

# “Zooming” in strategies and outcomes for trauma cases with Injury Severity Score (ISS) $\geq 16$ : promise or passé?

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## SUMMARY

**OBJECTIVE:** Rescuing severe trauma cases is extremely demanding. The present study purposed to analyze the efficiency of trauma management at Emergency Centre, University Clinical Centre of Serbia, Belgrade, included outcome within 28 days.

**METHODS:** This retrospective study involved 131 intensive care unit trauma cases with total Injury Severity Score  $\geq 16$ , in terms of administrating the two strategies: (i) definitive surgical repair and (ii) damage control laparotomy.

**RESULTS:** The damage control laparotomy cases revealed statistically higher Injury Severity Score and APACHE II scores, significant brain dysfunction, and hemorrhagic shock on arrival ( $p < 0.001$ ). In addition, the damage control laparotomy had a higher rate of respiratory complications, multiple organ deficiency syndrome, and surgical wound complications ( $p = 0.017$ ,  $< 0.001$ , and  $0.004$ , respectively), with more days on mechanical ventilation ( $p = 0.003$ ). Overall mortality was 29.8%. Although higher early mortality within  $\leq 24$  h in the damage control laparotomy ( $p = 0.021$ ) had been observed, no difference between groups ( $p = 0.172$ ) after the 4th day of hospitalization was detected.

**CONCLUSIONS:** Trauma patients have a high mortality rate in the 1st hours after the incident. Compelling evidence linking host and pathogen factors, such as mitochondrial apoptosis pathways, appears to correlate with loss of organ dysfunction, both cytopathologically and histopathologically. Adequate selection of patients necessitating damage control laparotomy, allowed by the World Society of Emergency Surgery, abdominopelvic trauma classifications, and improvements in resuscitation, may improve the results of severe trauma treatment.

**KEYWORDS:** Wounds and injuries. Emergencies. Pathology. Mortality.

## INTRODUCTION

Severe abdominal trauma associated with injuries could have been accompanied by fatal complications, and its management remains a great challenge. In a severe trauma patient, the biggest issues for the surgeon are choosing the most appropriate surgical approach and rapid controlling of injury. Severely traumatized patients could develop swiftly life-threatening traumatic coagulopathy induced by massive bleeding, hemodynamic shock, deregulation of the coagulation cascade, and activation of anticoagulant and fibrinolytic pathways. Definitive surgical repair (DSR) is a traditional approach dealing with convenient injuries during initial emergency laparotomies. However, damage control laparotomy (DCL) has been established in order

to minimize the pathophysiological impact of the relevant lethal triad<sup>1,2</sup>. The present study analyzes the effectiveness of two kinds of surgical approaches, DCL vs. DSR, in severely injured patients who had been treated multidisciplinary at the Emergency Centre, University Clinical Centre of Serbia, Belgrade, during a 1-year interval, considering the outcomes within the 28-day in-hospital mortality.

## METHODS

A total of 131 adult polytrauma cases (Injury Severity Score [ISS]  $\geq 16$ ), who had undergone the emergency laparotomy, due to the abdominal injuries grades III–V according to the American Association for the Surgery of Trauma (AAST), had

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Conflicts of interest: the authors declare there is no conflicts of interest. Funding: Former project CN175091, now contract No. 200110, funded by the Ministry of Education, Science and the Technological Development Republic of Serbia.

Received on February 14, 2022. Accepted on February 15, 2022.

