Research Square

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A Modified Prophylactic Negative Pressure Wound Therapy Technique Reduces Perineal Wound Infection After Irradiated Abdominoperineal Resection

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Abstract

Background

Perineal wound complications after abdominoperineal resection (APR), particularly in irradiated patients, remain a challenging clinical problem. Prophylactic negative pressure wound therapy (NPWT) has been proposed to prevent these complications; however, stable application of NPWT to the perineal region is technically difficult, and evidence in high-risk irradiated cases remains limited.

Methods

This single-center retrospective cohort study included 40 patients who underwent APR after radiotherapy for anorectal cancer. We applied a newly modified NPWT technique that creates a small perineal tract for foam placement and positions the dressing away from the surrounding skin to achieve stable sealing and continuous negative pressure. Eighteen patients received prophylactic NPWT and 22 received conventional gauze dressing. The primary endpoint was perineal wound infection.

Results

Perineal wound infection occurred less frequently in the NPWT group than in controls (16.7% vs. 50.0%, p = 0.046). A similar trend was observed for pelvic abscess (5.6% vs. 31.8%, p = 0.051). There was no significant difference in the severity of perineal wound infection or reoperation rates between the groups. Postoperative hospital stay was longer in the control group. The modified technique enabled stable device application without treatment discontinuation.

Conclusions

Prophylactic NPWT with the newly modified technique is effective in preventing perineal wound infections after APR for anorectal cancer following radiotherapy. This approach may represent a practical preventive strategy for high-risk patients.

Introduction

Abdominoperineal resection (APR) is performed not only in patients with advanced anorectal cancer but also as a salvage procedure for locally recurrent cancer (LRC). APR is associated with a high morbidity rate, notably due to perineal wound infections, which occur in 39–57% of cases [1, 2]. Radiotherapy has also been identified as a risk factor for these infections [2–4]. Perineal wound infections significantly affect patient recovery by reducing quality of life, extending hospital stays, and escalating healthcare costs [5–11]. Therefore, the effective management of these complications is crucial for enhancing patient outcomes.

Several techniques for pelvic floor reconstruction, such as omentoplasty [6, 12] and myocutaneous flap [13–16], have been explored to treat perineal wound infections. However, the optimal method remains controversial. Omentoplasty is technically difficult to perform in patients with a history of omental resection or inflammatory contractions [12, 17]. Myocutaneous flaps require extended surgery times, higher costs, and specialized plastic surgery skills. Furthermore, myocutaneous flaps are associated with the risk of flap necrosis [16–19].

Prophylactic negative pressure wound therapy (NPWT) has emerged as a promising technique for preventing perineal wound infections, and previous studies have demonstrated its efficacy [7–9, 17–23]. However, the majority of previous studies involved a combination of benign and malignant diseases as background conditions. Furthermore, to the best of our knowledge, there is limited data on the effect of prophylactic NPWT on perineal wound infections after APR for anorectal cancer following radiotherapy, which presents a heightened risk of perineal wound infections.

This study aimed to determine the effectiveness of prophylactic NPWT in managing perineal wounds and reducing perineal wound infections in patients undergoing APR for anorectal cancers following radiotherapy.

Methods

Study Design and Setting

This retrospective cohort study was conducted at the Osaka International Cancer Center. We identified 40 patients who underwent APR following radiation therapy for anorectal cancer between July 1, 2005, and July 31, 2023. These procedures included initial surgery after preoperative radiotherapy, salvage surgery after radical radiotherapy, and repeat surgery for LRC. Patients who underwent perineal reconstruction with omentoplasty or myocutaneous flaps were excluded. A comparative analysis was performed between a group of patients managed with the use of the NPWT device for perineal wounds (NPWT group: 18 patients) and a group of patients managed with traditional gauze dressings (control group: 22 patients) (Fig. 1). Data were collected retrospectively through a comprehensive review of patient charts.

