

Factors associated with postoperative complications and hernia recurrence for patients undergoing inguinal hernia repair: a report from the VA Cooperative Hernia Study Group

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Abstract

Background: We sought to determine perioperative variables predictive of complications or recurrence for patients undergoing surgical repair of inguinal hernias.

Patients and Methods: Using data from the Veterans Affairs trial, regression analyses were utilized to identify perioperative factors significantly associated with complications (overall, short-term and long-term), long-term pain, and to develop a risk model for recurrence.

Results: Recurrent and scrotal hernias were predictors for short term and overall complications, regardless of technique. Older age and higher Mental Component Score of the SF-36 were associated with higher risk of long term complications in the open group while prostatism and increased body mass index were the significant predictors in the laparoscopic group. Long-term pain complaints decreased as patient age increased in both groups. Patient and surgeon factors were predictive of recurrence but varied greatly depending on surgical technique.

Conclusions: Regardless of technique, scrotal and recurrent hernias were associated with a greater risk of complications and younger patients had more long-term pain. Predictors of recurrence vary based on surgical technique. © 2007 Excerpta Medica Inc. All rights reserved.

Keywords: Complications; Recurrence; Inguinal; Herniorrhaphy; Lichtenstein; Laparoscopic

Repair of inguinal hernias is one of the most commonly performed general surgery procedures in the United States, with more than 750,000 inguinal herniorrhaphies performed every year [1]. The procedure is relatively safe and straightforward, however, recurrence and complications still occur at a significant rate [2]. Most recent literature on inguinal hernias has focused on the recurrence rate after various

types of repair and surgical techniques [3,4]. The number of preoperative and perioperative factors analyzed for correlation with hernia recurrence and postoperative complications has been limited. Most often these assessments focus on the role of surgical technique in determining the likelihood of complications and ignore other possible factors. The purpose of this report is to identify the risk factors associated with complications or recurrences in patients undergoing laparoscopic and open inguinal hernia repair. We present a risk-assessment model for hernia recurrence.

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Patients and Methods

Over a 3-year period of time, a total of 2,164 men were enrolled in the Veterans Affairs Cooperative Studies Program Inguinal Hernia Trial: Tension-Free Inguinal Hernia Repair: Comparison of Open and Laparoscopic Surgical Techniques (Cooperative Studies Program #456). Of these, 1,983 underwent a randomly assigned surgical repair (laparoscopic vs open). The majority of patients (85%, $n = 1,696$) were followed up for a minimum of 2 years postoperatively. Complication data were analyzed for all patients who underwent surgery. The patients who completed 2 years of follow-up evaluation formed the basis for our recurrence risk model. Inclusion and exclusion criteria, baseline characteristics of these patients, and the details of the 2 surgical techniques used in this study, as well as the primary results, were described previously [5,6]. All patients gave informed consent and the study was cleared through the institutional review boards at participating hospitals.

Preoperative factors

Data were collected on patients' age, body mass index (BMI), ethnicity, employment status, marital status, education, physical activity level, health insurance, and caregiver status. In addition, at the time of entry into this trial (before surgery) all patients completed the Health-Related Quality of Life survey Short Form-36 version 2 (SF-36) [7]. SF-36, a widely used instrument to assess non-disease-specific health-related quality of life, can be summarized by 2 scores: a Physical Component Summary (PCS) and a Mental Component Summary (MCS). PCS and MCS scores both are standardized to a score of 50, with a standard deviation of 10. To facilitate interpretation, PCS and MCS scores were considered in 3-unit intervals (50–52, 53–55, and so forth).

Hernia factors, medical comorbidities, and surgical factors

Information was collected regarding characteristics of the hernia, including symptoms, duration, size, recent enlargement, unilateral versus bilateral, ability to reduce, and recurrent versus primary. Data also were collected preoperatively on participants' comorbid conditions including cardiovascular, central nervous system, gastrointestinal, nutritional/immune, peripheral vascular (claudication), pulmonary dysfunction (severe chronic obstructive pulmonary disease), prostatism, diabetes requiring medication, nonsteroidal anti-inflammatory or anticoagulant use, smoking, alcohol consumption, and weight loss. Functional status (independent, partially, or total dependent) and American Society of Anesthesiology (ASA) classification were recorded before the procedure. Surgical factors included self-reported surgeon experience, type of anesthesia, size of mesh, and procedure performed (open anterior tension-free mesh repair [Lichtenstein] vs laparoscopic repair [either totally extraperitoneal laparoscopic or transabdominal preperitoneal]).

