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ORIGINAL ARTICLE

Prophylactic prosthetic reinforcement of midline abdominal incisions in high-risk patients

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Abstract
Background/aim Incisional hernia is one of the major elements of morbidity after abdominal surgery, with high incidence in vertical midline abdominal incisions. However, the risk of developing an incisional hernia can be increased due to the patient's related factors; therefore, more consideration has to be given to the choice of incision, wound closure and wound healing to protect against incisional hernia, especially in high-risk patients. In this study, we used prophylactic subfascial non-absorbable mesh reinforcement of midline closure in high-risk patients to detect whether fixing the wound with mesh is risky on a short-term basis and whether it is protective on a long-term basis.
Patients and methods From October 2000 to December 2002, 40 high-risk patients liable to develop postoperative incisional hernia underwent elective abdominal operations through midline abdominal incisions at the Department of Surgery, Gastroenterology and Laparoscopic Unit, Tanta University Hospital, Egypt. They were randomly divided into two groups; group A: patients for whom the midline abdominal incisions were closed by conventional method and reinforced by subfascial polypropylene mesh (20 patients); and group B: patients for whom the midline abdominal incisions were closed by conventional method only (20 patients) with a follow up period of more than 20 months.
Results There was no significant difference ($P = 0.075$) in both groups regarding the age, sex and the average risk factor. Twenty-three patients (57.5%) presented with more than one risk factor (11 in group A and 12 in group B). The upper midline abdominal incisions were reported in 33 patients (19 upper and 14 extended upper). There was no significant difference between the overall local and systemic complications in both groups ($P = 0.4082$). However, the subcutaneous seroma and chronic wound pain were greater in patients with prophylactic mesh than those without mesh. One group A patients (5%) and three group B patients (15%) developed postoperative incisional hernia during the follow up period.
Conclusion Prophylactic subfascial non-absorbable mesh reinforcement of midline closure in high-risk patients can be used safely and effectively to provide extrinsic strength of the wound without relying too much on the defective development of its own intrinsic strength and to prevent subsequent incisional hernia. There was no risk in the use of the mesh regarding local and systemic complication. However, the final statement should await the outcomes of the long-term follow up of the studied cases.

Keywords Incisional hernia · Risky patients · Polypropylene mesh

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Introduction

Abdominal wall defects that appear after surgical intervention are known as incisional hernias or post-laparotomy evisceration. The incidence of incisional hernias in centres

by long-term follow up studies varies between 2 and 13% and may reach up to 45% in high-risk patients [1].

Most incisional hernias develop during the first three months after surgery, which is a critical period for the healing of transected muscular and fibrous layers of the abdominal wall [2]. However, most studies recommended a long-term follow up period of up to at least 5 years of midline abdominal incisions to determine the actual incidence of incisional hernia [3, 4].

The midline abdominal incision is preferred in abdominal surgery, as it provides wide and rapid access compared other incisions. However, the incidence of incisional hernias is higher following midline abdominal incisions than in other abdominal incisions because the tension at the suture lines in other abdominal incisions is lower, since it is distributed in different directions and several layers [5].

Several factors affect the process of wound healing:

1. Surgical site infection (SSI): there was a high correlation between SSIs and subsequent incisional hernia formation as the incidence of incisional hernia increased up to 38.3% with SSIs [6]
2. Poor surgical technique: the ideal method for the closure of midline abdominal incision that reduces the incidence of incisional hernia is mass closure using continuous sutures, which should be placed at least 1 cm from the cut edge at intervals of not more than 2 cm, with adequate suture length (wound length ratio at least 4:1) using non-absorbable or slowly absorbable material [7, 8]
3. Patient-related factors: many patient-related factors affect healing and include:

   - Old age
   - Obesity
   - Diabetes mellitus (DM)
   - Nutritional deficiencies (anaemia, hypo-proteinaemia and vitamin depletion)
   - Hepatic cirrhosis
   - Jaundice
   - Renal impairment
   - Malignancy
   - Cardiac disease
   - Chest problems
   - Previous abdominal incisions
   - Steroid therapy [1, 9–11]