Surgical Techniques and Perioperative Management

The surgical approach for all patients involved conventional APR, excluding extralevator abdominoperineal excision to standardize the procedure. Before surgery, each patient underwent preoperative mechanical bowel preparation. All patients received cefmetazole intravenously at a dose of 1 g every 3 h during surgery and 1 g every 12 h postoperatively until postoperative day two, ensuring a consistent protocol. The surgeries were performed uniformly in the lithotomy position. Total mesorectal excision was performed in all patients. Subcutaneous closure of the perineal wound was achieved using simple interrupted sutures. The skin in the control group was closed using simple interrupted sutures.

Conversely, in the NPWT group, the NPWT device was applied to the perineal wound immediately after surgery, and negative pressure management was initiated. Both groups were operated on by professional surgeons with board certifications in gastrointestinal surgery. Surgeries in the NPWT group were exclusively performed by two surgeons in all patients. Surgeries in the control group were performed by other surgeons. To manage potential postoperative fluid accumulation, a closed-suction drain was inserted into the pelvic floor through the abdomen.

Prophylactic NPWT with the Newly Modified Technique

The use of prophylactic NPWT for managing postoperative perineal wound was initiated in 2015. In the NPWT group, a portion of the wound on the dorsal side was intentionally left open, creating a 3 cm tract for the insertion of polyurethane foam. The foam was carefully positioned to facilitate negative pressure therapy without direct skin contact. To achieve this, film tape was applied over the perineal wound and extended to the thigh area, avoiding the section where the foam was inserted. An additional layer of film tape was then applied over the foam, securing it in place, and enhancing the seal to optimize the therapeutic effect of NPWT (Fig. 2).

In this study, we used ACTIV.A.C. Therapy System (KCI, San Antonio, Texas, USA) as the NPWT device. The negative pressure level was set at a target value of 75 mmHg, based on previous experimental and clinical studies indicating that lower-pressure NPWT may be sufficient for closed surgical wounds with dead space and may reduce pain and skin-related complications compared with the conventional 125 mmHg setting [8, 17–22].

In principle, the pressure was maintained at 75 mmHg in all patients; however, minor adjustments within the range of 75–150 mmHg were permitted at the surgeon's discretion when necessary to accommodate individual patient factors such as sealing difficulty, discomfort, or excessive exudate. Nevertheless, the majority of patients were managed at 75 mmHg. The device was applied immediately after the surgery. The duration of NPWT was determined based on clinical needs, with a median duration of 7.5 days (range, 5–27 days).

To monitor the effectiveness of NPWT and assess fluid accumulation, computed tomography (CT) was conducted on all patients between 5 and 7 days after the surgery. These scans targeted the pelvic area and ischiorectal fossa. When no fluid accumulation was detected, the NPWT device was removed. If fluid accumulation was still evident, the device was replaced to continue treatment. Except for one instance, CT evaluation demonstrated absence of fluid accumulation in most cases, permitting removal of the NPWT device. Following removal of the device, the tract site was managed as an open wound. If perineal wound infection occurred in the NPWT group, NPWT was not re-applied, and standard wound management was administered instead.

Throughout the course of treatment, there were no instances in which NPWT had to be discontinued because of issues with maintaining negative pressure or equipment malfunction. Overall, the treatment

was well tolerated, with no reports of discontinuation owing to pain or skin problems.

Diagnosis of Perineal Wound Infection and Pelvic Abscess

Perineal wound infection was defined as an infection involving the perineal wound skin or the ischiorectal fossa. The diagnostic criteria were established based on the Centers for Disease Control and Prevention guidelines for surgical site infections (SSI) [23].

Pelvic abscess was evaluated as an exploratory endpoint and was defined as a localized infection within the dead pelvic space. The severity of complications, including perineal wound infection and pelvic abscess, was assessed using the Clavien–Dindo classification system [24].

