Foreword

Management of Children with Trauma in the PICUPablo Aguayo¹¹ Department of Surgery, Children's Mercy Hospital and Clinics, Kansas City, Missouri, United States*J Pediatr Intensive Care* 2015;4:1–3.

In every industrialized country in the world, injury is the leading killer of children. While mortality related to congenital malformations is the leading cause of death in children less than 1 year of age, the number of deaths from trauma-related injuries in the 1 to 19-year-old population is greater than all other causes of death combined. Altogether, traffic accidents, intentional injuries, drownings, falls, and other accidents kill more than 20,000 in 1 to 14-year-old every year in 26 of the world's richest nations.¹ This roughly translates into the death of 1 child every 30 minutes or over 50 children dying from trauma-related injuries every single day in these countries. While these statistics may be startling, it is important to keep in mind that they are based on figures from some of the world's richest countries. Each year, intentional and unintentional injuries account for nearly 1 in 10 deaths worldwide.² Road traffic injuries account for approximately one-quarter of the total number of deaths and 90% of this burden is borne by low/middle income countries.² The number of trauma-related deaths in these areas is staggering. For every 100,000 children (age 1–14 years) in the richest nations, less than 200 will die from injuries before the age of 15 years. In Africa, Asia, and Latin America it is estimated that there are more than one million child injury deaths per year.

While the death of even one child due to trauma is a tragedy, each death actually represents a much larger burden, that of nonfatal injuries and disabilities. In the United States, for example, there were 13,076 trauma-related deaths in 2010 in children aged 0 to 19 years. Over the same time period and same age group there were over 305,000 hospital admissions and over 8,000,000 emergency room visits. Medical costs for this cohort were estimated to total over \$8 billion. Taking into account work loss costs, the financial burden of traumatic injuries in children accounted for over \$32 billion in 2010. These figures do not represent the costs of long-term care for patients with chronic disabilities due to traumatic injuries. Currently, there are no data on the number of people who survive with some form of permanent disability for every injury-related death, but worldwide it has been estimated to be between 10 and 50 times more.³

From the aforementioned data, it is clear that there are some populations that are more prone to injury than others. The rate of injury among children actually varies considerably based on multiple risk factors. These risk factors consist of age, temperament, personality, cognitive development, socioeconomic status of the family, race, gender, and location of residence, among others. By far, the most well-established risk factors for injury are demographic in nature. It is well established that males, for example, experience injury more commonly than females.^{3–5} This finding is consistent historically, developmentally, and across cultures. Several possible explanations have been postulated for this gender disparity for injury risk. Boys, for example, may take more risks and may be more impulsive.⁶ Boys also tend to participate in more dangerous activities, including higher risk outdoor play, athletics, and use of heavy machinery. Gender socialization in which parents tend to encourage more risk taking from boys versus girls and tend to treat girls more cautiously in potentially hazardous situations plays a role as well.^{7,8} Low socioeconomic status is another separate but significant risk factor for unintentional injury in children. Race and ethnicity have also been implicated as possible risk factors for injury. While the research examining the role of race and ethnic disparities in injury risk is inconclusive, it appears that there may be differences in environmental exposure, which is closely tied to socioeconomic status. The possible link to race and ethnicity, at least in some countries, may be explained by the fact that minority children tend to be overrepresented in areas of lower socioeconomic status.^{9,10}

In this issue of pediatric trauma, we have put together a set of reviews on topics that pertain to some of the most common injuries sustained by children that one would manage in the intensive care setting. Each review presents the relevant epidemiology, most common mechanisms of injury, most common injury types related to each organ discussed, and the most up to date diagnostic and management strategies. We have included reviews on pediatric head trauma, pediatric spinal cord injuries, thoracic injuries, solid organ injuries, injuries to the duodenum and pancreas, pelvic injuries, and hemorrhagic shock. While many of the management strategies that are employed in the setting of pediatric trauma,

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meet the standard of care practices, it is important to note that compared with some of the adult literature, there is an overall paucity of literature and research in many areas of pediatric trauma.