Complications and follow-up evaluation

Complications were categorized by both timing and severity. Intraoperative complications were assessed on the

day of surgery and included excessive bleeding; injuries to bowel, bladder, vas deferens, nerves, or vascular structures; as well as anesthetic complications. The presence of a peritoneal defect over mesh after a laparoscopic inguinal hernia repair was considered an intraoperative complication. Short-term postoperative complications were assessed at the 2-week follow-up visit and included infection, hematoma, orchitis, seroma or hydrocele, pain of the groin or leg, and urinary tract problems (infection, retention, or hematuria). Long-term complications were assessed at 3 months and then at yearly intervals and included the same spectrum of complications as the short-term postoperative period. The overall complication rate was defined as the total number of unique patients with one or more intraoperative, short-term, or long-term postoperative complications divided by the number of patients available for evaluation at that time point.

Chronic pain patients were defined as having either groin or leg pain identified at any visit 3 or more months after the surgery. Chronic pain requiring treatment was defined similarly with the addition of specific medical or surgical treatment.

Complications that were present at the time of a follow-up visit were tallied for that time frame (short or long term). Patients may have had more than one complication recorded and had the same complication recorded more than once (ie, a single patient with a hematoma at both the 2-week and 3-month follow-up visit would be counted as contributing 2 complications, one each to short-term and long-term hematomas; however, this patient would contribute only a single end point to the overall complication rate).

Recurrence and follow-up evaluation

Hernia recurrence was diagnosed at any follow-up appointment by a surgeon not involved in the initial repair. Follow-up appointments were at 2 weeks, 3 months, and at 1 and 2 years after surgery. Recurrences were confirmed by another surgeon, by ultrasound examination, or at surgery for repair.

Statistics: complication data

Statistical analysis was performed based on the intention-to-treat principle. All statistical tests were 2-sided, and the statistical significance level was set at .05. Previous analysis of outcomes for patients in actual repair groups was not statistically different from intention-to-treat groups [5]. The relationship between surgical complication data and individual baseline variables was evaluated with the Pearson chi-square test or the Fisher exact test for categorical variables, and by using the Student *t* test for continuous variables. Multivariable best subsets logistic regression was applied to identify risk factors related to each type of complication outcome separately for each type of surgical approach (laparoscopic vs open). Baseline variables, including preoperative factors, hernia factors, medical comorbidities, and stratification variables of hernia type (primary/recurrent), and number of sides (unilateral/bilateral), all were included in the best subsets logistic regression model. Potential complication outcomes for multivariable modeling included intraoperative complications, short-term complications, long-term complications, overall complications, long-

term pain, and long-term pain requiring medical or surgical therapy. To ensure relatively stable models, only outcomes with at least 50 occurrences and with *P* values greater than .2 in the univariate comparisons for laparoscopic or open repair were modeled. These included short-term, long-term, and overall complications, and long-term pain. Assuming the 2 types of repairs have different sets of predictors, separate multivariable analyses were performed for patients undergoing open and laparoscopic inguinal hernia repair for each of the 4 outcomes. The best-fitted models were selected by examining the Mallows' Cp statistics, the generalized R², Likelihood Score statistics, the Akaike Information Criterion, and the Schwarz Criterion. The predictive accuracy of the multivariable models was assessed using both the concordance index (c-index) and the Hosmer-Lemeshow goodness-of-fit test statistics [8].

Statistics: recurrence data

The initial analysis of recurrence indicated the presence of an interaction between the type of repair performed and many preoperative and perioperative variables, therefore logistic regression models were developed for open and laparoscopic groups separately. Models then were developed in multiple steps of variable selection. First, demographic and comorbid risk factors with a bivariate *P* value of less than .20 were entered into a logistic regression model with recurrence as the dependent variable. The exception to this was BMI in the laparoscopic group, which closely approached our cut-off value at a *P* value of .21 and was included. Then, variables that were not significant at a *P* value of less than .05 were deleted sequentially until only statistically significant variables remained. These models then were used as the basis for the next step, with variables collected at surgery added and again variables significant at a *P* value of less than .05 were retained. All variables that reached significance in the first step of the model, with demographics and comorbid diseases, were retained for use in the final risk model.