Polypropylene mesh is widely used for the reconstruction of incisional hernias that cannot be closed primarily. Several techniques have been advocated to implant the mesh, with controversy about the advantages of each technique in preventing incisional hernia recurrence [12]. In our study, we used the polypropylene mesh material in subfascial positioning to create reinforcement at the linea alba to efficiently consolidate the laparotomy closure and substantially reduce the incidence of incisional hernia [13]. The purpose of this study is to detect whether fixing the wound with mesh is risky on a short-term basis, and whether it is protective on a long-term basis.

Methods

From October 2000 to December 2002, 40 high-risk patients liable to develop postoperative incisional hernia underwent elective abdominal operations through midline incisions at the Department of Surgery, Gastroenterology and Laparoscopic Unit, Tanta University Hospital, Egypt. High-risk patients means patients who had one or more risk factors that may affect the healing process and make them more liable to develop postoperative incisional hernia. So, according to our list of risk factors it was easy to differentiate between low- and high-risk patients.

Institutional Review Board approval and complete informed consent from patients was obtained after discussion of the risk/benefit ratio with patients with group A.

The patient cohort was randomly divided into two groups:

- Group A: patients for whom the midline abdominal incisions were closed by conventional method and reinforced by subfascial polypropylene mesh (20 patients)
- Group B: patients for whom the midline abdominal incisions were closed by conventional method only (20 patients)

All patients were subjected to:

1. Thorough history taking (full inquiry about the presence or history of well-known risk factors)
2. Full clinical examination
3. Routine laboratory and radiological investigations
4. Endoscopic examination when required
5. Operative details were recorded
6. Postoperative ultrasonography was done for all patients in both groups A and B on the 10th postoperative day to detect seroma or hematoma formation, especially those that were deep in relation to the mesh

Technique of mesh insertion in midline abdominal incisions in group A patients

Figures 1, 2 and 3 illustrate the technique used for group A patients.

The following points of the technique were noted:

