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CHAPTER 5.

PERIHEPATIC ASSOCIATED INJURIES

The Indications for Damage Control Laparotomy in major trauma with a concomitant Liver Injury

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Submitted

ABSTRACT:

Background: Damage control surgery (DCS) is a well-established surgical strategy in the management of the severely injured and shocked patient, but selection of patients for DCS remains controversial. The aim of this study was to assess the criteria for selection of patients requiring a damage control laparotomy.

Methods: Eighty-two severely injured patients with a complex pattern of injuries were treated in a 52-month period. Patients were divided into two groups according to operative strategy; Group I Definitive Repair (DR). Group II. DCL. Factors identifying patients who underwent a DCL were analyzed and evaluated.

Results: Twenty five (%) patients underwent a DCL and 55 (%) patients had DR. The number and severity of overall abdominal injuries were equally distributed in the two groups of patients. Patients who underwent a DCL presented more frequently hemodynamic unstable ($p=0.02$), required more units of blood and required more often intubation to secure the airway. Onset of metabolic failure was more profound in patients who underwent a DCL comparing to patients who had DR. The mean Base deficit was -7,0 and -3,8 respectively ($p=0.003$). Vascular abdominal ($p=0.001$) and major liver injuries ($p=0.006$) were more frequently diagnosed in the DCL group. Mortality, general complications ($p<0.0001$), hospital stay ($p<0.0001$) and ICU stay ($p<0.009$) were increased in patients who underwent DCS.

Conclusion: In severely injured patients with a complex pattern of injuries 33% of the patients required a damage control strategy with 84% survival rate. Physiologic behavior, abdominal vascular injuries and major liver injuries dictated the need for a damage control strategy.

INTRODUCTION

Damage control strategies are useful for a subset of trauma patients. Recognition of patients who are likely to benefit from a damage control laparotomy are those with gunshotwounds of the abdomen and major blunt abdominal trauma. The extension of this approach has also been described in the general emergency surgery population.[1,2] Patients with, coagulopathy, acidosis and hemodynamic instability are likely to benefit from a damage control laparotomy.[3,4,5] This approach resulted in improved survival of critical injured and shocked patients based on retrospective case series and when compared with historical controls (table 1). However there is concern about the lack of research relating to indications for a DCL.[6]

Table 1. Criteria for Damage Control Surgery in patients who sustained blunt abdominal trauma or abdominal gunshotwounds.

Criteria for DCS
Complex Pattern of Injuries [4,5,22,23]
Operating Time for DR of injuries > 60-90 minutes [22,23,24]
Initial hypothermia: T < 35° C [25,26,27,28]
Initial Acid Base Status: pH<7,2; BE < 10-15; lactate < 5mmol/L [27,28,29,30,31]
Non-surgical bleeding, onset of coagulopathy [20,32,33,34]
Transfusion requirements > 10 units packed cells [18,32,33,35,36]

DCS: Damage Control Surgery; DR:Definitive Repair; T: Temperature; BE: Base Excess.

The liver is the most common injured intraabdominal organ following trauma.[7] The mortality associated with severe hepatic injury is 10% with an isolated liver injury, but if three major organs are injured mortality approaches 70%.[8,9] The effectiveness and decrease in mortality of liver packing to control a major liver bleeding has been well established, and a damage control approach in patients with a vascular injury and two or more visceral injuries shows a survival benefit.[5,10] An early decision to initiate a damage control strategy is imperative after rapid assessment of internal injuries and before metabolic failure has set in. But concern has been expressed about identifying patients who might benefit from a damage control approach and patients who could tolerate definitive repair of injuries.[11,12] Appropriate selection for DCS is critical in order to decrease morbidity, unnecessary use of hospital facilities and costs.

We compared two groups of patients with major abdominal injuries who were treated with definitive repair of injuries or patients who were selected for a damage control laparotomy. The aim of this study was to assess the criteria for selection of severely injured patients for a damage control laparotomy.

METHODS

From September 1, 2008, to December 31, 2012, all patients with a liver injury requiring emergency surgery at the level-1 Trauma Center of the Groote Schuur Hospital University of Cape Town were considered for inclusion in the study.

