Surg Endosc
DOI 10.1007/s00464-008-0039-1

Comparison of early outcomes for laparoscopic ventral hernia repair between nonobese and morbidly obese patient populations

Siok S. Ching · Abeezar I. Sarela · Simon P. L. Dexter · Jeremy D. Hayden · Michael J. McMahon

Received: 13 February 2008 / Accepted: 20 May 2008

Abstract
Background Obesity predisposes to incisional herniation and increased the incidence of recurrence after conventional open repair. Only sparse data on the safety and security of laparoscopic ventral hernia repair (LVHR) for morbidly obese patients are available. This study compared the incidence of perioperative complications and early recurrence after LVHR between morbidly obese and non–morbidly obese patients.
Methods The case records of consecutive patients who underwent LVHR between December 2002 and August 2007 were reviewed. Patients with a body mass index (BMI) lower than 35 kg/m^2 were compared with morbidly obesity patients who had a BMI of 35 kg/m^2 or higher.
Results The study included 168 patients (87 men) with a median age of 55 years (range, 24–92 years). Two conversions to open repair (1.2%) were performed, both for non–morbidly obese patients. Of the 168 patients, 42 (25%) were morbidly obese (BMI range, 35.0–58.0 kg/m^2) and 126 (75%) were non–morbidly obese (BMI range, 15.5–34.9 kg/m^2). The groups showed no significant differences in age, gender, number or size of fascial defects, operative time, length of hospital stay, or incidence of perioperative complications. At a median follow-up period of 19 months (range, 6–62 months), 20 patients (12%) had recurrent hernias. The incidence of recurrence was significantly associated with the size of the fascial defect and the size of the mesh, but not with morbid obesity.
Conclusion No significant difference in the incidence of perioperative complications or recurrence after LVHR was observed between the morbidly obese patients and the non–morbidly obese patients.

Keywords Intraperitoneal onlay mesh · Laparoscopy · Morbid obesity · Ventral hernia

S. S. Ching · A. I. Sarela (✉) · S. P. L. Dexter · J. D. Hayden · M. J. McMahon
Academic Unit of Surgery, The General Infirmary at Leeds, Great George Street, Leeds, West Yorkshire LS1 3EX, UK
e-mail: abeezar.sarela@leedsth.nhs.uk

S. S. Ching
e-mail: ching_ss@hotmail.com

Concern is expressed about the risk of complications and recurrence after traditional (open) surgery for ventral hernias in obese patients [1–3]. Open ventral hernia repair is reported to be associated with a high incidence of recurrence (38–59%) as well as postoperative wound complications related to a long abdominal incision and wide tissue dissection [4, 5].

To be considered for an operation, patients often are advised to lose weight, but this may be unrealistic considering the current understanding of the pathophysiology of morbid obesity. A delay in ventral hernia repair for obese patients can be dangerous because they are at a particularly high risk for intestinal obstruction [6].

Laparoscopic ventral hernia repair (LVHR) in obese patients may have advantages over open surgery [7, 8]. Since we started performing ventral hernia repair laparoscopically in late 2002, this technique has become our preferred approach because we believe that minimal access can significantly reduce the high incidence of wound complications, mesh infection, and hernia recurrence that accompanies open repair [1–5].

Obesity has been assessed previously as a potential risk factor for recurrence after LVHR. However, most studies have used a body mass index (BMI) threshold of 30 kg/m^2,

and thus include patients who would not be categorized as morbidly obese [9–11]. If ventral hernia is considered a significant comorbidity, then a BMI of 35 kg/m^2 or higher would constitute morbid obesity.

We hypothesized that morbidly obese patients were at a higher risk for recurrence after LVHR and that attention should be focused on this group. Consequently, the current study aimed to compare the incidence of perioperative complications and early recurrence after LVHR between morbidly obese patients and non–morbidly obese patients.

Materials and methods

cWe reviewed the case records of 168 consecutive patients who underwent LVHR between December 2002 and August 2007. All the patients were followed up postoperatively for a minimum of 6 months. For patients with a ventral hernia, morbid obesity was defined as a BMI of 35 kg/m^2 or higher [12]. Recurrence after LVHR was defined as a defect in the abdominal wall appearing at the site of the previous hernia and confirmed by clinical examination, radiologic imaging, or subsequent surgery. Chronic abdominal pain after LVHR was defined as pain in the abdomen that persisted longer than 3 months and required analgesic control.

