



## Predictors for recurrence after open umbilical hernia repair in 979 patients



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### ABSTRACT

**Background:** Our study aims were to evaluate factors that predict recurrence after open umbilical hernia repair with either mesh or primary closure.

**Methods:** Consecutive patients ( $n = 1,125$ ) undergoing open umbilical hernia repair from 2009 to 2018 were identified from a prospectively managed, quality database. Kaplan-Meier curves and log-rank tests were used to analyze recurrence-free survival for preoperative, intraoperative, and postoperative factors. Univariable and multivariable Cox regression was used to analyze recurrence-free survival by age, sex, body mass index, concurrent laparoscopic inguinal hernia repair, smoking status, diabetes, postoperative infection, hernia size in greatest dimension, and type of repair.

**Results:** The overall recurrence rate was 3.3% with a median follow-up of 14 months. Univariable analysis revealed a difference in recurrence-free survival for current smoking ( $P = .039$ ), diabetes ( $P = .007$ ), higher body mass index ( $P = .057$ ), and postoperative infection ( $P < .001$ ). Multivariable analysis indicated higher body mass index ( $P = .007$ ), concurrent laparoscopic inguinal hernia repair ( $P = .044$ ), current smoking status ( $P = .020$ ), diabetes ( $P = .021$ ), and a primary closure repair of hernias  $\geq 1.5$  cm ( $P = .001$ ) had a greater risk of recurrence. Postoperative infection showed an association with recurrence ( $P = .053$ ).

**Conclusion:** Our results indicate higher body mass index, concurrent laparoscopic inguinal hernia repair, current smoking, diabetes, primary closure repair of hernias  $\geq 1.5$  cm, and postoperative infection were associated with a greater risk of recurrence after open umbilical hernia repair.

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### Introduction

An umbilical hernia occurs when tissue protrudes through a small opening or defect in the midline fascia midline at the umbilicus. Umbilical hernias can either be acquired over time or secondary to a congenital malformation of the umbilicus. Acquired umbilical hernias result from increased intra-abdominal pressure owing to obesity, excessive coughing, or multiple pregnancies. Congenital umbilical hernias result from the umbilical ring failing to close during gestation resulting in a weak spot in the abdominal wall where a hernia may form. Umbilical

hernia repairs are a frequently performed general surgical operation and are the second most common type of abdominal hernia, with about 175,000 hernias repaired annually.<sup>1,2</sup> Repair of umbilical hernias is typically done as an open operation using either mesh or primary closure (PC) to close the defect. PC repair is the simplest approach and consists of using either a permanent or absorbable suture to close the umbilical hernia defect. For mesh repairs, mesh is placed posterior to the hernia defect and secured to the stronger tissue surrounding the defect with suture fixation.

Although not common, recurrence after open umbilical hernia repair (OUHR) is a burden for patients and surgeons. Recurrence rates for mesh repair range from 0% to 8%, and for PC repair up to 14%.<sup>3,4</sup> Currently, there is little consensus on the most important factors predictive of recurrence. Determining the risk factors for recurrence will help distinguish the type of repair most suitable for individual patients and decrease the recurrence rates. The purpose

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of this study is to evaluate factors that predict recurrence after OUHR with either mesh or PC.

## Methods

Consecutive patients ( $n = 1,125$ ) undergoing OUHR from March 2009 to October 2018 were identified from a prospectively managed, quality database at NorthShore University HealthSystem. This database consists of all umbilical hernia repairs performed at North Shore University HealthSystem by 1 of 4 board-certified general surgeons. The database is maintained by research assistants who prospectively collect preoperative, intraoperative, and postoperative data. Data extraction was performed through review of the medical records of general surgery, primary care, and operative notes, and was conducted in accordance with the Institutional Review Board-approved protocol. Preoperative factors collected included age at operation, sex, body mass index (BMI), diabetes, serum hemoglobin A1c level (Hgb A1c), secondary umbilical hernia repair, and smoking status. For smoking status, patients were divided into 3 groups, patients with no history of smoking (never), patients who quit smoking at least 4 months before surgery (former), and patients who were currently smoking (current) at the time of hernia repair. Intraoperative factors collected included duration of the operation, type of repair: mesh or PC, hernia size, type of mesh, and suture used to fixate the mesh, the American Society of Anesthesiologist (ASA) class, concurrent laparoscopic or open inguinal repair, concurrent ventral hernia repair, and duration of hospital stay. Postoperative outcomes collected included postoperative infection, mesh or surgical site infections, and recurrence. Surgical site infections were classified using the operations manual of the ACS National Surgical Quality Improvement Program and were documented only if they occurred within 30 days after OUHR.

Electronic medical records were reviewed for hernia recurrence at 1, 3, 5, 7, and 10 years after the OUHR. This review was performed by querying the electronic medical record for the word hernia revealing every mention of hernia in an individual's chart. Research assistants then reviewed the most recent primary care or general surgery note to inquire about a hernia recurrence where physicians will record either no hernias or no hernia recurrence during the abdominal exam. If no hernia recurrence or no hernias was documented in the physicians note, then recurrence was not noted. In addition, this query of the word hernia will reveal any abdominal computed tomographies (CT) that noted a hernia. All CT images that designated a hernia were reviewed by at least 1 of the 4 general surgeons who did not perform the procedure to determine whether or not it was a recurrence. Recurrences were noted if a patient had a reoperation for recurrence, if a hernia was recognized during a physical examination by a general surgeon or primary care physician, or if an umbilical hernia was designated on CT imaging. The follow-up period was acquired from the time of hernia repair to the review of the most recent mention of the word hernia noted either on CT or during physical examination of the abdomen by a NorthShore University HealthSystem primary care physician or general surgeon.

