Paediatric trauma care

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ABSTRACT

Background: Childhood trauma has become a major cause of mortality and morbidity, disability and socio-economic burden and it is expected by the World Health Organization (WHO) that by 2020 it will be the number 1 disease globally. The WHO and UNICEF have published their third World Report on Child Injury Prevention in December 2008. **Materials and Methods:** A systematic review was performed on the history and magnitude of paediatric trauma worldwide. Additionally exciting developments and new trends were assessed and summarized. **Results:** Paediatric trauma is a growing field of clinical expertise. New developments include total body digital imaging of children presenting with polytrauma; targeted management of head injuries; conservative management of abdominal injuries in children and diagnostic laparoscopy, including the laparoscopic management of complications following the conservative management of solid organ injuries. **Conclusion:** Paediatric trauma has long been neglected by the medical profession. In order to deal with it appropriately, it makes sense to adopt the public health approach, requiring that we view child injuries similarly to any other disease or health problem. The greatest gain in our clinical practice with dealing with child injuries will result from a strong focus on primary (preventing the injury), secondary (dealing with the injury in the most efficient manner) as well as tertiary prevention (making sure that children treated for trauma will be appropriately reintegrated within our society). By actively promoting child safety we will not only achieve a most welcome reduction in medical cost and disability, but also the ever-so-much desired decline of avoidable childhood misery and suffering.

Key words: Children, trauma, injuries, violence, accident prevention

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THE HISTORY OF PAEDIATRIC TRAUMA CARE

Although trauma has accompanied mankind since for millennia, the massive pandemic of childhood trauma is a recent phenomenon, ever increasing in magnitude over the last three decades. It is often forgotten that much of the progress in medicine has its firm roots in trauma care. Galen, whose legacy of well over 80 medical works guided Western Medicine for over 15 centuries, received nearly all his training as a young physician appointed to the Gladiators of the Coliseum in Rome.[1] However, trauma care in general has been severely neglected in the medical literature until as recent as 1966 when the joint publication of the National Academy of Sciences and the National Research Council appeared under the title of 'Accidental Death and Disability; The Neglected Disease of Modern Society'. This was the first medical public acknowledgment of trauma as a medical disease. Only after the publication of 'Pediatric Trauma: the No. 1 Killer of children' in the *Journal of the American Medical Association* in 1983, did the focus turn firmly towards injured children.[2] Specific courses for the management of paediatric trauma and dedicated trauma units for children followed.

THE MAGNITUDE OF CHILDHOOD TRAUMA

Injuries do affect children disproportionally[3] [Figure 1].

Childhood trauma has become a major cause of mortality and morbidity, disability and socio-economic burden.

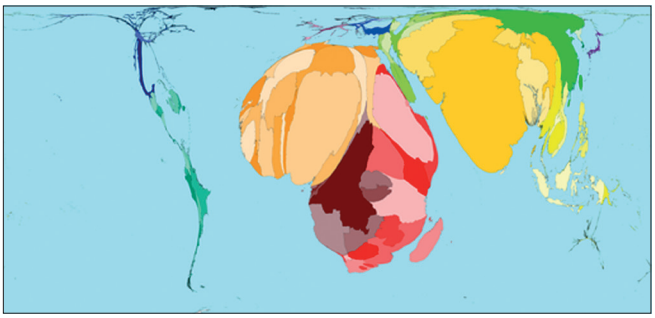


Figure 1: Child mortality of children between the age of 1 and 4 years, visually displayed over the world map; a large proportion of these deaths can be contributed to trauma. Source: http://www.worldmapper.org

The World Health Organization (WHO) and UNICEF dedicated and published the World Report on Child Injury Prevention in 2008.[4] The report regards child injuries and deaths as a major public health problem requiring urgent attention. Childhood injury and violence are the predominant killers of children throughout the world; it is estimated that they are responsible for approximately 1 million deaths of children under the age of 18 years. According to most reports, so-called accidental injuries account for the vast majority (90%) of these cases, while the remainder (10%) is estimated to be due to violence or maltreatment. In addition to these 1 million deaths, tens of millions of children require prolonged hospital care for their injuries, and many of the children are left with a degree of disability, often lifelong.[5] This burden of injuries is severely biased towards low and middle income countries; it is estimated that over 95% of all deaths in children due to injury occur in these countries.

