



Comparison of postoperative infection after emergency inguinal hernia surgery with enterectomy between mesh repair and non-mesh repair: a national database analysis

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Abstract

Purpose Synthetic non-absorbable mesh is used for elective inguinal hernia repair but is not commonly used for incarcerated or strangulated inguinal hernia requiring enterectomy to reduce the risk of surgical-site infection. This study aimed to evaluate the safety of synthetic non-absorbable mesh repair in patients with incarcerated or strangulated inguinal hernia requiring enterectomy versus non-mesh repair.

Methods We analyzed patients with incarcerated or strangulated inguinal hernia with enterectomy from April 2012 to March 2017 using a nationwide inpatient database in Japan. We conducted overlap propensity score-weighted analyses to compare surgical-site infection (SSI), duration of anesthesia, antibiotic use at > 3 days after surgery, postoperative hospital stay, and 30 day readmission. Two sensitivity analyses were performed. First, we compared the proportions of patients requiring wound culture at ≥ 3 days after surgery. Second, we performed overlap propensity score-weighted logistic regression analyses for surgical-site infection.

Results We identified 668 eligible patients, comprising 223 patients with mesh repair and 445 with non-mesh repair. Overlap propensity score-weighted analyses showed no significant differences between the mesh repair and non-mesh repair groups for SSI (2.5 vs. 2.8%, $P = 0.79$). Secondary outcomes did not differ significantly between the groups. Proportion of wound culture at ≥ 3 days after surgery was similar in the two groups (11.1 vs. 14.6%, $P = 0.18$). Logistic regression analysis showed no significant association between mesh repair and SSI (odds ratio, 0.93; 95% confidence interval, 0.34–2.57).

Conclusion Synthetic non-absorbable mesh use may be safe for incarcerated or strangulated inguinal hernia requiring enterectomy.

Keywords Inguinal hernia · Incarcerated hernia · Synthetic mesh · Surgical-site infection

Introduction

Inguinal hernia repair is one of the most common surgeries. As the first tension-free repair, the Lichtenstein technique was published in 1989 [1]. Currently, tension-free repair using synthetic non-absorbable mesh is the most common open repair. Although prevention of inguinal hernia recurrence is a primary objective in elective hernia repair, early recovery of intestinal function and prevention of infection are important in emergency surgery for incarcerated or strangulated inguinal hernia. Traditionally, non-mesh repair has been used for incarcerated or strangulated inguinal hernia requiring bowel resection. The safety of synthetic non-absorbable mesh for inguinal hernia surgery requiring bowel resection remains to be established, although mesh repair is sometimes selected in recent times.

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Studies on surgical-site infection after mesh repair and non-mesh repair have been limited by their small sample sizes. Previous reports using single-center data showed similar incidence of surgical-site infection between mesh repair and non-mesh repair groups among patients with incarcerated hernia [2–4]. Furthermore, mesh repair was reported to reduce hospital stay [2]. In contrast, mesh repair was associated with higher incidence of surgical-site infection than non-mesh repair in another report [5].

Some incarcerated hernias require bowel resection while others do not. However, the previous studies mixed patients with and without bowel resection. In addition, the patient characteristics differed between the groups. Because the previous reports used single-center data with less than about 100 cases, generalizable data are lacking for the safety of synthetic non-absorbable mesh use for incarcerated inguinal hernia requiring bowel resection.

In this study, we aimed to evaluate the short-term safety of mesh repair in patients with emergency hernia repair requiring bowel resection by comparing postoperative infection between mesh repair and non-mesh repair.

