

COST-EFFICIENT IMPLEMENTATION OF MULTI-STAGE SURGICAL STRATEGIES FOR SEVERE LIVER INJURIES USING THE “DAMAGE CONTROL” APPROACH

Abstract:

Severe liver trauma poses a significant clinical and economic challenge, particularly in emergency surgical care. The "damage control" strategy, based on a staged approach to surgical intervention, has demonstrated not only improved clinical outcomes but also reduced overall healthcare costs. This study analyzes 19 critical cases of liver trauma where the "damage control" method was applied, focusing on both medical results and cost-effectiveness.

The method involves initial rapid hemorrhage control, followed by intensive resuscitation, and delayed definitive surgery. This structured staging prevents complications such as multiple organ failure, reduces ICU and hospital stay duration, and limits the need for extensive surgical procedures. The average number of surgeries per patient was 2.7, with a significant reduction in mortality (from 53.3% to 19.5%) compared to the one-stage “early total care” model.

From an economic perspective, adopting "damage control" surgery minimizes resource depletion in critical phases and allows for optimal allocation of medical staff, surgical time, transfusion volumes, and critical care equipment. By preventing early fatal outcomes and costly complications, the strategy contributes to sustainable surgical care in resource-limited health systems.

Keywords: Liver trauma, damage control surgery, staged surgical intervention, critical care economics, resource optimization, cost-effectiveness, surgical planning, trauma systems.

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ЭКОНОМИЧНО ЭФФЕКТИВНАЯ РЕАЛИЗАЦИЯ МНОГОЭТАПНОЙ ХИРУРГИЧЕСКОЙ ТАКТИКИ ПРИ ТЯЖЕЛЫХ ПОВРЕЖДЕНИЯХ ПЕЧЕНИ С ИСПОЛЬЗОВАНИЕМ ПОДХОДА «DAMAGE CONTROL»

Аннотация:

Тяжелая травма печени представляет собой не только серьезную клиническую, но и экономическую проблему, особенно в условиях экстренной хирургической помощи. Стратегия «damage control», основанная на многоэтапном подходе к хирургическому вмешательству, показала не только улучшение клинических результатов, но и снижение общих расходов в системе здравоохранения.

В исследовании проанализированы 19 критических случаев травм печени, при лечении которых применялась тактика «damage control». Метод включает в себя три этапа: первоначальное

быстрое купирование кровотечения, интенсивную противошоковую терапию и отсроченное радикальное хирургическое вмешательство. Такой структурированный подход позволяет избежать осложнений, таких как полиорганная недостаточность, сократить продолжительность пребывания в отделении реанимации и стационаре, а также уменьшить объемы инвазивных вмешательств. Среднее количество операций на одного пациента составило 2,7, при этом летальность снизилась с 53,3% до 19,5% по сравнению с одноэтапной тактикой «раннего тотального лечения».

С экономической точки зрения, внедрение метода «damage control» способствует более рациональному использованию ресурсов в критические периоды. Это позволяет оптимально распределять рабочее время медицинского персонала, операционные ресурсы, объемы переливания крови и использование оборудования интенсивной терапии. Профилактика летальных исходов и дорогостоящих осложнений делает данный подход устойчивым и экономически оправданным в системах здравоохранения с ограниченными ресурсами.

Ключевые слова: травма печени, хирургия damage control, многоэтапное хирургическое вмешательство, экономика интенсивной терапии, оптимизация ресурсов, экономическая эффективность, планирование хирургии, травматологическая система.

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ЖИГАРНИНГ ОҒИР ШИКАСТЛАНИШЛАРИДА "DAMAGE CONTROL" ЁНДАШУВИДАН ФОЙДАЛАНГАН ҲОЛДА КЎП БОСҚИЧЛИ ЖАРРОҲЛИК ТАКТИКАСИНИ ТЕЖАМКОРЛИК БИЛАН АМАЛГА ОШИРИШ.

Аннотация: Жигарнинг оғир шикастланиши нафақат жиддий клиник, балки иқтисодий муаммо ҳамдир, айниқса шошилинч жарроҳлик ёрдами шароитида. Жарроҳлик аралашувига кўп босқичли ёндашувга асосланган "зарарларни назорат қилиш" стратегияси нафақат клиник натижаларнинг яхшиланишини, балки соғлиқни сақлаш тизимида умумий харажатларнинг камайишини ҳам кўрсатди.