Statistical Analysis

We conducted a comparative analysis of the patient characteristics and surgical outcomes between the NPWT and control groups. Continuous variables were analyzed using the Mann–Whitney U test for non-normally distributed data and the Welch's t-test for normally distributed data. Categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate. All statistical analyses were performed using Easy R (EZR; version 1.68; Saitama Medical Center, Jichi Medical University, Saitama, Japan), a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at $p < 0.05$, indicating a meaningful difference between the groups.

Results

Patient Characteristics and Tumor Characteristics

The median age of patients in the NPWT group was significantly higher than that in the control group ($p = 0.035$). No significant differences were observed between the groups in sex, body mass index, American Society of Anesthesiologists Physical Status (ASA-PS) score, smoking history, nutritional status (serum albumin levels and prognostic nutritional index), or history of comorbidities. Tumor characteristics were also comparable between the groups. A summary of patient and tumor characteristics is provided in Table 1.

Table 1
Baseline patient and perioperative characteristics in the control and NPWT groups

Patient characteristics	Control (n = 22)	NPWT (n = 18)	p value
Age (y), median (range)	60 (45–87)	69 (34–84)	0.04
Sex			0.76
Male	11 (50.0)	10 (55.6)	
Female	11 (50.0)	8 (44.4)	
BMI (kg/m^2), mean ± SD	22.2 ± 4.1	22.0 ± 3.7	0.86
ASA-PS			0.22
1	3 (13.6)	0 (0.0)	
2	18 (81.8)	15 (83.3)	
3	1 (4.5)	3 (16.7)	
Albumin (mg/dL), mean ± SD	4.0 ± 0.5	3.9 ± 0.4	0.09
PNI, mean ± SD	41.5 ± 5.8	41.0 ± 6.2	0.09
History of smoking within 4 weeks	0 (0.0)	3 (16.7)	0.08
Cardiovascular disease	1 (4.5)	2 (11.1)	0.58
Diabetes mellitus	1 (4.5)	2 (11.1)	0.58
Oncologic factor			
pT			0.48
0–2	7 (31.8)	3 (20.0)	
3–4	15 (68.2)	12 (80.0)	
pStage			0.73
0–2	8 (36.4)	7 (46.7)	
3–4	14 (63.6)	8 (53.3)	
Radiation therapy			
Purpose of RT			
Preoperative RT for primary cancer	20 (90.9)	13 (72.2)	0.14
Preoperative RT for LRC	0 (0.0)	3 (16.7)	
Radical RT	2 (9.0)	2 (11.1)	

Patient characteristics	Control (n = 22)	NPWT (n = 18)	p value
Types of RT			
RT	5 (22.7)	1 (5.6)	0.20
CRT	17 (77.3)	17 (94.4)	
Radiation dose			0.76
≤50 Gy	10 (45.5)	7 (38.9)	
>50 Gy	12 (54.5)	11 (61.1)	
Interval from RT to surgery (week)	7.0 (1–112)	7.5 (1–226)	0.58
Surgical factor			
Surgical procedure			0.06
MIS	9 (40.9)	13 (72.2)	
Open	13 (59.1)	5 (27.8)	
Operation time (min), mean ± SD	495 ± 298	441 ± 119	0.47
Blood loss (mL), median (range)	908 (30–2420)	145 (0–6880)	0.06
Additional surgical procedures			
LLND	13 (59.1)	5 (27.8)	0.06
Combined resection	8 (36.4)	3 (16.7)	0.29
Transfusion	10 (47.6)	2 (11.1)	0.02
Postoperative therapy			
AC	8 (38.1)	4 (26.7)	0.72
Interval from surgery to AC (day), median (range)	55 (34–108)	45 (39–64)	0.71

Data are presented as n (%) unless otherwise indicated.

