



Negative Pressure Wound Therapy to Decrease Surgical Nosocomial Events in Colorectal Resections

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1 Introduction

Surgical site infections (SSIs) cause significant morbidity to the colorectal surgery patient population. Infection rates are higher given the potential of contamination with gastrointestinal bacteria. SSIs are associated with further morbidity including prolonged hospital stay and higher risk for incisional hernias [1]. Rates of SSI in surgery range from 3 to 38%, with colorectal surgery at the higher end with reports of SSIs up to 45% [1–10]. The Surgical Care Improvement Project aimed to reduce SSI incidence and recommended a number of prophylactic measures including prophylactic IV antibiotics within 1 h of skin incision, appropriate antibiotic selection, discontinuing antibiotics within 24 h after surgery, appropriate hair clipping, perioperative normothermia, and strict perioperative glucose control in diabetic patients [11]. Other trials have demonstrated moderate improvements with the use of subcutaneous drains or wound protectors [1]. Laparoscopic surgery has been shown to decrease SSI incidence, but a large proportion of colorectal patients still require open laparotomies [1]. Therefore, despite all these prophylactic

measures, SSI remains to be a pertinent issue that needs to be addressed.

2 Negative Pressure Wound Therapy

Negative pressure wound therapy (NPWT) is used to accelerate wound healing in large open wounds or infected wounds by secondary intention. NPWT consists of a sterile sponge placed within the wound and attached to an external negative pressure device; the sterile sponge can also be placed outside a closed wound in incisional NPWT. The pressure applied causes a vacuum effect and removes fluid soaked in by the sponge. It also transmits mechanical forces to draw the surrounding tissue closer together. The sponge allows for equal transmission of pressure and force throughout the dressing. Currently, NPWT is indicated for open abdominal wounds, sternal wounds, soft tissue defects, skin graft fixation, fasciotomy wounds after compartment release, and burns [4, 12].

2.1 Mechanism of Action

There are a number of proposed mechanisms of action of NPWT. The first and most obvious benefit of this vacuum dressing is that it seals the incision in a sterile environment and prevents contamination [9, 13, 14]. The negative pressure

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allows consistent fluid removal, which decreases seroma/hematoma formation and pooling of fluid or blood that could become a culture medium for bacteria [9, 13]. Furthermore, studies have shown that the dressing and suction decreases lateral tissue tension and helps with tissue apposition [9, 14]. There is also preliminary evidence that NPWT increases blood flow to the tissue directly below [13]. This indicates better perfusion which stimulates healing and tissue granulation [13].

2.2 Incisional Negative Pressure Wound Therapy (iNPWT)

Incisional negative pressure wound therapy (iNPWT)—the utilization of NPWT as a mechanism to decrease SSI after wound closure is a relatively new concept. Incisional NPWT first emerged in the orthopedic trauma literature and was described by Gomoll et al. [12] in a case series of orthopedic patients at high risk for wound infection. In this series, they observed that iNPWT made a substantial difference in the postoperative wound care and zero out of 35 patients developed wound infections (follow-up 3 months). Since then, a number of surgeon investigators have also studied the effect of iNPWT on SSI in different patient populations. In 2013, Bonds et al. [1], Blackham et al. [3], and Matatov et al. [15] independently published three separate retrospective reviews analyzing the difference in SSI of patients who had standard dressing versus iNPWT. The patient population included general surgery patients undergoing open colectomies; surgical oncology patients undergoing laparotomy for colorectal, pancreatic, or peritoneal surface malignancies; and vascular patients with groin incisions [1, 3, 15]. All three studies demonstrated significantly decreased incidences of SSI in the iNPWT group (12.5% vs. 29.3%, $P = 0.036$; 6.7% vs. 19.5%, $P = 0.015$; 3% vs. 30%, $P = 0.0011$). In 2014, Chadi et al. [16] demonstrated significantly decreased SSI rate in patients who underwent abdominal perineal resection with iNPWT (15% vs. 41%, $P = 0.04$).

