



# Small bite fascial closure technique reduces incisional hernia rates in gynecologic oncology patients

Alli M Straubhar <sup>1</sup>, Cynthia Stroup,<sup>1</sup> Amanda Manorot,<sup>1</sup> Kevin McCool,<sup>2</sup> Aimee Rolston,<sup>1</sup> R Kevin Reynolds,<sup>2</sup> Karen McLean,<sup>2</sup> Olivia de Bear,<sup>1</sup> Jean Siedel,<sup>1</sup> Shitanshu Uppal<sup>1</sup>

<sup>1</sup>Department of Obstetrics and Gynecology, University of Michigan, Ann Arbor, Michigan, USA

<sup>2</sup>University of Michigan, Ann Arbor, Michigan, USA

## Correspondence to

Dr. Shitanshu Uppal, Department of Obstetrics and Gynecology, University of Michigan Health System, Ann Arbor, MI 48103, USA; [uppal@umich.edu](mailto:uppal@umich.edu)

Received 30 September 2023

Accepted 27 March 2024

Published Online First

19 April 2024



© IGCS and ESGO 2024. No commercial re-use. See rights and permissions. Published by BMJ.

**To cite:** Straubhar AM, Stroup C, Manorot A, et al. *Int J Gynecol Cancer* 2024;**34**:745–750.

## ABSTRACT

**Background** The potential for the technique of small bite fascial closure in mitigating incisional hernias in gynecologic oncology patients still needs to be investigated.

**Objective** To evaluate the impact of closure of small fascial bites compared with prior standard closure on incisional hernia rates in gynecologic oncology patients.

**Methods** This is a retrospective cohort study comparing patient outcomes before and after the intervention at a single institution at a comprehensive cancer center. Patients who underwent laparotomy with a vertical midline incision for a suspected or known gynecologic malignancy with a 1-year follow-up were included. The pre-intervention cohort (large bites) had ‘mass’ or modified running Smead-Jones closure. In contrast, the post-intervention cohort had fascial bites taken 5–8 mm laterally with no more than 5 mm travel (small bites) closure using a 2–0 polydioxanone suture.

The primary outcome was the incisional hernias rate determined by imaging or clinical examination within the first year of follow-up. Patient factors and peri-operative variates of interest were investigated for their association with hernia formation through univariate and multivariate analyses. These included age, body mass index (BMI), smoking history, estimated blood loss, pre-operative albumin, American Society of Anesthesia (ASA) physical status classification, or treatment with chemotherapy post-operatively.

**Results** Of the 255 patients included, the total hernia rate was 12.5% (32/255 patients). Patient characteristics were similar in both cohorts. Small bite closure led to a significant reduction in hernia rates from 17.2% (22/128 patients) to 7.9% (10/127 patients),  $p=0.025$ . According to logistic regression modeling, small bite closure (OR=0.40, 95% CI 0.17 to 0.94,  $p=0.036$ ) was independently associated with lower odds of hernia formation. Other factors associated with increased hernia rates were chemotherapy (OR=3.22, 95% CI 1.22 to 8.51,  $p=0.019$ ) and obesity (OR=23.4, 95% CI 3.09 to 177,  $p=0.002$ ). In obese patients, small bite closures led to maximal hernia rate reduction compared with large bites.

**Conclusions** The small bite closure technique effectively reduces hernia rates in gynecologic oncology patients undergoing midline laparotomy.

## INTRODUCTION

Incisional hernias are a common complication following midline laparotomy. One meta-analysis

## WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ A small bite fascial closure technique (fascial bites taken 5–8 mm laterally with no more than 5 mm travel (small bites) using a 2–0 polydioxanone suture reduces the rate of ventral hernias in the general surgery population.