EXCITING DEVELOPMENTS AND NEW TRENDS IN PAEDIATRIC TRAUMA CARE

Imaging of injured children

Due to a high proportion of injured children being poly-traumatized, often with an associated head injury, physical examination can be difficult, in particular in small children. Therefore, radiological imaging represents a significant part of the diagnostic process. The risks of ionizing radiation, however, remain an impediment to comprehensive imaging of the polytrauma patient, with each radiographic exposure increasing the cumulative dose of ionizing radiation. Childhood tissues are more vulnerable to the effects of radiation predisposing to malignancies in later life.[6,7] It is therefore of the utmost importance to limit the frequency and dose of radiographic examinations while maximizing the detection of injuries, i.e. limiting ionizing radiation to 'as low as reasonably achievable', ('ALARA' principle) as a guiding principle in radiology.[8] The development of a completely novel new total body digital imaging device with slot scanning technology (Lodox®) has been able to lower the radiation dose with a minimal amount of scattered radiation enabling parents or caretakers to remain in close proximity of the child while being imaged. This new type of total-body scanning with low radiation has revolutionized diagnostics of injured children.[9,10]

Targeted Management of Head Injuries

It has been increasingly appreciated in recent times that head injury is not a homogenous concept and is poorly classified for the purposes of treatment.[11] Severe traumatic brain injury can arise from a variety of pathologies, such as extradural haematoma, subdural haematoma, cerebral ischaemia, cerebral hyperaemia, vasospasm, focal haemorrhagic contusions or diffuse axonal injury. Beside this recognition of the heterogeneity of head injury is the growing appreciation of the role of secondary injury in determining outcome. Secondary injury accounts for everything that occurs after the primary injury that contributes to worsening brain damage. It may take the form of pathophysiological events initiated by the primary injury (such as brain swelling due to biochemical cascades), or secondary insults at a time when the brain is vulnerable, such as hypotension and hypoxia. Secondary injury represents an opportunity to intervene and improve outcome, but our tools for recognizing it before damage has been done have been poor. Recent advances in the intensive care unit environment, however, have improved our ability to detect potential secondary injury early and avoid its consequences. Although various reports have been published suggesting that intra-cranial pressure monitoring does not improve outcome, these are usually retrospective reports in which the indication for monitoring was not controlled, leading to more severely injured patients in the monitored group. Decompressive craniectomy is now far more aggressively employed than a decade ago.[12] The history of the operation though goes back to the beginning of the 20th century, since which it has fluctuated in popularity. Its modern resurgence has much to do with the recognition of the poor method with which it was applied in earlier times, modifications to the procedure and better selection of patients. During the operation a large bone flap is removed from the cranium and the dura is widely expanded with a graft to increase the amount of volume available for brain swelling and in so doing reduce the intra-cranial pressure. While historically the procedure was often performed only when patients had already been subjected to prolonged exposure to increased intra-cranial pressure or restricted to being a salvage procedure in the most severely injured patients, a more modern approach is to identify patients who are not responding adequately to medical measures for reducing intracranial pressure early and to perform an adequate controlled decompressive craniectomy while avoiding hypertension in the postoperative phase. When these guidelines are adhered to, decompressive craniectomy can markedly reduce the intracranial pressure and improve brain oxygenation.[13]