Methods

Using the diagnosis procedure combination database in Japan, we extracted data for patients with incarcerated or strangulated inguinal hernia who required emergency admission and underwent open hernia repair on the day of admission or following day between April 2012 and March 2017. The database contains administrative claims and discharge data for approximately 8 million patients per year from more than 1,200 hospitals. All university hospitals in Japan are required to participate in the database, while participation by community hospitals is voluntary. The database includes the following information: hospital identifiers; age; sex; height; weight; diagnoses, comorbidities, and complications recorded with Japanese text data and International classification of diseases, tenth revision (ICD-10) codes [6]; procedures recorded with Japanese original codes; and discharge status. Details of the database were reported elsewhere [7, 8]. Patients were categorized into four groups according to body mass index (< 18.5, 18.5–24.9, 25.0–29.9, and ≥ 30.0 kg/m²) and three groups according to smoking index (0, 1–49, and ≥ 50 pack-years). Diabetes was defined as conditions requiring medications for diabetes treatment, including insulin and oral hypoglycemic agents. Catecholamine administration was defined as use of catecholamines before or on the day of surgery. We calculated the Charlson comorbidity index and summed the ICD-10 codes for 17 comorbidities based on Quan's protocol [9]. Type of hospital was classified into teaching hospital or non-teaching hospital.

The primary outcome was incidence of surgical-site infection. We defined surgical-site infection as ICD-10 codes T793, T813, T814, and T941. The secondary outcomes were duration of anesthesia, antibiotic use at > 3 days after surgery, postoperative hospital stay and readmission within 30 days.

Patients with the following factors were excluded: non-emergency admission, interval from admission to surgery > 2 days, peritonitis on admission, pneumonia on admission, or missing data. The need for informed consent was waived for this study because of the anonymous nature of the data. Study approval was obtained from the Institutional Review Board at the University of Tokyo.

Statistical analysis

Overlap propensity score weighting

We conducted overlap propensity score weighting. Propensity scores for mesh repair were estimated from a generalized estimating equation model fitted with multivariable logistic regression analysis, after adjustment for sex, age, body mass index, smoking index, diabetes, Charlson comorbidity index, Barthel index, and hospital type to account for clustering of patients within hospitals. Overlap weighting involves weighting patients with the predicted probability of receiving opposite treatment. One feature of this method is that extreme weights are impossible because weights are calculated between 0 and 1 [10–12]. This method has some advantages over conventional propensity score methods, such as matching or inverse probability weighting, with respect to target population, balance, and precision. The created target population mimics the cohort of a randomized control trial without excluding patients from the original cohort. Overlap weighting achieves exact balance in measured variables and optimizes precision of the estimated association between treatment and outcome among other propensity score methods including inverse probability weighting and matching [13, 14]. An absolute standardized difference < 0.1 was considered to denote a negligible difference between the two groups [15].

We performed two sensitivity analyses for the results of surgical-site infection. First, we compared the proportions of patients who required wound culture at ≥ 3 days after surgery. Second, we performed overlap propensity score-weighted logistic regression analyses for surgical-site infection adjusted for the same variables used to estimate the propensity scores, in which the pseudo-population created by the overlap propensity score weighting was regressed by the variables [10]. The chi-square test was used to compare categorical variables. For continuous variables, Student's *t* test was used. The significance level was set at $P < 0.05$ for all statistical analyses, and all *P* values were two-sided. All