Surgical techniques

A standardized technique was used for LVHR. The primary port was 10.5 or 5.5 mm (Yello Port; Surgical Innovations Group plc, Leeds, UK) and placed by direct access or after peritoneal insufflation using a Veress needle or an optical-access trocar (Optiview; Ethicon Endo-Surgery, Cincinnati, OH, USA). Additional 5.5-mm ports were placed at the periphery of the abdominal wall, away from the defects and adhesions.

A straight or oblique viewing laparoscope (30° or 45°) was used, and adhesiolysis was performed using sharp scissor dissection, with or without monopolar diathermy or ultrasonic shears, either the Harmonic Scalpel (Ethicon Endo-Surgery) or LOTUS (S.R.A. Developments Ltd., South Devon, UK). An appropriate-size mesh was chosen for the patch so the mesh could overlap all parts of the defect by at least 3 cm. The main types of mesh used were polypropylene plus expanded polytetrafluoroethylene (ePTFE), composite mesh (Cousin Biotech, Wervicq-Sud, France, or Bard, Murray Hill, NJ, USA; used for 21% of patients), the Proceed mesh (polypropylene + polydioxanone polymer film + oxidized regenerated cellulose; Ethicon Endo-Surgery; used for 13% of patients), the Parietex composite mesh (multifilament polyethylene terephthalate with a collagen-based hydrogel component; Sofradim International, Trévoux, France; used for 55% of patients), and polyethylene terephthalate with dimethyl siloxane (Cousin Biotech, used for 7% of patients). Mesh fixation to the abdominal wall was accomplished using transfascial sutures only (for 28% of patients), ProTack 5-mm spiral titanium tacks (United States Surgical, Norwalk, CT, USA) only (for 41% patients), or a combination of both (for 31% of patients).

Statistical analysis

Statistical analysis was performed using SPSS Version 12.0 (SPSS Inc., Chicago, IL, USA). Univariate comparison of categorical factors was performed with chi-square or Fisher's exact tests. Univariate comparison of quantitative factors was performed using the Mann-Whitney *U* test. A two-tailed *p*-value less than 0.05 was considered statistically significant.

Results

The study included 87 men and 81 women with a median age of 55 years (range, 24–92 years). The procedure was converted to open surgery for two patients (1.2%). One woman (BMI of 29 kg/m^2, previous laparoscopic adjustable gastric banding) had a large primary paraumbilical hernia with extensive small bowel adhesions that could not be safely dissected laparoscopically. The second patient, a man (BMI of 24 kg/m^2, previous open gastrectomy for cancer), had a midline incisional hernia with a fascial defect 15 cm in diameter. He was deemed unsuitable for a laparoscopic repair and underwent an open subfascial mesh repair with mobilization and midline approximation of the anterior rectus sheaths. These two patients were excluded from further analyses.

The 166 patients included in this study had a total of 176 separate LVHR episodes. One patient had two reoperations for recurrences, and eight patients each had one reoperation for recurrence after primary LVHR. The ventral hernias were incisional in 111 patients (77 midline and 34 lateral in location) and primary in 55 patients (41 paraumbilical or umbilical, 9 midline, and 5 Spigelian).

A total of 42 patients (25%) were morbidly obese (median BMI, 39.9 kg/m^2; BMI range, 35–63.4 kg/m^2). Nine patients had previously undergone a Roux-en-Y gastric bypass (5 open and 4 laparoscopic) for morbid obesity. The BMI for these nine patients at the time of LVHR ranged from 24.6 to 42.6 kg/m^2. Those with a BMI lower than 35 kg/m^2 after previous bariatric surgery were included in the non–morbidly obese group for this study. Four patients with the highest BMI, ranging from 55.6 to 63.4 kg/m^2, had simultaneous laparoscopic Roux-en-Y gastric bypass and LVHR. Compared with the non–morbidly obese patients, the morbidly obese group comprised a

greater proportion of women, but there was no other significant difference (Table 1). Postoperatively, one patient in the morbidly obese group had an infected abdominal wall hematoma with cellulites, which was treated with intravenous antibiotics, and two patients had chronic abdominal pain (Table 2).