For OUHRs repaired with mesh, the majority were done with a piece of circular mesh placed in an intraperitoneal underlay position with facial closure and secured with permanent suture. Within the past few years of the study, the authors began making an effort to place the mesh in the preperitoneal space when able. In addition, the circular mesh patch used for repair has a protective covering to prevent adhesions to bowel and typical sizes of mesh used ranged between 4.2 and 6.4 cm in diameter. For umbilical hernias repaired by PC, the majority were done with permanent suture. Hernia size was determined during the operation by the surgeon and reported in the operative note. Surgeons were encouraged to use a ruler to

measure the hernia in largest dimension. Patients were excluded if hernia size was not documented in the procedure note or if a patient had no postoperative follow-up within the NorthShore University HealthSystem.

Statistical analysis compared recurrence rates of preoperative, intraoperative, and postoperative factors for the remaining 979 patients with the independent samples  $t$  or Wilcoxon rank-sum test and  $\chi^2$  or Fisher exact tests. Kaplan-Meier (KM) curves and log-rank tests were used to assess recurrence-free survival (RFS) for preoperative, intraoperative, and postoperative factors. Univariable and multivariable Cox regression was used to analyze RFS by age, sex, BMI, concurrent laparoscopic inguinal hernia repair (LIHR), smoking status, diabetes, postoperative infection, hernia size in greatest dimension, and type of repair. All statistical analysis was performed using SAS 9.3 (SAS Institute, Cary, NC).

## Results

Of the 1,125 patients who underwent OUHR, 979 patients fit our inclusion criteria. Preoperative, intraoperative factors, and postoperative outcomes for all 979 patients are summarized in Table I. In addition, recurrence rates for each factor are included in Table I. Mean age of all patients at time of operation was  $52.8 \pm 14.7$  years and mean age for patients that had a recurrence was  $55.7 \pm 17.1$  years ( $P = .307$ ). Mean BMI was  $28.5 \pm 5.5$  kg/m<sup>2</sup>, and the majority of patients were male (68.3%). The recurrence rates for females and males were 4.2% vs 2.8%, respectively ( $P = .268$ ). Of the patient cohort, 945 (96.5%) had a primary umbilical hernia repair, and 34 (3.5%) had a secondary umbilical hernia repair. The most common type of mesh used for repair was self-expanding polypropylene ePTFE (Ventalex, Warwick, RI), and the most common mesh suture type was 0-Braided Polyethylene Terephthalate (PETE) (Ethibond, Cincinnati, OH). The mean ASA class was  $1.9 \pm 0.7$ , with the majority of patients being classified as low-risk (ie, an ASA class of I or II [82.3%]). A total of 15 (1.5%) postoperative infections occurred in the patient cohort. Surgical site infections occurred in 12 (1.2%) and mesh infections in 3 (0.4%) patients. For all patients, the median follow-up time was 14 months, although for patients who had a recurrence, the median follow-up time was 61 months ( $P < .001$ ). Patients with no follow-up were not analyzed. Follow-up >12 months was achieved in 506 (51.7%) and follow-up <12 months was achieved in 473 (48.3%) patients.

Overall, 32 (3.3%) patients had an umbilical hernia recurrence with a median time to recurrence of 29 months (Table I). Patients with an ASA class of III or IV had a greater recurrence rate than patients with an ASA class of I and II (6.4% vs 2.6%;  $P = .038$ ). Mean ASA class for patients who had a recurrence was minimally greater compared with patients who did not have a recurrence ( $2.2 \pm 0.7$  vs  $1.9 \pm 0.6$ ;  $P = .030$ ). Univariable analysis revealed that an ASA class of III or IV (HR = 2.91, 95% confidence interval [CI], 1.03–8.24,  $P = .045$ ) was associated with a risk of recurrence. ASA was not included in multivariable analysis owing to collinearity with other key risk factors. The recurrence rate for patients that had a postoperative infection was in comparison to for patients who did not have a postoperative greater (33.3% vs 2.8%;  $P < .001$ ; Table I). Of the 5 patients who had a recurrence and postoperative infection, 2 were surgical site infections and 3 were mesh infections. Postoperative infection (HR = 9.45, 95% CI, 3.72–23.98,  $P < .001$ ) was associated with a risk of recurrence in univariable analysis. Multivariable analysis revealed postoperative infection to possibly have an association with increased risk of recurrence (HR = 3.19, 95% CI, 0.99–10.32,  $P = .053$ ; Table II).

Multivariable risk factors for recurrence were current smokers, diabetes, higher BMI, concurrent LIHR, and PC repair of hernias  $\geq 1.5$  cm (Table II). Of the 979 patients, 73 (7.5%) identified as a current,