Patients were identified in a prospective trauma database. Major abdominal trauma was defined as two or more organs injured in the right upper quadrant of the abdomen in patients with an Injury Severity Score[13] (ISS) > 15, and Abbreviated Injury Score[14] (AIS) (Abdomen) ≥ 3. Patients with major abdominal were included and further analysed. Patients with a single injury in the right upper quadrant, or ISS < 15, or AIS < 3 were excluded. Patients who died in the operating theatre or within 24 hours in the ICU were excluded for further analysis.

Outcome:

Primary outcome was survival till discharge. Secondary outcome was morbidity. Morbidity was defined as general and organ specific complications, duration of intensive care stay and hospital stay in days. Complications were graded by using the Clavien-Dindo grading system for the classification of surgical complications.[18]

Grading of injuries:

Intra-abdominal injuries were graded according the Organ Injury Scale of the American Association of Surgery for Trauma[15]. High grade injuries were considered to be grade 3 to 5.

Operative management:

Following initial resuscitation and management according the principles of the Advanced Trauma Life Support (ATLS®)[16], physiological parameters were documented. Potential candidates for a damage control laparotomy were non-responders to shock management, hypothermia, onset of metabolic failure, or a combination of these. Metabolic failure was defined as worsening metabolic acidosis (Base deficit), with or without the onset of coagulopathy (non-mechanical bleeding).

Indications for surgery were continued haemodynamic instability, peritonitis or CT-findings suggestive of bowel injury requiring surgical repair.

Operative management included definitive repair of injuries or damage control surgery (DCS). Operative management was based on institutional and Definitive Surgical Trauma Care[17] (DSTC®) guidelines. A DCL was defined as a limited operation for control of hemorrhage and contamination, secondary resuscitation in the ICU and definitive repair during a reoperation. The decision to perform or to convert to a damage control laparotomy was based on preoperative physiologic status, the severity of abdominal injuries and estimated time for repair of intra-abdominal injuries exceeding total operating time > 60-90 minutes. Massive fluid resuscitation, a decrease in Base Deficit after hemorrhage control, and the use of inotropes to improve hemodynamics were indication for conversion to a damage control strategy.

Damage control techniques included perihepatic packing. Splenectomy was undertaken for bleeding splenic injuries. An injury to the renal artery was treated with ligation and nephrectomy in the presence of a normal contralateral kidney. Injuries of the aorta were managed with primary repair or interposition graft. Injuries to the major abdominal veins were ligated or packed. In the patient with a limited number of small or large bowel injuries a rapid one layer, continuous, full thickness closure was used. Multiple large perforations within a short segment of the small bowel or colon were treated with segmental resection. In unstable patients or patients on inotropes, the bowel was ligated and neither an end-to end anastomosis nor the maturation of a colostomy was performed at the initial operation. Injuries to pancreatic head of the pancreas were packed. Parenchymal defects not involving the duct were drained. Ductal transections to the left of the mesenteric vessels that did not involve the splenic vessels were packed and drained. Major parenchymal or ductal injuries in the head or neck of the pancreas were also packed and drained, once bleeding from the pancreas or underlying vessels was controlled. Distal pancreatectomy, and pancreaticoduodenectomy were delayed until the relook laparotomy.

When severe shock, hypothermia, acidosis, and massive transfusion have led to coagulopathy and diffuse non-mechanical bleeding, the intraabdominal cavity was packed. Patients with intra-abdominal packing were managed as an open abdomen.

Patients were transferred to the intensive care unit for reversal of metabolic failure. The endpoints of resuscitation were defined as; temperature > 36 Celsius, Base deficit > -2, normal serum lactate, INR < 1,5, platelets > 50.000/ul, weaned off inotropes, fraction of inspired oxygen < 0.50 and O_2 Saturation > 95%.

Emergency reoperation was undertaken for the development of abdominal compartment syndrome or failure to attain the endpoints of resuscitation due to continuing hemorrhage.

Treatment of complications was multidisciplinary when appropriate and included endovascular, endoscopic interventions, and CT-guided drainage of abscesses.