Among the 124 non–morbidly obese patients (median BMI, 28.4 kg/m^2; BMI range, 15.5–34.9 kg/m^2), a colonic injury was recognized intraoperatively and satisfactorily repaired in two cases, followed by mesh placement for the hernia repair during the same procedure in both cases. Three patients experienced a "missed" enterotomy. Two patients had laparotomy for postoperative peritonitis, both 3 days after LVHR, and one patient had laparoscopy 1 day after LVHR. Two patients had relaparoscopy for investigation of unexpectedly severe abdominal pain on postoperative day 1. No clinically significant abnormality was detected in either case. Six patients experienced hematomas, and three of these patients also experienced extensive bruising of the abdominal wall. One hematoma of the hernial sac was aspirated. Two patients experienced cellulitis of the abdominal wall, which was treated with intravenous antibiotics. One patient readmitted with small bowel obstruction on postoperative day 3 underwent a laparotomy and bypass of a chronic-appearing stricture in the terminal ileum. Two patients experienced an enterocutaneous fistula, one due to erosion of a polypropylene plus ePTFE composite mesh into the small bowel 2 years after LVHR and another after laparotomy for missed enterotomy. Two patients experienced a chronic sinus on the anterior abdominal wall, which communicated with an infected polypropylene plus ePTFE composite mesh. Chronic abdominal pain after LVHR was experienced by 12 patients (Table 2).

Table 1 Perioperative characteristics of non–morbidly obese and morbidly obese patients

Variable	Non–morbidly obese (n = 124)	Morbidly obese (n = 42)	p Value
Previous open ventral hernia repair: n (%)	24 (19)	13 (31)	0.119
Male gender: n (%)	66 (53)	19 (45)	0.371
Age (years)[a]	56 (24–92)	51 (34–76)	0.058
Number of fascial defects[a]	1 (1–6)	1 (1–8)	0.411
Defect diameter (cm)[a]	3 (0.5–30)	5 (1–18)	0.411
Defect area (cm^2)[a]	7.5 (0.2–500)	10 (1–250)	0.661
Operative time (min)[a]	70 (25–245)	62 (20–330)	0.796
Postoperative length of stay (days)[a]	2 (0–59)	2 (0–21)	0.709

[a] Data are presented as median (range)

Table 2 Complications of non–morbidly obese and morbidly obese patients[a]

Complications	Non–morbidly obese (n = 124) n (%)	Morbidly obese (n = 42) n (%)	p Value
Enterotomy	5 (4)	0 (0)	0.331
Hematoma	6 (5)	1 (2)	0.680
Seroma	11 (9)	7 (17)	0.160
Chronic pain	12 (10)	2 (5)	0.522
Chronic wound sinus	2 (2)	0 (0)	1.000
Enterocutaneous fistula	2 (2)	0 (0)	1.000
Postoperative infection	11 (9)	1 (2)	0.299
Hernia recurrence	16 (13)	4 (10)	0.785

[a] Each patient might have more than one complication

During a median follow-up period of 19 months (range, 6–62 months), a recurrent ventral hernia developed in 20 patients (12%). Compared with those who had no recurrent hernia, the patients with a recurrence had a significantly larger fascial defect and a smaller mesh:defect ratio (Table 3). The median BMI of the patients with recurrence was similar to that of the patients without recurrence (Table 3). The number of patients with and without recurrence in each BMI category is shown in Fig. 1.

Table 3 Comparison of demographic and operative variables between patients with and those without recurrence after laparoscopic ventral hernia repair

Variable	Recurrence (n = 20)	No recurrence (n = 146)	p Value
Previous open ventral hernia repair: n (%)	5 (25)	32 (22)	0.756
Follow-up period (months)[a]	30 (6–57)	19 (6–62)	0.168
Age (years)[a]	57 (37–83)	55 (24–92)	0.374
Body mass index (kg/m^2)[a]	30.3 (18.1–48.0)	30.6 (15.5–63.4)	0.721
Number of fascial defects[a]	1 (1–6)	1 (1–8)	0.372
Diameter of defect (cm)[a]	9 (2–20)	3 (0.5–30)	0.001
Defect area (cm^2)[a]	40 (3.0–400)	7.0 (0.5–500)	<0.001
Mesh size (cm^2)[a]	400 (54–1200)	172 (16–1500)	0.001
Mesh area:defect area ratio[a, b]	11.0 (2.8–56.3)	22.6 (1.8–375)	0.003
Operative time (minutes)[a]	80 (25–330)	68 (20–330)	0.176
Postoperative infection: n (%)	4 (20)	8 (5)	0.041