## WHAT THIS STUDY ADDS

⇒ This quality improvement project demonstrates that this technique is associated with hernia reduction in gynecologic oncology patients undergoing midline laparotomy and may be used in this patient population.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These data may be used to support a prospective, randomized trial comparing fascial closure techniques, which would help further guide prevention strategies for incisional hernias in these high-risk patients.

reported an incidence of 12.8% at 1 year, with nearly one-third of patients requiring surgical intervention.<sup>1</sup> Moreover, the incidence of hernia is dependent on the time from surgery. Although nearly half of hernias will develop within 2 years of the operation,<sup>2</sup> some providers have advocated a 3-year follow-up as the cumulative incidence rate may be as high as 22%.<sup>3</sup> Known risk factors for hernia formation include patient characteristics like obesity, age, smoking history, diabetes, emergent surgery, as well as post-operative complications like surgical site infections.<sup>4–11</sup> Gynecologic oncology patients have many of these risk factors, but few studies have looked at hernia rates in this high-risk population, with reported hernia rates at 1 year of 8–15%.<sup>4 5 12</sup>

Several suturing techniques have been investigated to attempt to reduce the risk of incisional hernias. A continuous running method with a delayed absorbable monofilament suture reduces hernia formation compared with a more rapidly absorbable suture.<sup>13</sup> A randomized trial (STITCH trial) comparing smaller tissue bites of 5 mm every 5 mm of the aponeurosis only without the incorporation of fat or muscle with

**Table 1** Characteristics of patients who developed hernias

Characteristics	No hernia n=223 (87.5%)	Hernia n=32 (12.5%)	OR (95% CI)	P value
Age (years), median (IQR)	60.8 (52–69)	59.8 (49–69)	0.996 (0.971 to 1.023)	0.74
BMI (kg/m <sup>2</sup> ) median, (IQR)	28.2 (24.3–34.8)	33.1 (30.8–36.0)	1.026 (0.995 to 1.058)	<b>0.001</b>
Race, N (%)				0.23
White	183 (82.1)	29 (90.6)	Ref	
Non-white	40 (17.9)	3 (9.4)	0.473 (0.137 to 1.63)	
Smoking history, N (%)	84 (37.7)	14 (43.8)	1.263 (0.597 to 2.67)	0.51
Chemotherapy, N (%)	134 (60.1)	24 (75.0)	1.993 (0.857 to 4.63)	0.10
Pre-operative albumin (g/dL), median (IQR)	4.3 (4.0–4.5)	4.3 (4.0–4.5)	0.778 (0.273 to 2.215)	0.81
ASA, N (%)				0.21
Class 1–2	81 (36.3)	8 (25.0)	Ref	
Class 3–4	142 (63.7)	24 (75.0)	1.711 (0.735 to 3.985)	
EBL (mL), median (IQR)	200 (100–400)	200 (100–425)	0.999 (0.998 to 1.001)	0.76

ASA, American Society of Anesthesia; BMI, Body mass index; EBL, estimated blood loss.

large bites of 1 cm every 1 cm showed a reduction in hernia from 21% to 13%.<sup>14</sup> Based on these data, the European and American Hernia Societies recommend continuous small bite closure techniques for the fascial closure of elective midline incisions.<sup>15</sup> However, these trials did not include people with a malignancy, and the relatively lower body mass index (BMI) of patients enrolled in these trials questions the external validity of these results in obese patients.

Therefore, we designed a study with the primary objective to examine the impact of the adoption of a small fascial bites closure technique compared with prior standard large bite closure

techniques on incisional hernia rates in gynecologic oncology patients. The secondary objective was to assess the impact of patient and procedural factors on hernia formation in this population.

## METHODS

### Intervention and Timing

This retrospective cohort study evaluates a change in clinical practice: the adoption of the small bite fascial closure technique. Our healthcare setting is a comprehensive cancer referral center.

