



## PRACTICE REVIEW

### The history of paediatric trauma care in Cape Town

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Trauma is a leading cause of morbidity, mortality and disability in childhood. In most developed countries where 18% of the population are in the age group 0 - 15 years, injury exceeds all other causes of childhood mortality. In the developing countries of Africa, however, children aged 0 - 15 years constitute 43% of the population and trauma has an even bigger impact on child health.<sup>1</sup>

There is an erroneous perception that trauma is not a major health problem in Africa, derived from undue emphasis on mortality statistics alone. Yet, the impact of trauma ought to be measured not only in terms of death, but also the tremendous morbidity and disability caused by injuries, and their socio-economic consequences.<sup>2</sup>

#### History of emergency care

Until the late 60s and early 70s of the last century, medical trauma care received very little attention in most communities or from health care providers. Emergency medical care became a focus of widespread and continuing attention following publication in 1966 of the landmark report of the National Academy of Sciences (NAS) and the National Research Council (NRC): *Accidental Death and Disability: The Neglected Disease of Modern Society*. Morticians provided up to 50% of prehospital transport before that time, perhaps largely because hearses were the only available vehicles to accommodate stretchers.<sup>3</sup> The need for and success of emergency trauma care was firmly established by military surgeons on the battlefields of Korea and Vietnam.

#### Emergency care of children in Africa

The burden of trauma weighs heavily among all other diseases in modern times and although the industrialisation of Africa lags behind other continents, the most deadly transport vehicle, the motor car, continues to wreak havoc among our young population. There are reports that motor cars in Africa are responsible for more than 200 times more accidents, injuries and deaths than motor cars in the developed world. Motor vehicle accidents continue to be the leading cause of trauma in

children in most reports, and are responsible for 26 - 40% of all trauma-related childhood deaths in Africa.<sup>4</sup>

In South Africa more than one-third (39.5%) of infant transport-related deaths and more than half (56.4%) of child transport-related deaths were the result of pedestrian injuries. Among children, the 5 - 9-year age category was the most at risk for passenger injuries.<sup>5</sup> Of all the non-natural deaths occurring in South Africa, at least 10% are persons under the age of 18 years.<sup>5</sup>

#### Trauma care at Red Cross War Memorial Children's Hospital

Although it is now widely recognised that systematisation of trauma care reduces mortality and improves outcome in Africa, especially sub-Saharan Africa, trauma systems hardly exist. The development of such systems is urgently needed and involve several levels of planning. This was first recognised by Professor S Cywes, the head of Paediatric Surgery from 1975 to 1997. As a result of his vision, a Child Safety Centre was established at Red Cross Hospital in 1978, according to international standards, with the initial aid of a R1 000 grant from the Urban Foundation.<sup>6</sup> It has played a pioneering role concerning safety issues for children in Africa, and its staff became actively involved in improving the care of injured children, with a particular focus on preventive care.

Plans to develop a trauma unit, specifically dedicated to children, were also developed, and a previous administrative corridor on the ground floor of the B wing of the hospital was transformed to house the unit, comprised of a treatment and resuscitation room, a fully fledged radiodiagnostic imaging room, two operating theatres and a paediatric high-care ward with 10 beds. The unit was officially opened on 24 April 1984 and a new paediatric trauma surgeon appointed, together with a paediatrician. The specialised paediatric trauma unit proved to be an immediate success and in the first 5-year period 57 468 patients were treated (Table I).

During the course of 1997 a new system of health care referrals was introduced in the Western Cape, leading to a rather acute decrease in the number of patients presenting to our Unit. This decline continued until 2000; since then, however, the numbers have been rising gradually. Although the absolute numbers declined after 1997, the number of major trauma cases (resuscitations) actually increased, probably as a result of the increasing population of Cape Town.



**Table I. Patients treated and operated upon at the Red Cross Trauma Unit (1984 - 2004)**

Year	Patients treated	Operations
1984	11 178	507
1985	12 052	1 201
1986	12 860	1 064
1987	12 857	969
1988	12 923	921
1989	12 375	1 022
1990	14 892	912
1991	13 209	897
1992	12 461	778
1993	13 136	907
1994	14 780	1 397
1995	15 569	1 220
1996	13 473	951
1997	9 228	1 000
1998	8 752	1 013
1999	8 214	953
2000	6 923	861
2001	7 193	869
2002	8 050	829
2003	8 517	895
2004	8 798	892

