Peter Papadakos
Mark Gestring
Editors

Encyclopedia of Trauma Care

SpringerReference

Encyclopedia of Trauma Care

Peter J. Papadakos • Mark L. Gestring
Editors

Encyclopedia of Trauma Care

With 398 Figures and 146 Tables

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This work is dedicated to my children, Matthew and Sarah, and to my wife, Holly, for their consistent and unwavering support. It is also dedicated to my parents, Gidon and Anne, and to my brothers, Craig and Brian, for a lifetime's worth of advice, direction, and guidance.

Mark L. Gestring

A work cannot move forward without the support of one's family, and in this, I am very grateful to my wife Susan and my children Yanni and Ava. I could not have done this project without your help, love, and, of course, your understanding. This work is also dedicated to the many teachers of medicine and surgery who taught me both the art and science of this wonderful profession and to the many generations of students, residents, and fellows. I am in your debt for keeping me sharp, up to date and in focus all these years. I also have a special thanks to my administrative assistant Shari, who, over the years, has typed hundreds of papers and chapters, contacted authors and collaborators throughout the world, and kept me on schedule.

Peter J. Papadakos

Foreword

When I reflect on the last 25 years of progress in trauma care, it is overwhelming to consider the explosion of data that has emerged and transformed our management approach to patients across a broad spectrum of injury patterns and severity. With the emergence of new technology, better understanding of the physiology of shock and resuscitation, more judicious use of operative approaches, vigilant intensivist-driven bedside critical care, and a focus on achieving optimal outcomes for injured patients, the challenge of staying current in best practice has become monumental. Moreover, the focus of care provision has shifted from rapid *recall* of information to rapid *retrieval* of information for immediate integration and application into the patient care setting.

While a whole host of modalities have surfaced to assist the clinician in meeting this challenge, the *Encyclopedia of Trauma Care* stands as a seminal compendium of works that provide easily accessible, easily abstracted information at the ready. The scope of the material is expansive, the organization of the content is outstanding, and the structure of each review is systematic and consistent allowing the reader to hone in on key areas of interest without an undue amount of filtering and culling. The broad range of material and the easy alphabetical order of subject areas constitute a comprehensive yet convenient "first-stop" on the way to understanding straightforward approaches to not-so-straightforward clinical problems of interest.

The contributors to this two-volume set represent a "Who's Who" in international trauma care and their perspectives, based on their in-depth knowledge and years of experience in managing injured patients, are invaluable to the reader. It becomes immediately apparent on review of the text that this sort of expertise across a broad spectrum of trauma problems is a significant advantage in sorting the conundrums that complex injury patterns present to the working clinician. In over 1,200 pages replete with numerous tables and illustrations, the authors provide the most current and practical information available on topics such as airway emergencies, strategies in shock resuscitation, salvage modes of mechanical ventilation, prolonged open abdomen, mass casualty management, and teamwork in trauma care. Certainly, working knowledge of the material covered herein is of paramount importance in daily practice. Conveniently enough, it also serves as an exceptional review tool in preparation for examinations at every level.

Papadakos and Gestring have done a masterful job as editors of this text. They bring to the process a balanced approach due to their diverse backgrounds. While both share a passion for surgical critical care, Peter Papadakos is an anesthesiologist by training and brings this viewpoint and expertise to the work. Mark Gestring, an accomplished trauma surgeon, adds perspective that flavors the encyclopedia throughout. The work will be applicable and useful as an outstanding source of information for a broad range of physicians from many specialties, students, residents, fellows, nurses, advanced practice provides as well as scientists from bench top to bedside. This places the *Encyclopedia of Trauma Care* in a unique category of references; compiled in multidisciplinary fashion it offers great value to the readership.