Statistics:

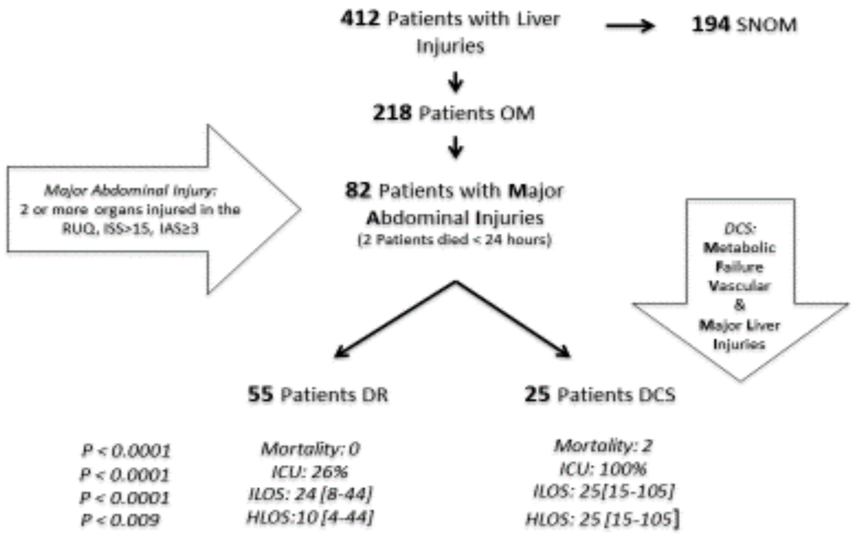
Results were presented as number (%) or as median (P_{25}-P_{75}). Patient groups were compared using the Pearson's chi-squared test or Fisher's exact test for categorical variables, and the Mann-Whitney test for non-normally distributed data. Statistical analyses were performed using SPSS statistical software, version 20. P values< 0.05 were considered statistically significant.

RESULTS

Four hundred and twelve patients were diagnosed a liver injury following abdominal trauma between 2008 and 2013. One hundred and ninety four were selected for nonoperative management. Two hundred and eighteen patients with a liver injury underwent surgery. Eighty-two (38%) patients with a complex pattern of injuries were identified. Figure 1 presents a management flow chart of all patients with abdominal trauma and a concomitant liver injury.

Two patients died on table or in the SICU within 24 hours. The first patient was a 19 year old male who sustained multiple thoracoabdominal gunshotwounds. He arrived hemodynamic stable (SBP 118), GCS 15 core temperature 35,1°C, BE -5,7, lactate 3,4, pH 7,22, and Hb 9,2 g/dl. RTS:7,108, ISS:25, PATI:25, During initial resuscitation he detoriated (abdominal distension and hypovolemic episodes) and was taken to the operating theatre immediately. He had a Gr III liver injury, stomach perforation, small bowel and colon laceration, a pancreatic tail injury and transection of the inferior mesenteric vein (IMV). The IMV was the main source of bleeding, and ligated. Non-surgical bleeding was controlled with packing of the liver and pancreas. Stomach lacerations were repaired with sutures, small bowel and colon were ligated. Perioperatively the patient received 14 packed cells, 4 FFP and 1 platelets. Despite control of surgical bleeding this patient

Figure 1. Management flow-chart patients with abdominal trauma and a concomitant liver injury.



SNOM: Selective nonoperative management, OM: operative management, RUQ: Right upper Quadrant, ISS: Injury Severity Score, AIS: Abdominal Injury Score, DCS: Damage Control Surgery, DR: Defitive repair, ILOS: Intensive care unit length of stay, HLOS: Hospital length of stay.

developed severe coagulopathy and ischemic SB and colon. The patient's condition could not tolerate an extended hemicolectomie and small bowel resection. He died in the operating room.

The second patient was a 54 year old male who was involved in a motor vehicle accident. He arrived intubated, heamodynamic unstable (SBP 68), GCS 7, core temperature 35,8 °C, BE -11,2, lactate 9,2, pH7,29 and Hb 6,3g/dl. RTS: 4,502, ISS: 34. He sustained an open skull fracture. He responded to initial resuscitation, and received 6 PC and 1 FFP. An urgent computed tomography revealed the following injuries; severe TBI, and Gr III LI, stomach, spleen, pancreas and kidney injuries and a lumbal spine, pelvic fracture, right femur and left tibial fracture. Although this patients was a transient responder to resuscitation the decision was made to withdrawal further treatment because of the extent of injuries and physiologic derangement.

Eighty patients (73 men, 7 women, mean age 26, range 13-57 years) who survived more than 24 -hours were included and further analyzed. Eleven (14%) patients sustained blunt trauma and 69 (86%) penetrating, 7 (10%) due to stab wounds and 62 (90%) gunshot wounds. The median ISS was 21.5 (range 16-32).

