Difference Between Delayed Anastomosis and Early Anastomosis in Damage Control Laparotomy Affecting the Infusion Volume and NPWT Output volume: Is Infusion Restriction Necessary in Delayed Anastomosis? A Single-Center Retrospective Analysis

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Abstract

Background: Delayed anastomosis is a treatment strategy used in damage control laparotomy (DCL).

During temporary abdominal closure (TAC) with DCL, infusion volume, and negative-pressure wound therapy (NPWT) output volume are associated with the success and prognosis of primary fascial closure (PFC). The same may also hold true for anastomosis. The aim of this research is to evaluate whether the difference between early anastomosis and delayed anastomosis in DCL is related to infusion volume and NPWT output volume.

Methods: This single-center retrospective analysis targeted patients managed with TAC during emergency surgery for trauma or intra-abdominal sepsis between January 2011 and December 2019. It included patients who underwent repair/anastomosis/artificial anus construction in the first surgery and patients who underwent intestinal resection in the first surgery followed by delayed anastomosis with no intestinal continuity. The main outcomes were infusion volume, NPWT output volume and complications.

Results: One hundred nine patients who underwent emergency surgery were evaluated. Seventy-three patients were managed with TAC using NPWT. In 16 patients with early anastomosis and 21 patients with delayed anastomosis, there was no difference in the infusion volume (p=0.2318) or NPWT output volume (p=0.7128) 48 hours after surgery. Additionally, there was no difference in the occurrence of surgical site infection (p=0.315) and suture failure (p=0.8428). During the second-look surgery after 48 hours, the anastomosis was further postponed for 48% of the patients who underwent delayed anastomosis. There was no difference in the infusion volume (p=0.0783) up to the second-look surgery between the patients whose delayed anastomosis was postponed and those who underwent delayed anastomosis, but there was a tendency toward a large NPWT output volume (p=0.024) in the postponed delayed anastomosis group. Anastomosis and PFC were achieved for all patients whose delayed anastomosis was postponed.

Conclusions: The presence or absence of anastomosis during TAC management does not affect NPWT output volume. Delayed anastomosis may be managed with the same infusion volume as that used for early anastomosis. There is also the option of postponing anastomosis if the planned delayed anastomosis is complicated.

Trial Registration

The retrospective protocol of this study was approved by our institutional review board (MH2018-611).

Background

Delayed anastomosis is a treatment strategy that is incorporated into damage control laparotomy (DCL) according to the physiological indicators and intra-abdominal environments of patients who have no intestinal continuity after undergoing only intestinal resection during initial surgery for hollow viscous injury (HVI) or mesenteric injury (MI) [1–6]. After DCL, the patient is moved quickly to the intensive Care

Unit for correcting hypothermia, acidosis, coagulative disorders and performing physiological optimization [1, 7–9]. Temporary abdominal closure (TAC) using negative-pressure wound therapy (NPWT) is the general approach used until repeat laparotomy is performed. These DCL treatment strategies are applied not only to trauma but also to intra-abdominal sepsis and are very important treatment strategies [10–12]. However, the decision to perform anastomosis during the first procedure or delay it is complex and must consider the patient's physiological indicators, damage status, contamination status, and other factors.

It has been reported that during primary fascial closure (PFC) after TAC, excessive infusion leads to tissue edema and prevents successful PFC [13–15] and that limited use of the crystalloid infusion protocol improves the success of PFC [16]. For similar reasons, excessive infusion may lead to the development of intestinal edema, which may prevent successful delayed anastomosis or require the construction of an artificial anus to avoid anastomosis. In addition, the NPWT output volume in TAC is an important fluid balance index, and hypoalbuminemia, in which albumin is lost when protein-rich ascites are drained [17], may pose a risk of anastomotic leakage [18–20] and present a disadvantage for the success of delayed anastomosis. However, there is little information regarding the differences and relevance of infusion volume and NPWT output volume during TAC for the management of early anastomosis and delayed anastomosis in DCL.

The aim of this research is to evaluate whether the difference between early anastomosis and delayed anastomosis is related to infusion volume and NPWT output volume in patients who underwent DCL due to trauma and intra-abdominal sepsis.

