Original Research

Risk Factors for Early-Occurring and Late-Occurring Incisional Hernias After Primary Laparotomy for Ovarian Cancer

Ryan J. Spencer, MD, Kristin D. Hayes, MD, Stephen Rose, MD, Qianqian Zhao, MS, Paul J. Rathouz, PhD, Laurel W. Rice, MD, and Ahmed N. Al-Niaimi, MD

OBJECTIVE: To evaluate a cohort of gynecologic oncology patients to discover risk factors for early- and late-occurring incisional hernia after midline incision for ovarian cancer.

METHODS: We collected retrospective data from patients undergoing primary laparotomy for ovarian cancer at the University of Wisconsin Hospitals and Clinics from 2001 to 2007. Patient characteristics and potential risk factors for hernia formation were noted. Physical examination, abdominal computerized assisted tomography scans, or both were used to detect hernias 1 year after surgery (early hernia) and 2 years after surgery (late hernia).

RESULTS: There were 265 patients available for the 1-year analysis and 189 patients for the 2-year analysis. Early and late hernia formation occurred in 9.8% (95% confidence interval [CI] 6.2–12%) and an additional 7.9% (95% CI 4.1–12%) of patients, respectively. Using multiple logistic regression, poor nutritional status (albumin less than 3 g/dL) and suboptimal cytoreductive surgery (1 cm or greater residual tumor) were significantly associated with the formation of early incisional hernia after midline incision ($P<.001$ for both). Late hernia formation was associated only with age 65 years or older ($P=.01$).

CONCLUSION: The formation of early incisional hernias after midline incision is associated with poor nutritional status and suboptimal cytoreductive surgery, whereas late hernia formation is associated with advanced age.

(Obstet Gynecol 2015;125:407–13)
DOI: 10.1097/AOG.0000000000000610

LEVEL OF EVIDENCE: II

Identifying modifiable risk factors of incisional hernia formation is of critical importance because preventing them is of major interest in the surgical community. Incisional hernias are a common complication with an incidence of 9.8% at 2 years.[1] Previously recognized risk factors include obesity, older age, male sex, surgical site infection, bowel surgery, smoking, and having multiple comorbid conditions.[2–5] A reduction in hernia incidence could bring about a significant improvement in patient outcomes.[6] Additionally, hernias can lead to surgical emergencies because 4.3% of hernia repairs are done as a result of small bowel incarceration.[7]

Intraoperative and postoperative factors can also contribute to the development of incisional hernias. The use of nonabsorbable or slowly absorbable suture material for abdominal closure is associated with fewer incisional hernias.[8] Meta-analyses of randomized trials show that a running closure leads to a lower rate of incisional hernias when compared with an interrupted closure.[8,9]

Additionally, postoperative surgical site infections are recognized to increase hernia risk.[10–12] In fact, a great deal of clinical data supports wound infection as the most important risk factor for the development of an incisional hernia.[5,13]

The primary aim of our study was to investigate the possible risk factors in the development of early- and late-occurring incisional hernias in women undergoing

From the Division of Gynecologic Oncology, Department of Obstetrics & Gynecology, University of Wisconsin Hospital and Clinics, and the Department of Biostatistics and Medical Informatics, University of Wisconsin School of Medicine and Public Health, Madison, Wisconsin; and the Department of Obstetrics and Gynecology, University of Michigan Health System, Ann Arbor, Michigan.

Supported by the Clinical and Translational Science Award (CTSA) program through the National Institutes of Health National Center for Advancing Translational Sciences (NCATS), grant UL1TR000427.

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Corresponding author: Ryan J. Spencer, MD, Division of Gynecologic Oncology, Department of Obstetrics and Gynecology, University of Wisconsin Hospital and Clinics, 600 Highland Avenue, CSC H4/664, Madison, WI 53792; e-mail: Rjspencer2@wisc.edu.

Financial Disclosure
The authors did not report any potential conflicts of interest.