NPWT, negative pressure wound therapy; BMI, body mass index; ASA, American Society of Anaesthesiologists-Physical Status; PNI, prognostic nutritional index; RT, radiation therapy; LRC, locally recurrent cancer; CRT, chemoradiotherapy; MIS, minimally invasive surgery; LLND, lateral lymph node dissection; AC, adjuvant chemotherapy

Radiation Therapy and Surgical Factors

More than half of the patients in both groups received a radiation dose of 50.4 Gy/28 Fr. The interval between radiation therapy and surgery did not differ significantly between the groups. The rates of open surgery and lateral lymph node dissection were higher in the control group. There was no significant difference in operation time between the groups. Blood loss tended to be higher in the control group (p = 0.06), and the rate of blood transfusion was significantly higher in the control group (11.1% vs. 47.6%, p = 0.02). Details of radiation therapy and surgical factors are summarized in Table 1.

Perioperative outcomes

The incidence of perineal wound infection was significantly lower in the NPWT group (16.7% vs. 50.0%, p = 0.046), while a similar trend was observed for pelvic abscess (5.6% vs. 31.8%, p = 0.051). However, there was no significant difference in the severity of perineal wound infections between the groups. Reoperation rates did not differ significantly between the two groups. The length of postoperative hospital stay tends to be longer in the control group. Postoperative outcomes are summarized in Table 2.

Table 2
Postoperative outcomes in the control and NPWT groups

Surgical Outcomes	Control (n = 22)	NPWT (n = 18)	p value
Perineal wound infection	11 (50.0)	3 (16.7)	0.046
Pelvic abscess	7 (31.8)	1 (5.6)	0.05
Severity of perineal wound infection			
Grade 2	2 (18.2)	0 (0.0)	1.00
Grade 3	9 (81.8)	3 (100.0)	
Ileus	1 (4.5)	4 (22.2)	0.17
Other complication	5 (22.7)	3 (16.7)	0.71
Reoperation	3 (14.3)	1 (6.7)	0.63
Postoperative hospital stay (day), median (range)	30.5 (10–159)	19.5 (12–91)	0.05

NPWT, negative pressure wound therapy

Discussion

This study demonstrates that our modified NPWT application technique enables stable and reproducible negative pressure management of the perineal wound after APR following radiotherapy and is associated with a lower incidence of wound infection. To our knowledge, this is the first comparative study that focused specifically on anorectal cancer cases after radiotherapy. Furthermore, we believe that these results are attributed to our newly modified NPWT device application technique.

Advancements in the understanding of the physiology of wound healing [25], research on SSI risk factor analysis [10] and the development of SSI prevention bundles [26–30] have significantly improved SSI incidence. However, perineal wound infections following APR remain a significant challenge. Perineal wounds are particularly susceptible due to the extensive dead space formed after surgery, which foster fluid accumulation and bacterial overgrowth [1, 17, 18]. Furthermore, the rigidity of the structures around the pelvis increases wound tension after suturing the wound [6, 7, 18]. It has been reported that NPWT may have been effective for closed surgical wounds with dead space [17–22] following APR.

Many studies have attempted to identify the risk factors for perineal wound infections following APR. Artioukh et al. [3] identified multiple risk factors for impaired perineal wound healing after APR using a multivariate analysis. Radiotherapy emerged as a significant risk factor in the multivariate analysis of unhealed perineal wounds. Kelli et al. [4] demonstrated that preoperative radiotherapy more than doubles the risk of perineal wound complications. The pathophysiology underlying this increased risk with radiotherapy appears to be associated with progressive occlusive vasculitis and fibrosis in adjacent tissues, which impair their capacity to fill the substantial defects created by the surgical procedure [5]. These reports indicate that preventing perineal wound infections after APR following radiotherapy is particularly important. Wiegering et al. [21] reported their experience with NPWT in treating perineal wounds after CRT. However, this study was a study with only six cases and did not prove its effectiveness. Our findings highlight the potential of NPWT as a viable treatment option for high-risk patients.