Methods

Target

The protocol of the study was approved by the institutional review board.

This retrospective study was conducted at the Iwate Medical University Critical Care Center from 2011 to 2019 with patients who underwent emergency surgery due to HVI/MI caused by abdominal trauma and patients who underwent emergency surgery for lower digestive tract perforation with diffuse peritonitis and peritoneal contamination in the form of intra-abdominal sepsis. The study included patients who underwent repair/anastomosis/artificial anus construction during the first DCL surgery and were managed with TAC using NPWT and patients who had no intestinal continuity after undergoing intestinal resection during the first surgery and were managed with TAC using NPWT. Clinical data and infusion volume, NPWT output, and urine volume up to 48 hours after surgery were extracted from chart review or clinical records review.

The study excluded patients who died within 48 hours after surgery, patients with solid organ injuries without HVI, patients who underwent nonsurgical treatment (for MI or intra-abdominal hemorrhage), patients on maintenance dialysis due to chronic renal failure, and patients with iatrogenic injuries.

Patients with perforated appendicitis and patients who underwent resurgery with DCL were not included in the study.

Treatment Strategy

Repair, Resection and Artificial Anus Construction

Treatment was conducted at the discretion of the surgeon and not protocolized according to specific injury or perforation site and morphology or contamination status. Intestinal resection was performed using a stapler. In cases in which delayed anastomosis was selected, the end of the intestinal resection remained stapled, and the intestine was left discontinuous and was directed into the abdominal cavity. No temporary artificial anus was created until anastomosis was performed. For delayed anastomosis, second-look surgery was performed 48 hours after the initial surgery to evaluate whether to restore intestinal continuity or create an artificial anus. Other options included postponing anastomosis with no intestinal continuity and postponing abdominal closure. When TAC was continued, the condition of the intestinal tract was evaluated in a timely manner at the intensive care unit or high-dependency care unit, and the abdomen was closed after anastomosis or artificial anus construction was selected at the discretion of the surgeon. Regarding the anastomosis technique, stapling anastomosis was performed in all cases, and hand-sewn anastomosis was not performed. Ileostomy was not performed after anastomosis.

Infusion Resuscitation

The infusion dose was based on physiological indicators such as heart rate, blood pressure, etc., and the diameter of the inferior vena cava according to ultrasound examination. Infusion up to 48 hours after surgery included basic infusion crystalloid fluid, bolus-administered crystalloid fluid, and albumin preparations. The administration of the albumin preparation was capped at 1 dose of 100 ml 20% albumin preparation per day. There was no protocol for bolus administration of crystalloid solution corresponding to the NPWT output amount. Furosemide was not used for up to 48 hours after surgery. When hemodynamics were unstable even after sufficient infusion (systolic blood pressure less than 90 mmHg), the administration of 0.05 μg/kg/min of norepinephrine as a vasopressor was started.

Negative-Pressure Wound Therapy

NPWT was carried out with a handmade negative pressure system after the abdominal cavity was thoroughly rinsed with saline. The intra-abdominal organs were covered with a sterile vinyl sheet. A 28 Fr gastric catheter was placed on the top of the vinyl sheet, a transparent adhesive film was affixed to the top of the catheter, and TAC was performed with a suction pressure of -30 cmH2O. After that, an elastic band was used to cover the abdomen to prevent the abdominal wall from retreating. During TAC management, sedatives, analgesics, and neuromuscular blocking drugs were administered and controlled based on ventilator monitoring.

The same surgical team performed all steps from diagnosis to surgery to postoperative management.

Blood Sampling and Assay

Blood and serum biochemical tests and arterial blood gas analysis were performed before, immediately after and 48 hours after surgery at our central clinical laboratory. The test data were extracted by reviewing the clinical records.

Definitions and Study Outcomes

Patients were classified as follows. Patients who underwent repair/anastomosis/artificial anus construction during the DCL first surgery and were managed with TAC using NPWT were classified as DCL-early, and patients who had no intestinal continuity after intestinal resection during the first surgery and were managed with TAC using NPWT were classified as DCL-delay. Patients who underwent early anastomosis were classified as DCL-early anastomosis, and patients who underwent delayed anastomosis were classified as DCL-delayed anastomosis. Patients were also grouped according to whether they underwent delayed anastomosis during second-look surgery 48 hours after the initial surgery or their delayed anastomosis was postponed.

