Does Negative-Pressure Wound Therapy for the Open Abdomen Benefit the Patient? A Retrospective Cohort Study

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ABSTRACT

OBJECTIVE: Negative-pressure wound therapy (NPWT) is the most modern and sophisticated method of temporary abdominal closure. The aim of the study was to determine the significant predictors for mortality in patients with NPWT.

SETTING: University Clinical Centre Maribor, Slovenia

MATERIALS AND METHODS: The authors performed a retrospective cohort study of all patients treated with NPWT between January 1, 2011, and December 31, 2014.

RESULTS: In the univariate analysis, the type of wound closure, more than 7 NPWT changes, the total days with NPWT, and time to wound closure were significantly associated with death of the patient. In the multivariate analysis, only the number of more than 7 NPWT changes was found as a significant predictor for death ($P = .038$).

CONCLUSIONS: Negative-pressure wound therapy is a method of choice for the treatment of open abdomen if there is a clear indication. However, clinicians should try all measures to remove the NPWT system and close the abdomen as soon as possible because prolonged use is associated with significantly higher mortality.

KEYWORDS: general surgery, mortality, negative-pressure wound therapy, open abdomen

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INTRODUCTION

The open abdomen (OA) is a serious condition that demands extensive clinical experience and knowledge. It is a complication of conditions such as severe abdominal trauma, abdominal sepsis, and intra-abdominal hypertension.[1] Treatment of OA, also called laparotomy, is challenging for the surgeon and the patient. Symptoms can include fluid loss, infection, perforation of the hollow viscera, and organ dysfunction, and it can cause death. Protracted abdominal decompression can induce intestinal adhesions, fascia retraction, loss of abdominal domain, formation of enteric fistulas, and the development of incision hernias, which require subsequent difficult abdominal wall reconstruction.[2,3]

One of the keystones in the development of OA treatment is the principle of "damage control surgery," which is one of the major advances in surgical techniques over the past 30 years. The principle is to restore normal physiology rather than normal anatomy in the unstable patient. The primary strategy is to surgically control hemorrhage and contamination and stabilize potentially fatal problems at first-look laparotomy, with secondary correction of abnormal physiological parameters followed by scheduled definitive surgery.[4]

A wide range of temporary abdominal closure (TAC) techniques are available to manage OA. The goals of TAC include protecting the viscera, preventing visceral adhesions, removing intra-abdominal fluid, and preventing fascial retraction.[5] The first articles on managing OA were published in the early 1970s, and there has been a continuous evolution in the quality and quantity of treatment techniques. Among the variety of TAC techniques, each with its own advantages and disadvantages, are the zipper, Bogota bag, meshes, Wittmann patch, and different systems with negative pressure.[6]

In the past decade, negative-pressure wound therapy (NPWT) has been recognized as a valid method of TAC. Although evidence for NPWT is emerging at an increasing rate, a consensus on how and when to use NPWT in the OA is lacking.[7]

Mortality rate after NPWT treatment is quite high. In septic nontraumatic patients, overall mortality may exceed 40%, and it is greatly influenced by the underlying medical condition.[8] In fact, some considerations indicate that TAC techniques and NPWT do not help patients but rather only prolong their suffering and inevitable death. But is this an accurate assessment?

The primary goal of this study was to evaluate risk factors for mortality after NPWT for OA.

MATERIALS AND METHODS

The authors performed a retrospective cohort study of a prospective database of all patients treated with NPWT for OA between 1 January 1, 2011, and December 31, 2014, at the University Clinical Centre Maribor, Slovenia. They followed protocols for all surgical patients, and those were searched for a diagnosis of OA and

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NPWT. The authors also crosschecked the hospital's computer database to be sure none of the patients were missed. The patients were followed from introduction of NPWT until discharge from the hospital or death. The authors were able to follow up on all of their patients.

