeon's left, and the incision was performed in the right flank. The peritoneal cavity was entered using the open approach. Purse-string sutures using 1 polydioxanone (PDS) and 1 polyglactin (Vicryl) were placed on the anterior and posterior recti muscle fascia, respectively, at 2, 4, 6, 8, 10, and 12 o'clock positions (if access in the right abdomen: at 6, 8, 10, 12, 2, and 4 o'clock positions). A reusable 11-mm metallic trocar was introduced inside the purse-string sutures, and a 10-mm, 30°-angled, rigid, standard-length scope (Karl Storz-Endoskope, Tuttlingen, Germany) was used. Curved reusable instruments (Karl Storz-Endoskope, Tuttlingen, Germany) were inserted in the abdomen through the same incision without trocars. The curved grasping forceps I (Fig. 1a), when used, was advanced through a separate fascia opening located outside the purse-string sutures and at 7 o'clock position (if access in the right abdomen: at 1 o'clock position). Other curved instruments, such as a coagulating hook (Fig. 1b), a pair of scissors (Fig. 1c), a suction device, and a 5-mm straight tacker device, were introduced alongside the 11-mm trocar and inside the purse-string sutures at 3 o'clock position (if access in the right abdomen: at 6 o'clock position) (Fig. 2). The sutures were tightened/adjusted to maintain a tight seal around the 5-mm instruments and the 11-mm trocar, and loosened/opened only for the change of the instruments and evacuation of the smoke created with the dissection. The hernia defect was freed from the greater omentum (if adherent) and from the fatty tissue covering the parietal peritoneum (Fig. 3a). Thanks to the curves of the instruments, no conflict between the surgeon's and the assistant's hands was evidenced (Fig. 3b). Perioperative estimation of the size of the hernia defect by percutaneous needles enabled appropriate prosthesis size selection resulting in a minimal overlap of 3 cm in all directions. A dualface prosthesis (21Composix/14Ventralex/7Sepramesh/8Ventralight, Bard Davol Inc., Warwick, RI, USA) was rolled tightly and inserted through the 11-mm trocar, and one or two percutaneous stitches were temporarily used to affix the mesh to the parietal wall. Absorbable tacks (SorbaFix, Bard Davol Inc., Warwick, RI, USA) were used to fix the prosthesis to the abdominal wall in a double crown (Fig. 4a), while the surgeon exerted external manual pressure (Fig. 4b). Next, the temporary percutaneous stitches and the instruments were removed under direct view. The purse-string sutures were tied, and additional sutures were placed to reinforce the access site and to close the separate opening for the grasper (if used) (Fig. 5). The cutaneous scar was closed by intradermal sutures.

Results

No conversion to open surgery or addition of one or more trocars was necessary. No drain was placed at the end of SAL. The procedure was performed without additional grasping forceps I, but only with the coagulating hook in 17 primary hernia patients and in 13 incisional hernia patients. Perioperative and postoperative outcomes are represented in the Table 1. Perioperative complications occurred in 4 patients: 1 bleeding after tack placement, treated by transabdominal percutaneous stitches; 1 bladder perforation (in a patient with suprapubic incisional hernia), treated by suturing; 2 difficulties of access site closure due to poor exposure, treated by enlarging the skin incision. Minor early complications (<30 days) were registered in 13 patients of each group (Table 2).

The mean follow-up was 16.1 ± 8.8 months (4–34), and 31 patients were followed up for a minimum time of

