Hernia (2008) 12:571–576
DOI 10.1007/s10029-008-0410-0

ORIGINAL ARTICLE

Laparoscopic management of incisional hernias ≥15 cm in diameter

G. C. Ferrari · A. Miranda · F. Sansonna · C. Magistro · S. Di Lernia · D. Maggioni · M. Franzetti · R. Pugliese

Received: 7 March 2008 / Accepted: 19 June 2008 / Published online: 8 August 2008

Abstract
Background Despite good results in terms of safety and minimal recurrence ensured by laparoscopy in the management of incisional hernias, the use of minimally invasive techniques for large incisional wall defects is still controversial.
Methods Between 2002 and 2008 as many as 36 patients with abdominal wall defects ≥15 cm were managed laparoscopically in our institution. The wall defects were ≥20 cm in eight cases. The diameter of parietal defects was measured from within the peritoneal cavity. None had loss of domain. Body mass index (BMI) for 18 patients was ≥30 kg/m^2.
Results The mean duration of operations was 195 ± 28 min (range 75–540). One patient needed conversion for ileal injury and massive adhesions. Post-operative complications occurred in nine patients; there were six surgical complications. Morbidity in obese and non-obese patients was not statistically different ($p > 0.05$). There was no post-operative death. Mean hospital stay was 4.97 ± 3.4 days (range 2–18). Mean follow up was 28 months (range 2–68) and only one hernia recurrence was observed.
Conclusions Minimum-access procedures can provide good results in the repair of giant incisional hernia. Obesity is not a contraindication to laparoscopic repair. Further studies are expected to confirm our promising results.

Keywords Giant incisional hernia · Laparoscopy · Intraperitoneal mesh repair

G. C. Ferrari · A. Miranda · F. Sansonna · C. Magistro · S. Di Lernia · D. Maggioni · M. Franzetti · R. Pugliese (✉)
Surgery and Videolaparoscopy Department, Niguarda Hospital, Milan, Piazza Ospedale Maggiore 3, 20162 Milan, Italy
e-mail: raffaele.pugliese@ospedaleniguarda.it

Introduction

The advent of mininvasive techniques has changed the management of incisional hernia in recent decades, introducing a valid alternative to open surgery through the laparoscopic technique of intraperitoneal underlay of meshes [1–12]. Both the use of prosthesic materials and the intraperitoneal underlay have substantially reduced recurrence of incisional hernia compared with primary suture, extra peritoneal underlay (sublay), inlay, and onlay techniques [6–8, 12]. Still, the use of laparoscopic incisional hernia repair (LIHR) for large fascial defects is controversial and practised by few surgeons [2, 13–15], and it is overlooked or contraindicated by other authors, who repair fascial defects >15 cm only by a conventional approach [16–21]. There is no unanimous definition of what surgeons actually mean by giant incisional hernia. The classification proposed by Chevrel is based on the diameter of the wall defect, suggesting the definition of giant or large for those ≥15 cm in transverse dimension [22, 23]. Definitions like major, large, very large, big, or massive incisional hernia may also be found in Medline research [13–16, 19–21, 25–29]. Some authors consider as giant or large wall defects with a surface area of approximately 170 cm^2, within the range 100–225 cm^2 [5, 14, 19, 24].

Materials and methods

Between April 2002 and February 2008 a total of 135 patients underwent LIHR in our institution, 36 for incisional hernia ≥15 cm in diameter. The demographics are listed in Table 1. Most patients in this study were affected by comorbidities such as blood hypertension ($n = 13$), chronic cardiac disease ($n = 6$), insulin-independent

Table 1 Demographics and type of hernia

Gender M/F	19/17
Age (years)	64 (range 42–85)
BMI kg/m^2 (mean)	30.47 (range 22.89–45)
ASA (mean)	2.2 (range 2–3)
Swiss-cheese hernia	5
Double hernia	1
Recurrent incisional hernia	9