In treating all of their patients, the authors used the RENASYS Open Abdominal Solution from Smith & Nephew, Fort Worth, Texas. The patient's physical status was assessed using the American Society of Anesthesiologists (ASA) score. The authors aimed to determine the significant predictors for mortality in patients with NPWT. Therefore, age, sex, the type of primary operation, OA classification after Björck et al,[9] time to first NPWT application, number of NPWT changes, days of NPWT, and type of wound closure were compared between survivors and deceased patients after NPWT therapy.

The authors used the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement as a guideline for reporting in their study.[10]

Statistical Analysis

Continuous data are expressed as mean ± SD, whereas categorical variables are given as percentages. The Shapiro-Wilk test was used to determine whether the continuous data were normally distributed. Comparisons of continuous variables were performed with Student *t* tests for parametric data and Mann–Whitney *U* tests for nonparametric data. The χ^2 tests were used for comparisons of discrete variables. The outcome variable was the survival or death of the patient. Significant predictors from univariate analysis were included in the multivariate analysis. To determine significant predictors for death, the binary logistic regression model was used. The variables were included in forward stepwise fashion. In the final model, only significant predictors were used. The limit of significance was defined as $P < .05$. For statistical analysis, PASW Statistics 18 (SPSS Inc, Chicago, Illinois) for Windows 7 was used.

RESULTS

Between January 1, 2010, and December 31, 2014, the authors operated on 52 patients and used NPWT for OA treatment. All patients were confirmed eligible, included in the study, and followed up until the end of the study. The mean age of patients was 67 years (25–85 years).

According to ASA classification, most of the patients were in the ASA II group. Table 1 shows the distribution of patients according to ASA classification. A total of 27 patients were treated with NPWT after an elective operation with complications, and 25 after emergency surgery. The most common indication for NPWT treatment after emergency surgery was peritonitis after perforation of the large or small bowel (Table 2).

Table 1.

DISTRIBUTION OF PATIENTS ACCORDING TO ASA CLASSIFICATION

ASA	No. of Patients
I	8
II	35
III	8
IV	1

Abbreviation: ASA, American Society of Anesthesiologists.

In elective surgery, the most common indications for NPWT were complications after colorectal surgery, pancreatic surgery, bile duct surgery, and gastric surgery. The Björck classification was used to identify wound types (Table 3).[9]

In 20 cases, the NPWT system was applied with the first surgery; in all other cases, several attempts were performed to manage the patient with other measurements. In 7 patients, NPWT was used at the second surgery, in 14 patients at the third surgery, and in 10 patients at the fourth or later surgery. The average number of NPWT system changes before closing was 4. In 5 patients, the NPWT system was changed 10 or more times. At each system change, the negative-pressure pump was detached, and the patient's dressing was changed.

Mortality during the first 30 days postoperatively was 29%; overall mortality was 50%. The most common cause of death in the first 30 days was sepsis with multiorganic failure. Other causes included acute myocardial infarction and respiratory failure. As shown in Table 3, 41% of patients died in Björck 1A group, 42% in Björck 1B, 33% in Björck 2A group, 55% in Björck 2B, 85% in Björck 3, and 75% in Björck 4 group (Table 3). The ASA score was not significantly associated with mortality.

In the survivor group, the abdomen was most commonly closed only with skin adaptation because of lateral abdominal wall retraction (42%). These patients were discharged with a ventral incisional hernia. The second most common type of wound closure in the group of surviving patients was the closure of all layers with interrupted sutures (27%). The deceased group of patients was almost exclusively treated with NPWT until their demise (73%). Only 19% of those patients had their laparotomy closed with skin suture before their death.

In the univariate analysis, the type of wound closure, more than 7 NPWT system changes, and time to wound closure were significantly associated with death. The difference in the number of surgeries before application of NPWT did not have any influence on postoperative survival. The distribution of variables between groups is shown in Table 4.

As the authors analyzed the mortality according to the duration and number of NPWT system changes, they discovered a

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Table 2.