**Table I**  
Demographics, intraoperative factors, and postoperative outcomes by recurrence

	All patients (N = 979)	Recurrence (N = 32, 3.3%)	P value	Months to recurrence (median = 29)	P value
	N (column %)	N (row %)	$\chi^2$	Median (Q1–Q3)	Log-rank
Age at operation (y, mean $\pm$ SD)	52.8 $\pm$ 14.7	55.7 $\pm$ 17.1	0.3070		
<50	433 (44.2)	13 (3)	0.4632	33 (21–51)	0.5165
50–64	327 (33.4)	9 (3)		31 (18–44)	
65+	219 (22.4)	10 (5)		23 (13–30)	
Female	310 (31.7)	13 (4)	0.2679	28 (11–53)	0.5135
Male	669 (68.3)	19 (3)		30 (20–50)	
BMI (kg/m <sup>2</sup> mean $\pm$ SD)	28.5 $\pm$ 5.5	30.0 $\pm$ 6.1	0.2017		
BMI <25	244 (24.9)	4 (2)	0.0946	28 (17–42)	0.0567
BMI 25–29.9	385 (39.3)	17 (4)		28 (16–44)	
BMI 30–34.9	240 (24.5)	5 (2)		36 (26–51)	
BMI $\geq$ 35	110 (11.2)	6 (6)		26 (11–56)	
Smoking status					
Never	623 (63.6)	17 (3)	0.0442	28 (20–50)	0.0388
Former	283 (28.9)	9 (3)		26 (11–36)	
Current	73 (7.5)	6 (8)		38 (10–51)	
Diabetes mellitus					
No	889 (90.8)	25 (3)	0.0219	28 (13–44)	0.0074
Yes	90 (9.2)	7 (8)		30 (20–56)	
Diabetes mellitus					
No	889 (90.8)	25 (3)	0.1180	28 (13–44)	0.0596
Well-controlled diabetes (Hgb A1c <7.0)	33 (3.5)	3 (9)		51 (18–69)	
Uncontrolled diabetes (Hgb A1c $\geq$ 7.0)	27 (2.9)	1 (4)		30 (30–30)	
Primary umbilical hernia repair	945 (96.5)	30 (3)	0.3830	27 (16–51)	0.1091
Secondary umbilical hernia repair	34 (3.5)	2 (6)		38 (32–44)	
ASA class					
1	232 (23.7)	5 (2)	0.0378	36 (28–53)	0.0615
2	574 (58.6)	16 (3)		25 (12–43)	
3 or 4	173 (17.7)	11 (6)		26 (20–56)	
Hernia size (cm)					
<1.0	217 (22.2)	8 (4)	0.9574	34 (22–58)	0.7273
1.0–1.4	186 (19.0)	6 (3)		27 (13–44)	
1.5–1.9	222 (22.7)	8 (4)		29 (13–55)	
2.0–2.4	205 (20.9)	5 (2)		30 (11–56)	
$\geq$ 2.5	149 (15.2)	5 (3)		20 (18–32)	
Concurrent repair type					
None	778 (79.5)	23 (3)	0.4336	28 (16–51)	0.6643
Lap inguinal repair	160 (79.6)	8 (5)		31 (14–53)	
Open inguinal hernia repair	19 (9.5)	1 (5)		26 (26–26)	
Lap or open ventral repair	22 (11.0)	0 (0)		—	
OR time (min, mean $\pm$ SD)	40 $\pm$ 31	46 $\pm$ 28	0.1288	—	—
Mesh repair	498 (50.9)	11 (2)	0.0578	30 (11–44)	0.0588
Primary closure repair	481 (49.1)	21 (4)		28 (18–51)	
Mesh type (N = 498)					
Self-expanding polypropylene ePTFE (Ventralex, Warwick, RI)	328 (65.9)	4 (1)	0.2145	12 (9–16)	0.7570
Lightweight Polypropylene–Polydioxanone (Ethicon, Cincinnati, OH)	79 (15.9)	4 (5)		46 (33–68)	
Monofilament Polypropylene (Perfix, Warwick, RI)	42 (8.4)	2 (5)		24 (4–44)	
Polyester–Collagen–Polyethylene Glycol–Glycerol (Parietex, Minneapolis, MN)	46 (9.1)	1 (2)		32 (32–32)	
Mesh suture type (N = 498)					
0-Braided Polyethylene Terephthalate (PETE) (Ethibond, Cincinnati, OH)	425 (85.3)	7 (2)	0.1174	20 (8–36)	0.4134
0-Monofilament Polypropylene (Prolene, Cincinnati, OH)	39 (7.8)	2 (5)		28 (13–44)	
Undocumented mesh suture type	34 (6.8)	2 (5)		43 (30–56)	
Duration of hospitalization (hours, median, Q1–Q3)	5.5 (4.4–6.8)	5.7 (4.5–8.5)	0.2341	—	—
Postoperative infection					
No	964 (98.5)	27 (3)	<.0001	31 (16–51)	<.0001
Yes	15 (1.5)	5 (33)		18 (17–30)	
Follow-up months (median, Q1–Q3)	14 (1–43)	61 (31–75)	<.0001	—	—

283 (28.9%) as former, and 623 (63.6%) as never smokers. Current smokers had a greater recurrence rate of 8.2% in comparison to the recurrence rate of former (3.2%) and never (2.7%) smokers ( $P = .044$ ; Table I). Figure 1, A to C shows a difference in RFS between current smokers and former or never smokers, with current smokers estimated to recur more frequently than non-smokers

( $P = .039$ ). Multivariable analysis indicated that current smokers have 3.2 times the risk of recurrence than former or never smokers (Table II).

In our patient cohort, 90 (9.2%) patients had diabetes. Of the diabetic patients, 33 (3.5%) were classified as having well-controlled diabetes (Hgb A1c <7.0), 27 (2.9%) with uncontrolled

**Table II**  
Multivariable Cox proportional hazards analysis of recurrence-free survival

Risk factor	HR (95% CI)	P value
Age, per year increase	1.01 (0.98–1.04)	.4017
BMI, per kg/m <sup>2</sup> increase	1.09 (1.02–1.16)	.0072
Female vs male	1.91 (0.82–4.46)	.1348
Concurrent lap inguinal hernia repair, yes vs no	2.54 (1.03–6.27)	.0437
Current smoker vs former/never	3.20 (1.20–8.55)	.0203
Diabetes mellitus, yes vs no	2.87 (1.17–7.01)	.0208
Postoperative infection, yes vs no	3.19 (0.99–10.32)	.0526
Hernia size and mesh used	Interaction	.0184
PC vs mesh, at size <1.5 cm	0.71 (0.17–3.02)	.6448
PC vs mesh, at size ≥1.5 cm	6.79 (2.20–20.92)	.0009

diabetes (Hgb A1c ≥7.0), and 10 (1.0%) who had no documented Hgb A1c level. Diabetic patients had a greater recurrence rate in comparison to nondiabetics (7.8% vs 2.8%;  $P = .022$ ; Table I). There was no difference in recurrence between well-controlled and uncontrolled diabetes (9.1% vs 3.7%,  $P = .620$ ). Figure 1, B demonstrates a difference in RFS between diabetic and nondiabetic patients, with diabetic patients estimated to recur at much greater rate ( $P = .007$ ). In addition, multivariable analysis showed diabetic patients have 2.8 times the risk of recurrence than nondiabetics (Table II).