ISSN: 0029-7844/15

laparotomy for ovarian cancer–specifically the contribution surgical site infection, nutritional status, and surgical cytoreduction may have. Both early and late hernias were investigated as they relate to surgical factors and patient factors, respectively.

MATERIALS AND METHODS

The institutional review board at the University of Wisconsin School of Medicine and Public Health approved this study. All patients with epithelial ovarian cancer who underwent primary cytoreductive surgery between January 1, 2001, and December 31, 2007, were identified from the cancer registry databases at the University of Wisconsin Hospital and Clinics.

After initial eligibility screening, the following inclusion criteria were applied to determine the final study sample: 1) use of a midline vertical incision and 2) clinical or radiographic determination of an incisional hernia after midline incision with longitudinal follow-up of 1–2 years in our system. All surgeries were performed by board-eligible or board-certified gynecologic oncologists. All patients underwent exploratory laparotomy with the intention of achieving optimal cytoreduction (less than 1 cm residual disease). Patients were excluded from the study for the following reasons: incomplete surgical–pathologic data and lack of longitudinal follow-up. The following data were extracted from the medical record: age at the time of initial surgery, body mass index (BMI, calculated as weight (kg)/[height (m)]^2), preoperative diagnosis of diabetes mellitus, nutritional status (normal defined as preoperative albumin 3 g/dL or greater), cancer stage, histology, and grade, whether optimal cytoreduction was accomplished (defined as less than 1 cm of residual tumor at the end of surgery), and facial closure technique (running compared with interrupted compared with mass closure compared with a combination method).

The length of the surgical incision was not collected. Large-scale reviews have not identified this as a risk factor, possibly as a result of the retrospective nature of most studies and the absence of these data for analysis.[14] Surgical site infection was defined using the 1999 Centers for Disease Control and Prevention criteria up to 30 days after surgery.[15] Nutritional status was analyzed as a binary variable using 3 g/dL as the cutoff because of data from our institution that this was a point at which perioperative complications increased.[16]

All the data were reviewed by two of the investigators (K.D.H. and A.N.A.-N.) for accuracy. Physical examination and abdominal computed tomography scans conducted during routine follow-up were used to diagnose postoperative incisional hernias. On physical examination, hernias were diagnosed by a palpable defect in the fascia along the surgical incision. Radiographically, hernias were diagnosed when a fascial defect demonstrated a hernia neck larger than 1 cm in greatest dimension–the smallest reliable defect detectable. The primary outcomes in this study were early-occurring hernias (diagnosed 1 year after surgery) and late-occurring hernias (diagnosed 2 years after surgery). These timeframes were selected because most incisional hernias appear within 2 years after surgery. The incidence does not significantly increase at time periods more distant from surgery (eg, 3 or 4 years). Therefore, 2 years from surgery has been accepted as a timeframe when hernia rate reaches its plateau.[17]

Univariate logistic regression analysis was used to test for an association between the mentioned variables and the development of an incisional hernia after a midline incision. Multivariate logistic regression models were used to test adjusted associations for any variables that predicted incisional hernia formation with $P<.20$ in univariate logistic regression. Results were quantified in terms of relative risk. All P values reported are for two-sided statistical tests that were considered statistically significant at $<.05$. Data analysis was performed in SAS 9.3.

A total of 326 patients who underwent primary cytoreductive surgery during the study period were identified. The final analysis at 1 year included 265 patients after excluding 61 patients for the following reasons: 22 for low malignant potential tumors, 11 for insufficient medical information, and 28 for lack of follow-up at the 1-year interval.

The analysis at 2 years included 189 patients after excluding 76 patients. Twenty-six patients were excluded as a result of diagnosis of hernia at 1 year and 50 patients were lost to follow-up. There was no clustering in the timing of the hernia diagnosis and incidence was generally spread evenly throughout the time periods under review. Patient characteristics for both groups can be found in Table 1.