diabetes mellitus ($n = 5$), and chronic bronchopneumopathy ($n = 4$). Patients' general conditions were classified according to the criteria of the American Society of Anaesthesiology (ASA). Eighteen patients (50%) were obese, with a BMI (body mass index) $\geq$30kg/m^2. We defined as "giant" fascial defects with diameter $\geq$15 cm measured intraoperatively from within the peritoneal cavity. In fact, measurement of the distance between two external points of incisional hernias on the abdominal surface can lead to overestimation of size by 2.5 cm. Parietal defects averaged 17.44 cm in size (range 15–22) and 149.33 $\pm$ 36 cm^2 in area (range 81.6–219.8). The diameter of wall defects was 15 cm in seven patients, between 15 and 19 cm in 21, and $\geq$20 cm in eight; the data are shown in Table 2. No patient had hernias with loss of domain in our series. Each patient had undergone 2.14 laparotomies on average (range 1–12). The incisional hernia was located on the median line in 29 cases and laterally in six. In cases of double wall defect with two separated orifices and two scars, in median and lateral sites, the hernias were classified according to the greater diameter. Multiple defects located along a unique scar of the median line were defined as multiorificial or complex (Swiss-cheese hernia). A recurrent incisional hernia was present in nine patients—in six following previous repair with mesh and in three following previous repair without mesh (Table 1). Indications for a laparoscopic approach include having enough abdominal surface to insert trocars, enough working chamber, and adequate overlap (at least 4 cm) of mesh. All the patients were asked for appropriate consent before LIHR and all the operations were performed by the same surgeon.

Preparation of patients

All patients received antithrombotic prophylaxis with nadroparine 0.3–0.5 ml administered subcutaneously the night before surgery, plus stocking or bandage of the lower limbs for obese patients. An enema was given the night before surgery. Short-term antibioprophylaxis consisted of cephazoline 2 g i.v. the day of surgery.

Study design

This study was designed to validate retrospectively feasibility and effectiveness of LIHR in giant incisional hernia. Conversion rate, operating time, early morbidity and mortality (within 30 days), hospital stay, and late morbidity were analyzed. Once discharged, the patients were monitored by clinical examination with echography (with a 7.5 MHz probe) on the 10th, 30th, and 60th post-operative (p.o.) day. Later they were followed-up by clinical examination or telephone call. The mean follow-up was 28 months (range 2–68).

Statistical analysis

The database of 36 patients with giant wall defects $\geq$15 cm was analyzed retrospectively. Data treatment was by use of the SPSS 11.0 statistical analysis software package. Continuous variables were evaluated by use of the Student t test and discrete variables by use of the χ^2 test. Statistically significant values were set for $p < 0.05$ (confidence interval, C.I. = 95%).

Operative technique of LIHR

The patient is intubated under general anaesthesia and firmly secured to the table. A nasogastric tube and a Foley catheter are routinely placed in the operating room. The pneumoperiteoneum is established by insufflating the peritoneal cavity to 12–13 mmHg through a Verhess needle inserted in the left hypochondrium. Subsequently, an optic view is introduced into the peritoneal cavity through a 12 mm bladeless trocar in the left subcostal space with a 0° endoscope for direct visualization (Endopath® X cel™ Ethicon, Cincinnati OH). Then, two more trocars of 5 and 10–12 mm are inserted, depending on the location of hernia, generally on the patient's left side for midline incisional defects. Further on, the 0° optic view is retrieved and replaced by a 30° optic view inserted in the 10 mm trocar. The peritoneal cavity is inspected, and in cases of recurrent hernias trocars are inserted in the intact areas of the abdominal wall to minimize the risk of iatrogenic intestinal injury. The adhesions are divided by ultrasound scalpel (Ultracision; Ethicon) or by scissors flush with the intestinal loops. The fat tissue all around the edges of the wall defect is removed. For measurement of parietal defects the abdominal pressure is reduced to 6 mmHg., then four spinal needles (22-gauge) are inserted looking from inside the cavity on either edge of the hernia; the external distance between the needles should correspond exactly to the internal diameter of the wall defect. Later, the pressure is increased again to 12 mmHg. The mesh is made of expanded polytetrafluoroethylene