**Table 2** Characteristics of the two cohorts

Characteristics	Large bites n=128 (50.2%)	Small bites n=127 (49.8%)	P value
Age (years), median (IQR)	59.7 (51–70.5)	61 (52–68)	0.71
BMI (kg/m <sup>2</sup> ), median, (IQR)	30.1 (25.0–35.1)	28.3 (24.7–35.6)	0.33
Race, N (%)			0.64
White	105 (82.0)	107 (84.3)	
Non-white	23 (18.0)	20 (15.7)	
Smoking history, N (%)	52 (40.6)	46 (36.2)	0.47
Chemotherapy, N (%)	81 (63.3)	77 (60.6)	0.66
Pre-operative albumin (g/dL), median (IQR)	4.2 (4.0–4.5)	4.3 (4.0–4.5)	0.60
ASA, N (%)			0.73
Class 1–2	46 (35.9)	43 (33.9)	
Class 3–4	82 (64.1)	84 (66.1)	
EBL (mL), median (IQR)	150 (100–387.5)	200 (100–400)	0.10
Surgery duration (min), median (IQR)	188 (148.5–299)	175 (136–225)	0.26
<b>Hernia, N (%)</b>	<b>22 (17.2)</b>	<b>10 (7.9)</b>	<b>0.025</b>
Post-operative infection, N (%)	8 (6.3)	3 (2.4)	0.13

Large bites: mass closure or modified running Smead-Jones closure.  
Small bites: fascial bites taken 5–8 mm laterally with no more than 5 mm travel.  
ASA, American Society of Anesthesia; BMI, body mass index; EBL, estimated blood loss.

Almost 90% of patients undergoing laparotomy are diagnosed with a malignancy, and two-thirds receive post-operative chemotherapy. Additionally, half of our patients are categorized as obese (BMI > 30 kg/m<sup>2</sup>), and one in five falls within the class III obesity spectrum (BMI > 40 kg/m<sup>2</sup>). Given our distinct patient population compared with those in previous randomized trials, we initiated a pre- and post-intervention study to investigate if the adoption of a small bite closure technique can mitigate hernia rates among our patients.

Training for surgeons started in July 2019, with the adoption rate of the technique varying during the initial 6 months. Training the surgeons included a discussion of the data and reading the methods described in the STITCH trial.<sup>14</sup> By December 2019, our surgeons were fully trained, and the use of small bite closure was consistent, reaching over 95%. To evaluate the effect of this intervention, we established two cohorts for comparison: the pre-intervention group, which included patients who underwent surgeries between May 2018 and July 2019, while the 6-month training period (July 2019 to December 2019) was excluded from the analysis. The post-intervention cohort comprised patients who underwent surgeries from January 2020 through June 2021.

We identified patients within our institution's prospectively curated gynecologic oncology surgical database who were aged 18 years and older and underwent surgery via a laparotomy incision for a suspected or known gynecologic malignancy. Patients were included if they had 1-year of follow-up within our electronic medical record. Patients undergoing a mini-laparotomy for specimen removal, a transverse incision (such as a Pfannenstiel incision), or those with prior hernia repair were excluded.

### Technique

The pre-intervention cohort, labeled the 'large bites' group, had 'mass' or modified running Smead-Jones closure with bites taken at least 10 mm or more apart and 10 mm or more lateral travel. The post-intervention cohort had 'small bites' fascial closure. This entailed taking 5–8 mm lateral fascial bites with no more than 5 mm travel closure along the incision using a 2–0 polydioxanone suture, with inclusion of the aponeurosis only and avoiding the incorporation of fat or muscle tissue.<sup>14</sup> Suturing was started at both ends of the incision towards the center. Most cases used 2–0 polydioxanone on a CT-2 needle, except during COVID-related supply chain disruptions, which mandated the use of 2–0 polydioxanone on a CT-1 needle. During surgeon training, closure guidelines emphasized maintaining a wound-to-suture length ratio of 1:4. Surgeon training consisted of a 1-hour session on the supporting small bite, followed by a demonstration of videos and pictures from previously published literature. Subsequent data collection did not include assessment of this parameter, given the challenges in consistently measuring wound and suture lengths due to time constraints.