1. Good dissection for about 2 cm on each side of the linea alba. We always tried to keep the peritoneal layer

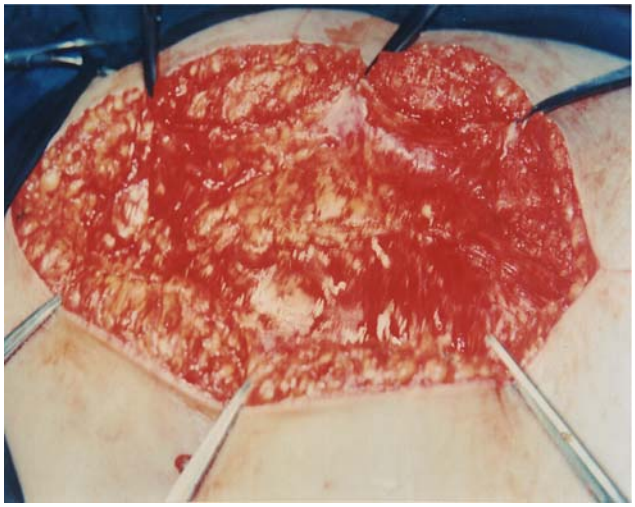

Fig. 1 The preperitoneal space after complete closure of the peritoneum

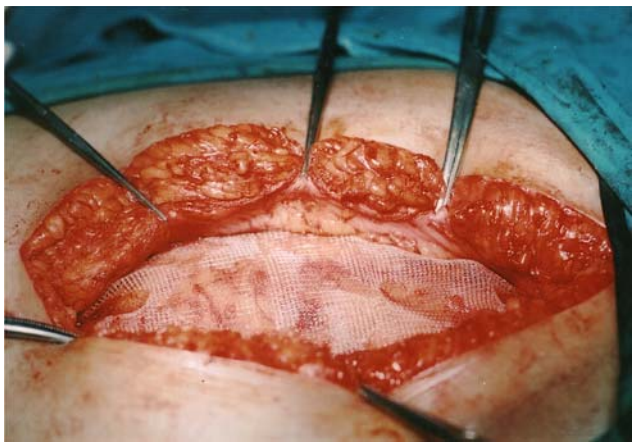

Fig. 2 Positioning of the polypropylene mesh in the preperitoneal space

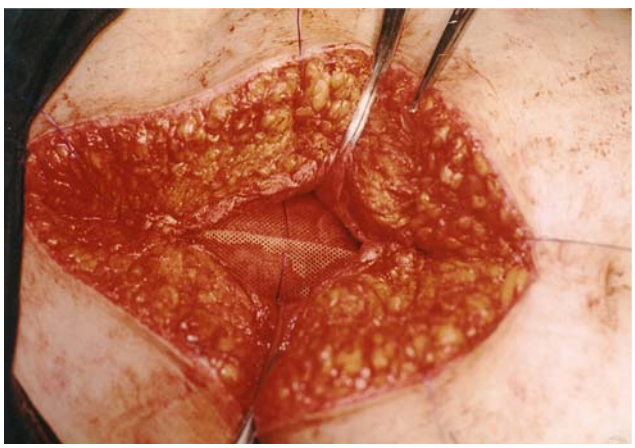

Fig. 3 Complete closure of the linea alba as a mass-continuous closure

intact during the dissection and avoided making any holes in the peritoneum. In this study, we made this dissection first during the opening of the abdomen, as this was easier and better in keeping the peritoneum intact before opening. We always tried to cover the bowel with omentum as much as possible to be sure that there was no risk from the mesh positioning to the intestine.

2. After closure of the peritoneum by continuous suture using polyglactin 2/0 and before we started to insert the mesh, we were sure that there was no gap or rents in the peritoneum.
3. The polypropylene mesh was then inserted preperitoneally in the same direction of closure of the peritoneum.
4. After adjustment of the mesh size to the available preperitoneal space, four sutures were taken in the angle of the mesh to be fixed and were not rolled; these sutures were fixed up to the rectus muscle and down to the peritoneum.
5. After good fixation of the mesh and making sure that there was no contact between the mesh and the bowel, the abdominal wall was closed by continuous non-absorbable sutures using polypropylene no. 1 by mass closure of the linea alba with sutures placed from the angle of the wound spaced 1 cm apart and 1 cm from the cut edge. During this closure, we usually passed some interrupted suture from one edge of the linea alba to the other, passing through the mesh pores to give a better fixation of the mesh and to prevent any migration or rolling.

Technique of closure of the midline abdominal incisions in group B patients

The abdominal wall was closed by continuous non-absorbable sutures using polypropylene no. 1 by mass closure of the linea alba with sutures placed from the angle of the wound spaced 1 cm apart and 1 cm from the cut edge.

In both methods, the subcutaneous tissue was closed by absorbable sutures and the skin was closed by interrupted sutures no. 3/0. We did not insert any wound drains in the subcutaneous space in both groups.

Follow up

All patients were examined 2 weeks after discharge and every month for 6 months, and then every three months for the period of the study. Postoperative ultrasonography was done for all patients in both groups on the 10th postoperative day to detect seroma or hematoma formation, especially those that were deep in relation to the mesh.

There were no missing patients in both groups but two patients, one from each group, died after 2 and 3 years postoperatively, respectively.

Results

Baseline parameters

This study included 40 patients who were equally divided into two group (A = 20 and B = 20). There was no statistical difference between the groups regarding sex, age, follow up period, risk factors, the type of incision and the family history of hernia. The mean age of both groups was 47.7 years. Most patients presented in the age group 50–60 years (five in group A and six in group B). The period of follow up had a mean ± SD of 2.65 ± 1.67 months in group A versus 2.01 ± 1.03 in group B ($P = 0.81$). Regarding the risk factors, there was also no significant difference in both groups; 2.32 ± 1.42 ($P = 0.075$). A positive family history of hernia was reported in three patients (15%) in group A versus one patient (5%) in group B. Regarding the types of midline abdominal incisions, classic upper midline incisions were presented in 19 patients (11 in group A and eight in group B), extended upper midline incisions were presented in 14 patients (six in group A and eight in group B), while lower midline incisions were presented in seven patients only (three in group A and four in group B) (Table 1).