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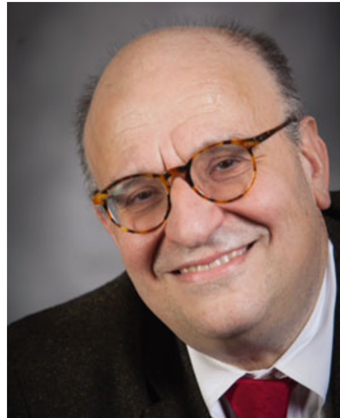

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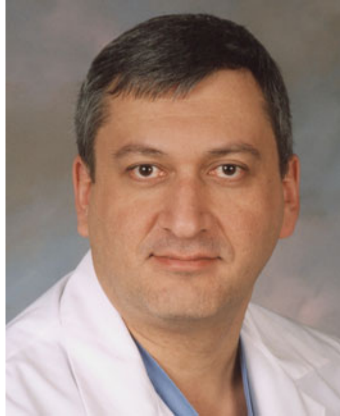

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A

Abbreviated Laparotomy

▶ Damage Control Surgery

Abbreviated Laparotomy Outcomes

▶ Damage Control Surgery: Outcomes of the Open Abdomen

ABCDE of Trauma Care

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Synonyms

Initial trauma assessment; Initial trauma evaluation; Initial trauma resuscitation; Primary trauma survey; The "golden" hour of trauma care

Definition

The ABCDE of trauma care represents a systematic approach to goal-oriented initial evaluation and resuscitation of injured patients. It is a five-step sequence:

- **A**. . . Airway must be either maintained or secured while protecting the cervical spine
- **B**. . . Breathing must be either supported or controlled while oxygen is delivered
- **C**. . . Circulation is supported and hemorrhage contained
- **D**. . . Disability is assessed and the risk of secondary injury is restricted
- **E**. . . Exposure helps evaluate the full extent of obvious injuries/Environmental control helps minimize or prevent hypothermia

The ABCDE sequence is usually performed in a coordinated team effort. The primary survey is followed by a more detailed secondary survey. The "golden" hour of trauma care refers to the entire initial period of trauma assessment and resuscitation that plays the crucial role in trauma outcomes. Advanced Trauma Life Support® (ATLS®) represents the foundation of the ABCDE procedure.

Preexisting Condition

The epidemic of trauma has massively increased the need for field responses and hospital treatment of injured patients in the modern era. Injury is a disease that can affect any body system; it may lead to quick deterioration of vital functions, and

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an instantaneous or early death. Conversely, consequences of a contained trauma may lead to long-term disease, disability, and late death. It has been emphasized "that injury kills in certain reproducible time frames" and that the greatest threat to life should be recognized and treated first (ATLS 2008). Thus, the purpose of the ABCDE approach is to highlight the effective sequence of evaluation and resuscitation in trauma. The primary survey must never be delayed in order to obtain a detailed medical history. The lack of definitive diagnosis should never impede the application of an indicated treatment.

There are three peaks of death caused by or related to trauma. The tallest peak occurs within 1 hour of injury. Severe traumatic brain injuries and high spinal cord injuries may result in apnea while rupture of the heart or injury of large blood vessels may lead to rapid exsanguination. Rapid physiologic deterioration due to apnea, exsanguination, or both may cause death within minutes of such severe trauma. The second peak occurs within first 24 h of injury (typically within first few hours) as a consequence of concealed hemorrhage within the intracranial, thoracic, abdominal, and pelvic cavities, or hemorrhages at multiple sites. Once the threshold of physiologic decompensation of a vital organ is reached, life-threatening neurologic, respiratory, or hemodynamic deterioration may occur. The third peak of trauma-related death occurs a few weeks subsequent to injury. These late deaths are usually caused by sepsis or multiple organ failure. However, the distribution of deaths may differ between various trauma systems, e.g., urban vs. rural systems. Advanced medical care has improved survival in modern trauma systems, and it has modified the classic trimodal distribution of trauma-related deaths to bimodal distribution. The first peak still occurs within the first hour, while the second peak occurs 24–48 h subsequent to trauma (Demetriades et al. 2005). However, there is no discernible peak of trauma-related death after the 48 h period. The mechanism of injury, the body area affected by the major impact of the mechanical force, and age of the injured patient are the most important determinants of trauma outcome. Severe head injuries do not follow described temporal distribution of death (Demetriades et al. 2005). In general, penetrating injuries cause more early deaths than blunt injuries. However, blunt trauma may be more difficult to diagnose and treat than penetrating trauma. Assessment is more difficult because the symptoms and signs of internal injuries may be still subclinical and thus the pathologic process not easy to diagnose. Additionally, multiple concurrent injuries may have opposing physiologic resuscitation goals, e.g., coexisting traumatic brain injury vs. intraabdominal hemorrhage. The severity of total body injury in case of multitrauma is related to the number of injuries and to the severity of every individual injury present.