This study showed that prophylactic NPWT not only reduced incisional infections but also hinted at a decrease in pelvic abscesses. For perineal wounds, only a few studies have detailed the distinction and analysis of SSI into superficial areas and the ischiorectal fossa versus pelvic area categories. Sami et al. reported no variance in the rate of intra-abdominal abscesses with prophylactic NPWT [20]. The variance noted in our study could stem from our modified technique of intentionally leaving part of the perineal wound open, thereby creating a tract. This alteration likely enhances the removal of exudates, indicating a possible advantage for managing deep infections more effectively.

The technical difficulties associated with applying NPWT device to perineal wounds, especially in female patients, have been discussed. Tellu et al. [22] reported that effectively sealing the device at the vaginal introitus to prevent leakage is a major challenge. These technical difficulties may be related to the uncertainty regarding the effectiveness of NPWT for perineal wounds. Assar et al. [18] reported that the majority of perineal wound complications with closed-incision negative pressure therapy occurred in females (6 of 8 patients). In contrast, our modified technique, which keeps the foam away from the vaginal area, establishes a method for stable negative pressure management, regardless of sex. In this study, NPWT was applied in seven female patients, with only one case of ineffective negative pressure due to film detachment caused by urine. This result is favorable compared with those of previous studies. In addition, the selection of a standardized negative pressure level was another practical consideration in applying NPWT to the perineal region. Although a pressure of 75 mmHg was used as the institutional standard based on previous literature and clinical feasibility, minor adjustments were

occasionally required because of difficulties in maintaining an airtight seal, particularly when film detachment occurred. This variation reflects the technical challenges inherent to the perineal anatomy rather than differences in therapeutic intention, and the majority of patients were effectively treated at the target pressure of 75 mmHg. This approach supports real-world applicability while maintaining methodological reproducibility, which may be more clinically relevant than a rigid pressure protocol.

Another advantage of our newly modified NPWT method is the lack of pain. A review of the literature on patient experiences reported pain associated with the use of NPWT [6, 8, 31]. However, in our study, there were no cases in which NPWT was discontinued because of pain. Our method minimizes this issue by ensuring that the foam contacts the body solely at the tract site, avoiding extensive contact between the skin and area under negative pressure. This technique reduces patient discomfort and pain, enabling more stable and continuous use of NPWT.

This study has several limitations. First, owing to the small sample size, we could not completely rule out the involvement of confounding factors. Notably, to date, this trial is the largest to investigate the application of NPWT for perineal wounds after APR following radiation therapy, and it successfully detected statistical differences despite a small sample size, which should be sufficiently acknowledged. Second, the cost-effectiveness of NPWT was not thoroughly examined. The use of NPWT may reduce the total cost of managing perineal wounds by preventing infections. However, it is important to note that the initial cost of NPWT is higher than that of traditional dressings. In future studies, we plan to evaluate its cost-effectiveness.

Conclusion

This study suggests that prophylactic NPWT with our newly modified technique is effective in preventing perineal wound infections after APR for anorectal cancer following radiotherapy. Furthermore, prophylactic NPWT can contribute to reducing pelvic abscesses.

Declarations

Conflict of interest

The authors have no relevant financial or non-financial interests to disclose.

Ethical approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Osaka International Cancer Institute (approval no. 18033).

Consent to participate

The requirement for informed consent was waived by the Institutional Review Board of Osaka International Cancer Institute because of the retrospective nature of the study and the use of anonymized data.

Consent to publish

Not applicable as the manuscript does not contain any identifiable individual data.

FUNDING INFORMATION

The study did not receive any form of funding.

Author Contribution

T.S. designed the study, collected and analyzed the data, and wrote the main manuscript text. R.M., M.K., and T.Su. contributed to data collection. M.Y., J.N., Y.K., and M.O. contributed to study design and data interpretation. T.S., M.Y., R.M., and M.K. prepared Figure 1; T.S., M.Y., T.Su., M.K., and N.M. prepared Figure 2; T.S., M.Y., Y.K., M.O., and N.M. prepared Table 1; and T.S., M.Y., J.N., and Y.K. prepared Table 2. All authors reviewed the manuscript.

