Experience with Negative Pressure Therapy in Temporary Abdominal Closure of Patients with Secondary Peritonitis

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Abstract—The purpose of this review was to evaluate mortality rates of open abdomen patients with severe peritonitis who received negative pressure therapy (NPT) versus open packing techniques as a method of temporary abdominal closure (TAC). Authors retrospectively reviewed consecutive records from five different surgical departments of patients who received NPT (V.A.C. technology) and open packing (OP) following severe secondary peritonitis. Patient demographics, number of days in ICU, and mortality were recorded and analyzed. Medical records of 239 patients were analyzed. The APACHE II score was significantly higher for the VAWD group (p<0.002). Mortality rates were significantly higher for the OP group (76%), compared to 37% and 36% for the CV and VAWD groups, respectively (p<0.01). The number of days in ICU was highest in the OP group (38.6), compared to 30.0 for CV and 36.4 for VAWD, but the difference was not significant. An algorithm to guide NPT use in this patient population is presented. Results suggest that the application of NPT in the open abdomen following diffuse peritonitis may significantly reduce patient mortality, compared to open packing techniques. NPT appears to be a safe and viable method of temporary abdominal closure in open abdomen following severe peritonitis.

Keywords — Negative pressure therapy, open abdomen, secondary peritonitis, TAC, V.A.C.

1. INTRODUCTION

Open abdominal wound management of patients with severe secondary peritonitis is a challenge for both surgical and intensive care personnel. Secondary peritonitis is classified as acute peritonitis by perforation, postoperative peritonitis, or post-traumatic peritonitis. While the majority of patients with peritoneal inflammations can be treated adequately with a single surgery, an estimated 10-15% develop severe secondary peritonitis and require additional surgical treatment. These patients cannot be closed due to massive bowel edema after emergent surgery and resuscitation. Reported mortality rates vary widely from 30 to 60%, somewhat due to the fact that various entities are summarized under the term peritonitis.

The standard surgical approach for treatment of peritonitis was first described by Martin Kirschner in 1926. It is based on local focus control, substantial debridement and intra-operative lavage with subsequent definitive abdominal wall closure. Systemic antibiotic therapy is started at the time of therapy. In severe secondary peritonitis, an open abdomen is maintained to widely expose the peritoneal cavity and achieve more effective drainage. Irrigation and dressing changes are performed along with staged relaparotomies. This procedure has remained routine in numerous clinics throughout the world, although the method and length of coverage of the open abdomen in advanced peritonitis remains somewhat controversial.

Prolonged management of the open abdomen has proven to be time consuming for caregivers and is associated with numerous complications including fistulisation, wound sepsis, fascial retraction, respiratory difficulties, segmental colonic necrosis and large incisional hernias. These complications and the potential risk of developing intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS) have led to an evolution of temporary abdominal closure (TAC) techniques designed to facilitate delayed abdominal closure.

Current methods of TAC include vacuum-assisted closure, vacuum pack, polyvinyl chloride bag (Bogotá Bag), artificial Burr, Mesh/sheet with zipper, silo, skin closure, dynamic retention sutures, and loose gauze packing. Use of negative
pressure therapy (NPT) in the form of Vacuum-Assisted Closure (V.A.C., KCI, Austria) with reticulated open cell foam (ROCF) as a bridge over the open fascia has increased dramatically during the past decade. Proposed beneficial effects of adjunctive NPT in the presence of diffuse peritonitis include continuous evacuation of intraabdominal infectious fluids, the ability to quantify third space fluid losses, augmentation of granulation tissue, decreased potential for fascial retraction and decreased risk of developing abdominal compartment syndrome.5

II. MATERIALS AND METHODS

This record review was approved by the ethical committee of the Medical University of Vienna. A retrospective review was performed of consecutive patients with an open abdomen due to secondary peritonitis treated between January 2001 and December 2006. Patient records from five different surgical departments in Austria were entered into one database. Incomplete patient records were excluded. Records were divided into three different groups according to employed method of TAC: 1) NPT applied with a conventional ROCF dressing (CV group), 2) NPT applied with the specialized V.A.C. Abdominal Wound Dressing (VAWD group) and 3) open packing techniques without application of negative pressure (OP group). Patient demographics, Acute Physiology and Chronic Health Evaluation—II (APACHE-II) score at the first operation for peritonitis, number of days in ICU, and mortality were recorded for each patient.