[a] Data are presented as median (range)

[b] Calculated by dividing the mesh size by the defect area for each patient

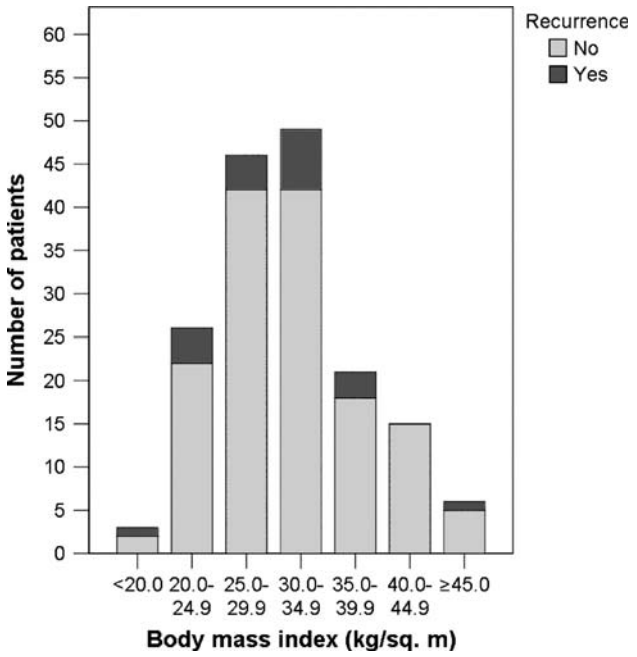

Fig. 1 Recurrence after laparoscopic ventral hernia repair according to body mass index

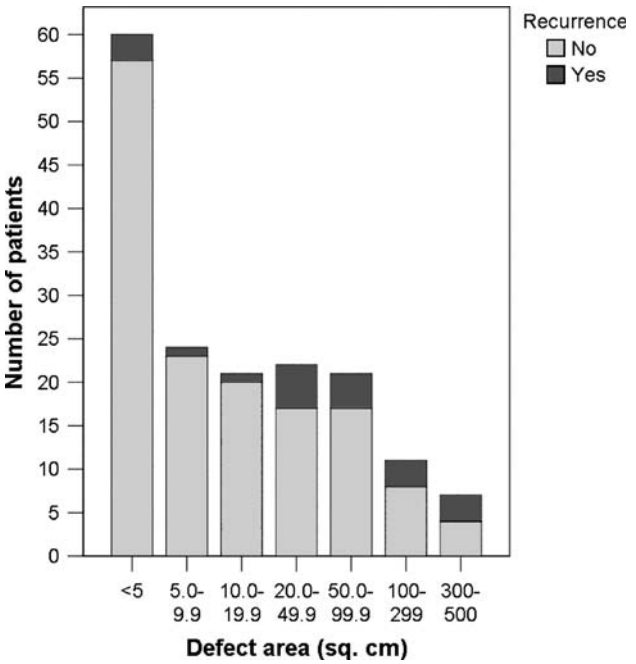

Fig. 2 Recurrence after laparoscopic ventral hernia repair according to defect area

Infective complications occurred for 12 patients (7%). These included the three patients who experienced peritonitis from "missed" enterotomy, one patient with enterocutaneous fistula, one patient with abdominal wall sinus, one patient with intraabdominal collection, and six patients with abdominal wound infection. Six patients required reoperation, five of whom had their infected mesh removed. Of these 12 patients, 4 (33%) experienced recurrent hernia. The presence of infection significantly increased the risk of hernia recurrence (Table 3).

Of 60 patients with a defect smaller than 5 cm^2, 3 (5%) experienced a recurrence (Fig. 2). In the first case, two small fascial defects were in close proximity and covered with one piece of mesh at the time of LVHR. The second patient experienced a "missed" enterotomy, which probably occurred during insertion of a trocar, and underwent a laparotomy and small bowel resection. This patient subsequently experienced an incisional hernia. In the third case, the recurrence was at a site remote from the initial incisional hernia repair.