RESULTS

The median age of the study population was 59 years (range 15–85 years) with mean age 58.7 years (standard deviation [SD] 12.5). Median BMI was 27.7 (range 16.7–56.2), and mean BMI was 29.0 (SD 6.83). Median estimated blood loss was 500 mL (range 50–5,000 mL) and mean estimated blood loss was 696 mL (SD 677). Median length of surgery was 287 minutes (range 114–595 minutes) with mean surgery length 295 minutes (SD 78.7). The majority of the patients were white (251/265 [95%]). One hundred eighty-seven patients

Table 1. Patient Characteristics

Variable	1 Year (n=265)	2 Years (n=189)
Age (y)		
Younger than 65	177 (67)	134 (71)
Older than 65	88 (33)	55 (29)
BMI (kg/m^2)		
Obese (30 or higher)	99 (37)	66 (35)
Nonobese (lower than 30)	166 (63)	123 (65)
Race		
White	251 (95)	180 (95)
Others	14 (5)	9 (5)
Diabetes mellitus		
Present	26 (10)	16 (9)
Absent	239 (90)	173 (92)
Nutritional status		
Normal	187 (71)	145 (77)
Depleted	69 (26)	38 (20)
Unknown	9 (3)	6 (3)
Disease stage		
Early (stages I, II)	78 (29)	58 (31)
Late (stages III, IV)	187 (71)	131 (69)
Cell histology		
Papillary serous	187 (71)	130 (69)
Other	77 (29)	59 (31)
Unknown	1 (0)	0
Pathology grade		
1 and 2	56 (21)	42 (22)
3	209 (79)	147 (78)
Cytoreductive surgery		
Optimal	216 (82)	156 (87)
Suboptimal	49 (19)	24 (13)
Closure technique		
Running	185 (70)	132 (70)
Other	80 (30)	57 (30)
Estimated blood loss (mL)		
Less than 800	189 (71)	137 (73)
More than 800	76 (29)	52 (28)
Chemotherapy mode		
Intravenous	238 (90)	169 (89)
Intraperitoneal	12 (5)	10 (5)
None	15 (6)	10 (5)
Surgical site infection		
Present	32 (12)	18 (10)
Absent	233 (88)	171 (91)
Hernia incidence		
Present	26 (10)	15 (8)
Absent	239 (90)	174 (92)

BMI, body mass index.
Data are n (%).

(187/265 [71%]) had papillary serous histology. Optimal surgical cytoreduction was achieved in 216 patients (216/265 [82%]), whereas 49 patients (49/265 [19%]) were suboptimally cytoreduced. One hundred eighty-seven patients (187/265 [71%]) had advanced disease and 209 patients (209/265 [79%]) had high-grade tumors. One hundred eighty-five patients (185/265 [70%]) had their fascia closed with running suture. Surgical site infection occurred in 32 (32/265 [12%]) patients.

The majority of patients (238/265 [90%]) received intravenous platinum and taxane combination chemotherapy. The mean number of cycles of adjuvant chemotherapy received was the same in patients with hernia (5.61, SD 1.35, P=.49) and without hernia (5.83, SD 1.05). No woman in either group received more than eight cycles of adjuvant chemotherapy. Data regarding time to recurrence were not made available for this study.

The overall incidence of early incisional hernias was 9.8% (95% confidence interval [CI] 6.2–12%, n=26/265), whereas the incidence of late-occurring hernias was an additional 7.9% (95% CI 4.1–12%, n=15/189). The hernia detection rate was split nearly evenly between physical examination and CT scan (56 and 44%, respectively). Obesity was the only limiting factor for detection on examination.