Point values then were assigned to each risk factor by multiplying the B-coefficients from the regression model by 10, rounding to the nearest integer as previously described by Le Gall et al [9]. Point values then were transformed to make all integers positive so increased point values indicated increased risk of hernia recurrence. To test the model, point totals for an individual patient were calculated using a simple sum of the patient's individual point values. The risk index values then were divided into discrete ranges. For each range, the mean predicted probability of recurrence produced from the initial regression equation was calculated. Multiplying these means by 100 produced the expected proportion of recurrence. Next, 10 bootstrap samples for each model (size 867 for open repairs, and 817 for laparoscopic repairs) were selected and the final model was run on each. Expected proportions of recurrence were compared with the observed proportions of recurrence in each range of the risk index using a chi-square goodness-of-fit test. Discrimination and calibration of the regression models were determined using the c-statistic and the Hosmer-Lemeshow goodness-of-fit test [8].

Complication frequency data from prior report

A total of 1,983 patients underwent surgical repair of an inguinal hernia. A total of 1,087 complications occurred in 695 (35%) patients (Table 1) [5]. Although there was significant variation in complication frequencies reported among the 14 centers (range, 12%–57%), in aggregate, the overall complication rate was higher in the patients undergoing laparoscopic repair than in the open repair group (39% vs 33%; *P* = .02). The most common complication for open repairs was chronic groin or leg pain followed by hematoma of the wound or scrotum. For the laparoscopic group the order of these complications was reversed; hematomas of the wound or scrotum were slightly more common than complaints of chronic pain. The results of univariate comparisons of the rates of complications between open and laparoscopic repair also are presented (Table 1).

Table 1
Complications of inguinal hernia repair

Specific complication	Lichtenstein	Laparoscopic
Intraoperative complications	n = 993	n = 989
Bleeding	1	3
Injury to vas deferens	1	0
Injury to nerve	7	1
Injury to vascular structure	0	5
Peritoneal defect over mesh	1	13
Anesthetic complication	6	8
Other	5	22
Total occurrences*	21	52
Number of unique patients†	19 (2%)	47 (5%)
Short-term complications	n = 965	n = 967
Hernia site infection	13	5
Trocar site infection	0	5
Wound hematoma	63	57
Scrotal hematoma	34	57
Orchitis	10	13
Seroma or hydrocele	31	44
Chronic leg pain	10	13
Chronic groin pain	19	23
Urinary tract infection	4	10
Urinary retention	21	28
Other	42	67
Total occurrences*	247	322
Number of unique patients†	197 (20%)	250 (26%)
Long-term complications	n = 950	n = 943
Hernia site infection	4	1
Trocar site infection	0	3
Wound hematoma	2	12
Scrotal hematoma	3	9
Orchitis	7	11
Seroma or hydrocele	12	29
Chronic leg pain	17	18
Chronic groin pain	82	53
Other	80	86
Total*	207	222
Number of unique patients†	165 (17%)	170 (18%)

Data from Neumayer et al [5].

* Individual patients may have had more than one complication.

† *P* values for comparison of laparoscopic and open repair with respect to intraoperative complications, postoperative complications, and long-term complications were .0004, .005, and .707, respectively.

Table 2
Predictors of complications in multivariate analysis for patients undergoing open inguinal hernia repair

Complications	Significant predictors ($P < .05$)	P value	Adjusted OR	95% CI of OR
Short-term (c-index = .655)	Type of hernia: recurrent	.006	2.02	1.22–3.32
	Hispanic ethnicity	.043	2.94	1.03–8.35
	Hernia into scrotum on examination	.0005	2.41	1.47–3.94
Long-term (c-index = .624)	SF-36 MCS score, OR for each 3-unit increase	.008	.95	.92–.99
	Age, OR for each 5-y increase	.003	.90	.84–.97
	Type of hernia: recurrent	.023	1.71	1.08–2.72
Overall (c-index = .629)	Caucasian race	.029	1.49	1.04–2.13
	College education or higher	.025	1.38	1.04–1.83
	Hernia into scrotum on examination	.005	2.05	1.24–3.37
	Age, OR for each 5-y increase	<.0001	.82	.75–.90
Long-term pain (c-index = .649)				