Only injury prevention can significantly reduce the number of instantaneous deaths caused by trauma. This is a major public health problem especially among adolescents and young adults. On the other hand, early recognition of concealed hemorrhage(s) that represent significant threat to life or a vital organ function may help reduce the number of early deaths. Since injuries kill in reproducible time frames and a successful surgical intervention provides a definitive treatment, this initial time period is often referred to as "the golden hour of trauma care." Triage may be necessary in case of multiple persons injured as well as in case of disasters in order to prioritize care based on severity of injuries, make rational decisions about transport, and the most optimal use of available medical resources.

Application

Primary Survey

In order to achieve necessary rapidity and completeness of trauma evaluation and resuscitation, primary survey is usually a team effort. The ABCDE sequence is a process repeated at different levels of care until definitive trauma care can be provided. It starts at the site of injury and it continues on a transport vehicle by the prehospital team. The primary survey is then performed in the emergency room by the hospital team. The initial trauma assessment and resuscitation involves coordinated participation of multiple medical

professionals with a team leader facilitating active communication, directing, and supervising procedures. Close communication between the prehospital team and the hospital team is important. On one hand the assistance may be provided to the prehospital team, while on the other hand admitting team's preparation and consequently the trauma patient's resuscitation may be facilitated by such communication. Sometimes, if it is obvious or highly suspected that a potentially lifesaving immediate surgical intervention is unavoidable, the team leader, usually a trauma surgeon, may decide to transfer a trauma victim directly from the emergency room to the operating room. Otherwise the primary survey is followed by the secondary survey, laboratory, and imaging investigations.

Airway

Airway Assessment

Due to the rapidity of hypoxic brain injury, death may be imminent without an immediate intervention in cases of severe airway obstruction or significant ventilatory compromise. Thus, ensuring airway patency, while protecting the cervical spine, is the first resuscitation priority in trauma care. Patient's ability to produce normal voice is a reassuring sign about preserved patency of the upper airway. However, the extent and the mechanism of injury may point toward the potential for development of a progressive and potentially fatal respiratory failure. Progressive airway edema as a consequence of a severe inhalational injury or blunt neck trauma may exemplify such risk. On the other hand, compromise of ventilation is frequent with tension pneumothorax or massive hemothorax. Thus, securing the airway by performing a prophylactic tracheal intubation will prevent the potential for loss of the airway or ventilatory failure under such clinical circumstances.

Airway evaluation is performed simultaneously with administration of supplemental oxygen, assessment of the efficacy of spontaneous ventilation, and measurement of arterial hemoglobin saturation using the pulse oximeter. If airway patency is preserved, spontaneous ventilation is maintained, and an imminent or progressive airway compromise is not anticipated, administration of supplemental oxygen and close monitoring of such trauma victim may be sufficient. Otherwise, airway must be secured while protecting the cervical spine. The patency of a compromised airway may be attained by chin-lift, jaw-thrust, and bag-valve-mask ventilation. Placement of a supraglottic, glottic, or infraglottic airway may follow depending on the initial assessment of the trauma victim, expertise of resuscitators, availability of drugs, and the airway equipment. Any cervical spine movement must be minimized while performing airway rescue procedures either by applying manual inline immobilization or by maintaining cervical collar in place.

Airway Maintenance

Due to multiple circumstantial factors, tracheal intubation in the field may be very challenging, incidence of hypoxia is frequent, and thus risks and benefits of placing an artificial airway, when muscle paralysis is required, must be cautiously considered. This is especially true in medical systems where prehospital trauma care is provided by less experienced providers and risks of intubation failure may be high (Cobas et al. 2009). Hypoxia of significant degree and duration may be especially damaging to patients with traumatic brain injury. Maintenance of normocapnia is another important factor that determines the outcome of brain injured patients (Davis et al. 2004; Boer et al. 2012). Thus, in order to avoid potential devastating risks of muscle paralysis and hypoxia one should always carefully consider feasibility of airway maintenance as an airway management option under difficult trauma circumstances.

Bag-valve-mask ventilation is the first step in maintenance of the airway and it has two goals: (a) assessing its efficacy as a temporary airway maintenance tool and (b) increasing lung oxygen reserve in order to ensure maximal length of the safe apnea time following anesthetic induction. Effective application of bag-valve-mask ventilation may prove difficult in patients having any of the following seven findings: beard, obesity, no dentition, elderly (older than 55), history of