Our first two reviews discuss traumatic brain injury and spinal cord injuries. While the incidence of pediatric spinal cord injuries is low, head trauma is not only the most common isolated injury, but also it continues to be the leading cause of death and disability in the injured child. In the United States, the estimated average annual numbers of traumatic brain injury included 473,947 emergency department visits, 35,136 hospitalizations, and 2,174 deaths in the 0 to 14-year-old age group.¹¹ The authors review the Monroe-Kellie doctrine and how differences in anatomy between children and adults may lead to differences in response to injury. The key to these observations is the importance of cerebral blood flow during the developmental stages of the maturing brain. While the monitoring of cerebral blood flow has not established itself as the standard of care, its surrogate, cerebral perfusion pressure is very often utilized to guide intensive care management. In tertiary referral centers across the United States intracranial pressure monitoring is becoming the standard of care despite the lack of any level-1 evidence of its utility. The authors proceed to describe the different types of traumatic brain injuries and mechanisms of injury. They conclude with a review of the most recent evidence-based guidelines for the acute management of pediatric traumatic brain injury from 2012 and an overview of second-line treatment options for refractory intracranial hypertension.

Although accounting for only 10% of all pediatric traumas, thoracic injury is a significant predictor of morbidity and mortality. The authors of our next review, pediatric blunt thoracic trauma, begin by describing the anatomical and physiological differences between adults and children that predispose them to more significant injuries. These differences include chest wall compliance, incomplete ossification, decreased muscle mass, and a larger surface area. While penetrating trauma to the chest can wreak significant havoc within the thoracic cavity, the vast majority of thoracic injuries occur secondary to blunt trauma, and 75% of these occur as a result of motor vehicle accidents. Thoracic injuries such as rib fractures, pneumothoraxes, or hemothoraxes, or significant pulmonary injury can be particularly problematic from a pain and respiratory standpoint. The majority of thoracic injuries can usually be diagnosed with a good physical examination and plain radiographs. All moderate-to-significant pneumothoraxes and hemothoraxes should be immediately evacuated with a large-bore thoracostomy tube. Neither rib fractures, pneumothoraxes, hemothoraxes, diaphragmatic injury nor pulmonary contusions require any imaging other than a plain X-ray. Computed tomography (CT) of the chest should be reserved for patients with suspected cardiac or vascular injuries. The authors conclude with a section on the management of suspected esophageal injury, including the most appropriate imaging modalities.

Moving on to abdominal injuries, the next two reviews focus on solid organ injuries. For much of the 20th century, the management of significant blunt spleen and liver injury

mandated surgical intervention. For the spleen, it usually meant a splenectomy. The most significant advancement in management of these injuries has been the development of a nonoperative approach. The authors of the article entitled blunt spleen and liver trauma review the most recent literature describing the diagnostic and the management algorithms of these injuries. While CT scan is the most sensitive and specific diagnostic modality for detecting intra-abdominal injuries, the increased use of ionizing radiation has been linked to a risk of cancer particularly in children.¹² In light of this data, there has been a movement toward decreasing the use of routine CT scans for evaluation of blunt abdominal injury. The authors review one of many proposed algorithms that are used to predict the likelihood of finding a significant intra-abdominal injury. This model uses physical examination, certain laboratory values, vital signs, and plain X-rays to assist the practitioner in deciding whether or not to utilize a CT scan for further evaluation. The authors also discuss the most recent evidence regarding the focused assessment sonography for trauma. The most important recent development, however, has been the revision of more appropriate bedrest protocols for spleen and liver injuries. A recent prospective trial and follow-up to that prospective trial found that one night bedrest for grades I and II and two nights of bedrest for grades III to V were as safe as more days of bedrest but lead to significantly decreased hospital lengths of stay and costs.