Diagnostic laparoscopy

Use of minimally invasive surgery in paediatrics

developed more gradually than in general surgery.[14] However, today its role is well established and indications are increasing daily. This was also the case in abdominal trauma and initial use has been mainly in diagnostics. As the technology and experience have improved indications have also become more therapeutic. Many diagnostic methods exist (CT, ultrasound, diagnostic peritoneal lavage) for evaluation of abdominal injuries. Despite these it can sometimes still be difficult to detect the presence and evaluate the severity of intra-abdominal injuries in children. Most blunt abdominal injuries are treated non-operatively. It is also useful in children injured with sharp objects to evaluate the presence of intra-abdominal extension, establish hollow viscus injury and in some cases surgical treatment of such injury. Minimally invasive surgery has the added benefit of less postoperative pain, reduced hospital stay and fewer postoperative complications such as adhesive bowel obstructions. The diagnosis of intestinal injuries can be delayed, despite strong clinical suspicion, serial physical examination and careful evaluation of radiological investigations such as CT scanning. Thus, in a stable patient laparoscopy has the advantage of diagnostic accuracy and can help to avoid non-therapeutic laparotomies in up to 40% of patients. Laparotomy however remains the gold standard for diagnosis and treatment of injuries in a child with haemodynamic instability. Diagnostic laparoscopy has successfully been utilized in this setting. It is particularly important in children where short-term observations may not reveal significant information, when fever, abdominal tenderness and leucocytosis are present. Laparoscopy allows full visual assessment of abdominal cavity, fluid can be aspirated and sent for analysis and the whole length of the intestine can be evaluated. Retroperitoneal organs are more difficult to evaluate but very often CT scan has already demonstrated injuries prior to laparoscopy. Identification of solid organ injuries depends on a high index of suspicion, abnormal physical examination findings and use of imaging and laboratory investigations. The majority of solid organ injuries can be managed conservatively (90%).[15] Abdominal CT scans are currently the most commonly used diagnostic studies; however, these expose the children to large doses of radiation. Haemodynamic instability despite aggressive resuscitation requires urgent laparotomy for diagnostic and therapeutic purposes. Valuable time should not be wasted with unnecessary imaging. Despite the excellent accuracy of abdominal imaging there remains a subgroup of patients in which diagnostic uncertainty remains. It is in these cases that laparoscopy has an important role. Minimally invasive surgery has not only been utilized for diagnostic purposes but also has been performed for the management of complications following conservative management of solid organ injuries. Splenic cysts which do not resolve over time can be treated with partial splenic decapsulation. Bile leaks following conservative management of liver injuries can occur in up to 6% of patients. Endoscopic retrograde cholangio-pancreaticography (ERCP) and stent placement accompanied by external drainage of bile collections is the preferred treatment modality for intrahepatic duct injuries or small extrahepatic duct leaks. Directed external drainage can also be performed by laparoscopy, allowing excellent viewing of abdominal cavity breakdown of loculations and correct positioning of intra-abdominal drains. Where minimally invasive surgery has been slow to gain popularity in paediatric surgical practice, improved equipment and instrumentation suitable for children, more complex cases can successfully be treated today. Benefits of minimally invasive surgery are such as less postoperative pain, shorter hospital stay and shorter time to return.[14]

Conservative management of abdominal injuries

Management of paediatric abdominal trauma has evolved over the last four decades. Current strategies of non-operative management for most blunt solid organ injuries developed out of the observation that most solid organ injuries would 'heal themselves' and that operative intervention could indeed interfere with this process.[15] Organs most commonly injured are the liver and spleen, followed by kidney, pancreas and hollow viscera. It should also be stated at the outset that although conservative management is appropriate for the vast majority of patients who have sustained blunt abdominal trauma, the care of unstable patients should never be compromised by persevering with a conservative approach in the presence of life-threatening haemodynamic instability. Prescription during the admission process includes intravenous maintenance fluids, appropriate analgesia and a nil per os regime, as well as bed rest for a 'clinically appropriate' duration. The setting of the care, i.e. whether in a high care/intensive care or ward environment will be dictated by the clinical and metabolic condition of the patient, as well as by associated injuries, particularly intracranial pathology. The hospital for sick children in Toronto first reported conservative management of blunt splenic trauma in 1968,[16] and in 2000 the American Paediatric Surgical Association published recommendations to this end, particularly providing

