Clinical Study

VAWCM-Instillation Improves Delayed Primary Fascial Closure of Open Septic Abdomen

Qingsong Tao,1 Jianan Ren,2 Zhenling Ji,1 Shengli Liu,1 Baochai Wang,1 Yu Zheng,3 Guosheng Gu,2 Xinbo Wang,2 and Jieshou Li2

1Department of General Surgery, Affiliated Zhongda Hospital, Southeast University Medical School, 87 Dingjiaqiao, Nanjing, Jiangsu 210089, China
2Research Institute of General Surgery, Jinling Hospital, Nanjing University Medical School, 305 East Zhongshan Road, Nanjing, Jiangsu 210093, China
3Department of Surgery, Haian People’s Hospital, Nantong University Medical School, 17 Zhongba Road, Nantong, Jiangsu 226600, China

Correspondence should be addressed to Qingsong Tao; taoqs_nju@126.com

Received 24 August 2014; Accepted 18 November 2014; Published 7 December 2014

Academic Editor: Antoni Castells

Copyright © 2014 Qingsong Tao et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Background. Failure to achieve delayed primary fascial closure (DPFC) is one of the main complications of open abdomen (OA), certainly when abdominal sepsis is present. This retrospective cohort study aims to evaluate the effect of combined therapy of vacuum-assisted mesh-mediated fascial traction and topical instillation (VAWCM-instillation) on DPFC in the open septic abdomen.

Methods. The patients with abdominal sepsis who underwent OA using VAWCM were included and divided into the instillation and noninstillation (control) groups. The DPFC rate and other outcomes were compared between the two groups.

Results. Between 2007 and 2013, 73 patients with open septic abdomen were treated with VAWCM-instillation and 61 cases with VAWCM-only. The DPFC rate in the instillation group was significantly increased (63% versus 41%, \( P = 0.011 \)). The mortality with OA was similar (24.6% versus 23%, \( P = 0.817 \)) between the two groups. However, time to DPFC (\( P = 0.003 \)) and length of stay in hospital (\( P = 0.022 \)) of the survivals were significantly decreased in the instillation group. In addition, VAWCM-instillation (OR 1.453, 95% CI 1.222–4.927, \( P = 0.011 \)) was an independent influencing factor related to successful DPFC.

Conclusions. VAWCM-instillation could improve the DPFC rate but could not decrease the mortality in the patients with open septic abdomen.

1. Introduction

Open abdomen (OA) has been considered a common technique in the management of abdominal compartment syndrome (ACS), severely abdominal trauma, and abdominal sepsis [1, 2]. Comparing to the trauma patients, a longer time may be required to achieve delayed primary fascial closure (DPFC) in the patients with open abdominal sepsis [3]. If DPFC could not be achieved, skin-only closure or split-thickness skin grafting would usually be applied after wound infection was cleared and healthy granulation bed was formed, and the planned ventral hernia has to be dealt with later [4].

The role of OA in the management of abdominal sepsis has been a controversial issue. Some studies failed to show any significant benefit for the open septic abdomen using traditional passive abdominal packing [5], which was unable to drain effectively any toxic or infected intra-abdominal fluid. Recent experimental and clinical studies have indicated that vacuum-assisted closure (VAC) is associated with superior outcomes in the treatment of open abdominal sepsis [7–9]. Vacuum-assisted wound closure and mesh-mediated fascial traction (VAWCM) seemed to be a promising technique providing a higher DPFC rate and few complications after long-term treatment of OA [10–12]. It has become a routine temporary abdominal closure (TAC) technique for open septic abdomen at our institutions [13].

Recently, VAC-instillation therapy (KCI, San Antonio, USA), a combined technique of VAC or negative pressure wound therapy (NPWT) and topical instillation, has been
introduced in wound care. Studies have demonstrated that VAC-instillation showed a significant decrease in the mean time of bioburden reduction, wound closure, and hospital discharge compared with VAC-only method [14–16]. D’Hondt et al. reported the encouraging results of the VAC-instillation in five patients with open septic abdomen [17,18]. However, no clinical data have been attempted to evaluate the role of VAWCM-instillation in the management of open septic abdomen. The main purpose of this study was to evaluate the role of VAWCM-instillation in the management of open septic abdomen.