Тадқиқотда 19 та жигар шикастланишининг критик ҳолатлари таҳлил қилинган, уларни даволашда "damage control" тактикаси қўлланилган. Усул учта босқични ўз ичига олади: қон кетишини дастлабки тезда тўхтатиш, шокка қарши интенсив терапия ва кечиктирилган радикал жарроҳлик аралашуви. Бундай тизимли ёндашув полиорган етишмовчилик каби асоратларнинг олдини олиш, реанимация бўлими ва шифохонада бўлиш муддатини қисқартириш, шунингдек, инвазив аралашувлар ҳажмини камайтириш имконини беради. Бир беморга тўғри келадиган операцияларнинг ўртача сони 2,7 ни ташкил этди, ўлим даражаси бир босқичли "эрта тотал даволаш" тактикасига нисбатан 53,3% дан 19,5% гача камайди.

Иқтисодий нуқтаи назардан, "зарарни назорат қилиш" усулини жорий этиш танқидий даврларда ресурслардан янада оқилона фойдаланишга ёрдам беради. Бу тиббиёт ходимларининг иш вақтини, операцион ресурсларни, қон қуйиш ҳажмини ва интенсив терапия ускуналаридан фойдаланишни оптимал тақсимлаш имконини беради. Ўлим ҳолатлари ва қиммат асоратларнинг олдини олиш ушбу ёндашувни ресурслари чекланган соғлиқни сақлаш тизимларида барқарор ва иқтисодий жиҳатдан ўзини оқлайдиган қилади.

Калит сўзлар: жигар жароҳати, жарроҳлик шикастланишни назорат қилиш, кўп босқичли жарроҳлик аралашуви, интенсив терапия иқтисодиёти, ресурсларни оптималлаштириш, иқтисодий самарадорлик, жарроҳликни режалаштириш, травматологик тизим.

Introduction

Liver trauma, particularly of a severe nature, represents one of the most complex challenges in emergency abdominal surgery. The incidence of liver damage ranges from 20–46.9% in blunt abdominal trauma and up to 86.4% in penetrating injuries. According to various studies, mortality rates vary widely: approximately 30.4% for blunt trauma, 4–10.5% for stab wounds, and as high as 39.3% in polytrauma cases.

When the injury reaches grades IV or V (Moore classification), mortality may escalate to 40–80%, often complicated by hemorrhagic shock, abdominal compartment syndrome, and sepsis.

Traditional strategies involve one-stage laparotomy and comprehensive repair, which may be overly invasive in unstable patients. In contrast, "damage control" surgery, as introduced by M. Rotondo in 1993, emphasizes early bleeding control, intensive resuscitation, and delayed definitive repair.

In recent decades, the management of hepatic trauma has undergone significant evolution due to advances in imaging, critical care, and surgical techniques. Despite these improvements, high-grade liver injuries (grades IV–V) continue to be associated with a high mortality rate, particularly in settings lacking access to advanced medical infrastructure.

The liver is the second most frequently injured organ in abdominal trauma, following the spleen. According to the World Society of Emergency Surgery (WSES) guidelines (2020), liver trauma accounts for approximately 35–45% of all abdominal trauma cases, with non-operative management (NOM) being effective in more than 80% of low-grade injuries. However, NOM is not feasible in hemodynamically unstable patients or those with high-grade injuries and active bleeding.

Recent systematic reviews suggest that in patients with major hepatic injuries, early mortality is primarily driven by exsanguination, while late mortality is frequently due to sepsis and multiorgan dysfunction syndrome (MODS). Therefore, treatment protocols that prioritize early hemostasis and physiological stabilization have gained prominence.

The "damage control surgery" concept, originally introduced by Rotondo et al. in 1993, has become a cornerstone in modern trauma surgery. This approach focuses on the initial control of bleeding and contamination, temporary abdominal closure, followed by intensive care resuscitation and delayed definitive repair. Its application has been associated with significant improvements in survival, especially among patients with severe trauma and physiological derangements.

Objective

The primary objective of this study is to assess the clinical efficacy of the "damage control" surgical approach in the management of patients with critical liver trauma, particularly those presenting with high-grade (IV–V) injuries and hemodynamic instability. This includes evaluating patient outcomes in terms of mortality, complication rates, and recovery timelines.

In parallel, the study aims to examine the economic and logistical feasibility of implementing a multi-stage surgical strategy in an emergency care setting. Special attention is given to the optimization of

critical care resources, including operating room time, blood transfusion requirements, ICU occupancy, and staff workload.

Additionally, the research seeks to validate a severity-based triage algorithm designed to assist in early identification of patients who would most benefit from staged surgical intervention, thus enhancing individualized treatment planning and overall system efficiency.