Risk factors

There was no significant difference between both groups regarding the risk factors, with mean of 2.65 ± 1.67 in group A versus 2.01 ± 1.03 in group B ($P = 0.075$). Morbid obesity was the common risk factor in our study in 17 patients (42.5%) (nine in group A and eight in group B), while renal impairment was presented in only one patient in group A. In this study, 23 patients (57.5%) presented with more than one risk factor (nine in group A and 14 in group B) (Table 2).

Local and systemic complications

There was no significant difference between the overall local and systemic complications in both groups; the

Table 1 Baseline parameters in both groups

Baseline parameter	Group A ($n = 20$)	Group B ($n = 20$)	Total ($n = 40$)
Sex (male/female)	1/1.5	1/1	1/1.2
Age at operation, mean ± SD, years	47.86 ± 13.82	47.61 ± 14.11	47.72 ± 14.78*
Average number of risk factors, mean ± SD	2.65 ± 1.67	2.01 ± 1.03	2. 32 ± 1.42**
Follow up period, mean ± SD, months	37.15 ± 9.967	36.25 ± 10.84	36.73 ± 10.288***
Abdominal incisions, *n* (%)			
Classic upper	11 (55%)	8 (40%)	19 (47.5%)
Extended upper	6 (30%)	8 (40%)	14 (35%)
Lower	3 (15%)	4 (20%)	7 (17.5%)
Family history of hernia, *n* (%)	3 (15%)	1 (5%)	4 (10%)

* $P > 0.05$; ** $P = 0.075$; *** $P = 0.081$

Table 2 Various risk factors present in the studied patients

Risk factors	Group A, *n* (%)	Group B, *n* (%)	Total, *n* (%)
Chest disease	4 (20)	2 (10)	6 (15)
Morbidly obese	9 (45)	8 (40)	17 (42.5)
Multiparity	6 (30)	5 (25)	11 (27.5)
Diabetes mellitus (DM)	4 (20)	4 (20)	8 (20)
Liver disease	9 (45)	7 (35)	16 (40)
Cardiovascular disease	3 (15)	5 (25)	8 (20)
Malignancy	4 (20)	5 (25)	9 (22.5)
Hypersplenism	3 (15)	1 (5)	4 (10)
Renal impairment	1 (5)	0	1 (2.5)
Previous abdominal incision	8 (40)	5 (25)	13 (32.5)
Malnutrition	2 (10)	1 (5)	3 (7.5)

incidence of complication in group A was 1.88 ± 1.45 versus 1.66 ± 1.22 in group B ($P = 0.4082$) (Table 3).

Hernia formation

A total of four patients (10%), only one patient in group A, developed postoperative incisional hernia during the period of follow up, while three patients (15%) in group B developed postoperative incisional hernia. There was a significant statistical difference in the rate of hernia formation in both groups ($P = 0.01$) (Table 4).

Table 4 Incisional hernia result

	Group A	Group B	Total
Hernia, *n* (%)	1 (5%)	3 (15%)	4 (10%)
Follow up period, mean ± SD, months	37.15 ± 9.967	36.25 ± 10.84	36.73 ± 10.288***

*** $P = 0.081$

Discussion

Recent studies show that certain approaches for the closure of laparotomy can reduce the likelihood of incisional hernias. Nevertheless, even in the best samples, the frequency of its occurrence varies between 5 and 15% and up to 49% when patients are monitored for several years or when factors associated with laparotomy greatly increase the risk of incisional hernias [13].

