Damage Control Management
in the Polytrauma Patient
Damage Control Management in the Polytrauma Patient

Forewords by
Roy Sanders, MD
Donald D. Trunkey, MD
To those who put themselves in harm’s way in their mission to provide care for the injured, to all the physicians and nurses who place the saving of life as the ultimate reason to be, and to all the patients who have taught us how to save lives.

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To my parents, Klaus and Marie Luise, who enabled and inspired me to pursue a career in medicine, and to my wife, Claudia, and my children, Julia and Eva, who supported me throughout.

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To my partners and housestaff, who teach us; to our families, who provide our strength.

Andrew B. Peitzman, MD

To my fellows, faculty, and partners, who have selflessly labored to care for the injured, expand knowledge, and share experience as we advanced the concepts of Damage Control.

C. William Schwab, MD, FACS

To my wife, Rania, and my children, Marilena and Vasilis. Their love, understanding, and ongoing support throughout my career have been vital sources of energy, creativity, and commitment to education.

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Foreword

Orthopedic trauma is largely limited to the stabilization and subsequent surgical management of fractures and dislocations, with most patients presenting to their local emergency departments with isolated injuries. Modern techniques and implants have made outcomes for these injuries more predictable. Intramedullary nailing, for example, has become standard treatment for a displaced fracture of the femoral shaft. These conditions can be managed by the majority of general orthopedists being trained today. Interestingly, they most likely do not even understand or remember that this treatment evolved from the management of the polytraumatized patient with fractures.

The polytraumatized patient is, of course, a completely different matter. For many years, the only experience with these types of injuries was in casualties sustained by combatants during armed conflicts. Basic concepts such as anesthesia, blood transfusions, intravenous therapy, wound management, and even the development of nursing and the modern hospital were all learned and founded in armed conflicts such as the Crimean War, the Boer War, and World War I. The Second World War saw improvements in the management of both abdominal and extremity wounds, and this was further refined in the Korean and Vietnam Conflicts. These, however, were limited to saving lives and limbs that benefited from very basic care. Understanding even the most rudimentary physiological concepts now taken for granted eluded us, and this showed how limited knowledge was at that time.

Beginning in the 1960s, various technological advances occurred that would radically change the methods of management. The introduction of arterial blood gas machines, the Swan-Ganz catheter, PEEP, and volume-cycled ventilators all became commonplace, decreasing the risk of cardiopulmonary failure. Recovery rooms and intensive care units were developed at this time as well, finally allowing for the monitoring of patients in the peri-operative period. Amazingly, before that, postoperative cardiopulmonary failure was undiagnosed and left untreated. After successful resuscitation of the patient from the initial cardiopulmonary insult, the prolonged septic state ended in a cachectic and malnourished patient. The development of hyperalimentation was critical in reversing this, only to lead to the multiple organ system failure syndrome, which was then addressed in the 1970s and 1980s.
While all this cardiothoracic and thoraco-abdominal care was proceeding, fracture management was lagging behind. The recognition of the systemic consequences of leaving a patient in traction became evident in the 1970s, with the understanding of the fat embolus syndrome. Furthermore, it was shown that the length of time in traction, and not the Injury Severity Score, was the only variable that correlated to multiple organ system failure and pulmonary failure in these patients. It also became clear at this time that cardiopulmonary failure and the septic states of the post-severe trauma patient were due to treatment modalities employed and not to the original injury. Similarly, compartment syndromes and their complications were better understood and managed, both in the extremities and abdominal cavity.

At the same time, high speed motor vehicular trauma began a spectacular rise in the West. Although fatalities from these accidents were initially high, when basic safety precautions came into being such as the seat belt, patients who formerly would expire at the scene now became severely traumatized civilian casualties. The attempt to save these lives brought methods formerly reserved for the military into everyday use, namely Emergency Medical Service ambulances and the development of civilian trauma units. In the United States, one of the first such units was the Baltimore Shock-Trauma Center. This center managed polytrauma patients with a minimum of three organ system injuries from a five-state region, using three helicopters with resuscitative capabilities onboard for rapid transport to the facility. This was, in essence, a civilian M.A.S.H. unit.

Today, benefits of these advances are apparent. Emergency medical systems coupled to regional trauma centers allow for the timely response to injuries in almost any location. Across the world, lessons learned in resuscitation, anesthesia, and critical care allow for the management of patients with varying degrees of general and extremity injury. Specialists in each of the many disciplines address the specific problems of the patient in an orderly, algorithmic manner, maximizing outcomes based on firm scientific knowledge learned over the last half century. Truly, this is a better place.

Damage Control Management in the Polytrauma Patient attempts to carefully collate and combine current knowledge in this field, which in today’s parlance is known as “Damage Control.” This implies the ability to actually manage these patients rather than to chase their problems, as was done in the past.

This monumental task has been performed by editors and contributors who have a deep understanding of the management of severely injured patients who have also sustained skeletal trauma. The scientific basis for treatment, starting with the epidemiology and pathophysiology of the trauma state, is clearly and expertly covered. Similarly, phases of management as well as treatment of individual organ systems are explained so that each member of the team will have better insight into the decision-making process of the other. Finally, a frank discussion of the complications and limitations associated with these patients is included so that the reader is aware of where scientific endeavors need to continue in order to solve present-day problems.

This book is a testament to past limitations, the present concepts of management, and where the future lies. The editors are to be commended for putting
together a superb volume on the current state of the art. The surgeon and patient alike will be better off for having their traumatologist read this text.