In 80 patients 108 high grade injuries in the right upper quadrant of the abdomen were diagnosed, liver (46), extra hepatic biliary tract (2), major vascular (12), right kidney (26), duodenum (10) and pancreas (12). Other associated intra-abdominal injuries diagnosed were stomach (21), diaphragm (15), small bowel (26), colon (17), spleen (13), left kidney (13), ureter (5), bladder (4), vascular (10) and pelvic fractures (4).

Thirty-four (42.5%) patients had isolated abdominal injuries. Forty six (58%) patients sustained injuries in body regions other than the abdomen, included head and neck (n=9), face (n=5), thorax (n=36), and extremities (n=18).

The indications for surgery were hemodynamic instability in 17 (21%) patients, an acute abdomen in 56 (70%) patients, and 7 (9%) patients had CT findings of intra-abdominal injuries that required surgical repair. Fifty-five patients had definitive repair of their injuries, and 25 patients underwent a damage control laparotomy.

The operative procedures in 25 patients who underwent a damage control laparotomy are presented in table 2a. General surgical complications and organ specific complications are presented in table 2b.

Magnitude of Injuries:

Comparing the magnitude of injuries between patients who underwent a damage control laparotomy and patients who had definitive repair, the Injury Severity Score was higher, more abdominal vascular injuries and more high grade liver injuries were diagnosed in patients who underwent a damage control laparotomy, table 3.

Table 2a. Damage control surgical techniques in 25 patients.

- Perihepatic packing: 20
- IVC packing: 4
- Drainage Common Bile Duct Injury
- Kidney packing: 1
- Duodenal primary repair: 3
- Nefrectomy: 6
- Infrarenal IVC ligation: 2
- Distal pancreatectomy: 3
- Colon ligation: 5
- Small bowel ligation: 1

Table 2b. Hundred and four surgical complications occurred in 25, complications classified according Clavien-Dindo classification.

General complications:	Organ specific complications:
Grade I: 18	Liver related complications:
Grade II: 29	Biliary fistula: 7
Grade III a: 11	Pseudoaneurysm: 1
Grade III b: 10	Hepatic necrosis:1
Grade IV a: 25	Stricture Common BileDuct:1
Grade IV b: 7	Pancreatic related complications:
Grade V: 4	Peri-pancreatic collection: 1
	Pancreatic Fistula: 2
	Urogenital related complications:
	Urinoma: 1
	Duodenal related complications:
	Anastomic breakdown: 3

Physiological State:

Patients who required a damage control laparotomy were older, presented more often with hypotension, required more frequently intubation to secure the airway, and had greater units of blood transfused. Comparing patients who underwent definitive repair and patients who underwent damage control surgery, a more profound metabolic acidosis was found in patients who required a damage control laparotomy, table 4.

Outcome:

Patients who underwent a DCL had an increased mortality, more surgical complications, liver related complications and duodenal complications. Hospital stay and the number of patients requiring ICU and ICU stay were increased in patients who underwent a DCL, table 5.

Deaths:

Two patients died later during hospital stay (HLOS 12 and 15 days). The first patient was a 35 year old male who sustained multiple gunshotwounds (abdominal, groin and buttocks and extremities). He arrived hemodynamically stable, SBP 138, GCS 15 core temperature 36,5°C, BE:-4,9 , lactate: 4,3 , pH:7,21 , and Hb: 6,6 . RTS:7,841, ISS:26, PATI:38. During surgery he deteriorated and a decision to bail out and perform a damage control laparotomy initiated. He had a Gr V LI, right kidney injury. A nephrectomy was performed and the bleeding liver was controlled with packing. Perioperative the patient received 5 packed cells and 5 FFP. Despite control of surgical bleeding this patient developed

Table 3. General patient`s characteristics and magnitude of injuries.