Since it was proved by different studies that there is a predisposing collagen metabolism disturbance in patients with inguinal hernias who developed recurrence or contralateral herniation on follow up, the concept of mesh repair for primary hernia has been established to safeguard against this process of defective collagen metabolism [14].

There was a high correlation between surgical site infections (SSIs) and subsequent incisional hernia formation. The incidence of incisional hernia is about 14.4% without SSIs and increased up to 38.3% with SSIs [3]. Mason et al. [15], who did not record wounds that drained serous fluid and were treated with open packing as infected, reported a 1.6% SSI rate in 5,178 operations in severe obesity cases. Barber et al. [16]. considered wounds with suture line erythema more than 1 cm as infected and reported a total SSI rate of 8%.

In this study, the SSI rate was 15% among the high-risk patients who all except one underwent clean contaminated operations (class 11). This incidence of SSI in this work was acceptable among other studies of high-risk patients. Classen et al. [17] found that the lowest rate of SSI (0.59% in 1,708 operations) occurred in patients who received preoperative antibiotics within 0–2 h, which matched with our time of prophylactic antibiotic.

Shaffer et al. [18] found that there was no significant difference in the incidence of SSI with the use of drains compared with simple abdominal closure, reporting a 10.8% SSIs rate in the drainage group versus 10.9% in the control group. Kozol et al. [19] found that there is no reduction in SSI incidence with the use of closed suction drains in obese patients. Obesity and surgical procedure category (clean, clean contaminated, contaminated and dirty infected) are the most accepted dominant risk factors for SSIs [16, 20].

Although the healing of surgical wounds is dependent on many factors, the suture technique is of particular concern because it is completely controlled by the surgeon. In a comprehensive review, Poole [21] concluded that local mechanical factors were more important than systemic diseases in the prevention of fascial dehiscence.

The continuous single-layer mass closure technique with non-absorbable polypropylene sutures was the technique adopted for midline closure in all 40 high-risk patients of group A and B in this study. Only in group A patients was the fascial closure reinforced with subfascial polypropylene mesh. All laparotomies in this work were closed either by a senior surgeon or by a senior resident under strict observation

Table 3 Local and systemic postoperative complications

Complications	Group A, *n* (%)	Group B, *n* (%)	Total, *n* (%)
Subcutaneous seroma	4 (20)	3 (15)	7 (17.5)
Surgical site infection	2 (10)	4 (20)	6 (15)
Partial wound disruption	1 (5)	2 (10)	3 (7.5)
Complete wound disruption (complete burst)	0	1 (5)	1 (2.5)
Chronic wound pain	3 (15)	0	3 (7.5)
Cardiac	1 (5)	1 (5)	2 (5)
Deep vein thrombosis (DVT)	0	1 (5)	1 (2.5)
Pulmonary problems	3 (15)	2 (10)	5 (12.5)
Ascites	3 (15)	1 (5)	4 (10)

of a senior surgeon to rule out the question regarding surgeon skill.

One patient belonging to group A (5%) developed partial wound dehiscence, while three patients in group B (15%) developed wound dehiscence, two partial and one complete, with 10% total incidence of wound dehiscence in this study.

To date, only two reports were found comparing the outcomes of prophylactic mesh reinforcement in high-risk patients versus conventional fascial closure in regard to wound dehiscence and incisional hernia occurrence. Only the results of group B patients (conventional closure) will be suitable for comparison with the results recorded in different series to verify the effect of risk factors on the healing of abdominal wounds. Because most of the patients (57.5%) presented with more than one risk factor in this study, it was difficult to compare our study with the scarce published literature studying the effect of a specific risk factor on wound healing.

In this work, ten morbidly obese patients underwent gastric bariatric surgery (five in group A and five in group B), who had no wound dehiscence. This is in agreement with that reported by Yale [22]. Brolin [23] reported that there was a 2% incidence of acute fascial dehiscence and this increased up to 3.6% when obesity was associated with DM, as also found by Pories et al. [24].