been involved in the present retrospective study<sup>3</sup>. Dead on arrival and patients treated by nonoperative management (NOM) had been excluded from the study by administrating the cases with the two surgical approaches, DCL vs. DSR, for the therapeutic purposes<sup>4</sup>. To this end, DSR had been opted for a total of 109 (83.2%) patients, through the midline incision abdominal exploration, followed by a hemostatic control and definitive injury repair, such as the simple suture for the intestinal injury, organ resection, selective vascular ligation, and debridement of the extensive devitalized tissue, whereas DCL had been applied in 22 (16.8%) patients with an indication of life-saving bleeding control in the hemodynamically unstable cases who had not responded to the initial resuscitation due to the complex liver injuries, pelvic fracture, and physiological derangement as the metabolic acidosis (lactate  $< 5$  mmol/L, pH  $< 7.2$ , base deficit  $> 14$ ), hypothermia (temperature  $< 34^{\circ}\text{C}$ ), and coagulopathy (INR  $> 1.5$  with PT and PTT  $> 2$  folds). The first stage of the DCL was middle line laparotomy, followed by a rapid control of life-threatening hemorrhage and source control for a hollow viscus perforation. In case of liver trauma, blood vessels were suture/ligated before the packing and the Pringle maneuver had been used temporarily for providing the inflow vascular control purposes. For the perihepatic packing procedure, we used approximately 4–6 sterile abdominal swabs, which were never placed directly onto the liver laceration or hematoma. During the explorative laparotomy in cases with the concomitant unstable complex pelvic fracture and progressive retroperitoneal hematoma, we indicated the transabdominal pelvic packing. Arterial and major venous injuries within the internal iliac distribution had been controlled by vascular repair or ligation while the pelvic tamponade had been used to control venous hemorrhage from the presacral plexus and prevesical veins, followed by an orthopedic external pelvic stabilization. As the second stage had comprised the multidisciplinary treatment in an intensive care unit (ICU) to stabilize the physiological status of the cases in the next 48 h, the third stage in DCL had been a planned re-laparotomy, including removal of the abdominal packing and definitive surgical reconstruction. All the cases had been followed up for 28 days. Major complications were defined as Clavien-Dindo grade  $\geq 3$ : diffuse peritonitis, traumatic coagulopathy, ventilator-associated pneumonia (VAP), sepsis, and multiple organ deficiency syndrome (MODS)<sup>5-8</sup>, while early mortality as a death occurred within the first 24 h and the late one occurred after 96 h.

### Statistical analyses

Depending on the type of variables and the normality of the distribution, results were presented as frequency (percent),

median (range), and mean  $\pm$  standard deviation. The statistical hypotheses were tested using (i) the Student’s t-test, (ii) the Mann-Whitney U test, (iii) the chi-square test, and (iv) the Fisher’s exact test. A statistical hypothesis was analyzed at the level of significance of 0.05, while the statistical data analyses were performed using IBM SPSS Statistics 22.0 (IBM Corporation, Armonk, NY, USA).

## RESULTS

No significant difference was recognized in terms of sex, age, comorbidity, and mechanism of injury ( $p > 0.05$ , Table 1). The leading cause of the blunt trauma occurred due to road

**Table 1.** Demographic and initial clinical presentation on admission for the damage control laparotomy vs. definitive surgical repair.

Characteristics	DCL n (%) 22 (16.8)	DSR n (%) 109 (83.2)	p
Sex			
Male	20 (90.9)	94 (86.2)	0.736
Female	2 (9.1)	15 (13.8)	
Age (years) <sup>a</sup>	42.23 $\pm$ 20.84	40.90 $\pm$ 16.64	0.781
Comorbidity $\geq 2$	7 (31.8)	20 (18.3)	0.160
Blunt trauma	20 (90.9)	80 (73.4)	0.100
SBP $< 90$	18 (81.8)	34 (32.2)	$< 0.001$
Hemorrhagic shock	21 (95.5)	23 (21.1)	$< 0.001$
GCS $\leq 12$ <sup>b</sup>	14 (63.6)	26 (23.9)	$< 0.001$
ISS <sup>a</sup>	40.05 $\pm$ 11.01	29.75 $\pm$ 9.46	$< 0.001$
APACHE II <sup>a</sup>	25.50 $\pm$ 3.39	21.06 $\pm$ 5.15	$< 0.001$
Retroperitoneal hematoma (RPH)	9 (40.9)	30 (27.5)	0.050
Stomach <sup>AAST <math>\geq 3</math></sup>	4 (18.2)	6 (5.5)	0.064
Small intestine <sup>AAST <math>\geq 3</math></sup>	4 (18.2)	18 (16.5)	0.764
Colon <sup>AAST <math>\geq 3</math></sup>	7 (31.8)	20 (18.3)	0.160
Pancreas <sup>AAST <math>\geq 3</math></sup>	2 (9.1)	6 (5.5)	0.621
Kidney <sup>AAST <math>\geq 3</math></sup>	3 (13.6)	6 (5.5)	0.175
Thorax injury <sup>AIS <math>\geq 3</math></sup>	19 (86.4)	58 (53.2)	0.004
Orthopedic injury <sup>AIS <math>\geq 3</math></sup>	17 (77.3)	35 (32.1)	$< 0.001$
Spinal injury <sup>AIS <math>\geq 3</math></sup>	4 (18.2)	16 (14.7)	0.746
Head injury <sup>AIS <math>\geq 3</math></sup>	13 (59.1)	26 (23.9)	0.001
Maxillofacial injury <sup>AIS <math>\geq 3</math></sup>	4 (18.2)	16 (14.7)	0.746
Vascular injury <sup>AIS <math>\geq 3</math></sup>	3 (13.6)	12 (11.0)	0.717