2. Patients and Methods

2.1. Study Design and Patients. This was a multiple-center retrospective cohort study on the patients with abdominal sepsis who experienced open abdomen (OA) using VAWCM between January 2007 and November 2013. The patients with septic OA of grades 1–3, as classified by Björck et al. [19], were suitable for inclusion. Exclusion criteria included < 18 years, frozen OA with adherent bowel (grade 4), preexisting large ventral hernia, end-stage renal disease, severe liver disease, uncontrolled diabetes, critical wound ischemia, and any issue with an obviously high risk of delayed wound healing. Conventional therapies [20] for patient-specific sepsis were also recorded for analyses. Delayed primary fascial closure (DPFC) referred to the ability to achieve fascial closure during the initial hospital stay [11].

2.2. VAWCM and Topical Instillation. The principle of VAWCM has been described previously [11]. In brief, a sterile nonadhesive plastic sheet was placed intra-abdominally to cover the viscera and an oval-shaped polypropylene mesh (Prolene; Ethicon, Johnson & Johnson, Somerville, NJ) was sutured to the fascial edges with a running 0 monofilament suture. Moist gauze dressings were placed overlying these drapes. Then, as shown in Figure 1, instillation and suction catheters (instillation) or only suction catheters (control) were embedded in gauze dressings. The suction catheter of sump drain was attached to an aspiration pump with continuous topical negative pressure of 150 to 200 millibars. Persistent instillation by normal saline (150–300 mL/h) was performed, meantime, through the instillation catheter. The drains were covered with a layer of dry laparotomy pads and the wound was sealed with adhesive plastic dressings. This TAC system was changed every 2 to 3 days with debridement as needed, followed by catheter replacing and gauze redressing. Meanwhile, the possibility to close the abdomen was evaluated. If possible, the abdominal wall was closed. Otherwise, the mesh was cut in the midline and tightened by suturing in the midline with a running 0 monofilament suture, keeping the viscera from protruding and putting some...
tension on the abdominal wall. When 3–5 cm of separation of the fascial edges remained with weak tension, fascial closure was considered followed by skin closure or split skin grafting.

2.3. Other Strategies for the Management of Open Septic Abdomen. The early postoperative management after OA was to correct the oxygen and energy debt, hypothermia, and coagulopathy [21]. Sedation [22], analgesia [22], and/or neuromuscular blockade [23] were used to decrease intra-abdominal pressure. Although early goal-directed fluid resuscitation is critical to correct hypovolemia, restricted crystalloid fluid infusion or negative fluid balance was paid more attention to avoid the risk of worsening intra-abdominal hypertension. Early enteral feeding (EEF), defined as a successful initiation of enteral feeding within 1 week, was recommended for the patients without any intolerance response [24, 25]. Antibiotic coverage would initially be broad to cover the wide range of skin and bowel flora and then tapered according to intraoperative culture results [22].

2.4. Outcome Measurement. For each patient, the daily flow charts with clinical data were reviewed during OA treatment. Mortality, fascial closure, length of stay in hospital, and postoperative complications were collected.

2.5. Statistical Analysis. Data are expressed as mean ± SD. Student’s t-test was performed for continuous parametric variables, Mann-Whitney U test for continuous nonparametric variables, and Chi-square test or Fisher’s exact test for categorical variables. Fascial closure rates were analyzed by the Kaplan-Meier method and compared by log-rank test. Multivariable analysis of factors influencing successful delayed primary fascial closure was performed using logistic regression, with results being presented as odds ratio (OR) with 95% confidence interval (CI). All data were analyzed using SPSS V20 (IBM, Armonk, New York, USA). Statistical significance was set at $P < 0.05$.

3. Results

3.1. Patients. As shown in Figure 2, 169 (116 males and 53 females) consecutive patients with open septic abdomen were included between January 2007 and November 2013, 92 in instillation group and 77 in control group. 10 patients underwent early fascial closure at the time of first dressing change (less than 5 days, 7 in the instillation group and 3 in the control group, $P = 0.349$), 14 patients were treated with other TAC methods (3 with skin only, 3 with Dacron strip, and 8 with Bogota bag; 6 in the instillation group and 8 in the control group, $P = 0.364$), and 11 patients with massive abdominal wall loss were also excluded (6 in the instillation group and 5 in the control group, $P = 0.994$), without being further considered, leaving 134 patients (92 males and 42 females, 73 in instillation group and 61 in control group) in the final analysis. Patient characteristics are summarized in Table 1.