Concerning the incidence of incisional hernia in this study, three patients (15%) belonging to group B (conventional closure) had developed incisional hernia, while one of the group A patients (5%) (prophylactic mesh reinforcement) had developed incisional hernia during 3.5 years of follow up, with 10% total incidence of incisional hernia. In regard to the risk factors in cases of incisional hernia formation in group B patients, the first patient had four risk factors (old age, liver cirrhosis, malignancy and previous midline incision), the second had four factors (old age, multiparty, obesity and chest disease) and the third had three factors (old age, obesity and liver cirrhosis). The patient in group A was female with three risk factors (obese, multiparity and cirrhosis).

Fortunately, five cirrhotic patients were in group A versus one in group B. Three of those in group A and the one in group B had developed postoperative ascites. Two of the seven cirrhotic patients in group B developed incisional hernia, while none of the nine cirrhotic patients in group A developed incisional hernia. This reflects the impact of prophylactic mesh reinforcement on the incidence of incisional hernia in these high-risk patients.

Irvin et al. [25] reported that there was a 12.5% incidence of incisional hernia in jaundiced patients, with a slightly higher incidence in deeply icteric patients versus 3.6% in anicteric cases during two-year follow up. Janssen et al. [26] reported that 17% of the liver-transplanted patients developed incisional hernia during a period of 6 months postoperatively; 66% of these hernias were involved the upper midline incision.

Seventeen morbidly obese patients were included in this study (nine in group A and eight in group B). Two of those in group B (with three or more risk factors) had developed incisional hernia with an incidence of 25%, while one patient in group A (11%) had developed incisional hernia during the period of follow up.

Israelsson and Jonsson [27] demonstrated that there was a direct correlation between increased body mass index (BMI) and the development of incisional hernia during 12 months of follow up, with an incidence of 10% for BMI < 25, 19% for BMI 25–29 and 22% for BMI > 30. Old age and wound infection were also associated with higher rates of incisional hernia in these obese patients.

After vertical banded gastroplasty for 80 morbidly obese patients, Arribas et al. [28] found that the incidence of incisional hernia increased in obese patients (24%), super obese with BMI > 50 (51%), age > 50 years (50%), diabetics (66%), SSIs (37%) and anaemia (50%). They concluded that the BMI is the only patient-related factor that significantly influences the incidence of incisional hernia formation in morbidly obese patients. In this study, four patients with previous midline abdominal incisions were re-opened and only one in group B had developed incisional hernia. Lament and Ellis [29] reported an incidence of 12% incisional hernia formation in re-opened scars.

A short-term follow up study from 2 to 3 years of midline abdominal incisions for incisional hernia formation seems to be not long enough to represent the true incidence of incisional hernia. Mudge and Hughes [3], in a 10-year prospective study, demonstrated that less than 50% of incisional hernias occur in the first year after surgery. So, Gallup et al. [4] stated that, a 10-year follow up of patients is probably needed to determine the actual incidence of incisional hernia.

In the presented study, chronic wound pain was a late complication. Three patients (15%) in group A complained of chronic pain which was tolerable and did not disturb their usual daily activities. The explanation for this chronic pain is hypothesised to be due to the presence of rents and ischaemic areas in the peritoneal closure line and the inflammatory reaction induced by the subfascial (preperitoneal) mesh; because the peritoneal flaps were dissected from the underlying tissue, these peritoneal rents could never close as the peritoneal healing occurs by metaplasia of the subperitoneal per vascular connective tissue cells and not by a process of centripetal growth from the wound margins, as reported by Raftery [30, 31].

Concerning the subfascial positioning of the mesh in this work, it follows the idea of Pascal's theory, as the pressure will be equally distributed all over the mesh, which is

sandwiched between the intra-abdominal pressure and the muscular tone of the abdominal wall.