INDICATIONS FOR NPWT TREATMENT AFTER EMERGENCY SURGERY

Diagnosis	No. of Patients
Perforation of large bowel	9
Perforation of small bowel	5
Pancreatitis with complications	3
Adhesive bowel obstruction	3
Other	3

Abbreviation: NPWT, negative-pressure wound therapy.

sudden increase in mortality after 15 days and after 7 NPWT changes (Table 5). Therefore, the authors compared whether more than 7 system changes had a direct impact on mortality. In the univariate analysis, more than 7 NPWT system changes were significantly associated with death of the patient ($P = .034$). Patients with more than 7 NPWT system changes also had a significantly longer duration of NPWT treatment (57.9 ± 42 days vs 11.6 ± 10 days; $P = .001$), were mostly male ($P = .028$), and had higher grade levels according to the Björck classification ($P = .013$). The mortality in the group of patients with more than 7 NPWT system changes was 73%, whereas patients with a shorter duration of NPWT had a 27% mortality rate ($P = .034$).

Multivariate Analysis

Significant predictors from the univariate analysis were included in a binary logistic regression model. From all included predictors, only the number of more than 7 NPWT system changes was found to be a significant predictor for death ($P = .038$). The hazard ratio for death in the group of patients with more than 7 NPWT system changes was 4.033 (95% confidence interval, 1.078–15.086).

DISCUSSION

The technique of TAC for OA is a lifesaving operation but is associated with important morbidity and mortality.[11] Studies show that NPWT is the most advanced and efficient treatment for the patient, surgeon, and staff. Use of NPWT effectively covers many important areas of treatment: It provides temporary wound cover until fascial closure is possible or desired, extends the window for primary fascial closure, prevents wound progression, encourages healing of the closed incision, promotes granulation tissue formation to create a good wound bed for grafting, and splints the wound.[12,13]

The authors' experience and literature data strongly suggest that NPWT is the best available solution to treat patients with OA.[14,15] In most cases, patients with OA receive NPWT after emergency surgery or because of complications following major surgical procedures for cancer.

According to the authors' data, NPWT was not applied at the patient's first surgery in several cases. Overall outcomes may have improved if NPWT was initiated immediately. The authors believe time was wasted in cases where patients underwent 3 or more surgeries before NPWT was administered. The authors found that the worst results were in the group of the patients where NPWT was not applied at the first surgery; however, the results were not statistically significant.

Mortality after treatment with NPWT is high because of several reasons. One factor could be preoperative morbidity, but the ASA score as an assessor of preoperative comorbidity was not

Table 3.

BJÖRCK CLASSIFICATION OF WOUNDS

Björck	No. of Patients
1A	12
1B	14
2A	6
2B	9
3	7
4	4

Table 4.

THE DISTRIBUTION OF VARIABLES BETWEEN GROUPS

	Group		
	Survivors	Deceased	*P*
Sex			NS
Male	16 (61.5%)	17 (65.4%)	
Female	10 (38.5%)	9 (34.6%)	
Age, y	66 ± 11.6	68 ± 12.2	NS
Type of operation			NS
Urgent	13 (50%)	12 (46.2%)	
Scheduled	13 (50%)	14 (53.8%)	
Type of abdominal closure			.002
Laparotomy	3 (11.5%)	19 (73.1%)	
Fascia closure	7 (26.9%)	1 (3.8%)	
Mesh	2 (7.7%)	0 (0%)	
1 Layer	3 (11.5%)	1 (3.8%)	
Skin only	11 (42.3%)	5 (19.2%)	
No. of NPWT changes			.034
<7	22 (84.6%)	15 (57.7%)	
>7	4 (15.4%)	11 (42.3%)	
Björck			NS
1A	7 (28%)	5 (19.2%)	
1B	8 (32%)	6 (23.1%)	
2A	4 (16%)	2 (7.7%)	
2B	5 (16%)	4 (15.4%)	
3	1 (4%)	6 (23.1%)	
4	1 (4%)	3 (11.5%)	
NPWT duration	16 ± 11.7 d	36 ± 41.6 d	<.0001
No. of operations to NPWT	1 ± 1.1	1 ± 2.2	NS

Abbreviations: NPWT, negative-pressure wound therapy; NS, not statistically significant.