Data Availability

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Figures

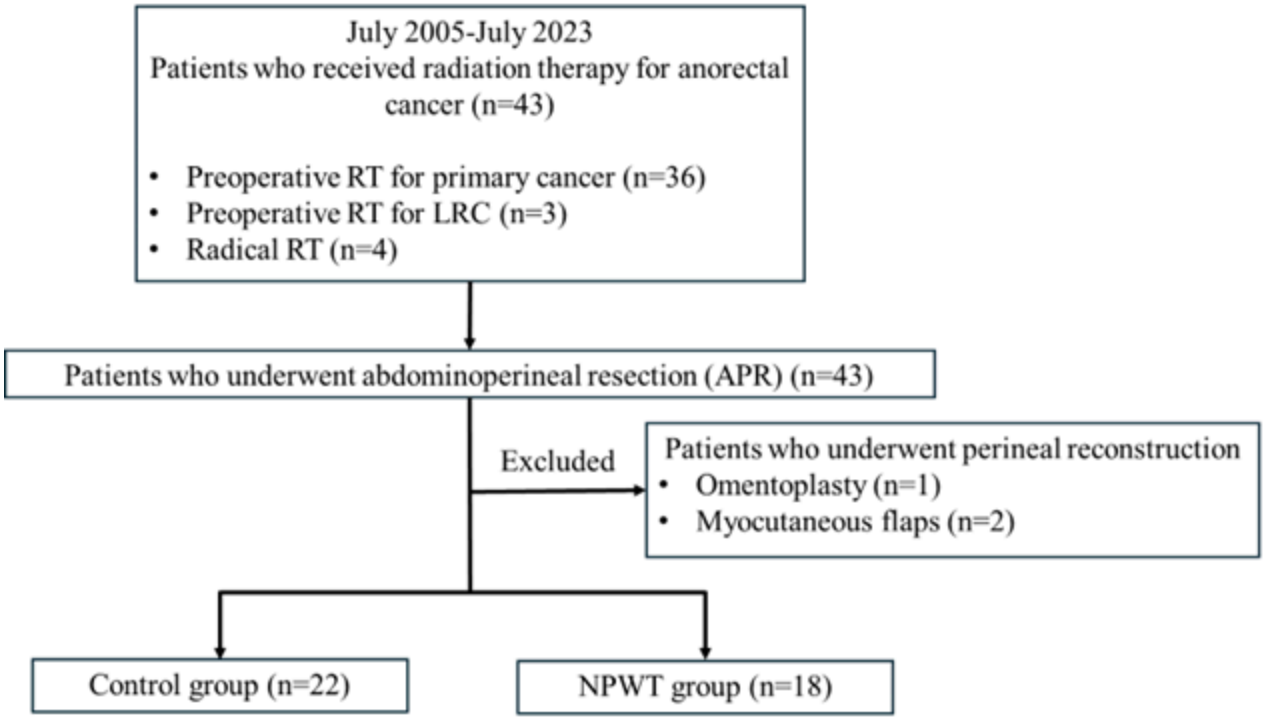


Figure 1

Study flow diagram

RT, radiation therapy; LRC, locally recurrent cancer; APR, abdominoperineal resection