The important research results were infusion volume and NPWT output up to 48 hours after the initial surgery with early anastomosis and delayed anastomosis. Secondary results were infusion volume with or without therapeutic intervention or complications, NPWT output, and urine volume. The delayed anastomosis implementation status and frequency of complications were also included. Complications were surgical site infection (SSI), intestinal obstruction, and suture failure.

Statistical Analysis

All statistical analyses were performed with the statistical package JMP® 11 (SAS Institute Inc., Cary, NC, USA). Continuous variables are expressed as the mean ± SD. Categorical variables are expressed as frequency (n, %), as appropriate. Normal distribution of all data was confirmed using the Shapiro-Wilk test. The data were analyzed using the chi-squared test, Wilcoxon rank-sum test, and Kruskal-Wallis test. When a significant difference was found by the Kruskal-Wallis test, the significance of the difference was examined by the Wilcoxon rank-sum test; p values < 0.05 were considered to indicate statistical significance.

Results

Study Population

A total of 109 patients were included in this study (Fig. 1). Among the 49 patients with trauma, 10 (20%) had penetrating trauma. There were 73 patients who underwent DCL and were managed with TAC using NPWT, including 36 (73%) with trauma and 37 (62%) with intra-abdominal sepsis. Among the 49 trauma patients, injury to the large intestine that required repair or anastomosis was observed in 21. The site of large intestinal injury was the ascending colon in 33% (7 patients), the transverse colon in 38% (8 patients), the descending colon in 14% (3 patients), the sigmoid colon in 28% (6 patients) and in 2

different sites of the large intestine in 3 patients. The site of perforation of the lower digestive tract was the ascending colon in 15% (9 patients), the transverse colon in 8% (5 patients), the descending colon in 3% (2 patients), the sigmoid colon in 55% (33 patients), the rectum in 13 patients (21%) and several different sites of the large intestine in 2 patients.

The no-DCL group included 9 patients who underwent repair, 8 who underwent colostomy (including 1 who underwent the Miles technique), 7 who underwent small intestine-small intestine anastomosis, 6 who underwent small intestine-colon anastomosis, and 6 who underwent colon-colon anastomosis.

The DCL-early group included 19 patients who underwent repair, 6 who underwent colostomy (including 3 who underwent the Miles technique), 1 who underwent stomach-small intestine anastomosis, 3 who underwent small intestine-small intestine anastomosis, 2 who underwent small intestine-colon anastomosis, 7 who underwent colon-colon anastomosis, and 3 who underwent colon-rectal anastomosis.

During the second-look procedure, the DCL-delay group included 7 patients who underwent ileal stoma, 4 who underwent colostomy, 6 who underwent small intestine-small intestine anastomosis, 5 who underwent small intestine-colon anastomosis, 8 who underwent colon-colon anastomosis, and 2 who underwent colon-rectal anastomosis. Of the 7 patients who underwent ileostomy, 5 required total colectomy.

Clinical Characteristics of the no-DCL and DCL-early, and DCL-delay Patients

Among the 73 people who were selected to undergo DCL, 41 underwent repair/anastomosis/artificial anus creation during the initial surgery (DCL-early) and 32 underwent anastomosis/artificial anus creation during second-look surgery (DCL-delay). The average injury severity score (ISS) for overall trauma was 24.3 ± 10. The average APACHE II score for overall intra-abdominal sepsis was 30.8 ± 6.7. A significant difference was observed between the no-DCL and DCL-delay groups during the initial surgery ($p = 0.0018$). In terms of the amount of bleeding during the initial trauma surgery, a significant difference was observed between the no-DCL and DCL-delay groups and between the DCL-early and DCL-delay groups ($p = 0.0002$ and $p = 0.0004$, respectively). In terms of the infusion volume 48 hours after surgery, a significant difference was observed between the no-DCL and DCL-early groups, between the no-DCL and DCL-delay groups, and between the DCL-early and DCL-delay groups ($p = 0.0001$, $p < 0.0001$, and $p = 0.0128$, respectively). There was no difference in the NPWT output or the relaparotomy duration between the DCL-early and DCL-delay groups, and it was possible to achieve PFC in all cases (Table 1). Anastomotic leak was observed in a total of 6 patients, including 2 in the no-DCL group (1 who underwent repair and 1 who underwent artificial anus construction) and 4 who underwent DCL (2 who underwent repair and 2 who underwent anastomosis).