Of all patients, 17.1% required admission. The majority of children presented to the trauma unit after a fall (43%), while other most common causes were bumps and blows (15%), transport-related injuries (11%) and burns (11%).<sup>7</sup>

In 2001, we performed a 10-year review, analysing the major causes of admission. Results are shown in Fig. 1. A total of 88 822 children were treated at the trauma unit in the period from 1991 to 2000. The most common injuries were falls ( $N = 32\ 766$ ) (21%), transport-related injuries ( $N = 11\ 915$ ) (13%), burns ( $N = 7\ 241$ ) (8%), struck by or against an object ( $N = 9\ 064$ ) (10%), foreign bodies ( $N = 3\ 677$ ) (4%), sharp instruments ( $N = 3\ 601$ ) (4%) and non-accidental injuries ( $N = 3\ 302$ ) (3%).<sup>8</sup>

One of the strengths of close co-operation between the trauma unit and the Child Safety Centre was the opportunity

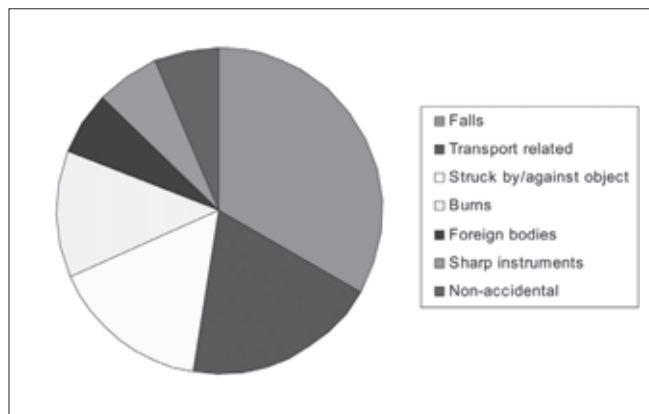


Fig. 1. Most common mechanisms of injury of patients admitted to the trauma unit ( $N = 88\ 822$ ).

to enter all paediatric trauma patients' details in the database at the Child Safety Centre. This made it possible to extensively study and analyse paediatric trauma, with the particular aim of designing effective accident-prevention programmes.

## The new trauma unit at Red Cross Hospital

During the late 90s it was recognised that the transformed administrative corridor was not the ideal geographical location to have a busy trauma unit. In accordance with the international trend to have a single unit dealing with emergency medical care as well as trauma, plans were designed to develop a new trauma unit with direct access to the medical emergency unit. This has several advantages. There is no patient confusion. All emergency patients enter the same door, with both the medical and surgical resuscitation rooms in close proximity of the emergency entrance. Another advantage is closer co-operation between medical emergency staff and surgeons. Also, in case of a mass disaster the units can become seamless and overflow into each other.

With great help from the Red Cross Hospital Trust R17 million was fundraised within a record time, and the unit was opened in October 2004. The new unit consists of a vastly modernised resuscitation room, including digital radiological equipment, two state-of-the-art modern operating theatres



Fig. 2. The new Trauma Unit at Red Cross Children's Hospital.



Fig. 3. The digital whole-body imaging device (Lodox StatScan) in the resuscitation room.



and a trauma admission ward, double the size of the old unit. The surface area of the unit has increased by 100%, enabling treatment and resuscitations to be more effective. In the old trauma unit the distance between the specially manufactured paediatric cots was only 60 cm, while in the new unit the international standard of 1.8 metres was achieved. This provides the nursing staff with ample space to conduct their duties without being hindered by other patients or visitors. The new unit is also designed to be naturally lit by daylight rather than artificial light, providing the children with a pleasant environment in which to recuperate (Fig. 2).

Another valuable asset to the new unit is a digital whole-body scanner, the Lodox StatScan. This imaging device, located in the resuscitation room, is able to perform a whole-body radiological scan within minutes after arrival of the child in the Trauma Unit, at significantly lower levels of radiation as compared with conventional radiological imaging. This is of particular advantage when dealing with large numbers of paediatric polytrauma patients. It also highlights subtle fractures that may be clinically missed initially (Fig. 3).

## Conclusion

Paediatric trauma care at our hospital has come a long way over the last 25 years, from practically being non-existent to an excellent, dedicated paediatric tertiary trauma centre, with a specialised surgeon present 24 hours a day. We can only hope that the care in other parts of the country will catch up soon.