guidelines for length of hospital admission and restriction of activity, all based on the radiological grade of injury.[17] Wherever the patient is monitored, regular repeat assessment is mandatory from both a clinical and metabolic perspective, and occasionally laparotomy becomes indicated on the basis of acute peritonitis or significant continued bleeding. What is not standardized is the length of bed rest after injury and whilst this used to be in excess of a week's duration, the current trend is for significantly shorter periods of both bed rest and hospitalization. In patients with a documented intra-abdominal injury, the initial 24 h period is critical, with the majority of treatment failures occurring within the first 12 h. The single most common indication for exploration of the injury remains ongoing transfusion requirements in excess of 40 ml/kg of packed red blood cells. Bleeding and hollow visceral injury aside, a percentage of conservatively managed patients may ultimately come to some type of intervention for ongoing complications, particularly biliary and urine leaks as well as delayed vascular complications. The majority of these can be managed outside of the acute period, and in addition, many interventions will be performed percutaneously and endoscopically, avoiding open exploration.[14] Despite their delayed intervention, the long-term outcome of this group of patients is not compromised, with the benefit that they spared the insults of early surgery. Controversy abounds with respect to length of bed rest and hospital stay, as well as the role of follow up imaging. It is not necessary to repeat radiological imaging routinely and we request this on an individual basis; however higher 'grade' injuries should be reviewed after 6 weeks particularly where the patient is being restricted from contact sports as one would like to see healing of the injury before allowing such contact again.[18] Based on the pathology of the healing process, this would mandate a 10-12 week period of rest. No level 1 evidence exists to support these practices.

PREVENTION OF CHILDHOOD INJURIES AND A NEW APPROACH TO CHILD INJURIES

The public health approach requires that we view child injuries similarly to any other disease or health problem.[19] This means that there is a human host (patient) who has a specific risk profile, there are mechanisms which cause or aggravate injuries, for instance a gun and there are a number of socio-economic environmental factors that either act as a protective barrier or increase the child's risk of exposure to violence. The public health approach stipulates that injuries are predictable rather than random events and it is by utilizing a combination of strategy (the four E's of injury control: Education, Enforcement, Engineering and Environment modification of incidence of violent injuries can be influenced). In the early 1970s, Haddon[20] proposed a conceptual framework that crossed time periods (pre events, intermediate post event and outcomes) and risk factors (human, injury, vehicle or environment). It is however very likely that a big percentage of the so-called accidental injuries of children are actually outcomes of certain types of abuse. A psychiatric model for child abuse and neglect evolved, implicating immaturity and psychopathology of the parents as the primary cause of abuse. Scientists working in the area of unintentional injuries strongly maintain that injuries to children do not constitute accidents and that using such a label perpetuates the myth that such events are unavoidable.[21] Therefore the definition of maltreatment should encompass all patterns of parenting that place the child at risk, including rejecting, isolating, terrorising, ignoring or corrupting. The most difficult practical issues for medical personnel dealing with child injuries is that it is often wrongly assumed that inflicted injuries can be readily separated from accidental injuries. Additionally, standards or guidelines for evaluation of what comprises an unintentional injury are lacking completely. A strong case can be made that children who do not possess the mature neuro-developmental state to assess the dangers in their environment adequately and/or respond to these dangers appropriately all represent forms of neglect (abuse).[22] Although it is well known and accepted that children must rely on caregiver supervision to remain safe and that supervision failing to meet community standards constitutes neglect, there is much uncertainty about what constitutes community standard for supervision. All forms of child neglect are difficult to identify because they constitute the absence rather than the presence of responding. The absence of appropriate supervision is extremely difficult to identify both because it is difficult to observe a non-response and because there are no standards to define adequate supervision. In theory almost all serious injuries could be prevented by adequate care giving. Over the last few years we have witnessed a medical strive to improve trauma care in nearly all countries. However, the moment has now arrived that paediatric care providers, and in particular paediatricians and paediatric surgeons should unite in order to establish a proper foundation on which preventative strategies can be build in the future.

By actively promoting child safety we will not only achieve a most welcome reduction in medical cost and disability, but the ever-so-much desired decline of avoidable childhood misery and suffering.