Comparison of the Presence/Absence of Complications and Therapeutic Intervention in DCL Patients and the Infusion Volume, NPWT Output, and Urine Volume

The average infusion volume up to 48 hours from surgery in all patients who underwent DCL was 11246.5 ± 4305.0 ml, the average NPWT output was 1239.9 ± 712.0 ml, and the average urine volume was 2876.6 ± 2253.1 ml. Renal replacement therapy was performed for 19 patients with abdominal sepsis and 8 patients with trauma ($p = 0.01$). All cases of anastomotic leakage occurred in the patients with intra-abdominal sepsis ($p = 0.0424$) (Table 2). There was no difference between patients with trauma and those with intra-abdominal sepsis in the rate of vasopressor infusion, albumin administration, SSI, onset of adhesive intestinal obstruction, and death within 28 days, ($p = 0.2616$, $p = 0.5617$, $p = 0.1285$, $p = 0.3749$, and $p = 0.081$, respectively) (Table 2).

Comparison of the Early-Anastomosis and Delayed-Anastomosis Groups

Among the patients who underwent DCL, 16 underwent early anastomosis, and 21 underwent delayed anastomosis. There was no difference in terms of age, APACHE II score, or ISS. The delayed-anastomosis group included several patients with colon injury due to trauma ($p = 0.0271$). The surgery duration was significantly shorter in the delayed-anastomosis group ($p = 0.0001$). No difference was observed in infusion volume, NPWT output, or urine volume 48 hours after the initial surgery. There were no differences in SSI, intestinal obstruction, suture failure, or death within 28 days (Table 3). The average time until anastomosis in the delayed-anastomosis group was 72.9 ± 40.9 min.

Comparison of the Patients who Did or Did not Undergo Delayed Anastomosis During Second-Look Surgery

During second-look surgery performed 48 hours after the initial surgery, anastomosis was performed in 11 patients and postponed in 10 patients. Among the 11 patients who underwent anastomosis during the second-look surgery, 10 underwent a simultaneous procedure to close the abdomen. Regarding the serum albumin value 48 hours after the initial surgery (before second-look surgery), there was no significant difference between the anastomosis group and the group for which anastomosis was postponed (Table 4).

Discussion

This research showed that there was no difference in the infusion volume and NPWT output volume between early anastomosis and delayed anastomosis during TAC in DCL. The presence or absence of anastomosis during TAC management does not affect NPWT output volume. In patients with delayed anastomosis who received the same infusion volume as the early anastomosis patients, anastomosis and abdominal closure were possible in all cases, and infusion restrictions were not necessary in delayed anastomosis compared with early anastomosis. However, it is necessary to exercise care when performing delayed anastomosis. When a delayed anastomosis planned for 48 hours after initial surgery is complicated, the surgeon must consider postponing anastomosis instead of performing it forcibly. Moreover, the serum albumin value 48 hours after the initial surgery is not a useful indicator of whether delayed anastomosis should be postponed or conducted.