3.2. Mortality and Postoperative Complications. Thirty-two patients (23.9%) died before abdominal closure, 18 in the instillation group and 14 in the control group ($P = 0.817$, Table 2). Infectious complications were found in almost all the patients in whom primary fascial closure was unsuccessful or who died before abdominal closure (61/63, 96.8%), such as postoperative intra-abdominal abscess (31/63, 49.2%) or complicated fistula formation (27/63, 42.8%) (Table 2). Of note, topical instillation decreased the secondary intra-abdominal abscess after OA (16.4% versus 31.1%, $P = 0.044$).

3.3. DPFC Rate. Delayed primary fascial closure was achieved in 46 patients (63%) in the instillation group, significantly higher ($P = 0.011$, Table 2) than the control group (25 patients, 41%). In all the survivors with abdominal closure, delayed primary fascial closure was achieved in 83.6% (46 of 55 patients) in the instillation group, significantly higher than 53.2% (25 of 47) in the control ($P = 0.001$, Table 2).

3.4. Length of Stay in Hospital. The average length of stay (LOS) in hospital was 39 ± 15 d (19–88) and 44 ± 19 d (27–79) in the groups with and without topical instillation, respectively ($P = 0.022$). Moreover, in the patients who achieved fascial closure, it took less time for the instillation group (23 ± 7 days) than the control (28 ± 10 days, $P = 0.003$). As shown in Figure 3, the topical instillation technique significantly improved the fascial closure rate, as compared with the control ($P = 0.013$).

3.5. Factors Related to DPFC. All data were pooled to analyze the confounding factors that could influence the delayed primary fascial closure rate (Table 3). Independent factors of DPFC were identified by multivariable logistic regression analysis. The topical instillation was an only significant positive risk factor for DPFC (OR = 2.453, 95% CI 1.222–4.927, $P = 0.011$). Other independent factors might positively influence the DPFC rate but, without significance, were restricted crystalloid fluid infusion (OR = 1.793, 95% CI 0.900–3.569; $P = 0.095$) and early enteral feeding (OR = 1.670, 95% CI 0.827–3.372; $P = 0.113$).

4. Discussion

Open abdomen has become an important approach for damage-control procedures, ACS, and severe intra-abdominal sepsis. However, when delayed primary fascial closure cannot be achieved, OA can be associated with serious complications including giant hernia formation, wound infection, and intestinal fistula [26]. According to recent studies, the VAC method has the best results for patients with open septic abdomen, as compared with other TAC methods [27]. The documented benefits of VAC are enhanced tissue perfusion, promotion of granulation, increased bacterial wound clearance, and decreased tissue edema [28]. The VAWCM and continuous instillation could provide the effective drainage by reducing the occlusion of suction tube, enable effective debridement by diluting...
open septic abdomen

92 topical instillation and suction

77 only suction

6 other TAC methods

6 massive abdominal wall loss

7 early fascial closure with mesh reinforcement

8 other TAC methods

5 massive abdominal wall loss

3 early fascial closure with mesh reinforcement

73 VAWCM topical instillation and suction

61 VAWCM-only suction

18 died with OA

14 died with OA

55 survived until abdominal closure

47 survived until abdominal closure

46 delayed primary fascial closure

9 partial fascial closure

25 delayed primary fascial closure

22 partial fascial closure

2 died in hospital

44 survived until discharge

9 survived until discharge

25 survived until discharge

22 survived until discharge

Figure 2: Flowchart describing the delayed primary fascial closure and mortality included in this study.

Table 1: Patients characteristics for final analysis.