Patients who had a recurrence had a mean BMI of  $30.0 \pm 17.1$  compared with  $28.4 \pm 5.5$  for those who did not have a recurrence ( $P = .202$ ). Patients were grouped by BMI into 4 classes, normal weight (<25 kg/m<sup>2</sup>), overweight (25–29.9 kg/m<sup>2</sup>), obese (30–34.9 kg/m<sup>2</sup>), and BMI ≥35 kg/m<sup>2</sup> (Table 1). In our patient cohort, 244 (24.9%) patients were normal weight, 385 (39.3%) were overweight, 240 (24.5%) were obese, and 110 (11.2%) had a BMI ≥35 kg/m<sup>2</sup>. There were 4 (1.6%) recurrences in patients with a normal BMI, 17 in overweight patients (4.4%), 5 in obese patients (2.1%), and 6 in patients (5.5%) with a BMI ≥35 kg/m<sup>2</sup> ( $P = .095$ ). The KM curve revealed that the RFS was decreased for patients with a BMI ≥35 kg/m<sup>2</sup> ( $P = .057$ ). Multivariable analysis revealed that an increase of 1 kg/m<sup>2</sup> in BMI was associated with about a 9% increased risk of recurrence (Table II).

Concurrent hernia repair was performed in 201 patients (20.5%), with the majority being LIHR (79.6%). There was no difference in unadjusted recurrence rates between concurrent LIHR, concurrent open inguinal hernia repair, concurrent ventral hernia repair, and patients with no concurrent hernia repairs ( $P = .434$ ). The KM for concurrent inguinal hernia repair revealed RFS of the umbilical hernia repair was essentially no different for concurrent LIHR patients as time passed from the date of the OUHR ( $P = .664$ ). When controlled for in multivariable analysis, patients who have a concurrent LIHR had 2.5 times the risk of recurrence than patients who did not have a concurrent LIHR (Table II).

The mean hernia size was  $1.6 \pm 0.9$  cm, with the majority of patients having a hernia between 1.5 and 1.9 cm (22.7%). Mesh repairs were performed in 50.9% of patients and PC repair in 49.1% (Table 1). There was no difference in recurrence rates between repair types, PC and mesh, although PC repairs tended to have slightly more recurrences than mesh repair (4.4% vs 2.2%,  $P = .058$ ). In addition, there was no difference in recurrence rates between hernia size groups <1 cm, 1.0 to 1.4 cm, 1.5 to 1.9 cm, 2.0 to 2.4 cm and ≥2 cm ( $P = .957$ ); however, the recurrence rate for PC repair of hernias ≥1.5 cm was greatest at 7.3%. RFS for PC and mesh repairs of hernias <1.5 cm and ≥1.5 cm revealed an increased rate of recurrence for PC repair of hernias ≥1.5 cm ( $P = .0442$ ; Fig 1, C). Furthermore, multivariable analysis indicated that PC repairs of hernias ≥1.5 cm had almost 7 times greater risk of recurrence than those repaired with mesh (Table II).

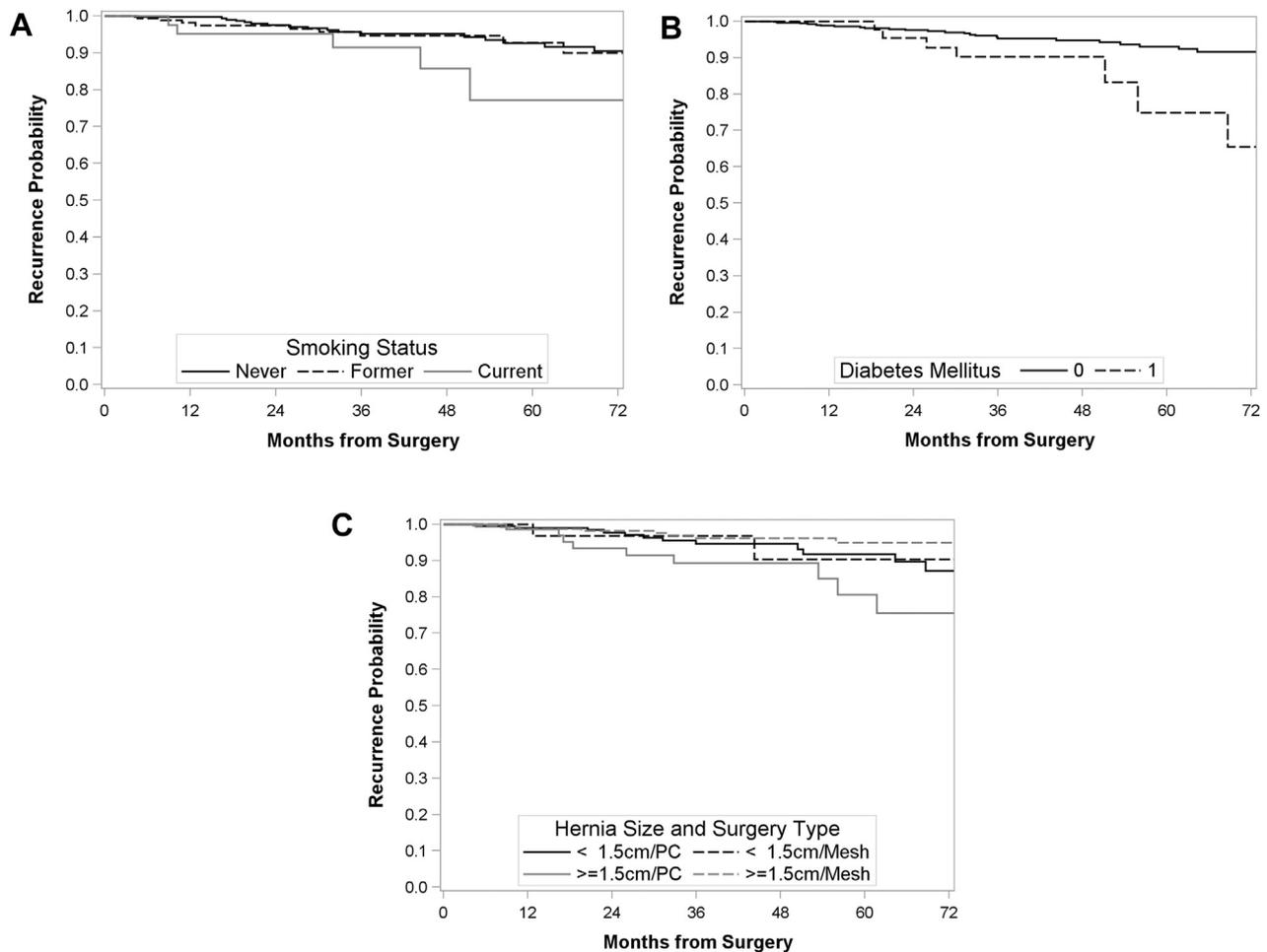
Table III shows the unadjusted recurrence rate for each of the 6 risk factors identified. In our cohort, 517 (52.8%) patients had zero