Recurrence data from prior report

In the laparoscopic group more recurrences were noted ($n = 87/862$, 10%) than in the open repair group ($n = 41/834$, 5%) [5]. The difference in recurrence between laparoscopic repair and open repair (odds ratio [OR], 2.2; 95% confidence interval [CI], 1.5–3.2) was analyzed with logistic regression models to control for study site, multiple hernias at the time of surgery, and whether the hernia had been repaired previously, and it remained increased significantly. The difference in recurrence remained statistically significant when cross-overs were assigned to their new group in the analysis. Results were not changed when the variable of multiple hernia repairs at the same time was added, however, primary or recurrent hernia did affect the recurrence. Patients who had a previous hernia repair tended to have a lower rate of recurrence after laparoscopic repair (10%) compared with open repair (14%; OR, .7; 95% CI, .3–2.0). The result was not significant because the CI for the OR included 1.0, likely owing to the small number of recurrent hernias in the sample. Surgeon laparoscopic repair volume also impacted recurrence. Case volumes less than 250 were associated with a higher rate of recurrence (10%) than case volume greater than 250 (5%, $P < .001$).

Results

Complications

With open repair, the likelihood of a short-term complication was increased in patients who were Hispanic, had a recurrent hernia, or a hernia extending into the scrotum (Table 2). Long-term complications occurred less often among older patients, or in those with a higher SF-36 MCS score. The overall likelihood of any complication occurring was increased in patients who were white, with recurrent hernias, with a hernia extending into the scrotum, or with a college education or higher. Long-term pain occurred less often among older patients.

With laparoscopic repair, the likelihood of a postoperative complication was increased in patients who had prostatism, a hernia that enlarged in the 6 weeks before entry into the study, a hernia present for more than 1 year before the repair, a hernia extending into the scrotum, or a recurrent hernia (Table 3). Long-term complications occurred more often among patients who had prostatism, or a higher BMI. The overall likelihood of any complication occurring was increased in patients who were married, had prostatism,

a bilateral hernia, a recurrent hernia that was recurrent, a hernia that enlarged in the past 6 weeks, a hernia that was nonreducible or reduced with difficulty, a hernia extending into the scrotum, or a higher BMI. Long-term pain occurred less often among older patients and in those whose highest physical activity level was moderate to heavy instead of light.

A total of 151 (8%) patients reported chronic pain of the leg or groin. The rate of chronic pain was 6% for the laparoscopic group and 9% for the open repair group ($P = .016$). Medical or surgical treatment for chronic pain was needed in 55 patients. Of these, 25 had undergone laparoscopic repair and 30 had undergone open repair (2.6% vs 3.1%; $P = .51$).

Recurrence

In bivariate analysis of patients undergoing open repair, patients whose hernia recurred were less likely to be single and more likely to have a marital status of separated, more likely to have functional status classified as totally dependent, and more likely to have cirrhosis. Surgical time was 9 minutes shorter on average in patients with recurrence.

In multivariable analysis, independent predictors of recurrence in the open repair group were recurrent hernia, the absence of a caregiver, higher Nyhus classification of the hernia, and the length of surgery (Table 4). The c-index for this model was .73. The rescaled (such that all point values would be positive integers) point values for risk factors in open hernia repair are shown in Table 4; the higher the score, the higher risk of recurrence. The patients were separated into 5 categories based on the likelihood of recurrence. The risk category, risk score range, percentage predicted recurrence, and observed recurrence from bootstrap analysis are shown in Table 5. Predicted recurrence and observed recurrence were similar with a goodness-of-fit statistic of 4.74 ($P = .69$).

In bivariate analysis of patients undergoing laparoscopic repair, patients whose hernia was more likely to recur included those who received a Foley catheter, or those with a smaller piece of mesh. Patients who recurred after laparoscopic repair had higher rates of congestive heart failure, although this did not reach statistical significance ($P = .08$).

By using multiple logistic regression, independent predictors of recurrence in the laparoscopic group were an active lifestyle, a BMI of 25 or less, or low surgeon volume

Table 3
Predictors of complications in multivariate analysis for patients undergoing laparoscopic inguinal hernia repair

Complications	Significant predictors ($P < .05$)	P value	Adjusted OR	95% CI of OR
Short-term (c-index = .644)	Enlargement of hernia in past 6 mo	.01	1.50	1.10–2.05
	Duration: present for >1 y	.004	1.59	1.16–2.18
	Hernia into scrotum on examination	.011	2.02	1.18–3.46
	Prostatism	.0005	1.94	1.34–2.81
	Recurrent hernia type	.003	2.04	1.27–3.27
Long-term (c-index = .631)	Prostatism	.009	1.71	1.14–2.57
	BMI, OR for each 1-unit BMI increase	.006	1.07	1.02–1.12
	Bilateral hernia	.024	1.50	1.06–2.12
Overall (c-index = .645)	Recurrent hernia type	.033	1.61	1.04–2.50
	Married	.042	1.32	1.01–1.74
	Enlargement of hernia in past 6 mo	.03	1.35	1.03–1.77
	Hernia nonreducible or reducible but difficult	.047	1.73	1.01–2.98
	Hernia into scrotum on examination	.016	1.91	1.13–3.24
	Prostatism	<.0001	2.17	1.55–3.04
	BMI, OR for each 1-unit BMI increase	.002	1.06	1.02–1.10
	Highest physical activity level medium/heavy/ very heavy work or recreation	.017	.52	.30–.89
	Age, OR for every 5-y increase	.0006	.83	.75–.92
Long-term pain (c-index = .666)				