### Statistical Analysis

The primary outcome was whether or not an incisional hernia developed within 1 year of surgery. Hernias were identified on review of imaging studies by radiologists and/or

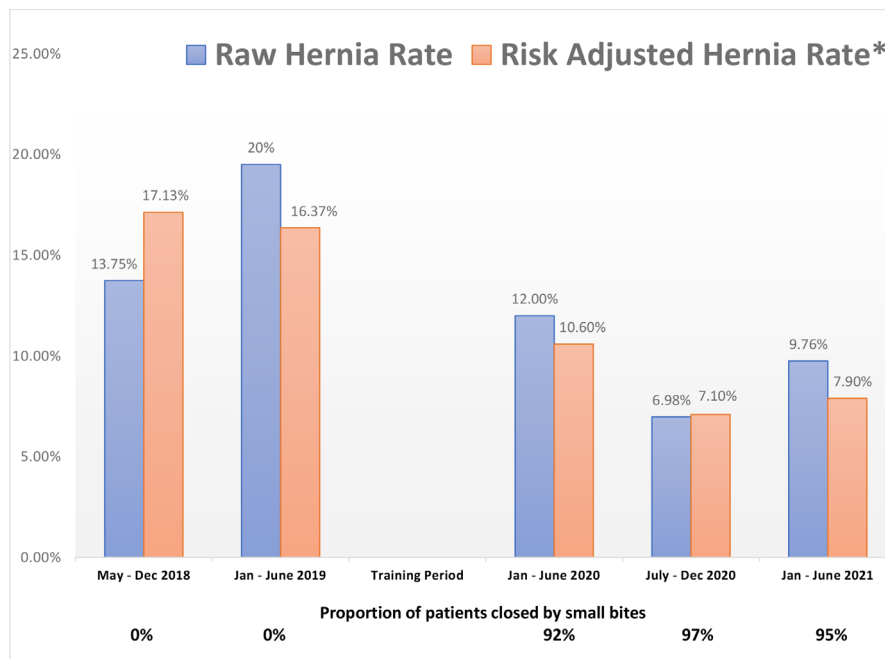
documentation of a hernia on the physical examination within the medical record. Independent variates of interest, including patient and peri-operative factors, were abstracted from the electronic medical record to a REDCap database. These included age, BMI, smoking history, pre-operative albumin, American Society of Anesthesia (ASA) physical status classification, a final diagnosis of malignancy, primary disease site, estimated blood loss, and whether patients received chemotherapy within 30 days of surgery. Of note, no patients in this cohort received hyperthermic intraperitoneal chemotherapy. A multivariate logistic regression model was constructed using clinically significant variables that had a plausible relation to the outcome of interest. To account for violations in model assumptions due to the non-independence of observations within clusters of the data (surgeon-level clustering), Huber-Eicker-White robust standard errors were used.

The mean marginal effect was derived from the logistical regression models to examine the magnitude of the effect of independent variables on hernia formation. This analysis examines the logistical regression model in a clinical context as it describes the predictive probability change of the outcome concerning discrete changes in covariates.<sup>16</sup> We also performed pairwise comparisons to identify subgroups of patients benefiting the most from small bite closure. This study is reported using the SQUIRE 2.0 guidelines.<sup>17</sup> STATA 17 was used for the statistical analyses. This article was exempt by the University of Michigan institutional review Board (HUM00190295).

## RESULTS

A total of 255 patients underwent surgery and had 1-year of follow-up, with 128 patients (50.2%) who underwent a large fascial closure, and 127 patients (49.8%) who underwent a small bite closure. The median age (range) for the cohort was 60.8 years (IQR 52–69 years). The most common disease sites were as follows: ovarian (n=163, 64%); uterine (n=56, 22%); cervical (n=14, 5.5%); other (n=22, 8.5%). The most common procedure performed was a total abdominal hysterectomy, bilateral salpingo-oophorectomy, with debulking and omentectomy. The median operative time was 180 min (IQR 146–226 min). The median length of stay in hospital was 3 days (IQR 2–4 days). The complication rate for the cohort was 47/255 (18.4%). The overall hernia rate was 12.5% (32/255 patients). Patients who developed hernias were more likely to have a higher BMI (33.1 vs 28.2, p=0.001). Characteristics of patients who developed hernias are shown in [Table 1](#).

