Primary Placement of Incisional Negative Pressure Wound Therapy at Time of Laparotomy for Gynecologic Malignancies

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Objective: Wound complications are an important cause of postoperative morbidity amongst patient with gynecologic malignancies. We evaluated whether the placement of prophylactic negative pressure wound therapy (NPWT) at the time of laparotomy for gynecologic cancer surgery reduces wound complication rates.

Methods: A retrospective analysis of patients undergoing laparotomy with primary wound closure performed by a gynecologic oncologist at a single academic institution over a 5-year study period was performed. Patients who had placement of prophylactic NPWT dressing were compared with patients with a standard closure. Postoperative outcomes were examined.

Results: A total of 230 patients were identified: 208 women received standard wound care, 22 received NPWT. Groups were similar in age, prevalence of diabetes, tobacco use, and number of previous abdominal procedures. Intraoperative factors including length of procedure and transfusion requirements were similar. Body mass index for patients receiving standard treatment was 30.67 compared with 41.29 for NPWT group ($P < 0.001$). Incidence of all wound complications was 19.7% for those receiving standard treatment versus 27.3% for NPWT group ($P = 0.40$). Length of hospital stay was similar between the 2 groups (5.25 vs 6.22 days, $P = 0.20$). There were 3 hospital readmissions for wound complications—none occurred in women with a prophylactic NPWT dressing.

Conclusions: Despite significantly higher obesity rates, patients with prophylactic NPWT dressing placement had similar rates of wound complications. Our findings suggest a potential therapeutic benefit in the use of prophylactic NPWT for the reduction of wound complications in this high-risk gynecologic oncology patient population.

Key Words: Closed incision, Negative pressure wound therapy, Surgical site infections, Laparotomy, Quality improvement

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An estimated 105,890 American women will be diagnosed with a primary gynecologic malignancy in 2016, of which a majority will require surgical management.[1] Despite advances in minimally invasive surgical practices and widespread adoption of these techniques, a significant proportion of these patients will require laparotomy in the treatment of disease. A balance between optimal surgical treatment and reduction of postoperative morbidity and mortality for these patients continue to challenge gynecologic oncologists.

Wound complications lead to extended hospital stays, additional outpatient and home services in the postoperative period and decreased quality of life for the patient. This category of adverse events related to surgical site includes wound separation, hematoma, seroma, and surgical site infection (SSI). Wound complications may affect as many as 34% of patients undergoing surgical management of gynecologic malignancy in the United States, with SSI occurring in 7% to 15% of this patient population.[2–5] An estimated cost increase of at least US

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$5447 can be attributed to SSI, as demonstrated in an analysis conducted among patients with endometrial cancer by Bakkum-Gamez et al.[6] Most worrisome for the gynecologic oncology patient is the adverse impact on overall survival of wound complications at their primary surgical procedure as evidenced in patients with ovarian cancer.[7,8]

Increased operative time, surgical complexity, estimated blood loss and medical comorbidities, and most significantly, obesity have been identified as independent factors predisposing patients to wound complications. Up to 60% of obese patients (body mass index [BMI] $\geq$ 30 kg/m^2) undergoing gynecologic cancer surgery via a vertical midline incisions have been reported to have postoperative wound complications.[5,8,9] The ongoing obesity epidemic in the United States coupled with the frequency of obesity in the gynecologic cancer population has led to interest in the development of interventions to prevent wound complications.

Negative pressure wound therapy (NPWT) was first described by Fleischmann et al in 1993 for the management of complex orthopedic fractures, and has since been adapted for use over closed surgical incisions in cardiothoracic, vascular, and other disciplines.[10–15] The use of subatmospheric pressures facilitates granulation tissue formation and angiogenesis with an overlaying adhesive barrier to promote wound contracture. This system reduces infection and time to healing while reducing tissue edema.[16] Investigations of the prophylactic use of NPWT over closed incisions suggest reduced incidence of SSI and wound complications in a general surgical patient population.[11–15,17,18]

We undertook this study to determine whether placement of NPWT at the time of laparotomy can decrease the rate of wound complications for patients undergoing surgery for gynecologic malignancy. A retrospective analysis of patients on a gynecologic cancer service undergoing laparotomy was undertaken to identify a role of NPWT in prevention of wound complications.