as we have reported previously (Table 6) [5]. We found a significant interaction between ASA classification and recent enlargement of the hernia. For ASA 3 patients, those who had a recent (within the past 6 months) enlargement of their hernia were more likely to have a recurrence than those without a recent enlargement. The c-index for the model is .67. The rescaled point values for risk factors in the laparoscopic group is shown in Table 6; the higher the score, the higher the risk for hernia recurrence. When the predicted rate of recurrence and observed recurrence rate were compared with bootstrap analysis (Table 7), the results were similar with a goodness-of-fit statistic of 5.42 ($P = .71$).

Comments

Few prospective randomized studies have been performed that specifically assess the efficacy of laparoscopic inguinal hernia repair and open anterior tension-free mesh inguinal hernia repair [3,4]. These trials have focused on

hernia recurrence rates as their primary outcome and have reported only limited information on complications that occur during and after the procedure. Furthermore, the likelihood of complications in these trials has been assessed only in the context of the surgical technique used and other potentially important variables were ignored. Therefore, there is little information that would help guide clinicians and patients regarding the likelihood of specific and overall complications. Meaningful statistics regarding complication rates can be generated only by large well-designed prospective studies with clear definitions of clinical end points and careful data collection. Likewise, hernia recurrence has not been reviewed systematically in the context of multiple preoperative and perioperative risks. Failure of the procedure in hernia repair often necessitates reoperation; therefore, a model to describe the factors involved in a specific repair would be helpful in determining the risk for recurrence.

In the course of this trial, nearly 2,000 patients underwent surgical repair of an inguinal hernia. Complications were defined carefully, assessed at multiple time points, and graded for severity. This trial provides an excellent database for further analysis of the independent patient and surgery-specific variables that predict postoperative complications and recurrence.

Table 4
Model for predicting risk of recurrence for open repair

Variable	Average β	95% CI	Point value for risk score
Hernia type			
Primary	-.908	-1.37 to -.45	4
Recurrent	0		13
Caregiver			
No	.859	.51–1.20	22
Yes	0		13
Nyhus class			
1	-1.081	-1.79 to -.37	2
2	-1.318	-2.02 to -.61	0
3	.112	-.51 to .73	14
4	0		13
Surgery time			
>72 min	-.881	-1.08 to -.69	4
<72 min	0		13

Table 5
Predicted and observed recurrence in open group based on bootstrap estimates

Risk category	Risk score*	N	Predicted, % (N)	Observed, % (N)
Very low (1%–3%)	21–39	388	1.59 (6.16)	1.55 (6)
Low (3%–5%)	40–44	317	4.78 (15.14)	5.36 (17)
Moderate (5%–10%)	45–52	22	10.28 (2.26)	9.09 (2)
High (10%–20%)	53–59	124	11.70 (14.51)	9.68 (12)
Very high (>20%)	>59	16	24.43 (3.91)	31.25 (5)

* Risk score is a sum of each patient's point values.

Table 6
Model for predicting risk of recurrence for laparoscopic repair

Variable	Average β	95% CI	Point value for risk score
Activity level			
Active	.634	.35–.92	20
Sedentary	0		14
BMI			
>25	-.378	-.57 to -.18	10
<25	0		14
Attending experience			
High	-1.140	-1.52 to -.76	3
Low	0		14
ASA/enlargement			
ASA1, not enlarged	-.628	-.97 to -.29	8
ASA1, enlarged	-.160	-.44 to .12	12
ASA 2, not enlarged	-.510	-.88 to -.14	9
ASA 2, enlarged	-.615	-.90 to -.33	8
ASA 3, not enlarged	-1.360	-1.92 to -.80	0
ASA 3, enlarged	0		14

No single factor was associated with all the complication end points considered. However, in both types of repairs considered in the trial, recurrent hernias were more likely to result in complications than primary hernias, as were hernias that extended into the scrotum. These findings support the clinical impression of most herniorrhaphists that large and recurrent hernias are more difficult to repair and result both in higher rates of hernia recurrence as well as higher rates of complications. It is also important to note that despite some common findings, the predictors of complications differed based on the surgical approach used. For example, prostatism, which was a significant risk factor for many complications in laparoscopic repairs, was not a risk factor for the development of complications in open repairs. Many of the other independent risk factors for complications with laparoscopic repair could be construed as patient or hernia characteristics that would make laparoscopic repair more technically difficult.