In 2016, Swanson et al. [17] conducted a systematic review and meta-analysis on the effect of iNPWT after ventral hernia repair (VHR). They identified five observational comparative studies that analyzed rates of SSI, wound dehiscence, seroma formation, and hernia recurrence in VHR patients with standard dressing vs. iNPWT. Not only was there a significantly lower incidence of SSI in the iNPWT group (11.8% vs. 27%, $P < 0.0001$), iNPWT was also associated with less wound dehiscence (4.3% vs. 19.7%, $P = 0.001$) and lower hernia recurrence (2.4% vs. 10.1%, $P = 0.01$) [17].

2.3 Current Evidence

There are only two published randomized controlled trials (RCT) looking at the effect of iNPWT, both published in 2017. The studies demonstrate opposing findings. O'Leary et al. [7] conducted an open-label RCT of adult patients undergoing either elective or emergency laparotomy. Wound classes I (clean), II (clean-contaminated), and III (contaminated) were included in this trial. They had a small number of participants—24 in the treatment group, 25 in the control group. Their primary outcome was 30-day SSI rate, which was significantly lower in the treatment group (8.3% vs. 32%, $P = 0.043$) [7]. Contrarily, Shen et al. [9] conducted a phase II RCT of surgical oncology patients undergoing laparotomy for bowel resection, pancreatectomy, or HIPEC for peritoneal surface malignancy. Only wound class II (clean-contaminated) patients were included. A total of 132 patients were analyzed in the treatment group and 133 in the placebo group. In this study, they found absolutely no difference in overall SSI, superficial SSI, deep SSI, or organ/space infection (15.9% vs. 15.8%, $P > 0.99$; 12.9% vs. 12.8%, $P > 0.99$; 3.0% vs. 3.0%, $P > 0.99$; 3.8% vs. 5.3%, $P = 0.77$) [9]. From this trial, the evidence does not support routine iNPWT, at least for class II wounds. There are notable differences between these two trials—the patient population, wound class, and power of study. Any of which may contribute to the difference in end results.

Table 1 Patient-related risk factors for wound complications [14]

Patient-related risk factors
Diabetes mellitus ^a
ASA score ≥ 3
Advanced age
Obesity BMI > 30 ^a
Active tobacco use ^a
Hypoalbuminemia
Corticosteroid usage
Active alcoholism
Male
Chronic renal insufficiency
Chronic obstructive pulmonary disease
Hematoma

^aIndicates most commonly noted risk factors seen in literature

There is one more RCT by Chadi et al. [18] that is currently undergoing. The patient population is colorectal surgery patients undergoing colorectal resections via laparotomy. Primary outcome is the incidence of SSI within 30 days of surgery. The study plans to recruit 300 patients total, 150 in the control group and 150 in the therapeutic group. Because all the patients are undergoing colorectal resection, the wound class is at least II. Results from this trial have yet to be published; however, it may help shed a new light on the recent contradicting results of the previous RCTs.

In 2017, Willy et al. [14] published international multidisciplinary consensus recommendations on iNPWT. Twelve international experts attended a multidisciplinary consensus meeting and developed consensus recommendations after detailed literature review. In this document, they identified 12 patient-related risk factors (Table 1) and 10 surgery-related risk factors (Table 2) for wound complications. Currently, there are no guidelines or rules designating how many risk factors are needed before one should consider using iNPWT. Both the authors and the international multidisciplinary consensus recommend that surgeons use their clinical judgment and experience. If a patient has one or more risk factors listed below, surgeons should consider using iNPWT as a prophylactic measure to decrease chances of wound complications. There has not been any cost-benefit analysis conducted on iNPWT to this date.