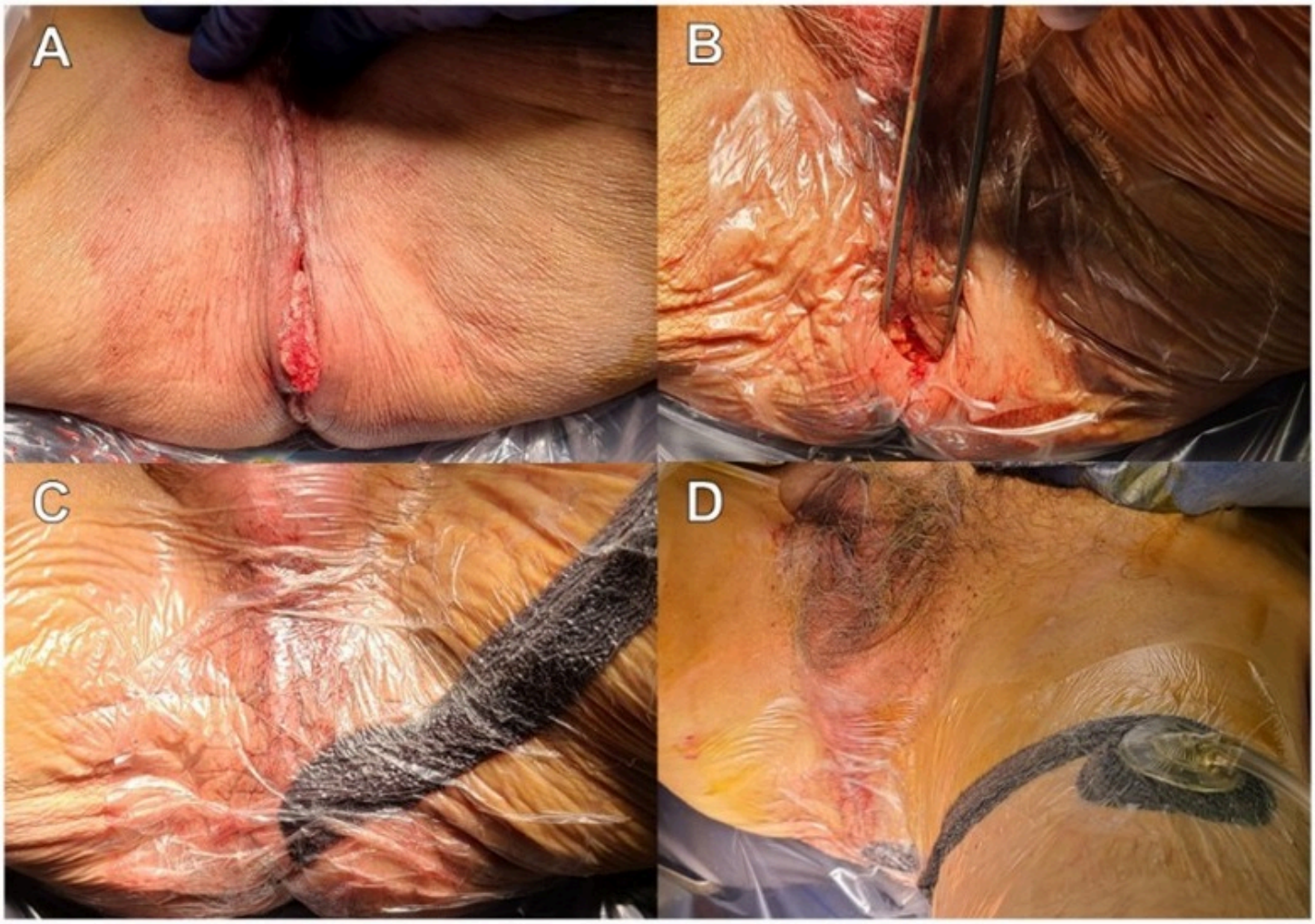


Figure 2

NPWT setup for perineal wounds with newly modified technique

A portion of the wound was intentionally left open, creating a 3 cm tract for the insertion of polyurethane foam (A). Around the wound, except for the open area, a base film was applied, extending to the thigh (B). The foam was then placed within the tract and along the thigh on top of the base film (C). The sealing film covers the foam to complete the NPWT setup (D).

NPWT, negative pressure wound therapy