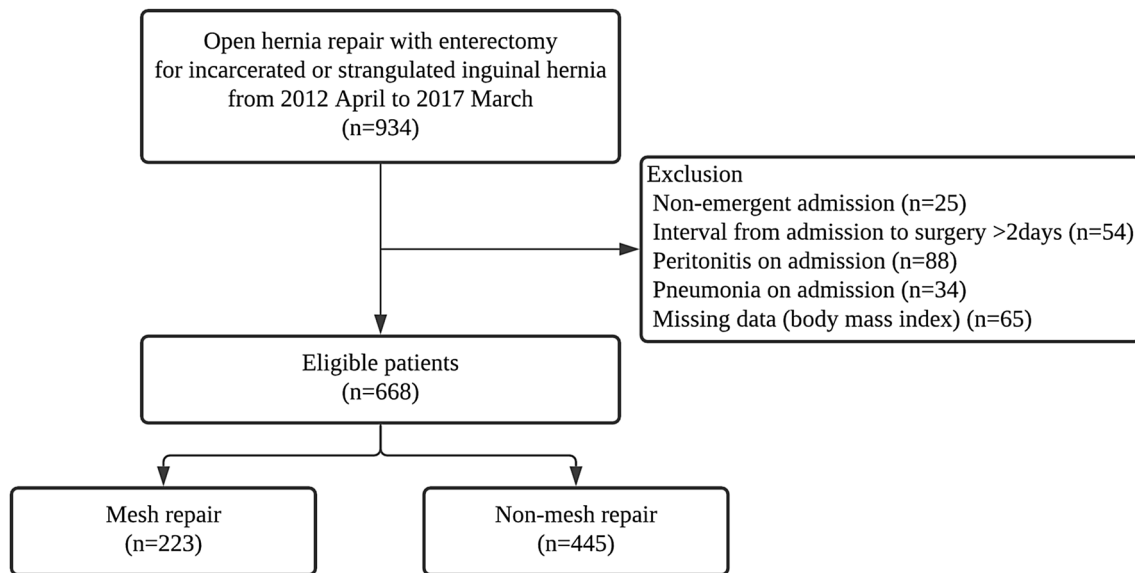


Fig. 1 Study flowchart

statistical analyses were conducted using Stata/MP™ version 15.0 (StataCorp, College Station, TX).

Results

We extracted data for 934 patients who were admitted to hospital with incarcerated or strangulated inguinal hernia and underwent open hernia repair with enterectomy during the study period. We excluded the following patients: non-emergency admission ($n = 25$), interval from admission to surgery > 2 days ($n = 54$), peritonitis on admission ($n = 88$), pneumonia on admission ($n = 34$), and missing data ($n = 65$). As a result, we identified 668 eligible patients, comprising 223 patients who underwent mesh repair and 445 patients who underwent non-mesh repair (see Fig. 1).

Table 1 shows the characteristics of the patients with incarcerated or strangulated inguinal hernia treated with mesh repair and non-mesh repair. Before adjustment, there were significant imbalances in sex, age, Charlson comorbidity index, and catecholamine administration between the two groups (absolute standardized difference > 0.1). The proportion of female patients was lower in the mesh repair group than in the non-mesh repair group (17.5 vs. 23.1%). The proportion of patients aged ≤ 40 years was larger in the mesh repair group than in the non-mesh repair group (7.2 vs. 4.0%). The proportion of patients aged ≥ 80 years was the largest in both groups (36.3 vs. 33.7%). More than half of the patients had body mass index of 18.5–24.9 kg/m² in both groups (67.7 vs. 70.8%).

The proportion of patients who required catecholamine administration was lower in the mesh repair group than in the non-mesh repair group (53.4 vs. 61.1%). After adjustment by overlap propensity score weighting, the absolute standardized differences for all variables were < 0.1 .

Table 2 shows the outcomes of the two groups before and after adjustment by overlap propensity score weighting. Before adjustment, the incidence of surgical-site infection was similar between the two groups (2.7 vs. 3.4%, $P = 0.63$). The duration of anesthesia was similar between the mesh repair and non-mesh repair groups (193.1 vs 192.2 min, respectively; $P = 0.88$). The proportion of antibiotic use at > 3 days after surgery was lower in the mesh repair group than in the non-mesh repair group (53.4 vs 63.4%, respectively; $P = 0.01$). Comparing the mesh repair group with the non-mesh repair group, respectively, postoperative hospital stay was similar (16.1 vs. 18.4 days, $P = 0.19$); the proportion of readmission within 30 days did not differ significantly (12.1 vs. 12.4%, $P = 0.93$); after adjustment, the incidence of surgical-site infection was similar (2.5 vs. 2.8%, $P = 0.79$); postoperative hospital stay was similar (16.5 vs. 18.0 days, $P = 0.34$); the duration of anesthesia was similar (193.4 vs 189.6 min; $P = 0.88$); the proportion of antibiotic use at > 3 days after surgery did not differ significantly (54.9 vs 62.3%; $P = 0.056$); and the proportion of readmission within 30 days was similar (12.0 vs. 12.5%, $P = 0.86$). In the sensitivity analyses, the proportion of patients who required wound culture ≥ 3 days after surgery was similar between the mesh repair and non-mesh repair groups (11.1 vs. 14.6%, respectively; $P = 0.18$). The overlap propensity