Of 20 patients with hernia recurrence, 16 (80%) had further repairs. Ten patients had a total of 11 redo LVHRs 3 days to 28 months after the initial LVHR, and six patients had an open hernia repair 4 to 16 months after the initial LVHR.

Discussion

In the current series, there was no increase in the incidence or severity of perioperative complications in morbidly obese patients. Furthermore, morbidly obese patients did not have a higher incidence of recurrent hernias. These results are consistent with those of previous studies investigating LVHR in obese patients (Table 4). Notably, 31% of the morbidly obese patients in this series underwent LVHR for recurrence after previous open repair, as compared with only 19% of non–morbidly obese patients (Table 1).

The difference in the proportion of failed open repairs is not surprising because obesity has been established as an important risk factor for recurrence after an open repair [1–3]. Previous studies have reported a failed previous open repair as a significant risk factor for further recurrence after LVHR [11, 13]. As such, the nonelevated incidence of recurrence in the morbidly obese group was notable (Table 2).

The data on whether preoperative weight loss in obese patients decreases the incidence of recurrence after hernia repair are sparse. In a study from the Shouldice Clinic, weight reduction did not alter the incidence of recurrence after open repair with sutures or subfascial mesh [14]. However, this study included patients with a limited reduction in BMI (from 28.9 ± 13.1 to 26.7 ± 13.5 kg/m^2). Although we found no increase in recurrence rates for the morbidly obese patients, we do not know what influence weight loss may have had. We recommend caution in extrapolating our data for superobese patients because these constituted only a small number in our series (5 patients [3%] with a BMI ≥ 50 kg/m^2).

Table 4 Studies on laparoscopic ventral hernia repair that assessed obesity as a potential risk factor for recurrence

Authors	Period	*n*	BMI obesity criteria	Prevalence of obesity *n* (%)	Average follow-up (mo)	Recurrence in obese patients %	Recurrence in nonobese patients %	*p* Value
Bageacu et al. [9]	1993–1998	159	≥30	53 (33)	49	17	9	0.167
Raftopoulos et al. [10]	1994–2001	50	≥30	26 (52)	21	4	0	1.000
Rosen et al. [11]	1996–2001	96	≥30	44 (46)	30	21	15	0.517
Novitsky et al. [16]	1998–2003	278	≥30	163 (59)	25	6	Not available	–
Raftopoulos and Courcoulas [17]	2003–2006	27	≥35	27 (100)	15	19	–	–
Current study	2002–2007	166	≥35	42 (25)	19	10	13%	0.785

BMI, body mass index (kg/m^2)

When bariatric surgery is undertaken in morbidly obese patients with a ventral hernia, the timing of the ventral hernia repair becomes an important consideration. Both procedures may be performed simultaneously because a study has shown that more than one-third of patients who had deferred treatment of their hernias during laparoscopic Roux-en-Y gastric bypass experienced subsequent development of small bowel obstruction and required an urgent operation [6].

An alternative option is a staged procedure. Initially, a laparoscopic sleeve gastrectomy can be performed because it avoids the need for dissection of small bowel in the hernia and can be carried out entirely in the upper abdomen. Adhesiolysis and hernia repair can be undertaken as a later second-stage procedure after weight reduction. The value of such a strategy needs further evaluation.

Our study had some limitations, especially with respect to follow-up evaluation. A large population-based study has shown that recurrence may occur 10 years after open ventral hernia repair and that there is no substantial difference in this pattern between the open and laparoscopic approaches [15]. The follow-up period in the current study and many previous studies on LVHR in obese patients has been relatively short (Table 4), and a difference in recurrence rates between morbidly obese and nonobese patients may become apparent over a longer interval [9–11, 16, 17].

Consistent with the report on a large series by Heniford et al. [13], the patients who experienced recurrence after LVHR in our series had significantly larger fascial defects. It was encouraging that our incidence of recurrence after laparoscopic repair of a previously recurrent hernia was similar to that for nonrecurrent hernia (13.5% vs 11.6%, respectively). Nonetheless, previous studies have quite convincingly demonstrated that laparoscopic repair of a recurrent hernia is associated with a significantly higher risk of further recurrence [11, 13]. It is possible that our study lacked sufficient statistical power or length of follow-up evaluation.