The drainage of ascites using NPWT during TAC has been shown to be beneficial due to such effects as the reduction of intestinal edema [15]and the lowering of inflammatory mediator levels [21–23]. However, there are also reports that suggest that NPWT output volume is correlated with infusion volume and is higher in fatal cases [24]. When ascites are drained with NPWT, albumin is lost, which is associated with the failure of PFC after TAC [17]. Moreover, hypoalbuminemia is a potential factor for dilutive hypoalbuminemia caused by infusion resuscitation [25, 26] and is associated with anastomotic leakage after digestive tract surgery [18–20]. Loftus et al. [17] found that late hypoalbuminemia is associated with failure of PFC. According to that report, no difference was observed in the serum albumin value up to 96 hours after TAC between the group with PFC and the group in which PFC could not be achieved. In this study, no difference in the serum albumin level 48 hours after surgery was observed between the no DCL group, the DCL-early group, and the DCL-delay group. Albumin loss due to NPWT output or dilution due to infusion, differenced between abdominal closure and laparotomy were not related to the albumin value. Additionally, there was no difference in the serum albumin value between the group that underwent delayed anastomosis during second-look surgery and the group in which delayed anastomosis was postponed. From these results, we cannot say that the serum albumin value after 48 hours from the initial surgery is a useful indicator of anastomosis. Considering the limited doses of albumin preparation administered and the low number of suture failures, the administration of exogenous albumin to prevent anastomotic leakage and reduce intestinal edema in cases of delayed anastomosis is not always useful.

Increased NPWT output was observed with vasopressor use. Since the NPWT output is related to prognosis, the NPWT output tended to be large in the group that received vasopressors, with the exception of the 3 patients who died within 28 days (1513.4 ± 779.7 ml vs 981.4 ± 449.3 ml; $p = 0.0021$). Norepinephrine is an α-adrenergic agonist that has a strong vasoconstricting action [27], and the possibility that it could reduce NPWT output was also considered. However, vasoconstriction leads to increase in venous reflux [28] and creates a special intra-abdominal environment in the only abdominal pressure is negative pressure, which could cause edema and extravasation of water and may be related to the increase in NPWT output. The selection of delayed anastomosis over early anastomosis did not increase the need for renal replacement therapy or the administration of vasoactive drugs or albumin. These findings show that the financial burden associated with delayed anastomosis is the same as that associated with early anastomosis. Interestingly, the delayed anastomosis group tended to have a shorter laparotomy duration than the early anastomosis group. The financial burden associated with TAC management is a result of delayed anastomosis. Delayed anastomosis involves considerable trauma and may be associated less with intra-abdominal contamination than with intra-abdominal sepsis and persistent inflammation resulting from intra-abdominal sepsis and intestinal edema [29]. The laparotomy duration found in this study is considered to be a localized result in view of bias regarding the disease and that the abdomen was closed at the discretion of the surgeon.

An association between insufficient infusion and NPWT output volume has been indicated as a reason for acute kidney injury [30]. In this study, it was observed that the NPWT output volume tended to be large in the group that received renal replacement therapy. No difference was observed in the infusion volume, but the urine volume differed. Renal damage is considered to be the reason for the suppressed urine

volume and large NPWT output. However, the possibility that increased NPWT output and insufficient infusion led to the occurrence of renal damage cannot be ruled out. A bolus administration of infusion corresponding to the NPWT output volume could have prevented the need for renal replacement therapy. In NPWT management, the optimal negative pressure treatment to maximize tissue growth is approximately − 125 mmHg, and the pressure level when active bleeding due to coagulative failure is suspected is approximately − 75 mmHg [31, 32]. Loftus et al. [16, 17, 29, 33] reported that 1300–1900 ml was the median value of NPWT output up to 48 hours after TAC in 4 studies that reported NPWT output. However, this could not be confirmed except in 1 report in which the NPWT negative pressure (suction amount) was − 75 mmHg. In this study, the median value of NPWT output up to 48 hours after surgery was 1080 ml. The NPWT output was less than that in the previously mentioned report. Our suction pressure setting was − 30 cmH2O (1 mmHg = 1.36 cmH2O), and low pressure management was considered one of the factors for this comparably low output. This study showed that the presence or absence of anastomosis does not impact NPWT ejection volume; however, since the NPWT output volume is predicted to depend on the suction pressure, it is necessary to consider the difference in suction pressure.