Table 2 Data for 36 incisional hernias ≥15 cm

	Diameter (cm)	Area (cm^2)	BMI (kg/m^2)	Complications	Oral intake (p.o. day)	Hospital stay (days)
1	15	82.00	37.65		1	3
2	15	81.64	29.05	Recurrence	1	2
3	15	81.85	29.39		1	2
4	15	92.6	35.70		1	3
5	15	117.5	32.47		1	2
6	15	176.6	26.42	Acute renal failure	1	3
7	15	196.2	45.00		1	5
8	16	150.72	26.30	Port site hernia	1	6
9	16	100.48	24.35		1	2
10	16	101.24	23.11	p.o. ileus	3	6
11	16	127.7	32.27		1	5
12	16	150.72	22.89		1	2
13	16	125.6	28.41		1	8
14	16	150.72	23.44		1	4
15	16	114.99	32.34		1	6
16	16	125.6	30.49		6	14
17	16	125.5	39.84		1	4
18	17	173.48	32.46	Port site hernia	1	3
19	17	173.48	29.38		1	2
20	17	173.49	29.41		1	2
21	17	140.6	32.00		1	6
22	18	169.56	29.39		4	9
23	18	169.56	26.42		1	4
24	18	113.4	32.65	Urinary retention	1	4
25	18	169.56	24.09		1	3
26	18	141.3	30.09	Seroma	1	7
27	18	161.3	38.22	Skin necrosis	1	18
28	19	179.1	28.65		1	3
29	20	219.8	30.39		1	5
30	20	204.1	33.33	Chronic pain	1	5
31	20	219.8	27.68		1	6
32	20	141.3	33.59		1	4
33	20	129.45	35.16		1	4
34	22	207.24	23.15		1	3
35	22	138.16	31.17		1	6
36	22	182.5	29.41		1	4

p.o., post-operative

(ePTFE) with one smooth, darker shaded, non-ingrowth surface to be placed adjacent to the intestinal loops and another textured, lighter, ingrowth surface to be placed away from hollow viscus (Gore Dual Mesh Plus Biomaterial; Gore and Associates, Flagstaff, AZ, USA). The prosthetic biomaterial contains silver carbonate and chlorexidine diacetate that inhibit microbial colonization for ten days after implantation. The prothesis is trimmed with a minimal overlap of 3–4 cm; it is then rolled up and introduced into the cavity through a 12 mm port. One coil of a 5 mm tacking device (Pro-Tack Auto Suture; Tyco US, Norwalk, CT, USA) is used for initial fixing of the prosthetic material before its attachment to the wall by use of four suture-passer transparietal threads (Gore Suture Passer Instrument WL; Gore). Successively, the pressure is lowered again to 6 mmHg and complete fixation of the mesh is achieved by means of a double crown of titanium tacks, with a distance of 2 cm between the two crowns. In subxyphoid or subcostal fascial defects the falciform ligament is divided and the mesh is secured to subcostal regions by tacks, whereas in the suprapubic region fixation to the pubis is achieved by tacks after dissection of the urinary bladder.

The peritoneal linen of the sac is never treated. No drainage is placed in either the abdominal cavity or in the subcutaneous layer. Port-sites >1 cm are sutured. An abdominal compressive packing is kept in place for 4–5 days.

Results

A total of 36 consecutive patients with incisional hernia ≥15 cm in transverse dimension were managed by LIHR in our institution over the last six years. One half of the patients were obese. There was one intraoperative complication, an intestinal injury without peritoneal contamination needing conversion for massive adhesions, requiring ileal resection, and the longest operative time (540 min), the greatest blood loss (325 ml), and a long hospital stay (14 days). The overall conversion rate was 2.7%. Overall, the mean duration of surgery was 195 ± 28 min (range 75–540). The mean operative time was 145 ± 19 min (range 75–275) for incisional hernias of 15 cm and 204 ± 39 min (range 85–540) for hernias >15 cm. On average, 3.4 trocars and 75 titanium tacks (range 45–110), disposed in double crown, were used for each patient. The estimated mean blood loss in completely laparoscopic procedures was 72 ± 77 ml (range 10–325). Another five laparoscopic procedures, three cholecystectomies and two groin hernia repairs, were performed on the patients; the duration of the these procedures was not included in the duration of surgery. Oral intake and ambulation started between the first and the second p.o. day for all patients except two elderly patients (Table 2). The mean hospital stay was 4.97 ± 3.4 days (range 2–18). Obese and non-obese patients had comparable mean hospital stay and showed no significant difference in short-term results ($p > 0.05$). Overall morbidity was 25%. All the data are listed in Table 3. Morbidity in the obese patients (27%) and non-obese patients (22%) did not differ significantly with the χ^2 test ($p > 0.05$). No wall haematoma was registered. Neither cutaneous nor intestinal leaks were observed. No prosthetic migration occurred. The post operative course of hernias ≥20 cm was uneventful. There was no post-operative death. Regarding early morbidity, skin necrosis was observed on the 7th p.o. day in one obese patient with a wall defect of 18 cm who had undergone 12 previous laparotomies; the patient was discharged on the 18th p.o. day. No prosthetic infection was observed with silver/chlorexidine ePTFE. In one patient after 10 days a 10-cm seroma was observed, requiring only one aspiration after 60 days, not complicated by infection or encapsulation, and showing gradual reabsorption after 80 days. In our experience, only seromas persisting without modification for 60 days after surgery or infected or causing symptoms need draining [2]. One patient was lost to follow up and one died from neoplastic disease. As to late morbidity, one patient experienced chronic pain beyond the 180th p.o. day. Two port site incisional hernias of very small size (<2 cm) were observed 180 days after LIHR, and both were treated conservatively. One hernia recurrence was observed in this study 18 months after repair of a wall defect of 15 cm (recurrence rate 2.7%), although it had not yet been diagnosed at the time of our last report on LIHR [2].