At the 1-year time point for early hernia formation, univariate analysis showed that nutritional status (preoperative albumin 3 g/dL or less, relative risk [RR] 60, P<.001), suboptimal cytoreduction (RR 5.1, P<.001), surgical site infection (RR 2.7, P=.024), and BMI higher than 30 (RR 3.2, P=.003) may be associated with increased risk for incisional hernias (Table 2). However, after incorporating nutritional status, cytoreduction status, surgical site infection, BMI, type of fascial closure, and age into a multivariate model, only nutritional status (RR 48, P<.001) and suboptimal cytoreduction (RR 4.3, P<.001) remained significantly correlated with development of incisional hernias. For the 2-year time point corresponding to late hernia formation, age 65 years or older (RR 3.7, P=.014) was the only factor associated with formation of incisional hernias after multivariate modeling (Table 3). This represents a risk factor for patients who did not develop a hernia during their first year.

All patients who had an incisional hernia were evaluated by a general surgeon who specializes in hernia repairs. We recommend this approach be taken to identify the most appropriate candidates and to establish care in the event they need surgical correction close to the time of hernia diagnosis or emergently in the future. Seven of the patients involved in this study had an elective hernia repair after their consultation. No patient required emergent surgical correction of their hernia.

DISCUSSION

Our study found that approximately 10% of women will have incisional hernias 1 year after laparotomy for ovarian cancer. Suboptimal cytoreduction and

Table 2. Risk Factors for Ventral Hernia in the First Year After Surgery

Variable	% With Hernia	Univariate RR	Univariate 95% CI	Univariate *P*	Multivariate*† RR	Multivariate*† 95% CI	Multivariate*† *P*
Race		1.5	(0.39–5.7)	.64			
Other	14.3						
White	9.6						
Diabetes		0.77	(0.19–3.1)	1.000			
Present	7.7						
Absent	10.0						
Nutritional status		**60**	**(8.2−434)**	**<.001**	**48**	**(14–164)**	**<.001**
Deficient	31.9						
Normal	0.5						
Cancer stage		0.94	(0.43–2.1)	.83			
Late	9.6						
Early	10.3						
Histology		1.1	(0.46–2.4)	1.000			
Serous	9.6						
Other	9.1						
Pathology grade		1.1	(0.44–2.9)	1.000			
3	10.1						
1 or 2	8.9						
Cytoreductive surgery		**5.1**	**(2.5–10)**	**<.001**	**4.3**	**(2.5–7.3)**	**<.001**
Suboptimal	28.6						
Optimal	5.6						
Fascia closure		2.0	(0.96–4.1)	.073			
Other	15.0						
Running	7.6						
Chemotherapy mode		0.79	(0.12–5.4)	1.000			
Intraperitoneal	8.3						
Intravenous	10.5						
Surgical site infection		**2.7**	**(1.2–5.9)**	**.024**	1.4	(0.78–2.5)	.25
Present	21.9						
Absent	8.2						
Age (y)		0.48	(0.19–1.2)	.13			
65 or older	5.7						
Younger than 65	11.9						
BMI‡		**3.2**	**(1.5−6.8)**	**.003**	1.4	(0.81–2.3)	.25
Obese	17.2						
Nonobese	5.4						
Estimated blood loss (mL)		1.3	(0.61–2.8)	.50			
800 or more	11.8						
Less than 800	9.0						

RR, relative risk; CI, confidence interval; BMI, body mass index.
Bolded values represent those significant at $P<.05$.
* Model included nutritional status, cytoreductive surgery, surgical site infection, and BMI as well as adjustment for fascial closure and age.
† The multivariate analysis column contains empty cells because only variables with $P<.05$ on univariate analysis were tested in the model.
‡ Obese, BMI 30 or higher; nonobese, BMI lower than 30.

poor nutritional status are significant factors for this occurrence. Remarkably, an additional 7.9% will have an incisional hernia diagnosed 1–2 years after surgery–nearly doubling the overall incidence of incisional hernias in this population. Age appears to be the only significant factor in this 1- to 2-year postoperative period. These factors are valuable for both preoperative and postoperative counseling. These data can also serve as a helpful reminder for the clinician to remain vigilant during the initial cancer surveillance period, especially in the elderly.