<table>
<thead>
<tr>
<th></th>
<th>Pooled (n = 134)</th>
<th>Irrigation (n = 73)</th>
<th>Control (n = 61)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years (range)</td>
<td>49 (20–79)</td>
<td>47 (20–79)</td>
<td>51 (28–77)</td>
<td>0.090</td>
</tr>
<tr>
<td>Gender (M : F)</td>
<td>92 : 42</td>
<td>52 : 21</td>
<td>40 : 21</td>
<td>0.482</td>
</tr>
<tr>
<td>Primary diagnosis, number (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postoperative anastomotic leakage without hemorrhage</td>
<td>51 (38.1)</td>
<td>26 (35.6)</td>
<td>25 (41.0)</td>
<td>0.524</td>
</tr>
<tr>
<td>Postoperative anastomotic leakage with hemorrhage</td>
<td>8 (6.0)</td>
<td>5 (6.8)</td>
<td>3 (4.9)</td>
<td>0.638</td>
</tr>
<tr>
<td>Severe acute pancreatitis</td>
<td>41 (30.6)</td>
<td>21 (28.8)</td>
<td>20 (32.8)</td>
<td>0.615</td>
</tr>
<tr>
<td>Perforation of gastric/duodenal/intestine</td>
<td>22 (16.4)</td>
<td>13 (17.8)</td>
<td>9 (14.8)</td>
<td>0.635</td>
</tr>
<tr>
<td>Complicated abdominal abscess</td>
<td>7 (5.2)</td>
<td>5 (6.8)</td>
<td>2 (3.3)</td>
<td>0.301</td>
</tr>
<tr>
<td>Other^</td>
<td>5 (3.7)</td>
<td>3 (4.1)</td>
<td>2 (3.3)</td>
<td>0.585</td>
</tr>
<tr>
<td>Classification of OA, number (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean OA without adherence (1a)</td>
<td>37 (27.6)</td>
<td>21 (28.8)</td>
<td>14 (23.0)</td>
<td>0.445</td>
</tr>
<tr>
<td>Contaminated OA without adherence (1b)</td>
<td>59 (44.0)</td>
<td>34 (46.5)</td>
<td>25 (41.0)</td>
<td>0.471</td>
</tr>
<tr>
<td>Clean OA developing adherence (2a)</td>
<td>21 (15.7)</td>
<td>13 (17.9)</td>
<td>8 (13.1)</td>
<td>0.457</td>
</tr>
<tr>
<td>Contaminated OA developing adherence (2b)</td>
<td>2 (1.5)</td>
<td>1 (1.4)</td>
<td>1 (1.6)</td>
<td>0.705</td>
</tr>
<tr>
<td>OA complicated by fistula formation (3)</td>
<td>7 (5.2)</td>
<td>4 (5.5)</td>
<td>3 (4.9)</td>
<td>0.599</td>
</tr>
<tr>
<td>APACHE II score^, mean (range)</td>
<td>13.9 (7–29)</td>
<td>14.2 (9–28)</td>
<td>13.7 (7–29)</td>
<td>0.433</td>
</tr>
</tbody>
</table>

Other diagnoses included complicated infected hematoma, septic incomplete abortion with traumatized uterus and perforation, acute ileus, and complicated cholecystitis. ^Acute physiology score and chronic health evaluation II. The “1a, 1b, 2a, 2b, 3” are referred to the classification of the patients with septic OA (see [19]).
Table 2: The comparison of clinical outcomes between the irrigation and control groups.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Pooled (n = 134)</th>
<th>Irrigation (n = 73)</th>
<th>Control (n = 61)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality before abdominal closure&lt;sup&gt;a&lt;/sup&gt;, n (%)</td>
<td>32 (23.9)</td>
<td>18 (24.6)</td>
<td>14 (23.0)</td>
<td>0.817</td>
</tr>
<tr>
<td>Primary fascial closure, n (%)</td>
<td>71 (53.0)</td>
<td>46 (63.0)</td>
<td>25 (41.0)</td>
<td>0.011</td>
</tr>
<tr>
<td>Primary fascial closure in the survivals&lt;sup&gt;b&lt;/sup&gt;, n/total survivals (%)</td>
<td>71/102 (69.6)</td>
<td>46/55 (83.6)</td>
<td>25/47 (53.2)</td>
<td>0.001</td>
</tr>
<tr>
<td>Time to primary fascial closure, days (range)</td>
<td>25 (11–42)</td>
<td>23 (11–34)</td>
<td>28 (15–42)</td>
<td>0.003</td>
</tr>
<tr>
<td>Hospital LOS in the survivals&lt;sup&gt;c&lt;/sup&gt;, days (range)</td>
<td>41 (19–88)</td>
<td>39 (19–88)</td>
<td>44 (27–79)</td>
<td>0.022</td>
</tr>
<tr>
<td>Hospital LOS in the survivals&lt;sup&gt;c&lt;/sup&gt; with fascial closure, days (range)</td>
<td>34 (19–53)</td>
<td>33 (19–44)</td>
<td>37 (27–53)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

<sup>a</sup>Abdominal closure refers to the delayed primary fascial closure, partial fascial closure, skin grafting, or skin-only suturing. <sup>b</sup>The survivals until abdominal closure. <sup>c</sup>The survivals until hospital discharge. <sup>d</sup>Other complications included catheter-associated infection, deep venous thrombosis, and pulmonary embolism.