REFERENCES

1. van AS AB. A brief history of Medicine. Med J 2002;44:15-7.
2. Haller JA. Pediatric Trauma: The No. 1 Killer of Children. JAMA 1983;249:47.
3. van As AB and Millar AJW. What's new in paediatric trauma? (Editorial). Continuing Medical Education. March 2010; 28(3): 102.
4. Peden M, Oyegbite K, Ozanne-Smith J, Hyder AJ, Branche C, Fazlur Rahman AKM et al., eds. World Report on Child Injury Prevention. Geneva: WHO and UNICEF, 2008. http://www.who.int/violence_injury_prevention/child/en/ [Last accessed 19 August 2010]
5. Krug EG, Dahlberg LL, Mercy JA, Zwi A, Lozano R. World Report on Violence and Health. Geneva: World Health Organization; 2002.
6. ICRP. 1990 Recommendations of the international commission of radiological protection. Ann ICRP 1991;21:1-201.
7. Ron E. Ionizing radiation and cancer risk: Evidence from epidemiology. Pediatr Radiol 2002;32:232-7.
8. Willis CE, Slovis TL. The ALARA concept in pediatric CR and DR: Dose reduction in pediatric radiographic exams - A white paper conference Executive Summary. Pediatr Radiol 2004;34:S162-4.
9. van As AB, Douglas TS, Kilborn T, Pitcher R, Rode H. Multiple injuries diagnosed using full-body digital x-ray. J Pediatr Surg 2006;41:e25-8.
10. Douglas TS, Sanders V, Pitcher R, van As AB. Early detection of fractures with low-dose digital x-ray images in a pediatric trauma unit. J Trauma 2008;65:E4-7.
11. Saatman KE, Duhaime AC, Bullock R, Maas AI, Valadka A, Manley GT, *et al*. Classification of traumatic brain injury for targeted therapies. J Neurotrauma 2008;25:719-38.
12. Figaji AA. Targeted treatment of severe head injury. Continuing Medical Education. March 2010; 28(3): 104-107.
13. Figaji AA, Fieggen AG, Argent AC, LeRoux PD, Peter JC. Intracranial pressure and cerebral oxygenation changes after decompressive craniectomy in children with severe traumatic brain injury. Acta Neurochir Suppl 2008;102:77-80.
14. Numanoglu A. Laparoscopy in abdominal trauma. Continuing Medical Education. March 2010; 28(3) 119-121
15. Gaines BA. Intra-abdominal solid organ injury in children: Diagnosis and treatment. J Trauma 2009;67:135-9.
16. Davies DA, Pearl RH, Ein SH, Langer JC, Wales PW. Management of blunt splenic injury in children: Evolution of the nonoperative approach. J Pediatr Surg 2009:44:1005-8.
17. Stylianos S. Evidence- based guidelines for resource utilization in children with isolated spleen or liver injury: The APSA Trauma Committee. J Pediatr Surg 2000;35:164-9.
18. Lynn KN, Werder GM, Callaghan RM, Sullivan AN, Jafri ZH, Bloom DA. Pediatric blunt splenic trauma: A comprehensive review. Pediatr Radiol 2009;39:904-16.
19. Matzopoulos R, Bowman B. Violence and children in South Africa. In: van As AB, Naidoo S, editors. Paediatric Trauma and Child Abuse Chapter 2. South Africa, Cape Town: Oxford University Press; 2006. p. 19-28.
20. Haddon W Jr. A logical framework for categorizing highway safety phenomena and activity. J Trauma 1972;12:193-207.
21. Peterson L, Brown D. Integrating child injury and abuse-neglect research: Common histories, etiologies, and solutions. Psychol Bull 1994;116:293-315.
22. Du Toit N, van Niekerk A, van As AB. Child injuries and prevention. In: van As AB, Naidoo S, editors. Paediatric Trauma and Child Abuse Chapter 1. South Africa, Cape Town: Oxford University Press; 2006. p. 3-18.

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