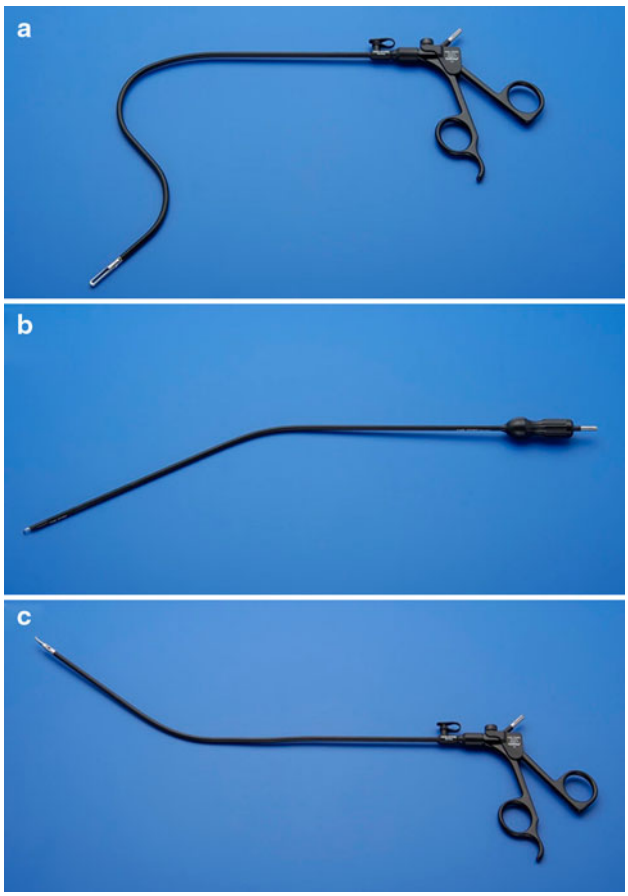

Fig. 1 DAPRI curved reusable instruments: grasping forceps I (**a**), coagulating hook (**b**), scissors (**c**) (*source*: Karl Storz-Endoskope, Tuttlingen, Germany)

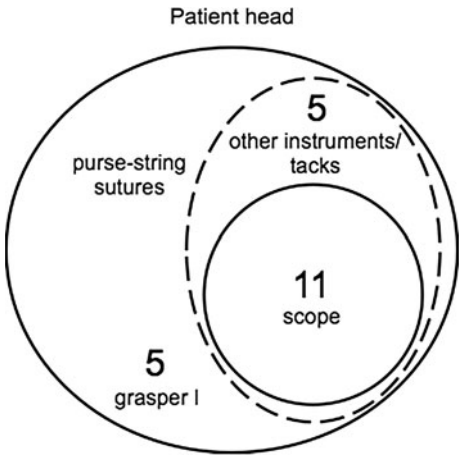

Fig. 2 Single-access in the left abdomen: placement of the 11-mm trocar for the scope, curved reusable instruments without trocars, and purse-string sutures

12 months. During this period, two late complications (>30 days) were observed in one patient of each group, and it consisted in the appearance of incisional hernia at the access site.