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## Fifty years of paediatric anaesthesia – new approaches to an old technique

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The safety of paediatric anaesthesia has improved since Red Cross Children's Hospital opened its doors 50 years ago. At that time routine surgical procedures were considered life-threatening. To avoid the dangers of general anaesthesia some surgery was performed under local infiltration. However significant advances in virtually all aspects of paediatric anaesthesia have occurred over the past five decades. The peri-operative well-being of all children has become an expectation. Economic pressures may have modified practice so that children after minor and some major surgical procedures can be discharged the same day.

Peri-operative well-being is paramount. Improved outcome in children of all ages has become the focus of the modern paediatric anaesthesiologist. This has taken place in the face of improved surgical techniques and advances in neonatal care. More and more complex surgery, even in premature babies, who were not previously expected to survive, is being performed with good outcomes. Without the advances in anaesthesia, many of the surgical procedures performed at Red Cross Children's Hospital could not be done.

Computers and information technology have become an integral part of our lives. Evolution of this technology has influenced the way we conduct modern anaesthesia. Anaesthetic machines are self-calibrating with built-in safety checks to ensure safe delivery, fluid therapy and the infusion of intravenous agents can be tightly controlled and fine tuned, and ventilators and monitoring equipment have become highly sophisticated computer-controlled apparatus. Even anaesthetic record keeping can be automated.

Some of the more important advances considered to have had the greatest impact on the safety of anaesthesia and the well-being of children undergoing surgery are highlighted.

### Improved safety

Digby Leigh and Kathleen Belton wrote the first paediatric anaesthesia textbook<sup>1</sup> before the foundations to Red Cross Children's Hospital were even laid. Jackson Rees wrote his seminal paper on neonatal anaesthesia in 1952.<sup>2</sup> In South Africa

peri-operative mortality in the general population was 89 per 10 000. Anaesthesia mortality, defined as mortality partially or totally related to anaesthesia, was in the order of 3.3:10 000.<sup>3</sup>

By the mid-eighties the frequency had fallen below 1:10 000 and was comparable to rates in developed countries. In children the decrease in peri-operative mortality has followed similar trends with the most significant decrease occurring over the past three decades. Mortality has decreased from 1.8:10 000 in 1954 - 1966<sup>4</sup> to < 1:10 000 in developed countries,<sup>5,6</sup> even in high-risk children less than 1 year of age. The National Confidential Enquiry into Perioperative Deaths (NCEPOD) in the UK, established to evaluate the number of deaths in children under 10 years, recorded that only 5 of the 417 deaths were attributable to anaesthesia. Most recent figures from Australasia record deaths attributable to anaesthesia as low as 1 in 68 000.<sup>7</sup>

Surgery-associated mortality in the neonate has declined from more than 60% to less than 10% over the past 35 years. Red Cross Children's Hospital surgeons under Professor Louw could boast a lower neonatal mortality (1.8%), considerably better than any reported in the mid-70s.<sup>8</sup> This progress is attributable, almost entirely, to a better understanding of the pathophysiological changes that can occur during the perioperative period. It became increasingly apparent that the acute metabolic response to injury plays a central role in determining the clinical outcome of the critically ill infant. Unfortunately the impact of the HIV epidemic has had a significant impact on surgical outcome over the past decade.

### Induction

The aim of modern paediatric practice has been to reduce the impact of hospitalisation. Anaesthetists have played their role in this regard. Intramuscular injections are no longer used for premedication or analgesia unless specifically indicated. Children, and some parents, do not understand the need for preoperative starvation. Fortunately attitudes have changed and research has shown that the old maxim 'starve from midnight' is inappropriate. Children may be given clear sweet fluids up to 2 hours before elective surgery without additional risk.

The whole anaesthetic induction process is more 'child-friendly' in an attempt to make it a more congenial experience for children of all ages.<sup>9</sup> Rapid-onset, short-acting sedatives (midazolam) are popular in day-case surgery. Despite early resistance,<sup>8</sup> parents are allowed to accompany their child to the operating theatre until they are 'asleep.' (Fig. 1). Favourite



toys or other 'security blankets' are welcomed. Pungent odours of some anaesthetic vapours can be disguised by flavoured facemasks that are now produced in a variety of colours. Sevoflurane, even in high concentrations, is more pleasant, faster acting and has an odour that is more easily disguised than halothane or ether.



Fig. 1. Parental presence at induction, previously considered impossible, is now common practice in many institutions. Innovative methods can reduce anxiety at induction.