In the large bite group, the hernia rate of 17.2% (22/128 patients) was significantly higher than the rate of 7.9% (10/127 patients) in the small bite group (p=0.025). The pre-intervention and post-intervention cohorts were evenly matched with no significant difference in age, BMI, estimated blood loss, pre-operative albumin, treatment with chemotherapy within 30-days (neoadjuvant and/or adjuvant), or smoking history (p>0.05). Characteristics of the two cohorts are shown in [Table 2](#). Hernia rates (raw and risk adjusted) at different time points are shown in [Figure 1](#). Post training period, a steady decrease in hernia rates was noted.



**Figure 1** Hernia rates over time in gynecologic oncology patients who underwent midline laparotomy. \*Adjusted for body mass index, adjuvant chemotherapy, smoking status, surgical site infections, albumin levels, age, and race.

In the logistical regression model, age, non-white race, smoking history, pre-operative albumin level, and surgery duration did not impact hernia formation. Obese patients and patients who received chemotherapy were more likely to develop hernias ( $p < 0.05$ ). Patients who underwent fascial closure with the small bite technique were less likely to develop hernias (OR=0.402, 95% CI 0.17 to 0.94) (Table 3: Logistical Regression analysis).

Based on our predictive model, although the hernia rates increase with an increasing BMI, the rate of increase is much lower for small bite closure than with large bite closure. For example, a patient with a BMI of 25 kg/m<sup>2</sup> receiving adjuvant chemotherapy has a risk reduction of 8.9% compared with a patient with a BMI of 40 kg/m<sup>2</sup>, where risk reduction is 12.3% with small bite closure compared with large bite closure. Figure 2 highlights the results of the marginal effects model that predicts hernia formation by

BMI and the closure type stratified by whether or not the patient received adjuvant chemotherapy.

## DISCUSSION

### Summary of Main Results

Our study showed that the small bite fascial closure technique reduces hernia formation in patients undergoing laparotomy for known or suspected gynecologic malignancy. These data are consistent with prior randomized trials and suggest that this technique is safe and should be considered the standard method of closure in this patient population.

### Results in the Context of Published literature

Updated in 2022, the European Hernia Society, in collaboration with the American Hernia Society, now endorses the continuous small bite suturing technique with slowly absorbable sutures.<sup>18</sup> The enhanced wound strength exhibited by closures using this technique is primarily attributed to the optimal distribution of tension across the wound. By minimizing the tension exerted per suture, the propensity for tissue tearing and the formation of loose points is effectively reduced. Moreover, this approach significantly mitigates complications associated with adversely altering blood supply to the tissue by preventing strangulation.<sup>19</sup>

Despite these recommendations and demonstrated advantages, adoption of the small bite closure technique for abdominal wall closure has been sluggish, with considerable variation still evident in practice.<sup>20,21</sup> The reasons underpinning this slow uptake primarily pertain to the perceived limitations presented in the initial randomized controlled trials. These apparent limitations encompass the lower BMI of patients enrolled in these trials, the increased operative time required for small bite closure, and questions regarding the strength of the small bite technique compared with traditional methods.