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Foreword

The ravages of limb compartment syndrome were first reported by Volkmann in 1881. This led to treatment by releasing compartment pressure using fasciotomy. General surgeons soon encountered the same phenomenon in the abdomen, primarily related to management of severe liver injuries. The anatomy of the liver was not well understood, and resectional debridement or formal lobectomy was simply not done. Treatment consisted of packs, drains, and the electrocautery unit. Attempts to close the abdomen in such patients were fraught with difficulty, and it was soon recognized that it was better to stage and delay abdominal closure, an approach now recognized as damage control.

Compartment syndromes are now recognized to occur in any closed space in which blood, fluid, or air causes expansion of the space and meets resistance of the container. Compartment syndrome can occur in the cranial vault and is usually associated with blood in the epidural and subdural space or intraparenchymal tissue. Each hemithorax is subject to compartment syndrome that is caused by blood, air, or chyle. Compartment syndromes in the abdomen, including the retroperitoneum and pelvis, are frequently common following severe injury. The complexity and the anatomy of the extremities are such that there are multiple compartments in both the upper and lower extremity. Even the hand is subject to compartment syndromes.

Although compartment syndromes existed prior to the mid-twentieth century, they were exacerbated by advances in surgical care and resuscitation. During the late 1950s, pressure-regulated ventilators were introduced, followed shortly by surgical intensive care units, and patients were managed on ventilators following their initial surgery. It was not uncommon to attempt to close all abdominal incisions following major injury, only to have the anesthesiologist tell the surgeon that the patient was difficult to ventilate. It soon was recognized that this was associated with an increase in peak inspiratory pressures, and patients often went on to have multiple pneumothoraces and deterioration of pulmonary function. This did not improve when volume-regulated ventilators became more popular than the older pressure-regulated ventilators.

Another advance occurred in 1964 when the work of Shires and others changed our fluid resuscitation of the trauma patient. During World War II and the Korean Conflict, acute renal failure occurred in 80% of all patients who presented in shock, and, of those, a high percentage died until the introduction of renal dialysis.
In 1964, Shires showed in an animal model that, during resuscitation following severe shock, the interstitial space was constricted and intracellular water increased, which could only be addressed by increasing the amount of crystalloid solution during the resuscitation period. As a consequence, acute renal failure almost disappeared as a major problem during the Vietnam Conflict, but a new syndrome was recognized: Da Nang lung. There is no question that some of these patients were over-resuscitated with crystalloid since the prevailing concept at that time was that one had to “fill the pump” to get maximum cardiac output.

Since the Vietnam Conflict, another physiologic phenomenon has been on the scene: the lethal triad of hypothermia, coagulopathy, and acidosis. A fourth component to this lethal triad is reperfusion injury, which also occurs during prolonged shock when resuscitation is initiated. The combination of these four factors aggravates the pathophysiology of compartment syndromes wherever they occur in the multiply-injured patient.

In *Damage Control Management in the Polytrauma Patient*, the editors have focused on approaching damage control surgery in a logical and comprehensive fashion. They have appropriately introduced the subject with epidemiology and pathophysiology. This is comprehensive and primarily focuses on extremity trauma and the patient with polytrauma. Importantly, the editors have divided damage control into phases, emphasizing that the problem begins in the prehospital setting and that prevention is far better than most treatment. The timing of surgery is addressed. The importance of early second operation when the physiology has been corrected is also emphasized. Reconstruction during what the editors term phase four and adjunctive maneuvers are also presented to the reader.

Special aspects of damage control are important and also addressed. The editors approach this topic from an anatomic standpoint, but they also look at the very young patient and the older patient. It would have been inappropriate not to have also discussed the military situation, which is done nicely here. Finally, the editors address complications and outcomes, emphasizing again that this book is comprehensive and will be a reference book for orthopedic and general surgery residents and practicing surgeons, as well as a book that will be referred to often in academic centers.

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Preface

The sustained improvements in the observed survival rates of polytrauma patients within the last two decades are attributable to multiple factors. While advances in rescue and intensive care management have been widely recognized in the past, the dramatic management changes performed regarding surgical management have occurred more quietly.

Nevertheless, all surgical subspecialties involved in the care of these patients have been commonly affected, thus requiring closer cooperation than ever. The common goal is to control life-threatening conditions first, such as severe hemorrhage, impaired oxygenation, and cerebral herniation. Fixation of major pelvic and extremity fractures then follows, thus preventing secondary hemorrhage and secondary soft tissue damage. The overall goal is to achieve all these tasks in a timely fashion, where all surgical specialties must respect the effects of prolonged shock, coagulopathy, hypothermia, and untreated soft tissue necrosis.

The limitations in the duration of initial operations and the reduction in complication rates have been so striking that they justify the compromises associated with this management change. For general surgeons, the downsides may imply inability to close the abdominal incision initially and to deal with the complications induced by large abdominal wall defects. For orthopedic surgeons, temporary external fixation requires re-operations, and local infections can occur along the Schanz screws. Considerations of these issues are included in this book.

In view of these aspects, the editors have purposefully tried to compile a cooperative approach among all major subspecialties involved in the care of polytrauma patients. The major goal of this book is to improve the overall understanding of every reader towards a common, integrated approach to polytrauma care. The editors hope that this book will help combine the vision required to perform life-saving operations with the vision required to treat limb-threatening conditions, resulting in the best possible clinical outcome for every individual patient. The editors are grateful to outstanding clinician scientists who have achieved this difficult task.

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