Of great interest to surgeons and patients is the frequency of chronic pain. The rate of long-term pain (8%) and pain requiring medical or surgical therapy (3%) reported in the present series is similar to other studies in which rates generally have varied between 1% and 10% [3,4,10–14]. When possible factors associated with long-term pain were considered in multivariate analysis, age proved to be a significant predictor for patients undergoing either surgical approach. This finding has been reported consistently in prior studies of both open and laparoscopic inguinal hernia repair and may be related to actual anatomic/physiologic differences, altered perceptions of pain based on age, or differing expectations of outcome [11,15–17]. We have reported previously on the impact of recurrence, complications, and long-term pain on patients' quality of life [17]. These analyses both suggest that when the efficacy of inguinal hernia repair is studied in the future, a combined outcome measure of recurrence plus complications plus long-term pain would be justified.

Factors that were associated with hernia recurrence differed between the laparoscopic and open repair groups. A

previously repaired hernia was a significant predictor in the open group, but not in the laparoscopic group. Perhaps when an open repair fails, one should consider a laparoscopic approach, albeit with an experienced surgeon. Obesity being protective for hernia formation (or perhaps hernia detection) has been described previously by Abramson et al [18] in an Israeli population study that was a retrospective analysis of patients presenting with primary and recurrent hernias. We found a BMI of less than 25 to be a risk factor for recurrence only in the laparoscopic group. Interesting recurrence risk factors not previously described are the preoperative activity level of the patient, influence of a caregiver, ASA class, and whether or not the hernia had enlarged recently. Previous studies have described prostatic hypertrophy, hemorrhoids, and smoking as being predictors for hernia recurrence [19–22]. In our study, none of these factors were found to be independent predictors of recurrence with either surgical technique. Similar to what we have found, many investigators have described the type of hernia and the experience of the surgeon as risk factors for recurrence [4,5,23–28].

The predictive model that we propose is useful in providing surgeons with factors that are associated with recurrence and complications depending on technique and whether a recurrence or long-term pain is more of a worry postoperatively. In addition, for a surgeon performing an open repair for a large and/or recurrent hernia, taking more time in the operating room may help reduce the risk of recurrence in such patients. However, our models need validation in another patient dataset before widespread adaptation.

Although this study obtained a large cohort of patients in whom complications were documented carefully according to prespecified definitions, there were several limitations that must be acknowledged. First, this study was conducted in 14 VA Medical Centers in the United States. As such, the study population closely mirrors the patient population encountered in these hospitals (older, male, Caucasian, lower socioeconomic status, and so forth). The results of this study, therefore, may not be generalizable to different populations. Furthermore, only 2 of many different techniques of hernia repair were tested in the context of this study. Complication rates after other forms of repair may differ from the rates reported here. Last, although we have examined a large number of patients and variables associated with recurrence, it is possible that factors such as patient genetics or family history play a significant role that was not assessed in this study.

Table 7
Predicted and observed recurrence in laparoscopic group based on bootstrap estimates

Risk category	Risk score*	N	Predicted, % (N)	Observed, % (N)
Very low (1%–3%)	27–39	65	1.82 (1.18)	0 (0)
Low (3%–5%)	40–44	106	3.85 (4.08)	4.72 (5)
Moderate (5%–10%)	45–51	136	6.23 (8.47)	7.35 (10)
High (10%–20%)	52–59	444	12.79 (56.80)	12.84 (57)
Very high (>20%)	>59	69	20.90 (14.42)	18.84 (13)

* Risk score is a sum of each patient's point values.

By using the data from a large randomized trial, we have defined associations between patient and hernia characteristics and surgical techniques and the outcomes of recurrence, complications, and long-term pain. By using regression analyses we have developed predictive models for these outcomes. These models may be useful in determining an appropriate surgical approach for an individual patient to reduce their risk of recurrence and complications.

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