Table 2 Surgery-related risk factors for wound complications [14]

Surgery-related risk factors
High tension incision
Repeated incisions
Extensive undermining
Traumatized soft tissue
Edema
Contamination
Emergency procedure
Mechanically unfavorable site
Prolonged operation time ^a
Postsurgical radiation

^aIndicates most commonly noted risk factors seen in literature

2.4 Technique

Pre- and perioperative principles for preventing SSIs still apply. Patients should receive preoperative antibiotics within 1 h of surgery. Additional doses of antibiotics should be given if the operation extends beyond the half-life of the initial antibiotic. The abdomen should be thoroughly prepped with 2% chlorhexidine before initiation of surgery. The skin can be closed with staplers or subcutaneous absorbable sutures. The incision should be cleaned and dried thoroughly while maintaining sterile technique. At this point, if the surgeons are in the practice of double gloving, the authors recommend taking off the outer gloves and proceed with the clean inner gloves. A piece of Adaptic (Johnson & Johnson Wound Management) or any other nonadhesive but permeable dressing should be placed over the wound. This is to cover the skin directly underneath the sponge to prevent dermal irritation from the appliance. A piece of sponge should be cut to precisely just cover the incision, with approximately 1 in. of foam on either side of the incision. The sponge is then secured in place with occlusive adhesive dressing. It is important to ensure that the adhesive dressing is completely stuck to the skin and that there is no leak. This is why the skin must be dried well with sterile gauze before application. Finally, make a cut over the sponge and attach the suction tubing.

The vacuum can be set to either 75 or 125 mmHg to work effectively [1, 3, 12, 15–17, 19]. There has

not been evidence to suggest adverse effects from either setting. It is the authors' practice to set the vacuum to 125 mmHg to maximize the effect of iNPWT. If there is evidence of skin irritation, blistering, maceration, necrosis, or pain, then suction can be turned down to 75 mmHg or the dressing can be taken off. In studies analyzing complications of iNPWT, only two patients experienced blistering of the skin due to adhesives, which resolved after NPWT removal [19]. There were no reports of pain or discomfort related to iNPWT at continuously high pressures [20]. In fact, the iNPWT dressing lowered patient anxiety and decreased pain and discomfort of frequent dressing changes.

There have not been any studies to demonstrate the optimal length of time to leave the iNPWT dressing. Historically, it has been left on from a range of 4–7 days [1, 3, 10, 12, 15–17]. The authors' current practice is to leave the dressing on for 5 days or until the day of discharge, whichever is first.

Conclusions

Incisional NPWT is likely beneficial in decreasing SSI in high-risk colorectal surgery patients undergoing bowel resection. Patients with additional risk factors for wound infection such as diabetes, chronic smoking status, immunocompromised, and obesity should be considered for iNPWT. Overall, iNPWT is very low risk to the patient, and most evidence suggests lower rates of infection. Further investigations are warranted to assess the cost-benefit of iNPWT, optimal vacuum setting, and optimal duration of dressing placement.

References

1. Bonds AM, Novick TK, Dietert JB, Araghizadeh FY, Olson CH (2013) Incisional negative pressure wound therapy significantly reduces surgical site infection in open colorectal surgery. *Dis Colon Rectum* 56:1403–1408
2. Smith RL, Bohl JK, McElearney ST, Friel CM, Barclay MM, Sawyer RG, Foley EF (2004) Wound