	DR N=55 (69%)	**DCL** N= 25 (31%)	**P-Value**
Sex, N (%)			
M	51 (93%)	22 (88%)	0,67[1]
F	4 (7%)	3 (12%)	
Age in years	**25**	**30**	**0,03**[2]
Mechanism, N (%)			
Blunt	7 (13%)	4 (16%)	0.73[1]
Penetrating	48 (87)	21 (84%)	
Gunshot wound	42/48 (87%)	20/21 (95%)	0.43[1]
Stab wound	6/48 (13%)	1/21 (5%)	
Injury Severity Score	**19**	**26**	**0.002**[2]
Liver Injury, N (%)			
Low	**29/55 (53%)**	**5/25 (20%)**	**0.006**[4]
High	**26/55 (47%)**	**20/25 (80%)**	
Abdominal Vascular Injury, N (%)			
All	**9 (16%)**	**13 (52%)**	**0.001**[4]
Low	2/9 (22%)	3/13 (23%)	1.00[1]
High	7/9 (78%)	10/13 (77%)	
Extrahepatic biliary tree injury, N (%)			
Low	3/3 (100%)	0/2 (0%)	1.00[1]
High	0/3 (0%)	2/2 (100%)	
Pancreatic Injury, N (%)			
Low	12/20 (60%)	7/11 (64%)	1.00[1]
High	8/20 (40%)	4/11 (36%)	
Duodenal Injury, N (%)			
Low	7/14 (50%)	2/5 (40%)	1.00[1]
High	7/14 (50%)	3/5 (60%)	
Right Kidney Injury, N (%)			
Low	10/28	2/10	0.45[1]
High	18/28	8/10	
Bowel Injury, N (%)			
All	22 (40%)	11(44%)	0.74[4]
Small Bowel	18 (33%)	8 (32%)	0.95[4]
Large Bowel	10 (18%)	7 (28%)	0.32[4]
Abdominal Injuries, N (%)			
3 organs	14 (25%)	2 (8%)	0.16[4]
4 organs	11 (20%)	9 (36%)	
5 organs	17 (31%)	6(24%)	
> 5 organs	13 (24%)	8(32%)	

severe abdominal sepsis and required 3 relook laparotomies. Eventually this patient died due to multi organ failure on day 15.

The second patient was a 23 year old male who sustained an abdominal gunshot-wound and precordial stab. He arrived unstable (SBP 89), GCS 14, core temperature 35,8 °C, BE -3, lactate: 4,6, pH:7,31 and Hb:12,2. RTS: 7,108 , ISS:25 PATI:29. He sustained an open

Table 4. Physiologic parameters in 80 patients with severe abdominal trauma comparing patietns undergoing DR versus DCS.

	Definitive repair N=55 (69%)	Damage Control laparotomy n=25 (31%)	P-Value
Blood pressure < 90 mmHg on admission, N (%)	3 (5)	6(24)	**0.02**[1]
Intubation on admission, N (%)	8 (15)	16 (64)	**< 0.0001**[4]
Glascow Coma Scale ≤ 8 on admission, N (%)	1(2)	3 (12)	0.09[1]
Hemoglobin in g/dl, mean (SD)	11 (2)	10 (3)	0.06[2]
pH, mean (SD)	7.34 (0.09)	7.28 (0.08)	**0.01**[2]
Lactate in mmol/L, mean (SD)	2.6 (2.1)	3.9 (2.8)	**0.03**[2]
Base deficit, mean (SD)	- 3.8 (4.0)	-7.0 (4.9)	**0.003**[2]
Blood Transfusion			
N (%)	18 (33%)	21 (84%)	**< 0.0001**[4]
Units of Blood, median, range	0 (0-7)	4 (0-12)	**< 0.0001**[3]

DR: Definitive Repair, DCS: Damage Control Surgery

Table 5. Morbidity in 80 patients undergoing DR versus DCS.

	Definitive Repair n=55 (69%)	Damage Control Laparotomy n=25 (31%)	P-Value
Patients with surgical complications	27 (49%)	24 (96%)	**< 0.0001**[3]
Number of Liver related complications	10 (18%)	10 (40%)	**0.04**[4]
Number of Pancreatic related complications	6/20 (30%)	3/11 (27%)	1.00[1]
Number of Duodenal related complications	0/14 (0%)	3/5 (60%)	**0.01**[1]
Number of Kidney related complications	3/28 (11%)	1/10 (10%)	1.00[1]
Hospital stay in days	10 (4-44)	25 (15-105)	**< 0.0001**[3]
ICU stay in days			
Patients requiring ICU	14 (26%)	25 (100%)	**< 0.0001**[4]
ICU-stay in days	24 (8-44)	25 (15-105)	**0.009**[3]
Mortality	0 (0%)	2 (8%)	0.10[1]

DR: Definitive Repair, DCS: Damage Control Surgery.

skull fracture. He responded to initial resuscitation, was take to the operating room, a laparotomy and sternotomy were performed. The patient arrested 3 times during surgery. A cardiac injury was sutured with pledgets, a diaphragm injury, a grade 5 liver injury, and a pancreatic and gastric injury were identified. He received 12 PC, 7 FFP, and 1 platelets. Despite control of bleeding with packing, this patient developed abdominal sepsis and died due to multi organ failure on day 15 post injury.