The inherent fear of needles has swayed anaesthetists to use of inhalation inductions rather than intravenous inductions in children. The advent of EMLA (eutectic mixture of local anaesthetics), a topical local anaesthetic cream that allows painless needle insertion, has changed the practice in some institutions. Unfortunately the onset time for adequate anaesthesia is approximately 1 hour, limiting its use in a busy environment. Other agents (amethocaine, lidocaine iontophoresis) with slightly shorter onset times have also proved impractical.

## Pain management

Less than 30 years ago pain management was not considered a priority for children undergoing surgery. 'Children seldom needed medication for the relief of pain after general surgery. They tolerate discomfort well.'<sup>1</sup> Attitudes changed in the early eighties with the realisation that better pain management and suppression of the stress response improved surgical outcome.<sup>10</sup> Inadequately treated pain in the newborn may also contribute to an increased sensitivity to pain in childhood.<sup>11</sup>

A multimodal approach to pain management is considered optimal.<sup>12</sup> The pharmacokinetics of paracetamol and non-steroidal anti-inflammatory drugs (NSAIDs) has been researched in children over the past decade. Much larger doses are required for analgesia and paracetamol has significant 'morphine-sparing' effects. An intravenous form of paracetamol has recently become available. Furthermore, with

a better understanding of the pharmacokinetics of morphine and other opiates, continuous infusions of these agents are used routinely.

Continuous opiate infusions dictate adequate monitoring. Children old enough to understand – about 5 - 6 years and older – can use patient-controlled analgesia (PCA). PCA gives children autonomy, something they were not granted in the past. Lower doses are required to provide satisfactory analgesia when using PCA.

Proponents of regional anaesthesia argue the benefits of continuous epidural infusions and more recently continuous peripheral nerve blockade. Regional anaesthesia fell out of vogue with the introduction of inhalational anaesthesia in the early part of the 20th century. Regional anaesthesia became popular when it was re-introduced in the mid-80s as the benefits of pain relief were realised and the increased survival of premature infants challenged the anaesthesiologist. The use of regional anaesthetic techniques has gathered momentum as equipment more appropriate for use in children has become available. It is now possible to perform epidural anaesthesia even in extremely low-birth-weight babies.<sup>13</sup>

Pharmacokinetic studies,<sup>14,15</sup> some performed at Red Cross Children's Hospital, have demonstrated the safety of continuous epidural infusions even in neonates.<sup>15</sup> The benefits include profound analgesia without opiate-induced respiratory depression, less need for postoperative ventilatory support, reduced nausea and vomiting, and no problems on withdrawal. Drug dosages, previously extrapolated from adults, have now been determined for children of all ages. Recent prospective studies<sup>16</sup> show that the major complications of regional anaesthesia in children are transient, easily treated and occur while the anaesthetist is still in attendance.

Evaluation of the efficacy of any treatment modality requires a validated pain scoring system. Many have been used and validated for children of different ages. All require education, time, understanding and a sufficient level of trained personnel. The BOPAS (Burn Observational Pain and Anxiety Scale) scoring systems,<sup>17</sup> developed and validated at Red Cross, have become an integral part of the management of children with burns.<sup>18</sup>

## Monitoring

Early monitoring was rudimentary; at times the anaesthetist 'barely knew whether the paediatric patient was alive or dead' (Tom Voss – personal communication). In this computer age the level of sophistication reached today would be the envy of our predecessors. Monitoring and maintenance of physiological function is an essential component of any anaesthetic. The more parameters monitored, the more information obtained and, provided the anaesthetist responds to the changes in the correct manner, the better the outcome will be. Gone are the days of a 'finger on the pulse' and prioritising the only available ECG machine, which was usually seized by the 'alpha' anaesthetist, to the highest risk patient. Automated non-



invasive blood pressure monitors with appropriate-sized cuffs are far more accurate than a baumanometer reading with an inappropriately large cuff. Fine-gauge arterial cannulas have replaced the 'needle in radial or brachial artery' (Tom Voss – personal communication).

Perhaps the most significant single development in modern anaesthesia has been pulse oximetry. Anaesthetists soon learnt to their horror that bradycardia was not an early sign of hypoxia. To wait for SpO<sub>2</sub> of 40% before triggering a response courted disaster. Further technological advances have led to cerebral oximetry using near-infrared spectrometry (NIRS). The FDA has recently approved the INVOS 5100 (Somanetics, Troy, MI, USA) cerebral oxygenation monitor. The INVOS employs an infra-red light source and two sensors applied over the skin of the left and right frontal cortical region. Each sensor transmits two beams of infra-red light. One sensor detects reflected infra-red light predominantly from skin and bone, and the other sensor analyses reflected light returning from brain tissue at a depth of 2.5 cm.<sup>19</sup> The monitor displays a regional saturation index (rSO<sub>2</sub>) of the mixed venous blood in the cerebral cortex that in return reflects the adequacy of regional cerebral perfusion.

