Test file: The Role of Minimally Invasive Surgery in the Management of Severe Abdominal Surgical Trauma

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Abstract

Objective: To evaluate the clinical efficacy and safety of minimally invasive surgery (MIS) compared with open surgery in the treatment of severe abdominal surgical trauma. Methods: A retrospective cohort study was conducted involving 216 patients with grade III–V abdominal trauma admitted to our institution between January 2018 and December 2022. Patients were divided into the MIS group (n=102) and the open surgery group (n=114) based on the surgical approach adopted. Perioperative indicators, including operation time, intraoperative blood loss, length of hospital stay, and postoperative complication rates, were compared between the two groups. In addition, the 30-day mortality rate was analyzed as the primary outcome measure. Results: The MIS group exhibited significantly shorter operation time (125.6 ± 32.4 min vs. 168.3 ± 41.2 min, $P<0.001$), less intraoperative blood loss (350.2 ± 120.5 mL vs. 820.6 ± 210.8 mL, $P<0.001$), and shorter hospital stay (10.2 ± 3.1 days vs. 15.6 ± 4.3 days, $P<0.001$) than the open surgery group. The overall postoperative complication rate was lower in the MIS group (18.6% vs. 35.1%, $P<0.01$), with significant differences in the incidence of wound infection and abdominal adhesion. There was no statistically significant difference in the 30-day mortality rate between the two groups (6.9% vs. 8.8%, $P>0.05$). Conclusion: Minimally invasive surgery is a safe and effective approach for selected patients with severe abdominal surgical trauma, offering advantages such as reduced intraoperative trauma, faster postoperative recovery, and lower complication rates without increasing mortality risk.

Keywords:Minimally invasive surgery; Abdominal trauma; Surgical management; Postoperative complications; Clinical outcome

1. Introduction

Surgical trauma, particularly severe abdominal trauma, remains a leading cause of mortality and morbidity in trauma patients worldwide, accounting for approximately 20% of all trauma-related deaths each year [1]. The traditional management of severe abdominal trauma relies heavily on open laparotomy, which allows direct visualization and rapid control of bleeding and organ injury[2]. However, open surgery is associated with large incisions, extensive tissue dissection, and high rates of postoperative complications, including wound infection, abdominal adhesion, and prolonged hospital stay[3]. In recent years, the development of minimally invasive surgical techniques, such as laparoscopy and robot-assisted surgery, has revolutionized the field of general surgery, and these approaches have gradually been extended to the management of traumatic injuries[4]. Despite the growing application of MIS in trauma surgery, its safety and efficacy in patients with severe abdominal trauma remain controversial, as these patients often present with hemodynamic instability and complex organ injuries, which are considered relative contraindications for minimally invasive procedures[5]. This study aims to compare the clinical outcomes of MIS and open surgery in patients with severe abdominal trauma, providing evidence-based guidance for the selection of surgical approaches in trauma management.

2. Materials and Methods

2.1 Study Population

This retrospective cohort study included patients with severe abdominal trauma admitted to the Department of General and Trauma Surgery, Massachusetts General Hospital, from January 2018 to December 2022. The inclusion criteria were as follows: (1) diagnosis of abdominal trauma confirmed by computed tomography (CT) scan or intraoperative findings; (2) injury severity score (ISS) ≥ 16; (3) abdominal organ injury grade III–V according to the American Association for the Surgery of Trauma (AAST) classification; (4) surgical intervention performed within 24 hours of injury. Exclusion criteria included: (1) hemodynamic instability requiring immediate laparotomy (systolic blood pressure < 90 mmHg despite fluid resuscitation); (2) combined severe head injury or spinal cord injury; (3) pre-existing coagulopathy or immunosuppressive conditions; (4) incomplete clinical data. The study protocol was approved by the Institutional Review Board of Massachusetts General Hospital (IRB approval number: 2023P000567), and informed consent was waived due to the retrospective nature of the study.

2.2 Surgical Procedures

Patients in the MIS group underwent laparoscopic or robot-assisted laparoscopic surgery. The surgical approach was determined by the attending surgeon based on the location and severity of organ injury, as well as the patient's hemodynamic status. Laparoscopic surgery was performed using a 3–4 trocar technique, with pneumoperitoneum pressure maintained at 10–12 mmHg. Intraoperative exploration was conducted to identify the site of injury, and corresponding procedures, including hemostasis, repair of injured organs, or segmental resection, were performed under laparoscopic visualization. Robot-assisted surgery was used for complex injuries requiring precise suturing, such as pancreatic or biliary tract injuries. Patients in the open surgery group underwent standard midline laparotomy, with incision length ranging from 15 to 25 cm. The same principles of injury control and organ repair were applied as in the MIS group.

2.3 Data Collection and Outcome Measures

Clinical data were collected from the hospital's electronic medical records, including patient demographics (age, gender, mechanism of injury), injury characteristics (ISS, AAST organ injury grade), perioperative indicators (operation time, intraoperative blood loss, volume of blood transfusion), and postoperative outcomes (length of hospital stay, intensive care unit (ICU) admission time, postoperative complications, 30-day mortality). Postoperative complications were classified according to the Clavien-Dindo classification system, and included wound infection, abdominal abscess, ileus, abdominal adhesion, and respiratory failure. The primary outcome measure was the 30-day mortality rate, and the secondary outcome measures included operation time, intraoperative blood loss, length of hospital stay, and postoperative complication rates.