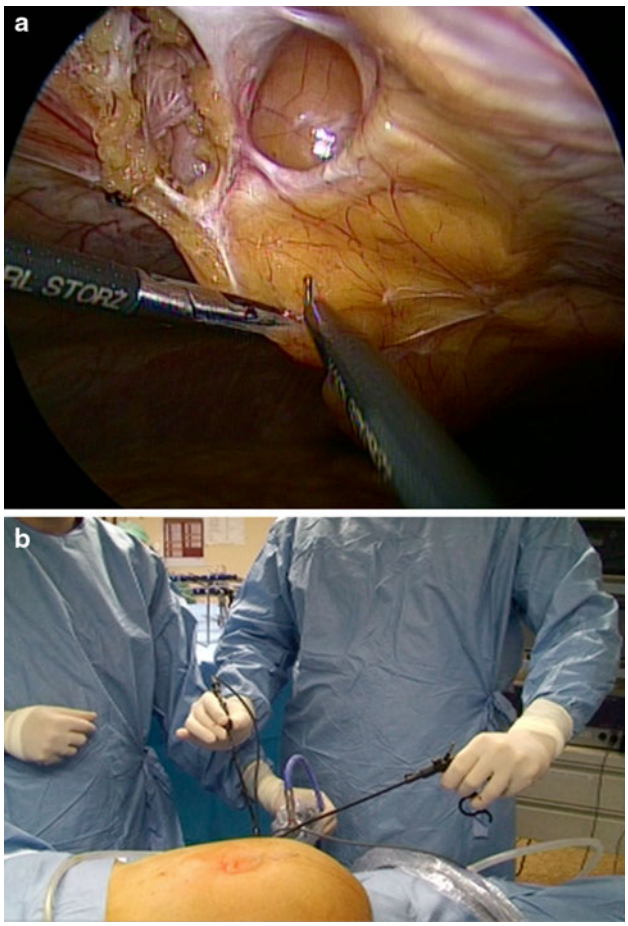

Fig. 3 Intracorporeal working triangulation (**a**) and surgeon's ergonomy without crossing of the hands or clashing of the instruments' tips (**b**)

Discussion

For primary hernia repair, our preferred abdominal quadrant for the access site of SAL was the left flank, because of ease of performance and remoteness of solid/visceral organs that could be endangered. During incisional hernia repair, the choice of the access site was dependent on the localization of the hernia defect, so as to respect the laparoscopic principle that the surgeon's head, the operative field, and the video monitor should be on the same axis [32].

SAL hernia repair has been shown to be feasible using conventional [22, 25–29] or articulating [30] laparoscopic instruments. Frequently in SAL, the conflict between the instruments' tips and/or the crossing of the surgeon's hands appeared problematics [33]. Therefore, the idea was to create specially designed curved instruments that would allow to obtain the intra-abdominal working triangulation as in multitrocar laparoscopy (Fig. 3a). This would improve the surgeon's ergonomy (Fig. 3b) and overall implement a second rule of laparoscopy: the working

Fig. 4 Fixation of the dualface prosthesis to the abdominal wall using tacks (**a**) and surgeon's manual pressure extern to the abdomen (**b**)

Fig. 5 Final scar length

triangulation, which is to have the optical system at the bisector of the working instruments [34].

Thanks to this technique, the cost of SAL remained similar to multitrocar laparoscopic hernia repair, because the usual disposable port devices or instruments adopted during SAL [35] were not used. A reusable 11-mm metallic trocar was preferred together with curved reusable instruments. Hence, in order to maintain pneumoperitoneum during the entire procedure, purse-string sutures had to be placed in both recti fascia. The curved instruments kept in the surgeon's dominant hand (coagulating hook, scissors, suction device, tacker device) were introduced inside the purse-string sutures and parallel to the 11-mm trocar at 3 o'clock position, to permit an easy change during the procedure. The purse-string sutures were tightened to maintain pneumoperitoneum and enlarged only for the instruments' change or for evacuation of the smoke created during dissection; this technique allowed for minimal air leaks. When used, the instrument for the surgeon's non-dominant hand (additional curved grasper) was inserted through a separate window in the fascia, created outside the purse-string sutures through the same skin incision, to reduce the loss of pneumoperitoneum.

The preperitoneal fatty tissue and the greater omentum adherent to the hernia edges, when present, were dissected off because, as for multitrocar laparoscopy, this manoeuver is requested for the prosthesis integration and the deep insertion of the tacks at 90° angle with the abdominal wall. To avoid placement of other trocars in the abdomen, temporary percutaneous stitches were passed through the abdominal wall into the prosthesis to maintain the mesh close to the abdominal wall for the tacks' fixation. As in multitrocar laparoscopy, an important manoeuver remained the external surgeon's manual pressure on the abdominal wall during the placement of the tacks.

The prosthesis was inserted in the abdominal cavity through the 11-mm trocar. This step represented a definite advantage of the SAL technique described here, because a disposable port device as commonly used during SAL has to be removed for the introduction of the mesh in the abdomen [30].

The intraperitoneal onlay prosthesis repair without transfascial closures was the preferred technique, because we believe in the philosophy of non-destruction of anatomical structures around the hernia [36]. In addition, most hernia defects treated were small. The measure of hernia defect was performed perioperatively using straight needles, as during multitrocar laparoscopy, which has proven to be simple, fast, and allowing the appropriate choice of prosthesis.