There are few published reports using prophylactic prosthetic material for the primary closure of laparotomies with high risk of incisional hernia. Gutiérrez de la Peña et al. [13], in a prospective randomised study, recorded that the incidence of incisional hernia in patients without mesh was 11.3% versus none in the group with mesh implantation during a 3-year follow up period. Six (8.3%) of their patients with mesh experienced chronic pain in the scar. The only technical difference in this study was only their positioning of the mesh, which carries certain disadvantages. Onlay grafts require dissection of the subcutaneous gaps, exposing the prosthetic material to poorly vascularised fat, increasing the likelihood occurrence of seroma and wound infection. Another disadvantage is that onlay grafts do not follow Pascal's theory, so, abdominal wall forces may break down the primary closure and push the graft off the outer fascial surface, predisposing to herniation and eliminating the idea of prophylactic mesh reinforcement, especially in high-risk patients.

The second series was reported by Strzelczyk et al. [32]. In their standard wound closure group, the incisional hernia rate was 20% versus none in the prophylactic mesh group after one year. Mesh implantation was done in those with the highest BMI, profound liver damage and/or history of abdominal hernia, and was complicated with wound discharge in 25% of cases.

Conclusion

Prophylactic subfascial non-absorbable mesh reinforcement of midline closure in high-risk patients can be used safely and effectively to provide extrinsic strength of the wound without relying too much on the defective development of its own intrinsic strength and to prevent subsequent incisional hernia. There was no more risk in the use of the mesh regarding local and systemic complications in comparison to the non-use of mesh. However, the final statement should await the outcomes of the long-term follow up of the studied cases.

References

1. Martín-Duce A, Noguerales F, Villeta R, Hernández P, Lozano O, Keller J, Granell J (2001) Modifications to Rives technique for midline incisional hernia repair. Hernia 5:70–72
2. Richards PC, Balch CM, Aldrete JS (1983) Abdominal wound closure. A randomized prospective study of 571 patients comparing continuous vs. interrupted suture techniques. Ann Surg 197:238–243
3. Mudge M, Hughes LE (1985) Incisional hernia: a 10 year prospective study of incidence and attitudes. Br J Surg 72:70–71
4. Gallup DG, Talledo OE, King LA (1989) Primary mass closure of midline incisions with a continuous running monofilament suture in gynecologic patients. Obstet Gynecol 73:675–677
5. Gislason H, Grønbech JE, Søreide O (1995) Burst abdomen and incisional hernia after major gastrointestinal operations—comparison of three closure techniques. Eur J Surg 161:349–354
6. Christou NV, Jarand J, Sylvestre JL, McLean APH (2004) Analysis of the incidence and risk factors for wound infections in open bariatric surgery. Obes Surg 14:16–22
7. Koniaris LG, Hendrickson RJ, Drugas G, Abt P, Schoeniger LO (2001) Dynamic retention: a technique for closure of the complex abdomen in critically ill patients. Arch Surg 130:1359–1363
8. Wissing J, van Vroonhoven TJ, Schattenkerk ME, Veen HF, Ponsen RJ, Jeekel J (1987) Fascia closure after midline laparotomy: results of a randomized trial. Br J Surg 74:738–741
9. Abrahamson J (1997) Postoperative ventral abdominal hernia, Chap. 11. In: Zinner MJ, Schwartz SI, Ellis H (eds) Maingot's abdominal operation, 10th edn. Stanford, Appleton and Lange, pp 479–580
10. Albina JE (1994) Nutrition and wound healing. J Parenter Enteral Nutr 18:367–376
11. Kelman CI, Robert FD, Dome RY, Graham M, Marcy C (2002) Wound healing, Chap. 8. In: Schwartz SI, Tom GS, Spencer FC, Daly JM, Fischer JE, Galloway AC (eds) Principles of surgery, 7th edn. McGraw-Hill, New York, pp 263–297
12. Luijendijk RW, Hop WC, van den Tol MP, de Lange DC, Braaksma MM, IJzermans JN, Boelhouwer RU, de Vries BC, Salu MK, Wereldsma JC, Bruijninckx CM, Jeekel J (2000) A comparison of suture repair with mesh repair for incisional hernia. N Engl J Med 6:392–398
13. Gutiérrez de la Peña C, Medina Achirica C, Domínguez-Adame E, Medina Díez J (2003) Primary closure of laparotomies with high risk of incisional hernia using prosthetic material: analysis of usefulness. Hernia 7:134–136
14. Wagh PV, Read RC (1971) Collagen deficiency in rectus sheath of patients with inguinal herniation. Proc Soc Exp Biol Med 137:382–384
15. Mason EE, Renquist KE, Jiang D (1992) Perioperative risks and safety of surgery for severe obesity. Am J Clin Nutr 55:573–576
16. Barber GR, Miransky J, Brown AE, Coit DG, Lewis FM, Thaler HT, Kiehn TE, Armstrong D (1995) Direct observations of surgical wound infections at a comprehensive cancer center. Arch Surg 130:1042–1047
17. Classen DC, Evans RS, Pestotnik SL, Horn SD, Menlove RL, Burke JP (1992) The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. N Engl J Med 326:281–286
18. Shaffer D, Benotti PN, Bothe A Jr, Jenkins RL, Blackburn GL (1987) A prospective, randomized trial of abdominal wound drainage in gastric bypass surgery. Ann Surg 206:134–137
19. Kozol RA, Fromm D, Ackerman NB, Chung R (1986) Wound closure in obese patients. Surg Gynecol Obstet 162:442–444
20. Miransky J, Ruo L, Nicoletta S, Eagan J, Sepkowitz K, Margetson N, Thaler H, Cohen AM, Guillem JG (2001) Impact of a surgeon-trained observer on accuracy of colorectal surgical site infection rates. Dis Colon Rectum 44:1100–1105
21. Poole GV Jr (1985) Mechanical factors in abdominal wound closure: the prevention of fascial dehiscence. Surgery 97:631–640
22. Yale CE (1989) Gastric surgery for morbid obesity. Complications and long-term weight control. Arch Surg 124:941–946
23. Brolin RE (1996) Prospective, randomized evaluation of midline fascial closure in gastric bariatric operations. Am J Surg 172:328–331
24. Pories WJ, MacDonald KG Jr, Flickinger EG, Dohm GL, Sinha MK, Barakat HA, May HJ, Khazanie P, Swanson MS, Morgan E, Leggett-Frazier N, Long SD, Brown BM, O'Brien K,