Suboptimal cytoreduction as a risk factor for incisional hernias is an important finding. One reason for this result could be that residual tumor burden strips the body of nutritional resources that would otherwise be dedicated to optimal wound healing. These data provide an additional incentive to achieve optimal cytoreduction.[18,19]

Table 3. Risk Factors for Ventral Hernia in the Second Year After Surgery

		Univariate			Multivariate*†		
Variable	% with Hernia	RR	95% CI	*P*	RR	95% CI	*P*
Race		0	(0–3.5)	1.000			
Other	0.0						
White	8.3						
Diabetes		0.77	(0.11–5.5)	1.000			
Present	6.3						
Absent	8.1						
Nutritional status		1.4	(0.47–4.1)	.52			
Deficient	10.5						
Normal	7.6						
Cancer stage		0.51	(0.19–1.3)	.24			
Late	6.1						
Early	12.1						
Histology		1.3	(0.41–3.8)	.78			
Serous	8.5						
Other	6.8						
Pathology grade		4.00	(0.54–29)	.20			
3	9.5						
1 or 2	2.4						
Cytoreductive surgery		1.7	(0.52–5.7)	.41			
Suboptimal	12.5						
Optimal	7.3						
Fascia closure		1.5	(0.58–4.1)	.39			
Other	10.5						
Running	6.8						
Chemotherapy mode		0	(0–3.0)	1.000			
Intraperitoneal	0.0						
Intravenous	8.9						
Surgical site infection		1.5	(0.36–6.0)	.64			
Present	11.1						
Absent	7.6						
Age (y)		**3.7**	**(1.4–9.8)**	**.014**	**3.5**	**(1.3–9.4)**	**.01**
65 or older	16.4						
Younger than 65	4.5						
BMI‡		1.6	(0.62–4.3)	.40			
Obese	10.6						
Nonobese	6.5						
Estimated blood loss (mL)		0.66	(0.19–2.2)	.76			
800 or more	5.8						
Less than 800	8.8						

RR, relative risk; CI, confidence interval; BMI, body mass index.
Bolded values represent those significant at $P<.05$.
* Model includes age and adjustment for pathologic grade.
† The multivariate analysis column contains empty cells because only variables with $P<.05$ on univariate analysis were tested in the model.
‡ Obese, BMI 30 or higher; nonobese, BMI lower than 30.

Nutritionally depleted patients develop significantly more early hernias than well-nourished counterparts. Poor nutrition causes suboptimal fascial healing, leading to early hernias as tissues break down.[20] Unfortunately, it can prove difficult to significantly improve the nutritional status of patients with ovarian cancer. Even for patients who need parenteral nutrition, the optimal duration to improve wound healing is unknown.

Patients older than 65 years of age had an increased incidence of late-appearing incisional hernias. Elderly patients have hematologic issues, vascular deficiencies, and neurologic abnormalities that could account for long-term deficits of fascial tensile strength.[21] Existing data suggest that a running closure with delayed absorbable suture is still the most appropriate intervention to decrease risk, even in the elderly.[8,9,14]

We were unable to find any correlation with chemotherapy characteristics and the development of incisional hernias. However, because only 5% of patients received intraperitoneal chemotherapy, the

data are unlikely powered to detect any association. A previous report in which 36.4% of patients received intraperitoneal chemotherapy did identify it as an independent risk factor.[22] Although bevacizumab has also been found to hasten the onset of incisional hernia formation,[23] our institution did not routinely use it for primary therapy during the study period. It is thus uncertain how our data may apply to women treated with these two modalities. In general, the risk factors found in this analysis should be applicable to most patients because carboplatin and paclitaxel remain the mainstays of adjuvant therapy.