risk factors for recurrence, 365 (37.3%) had one risk factor, and 97 (9.9%) had ≥2 risk factors. The recurrence rate for patients with zero risk factors was 1.4%, for patients with one risk factor was 4.1%, and for patients with ≥2 risk factors was 10.3% (Table III). When controlling for age and sex, multivariable analysis of RFS indicated a patient with one risk factor has almost 3 times the risk of recurrence than a patient with zero risk factors (HR = 2.97, 95% CI, 1.21–7.29,  $P = .018$ ). A patient with ≥2 risk factors has >7 times the risk of recurrence than a patient with zero risk factors (HR = 7.28, 95% CI, 2.72–19.51,  $P < .001$ ).

## Discussion

Umbilical hernia repair is a common general surgical operation for adults. Although frequent, not much is known on predictors for recurrent after umbilical herniorrhaphy. Several smaller sized studies have attempted to identify factors associated with recurrence; however, there is still little consensus. Our review of 979 OUHR sought to identify preoperative, intraoperative, and postoperative factors associated with patients who are more likely to develop a recurrence after OUHR. Our data revealed current smokers, higher BMI, and diabetes as preoperative risk factors associated with recurrence. In addition, our data identified he intraoperative factors of PC repair of hernias ≥1.5 cm, concurrent LIHR, and postoperative infection as predictors of recurrence.

In our study, follow-up time was considerably greater for patients who had a recurrence. The likely reason for this could be that recurrences occur progressively during follow-up, and patients with a recurrence seek medical evaluation, whereas patients with no hernia recurrence or are asymptomatic do not seek medical attention, and therefore, their follow-up is much less. For our patient cohort, the overall recurrence rate and the recurrence rates for PC and mesh repairs are within the range of what prior large sample studies have reported as well. In a retrospective review of 934 umbilical hernia repairs, Porrero et al<sup>5</sup> reported a similar overall recurrence rate of 3.8%. The Denmark Nationwide Registry reviewed 4,786 open umbilical and epigastric hernia repairs and stated an overall recurrence rate of 4.8%. In addition, they reported a significantly greater recurrence rate for PC (5.6%) repairs than for mesh repairs (2.2%) of umbilical hernias ≤2 cm.<sup>6</sup> Our data revealed PC repairs to have similar recurrence rates as mesh repairs. Dalenbäck et al<sup>7</sup> reported similar results and found no difference between recurrence rates for PC and mesh repairs of umbilical hernias. They recommended PC repair for hernias <2 cm and mesh repairs for hernias greater than that.<sup>7</sup> Although Shankar et al<sup>8</sup> reviewed 328 umbilical hernia repairs and demonstrated a decrease in the risk of recurrence by 3.6 times for mesh repairs in multivariable analysis. Our analysis revealed a high recurrence rate and a high risk of recurrence for PC repair of hernias ≥1.5 cm in comparison to mesh repair of hernias ≥1.5 cm. Similar results have been reported by umbilical hernia studies that excluded umbilical



**Fig 1.** Kaplan-Meier curve for recurrence-free survival of umbilical hernia (A) by smoking status (B) diabetes status ( $P = .007$ ), and (C) primary closure versus mesh repair of umbilical hernia  $<1.5$  cm and  $\geq 1.5$  cm;  $*P < .05$  each.