**Table 3** Logistical regression analysis assessing the impact of covariates on the risk of hernia formation

Characteristics	OR (95% CI)	P value
Age (years)	0.98 (0.95 to 1.00)	0.236
BMI kg/m <sup>2</sup>		
Overweight	6.57 (0.76 to 57.0)	0.088
Obese	<b>23.4 (3.09 to 177)</b>	<b>0.002</b>
Non-white race	0.32 (0.08 to 1.26)	0.103
Chemotherapy	<b>3.22 (1.22 to 8.51)</b>	<b>0.019</b>
Smoking history	1.64 (0.73 to 3.67)	0.228
Surgical site infection	1.01 (0.19 to 5.24)	0.984
Surgery duration	0.99 (0.99 to 1.00)	0.996
Small bite closure	<b>0.40 (0.17 to 0.94)</b>	<b>0.036</b>

BMI, body mass index.



The lack of data in obese patients has also been a significant barrier to the adoption of the small bite technique. Body mass index is a known risk factor for hernia formation. In a study of 455 patients with cervical cancer or endometrial cancer who underwent vertical incisions, patients with a BMI > 27 kg/m<sup>2</sup> were more likely to develop hernias at 1 year.<sup>10</sup> In the first randomized trial to evaluate a small bite technique, the mean BMI was 26 (overall range 25–27).<sup>22</sup> Similarly, in the STITCH trial, patients with a BMI > 30 kg/m<sup>2</sup> were excluded, and the median BMI for both cohorts was 24 (overall range 22–27).<sup>14</sup> The current study validates the findings that increasing BMI correlates with higher hernia rates. But our results highlight that the small bite closure is effective in obese patients, and the magnitude of the risk reduction increases as the BMI increases.

A recent editorial in *JAMA Surgery* described the challenges of adopting the STITCH trial in general surgery. In addition to the concerns of the BMI, the perceived increase in the operative time of the closure was recognized as another barrier to adoption (14 vs 10 min).<sup>21</sup> Although our study did not specifically record the closure time, the overall surgical time between the pre-change and post-change cohorts was similar. Adequate training and consistency of closure (92% of adherence in this study) can help with these concerns.

Most literature within the domain of general surgery has traditionally concentrated on non-cancer patients. However, a retrospective cohort study scrutinizing hernia formation in patients with ovarian cancer demonstrated a clear divergence; 15% of patients who underwent intraperitoneal chemotherapy manifested a hernia within the first year post-therapy, compared with 5% among patients who did not undergo similar treatment.<sup>5</sup> In another retrospective study involving 399 patients who underwent hemicolectomies due to colon cancer, adjuvant chemotherapy was significantly associated with the development of incisional hernias. Interestingly, that study also posited that patients with the 2–0 polydioxanone short stitch technique for wound closure and subsequent adjuvant

chemotherapy had a decreased hernia rate.<sup>23</sup> Our current study adds to this literature as the analysis finds that exposure to chemotherapy in the adjuvant setting is a significant risk factor for hernia formation. Finally, our predictive analysis notes that the hernia risk in obese patients receiving adjuvant therapy is the highest, and small bite closure is likely to reduce hernia risk in this cohort.