DISCUSSION

In a small minority of patients, definitive organ repair cannot be undertaken safely in a patient with a critical physiological status. These patients are more likely to die from their intraoperative metabolic failure than they are from the failure to complete organ repairs. Physiologic behavior, abdominal vascular injuries and major liver injuries dictated the need for a damage control strategy in patients with major abdominal trauma evaluated in our study. Since the introduction of damage control it has been generally accepted that patients with severe injury and physiological derangements are selected for a DCS.[3,4,5,9,19] On the other hand DCS should not be performed in patients who can tolerate DR of their injuries, causing an increase in morbidity and subsequent increase in use of hospital facilities and costs.[10,11]

In liver trauma perihepatic packing has been a well established surgical technique to control liver bleeding.[9] In patients with a complex pattern of injuries control of bleeding is essential, and the severity of trauma and physiological derangements influence the decision to pack and delay definitive organ repair. The first step is recognition of patients in the resuscitation room likely to need a damage control laparotomy. The second step is an exploratory laparotomy and after control of bleeding a rapid assessment to classify the severity of trauma and estimate the time required for definitive repair. At this stage timing to initiate DCS is depending on physiological derangement. Previous studies demonstrated that changes in core temperature, acidosis and coagulation are essential, and initial preoperative temperature, Ph, BE, transfusion requirements, and haemodynamic status are vital, table 1.

Although there is no consensus on a validated definition of polytrauma[20], in this study we defined severely injured patients with a complex pattern of injuries as: three or more organ injuries in the right upper quadrant of the abdomen, AIS >3, and ISS> 15.

This study was performed in a busy level 1 trauma center. The incidence of DCS in this group of patients was 33%. A much higher incidence comparing to the literature 6 -18%.[21] The reason for a higher incidence is most likely influenced by selection, due to the fact that we only selected patients who sustained major abdominal trauma to the right upper quadrant. The overall mortality in patients undergoing DCS was 16%. In the literature the mortality rates for DCS varies from 26% to 67%.[20] The high rate of personal violence, in this series the majority of patients sustained abdominal gunshotwounds comparing to severe abdominal trauma, may be responsible for the better outcome. Mortality following penetrating abdominal trauma is 10%, whereas mortality following severe blunt abdominal exceeds 40%.[7] This may explain a lower overall mortality rate in our study comparing with the literature. However all patients who were selected for damage control surgery and reached the operating room had a 84% survival.

While the number of patients in this prospective series of severely injured patients with a complex injury pattern is low, comparison of small groups in this paper by means of significance testing needs to be interpreted in the light of the very low power to detect statistically significant differences. A clinical interpretation and familiarity with surgical strategies and techniques taught in the DSTC or similar course has to be put upon the comparisons and not just a statistical interpretation.

While an increase in incidence of patients who undergo damage control surgery has been noted, we should be aware for the increase in morbidity in patients who unnecessarily undergo a damage control laparotomy. Despite reports of increased survival after the introduction of damage control surgery and implementation of a damage control strategy in the field of emergency surgery[1,2] few authors conclude that evidence that supports the safety and efficacy of damage control is limited.[21] They call for the need of randomized controlled trials. An RCT would be confronted with the same dilemma, at first overuse of DCS in patients who could also tolerate DR, or vice versa an increase in mortality or morbidity in patients who are selected for DR.

This current prospective single center study did focus on criteria for selection of patients who might benefit from DCS. In conclusion 33% of the severely injured patients with a complex pattern of injuries required a damage control strategy with 84% survival rate. A moderate onset of metabolic failure or hypotension on arrival are not strict indications to perform a DCL. No improvement after hemorrhage control and perioperative resuscitation should alert the operating surgeon to perform a DCL. Physiologic behavior, abdominal vascular injuries, and major liver injuries dictate the need for a damage control strategy.

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