Application of SAL for the treatment of primary hernia, like umbilical, appeared interesting because, thanks to this approach, the patients end up with only a small visible scar. As for the patients prone to develop abdominal wall defects, such as patients with incisional hernia, the reduction of the number of the trocars potentially could prevent this complication [22].

Adequate patients' selection for SAL was obviously required in terms of hernia size, hernia position in the abdomen, and patient's body habitus evaluated by the BMI. We chose as inclusion criteria a hernia defect with a maximum diameter of 20 cm, to avoid the difficulty of intra-abdominal mesh deployment. Therefore, only one

Table 1 Perioperative and postoperative outcomes

	Primary Hernia	Incisional Hernia	*p*
Perioperative hernia length (cm)	4.0 ± 4.5 (2–24)	9.0 ± 4.6 (2–18.5)	<0.0001
Perioperative hernia width (cm)	4.0 ± 2.0 (1–9)	8.0 ± 3.1 (2.5–16)	<0.0001
Perioperative hernia surface (cm^2)	25.0 ± 44.3 (2.8–216)	80.0 ± 68.0 (6.2–268.2)	<0.0001
Prosthesis size (cm^2)	132.5 ± 100.6 (56.2–333.9)	235.4 ± 101.7 (64–505.6)	0.0003
Total operative time (min)	74.3 ± 22.3 (51–130)	98.4 ± 41.0 (54–200)	0.01
Laparoscopic time (min)	48.0 ± 20.5 (26–113)	70.5 ± 37.4 (28–153)	0.01
Blood loss (cc)	4.2 ± 3.2 (0–10)	8.9 ± 20.3 (0–100)	0.56
Final scar length (mm)	21.0 ± 4.6 (13–35)	21.2 ± 4.3 (14–30)	0.98
VAS 6 h	4.9 ± 1.7 (2–6)	5.0 ± 2.1 (2–9)	0.94
VAS 12 h	4.1 ± 1.9 (2–6)	3.4 ± 2.0 (2–6)	0.30
VAS 18 h	3.5 ± 4.4 (0–6)	3.3 ± 2.4 (0–6)	0.63
VAS 24 h	3.3 ± 2.0 (0–6)	3.3 ± 2.2 (0–6)	0.89
VAS 30 h	2.9 ± 1.9 (0–6)	2.8 ± 2.1 (0–6)	0.86
VAS 36 h	3.7 ± 1.9 (2–6)	2.7 ± 1.8 (0–6)	0.27
VAS 42 h	4.2 ± 1.9 (2–6)	2.8 ± 2.2 (0–6)	0.14
VAS 48 h	3.6 ± 1.9 (2–6)	3.0 ± 2.4 (0–9)	0.54
Mean VAS	3.8 ± 1.1 (1.5–6)	3.3 ± 1.4 (1–6)	0.26
Hospital stay (days)	1.7 ± 0.7 (1–3)	2.5 ± 1.3 (1–8)	0.02
Pain medication after discharge	7.5 ± 6.4 (0–21)	10.1 ± 8.7 (0–28)	0.5

Mean ± SD (range)

Table 2 Early postoperative complications

	Primary Hernia	Incisional Hernia	*p*
Hernia site seroma	8	8	0.77
Hernia site hematoma	4	1	0.17
Intra-abdominal hematoma	0	2	0.49
Respiratory insufficiency	0	1	1
Access site abscess	0	1	1
Access site hematoma	1	0	1

patient with a recti muscles diastasis of 24 cm was included in this series, because the patient presented a combined umbilical hernia. For umbilical hernias, we included all patients with a defect superior to 2–3 cm, because of the proved significant risk of recurrence with simple suture [3, 11, 37, 38]. We agree with other authors [28] not to consider obesity as a contraindication for SAL, but at the beginning of the experience, we considered it prudent to select patients with a BMI inferior to 35 kg/m^2. Conversely, we did not consider the presence of one or more previous surgeries, performed by laparotomy or laparoscopy, a contraindication to SAL because intra-abdominal adhesions can be dealt with an adhesiolysis "a la demande," which was performed in our hands without extensive dissection or placement of additional trocars.