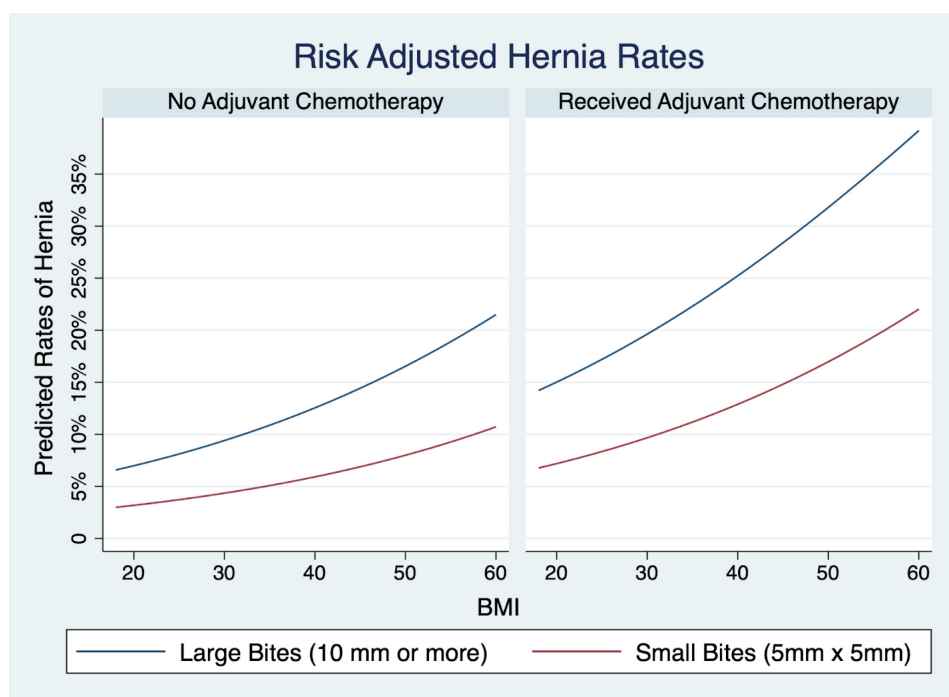
### Strengths and Limitations

Strengths of the study include standardization of the pre- and post-protocols for fascial closure. Additionally, the surgeons and patient populations did not significantly change for the pre- and post-cohorts, thus allowing a more direct comparison. There was division-wide acceptance of the protocol as an intervention that improves surgical quality.

This study has several limitations. It is a retrospective single-institution, quality-improvement project without a comparative arm—the non-randomized selection of patients has the potential to bias the results. Additionally, although surgeons were trained to use suture length to wound length of 4:1, no efforts were made to measure the length of the wound or the length of suture used due to constraints of time in the operating room. Hernia rates reported in this study are at 1-year follow-up, which is also a limitation. We believe that it is unlikely that the results will be dramatically different at 2-year and 5-year intervals. Finally, we used a composite of clinically detected and imaging studies to report hernia rates, which may be an under-representation of the real hernia burden.

### Implications for Practice and Future Research

This quality improvement project demonstrates that this technique is associated with hernia reduction in gynecologic oncology patients undergoing midline laparotomy. Moreover, this analysis shows that both obesity and adjuvant chemotherapy increase the risk of hernia formation and highlights the group of patients that may



**Figure 2** Risk adjusted hernia rate analysis of patients who underwent laparotomy. BMI, body mass index.

benefit the most from small bite closure. A prospective, randomized trial comparing fascial closure techniques would help further guide prevention strategies for incisional hernias in these high-risk patients.

## CONCLUSIONS

In conclusion, these data demonstrate that a small bite closure technique reduces hernia rates in gynecologic oncology patients undergoing laparotomy. Obesity is a known risk factor for hernia formation, and this is confirmed in the present study. Additionally, treatment with chemotherapy is also a risk factor for hernia development. The small bite closure technique was found to help to mitigate these risks.

X Shitanshu Uppal @uppal

**Contributors** Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work: all authors. Drafting/review/editing final manuscript: all authors. Final approval: all authors. Agree to be accountable for all materials: all authors. Guarantor: SU.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

**Competing interests** None declared.

**Patient consent for publication** Not applicable.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** All data relevant to the study are included in the article or uploaded as supplementary information.