The NPWT output was lower, and the urine volume tended to be higher, in the group that underwent anastomosis during second-look surgery than in the group with postponed anastomosis. Sustainable maintenance of urine volume is considered to have reduced NPWT output, and the suppression of intestinal edema made it possible to perform anastomosis. The group in which anastomosis was postponed had higher physiological severity and more frequently received renal replacement therapy. There was no protocol for postponing delayed anastomosis, and the decision was made at the discretion of the surgeon. In the group with postponed anastomosis, the PaO2/FiO2 ratio before the second-look surgery tended to be lower, and CRP tended to be high, and general conditions and inflammation may have been involved in the postponement of anastomosis. Regarding delayed anastomosis after 48 hours, the large NPWT output may be associated with the postponement of anastomosis reflecting persistent inflammation, intestinal edema and general conditions. Additionally, low NPWT output is not necessarily disadvantageous for delayed anastomosis. The effect of drainage due to NPWT output over 48 hours must be comprehensively evaluated in combination with other body fluid balance indicators. It is difficult to think of PFC and anastomosis as the same procedure since their purpose, time to implementation and such differ. When the ultimate goal is anastomosis, early anastomosis and delayed anastomosis can be managed with the same infusion volume. However, in terms of whether delayed anastomosis is conducted or postponed, the infusion volume is related to pathology and hence should be the subject of further study by disease with a greater number of subjects.

In this study, the delayed anastomosis group included many cases of large intestine damage due to trauma, and bias was observed. Possible reasons are as follows: In large intestine injury, there is no protocol for selecting delayed anastomosis, and the surgeon may have consciously avoided selecting patients with factors such as dislodging of the colon (mobilization) for reconstruction, etc., that may prolong the duration of surgery or cause unnecessary bleeding. In HVI and lower digestive tract perforation, controlling the leakage of intestinal contents must be considered. Even in cases in which the

abdomen can be physically closed, the advantage of selecting open abdomen as a drainage effect corresponding to intra-abdominal contamination has been shown [34]. The purpose of performing early anastomosis during the initial surgery and selecting TAC is to move the patient to intensive care with the aim of controlling rapid bleeding and contamination, shorten the surgery time to greatest the possible extent, and encourage early physiological optimization [35]. However, it is necessary to reconsider some matters, such as the need for TAC with early anastomosis and whether patients for whom early anastomosis is possible might not have been selected for delayed anastomosis. Regarding DCL, overuse [36] and increased risk of abdominal complications [37] have also been pointed out. In addition, it is necessary to recognize that delayed anastomosis itself can have negative impacts; reports have described it as a disadvantageous treatment strategy [38] and have raised the possibility of ongoing peritonitis [39], increased anastomotic leakage if PFC is not possible during second-look surgery [40], and other factors.

This study has several limitations. First, our data were obtained from a single center with a limited number of diseases and cases. Second, the albumin value included in the ascites drained from NPWT was not measured, and therefore, the amount of albumin lost could not be clarified. Third, there are no clear criteria regarding the decision to perform or postpone delayed anastomosis. It is necessary to establish objective treatment selection criteria that do not depend on the subjective judgment of the surgeon. In the future, reconsideration to address multiple breaking points is required.

Conclusions

Compared with patients who underwent early anastomosis, those for whom delayed anastomosis was selected during DCL do not necessarily require infusion restrictions for the purpose of anastomosis. The presence or absence of anastomosis during TAC management does not affect the NPWT output volume, and both early anastomosis and delayed anastomosis can be managed with the same infusion volume. However, in cases in which the planned delayed anastomosis is complicated, it is necessary to postpone anastomosis rather than perform it.

Abbreviations

DCL
Damage control laparotomy
NPWT
Negative pressure wound therapy
PFC
Primary fascial closure
HVI
Hollow viscous injury
MI
Mesenteric injury

TAC
Temporary abdominal closure

Declarations

Ethical Approval and Consent to Participate

The protocol of the study was approved by the Iwate Medical University review board (MH2018-611). Consent to participate is not applicable because the data sets were pseudonymous and this study was retrospective.

Consent for Publication

Not applicable

Availability of Data and Materials

All relevant data are presented in the published manuscript.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

YT, SS, MK designed the study.YT, AK, SS, YN, HS, KI collected the patient's clinical data. YT, MK contributed to wrote the paper. YN, SE, YI, AS contributed to data interpretation, and manuscript drafting. YT, SS, HS, MK contributed to the statistical analysis and data interpretation. AS contributed to manuscript critical revision. All authors read and approved the final manuscript.