Table 1 Patient demographic characteristics before and after overlap propensity score weighting adjustment

Factor	Before adjustment			After adjustment		
	Mesh repair	Non-mesh repair	ASD	Mesh repair	Non-mesh repair	ASD
	(<i>n</i> = 223)	(<i>n</i> = 445)		(<i>n</i> = 325)	(<i>n</i> = 322)	
Sex, <i>n</i> (%)						
Female	39 (17.5)	103 (23.1)	0.12	62 (19.0)	62 (19.2)	0.01
Male	184 (82.5)	342 (76.9)	0.12	264 (81.0)	260 (80.8)	0.01
Age (years), <i>n</i> (%)						
≤ 49	16 (7.2)	18 (4.0)	0.15	19 (5.7)	18 (5.6)	0.00
50–59	12 (5.4)	34 (7.6)	0.09	20 (6.2)	21 (6.4)	0.01
60–69	43 (19.3)	100 (22.5)	0.08	66 (20.3)	69 (21.4)	0.03
70–79	71 (31.8)	143 (32.1)	0.03	100 (30.9)	100 (31.0)	0.00
≥ 80	81 (36.3)	150 (33.7)	0.06	120 (37.0)	114 (35.5)	0.03
Body mass index (kg/m ²), <i>n</i> (%)						
< 18.5	34 (15.2)	59 (13.3)	0.07	46 (14)	48 (15.1)	0.03
18.5–24.9	151 (67.7)	315 (70.8)	0.06	225 (69.2)	223 (69.2)	0.00
25.0–29.9	35 (15.7)	65 (14.6)	0.01	50 (15.5)	45 (14.1)	0.04
≥ 30.0	3 (1.3)	6 (1.3)	0.00	4 (1.3)	5 (1.6)	0.03
Smoking index (pack-years), <i>n</i> (%)						
0	122 (54.7)	245 (55.1)	0.02	182 (55.8)	167 (52.1)	0.08
1–49	39 (17.5)	94 (21.1)	0.08	59 (18.2)	69 (21.4)	0.08
≥ 50	62 (27.8)	106 (23.8)	0.09	84 (25.9)	85 (26.6)	0.01
Diabetes, <i>n</i> (%)	34 (15.2)	77 (17.3)	0.06	50 (15.5)	49 (15.1)	0.01
Charlson comorbidity index, <i>n</i> (%)						
0	125 (56.1)	250 (56.2)	0.04	182 (56.0)	180 (56.1)	0.00
1	62 (27.8)	100 (22.5)	0.16	84 (25.9)	88 (27.5)	0.04
≥ 2	36 (16.1)	95 (21.3)	0.13	59 (18.2)	53 (16.4)	0.05
Barthel index, mean (SD)	56.5 (42.8)	53.1 (43.0)	0.08	54.9 (43.0)	55.6 (42.8)	0.02
Catecholamine administration, <i>n</i> (%)	119 (53.4)	272 (61.1)	0.14	184 (56.5)	185 (57.5)	0.02
Hospital type, <i>n</i> (%)						
Non-teaching hospital	29 (13.0)	57 (12.8)	0.01	44 (13.4)	46 (14.2)	0.02
Teaching hospital	194 (87.0)	388 (87.2)	0.01	282 (86.6)	276 (85.8)	0.02

ASD absolute standardized difference, SD standard deviation

score-weighted logistic regression analysis for surgical-site infection showed that the odds ratio (95% CI) for mesh use was 0.93 (0.34–2.57).