## ORCID iD

Alli M Straubhar <http://orcid.org/0000-0001-6657-5016>

## REFERENCES

- Bosanquet DC, Ansell J, Abdelrahman T, et al. Systematic review and meta-regression of factors affecting midline incisional hernia rates: analysis of 14,618 patients. *PLoS One* 2015;10:e0138745.
- Höer J, Lawong G, Klinge U, et al. Factors influencing the development of incisional hernia. A retrospective study of 2,983 laparotomy patients over a period of 10 years. *Chirurg* 2002;73:474–80.
- Fink C, Baumann P, Wente MN, et al. Incisional hernia rate 3 years after midline laparotomy. *Br J Surg* 2014;101:51–4.
- Spencer RJ, Hayes KD, Rose S, et al. Risk factors for early-occurring and late-occurring incisional hernias after primary laparotomy for ovarian cancer. *Obstet Gynecol* 2015;125:407–13.
- Long KC, Levinson KL, Diaz JP, et al. Ventral hernia following primary laparotomy for ovarian, fallopian tube, and primary peritoneal cancers. *Gynecol Oncol* 2011;120:33–7.
- Pereira JA, Pera M, Grande L. Incidence of incisional hernia after open and laparoscopic colorectal cancer resection. *Cirugía Española (English Edition)* 2013;91:44–9.
- Sugerman HJ, Kellum JM, Reines HD, et al. Greater risk of Incisional hernia with morbidly obese than steroid-dependent patients and low recurrence with prefascial polypropylene mesh. *Am J Surg* 1996;171:80–4.
- Murray BW, CIPHER DJ, Pham T, et al. The impact of surgical site infection on the development of incisional hernia and small bowel obstruction in colorectal surgery. *Am J Surg* 2011;202:558–60.
- Llaguna OH, Avgerinos DV, Lugo JZ, et al. Incidence and risk factors for the development of incisional hernia following elective laparoscopic versus open colon resections. *Am J Surg* 2010;200:265–9.
- Franchi M, Ghezzi F, Buttarelli M, et al. Incisional hernia in gynecologic oncology patients: a 10-year study. *Obstet Gynecol* 2001;97:696–700.
- Kingsnorth A. The management of incisional hernia. *Ann R Coll Surg Engl* 2006;88:252–60.
- Colombo M, Maggioni A, Parma G, et al. A randomized comparison of continuous versus interrupted mass closure of midline incisions in patients with gynecologic cancer. *Obstet Gynecol* 1997;89:684–9.
- Heger P, Feißt M, Krisam J, et al. Hernia reduction following laparotomy using small stitch abdominal wall closure with and without mesh augmentation (the HULC trial): study protocol for a randomized controlled trial. *Trials* 2019;20:738.
- Deerenberg EB, Harlaar JJ, Steyerberg EW, et al. Small bites versus large bites for closure of abdominal midline incisions (STITCH): a double-blind, multicentre, randomised controlled trial. *Lancet* 2015;386:1254–60.
- Deerenberg EB, Henriksen NA, Antoniou GA, et al. Updated guideline for closure of abdominal wall incisions from the European and American Hernia Societies. *Br J Surg* 2022;109:1239–50.
- Norton EC, Dowd BE, Maciejewski ML. Marginal effects-quantifying the effect of changes in risk factors in logistic regression models. *JAMA* 2019;321:1304–5.
- Ogrinc G, Davies L, Goodman D, et al. SQUIRE 2.0 (standards for quality improvement reporting excellence): revised publication guidelines from a detailed consensus process. *BMJ Qual Saf* 2016;25:986–92.
- Söderbäck H, Masood A, Leo J, et al. Introduction of small stitch small bite technique: a retrospective long-term follow-up. *Langenbecks Arch Surg* 2022;407:2527–35.
- Harlaar JJ, van Ramshorst GH, Nieuwenhuizen J, et al. Small stitches with small suture distances increase laparotomy closure strength. *Am J Surg* 2009;198:392–5.
- Paulsen CB, Zetner D, Rosenberg J. Variation in abdominal wall closure techniques in lower transverse incisions: a nationwide survey across specialties. *Hernia* 2021;25:345–52.
- Yheulon C, Davis SS. Adopting the STITCH trial: crossing the chasm from publication to practice. *JAMA Surg* 2019;154:1087–8.
- Millbourn D, Cengiz Y, Israelsson LA. Effect of stitch length on wound complications after closure of midline incisions: a randomized controlled trial. *Arch Surg* 2009;144:1056–9.
- Santos DA, Zhang L, Do K-A, et al. Chemotherapy and abdominal wall closure technique increase the probability of postoperative ventral incisional hernia in patients with colon cancer. *Am Surg* 2023;89:98–107.