Due to its severity and historically high mortality rate, in all cases, the diagnosis of diffuse secondary peritonitis was the highest priority of treatment, temporarily replacing treatment of any original primary diagnoses. Patients received appropriate antibiotic therapy and standard intensive care, and the abdominal wall was closed at the discretion of the treating physician, based on observed resolution of the peritonitis.

### TABLE I

#### PATIENT DEMOGRAPHICS

<table>
<thead>
<tr>
<th></th>
<th>OP</th>
<th>CV</th>
<th>VAWD</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient number (n)</td>
<td>62</td>
<td>102</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Mean Age (years)</td>
<td>60.3 (15.0)</td>
<td>62.8 (13.9)</td>
<td>61.8 (15.0)</td>
<td>0.5</td>
</tr>
<tr>
<td>Mean BMI</td>
<td>26.5 (7.6)</td>
<td>26.2 (5.6)</td>
<td>29.1 (8.5)</td>
<td>0.1</td>
</tr>
<tr>
<td>Mean Weight (kg)</td>
<td>79.6 (23.0)</td>
<td>76.3 (19.2)</td>
<td>82.9 (26.4)</td>
<td>0.06</td>
</tr>
<tr>
<td>Mean Apache II</td>
<td>18.9 (8.1)</td>
<td>16.8 (8.0)</td>
<td>19.3 (9.4)</td>
<td>0.002</td>
</tr>
</tbody>
</table>

NPT applied with a conventional ROCF dressing (CV group), NPT applied with the specialized V.A.C. Abdominal Wound Dressing (VAWD group) and open packing techniques without application of negative pressure (OP group).

*Kruskal-Wallis test

Standard deviation is recorded in the parentheses.

The method of applying CV consisted of a hospital-supplied fenestrated non-adherent polyurethane layer placed over the bowel contents and underneath the fascia, then tucked deeply into the abdominal space. A NPT/ROCF dressing was cut to fit and placed throughout the entire wound cavity over the non-adherent layer. A semi-permeable adhesive drape was placed over the ROCF, and subatmospheric pressure of -125 mmHg was applied via tubing and a computerized vacuum therapy unit. Dressing changes, re-exploration, and separation of adhesions were performed every 48 hours.

The NPT technique for the VAWD group differed slightly from applying a conventional NPT/ROCF dressing in that the dressings were supplied as a kit which included a ROCF dressing, adhesive drape, tubing, and a large fenestrated, non-adherent layer with encapsulated foam for bowel protection. The non-adherent layer was tucked deeply into the small pelvis, subdiaphragm and retroperitoneum to create a barrier between viscera and the abdominal wall. The ROCF dressing was trimmed at the perforations to fit the size of the wound and placed over the non-adherent drape. A large adhesive drape was sealed over the ROCF dressing, and negative pressure (-125 mmHg) was applied via the tubing.

In the OP group, temporary abdominal coverage consisted of either a sheet of polypropylene (Marlex) mesh with a nylon zipper/Velcro or a polyvinyl chloride bag placed around the bowel for protection, over which wet surgical towels were placed. Wounds in this group received at least once daily dressing changes and lavage. Washouts were performed as appropriate. Conventional drains, as opposed to a vacuum source, were used.

For more than two independent, arbitrarily distributed samples, the non-parametric Kruskal-Wallis test was used to analyze medians for significant differences. To analyze the significance of two independent and normal distributed samples—APACHE-II score and days in ICU—Mann—Whitney U test was used. For mortality, a Mann—Whitney U test was utilized, since the deviation from the normal distribution is negligible. A p value of <0.05 was accepted as significant.

### III. RESULTS

Two hundred and fifty-one patient medical records that included an open abdomen due to secondary peritonitis were initially extracted. Of these 251 patients, 239 patients fulfilled the entry criteria of listing data endpoints and TAC technique used. OP dressings were used in 62 patients, CV dressings were used in 102 patients and VAWDs were used in the remaining 75 patients.

There was no significant difference in age, weight or BMI between the three groups (Table I).

The APACHE II score was significantly higher for the VAWD group (p<0.002, Table I). Origins of primary surgery for all patients included stomach, small bowel, large bowel, pancreas, trauma, abscess, ascites, ileus and acute abdomen.