SBP: systolic blood pressure; GCS: Glasgow Coma Scale; ISS: Injury Severity Score; APACHE II: Acute Physiology and Chronic Health Evaluation II score; DCL: damage control laparotomy; DSR: definitive surgical repair. <sup>a</sup>Mean  $\pm$  SD. <sup>b</sup>GCS score  $\leq 12$  utilized for defined moderate to severe brain injury.

traffic accidents ( $p>0.05$ ). The DCL cases revealed significant hypotension on arrival, hemorrhage shock, and brain injury ( $p<0.001$  for all, Table 1). The DCL vs. DSR had significantly higher ISS ( $40.05\pm 11.01$  vs.  $29.75\pm 9.46$ ) and APACHE score ( $25.50\pm 3.39$  vs.  $21.06\pm 5.15$ ) ( $p<0.001$ , Table 1). In addition, the DCL exhibited significantly more extra-abdominal injuries: (i) the thorax (86.4 vs. 53.2%), (ii) orthopedic (77.3 vs. 32.1%), and (iii) the head (59.1% vs. 23.9%) ( $p=0.004$ ,  $<0.001$ , and  $0.001$ , respectively). A significant rate of severe liver and pelvis injury, according to WSES and AAST classification, was revealed in the DCL (Table 2), whereas the spleen was the most frequently injured abdominal solid organ in both groups (36.4% vs. 41.3%,  $p>0.05$ ). We performed the liver packing procedure in half of the cases with severe liver injury, while the implementation of transabdominal pelvic packing with the external fixation of the pelvis was done in the other half in DCL due to severe pelvic trauma. The definitive surgery for the liver trauma was performed by the liver resection in 5 (4.6%) cases, while the parenchyma suture was performed in 23 (21.1%) cases. A statistically more hollow viscus suture was recognized in the DCL ( $p=0.001$ , Table 3). Herein, no significant numerical difference was found ( $p>0.05$ ) while performing the splenectomy (22.7 vs. 41.3%), distal pancreatectomy (4.5 vs. 4.6%), adrenalectomy (4.5 vs. 1.8%), nephrectomy (4.5 vs. 3.7%), repair of bladder (18.2 vs. 8.3%), and hollow viscus resection (13.6% vs. 20.2%). In addition, significantly more patients in the DCL had developed the traumatic coagulopathy ( $p=0.006$ ), who had received more red blood cells (RBC) units of transfusion within the first 24 h ( $p=0.002$ ), including massive blood transfusion (MBT) protocol ( $p=0.001$ , Table 3). The sepsis had developed in 28 (21.4%) cases in total without any significance

( $p>0.05$ ). The DCL had been recognized as possessing significant respiratory complications, such as VAP and pleural effusion ( $p=0.017$ ). Of 32 (24.4%) cases, VAP was recorded without a significance (31.8% vs. 21.9%,  $p>0.05$ ) and 39 (29.8%) cases revealed the pleural effusion followed by the basal lung segment atelectasis, without difference between the groups (45.5 vs. 26.6%,  $p>0.05$ ). The DCL cases had a significantly higher rate of MODS ( $p<0.001$ ) and significantly more patients had surgical wound complications ( $p=0.004$ ) (Table 3). Notably, two (1.5%) patients had intestinal fistula, four (3.1%) had pancreatic fistula, and six (4.6%) had bile leakage, without significant difference ( $p>0.05$ ). The postoperative course had not revealed a statistical difference between ICU stay and overall hospital stay, though the DCL had possessed significantly more days on the mechanical ventilation ( $p=0.003$ ). Overall mortality in the present study had been detected as 29.8%. Analyzing outcomes in time interval had revealed significantly higher mortality within  $\leq 24$  h in the DCL cases involved in the present study ( $p=0.021$ ).