Table 3 Morbidity of LIHR for incisional hernia ≥15 cm

Early surgical morbidity	No	General complications	No
Seroma (>80 days)	1	Urinary retention	1
Skin necrosis	1	Acute renal failure	1
Late surgical morbidity		Post-operative ileus	1
Port-site incisional hernia	2		
Chronic pain (>180 days)	1		
Recurrence (after 18 months)	1		
Total	6	Total	3

LIHR, laparoscopic incisional hernia repair

Discussion

Our experience with LIHR has already yielded encouraging results with fascial defects of any size [2], but this study has confirmed the validity of minimally invasive surgery for management of defects ≥15 cm in transverse dimension also. No hernia had loss of domain in our series. Our indications for the laparoscopic approach in large incisional hernias included having enough abdominal surface to insert trocars, enough working chamber, and adequate overlap (4 cm at least) of meshes. The frequency of incisional hernia after abdominal surgery ranges between 0.5 and 20% [8, 14, 30]. The recurrence rate with open primary repair was 25% for defects <4 cm in size and up to 54% for defects exceeding 4 cm in size [7, 8, 12] The introduction of open repair with meshes has contributed to a significant reduction in recurrence, in particular with the intraperitoneal underlay technique [7, 31]. The recurrence rate with open intraperitoneal underlay is equal to the recurrence rate of intraperitoneal LIHR, that is, approximately 4.5%, range 1.4–9.3% [1, 2, 5, 7, 8, 15, 16, 32, 33]. It should be also emphasized how LIHR, in contrast with traditional surgery, has the advantage of identifying those small defects, the so called Swiss-cheese hernias, possible sources of recurrences, which may be missed during open repair [7]. Despite all these improvements resulting from use of LIHR, most surgeons still prefer to repair giant incisional hernias by open procedures [24–29]. Some authors use "giant" or "large" to describe parietal defects 100–225 cm^2 in area [5, 13, 18, 23]. The area of parietal defects in this

study was 149.33 ± 36 cm^2 on average (range 81.6–219.8). This study considered wall defects ≥15 cm as "giant" and demonstrated the feasibility and effectiveness of LIHR in such cases. Operative mortality was nil and morbidity was quite acceptable, comparable with those obtained with LIHR for incisional hernias of any size in our experience [2]. The ePTFE mesh with silver/chlorexidine is the least susceptible to infection of all biomaterials and it was implanted also in one case of associated ileal injury and in three cholecystectomies, strictly in absence of peritoneal contamination in all cases [34], No prosthetic infection was registered. One half of patients in this series were obese, but differences in morbidity and hospital stay from those for non-obese patients were not statistically relevant. A minimum overlap of 4–5 cm of the mesh was warranted to ensure a correct repair and to avoid recurrence, especially with a poorly incorporated material like ePTFE [35]. The recurrence rate was 2.7% although a longer follow up is necessary to evaluate the definite rate of hernia relapse. Full-thickness transfixion sutures have been proposed as a better method for securing meshes, supposing that fixation by tacks would bring about more adhesions and higher recurrence [35–38]. To date, no evidence of significant difference between the two methods of mesh fixation has been proven. Recently, no real advantage of transabdominal sutures over tack fixation was shown in experimental and human studies [5, 37, 39]. In our study all the meshes were fixed by tacks and morbidity and recurrence rate were quite acceptable. To summarize, tacks are a good tool for mesh fixation and all the advantages of mininvasive techniques have been ensured for large incisional hernias.