The mortality rates were significantly higher for the OP group, 76% compared to 37% and 36% for the CV and VAWD...
groups, respectively (p<0.01) (Table II). Patients died in a mean time of 26.7, 26.4 and 25.4 days for OP, CV and VAWD respectively, after the first operation. The number of days in ICU was highest in the OP group (38.6), compared to 30 for CV and 36.4 days for VAWD, but the difference was not significant.

IV. DISCUSSION

Our preliminary results showed a mortality rate reduction of approximately 50% for secondary peritonitis patients who received CV or VAWD, compared to OP. Anytime the discussion leads to different underlying disease like different cancer location, volvulus, ileus and other rare condition, what makes the patient groups non comparable. Severe peritonitis was the reason for death at the ICU, based on Mannheimer peritonitis index and not the underlying disease. The aim of this approach was to treat the peritonitis.

To compare, there are few reports of the use of NPT with the Abdominal Dressing System in peritonitis. A 0% mortality rate was reported in a prospective analysis of 20 patients who received NPT following laparotomy for severe peritonitis.6 As part of a larger series, Cipolla et al.7 reported a 0% mortality rate in 3 patients with diffuse peritonitis who received NPT. References describing experience with open packing techniques are more frequent and report mortality rates of 32%–58% with these approaches.8-13 The higher mortality rates for all groups in our series could be attributed to our large series size, difference in patient selection, and variable care between sites and caregivers.

**Fig 1.** Guide for using NPT/ROCF as TAC technique in the open abdomen following severe secondary peritonitis

**Table II**

<table>
<thead>
<tr>
<th>Therapy</th>
<th>Total Average Mortality Rate per Therapy (Percentage)</th>
</tr>
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<tbody>
<tr>
<td>OP</td>
<td>76%</td>
</tr>
<tr>
<td>CV</td>
<td>37%</td>
</tr>
<tr>
<td>VAWD</td>
<td>36%</td>
</tr>
</tbody>
</table>

*p-value

6 Mann-Whitney U test

7 Cipolla et al.
ICU stay was longer in each of our three groups than the average critical care unit stay of 20 days reported by Amin et al. in a pilot study of a similar population. Although not significant, the mean ICU stay was shorter in the CV group, compared to OP and VAWD groups. The longer ICU stay for the VAWD group could be influenced by the group’s higher average severity of illness (Apache II) scores. Increased nursing requirements and the potential risk of ‘under treatment’ at the normal ward for these patients could have resulted in a longer ICU stay.

Mortality rates between the two different V.A.C. modalities were similar. This is contrary to our expectation that a newer streamlined abdominal-specific dressing would yield better results. Again, the lack of difference could be attributed to a higher illness severity (Apache II), associated with a higher mortality, in the VAWD group. Another reason may be that the primary mechanisms of action of NPT do not differ between VAWD and CV.

Peritonitis entails stimulation of inflammatory cytokines which results in the creation of a fibrin mesh that temporarily blocks the reabsorption of fluid from the peritoneal cavity and traps bacteria. Pathophysiology of increased IAP is directly related to the peritoneal inflammatory response to trauma and abdominal sepsis. Success of the delayed primary closure approach has been shown to be largely due to the ability to control increases in IAP. NPT can affect underlying physiologic causes through the continuous removal of exudates and infectious materials to reduce bowel wall edema and the inflammatory burden.

NPT and open cell foam can also help preserve the abdominal domain and fascia. Saxena et al. found that NPT induces microdeformations of the wound edges directly in contact with the foam, stimulating cell division, proliferation and angiogenesis. These factors appear to help precondition the abdominal wall for delayed primary closure and reduce the need for additional surgeries.

We have identified advantages of this technology in intensive care to include a lack of restrictions in regular patient care. The closed system allows mobilization and proning, and helps protect the patient and caretaker against contaminated liquids or infectious materials. Reduced dressing changes and irrigation decrease the exposure of the open abdomen to outside contaminants. Abdominal fluid is continuously removed and can be quantified.

The primary advantage of VAWD in surgery is that there is no adherence of the bowel to the fascia, thereby facilitating delayed primary closure. Authors recommend extreme caution in ensuring the foam dressing is not in contact with the bowel. The non-adherent drape should be tucked deeply into the small pelvis, subdiaphragm and retroperitoneum to provide a barrier between viscera and the abdominal wall. Our experience is that the WAWD remains in place and prohibits hypergranulation of the intestines.