## DISCUSSION

It is a critical emergency surgery in which clinicians stay vigilant of DCL for unstable trauma patients as a life-saving surgical approach of rapid hemostatic and the relevant source control for gastrointestinal injury with temporary wound closure<sup>9-11</sup>. To this end, DSR, in terms of being a kind of time-consuming procedure, is not usually recommended in trauma cases with critical physiological status, despite excellent surgical techniques<sup>12</sup>. The rate of cases treated by the DCL approach in the present study was 16.8%, compared to 6–18% in the other studies<sup>13</sup>. However, Hommes et al.<sup>12</sup> reported treating

**Table 2.** World Society of Emergency Surgery and American Association for the Surgery of Trauma classification for liver, spleen, and pelvis trauma<sup>3,9,10,11</sup>.

		WSES grade		p	AAST grade		p
		Moderate	Severe		Moderate	Severe	
		II+III n (%)	IV n (%)		III n (%)	IV+V n (%)	
Liver	DSR	29 (82.9)	0 (0.0)	<0.001	24 (100.0)	5 (31.2)	<0.001
	DCL	6 (17.1)	5 (100.0)		0 (0.0)	11 (68.8)	
Spleen	DSR	34 (91.9)	11 (84.6)	0.594	12 (92.3)	33 (89.2)	1.000
	DCL	3 (8.1)	2 (15.4)		1 (7.7)	4 (10.8)	
Pelvis	DSR	22 (84.6)	0 (0.0)	<0.001	15 (100.0)	7 (38.9)	<0.001
	DCL	4 (15.4)	7 (100)		0 (0.0)	11 (61.1)	

WSES: The World Society of Emergency Surgery; AAST: The American Association for the Surgery of Trauma; DCL: damage control laparotomy; DSR: definitive surgical repair.

**Table 3.** The surgical procedures, ICU clinical course, and outcomes in the damage control laparotomy vs. definitive surgical repair.

Characteristics	DCL n (%) 22 (16.8)	DSR n (%) 109 (83.2)	p
Splenectomy	5 (22.7)	45 (41.3)	0.102
Liver resection	1 (4.5)	5 (4.6)	0.993
Liver suture	2 (9.1)	22 (20.2)	0.364
Hollow viscus suture	12 (54.5)	22 (20.2)	0.001
Maxillofacial surgery	3 (13.6)	12 (11.0)	0.717
Neurosurgical interventions	3 (13.6)	15 (13.8)	1.000
Orthopedic surgery	13 (59.1)	19 (17.4)	<0.001
Spinal surgery	1 (4.5)	6 (5.5)	1.000
Surgical tracheostomy <sup>a</sup>	8 (36.4)	16 (14.7)	0.030
Surgical gastrostomy <sup>a</sup>	8 (36.4)	14 (12.8)	0.012
Chest tube	14 (63.6)	42 (38.5)	0.030
Emergency thoracotomy	1 (4.5)	3 (2.8)	0.525
Emergency vascular procedures	2 (9.1)	5 (4.6)	0.334
MBT <sup>b</sup>	14 (63.6)	28 (25.7)	0.001
RBC units $\geq 24$ h <sup>a</sup>	10 (2–20)	5 (2–26)	0.002
Traumatic coagulopathy	19 (86.4)	9 (8.3)	<0.001
Sepsis	8 (36.4)	20 (18.3)	0.085
Respiratory complications	17 (77.3)	54 (49.5)	0.017
MODS	12 (54.5)	19 (17.4)	<0.001
Surgical wound complications	7 (31.8)	8 (7.3)	0.004
Abdominal complications	3 (13.6)	9 (8.2)	0.693
Re-laparotomy	0 (0.0)	5 (4.6)	0.589
MV <sup>day 1</sup>	5 (0–19)	1 (0–20)	0.003
ICU <sup>day 1</sup>	7 (1–24)	4 (0–25)	0.124
Hospital length of stay <sup>day 1</sup>	11 (1–28)	10 (1–28)	0.535
Early mortality $\leq 24$ h	6 (27.3)	9 (8.3)	0.021
Late mortality $\geq 96$ h	3 (13.6)	14 (12.8)	0.172
Mortality 24–96 h	0 (0)	7 (6.4)	0.359
Mortality	9 (40.9)	30 (27.5)	0.210

<sup>a</sup>Tracheostomy was indicated when MV was prolonged ( $\geq 10$  days) after the first spontaneous breathing trial. <sup>b</sup>Gastrostomy for enteral feeding indicated during prolonged MV ( $\geq 10$  days). RBC: red blood cells; MBT: massive blood transfusion; ICU: intensive care unit; MODS: multiple organ dysfunction syndrome; MV: mechanical ventilation. <sup>c</sup>Med (min–max).