Discussion

In this study, we conducted overlap propensity score weighting using a nationwide inpatient database to compare the incidence of surgical-site infection between mesh repair and non-mesh repair for incarcerated or strangulated inguinal hernia requiring bowel resection. The incidence of surgical-site infection did not differ significantly or clinically between the mesh repair and non-mesh repair groups. Postoperative hospital stay and readmission within 30 days were similar in both groups. The multivariable regression analysis did not show an association between mesh repair and surgical-site

infection. We excluded patients with non-emergency admission or with an interval from admission to surgery of > 2 days because these patients might have undergone reduction of an incarcerated hernia, receiving elective hernia repair with enterectomy. We believe emergent hernia repair is quite different from elective repair regarding preoperative and postoperative care. We also excluded patients with peritonitis on admission to exclude patients with contaminated wounds. Finally, we excluded patients with pneumonia on admission because duration of hospital stay may have been determined by pneumonia.

Our study showed that the incidence of surgical-site infection in the mesh repair and non-mesh repair groups was 2.5% and 2.8%, respectively, with no significant or clinical difference between the two groups. A prospective cohort study showed no surgical-site infection among 12 incarcerated inguinal hernia patients who underwent mesh repair with

Table 2 Outcomes of non-mesh repair and mesh repair for inguinal hernia repair requiring bowel resection

	Before adjustment				After adjustment					
	Mesh repair	Non-mesh repair	RD	95% CI	P value	Mesh repair	Non-mesh repair	RD	95% CI	P value
	(n=223)	(n=445)				(n=325)	(n=322)			
Surgical-site infection, n (%)	6 (2.7)	15 (3.4)	- 0.7%	- 3.4, 2.0	0.63	8 (2.5)	9 (2.8)	- 0.3%	- 2.8, 2.1	0.79
Wound culture at ≥ 3 days from surgery, n (%)	24 (10.8)	71 (16.0)	- 5.2%	- 10.5, 0.1	0.07	36 (11.1)	47 (14.6)	- 3.5%	- 8.7, 1.6	0.18
Duration of anesthesia (min), mean (SD)	193.1 (70.8)	192.2 (76.1)	0.9	- 11.0, 12.9	0.88	193.4 (71.1)	189.6 (72.9)	3.8	- 7.4, 14.9	0.51
Antibiotic use > at 3 days after surgery, n (%)	119 (53.4)	282 (63.4)	- 10.0%	- 17.9, - 2.1	0.01	179 (54.9)	200 (62.3)	- 7.4%	- 15.0, 0.2	0.056
Postoperative hospital stay (days), mean (SD)	16.1 (16.8)	18.4 (22.8)	- 2.3 (1.7)	- 5.7, 1.1	0.18	16.5 (17.2)	18.0 (23.2)	- 1.5 (1.6)	- 4.7, 1.6	0.34
Readmission within 30 days, n (%)	27 (12.1)	55 (12.4)	- 0.3%	- 5.5, 5.0	0.93	39 (12.0)	40 (12.5)	- 0.5%	- 0.1, 0.1	0.86

CI confidence interval, RD risk difference, SD standard deviation

enterectomy [16]. Other prospective cohort studies showed no surgical-site infection in 42 and 32 patients requiring bowel resection [17, 18]. In a further study, despite an incidence of surgical-site infection as high as 20% after mesh repair with enterectomy, no significant difference was seen between the mesh repair and non-mesh repair groups [19]. Additionally, a meta-analysis involving two retrospective studies showed no association with surgical-site infection between the two groups [20]. A recent single-center study of 257 patients showed that mesh use was not associated with increased incidence of surgical-site infection [2]. However, the findings for all of these studies are difficult to generalize because of their small sample sizes and single-center designs. The results of the present study on surgical-site infection were consistent with those in the previous studies and are generalizable because the study used a nationwide database and included > 600 patients.

Some previous reports discussed the safety of mesh repair in incarcerated or strangulated hernia by mixing groin hernias (inguinal and femoral) and ventral hernias [18, 21, 22]. However, we believe that these hernias should be distinguished before analysis. In the present study, we identified only incarcerated or strangulated inguinal hernia requiring enterectomy to determine the safety of mesh use for inguinal hernia repair.