Conclusions

LIHR is a safe and effective procedure even in the management of incisional hernias ≥15 cm Nevertheless, further studies and a longer follow up are necessary to confirm these preliminary results.

References

1. Carbajo MA, Martin del Olmo JC, Blanco JI, Toledano M, de la Cuesta C, Ferreras C, Vaquero C (2003) Laparoscopic approach to incisional hernia. Surg Endosc 17:118–122
2. Ferrari GC, Miranda A, Di Lernia S, Sansonna F, Magistro C, Maggioni D, Scandroglio I, Costanzi A, Franzetti M, Pugliese R (2008) Laparoscopic repair of incisional hernia. Outcomes of 100 consecutive cases comprising 25 wall defects >15 cm. Surg Endosc 22:1173–1180
3. Navarra G, Mugolino C, De Marco ML, Bartolotta M, Barbera A, Centorrino T (2007) Retromuscular sutured incisional hernia repair: a randomized controlled trial to compare open and laparoscopic approach. Surg Laparosc Endosc Percutan Tech 17:86–90
4. Novitsky YW, Cobb WS, Kercher KW, Matthews BD, Sing RF, Heniford BT (2006) Laparoscopic ventral hernia repair in obese patients. A new standard of care. Arch Surg 141:57–61
5. Perrone JM, Soper NJ, Eagon JC, Klingesmith ME, Aft RL, Frisella MM, Brunt LM (2005) Perioperative outcome and complications of laparoscopic ventral hernia repair. Surgery 138:708–715
6. de Vries Reilingh TS, van Geldere D, Langenhorst B, de Jong D, van der Wilt GJ, van Goor H, Bleichrodt RP (2004) Repair of large midline incisional hernias with polypropylene mesh: comparison of three operative techniques. Hernia 8:56–59
7. Rudmik LR, Schieman C, Dixon E, Debru E (2006) Laparoscopic incisional hernia repair: a review of the literature. Hernia 10:110–119
8. Franklin ME Jr, Gonzales JJ Jr, Glass JL, Manjarrez A (2004) Laparoscopic ventral and incisional hernia repair: an 11-year experience. Hernia 8:23–27
9. Samir J (2005) Laparoscopic incisional hernia repair in obese patients. JSLS 9:47–50
10. Sanchez LJ, Bencini L, Moretti R (2004) Recurrences after laparoscopic ventral hernia repair: results and critical review. Hernia 8:138–143
11. Topart P, Ferrand L, Vandenbroucke F, Lozac'h P (2005) Laparoscopic ventral hernia repair with the Goretex Dualmesh: long-term results and review of the literature. Hernia 9:348–352
12. Kannan K, Ng C, Ravintharan T (2004) Laparoscopic ventral hernia repair: local experience. Singapore med J 45:271–275
13. Carbajo MA, del Olmo JCM, Blanco JI, de la Cuesta C, Toledano M, Martin F, Vaquero C, Inglada L (1999) Laparoscopic treatment vs open surgery in the solution of major incisional and abdominal wall hernias with mesh. Surg Endosc 13:250–252
14. Parker HH, Nottingham JM, Bynoe RP, Yost MJ, Voyles R, Cofer JB, Patselas TN, Haley TO, Matthews BD (2002) Laparoscopic repair of large incisional hernias. Am Surg 68:530–534 Discussion
15. Kirshtein B, Lantsberg L, Avinoach E, Bayme M, Mizrahi S (2002) Laparoscopic repair of large incisional hernias. Surg Endosc 16:1717–1719
16. Dumanian GA, Denham W (2003) Comparison of repair for major incisional hernias. Am J Surg 185:61–65
17. Kingsnorth A (2006) The management of incisional hernia. Ann R Coll Surg Engl 88:252–260
18. Arnaud JP, Tuech JJ, Pessaux P, Hadchity Y (1999) Surgical treatment of postoperative incisional hernia by intraperitoneal insertion of dacron mesh and an aponeurotic graft. Arch Surg 134:1260–1262
19. Bernard C, Polliand C, Mutelica L, Champault G (2007) Repair of giant incisional abdominal wall hernias using open intraperitoneal mesh. Hernia 11:315–320
20. Hamy A, Pessaux P, Mucci-Hennekinne S, Radriamananjo S, Regent N, Arnaud JP (2003) Surgical treatment of large incisional hernias by an intraperitoneal dacron mesh and an aponeurotic graft. J Am Coll Surg 196:531–534
21. Ammaturo C, Bassi G (2004) Surgical treatment of large incisional hernias with an intraperitoneal parietex composite mesh: our preliminary experience on 26 cases. Hernia 8:242–246
22. Chevrel JP, Rath AM (2000) Classification of incisional hernias of the abdominal wall. Hernia 4:7–11
23. Korenkov M, Paul A, Sauerland S, Neugebauer E, Arndt M, Chevrel JP, Corcione F, Fingerhut A, Flament JB, Kux M, Matzinger A, Myrvold HE, Rath AM, Simmermacher RKJ (2001) Classification and surgical treatment of incisional hernia. Results of an experts' meeting. Langebecks Arch Surg 386:65–73
24. Itani KMF, Neumayer L, Reda D, Kim L, Anthony T (2004) Repair of ventral incisional hernia: the design of a randomized trial to compare open and laparoscopic surgical techniques. Am J Surg 188(Suppl 1):22–29