2.4 Statistical Analysis

Statistical analysis was performed using SPSS 26.0 software (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and compared using the independent samples t-test. Categorical variables were expressed as frequencies and percentages, and compared using the χ^2 test or Fisher's exact test. A P value < 0.05 was considered statistically significant.

3. Results

3.1Patient Demographics and Injury Characteristics

A total of 216 patients were included in the study, with 102 patients in the MIS group and 114 patients in the open surgery group. There were no significant differences in age, gender, mechanism of injury (blunt vs. penetrating trauma), ISS, or AAST organ injury grade between the two groups (P>0.05), indicating that the two groups were comparable in baseline characteristics (Table 1). The most common injured organs in both groups were the liver, spleen, and small intestine, accounting for 65.7%, 58.8%, and 42.1% of cases, respectively.

3.2 Perioperative Outcomes

The MIS group had significantly shorter operation time than the open surgery group (125.6 ± 32.4 min vs. 168.3 ± 41.2 min, P<0.001). Intraoperative blood loss was significantly lower in the MIS group (350.2 ± 120.5 mL vs. 820.6 ± 210.8 mL, P<0.001), and the volume of blood transfusion required was also less in the MIS group (2.1 ± 1.2 units vs. 4.8 ± 2.3 units, P<0.001). The length of hospital stay was 10.2 ± 3.1 days in the MIS group, which was significantly shorter than 15.6 ± 4.3 days in the open surgery group (P<0.001). The ICU admission time was also shorter in the MIS group (2.5 ± 1.1 days vs. 4.2 ± 1.8 days, P<0.001) (Table 2).

3.3 Postoperative Complications and Mortality

The overall postoperative complication rate was 18.6% (19/102) in the MIS group and 35.1% (40/114) in the open surgery group, with a statistically significant difference between the two groups (P<0.01). The most common complication in the open surgery group was wound infection (18.4%), followed by abdominal adhesion (10.5%) and ileus (6.1%). In the MIS group, the most common complication was ileus (5.9%), followed by wound infection (4.9%) and abdominal abscess (3.9%). The incidence of wound infection and abdominal adhesion was significantly lower in the MIS group than in the open surgery group (P<0.05). There was no significant difference in the incidence of other complications, such as abdominal abscess and respiratory failure, between the two groups (P>0.05). The 30-day mortality rate was 6.9% (7/102) in the MIS group and 8.8% (10/114) in the open surgery group, with no statistically significant difference (P>0.05) (Table 3).

4. Discussion

The management of severe abdominal trauma remains a challenging task for trauma surgeons, as the optimal surgical approach must balance the need for rapid control of injury with the goal of minimizing postoperative morbidity[6]. This study demonstrated that MIS is a safe and effective alternative to open surgery for selected patients with severe abdominal trauma, as evidenced by shorter operation time, less intraoperative blood loss, shorter hospital stay, and lower postoperative complication rates, without increasing the 30-day mortality rate.

The advantages of MIS in trauma surgery are mainly attributed to its minimally invasive nature, which reduces tissue trauma and inflammatory response[7]. The smaller incisions used in MIS result in less wound tension, lower risk of wound infection, and faster wound healing[8]. In addition, the magnified visualization provided by laparoscopy or robot-assisted systems allows for more precise hemostasis and organ repair, which contributes to reduced intraoperative blood loss and transfusion requirements[9]. The shorter hospital stay and ICU admission time observed in the MIS group are consistent with previous studies, indicating that minimally invasive approaches facilitate faster postoperative recovery and reduce healthcare costs[10].

Despite these advantages, the application of MIS in severe abdominal trauma is not without limitations. Hemodynamic instability is a well-recognized contraindication for MIS, as pneumoperitoneum may further compromise venous return and cardiac output[11]. Therefore, careful patient selection is crucial for the success of MIS in trauma surgery. In this study, patients with systolic blood pressure < 90 mmHg despite fluid resuscitation were excluded from the MIS group, which may explain the similar mortality rate between the two groups. In addition, MIS requires specialized surgical skills and equipment, which may not be available in all trauma centers, especially in resource-limited settings[12].

Another important finding of this study is that the incidence of abdominal adhesion was significantly lower in the MIS group. Abdominal adhesion is a common complication of open laparotomy, which can lead to chronic abdominal pain, ileus, and even infertility in female patients[13]. The reduced incidence of abdominal adhesion with MIS is a significant long-term benefit, as it improves the quality of life of trauma survivors.

This study has several limitations. First, it is a retrospective cohort study, which is subject to selection bias. The surgical approach was determined by the attending surgeon, which may have introduced confounding factors. Second, the study was conducted at a single institution, and the results may not be generalizable to other trauma centers with different patient populations and surgical protocols. Third, the follow-up period was limited to 30 days, and long-term outcomes, such as the incidence of abdominal adhesion and quality of life, were not evaluated. Future prospective randomized controlled trials with larger sample sizes and longer follow-up periods are needed to confirm the findings of this study.

5. Conclusion

Minimally invasive surgery is a safe and effective surgical approach for selected patients with severe abdominal surgical trauma. Compared with open surgery, MIS offers significant advantages in terms of reduced intraoperative trauma, faster postoperative recovery, and lower complication rates, without increasing the 30-day mortality risk. Careful patient selection and specialized surgical skills are essential for the successful application of MIS in trauma surgery. Further research is needed to evaluate the long-term outcomes of MIS in the management of severe abdominal trauma.

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