**Table III**  
Risk factors and recurrence rates

Risk factor	Recurrence rate (%)
Postoperative infection ( $N = 15$ )	33.3
Current smoker ( $N = 73$ )	8.2
Diabetes mellitus ( $N = 90$ )	7.8
BMI $\geq 35$ ( $N = 110$ )	5.5
Concurrent lap inguinal hernia repair ( $N = 160$ )	5.0
PC and size $\geq 1.5$ ( $N = 124$ )	7.3
No. of risk factors	
0 ( $N = 517$ )	1.4
1 ( $N = 365$ )	4.1
$\geq 2$ ( $N = 97$ )	10.3

hernias  $<1$  cm from analysis and demonstrated fewer recurrences after mesh repair of hernia sizes 1 to 4 cm.<sup>9,10</sup>

In our study, both univariable and multivariable analyses revealed current smoking, diabetes, and higher BMI increased the risk of developing recurrence; however, we were unable to identify a specific BMI range that increases risk of recurrence. Many smaller umbilical hernia studies have found variable but comparable results. In a retrospective review of 392 open umbilical hernia repairs, Berger et al<sup>11</sup> reported similar results demonstrating BMI and smoking status to be associated with recurrence. Yao et al<sup>12</sup> reviewed 199 OUHR and reported no difference between the recurrence rates amongst obese and nonobese patients. Asolati

et al<sup>13</sup> reviewed 299 OUHR and reported recurrence was associated with diabetes but were unable to find a relationship between recurrence, BMI, and smoking. Previous studies have also identified obesity as a risk factor for recurrence after ventral hernia repair.<sup>14</sup> Obesity leads to increased intra-abdominal pressure which can contribute to a greater risk of developing recurrence.<sup>15</sup> Current smoking is a well-known risk factor for hernia recurrence and postoperative complications, and therefore, our finding that smoking increases the risk of recurrence is consistent. Smoking can contribute to recurrence by impairing collagen synthesis and wound healing and increasing intra-abdominal pressure with associated chronic cough.<sup>16</sup> Furthermore, diabetes can contribute to hernia recurrence by interfering with the processes of wound healing and prevent the repair from healing correctly.<sup>17</sup> In our analysis of diabetes, comparing the recurrence rates of well-controlled and uncontrolled diabetes revealed no difference. This observation suggests that controlling diabetes does not affect recurrence rates but may still increase rates of infections because diabetes is a well-recognized risk factor for surgical site infection and wound complications.<sup>18</sup>

Another factor that increased the risk of recurrence was concurrent LIHR. In our study, we examined the patient population who underwent concurrent hernia repair to assess whether patient lifestyle was related to the increased risk for umbilical hernia recurrence. These patients were older, had lower BMI, had smaller diameter umbilical hernias  $\geq 1.5$  cm, and more were male, whereas

rates of current smoking, diabetes, infection in their original umbilical hernia repair, and umbilical hernias  $\geq 1.5$  repaired with PC were all similar between those who did and those who did not have a concurrent hernia repair. In addition, we performed a multivariable analysis excluding concurrent hernia repairs which revealed very similar results to our original multivariable analysis that included concurrent hernia repairs. Therefore, we think the difference in patient population or lifestyle was not related to why concurrent LIHR is a risk factor for umbilical hernia recurrence. Winsnes et al<sup>4</sup> reviewed 306 umbilical hernia repairs and found that coexisting hernia or previous history of hernia was also a univariable predictor of recurrence. In addition, they concluded that patients with multiple hernias may represent as a special group in whom the treatment of the hernia may need to be different.<sup>4</sup> Prior studies have reported that a family history of hernias should be considered when deciding the operative plan and can predispose individuals to multiple different types of hernia and to hernia recurrence.<sup>19,20</sup> In addition, several studies have implicated the roles of collagen genes and family history of multiple hernias as risks factors for recurrence.<sup>21</sup> In our study, however, we did not collect family history of hernias or any history of multiple hernias. Another reason concurrent LIHR increases umbilical hernia recurrence rates may be the difference in mechanism of repair, specifically the adjacent facial incision made next to the hernia to access the preperitoneal space.

Furthermore, our study revealed a greater risk of recurrence for individuals with one or multiple risk factors. This finding suggests that patients who have multiple risk factors, such as diabetes or obesity, and in addition are current smokers or have a coexisting inguinal hernia, should have an individualized treatment plan to decrease their risk of recurrence. In our study, univariable predictors for recurrence were postoperative infection and ASA class III or IV. In a retrospective review of 150 OUHR, Farrow et al<sup>22</sup> identified factors that increase the risk of infection or recurrence and reported that patients with an ASA class  $\geq 3$  were more likely to develop a postoperative infection than patients with an ASA  $< 3$ , probably related to their greater incidence of comorbidities.

Umbilical hernias can be repaired either by an open or laparoscopic procedure. Although a laparoscopic repair is becoming the procedure of choice for ventral hernias, it has not been adopted with the same enthusiasm for umbilical hernias. Studies that have compared the 2 types of umbilical hernia repair have revealed no difference in recurrence rates but slightly less wound complication rates for laparoscopic repair.<sup>23</sup> Some indications for laparoscopic repair of umbilical hernias are obese individuals, patients with a large hernia, or in some situations, patients who have a low risk of general anesthesia.<sup>24,25</sup> At our institution, whether we do these repairs open or laparoscopic was at the discretion of the surgeon, and for this particular study, we chose to focus on only OUHRs.

Our study has some limitations. The study had variable follow-up because of the 9-year time span; another limitation relates to the inability to capture recurrence in patients who sought medical attention outside of our institution for treatment.

In conclusion, recurrence rates after OUHR are related to concurrent risk factors. Patients with one risk factor have almost 3 times the risk of developing a recurrence and patients with  $\geq 2$  risk factors have  $> 7$  times the risk of recurrence than patients with zero risk factors; higher BMI, current smokers, diabetics, concurrent LIHR, a primary closure of an umbilical hernia  $\geq 1.5$  cm, and postoperative wound infection are the main risk factors for recurrence.

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## Conflict of interest/Disclosures

The authors have no relevant conflicts of interest.