Previous studies showed longer postoperative hospital stay in the non-mesh repair group compared with the mesh repair group [2, 23]. The differences in hospital stay between the groups in these previous studies may be due to differences in postoperative pain. Non-mesh repair is usually associated with more severe pain than mesh repair [24]. However, in the present study, postoperative hospital stay did not differ significantly between the two groups. This may be explained by the difference in severity of incarcerated or strangulated hernias between the previous studies and the present study. The previous studies included patients with and without bowel resection, while the present study included only patients with bowel resection. The length of hospital stay may have been determined by intestinal function or oral intake after surgery in the present study.

In this study, we used a Japanese nationwide database; more than 80% of the patients had a body mass index < 25 kg/m²; a small number had a body mass index of ≥ 30 kg/m². Obesity is a reported risk factor for surgical-site infection after ventral hernia repair [25]. Care should be taken when interpreting the results of this study in a Western population, in which the proportion of obese and overweight patients is higher than in Japan.

Before adjustment, the proportion of catecholamine use was higher in the non-mesh repair group. It is plausible that surgeons hesitated to use foreign body implantation in patients with unstable vital signs requiring catecholamines before surgery. However, even after minimizing selection

bias by overlap weighting, the rates of surgical-site infection and wound culture at ≥ 3 days after surgery did not differ significantly between mesh repair and non-mesh repair. This suggests that mesh repair itself was not associated with increased surgical-site infection rates.

The Centers for Disease Control and Prevention defined surgical-site infection as infection occurring within 30 days after surgery [26]. Readmission within 30 days was similar between the mesh repair and non-mesh repair groups in the present study. This result supports the notion that the disease severity was similar between the two groups and that the incidence of complications including surgical-site infection requiring readmission was similar between the two groups.

The present study has several limitations. First, the database did not have data on wound classification. Thus, our study included patients with clean-contaminated or contaminated wounds. If the strangulated bowel was necrotic or massive spillage was observed during surgery, the wound class was contaminated [27]. There was a possibility of imbalance regarding wound classification (severe local contamination) between the two groups; however, we reduced the selection bias as much as possible by excluding patients with apparent dirty wound classification (peritonitis) before surgery. Essentially, even if the incarcerated bowel was strangulated, the wound class was clean-contaminated as long as the bowel was not necrotic. Second, the details of the techniques were unknown, such as the layers in which the mesh was placed, the type of implanted mesh, surgeon's experience, and what types of non-mesh repairs were performed (e.g., Bassini, Lichtenstein, Rutkow–Robbins). However, these details were not confounders in the present study. Third, there may have been unmeasured confounders, such as postoperative drain placement, although no imbalance was seen in the measured factors between the two groups. Finally, data on long-term outcomes, such as late infection or hernia recurrence, were lacking.

In conclusion, synthetic non-absorbable mesh repair for incarcerated inguinal hernia was not associated with higher incidence of short-term surgical-site infection compared with non-mesh repair. Permanent mesh placement at the time of enterectomy did not result in different short-term infection rates between mesh vs non-mesh repair. It may be reasonable to select mesh repair for incarcerated or strangulated inguinal hernias regarding the short-term safety. Further studies investigating the probability of long-term mesh infection and the recurrence rate are needed to justify permanent mesh placement after enterectomy.

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Availability of data and material The datasets analyzed during the current study are not publicly available due to contracts with the hospitals providing data to the database.

Declarations

Conflict of interest The authors declare no conflicts of interest.

Ethical approval This study was approved by the Institutional Review Board of The University of Tokyo [approval number: 3501-(3) (December 25th, 2017)]. Because all data were de-identified, the requirement for patient informed consent was waived.

Human and animal rights The need for informed consent was waived for this study because of the anonymous nature of the data. Study approval was obtained from the Institutional Review Board at the University of Tokyo.

Consent to participate The requirement for informed consent was waived because of the anonymous nature of the data.

Consent for publication All authors have approved the manuscript and meet the requirements for authorship.

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