MATERIALS AND METHODS

All patients undergoing laparotomy for suspected or confirmed gynecologic malignancy by a trained gynecologic oncologist at a single academic institution in a 5-year study period were identified. Demographic factors, medical history, and social history were obtained through chart analysis. Anesthesia records, operative reports, and inpatient progress notes were reviewed. All incisions categorized per Centers for Disease Control (CDC) guidelines as class I (clean) or class II (clean-contaminated) were included.[19] Institutional review board approval for this study was obtained from the University of Maryland School of Medicine.

Preventative measures for SSI were standardized according to hospital protocol in accordance with CDC guidelines. Patients were shaven using surgical clippers when required and skin prepared with 2% chlorhexidine gluconate solution. Preoperative antibiotics were administered within 60 minutes of incision and readministered as indicated by surgical length or estimated blood loss. Postoperative antibiotic prophylaxis was not performed. Patients were selected for prophylactic incisional NPWT versus standard surgical dressing (SSD) based on assessment by attending gynecologic oncologist and presence of multiple risk factors for wound complications. All patients were considered candidates for NPWT. Individuals with morbid obesity, history of diabetes mellitus, current tobacco or chronic steroid use, and those with midline vertical incisions were considered at increased wound complication risk.

Negative pressure dressings were applied to clean, dry incision sites after closure with skin staples spaced 1.5 to 2 cm apart. A layer of nonadherent dressing (Adaptic; Johnson & Johnson, New Brunswick, NJ) was placed over the incision to minimize skin irritation while promoting removal of interstitial fluid and reapproximation of the wound and underlaying tissue. Sterile polyurethane foam was cut to cover the length of the incision and adhesive dressing was applied over both layers to maintain air seal. A vacuum assisted closure. system (Kinetic Concepts, Inc., San Antonio, TX) was applied and continuous negative pressure at 125 mm Hg was established. The NPWT dressings were continued between 2 and 5 days postoperatively. Patients receiving SSD received skin closure with subcuticular suture or skin staples. Incisions were covered with sterile gauze or Silverlon dressing (Argentum Medical, Geneva, IL) and maintained 2 days postoperatively.

The primary outcome of postoperative wound complication was identified through analysis of inpatient progress notes before discharge and postoperative follow-up for 90 days after the procedure. Patients who were lost to follow-up within 30 days of procedure were not included in data analysis. Surgical site complications were identified and characterized through chart review. Continuous data including were compared using *t* test and categorical data using χ^2 analysis.

RESULTS

A total of 230 women underwent laparotomy between October 2009 and March 2014 for treatment of gynecologic malignancy. Of these patients, 208 received SSD and 22 received NPWT.

Characteristics of the patients identified are described in Table 1. Groups were similar in age, prevalence of diabetes mellitus, tobacco use, and number of prior abdominal procedures. Patients treated with NPWT were significantly more likely to be obese than the patients treated without NPWT. Body mass index for patients receiving standard treatment was 30.67 kg/m^2 compared with 41.29 kg/m^2 in NPWT group ($P < 0.001$). The presence of malignancy as well as the stages and primary sites of cancer were similar between the groups (Table 2).

Intraoperative factors including duration of procedure were similar between SSD and NPWT groups, as well as need for transfusion within a 24-hour period of the surgical procedure (29.19% vs 27.27%; $P = 0.62$). Mean estimated blood loss varied between SSD and NPWT groups with the NPWT group having a higher mean blood loss (394 vs 656 mL; $P = 0.02$). The negative pressure wound therapy group was more likely than the SSD group to have skin staples for postoperative wound closure ($P < 0.001$).