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## Discussion



**Dr L. Michael Brunt** (St. Louis, MO): Congratulations on a very nicely presented study and for this detailed analysis in a large series of patients with umbilical hernia repairs. I think this is an understudied problem in surgery, and I appreciate the opportunity to review your manuscript well in advance.

How many times have we all seen patients who come in with a large recurrent hernia, sometimes even with partial or full loss of domain, and when you ask them the history, it started out as an umbilical hernia repair, and that was their only prior initial operation? So like so many things, getting this right and having the best possible outcome with the first operation is the best strategy for these patients.

I have a number of questions for you:

You indicated that the size of the hernia was 1.6 cm. How was that determined? Because this was multiple surgeons involved, did you record all of this prospectively? Did the surgeons routinely measure it at operation? We often times estimate size it but really should accurately measured to get that. Was that in the operative note or part of the prospective database?

You didn't really focus on this in the talk but in the manuscript discussed the nature of the repair. You said it was an underlay repair, but was it preperitoneal, intraperitoneal, sublay, or did it vary? Was the mesh circular mesh patch or a rectangular mesh? What were the sizes of mesh used? There are many preformed meshes designed for umbilical hernia repair. I'm curious, what was the distribution of mesh types by your surgeon and if there was any difference in recurrences or other variables by mesh type.

I would commend you on the follow-up analysis on such a large series. Can you give us a little more information about the nature of that data, since patients typically aren't seen after 3 or 4 weeks after umbilical hernia repair by the surgeon, unless they had a concern about a problem or had a CT scan. So what was the follow-up information you got? Was it from the electronic medical record? Was it mainly from notes from the primary care physicians? Did they consistently comment on the abdominal exam that there was no evidence of recurrence or no mention of recurrence, presumed to be no recurrence? If you could clarify that for us.

Finally, just looking at some of your data with the risk factors of smoking and diabetes, when we do more complex abdominal wall hernia repairs, we insist patients stop smoking, but probably most of us haven't been doing that routinely in first-time umbilical hernia repairs. Have the data that you have shown caused you to change your practice and really push people hard to stop smoking in advance of umbilical hernia repair?

**Kara Donovan:** Thank you for your questions. Hernia size was measured in largest dimension in the operating room by the surgeon.

For mesh repairs, mesh is typically placed in an underlay intraperitoneal position and this mesh is coated with a protective covering to prevent adhesions to bowel. The typical size of mesh used ranged between 4.2 to 6.4 cm in diameter.

**Dr L. Michael Brunt** (St. Louis, MO): One other question about the repair. Was the fascia closed primarily over it? What was the nature of the follow-up information that you got on these patients?

**Kara Donovan:** That is correct, the fascia was closed primarily over it. We checked for recurrence at 1, 3, 5, 7, and 10 years by

searching the electronic medical record for any mention of hernia, and that will bring up their most recent physical examination by a primary care physician which they will usually write "no hernia present." We also look at CT scans and see if there's any documentation about a hernia, and if there is, we have one of four general surgeons who do not perform the operation, review the CT scans to determine if there was a hernia recurrence, and we also check for reoperation for recurrence and any patient complaints about a hernia.

**Dr L. Michael Brunt** (St. Louis, MO): The last question was what are you doing now about smoking cessation in advance of umbilical hernia repair given your data showing higher recurrence rates?

**Kara Donovan:** When the surgeons see patients preoperatively, they request or they talk about the risk of recurrence for current smoking and request that they do not smoke.

**Dr Vic Velanovich** (Tampa, FL): Very nicely presented of a very large series. My question has to do with the follow-up.

I noticed that the median follow-up was 14 months, but the median time to recurrence was 29 months. So are you going to be really missing future recurrences with the data as you presented? As a follow-up to that, it might be better to analyze this more as like an actuarial time to recurrence rather than just giving us a raw number. Comments about that?

**Kara Donovan:** Yes, we did have variable follow-up. Half the patients had <12 months and half had >12 months of follow-up. We did use Kaplan-Meier curve method with log-rank tests and Cox regression to predict recurrence rates to compensate for the variable follow-up.

**Dr Vic Velanovich** (Tampa, FL): This might be more a question for Dr Ujiki than for you. One of the fascinating bits of data, there's a lot of it, but the one of the fascinating bits was the concomitant hernia repairs like inguinal and epigastric, et cetera, as a risk factor. Is that really more telling you something about the patient and the quality of the fascia rather than just doing another repair increasing your risk?

**Dr Michael Ujiki:** Thank you for the questions.

That was the one factor that was a surprise to us. I think the obesity, smoking, infections, they didn't really surprise us too much, but it was nice to actually put numbers to them and figure it out, and Kara did an amazing job working with our statistician on all of those and really helping us be able to now counsel patients when they walk in with multiple risk factors to be able to say, Look, you have 8 times chance for recurrence now unless you stop smoking and lose some weight first, which we do actually make mandatory now. We won't do an umbilical hernia repair on a smoker. We have had people yelling at us and walking out of clinic and saying, You're not taking care of me, and we say, Look, we are going to bring our best to the table, but you have to bring your best to the table as well, and we are sorry but this is for you, not us. And it's been a difficult conversation. Losing weight is a difficult conversation, but it's helped a lot.

Before I answer your question, I want to go back to Mike's question about the mesh. We do close the fascia. The majority of the mesh were placed intraperitoneal, but more recently we have worked toward putting the mesh in the preperitoneal space. As you know, if you have done a lot of these, sometimes it's hard to

preserve the peritoneum, but we try to do that, even if it means closing the peritoneum if it's been open. We will actually make an attempt to do that. And all the surgeons, we made an agreement many years ago that we were going to be very diligent about measuring the hernia size with a ruler, or sometimes we will use instruments to measure it. But we try to be very accurate with that.