During the first 3 years of the study period, the polypropylene plus ePTFE composite mesh was used in about half of the cases. There were two cases of mesh-related problems among the 36 patients who had implantation of the polypropylene plus ePTFE composite mesh. As stated, one patient experienced an enterocutaneous fistula and another patient had a chronic nonhealing sinus, both 2 years after the operation. Both patients required repeated operations to remove parts of the mesh exposed through the abdominal wound.

The exact cause of the aforementioned complications remains unclear. They may be due the properties of the mesh's polypropylene component, which resulted in low reactivity and thus poor tissue ingrowth and adhesion of the mesh to the abdominal wall at implantation. Adhesion of polypropylene to bowel and eventual erosion of the mesh into the bowel and abdominal wall causes infection and subsequent fistulization through the anterior abdominal wall.

Due to the problems encountered with the earlier polypropylene plus ePTFE mesh, we have adopted the use of the polypropylene plus polydioxanone polymer film plus oxidized regenerated cellulose (Proceed) mesh, followed by the multifilament polyethylene terephthalate (Parietex composite) mesh, which is more flexible and induces sufficient foreign body reaction (fibroblast response), resulting in its incorporation into the abdominal wall. The Parietex composite mesh, coated with a hydrophilic resorbable film on the visceral surface, was shown to reduce the risk of visceral adhesion and fistula formation [18]. In our experience, we found the Proceed mesh to be comparable with the Parietex composite mesh.

Laparoscopic ventral hernia repair is a safe procedure compared with the open approach. Recurrence rates after LVHR generally are lower than those after open ventral hernia repair for both nonobese and obese groups (Tables 4 and 5). With the evolution and improvement of mesh materials used for intraperitoneal onlay placement, the risk of earlier problems with mesh infection and fistulization should be diminished. However, a meticulous technique still is required to prevent accidental enterotomies during adhesiolysis. The routine use of bowel preparation before surgery in anticipation of such an uncommon complication probably is less important, but it may have a role in

Table 5 Studies on open ventral hernia repair that assessed obesity as a potential risk factor for recurrence

Authors	Year	*n*	Techniques of repair	BMI obesity criteria	Prevalence of obesity %	Average follow-up (mo)	Recurrence in obese patients %	Recurrence in nonobese patients %	*p* Value
Lamont and Ellis [19]	1988	36	Simple suture	Not defined	44	12	38	50	NS
Manninen et al. [1]	1991	172	Simple suture or vertical Mayo	≥25	73	53	39	13	<0.01
Hesselink et al. [20]	1993	298	Simple suture, vertical Mayo, or mesh	Not defined	30	35	44	35	NS
Luijendijk et al. [21]	1997	68	Vertical Mayo	≥25	59	35	46	37	NS
Paul et al. [22]	1998	114	Vertical Mayo	≥30	61	68	59	44	NS
Anthony et al. [4]	2000	77	Simple suture or mesh	≥28	67	45	48	38	<0.05[a]
Mittermair et al. [3]	2002	208	Vertical Mayo	≥30	23	60	50	23	< 0.01
Sauerland et al. [23]	2004	160	Vertical Mayo, mesh, or autodermal	≥30	33	24	13	9	<0.05

NS, not significant

[a] $p < 0.05$ only for mesh repair; p = NS for simple suture repair

potentially challenging cases. Difficulties during laparoscopy such as obtaining adequate access and performing the necessary adhesiolysis may be the most common reasons for conversion to an open approach.

In conclusion, morbidly obese patients undergoing LVHR did not appear to have more risks of perioperative complications or recurrence of the hernia than less obese individuals. We suggest that morbidly obese patients with problematic ventral hernias may be offered laparoscopic repair without insistence on significant preoperative weight loss. However, caution should be exercised in extrapolating the current results for superobese patients.