A main laparoscopic time similar to that reported by other authors [25–29] was recorded. A difference of 26.3 min (primary hernia) and 27.9 min (incisional hernia) was achieved between total and laparoscopic time, respectively. This difference can be explained by the time needed to get initial access to the abdominal cavity with the open technique and by the time required to close the main access and, in case of use, the separate window for the curved grasper toward the end of the procedure. We strongly recommend to spend time to close the access site meticulously in order to avoid an incisional hernia at this site, as happened with our 3rd patient after 6 months of SAL. Moreover, the laparoscopic time was influenced by the surgeon's learning curve, for adequate manipulation of the curved instruments. A statistical significant difference was recorded between both times of the two groups, because during incisional hernia repair, more time was needed for adhesiolysis.

Supplementary trocars or conversion to open surgery were not required like other authors [22, 25, 26, 28, 30]. If an additional trocar had to be inserted, it would be better to place it at the beginning of the procedure [39] to reduce the operative time and to perform a reduced port laparoscopic surgery.

Thanks to the technique described here, a mean final incision length of 21.0 mm (primary hernia) and 21.2 mm (incisional hernia) was possible to be achieved, respectively. This result is close to the visible scar used for a 12-mm trocar during multitrocar laparoscopy. It was obtained thanks to the trocar less introduction of the instruments in the abdomen, and it was facilitated by the low BMI of the patients treated.

During the hospitalization, we recorded a respiratory insufficiency in one patient, who suffered preoperatively from chronic bronchopneumonia, and who was medically treated. Concerning complications after discharge from the hospital, a subcutaneous seroma at the hernia site was present in 10 patients of the series at the first office consultation (10 days) and in 6 patients between postoperative day 10 and 30. Contrary to other authors, for whom a conservative strategy permitted the resolution of seroma after multitrocar laparoscopy [40] or SAL [22, 27, 29], we successfully adopted the strategy of ambulatory percutaneous ponctions. A subcutaneous hematoma at the hernia site appeared in 4 patients of the series at 10 days, and 1 patient between postoperative day 10 and 30. This complication resolved spontaneously similar to the intra-abdominal hematoma between the abdominal wall and the prosthesis, evidenced at CT scan in two more patients (incisional hernia). We did not use a drain at the end of the procedure, because there is insufficient evidence to determine the benefit of draining the operative site [41]. Only 1 abscess at the access site was evidenced in this series and treated by antibiotics without appearance of access site incisional hernia. One hematoma at the access site appeared in a patient (primary hernia), who developed after 15 months of follow-up an incisional hernia.

With the exception of the two patients who presented as late complication the incisional hernia at the access site, all other patients remained free of hernia recurrence or access site defect during the follow-up of 16.1 $\pm$ 8.8 months, as reported by other authors [22, 27, 29, 30]. More than 50 % of the patients treated have been followed up for at least 12 months.

Similarly to the report of the literature [26, 27, 29], a mean hospital stay of 1.7 (primary hernia) and 2.5 (incisional hernia) days was recorded, respectively. In our experience, we recorded a VAS score which did not allow to discharge of the patients earlier, and postoperative pain requested medication also after the discharge, similarly to the series of Bucher et al. [22], where the pain related to the prosthesis fixation persisted until the 3rd month. We recorded an equal abdominal pain related to the access site as well as to the tacks placement.

Finally, this study presents several limitations: most notably, it is not a prospective randomized study, it is a single-surgeon experience, including the learning curve for this technique, and more time will be necessary for patients' follow-up to confirm the absence of other late complications.

Conclusions

Primary and incisional hernia can be safely treated by SAL prosthetic repair, but a learning curve is unavoidable. Thanks to this approach, in patients with primary hernia, only a small scar is visible, and in patients who proved to be prone to develop incisional hernia, the number of fascial incisions can be reduced.

Conflict of interest The first author is consultant for Karl Storz-Endoskope, Tuttlingen, Germany. The other authors have no commercial associations that might be a conflict of interest in relation to this article.

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