Caro FJ (1992) Is type II diabetes (NIDDM) mellitus a surgical disease? Ann Surg 215:633–643
25. Irvin TT, Vassilakis JS, Chattopadhyay DK, Greaney MG (1978) Abdominal wound healing in jaundiced patients. Br J Surg 65:521–522
26. Janssen H, Lange R, Erhard J, Malagó M, Eigler FW, Broelsch CE (2002) Causative factors, surgical treatment and outcome of incisional hernia after liver transplantation. Br J Surg 89:1049–1054
27. Israelsson LA, Jonsson T (1997) Overweight and healing of midline incisions: the importance of suture technique. Eur J Surg 163:175–180
28. Arribas D, Elía M, Artigas C, Jiménez A, Aguilella V, Martínez M (2004) Incidence of incisional hernia following vertical banded gastroplasty. Hernia 8:135–137
29. Lamont PM, Ellis H (1988) Incisional hernia in re-opened abdominal incisions: an overlooked risk factor. Br J Surg 75:374–376
30. Raftery AT (1973) Regeneration of parietal and visceral peritoneum. A light microscopical study. Br J Surg 60:293–299
31. Raftery AT (1979) Regeneration of peritoneum: a fibrinolytic study. J Anat 129:659–664
32. Strzelczyk J, Czupryniak L, Loba J, Wasiak J (2002) The use of polypropylene mesh in midline incision closure following gastric by-pass surgery reduces the risk of postoperative hernia. Langenbecks Arch Surg 387:294–297