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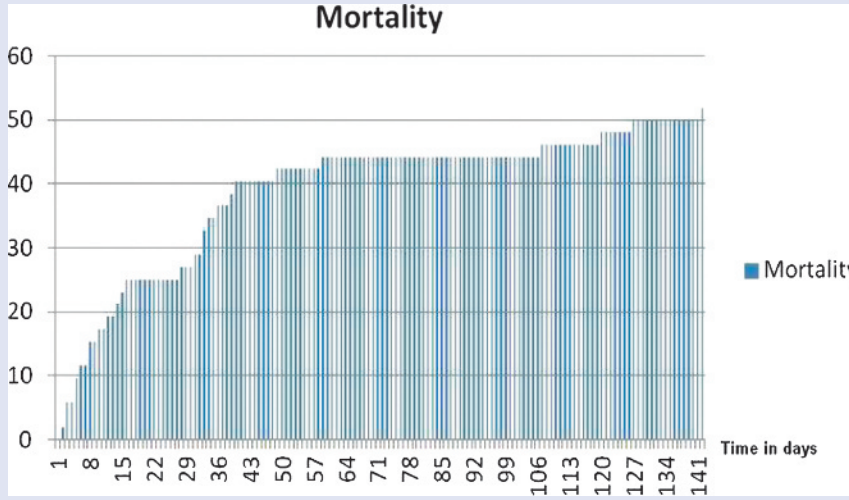
Table 5.

CUMULATIVE DAILY MORTALITY ASSOCIATED WITH THE DURATION OF NPWT



Abbreviation: NPWT, negative-pressure wound therapy.

significantly associated with mortality in this study. The authors believe that high mortality in patients with NPWT is associated with their preliminary conditions and a prolonged state of inflammation.

The factors that were significantly associated with death in the authors' study were more than 7 NPWT system changes, total number of days with NPWT, and the type of wound closure. It is understandable that patients who need prolonged OA treatment have the worst prognosis. The authors attribute this to complicated inflammation and immunosuppression mechanisms, which are activated in patients with severe trauma or critical illness.[16,17] Included in that group are the authors' patients, many with severe peritonitis and OA, who underwent surgeries every 48 to 72 hours and were continuously exposed to infection.

It is interesting to note that there is a significant increase in the postoperative mortality after 15 days of OA or 7 NPWT system changes. Mortality in this group was 3 times higher than in the group with fewer NPWT system changes. It is clear that there is a limit on how long a patient can compensate for OA. Approximately 10 to 20 days after major trauma, the global function of the immune system is often suppressed[18,19] and predisposes and endangers the organism to infections.[20] The body's systemic inflammatory response syndrome proceeds to compensatory anti-inflammatory response syndrome, which is a systemic deactivation of the immune system tasked with restoring homeostasis from an inflammatory state.[21]

One complication of NPWT is the development of enteral fistulas—estimated to occur in up to 25% of cases during the therapy of OA. Fistulas may be caused by dryness of the small or large bowel, resulting from exposure to the ambient air and by mechanical irritation of wound dressings. In the authors' experience, patients with enteral fistulas developed them mostly before the introduction of NPWT. Thus, the authors believe that NPWT did not directly influence their formation.[22,23]

LIMITATIONS

There are several limitations to this study. First, it was a retrospective study with a relatively small number of cases. Second, there was a great heterogeneity among patients. Patients in the study had elective or urgent surgeries; colorectal, gastric, and pancreatic procedures; and very different physical status. Furthermore, there was no protocol on how to treat the patient, so a number of surgeons made individual decisions on patient management. The authors' results indicate more investigations are needed through prospective trials.

CONCLUSIONS

Negative-pressure wound therapy is a method of choice for treating OA and it should be applied as soon as possible when appropriately indicated. Conversely, clinicians should try all conservative and surgical measures to remove NPWT and close the abdomen as soon as possible because prolonged use is associated with significantly higher mortality. ●

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