References

1. Manninen MJ, Lavonius M, Perhoniemi VJ (1991) Results of incisional hernia repair: a retrospective study of 172 unselected hernioplasties. Eur J Surg 157:29–31
2. Sugerman HJ, Kellum JM Jr, Reines HD, DeMaria EJ, Newsome HH, Lowry JW (1996) Greater risk of incisional hernia with morbidly obese than steroid-dependent patients and low recurrence with prefascial polypropylene mesh. Am J Surg 171:80–84
3. Mittermair RP, Klingler A, Wykypiel H, Gadenstätter M (2002) Vertical Mayo repair of midline incisional hernia: suggested guidelines for selection of patients. Eur J Surg 168:334–338
4. Anthony T, Bergen PC, Kim LT, Henderson M, Fahey T, Rege RV, Turnage RH (2000) Factors affecting recurrence following incisional herniorrhaphy. World J Surg 24:95–101
5. White TJ, Santos MC, Thompson JS (1998) Factors affecting wound complications in repair of ventral hernias. Am Surg 64:276–280
6. Eid GM, Mattar SG, Hamad G, Cottam DR, Lord JL, Watson A, Dallal RM, Schauer PR (2004) Repair of ventral hernias in morbidly obese patients undergoing laparoscopic gastric bypass should not be deferred. Surg Endosc 18:207–210
7. LeBlanc KA (2005) Incisional hernia repair: laparoscopic techniques. World J Surg 29:1073–1079
8. Misra MC, Bansal VK, Kulkarni MP, Pawar DK (2006) Comparison of laparoscopic and open repair of incisional and primary ventral hernia: results of a prospective randomised study. Surg Endosc 20:1839–1845
9. Bageacu S, Blanc P, Breton C, Gonzalez M, Porcheron J, Chabert M, Balique JG (2002) Laparoscopic repair of incisional hernia: a retrospective study of 159 patients. Surg Endosc 16:345–348
10. Raftopoulos I, Vanuno D, Khorsand J, Ninos J, Kouraklis G, Lasky P (2002) Outcome of laparoscopic ventral hernia repair in correlation with obesity, type of hernia, and hernia size. J Laparoendosc Adv Surg Tech 12:425–429
11. Rosen M, Brody F, Ponsky J, Walsh RM, Rosenblatt S, Duperier F, Fanning A, Siperstein A (2003) Recurrence after laparoscopic ventral hernia repair. Surg Endosc 17:123–128
12. Buchwald H (2005) Consensus Conference Statement: Bariatric surgery for morbid obesity: health implications for patients, health professionals, and third-party payers. J Am Coll Surg 200:593–604
13. Heniford BT, Park A, Ramshaw BJ, Voeller G (2003) Laparoscopic repair of ventral hernias: nine years' experience with 850 consecutive hernias. Ann Surg 238:391–400
14. Chan G, Chan CK (2005) A review of incisional hernia repairs: preoperative weight loss and selective use of the mesh repair. Hernia 9:37–41
15. Flum DR, Horvath K, Koepsell T (2003) Have outcomes of incisional hernia repair improved with time? A population-based analysis. Ann Surg 237:129–135
16. 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

17. Raftopoulos I, Courcoulas AP (2007) Outcome of laparoscopic ventral hernia repair in morbidly obese patients with a body mass index exceeding 35 kg/m^2. Surg Endosc 21:2293–2297
18. Balique JG, Benchetrit S, Bouillot JL, Flament JB, Gouillat C, Jarsaillon P, Lepère M, Mantion G, Arnaud JP, Magne E, Brunetti F (2005) Intraperitoneal treatment of incisional and umbilical hernias using an innovative composite mesh: four-year results of a prospective multicenter clinical trial. Hernia 9:68–74
19. Lamont PM, Ellis H (1988) Incisional hernia in reopened abdominal incisions: an overlooked risk factor. Br J Surg 75:374–376
20. Hesselink VJ, Luijendijk RW, de Wilt JH, Heide R, Jeekel J (1993) An evaluation of risk factors in incisional hernia recurrence. Surg Gynecol Obstet 176:228–234
21. Luijendijk RW, Lemmen MH, Hop WC, Wereldsma JC (1997) Incisional hernia recurrence following "vest-over-pants" or vertical Mayo repair of primary hernias of the midline. World J Surg 21:62–65
22. Paul A, Korenkov M, Peters S, Köhler L, Fischer S, Troidl H (1998) Unacceptable results of the Mayo procedure for repair of abdominal incisional hernias. Eur J Surg 164:361–367
23. Sauerland S, Korenkov M, Kleinen T, Arndt M, Paul A (2004) Obesity is a risk factor for recurrence after incisional hernia repair. Hernia 8:42–46