Recently, Björck et al. proposed a 6-grade classification system to assist in diagnosis and treatment of OA. A principal goal of incorporating the system would be to prevent further deterioration of the OA within the classification system resulting in a more complex wound. Based on this grading system, we have found that the abdominal dressing system largely maintains the wound at a Grade 2B (contaminated OA developing adherence/fixity) or better, preventing the OA from worsening to a grade 3 (OA complicated by fistula formation) or 4 (frozen OA with adherent/fixed bowel, unable to closure surgically).

To date, our study comprises the largest series of peritonitis patients who have received NPT/ROCF. However, this study has all of the major limitations of a non-randomized, retrospective study. Variance in standards and procedures, as
well as extent of usage, between participating hospitals potentially biases the results. The decrease in mortality rates for the NPT groups could have been influenced by consistent technique and materials that are somewhat inherent in the NPT system, but not standardized across open packing techniques. None of the hospitals had the same experience in using the different TAC options or had used different TAC options to the same extent (Table III).

Mortality rates varied extensively between hospitals. For example, in one hospital the mortality rate in the VAWD group was 11%, based on 30 patients, compared to the average VAWD mortality rate of 36% based on a total of 75 VAWD patients. In addition, a lack of consideration for other factors known to contribute to a decline in mortality rates for patients with diffuse peritonitis—improved antibiotics and surgical techniques, an increased understanding of physiology, monitoring and support of the cardiopulmonary system, and the role of damage control—further biases study results. We attempted to collect data on complications such as multi-organ failure, number of surgical revisions, and the integrity of the abdominal wall; however, inconsistencies in the medical records prevented us from collecting useful data with respect to these parameters. Well-designed, prospective, randomized studies with standardized care across all settings are needed to further compare the efficacy of TAC modalities.

Despite the limitations of this study, the lower mortality rates with NPT techniques are encouraging, and suggest that NPT is a safe and viable tool in open abdominal wound management following severe diffuse peritonitis. Importantly, this retrospective analysis has provided us with an opportunity to design and implement a new prospective, multicentre registry study to collect data on the treatment of this patient population.

We have also proposed a treatment pathway for NPT use in open abdomen following secondary peritonitis (Fig. 1).

Management of severe peritonitis is complex and requires a multidisciplinary approach. A learning curve exists for using NPT in this challenging indication and appropriate educational training for all involved staff is paramount to success. NPT should not be used in the presence of diffuse bleeding. Antibiotic therapy should be initiated as soon as possible.

NPT is initiated immediately after emergency when open treatment is required, or on the second or third post-operative day in cases of high intra-abdominal pressure (IAP) or infection. Literature has reported that earlier application (immediately after re-opening the abdomen) may be more beneficial versus postponing therapy application[23]. Kaplan and colleagues showed that acute care trauma wound patients with early initiation of NPT had significant reductions in length of stay, treatment days, lower rate of fistula, and ICU stay that translated into significantly lower patient treatment costs[24]. Other studies have also shown NPT to be associated with earlier fascial closure rates.21,25-27 Fistula rate were similar to the findings of Kaplan et al.

NPT should be continued until closure of the abdominal wall is possible. Usually, abdominal wall closure is indicated when the IAP is below 15 mmHg, the patient’s nutritional status is adequate, C-reactive protein levels have dropped below 5, leukocytes are below 12,000, the exudate composition looks clear, and the exudate volume is less than 100-200 ml per day. Kaplan8 suggested that the trend of IAP is more important than the absolute number. Patients with progressive increases in
intra-abdominal hypertension (IAH) or development of ACS should be decompressed immediately. NPT should be discontinued if an increase in IAP is observed while therapy is ongoing.

We have found several measures to be helpful in reducing fistula formation during NPT, including aggressive treatment of paralytic ileus, early enteral nutrition to prevent malnutrition, dressing change frequency no longer than 2-3 days, and vigilant identification of stenosis.

Dressing changes are performed at the bedside or in the operating room. During each dressing change, a thorough exploration is performed with attention to drainage of interloop fluid and exploration of all gutters. Bowel should be dissected free from the abdominal wall to the lateral, superior and inferior aspects of the abdomen. If abdominal wall closure is not possible within 14 days, the bowel should be allowed to granulate with NPT/ROCF and a late ventral hernia repair would be indicated.

REFERENCES