The authors of our next article entitled "Blunt renal trauma" describe the various diagnostic modalities to identify renal injury after blunt trauma. While CT scan is the most sensitive and specific modality, hemodynamically stable children with no evidence of hematuria require little in the way of radiographic imaging. Even in the face of parenchymal injury as demonstrated by CT, renal preservation rates of up to 99% are frequently being reported in the nonoperative management of renal injuries of all grades. Regarding the sequelae of renal injury, there are no studies that have reported long-term results on renal function or the incidence of hypertension in patients with traumatic renal injuries. Our institution prospectively collects data on the significance of hematuria and the incidence of hypertension and hope to be able to answer this question in the near future.

The topic of discussion of our next review is one we encounter rarely in our pediatric trauma patients, duodenal and pancreatic injuries. Although uncommon, pancreatic and duodenal injuries are particularly problematic because not only are they challenging to manage but they are difficult to diagnose. This difficulty often leads to a delay in treatment. Based on retrospective reviews, the most common and consistent presenting sign in these patients is abdominal pain secondary to blunt abdominal injury. A careful review of the patients' history, a good physical examination, and a high index of suspicion should guide the imaging requirements. In pancreatic injuries, ascertaining the patency of the main pancreatic duct is of utmost importance. First-line imaging modality should be a CT scan. In patients whose ductal anatomy is difficult to ascertain on CT, magnetic resonance imaging or endoscopic retrograde cholangiopancreatography

should be utilized. The management of grade I and II injuries can be safely managed nonoperatively with bowel rest and adequate pain control. The management of grade III through V injuries remains controversial. At our institution a patient with a grade III injury or higher usually undergoes surgical exploration with a laparoscopic, spleen preserving distal pancreatectomy. In duodenal injuries, differentiating between a hematoma and perforation may be difficult, but is key to the management of these patients. CT is, again, the first-line imaging modality and has essentially replaced the more labor-intensive contrast upper gastrointestinal study in the acute setting. Nonoperative management of duodenal hematomas consisting of nasogastric decompression, nil per os, and total parenteral nutrition until the obstruction has resolved is usually the rule. Duodenal perforation, on the other hand, mandates emergent surgical intervention. Surgical repair varies depending on the size of the defect, but the triple tube technique consisting of duodenal repair, gastric decompression, duodenal decompression, and distal jejunostomy has led to a significant decrease in postoperative complications when compared with surgical repair alone. The various surgical options are briefly discussed in the review.

The final two articles, review the current literature on pelvic injuries and hemorrhagic shock. The authors begin with a very detailed description of bony pelvic injuries. They go on to describe the most commonly utilized stabilization techniques that should be performed in the acute setting for patients with unstable fractures. The authors emphasize the significance of ongoing pelvic hemorrhage and some of the techniques currently available to control bleeding. The diagnosis and management of rectal, bladder, and urethral injuries is also discussed. In our review of hemorrhagic shock, the authors highlight the acute management of hemorrhage stemming from traumatic injury. Although the key step in this process is control of the bleeding source, the authors detail the resuscitation process, particularly as it relates to the need for transfusion of blood and blood products. They also discuss the most recent literature regarding objective end points of resuscitation. Finally, the incidence of transfusion-related complications is reviewed.

Traumatic injury continues to be one of the major global health issues today. It penetrates all rungs of society, although it disproportionately affects those individuals in lower socioeconomic brackets. In this special issue, we have reviewed some of the more common individual injuries that affect our pediatric population as well as the current diagnostic and

therapeutic approaches involved with each. We have also highlighted the fact that caring for the injured child is a complex endeavor. It requires special knowledge of the unique characteristics, pathophysiology, and the more common mechanisms of injury that health care providers will encounter in children. Finally, implicit in the reviews, while traumatic injury continues to be primarily a surgical problem, the concept of an expeditious evaluation and timely intervention as well as a multidisciplinary approach to care of the injured child is key to the management of this vulnerable population.

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