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Tables

Due to technical limitations, tables 1 to 4 is only available as a download in the Supplemental Files section.

Figures

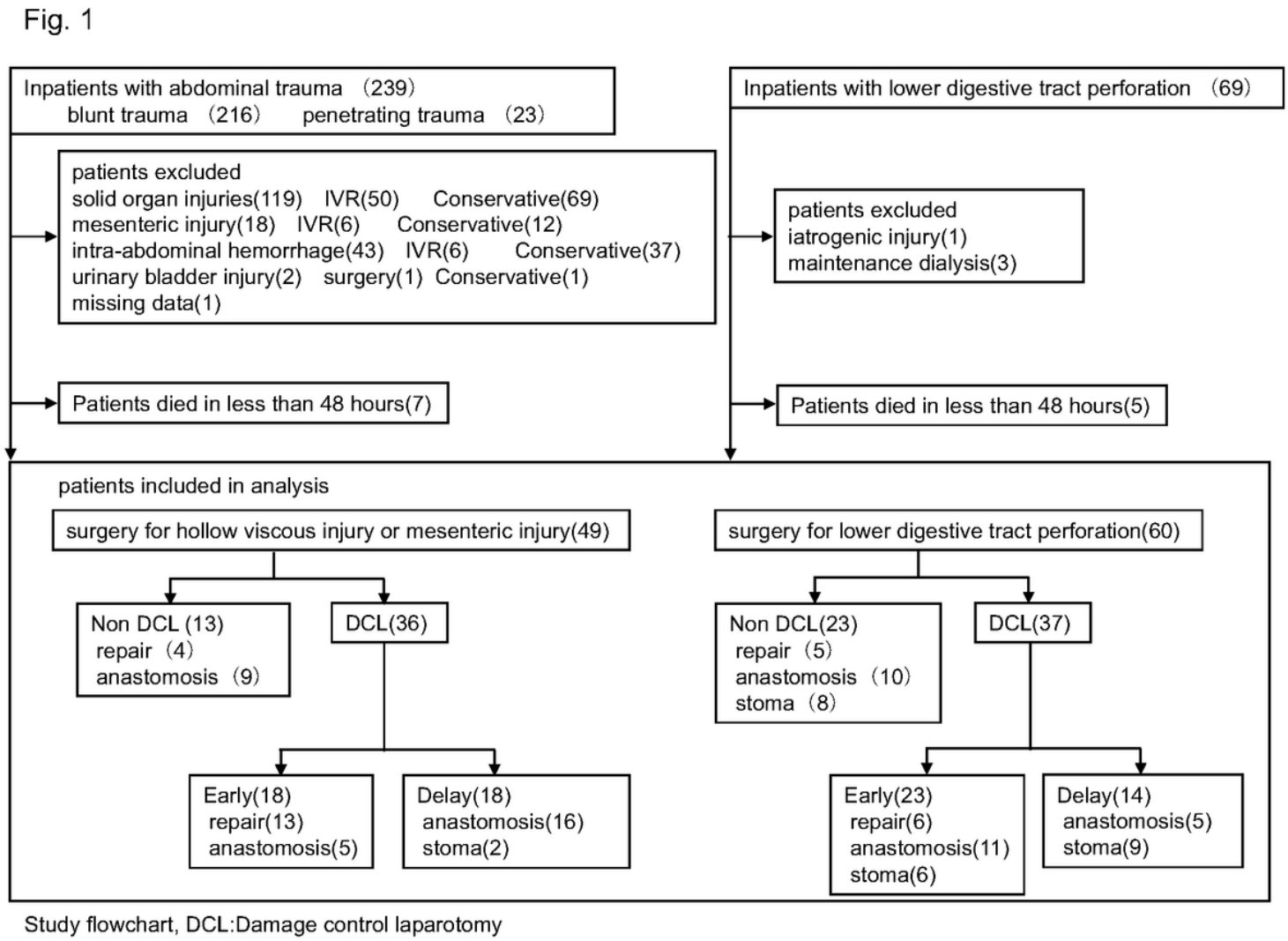

Figure 1

Study flowchart, DCL: Damage control laparotomy

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- table1.xlsx
- table2.xlsx
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