The overall incidence of wound complications in our study population was 22.59%, a majority of which included

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TABLE 1. Patient demographics and intraoperative factors

	Control	NPWT Group	*P*
Age, y	53.2	54.9	0.28
Race (%)			
White	71 (34.13)	11 (50.0)	0.45
Black	107 (50.0)	9 (40.91)	—
Hispanic	14 (6.73)	2 (9.09)	—
Asian	14 (6.73)	0	—
Other	2 (0.10)	0	—
BMI, kg/m^2	30.67	41.29	<0.001
Diabetes (%)	35 (16.83)	7 (31.82)	0.08
Tobacco use (%)	30 (14.42)	5 (22.73)	0.30
Steroid use (%)	6 (2.88)	0	0.42
HIV + (%)	14 (6.73)	0	0.21
Previous abdominal surgery (%)	70 (33.65)	12 (54.54)	0.05
Operative factors			
Intraoperative EBL in mL (mean)	394	656	0.02
Midline vertical incision (vs transverse, %)	159 (76.44)	19 (86.36)	0.29
Length of surgery, min	137	138	0.46
Intraoperative bowel resection (%)	34 (16.34)	0	0.14
Transfusion (%)	61 (29.19)	6 (27.27)	0.62
Staple closure (%)	106 (51.0)	19 (86.36)	<0.001
Length of postoperative stay, d	5.25	6.22	0.20
Wound complication rate (%, all types)	41 (19.71)	6 (27.27)	0.40

EBL, estimated blood loss.

superficial wound separation and cellulitis. These factors accounted for 75% of all wound complications in both study groups. The wound complications experienced by patients included in this study are described in Table 3. Incidence of all postoperative wound complications was 19.71% for those receiving standard treatment versus 27.27% for NPWT group ($P = 0.40$). Superficial wound separation and cellulitis accounted for 77.78% of wound complications in the SSD group versus 57.13% of the NPWT group. A total of 16 patients were diagnosed with SSI within the 30 day postoperative period, one of which occurred in the NPWT group versus 15 in the SSD group (4.54% vs. 7.21%, $P = 0.53$).

The wound complication rate for patients with BMI less than 30 kg/m^2 with NPWT was 0% (n = 2) versus 18.69% with SSD (n = 20) in our study. Among the 119 obese patients in

TABLE 2. Cancer demographic data

	Control	NPWT Group	*P*
Cancer diagnosis (%)	131 (62.98)	17 (77.27)	0.17
Neoadjuvant chemotherapy (%)	16 (12.21)	1 (5.88)	0.54
Site of cancer (%)			
Cervix	19 (14.50)	0	0.16
Uterine corpus	53 (40.45)	9 (52.94)	0.12
Ovarian	54 (41.22)	6 (35.29)	0.57
Cancer stage*, n			
I	49 (37.40)	5 (29.41)	0.74
II	9 (6.87)	1 (5.88)	0.68
III	34 (25.95)	5 (29.41)	0.48
IV	23 (17.55)	5 (29.41)	0.19
Recurrent	16 (12.21)	1 (5.88)	0.39
Total, n	131	17	—

*Staging according to FIGO Guidelines.

TABLE 3. Wound complications per occurrence

	Control n, (%)	NPWT Group n, (%)	*P*
Wound complication	45 (21.63)	7 (31.82)	0.20
Wound separation	25 (55.56)	3 (42.85)	0.41
Cellulitis	10 (22.22)	1 (14.28)	0.54
Seroma	6 (13.33)	2 (28.57)	0.29
Hematoma	3 (6.67)	1 (14.28)	0.45
Enterocutaneous fistula	3 (6.67)	0	0.64
	208	22	

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our study with a mean BMI of 42.73 kg/m^2, 20 received NPWT with a wound complication rate of 30% (n = 6) compared with 29.29% with standard postoperative dressing (n = 29, P = 0.57). These findings were despite higher mean BMI of obese patients receiving NPWT compared with standard treatment group (43.66 kg/m^2 in NPWT group; 36.33 kg/m^2 in standard group, $P < 0.001$). Length of hospital stay was similar between the SSD and NPWT groups as well (5.25 vs 6.22 days, P = 0.20). There were 3 hospital readmissions for wound complications within 90 days of initial surgical procedure, none of which occurred in NPWT treatment group and were secondary to deep SSI.