31% of patients using the DCL approach for liver trauma on severe abdominal injuries in the right upper quadrant. We also reported complex hepatic trauma management in which the liver packing had been performed at the rate of 48.8%<sup>14</sup>. According to these data, the DCL approach becomes

more frequent in the more selected cases of hepatic injury. In the present study, the DCL exhibited more orthopedic, thoracic, and head injuries with the additional extrabdominal surgical procedures.

Uncontrolled bleeding is considered a dominant cause of early trauma-related death in severe abdominal trauma<sup>1,2,15,16</sup>. Of note, the classification of organ injuries should be related not only to the topography but also to associated physiological derangement<sup>3,9,10,11</sup>, which might lead to more tailored management. Severe pelvic trauma with massive hemorrhage strongly contributes to a high mortality rate in polytrauma patients<sup>17</sup>. Complex treatment of pelvic trauma includes procedures to achieve hemodynamic stability and stabilization of the pelvic ring<sup>17,18</sup>. We performed the DCL transabdominal pelvic packing in the exsanguinated patients with associated complex pelvic trauma. According to the European guideline on management of major bleeding and coagulopathy following trauma, severely injured patients who presented with deep hemorrhagic shock, signs of bleeding, and coagulopathy should undergo DCL (Strong Recommendation [Grade 1B])<sup>2</sup>.

Severe trauma results in a strong inflammatory response and life-threatening complications. VAP in the ICU can be expected in critically injured cases who are on mechanical ventilation (MV)<sup>19</sup>, for more than 2 days, with an incidence ranging from 5% to 40% and a mortality rate of 10%<sup>20</sup>. The complex pathophysiology of MODS after trauma includes multifactorial pathologies such as initial exsanguination, MBT, and systemic inflammatory response, of which the most crucial is the severity of injury<sup>21</sup>. Multifactorial impairment of physiological status is the main reason for death in patients with severe trauma<sup>6–13</sup>. The severity of mitochondrial pathology was reported to correlate with sepsis-induced cell and organ failure, both cytopathologically and histopathologically<sup>22</sup>. Harvin et al.<sup>23</sup> stated that mortality following penetrating abdominal trauma was 10%, while it was much higher than 40% for blunt trauma. In the present study, the overall 28-day mortality was detected in 29.8%. The analysis of mortality concerning the period postulated that more patients die within the first 4 days. The deadliest period for the DCL was the first 24 h, with a significant difference in mortality for that interval between groups (27.3% vs. 8.3%). After 96 h, the distribution of mortality rates had become similar for both. Despite the high mortality rate, in the DCL, almost 60% of the cases survived the potentially fatal injuries, estimating the damage control in a multidisciplinary approach for hemostasis, and future improvements of initial resuscitation will be able to achieve rescuing the most severely traumatized patients.

## CONCLUSIONS

In emergency evaluation, trauma cases have a high mortality rate in the 1st hours after the incident. The prevention of early deaths and improvements in resuscitation can increase the chances of survival. Adequate selection of the cases requiring DCL procedure might improve the outcomes of therapeutic approaches for severe trauma cases. Furthermore, preliminary evidence currently indicates that to resolve these issues, opting for the optimal approach, such as DCL and DSR, could also play an important role in trauma cases, at least for significant comorbidities. For this purpose, additional studies are needed to address which specific emergency surgery treatment modality is optimal for this controversial issue.

## AUTHORS' CONTRIBUTIONS

**KD:** Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing-original draft. **ZL:** Conceptualization, Data curation, Formal Analysis,

Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing-original draft. **FC:** Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing-original draft. **PG:** Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing-original draft. **DM:** Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing-original draft. **ZB:** Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing-original draft. **PD:** Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing-original draft. **DS:** Investigation, Software, Supervision, Writing – review & editing. **IS:** Investigation, Methodology, Software, Supervision, Writing – review & editing.

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