By integrating clinical outcomes with cost-effectiveness analysis, the study endeavors to provide evidence-based recommendations for surgical practice in resource-limited trauma centers, ultimately contributing to improved survival rates and more sustainable trauma care delivery.

Materials and Methods

From 2012 to 2022, 170 patients with hepatic trauma were surgically treated at the SFRNCEMMP. Among them, 19 patients had high-grade injuries (grades IV–V). These patients underwent multi-stage interventions involving gauze or film tamponade, with an average of 2.7 operations per patient. Techniques included liver suturing, major vessel ligation, extensive hepatotomy, and atypical resections.

- Mean ISS: 34 (range: 17–76)
- Average ICU stay: 13 days
- Average hospital stay: 25 days
- Mortality rate: 26.3%

Additionally, a comparative analysis was conducted involving two patient cohorts:

- Group 1 (n=41): treated using the "damage control" method
- Group 2 (n=30): treated with a one-stage "early total care" approach

Mortality in Group 1 was significantly lower (19.5%) than in Group 2 (53.3%).

Proposed Algorithm and Severity Scoring

A tailored scoring system was introduced to determine the necessity of "damage control":

- <9 points: no indication
- 10–16 points: clear indication
- 8–9 points: clinical discretion

Factors considered: duration of illness, peritonitis source, type of necrosis or obstruction, shock severity, laboratory parameters (Hb, urea, electrolytes), ECG, vital signs.

Patients were stratified:

- 1–10: Compensated, favorable prognosis
- 11–29: Subcompensated, borderline status
- 30–44: Decompensated, poor prognosis

Results and Discussion

The application of the “damage control” surgical approach resulted in a marked reduction in mortality and postoperative complications among patients with severe hepatic trauma. Specifically, the mortality rate in the damage control group (Group 1) was 19.5%, significantly lower than the 53.3% observed in the early total care group (Group 2). This highlights the clinical advantage of staging surgical interventions in patients who are physiologically compromised at admission.

Patients undergoing damage control surgery also experienced improved hemodynamic stabilization during the resuscitation phase, which facilitated more effective subsequent definitive surgical repair. The mean number of operations per patient was 2.7, with a progressive decrease in intraoperative blood loss and transfusion volumes over the staged interventions.

ICU stay and total hospital stay were reduced in the damage control group, with average durations of 13 and 25 days, respectively. These outcomes suggest better recovery trajectories and lower incidence of complications such as abdominal sepsis, multi-organ dysfunction syndrome (MODS), and coagulopathy.

The economic analysis further supports the clinical findings. Resource allocation—particularly in terms of operative time, critical care equipment usage, and staff burden—was more efficient in the damage control cohort. By preventing early fatal deterioration and minimizing the need for high-complexity surgeries under unstable conditions, the damage control approach proved both clinically and economically advantageous.

Additionally, the implementation of the triage algorithm facilitated timely decision-making regarding the suitability of damage control intervention. Patients with high ISS scores and physiologic derangement clearly benefited from a structured, phased approach. The stratification system based on clinical, laboratory, and hemodynamic criteria proved effective in guiding management decisions.

These results align with global trauma surgery literature emphasizing the importance of early bleeding control, physiological stabilization, and delayed definitive procedures in reducing trauma-related mortality. The findings of this study confirm that even in resource-constrained environments, adopting structured damage control principles can lead to favorable outcomes comparable to those in high-income trauma centers.

Conclusions

- The “damage control” surgical strategy is a clinically effective and economically sustainable approach for managing severe liver trauma, particularly in cases involving hemodynamic instability, coagulopathy, and high injury severity scores.
- Multi-stage surgical intervention, consisting of rapid hemorrhage control, resuscitation in the ICU, and delayed definitive surgery, significantly reduces mortality rates and the incidence of postoperative complications such as MODS, abdominal sepsis, and prolonged ventilatory support.
- Compared to the one-stage “early total care” method, the damage control approach allows for more rational utilization of critical hospital resources—including operative time, blood transfusions, and intensive care capacities—especially vital in low-resource healthcare settings.
- The introduction of a structured clinical algorithm for patient stratification and decision-making enhanced the precision of surgical planning. Early identification of candidates for staged intervention contributed to improved outcomes and minimized unnecessary surgical burden.

- This study supports the broader adoption of damage control principles in trauma surgery protocols, advocating for their integration into national treatment guidelines—particularly in healthcare systems where infrastructure limitations demand cost-efficient and outcome-oriented strategies.

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