DISCUSSION

Despite modern surgical technique and standardization of hospital infection control practices, wound complications remain among the most common causes of morbidity in the surgical patient population and contribute an average US $3.3 billion to annual health care costs in the United States.[20] Wound complication rates are as high as 40% to 60% for gynecologic oncology patients due to the high incidence of coexisting medical comorbidities—particularly obesity.[5,6] Prevention of wound complications as a quality improvement measure in an era of health care reform is tantamount to the safe and effective treatment of gynecologic malignancy.

This investigation was conducted in a patient population with a high risk of wound complications secondary to obesity, and in the instance of the NPWT treatment group, morbid obesity. Our results confirm the high rate of wound complication in a gynecologic cancer cohort of patients. Also confirmed are the high rates of obesity, diabetes, tobacco use and intraoperative factors including estimated blood loss and procedure length that predispose patients to postoperative wound complications. Of note, the 27.3% wound complication rate in the NPWT cohort (the majority of whom had a BMI >30 kg/m^2) is substantially lower than published wound complication rates in similar patient populations.[5,6]

Negative pressure wound therapy is a known effective treatment modality in the management of complex wound failures, including the setting of gynecologic cancers.[21,22] The adaptation of this technique to management of closed surgical incisions, however, has previously demonstrated mixed results. A Cochrane review including 785 participants among 9 randomized trials examining the use of NPWT for clean, closed incisions in trauma, orthopedic, and general surgery populations suggest that the effect of this intervention on reduction of SSI and wound dehiscence remains largely unclear.[23] A meta-analysis conducted by Semsarzadeh et al[24] demonstrated an odds ratio of 0.436 (confidence interval, 0.32 to 0.59; $P < 0.0001$) for development of SSI with closed incision NPWT versus SSD among 4631 patients undergoing thoracotomy, orthopedic surgery, cesarean delivery, laparotomy for high-energy trauma, colorectal cancer surgery, or hernia repair. A majority of these patients were at increased risk of wound complications due to presence of chronic tobacco use, obesity, or history of diabetes mellitus and therefore subject to selection bias.

There are several limitations to this study, most significantly the inherent bias of a retrospective analysis conducted at a single institution. Inclusion in the NPWT intervention group was at surgeon discretion with individuals deemed at higher risk of wound complications selected for closed-incision NPWT. This accounts for a statistically significant difference in BMI, estimated blood loss, and staple closure between groups. Selection bias would suggest an inherently higher rate of wound complications in the intervention group. The finding of similar wound complication rates between the 2 groups suggests that this increased risk in the intervention group was potentially ameliorated by use of NPWT in our small sample size. Not all patients included in the study had a final pathologic diagnosis of malignancy which may further limit interpretation and generalizability of study results. These patients were included in analysis to reflect current practice trends among gynecologic oncologists as consultation and combined surgical cases for benign pathology accounted for 37% of intraoperative consultations for gynecologic oncologists at a tertiary academic facility.[25]

A recently published decision tree analysis of a hypothetical cohort of women undergoing laparotomy for endometrial cancer conducted by Lewis et al[26] identified a potential cost benefit for NPWT in reduction of wound care if rate of wound complication is effectively reduced by 33%. Although most preoperative risk factors for wound complications were similar between groups in our study, women in our study population who received NPWT were far more likely to be obese that patients receiving standard wound care ($P < 0.0001$). Individuals in the intervention group additionally had higher intraoperative blood loss (394 vs 656 mL, $P = 0.02$) and were more likely to have incision closure with staples (86.4% vs 51%, $P < 0.0001$). The subsequent similar wound complication rates suggest that placement of NPWT at the time of laparotomy may have decreased the rate of wound complications. Despite multiple risk factors associated with a higher rate of wound complications in our patients treated with NPWT, the equivalent rates of wound disruption suggest a therapeutic benefit to incisional NPWT for the reduction of wound complications in a high-risk gynecologic oncology patient population. Further studies investigating the prospective use of closed-incision NPWT in a larger patient population undergoing laparotomy for management of gynecologic malignancies are warranted.

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