Traditional risk factors for incisional hernias (eg, obesity, diabetes, and surgical site infection) seen in the general surgery literature were not identified. However, our results are in keeping with previous studies of patients with ovarian cancer. Rettenmaier et al[22] reported that BMI did not affect hernia formation, with an average BMI of 27.37–nearly the same as our data. Long et al[23] found BMI to be significant, but their patients had lower median BMIs (25.0). Neither of those two studies found diabetes alone nor surgical site infection at 1 year to correlate with hernia formation.

It is impossible to say why these risk factors may not be applicable in ovarian cancer. It may be because chemotherapy, suboptimal cytoreduction, and nutritional status are increasingly important for these patients and other factors no longer play as significant a part in hernia development.

The strengths of our study include the large number of patients for which the known risk factors for incisional hernias were collected and a population consisting entirely of patients with ovarian cancer. Limitations include the low number of events, as well as patients lost to follow-up, which may affect the power to detect differences as well as its retrospective nature, which introduces both information bias and selection bias.

Important areas for future study include investigating prophylactic nutrition supplementation[24] and the prevention of hernia formation. Second, there has been considerable discussion about the use of prophylactic mesh to prevent hernias in high-risk patients.[25–27]

The Ventral Hernia Working Group[28] has created a grading system for assessing the potential for hernias. A prospective study investigating its validity and clinical utility for patients with ovarian cancer may be valuable. Additionally, studying how adherence to the Ventral Hernia Working Group evidence-based guidelines may reduce hernia incidence may be informative. Ultimately, a prospective trial using mesh placement at the time of primary surgery may be warranted for those identified as high risk. The primary outcome should report incidence of incisional hernias 2 years after laparotomy based on our data showing an additional 7.9% of patients will develop a hernia 1–2 years after surgery.

REFERENCES

1. Hoer J, Lawong G, Klinge U, Schumpelick V. Factors influencing the development of incisional hernia. A retrospective study of 2,983 laparotomy patients over a period of 10 years [in German]. Chirurg 2002;73:474–80.
2. Pereira JA, Pera M, Grande L. Incidence of incisional hernia after open and laparoscopic colorectal cancer resection [in Spanish]. Cirugia Espanola 2013;91:44–9.
3. Sugerman HJ, Kellum JM Jr, Reines HD, DeMaria EJ, Newsome HH, Lowry JW. Greater risk of incisional hernia with morbidly obese than steroid-dependent patients and low recurrence with prefascial polypropylene mesh. Am J Surg 1996;171:80–4.
4. Murray BW, Cipher DJ, Pham T, Anthony T. The impact of surgical site infection on the development of incisional hernia and small bowel obstruction in colorectal surgery. Am J Surg 2011;202:558–60.
5. Bucknall TE, Cox PJ, Ellis H. Burst abdomen and incisional hernia–a prospective study of 1129 major laparotomies. Br Med J (Clin Res Ed) 1982;284:931–3.
6. Nieuwenhuizen J, Kleinrensink GJ, Hop WC, Jeekel J, Lange JF. Indications for incisional hernia repair: an international questionnaire among hernia surgeons. Hernia 2008;12:223–5.
7. Altom LK, Snyder CW, Gray SH, Graham LA, Vick CC, Hawn MT. Outcomes of emergent incisional hernia repair. Am Surg 2011;77:971–6.
8. van't Riet M, Steyerberg EW, Nellensteyn J, Bonjer HJ, Jeekel J. Meta-analysis of techniques for closure of midline abdominal incisions. Br J Surg 2002;89:1350–6.
9. Hodgson NC, Malthaner RA, Ostbye T. The search for an ideal method of abdominal fascial closure: a meta-analysis. Ann Surg 2000;231:436–42.
10. Long KC, Levinson KL, Diaz JP, Gardner GJ, Chi DS, Barakat RR, et al. Ventral hernia following primary laparotomy for ovarian, fallopian tube, and primary peritoneal cancers. Gynecol Oncol 2011;120:33–7.
11. Israaelson LA, Jonsson T. Incisional hernia after midline laparotomy: a prospective study. Eur J Surg 1996;162:125–9.
12. Llaguna OH, Avgerinos DV, Lugo JZ, Matatov T, Abbadessa B, Martz JE, et al. Incidence and risk factors for the development of incisional hernia following elective laparoscopic versus open colon resections. Am J Surg 2010;200:265–9.
13. Bucknall TE. Factors influencing wound complications: a clinical and experimental study. Ann R Coll Surg Engl 1983;65:71–7.
14. Caglià P, Tracia A, Borzì L, Amodeo L, Tracia L, Veroux M, et al. Incisional hernia in the elderly: risk factors and clinical considerations. Int J Surg 2014;12(suppl 2):S164–9.
15. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Atlanta (GA): Centers for Disease Control and Prevention; Available at: http://www.cdc.gov/hicpac/SSI/001_SSI.html. Retrieved October 19, 2014.
16. Uppal S, Al-Niaimi A, Rice LW, Rose SL, Kushner DM, Spencer RJ, et al. Preoperative hypoalbuminemia is an independent predictor of poor perioperative outcomes in women