25. Amid PK, Shulman AG, Lichtenstein IL (1995) A simple stapling technique for prosthetic repair of massive incisional hernias. Am Surg 60:934–937
26. Calderoni MW, Romano M, Bozza F, Pluchinotta AM, Pelizzo MR, Toniato A, Ranzato R (2005) Progressive pneumoperitoneum in the management of giant incisional hernias: a study of 41 patients. Br J Surg 77:306–307
27. Flament JB, Avisse C, Palot JP, Pluot M, Burde A, Rives J (1997) Thophic ulcers in giant incisional hernias—pathogenesis and treatment. A report on 33 cases. Hernia 1:71–76
28. Trivellini G, Bagni CM, Sollini A, Senni M, Leone S, Contessini Avesani E (2001) Repair of giant hernias using more prosthesis. Hernia 5:124–128
29. San Pio JR, Damsgaard TE, Momsen O, Villadsen I, Larsen J (2003) Repair of giant incisional hernias with polypropylene mesh: a retrospective study. Scand J Plast Reconstr Surg Hand Surg 37:102–106
30. Basoglu M, Yildirgan MI, Yilmaz BA, Celebi F, Atamanalp SS, Polat KY, Oren D (2004) Late complications of incisional hernias following prosthetic mesh repair. Acta Chir Belg 104:425–428
31. Millikan KW, Baptista M, Amin B, Deziel DJ, Doolas A (2003) Intraperitoneal underlay ventral hernia repair utilizing bilayer expanded polytetrafluoroethylene and propylene mesh. Am Surg 69:287–291 discussion 291–292
32. Berger D, Bientzle M, Muller A (2002) Postoperative complications after laparoscopic incisional hernia. Incidence and treatment. Surg Endosc 16:1720–1723
33. Frantzides CT, Carlson MA, Zografakis JG, Madan AK, Moore RE (2004) Minimally invasive incisional herniorraphy: a review of 208 cases. Surg Endosc 18:1488–1491
34. Carbonell AM, Matthews BD, Dréau D, Foster M, Austin CE, Kercher KW, Sing RF, Heniford BT (2005) The susceptibility of prosthetic biomaterials to infection. Surg Endosc 19:430–435
35. LeBlanc KA, Booth WV, Whitaker JM, Bellanger DE (2001) Laparoscopic incisional and ventral herniorraphy: our initial 100 patients. Hernia 5:41–45
36. Chelala E, Gaede F, Douillez V, Dessily M, Alle JL (2003) The suturing concept for laparoscopic mesh fixation in ventral incisional hernias: preliminary results. Hernia 7:191–196
37. Karahasanoglu T, Onur E, Baca B, Hamzaoglu I, Pekmezci S, Boler DE, Kilic N, Altug T (2004) Spiral tacks may contribute to intra-abdominal adhesion formation. Surg Today 34:860–864
38. Winslow ER, Diaz S, Desai K, Meininger T, Soper NJ, Kligensmith ME (2004) Laparoscopic incisional hernia in a porcine model. What do transfixion sutures add? Surg Endosc 18:529–535
39. Wassenaar EB, Raymakers JTFJ, Rakic S (2008) Impact of the mesh fixation technique on operation time in laparoscopic repair of ventral hernias. Hernia 12:23–25