There is some evidence that neurological outcome is improved with this type of monitoring, provided cerebral oxygenation is maintained, particularly during cardiopulmonary bypass (CPB) surgery.<sup>20</sup> Other monitors of cerebral function have been introduced but are not universally used in children. These include the Bispectral Index (BIS) monitor and Auditory Evoked Potential (AEP) monitors. The BIS, developed using integrated electroencephalograms (EEG) of adults, has only recently been validated using values obtained from anaesthetised or sedated children.

Automated self-calibrating machines that measure virtually every physiological parameter are the allies of the modern day anaesthetist. Inspired and expired gas measurement (oxygen, carbon dioxide and anaesthetic agent) give vital information that was not available to our predecessors. Blood gas analysis, serum electrolytes and clotting status can be determined within minutes. These are taken for granted today but were not even considered possible as little as 30 years ago.

## Management

Pharmacological advances, an improved understanding of neonatal physiology and goal-directed intensive care have all contributed to improved outcome. Long-term ventilation of newborns with tetanus was first performed at Red Cross.<sup>21</sup> No paediatric, let alone neonatal, ventilators were available at the time and innovative modifications of adult ventilators were made to reduce deadspace<sup>22</sup> and to reduce complications (e.g. barotrauma). This innovative work by Tom Voss proved to be a forerunner of ventilatory support and respiratory care that altered the expectations of surgeons, paediatricians and parents of children requiring major surgery forever.

Ventilatory support together with drugs that modify cardiopulmonary physiology have significantly improved the outcome of critically ill infants. Modes of ventilation have come a long way since modifications were made to 'adult' ventilators.<sup>22</sup> Perhaps the most advanced mode of ventilation in regular use today is high-frequency oscillatory ventilation (HFOV) which is essentially used to maintain oxygenation at low airway pressures in 'stiff lungs' to reduce barotrauma. CPB is no longer confined to cardiac surgery. CPB is used in some intensive care units to support infants with life-threatening pulmonary pathology, e.g. meconium aspiration or pulmonary hypoplasia associated with congenital diaphragmatic hernia.

Pharmacological advances have been a major factor in improving outcome and are likely to continue as the secrets of cellular and genetic function at the molecular level are revealed. Prostaglandin E infusions are now used routinely to maintain the patency of the ductus arteriosus in cyanosed newborns with duct-dependent pulmonary perfusion. Surfactant has proved life-saving for many preterm infants, not only improving their chances of survival but also reducing the severity of pulmonary barotrauma and bronchopulmonary dysplasia. Inhaled nitric oxide, a potent evanescent pulmonary vasodilator, may be used to improve pulmonary perfusion in certain reversible pulmonary hypertensive conditions.

Drugs that support or augment myocardial function have also played a major role. For example, milrinone, an inodilator, increases cAMP independent of adrenergic receptor stimulation. In children, milrinone decreases systemic vascular resistance by 37% and pulmonary vascular resistance by 27%<sup>23</sup> and thus decreases right and left heart-filling pressures. The inodilator effects of milrinone are greater than dobutamine and nitroprusside and it has played a major role in decreasing the risk of low cardiac output syndrome after congenital heart surgery, particularly following single ventricle repair.<sup>24</sup>

## Anaesthetic agents

Halothane was introduced into clinical practice in 1956. Arthur Bull was one of the first to use halothane anaesthesia in children when surgery began at Red Cross<sup>5</sup> (Fig. 2). Halothane has remained popular for use in children but is slowly being replaced by sevoflurane, a rapidly acting less pungent agent with less cardiovascular depression. Other agents (isoflurane, desflurane) are also less myocardial depressant. These agents are used for maintenance rather than induction of anaesthesia because they are too irritant for the paediatric airway.

The trend in modern anaesthesia is to develop rapid-onset, short-acting agents with rapid offset of action and fewer side-effects. Thiopentone has, until recently, been the mainstay of intravenous induction. Althesin and propanidid were popular for a while but were withdrawn because of the high incidence of anaphylactoid reactions to the cremophor vehicle. Propofol, a rapidly metabolised agent, has made a huge impact and has virtually replaced thiopentone. Propofol is much more forgiving on the paediatric airway. Many anaesthetists now