- infection after elective colorectal resection. *Ann Surg* 239(5):599–607
3. Blackham AU, Farrah JP, TP MC, Schmidt BS, Shen P (2013) Prevention of surgical site infections in high-risk patients with laparotomy incisions using negative-pressure therapy. *Am J Surg* 205(6):647–654
4. Bovill E, Banwell PE, Teot L, Eriksson E, Song C, Mahoney J, Gustafsson R, Horch R, Deva A, Whitworth I, International Advisory Panel on Topical Negative Pressure (2008) Topical negative pressure wound therapy: a review of its role and guidelines for its use in the management of acute wounds. *Int Wound J* 5(4):511–529
5. Kobayashi M, Yasuhiro M, Yasuhiro I, Okita Y, Miki C, Kusunoki M (2008) Continuous follow-up of surgical site infections for 30 days after colorectal surgery. *World J Surg* 32:1142–1146
6. Konishi T, Watanabe T, Kishimoto J, Nagawa H (2006) Elective colon and rectal surgery differ in risk factors for wound infection. *Ann Surg* 244(5):758–763
7. O'Leary DP, Peirce C, Anglim B, Burton M, Concannon E, Carter M, Hickey K, Coffey JC (2017) Prophylactic negative pressure dressing use in closed laparotomy wounds following abdominal operations. *Ann Surg* 265(6):1082–1086
8. Pellino G, Sciaudone G, Selvaggi F, Canonico S (2015) Prophylactic negative pressure wound therapy in colorectal surgery. Effects on surgical site events: current status and call to action. *Updat Surg* 67(3):235–245
9. Shen P, Blackham AU, Lewis S, Clark CJ, Howerton R, Mogal HD, Dodson RM, Russell GB, Levine EA (2017) Phase II randomized trial of negative-pressure wound therapy to decrease surgical site infection in patients undergoing laparotomy for gastrointestinal, pancreatic, and peritoneal surface malignancies. *J Am Coll Surg* 224:726–737
10. Zaidi A, El-Masry S (2016) Closed-incision negative-pressure therapy in high-risk general surgery patients following laparotomy: a retrospective study. *Color Dis* 19:283–287
11. Rosenberger LH, Politano AD, Sawyer RG (2011) The surgical care improvement project and prevention of post-operative infection, including surgical site infection. *Surg Infect* 12(3):163–168
12. Gomoll AH, Lin A, Harris MB (2006) Incisional vacuum-assisted closure therapy. *J Orthop Trauma* 20(10):705–709
13. Horch RE (2015) Incisional negative pressure wound therapy for high risk wounds. *J Wound Care* 24(4):21–28
14. Willy C, Agarwal A, Andersen CA, Santis G, Gabriel A, Grauhan O, Guerra OM, Lipsky BA, Malas MB, Mathiesen LL, Singh DP, Reddy VS (2016) Closed incision negative pressure therapy: international multidisciplinary consensus recommendations. *Int Wound J* 14:385–398
15. Matatov T, Reddy KN, Doucet LD, Zhao CX, Zhang WW (2011) Experience with a new negative pressure incision management system in prevention of groin

- wound infection in vascular surgery patients. *J Vasc Surg* 57(3):791–795
16. Chadi S, Kidane B, Britto K, Brackstone M, Ott MC (2014) Incisional negative pressure wound therapy decreases the frequency of postoperative perineal surgical site infections: a cohort study. *Dis Colon Rectum* 57(8):999–1006
 17. Swanson EW, Cheng HT, Susarla SM, Lough DM, Kumar AR (2016) Does negative pressure wound therapy applied to closed incisions following ventral hernia repair prevent wound complications and hernia recurrence? A systematic review and meta-analysis. *Plast Surg (Oakv)* 24(2):113–118
 18. Chadi SA, Vogt KN, Knowles S, Murphy PB, Van Koughnett JA, Brackstone M, Ott MC (2015) Negative pressure wound therapy use to decrease surgical nosocomial events in colorectal resections (NEPTUNE): study protocol for a randomized controlled trial. *Trials* 16:322
 19. Saxena V, Hwang CW, Huang S, Eichbaum Q, Ingber D, Orgill DP (2004) Vacuum-assisted closure: micro-deformations of wounds and cell proliferation. *Plast Reconstr Surg* 114:1086–1096
 20. Scalise A, Calamita R, Tartaglione C, Pierangeli M, Bolletta E, Gioacchini M, Gesuita R, Di Benedetto G (2016) Improving wound healing and preventing surgical site complications of closed surgical incisions: a possible role of incisional negative pressure wound therapy. A systematic review of the literature. *Int Wound J* 13(6):1260–1281