So the concurrent hernia, I think it's probably both what you said. I think it is saying something about the patient, patients that come in with an umbilical hernia and 2 bilateral inguinal hernias. Those patients, we are fixing them and, interestingly, their umbilical hernias are coming back, and we are still trying to figure out why. Some of that may be the dissection of the fascia around the umbilicus near the hernia to get into that retrorectus space and maybe that might be part of it, but we haven't figured that out. But we are looking at that a little bit more in detail. But that was one surprise. Excellent and thoughtful questions, of course.

**Dr Peter Angelos** (Chicago, IL): Beautifully presented paper. This is, again, perhaps more of a question for Mike. I want to push you a little on that issue of the patients who have risk factors who say, "As a patient, I am willing to accept the increased risk," and you are telling them, "I am not willing to allow you to accept the increased risk." What number of risk factors prompt you to deny surgery even when the patient wants to assume the risk? You said that smoking is a risk factor that leads you to conclude that you won't operate. What are the absolute contraindications to surgery where you say, "I don't care how much you want it, I don't care how much this hernia may be debilitating your life, I am not going to allow you to get a hernia repair from me"?

**Dr Michael Ujiki:** Smoking is the easy one. We say no, and it has been very interesting. It was something where the 4 of us that do the majority of hernia repairs at Northshore all had to kind of agree, because what we saw at the beginning was some of us were very early adapters of that and some weren't, and so the patients were basically going from one surgeon to the other. But ultimately we all kind of agreed, you know, ethically we have to do what's right for the patient, so we all agreed we are not operating if you are smoking, and we are going to test your urine for nicotine.

We have canceled people, actually, in the preoperative area when that nicotine test came back the day of and was positive, and we have actually sent people home.

I'll give a great example. I had a patient who called me very upset when his nicotine test came back, and I called him and said, we can't do the surgery. He said, I have had 4 surgeries, and you are supposed to be the one that was going to figure this one out, because I have recurred 4 times. I said exactly. That's exactly right.

So nicotine is an easy one. The weight one is a hard one because the weight is one where somebody has a body mass index of 42, it's likely going to take them 6 to 12 months at best to get below a threshold of 35 where we found is the major threshold. And if someone is very symptomatic, it can be very difficult to make them wait. So I have to say that although the majority of the time we are telling patients with a BMI >35, you have got to lose weight and come back, there are definitely some that slip through and have to get it done because we just tell them, you know, you are very symptomatic, we understand, we are going to do it, but your recurrence rate is going to be very high. It a very good question.

**Dr Michael S. Nussbaum** (Roanoke, VA): In relation to involving the patients in the discussion regarding risk reduction there is a great App for your phone that was developed at Carolinas; the Carolinas Equation for Determining Associated Risks or CeDAR. It can be very impactful when discussing risk factors related to hernia repair with patients. You can easily demonstrate to them the

differences if they continue to smoke versus smoking cessation, what happens if the BMI decreases and how those changes can impact the complication/recurrence rate and the cost. I have 2 questions.

1. How long do you expect the patients to be off of smoking before you feel that it is safe to operate on them from a recurrence standpoint?
2. Why is the cutoff for the use of mesh 1.5 cm? That is just a little larger than the size of a 10 mm laparoscopic port site which is generally closed primarily. Please explain how you made that determination.

**Kara Donovan:** We tell them 4 weeks prior to hernia repair they must refrain from smoking. We looked at former smokers, which included patients who quit smoking 4 weeks prior to hernia repair, and this revealed no difference in their recurrence rates between former and never smokers.

For hernia size, we ran Kaplan-Meier curves comparing mesh and primary closure for each of the 5 hernia size groups, and we saw a trend of hernias 1.5 cm repaired with primary closure recurring more often after surgery than mesh repairs of hernias 1.5 cm. Based off that, we split patients into 2 categories of hernias <1.5 cm and hernias ≥1.5 cm and ran Kaplan-Meier curves. This showed a significantly higher recurrence rate for primary closure repairs of hernias ≥1.5 cm.

**Dr Michael Ujiki:** If I may add, this data actually changed the way that we practice. We kind of use the well-known >2 cm you should use mesh for many years. But when we actually looked, we had probably >1,200 patients with umbilical hernia repairs that we looked at, and we ran the data and we found actually those patients that were between 1.5 and 2 that we were having a higher recurrence rate significantly. And then we looked even more, maybe we should be putting mesh in people with a tiny 1 cm hernia, but we found it did not change recurrence rate, and they had more wound complication. So we actually found that 1.5 cm should be a cut-off. I know we are talking about a 5-mm difference, but it is making a difference. So we do measure them, and we use mesh if it is ≥1.5.

**Dr Gerald Fried** (Montreal, QC): First I want to compliment you on your poise and beautiful presentation.

My question is about rectus diastasis. In your database did you have information about whether or not the patient had a rectus diastasis and whether that interacted with size or any other factor in terms of predicting recurrence?

**Kara Donovan:** We do collect that in the database but we did not include it in the analysis for the paper.

**Dr R. Matthew Walsh** (Cleveland, OH): My question concerns diabetes, it's interesting that hemoglobin A1c didn't correlate with outcome. Did you look at the glucose level on the day of surgery?

**Kara Donovan:** No, we did not. We only looked at hemoglobin A1c scores 90 days within hernia repair.

**Dr R. Matthew Walsh** (Cleveland, OH): Because that may also correlate with your infection rate. That might be interesting to look at.

My other comment would be that a lot of these are concomitant surgeries, and I suspect what they really came in for was the inguinal hernia. During your evaluation you also noticed an unsuspected umbilical hernia and you said you would fix that too. You may think that is an innocuous part of the operation, just a little hernia that you happened to find, but it's actually a very important component of the combined procedure.