Table 3: Factors related to fascial closure of the open septic abdomen.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Patients, n (%)</th>
<th>Fascial closure, events/total</th>
<th>OR</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, ≤60 y</td>
<td>99 (73.9)</td>
<td>55/71</td>
<td>1.484</td>
<td>0.684–3.219</td>
<td>0.316</td>
</tr>
<tr>
<td>Gender, male</td>
<td>92 (68.7)</td>
<td>50/71</td>
<td>1.19</td>
<td>0.573–2.472</td>
<td>0.640</td>
</tr>
<tr>
<td>Topical irrigation</td>
<td>73 (54.5)</td>
<td>46/71</td>
<td>2.453</td>
<td>1.222–4.927</td>
<td>0.011</td>
</tr>
<tr>
<td>Early enteral feeding</td>
<td>83 (61.9)</td>
<td>48/71</td>
<td>1.670</td>
<td>0.827–3.372</td>
<td>0.152</td>
</tr>
<tr>
<td>Early goal-directed fluid resuscitation</td>
<td>40 (29.8)</td>
<td>17/71</td>
<td>0.548</td>
<td>0.259–1.157</td>
<td>0.113</td>
</tr>
<tr>
<td>Restricted crystalloid fluid infusion</td>
<td>74 (55.2)</td>
<td>44/71</td>
<td>1.793</td>
<td>0.900–3.569</td>
<td>0.095</td>
</tr>
<tr>
<td>CRRT</td>
<td>48 (35.8)</td>
<td>26/71</td>
<td>1.077</td>
<td>0.530–2.186</td>
<td>0.838</td>
</tr>
</tbody>
</table>

In the past few years, concept and approach of fluid resuscitation have changed, including a more balanced transfusion protocol (including 1:1 ratios), limited use of crystalloid resuscitation, and widespread use of damage-control approaches [32]. Aggressive crystalloid infusion can lead to fluid volume overload and increased risks of ACS, pulmonary edema, and acute respiratory distress syndrome [33]. Restrictive crystalloid fluid infusion (RCFI) may decrease the incidence of ACS and increase early closure rates of OA [34, 35]. In this study, our results indicated that DPFC was achieved in 44 of 74 (59%) patients with RCFI and 27 of 60 (45%) patients without RCFI.

One of the challenges of the study is complicated postoperative fistula. This embarrassing issue would cause DPFC to be almost impossible. Diaz Jr. et al. [36] reported complicated fistula formed in as many as 75% of patients if a nonadherent barrier or omentum was not placed over the viscera for...
protection. In this study, nonadhesive plastic drapes, which were also filled with sterile vaseline, were placed between viscera and mesh. However, complicated postoperative fistula still occurred in 27 (20%) patients.

In this study, unexpectedly, the mortality rate under the instillation method was not significantly different in comparison with the control approach. The data indicated that the main causes of death are the continuum of clinical events from severe sepsis to septic shock and to multiple organ dysfunction syndromes (MODS). The mortality was not related to the application of instillation method in this study. But further prospective studies are required.

There are some limitations of this study. The length of ICU stay did not account for a clinical outcome in our study. The hospitals have not been expanded before the government increased the financial investment in the medical service 5-6 years ago. Even now, we have not offered enough regular beds yet for our in-patients in a country who has a 1.4-billion population. The recovered ICU patients had to wait a couple of days for a regular bed available to transfer in.

The other limitation is the self-made VAWCM-instillation package. The commercial VAC-Instill package is very costly. In China, most of the import medical instruments have to be paid by the patients themselves owing to the limited medical insurance coverage. In this study, the homemade VAWCM-instillation package, in which a mesh and nonadhesive plastic sheet were used to cover the exposed viscera, and suction tubes were placed between the mesh and the skin-attached drape. All the materials can be afforded. There are no technical problems with the self-made package. Nevertheless, that might increase the burden to both doctors and nurses.

In conclusion, the application of VAWCM-instillation resulted in an unimproved mortality but a significant increased delayed primary fascial closure rate in the patients with open septic abdomen.

Conflict of Interests
The authors declare that there is no conflict of interests regarding the publication of this paper.

Authors’ Contribution
Qingsong Tao, Jianan Ren, and Jieshou Li designed research; Qingsong Tao, Baochai Wang, Yu Zheng, Guosheng Gu, Xinbo Wang, Zhenling Ji, and Shengli Liu performed research; Qingsong Tao, Baochai Wang, and Yu Zheng analyzed data; Qingsong Tao, Baochai Wang, and Yu Zheng wrote the paper; all authors approved the paper.

Acknowledgments
This work was supported by Grants from National Foundation for Natural Scientific Research of China (no. 81000153) and Foundation for Natural Scientific Research of Jiangsu Province (BK2010415).

References