undergoing open surgery for gynecologic malignancies. Gynecol Oncol 2013;131:416–22.

17. Funk LM, Perry KA, Narula VK, Mikami DJ, Melvin WS. Current national practice patterns for inpatient management of ventral abdominal wall hernia in the United States. Surg Endosc 2013;27:4104–12.
18. Curtin JP, Malik R, Venkatraman ES, Barakat RR, Hoskins WJ. Stage IV ovarian cancer: impact of surgical debulking. J Gynecol Oncol 1997;64:9–12.
19. Bristow RE, Montz FJ, Lagasse LD, Leuchter RS, Karlan BK. Survival impact of surgical cytoreduction in stage IV epithelial ovarian cancer. Gynecol Oncol 1999;72:278–87.
20. Kavalukas SL, Barbul A. Nutrition and wound healing: an update. Plast Reconstr Surg 2010;127(suppl 1):38S–43S.
21. Van de Kerkhof PC, Van Bergen B, Spruijt K, Kuiper JP. Age-related changes in wound healing. Clin Exp Dermatol 1994;19: 369–74.
22. Rettenmaier MA, Abaid LN, Brown JV III, Micha JP, Goldstein BH. Chemotherapy and patient co-morbidity in ventral site hernia development. J Gynecol Oncol 2009;20:246–50.
23. Long KC, Levinson KL, Diaz JP, Gardner GJ, Chi DS, Barakat RR, et al. Ventral hernia following primary laparotomy for ovarian, fallopian tube, and primary peritoneal cancers. Gynecol Oncol 2011;120:33–7.
24. Eneroth M, Apelqvist J, Larsson J, Persson BM. Improved wound healing in transtibial amputees receiving supplementary nutrition. Int Orthop 1997;21:104–8.
25. Llaguna OH, Avgerinos DV, Nagda P, Elfant D, Leitman IM, Goodman E. Does prophylactic biologic mesh placement protect against the development of incisional hernia in high-risk patients? World J Surg 2011;35: 1651–5.
26. Curro G, Centorrino T, Low V, Sarra G, Navarra G. Long-term outcome with the prophylactic use of polypropylene mesh in morbidly obese patients undergoing biliopancreatic diversion. Obes Surg 2012;22:279–82.
27. Gutiérrez de la Peña C, Medina Achirica C, Domínguez-Adame E, Medina Díez J. Primary closure of laparotomies with high risk of incisional hernia using prosthetic material: analysis of usefulness. Hernia 2003;7:134–6.
28. The Ventral Hernia Working Group, Breuing K, Butler CE, Ferzoco S, Franz M, Hultman CS, et al. Incisional ventral hernias: review of the literature and recommendations regarding the grading and technique of repair. Surgery 2010;148: 544–58.