

tures, reading, classroom teaching, and optimally large numbers of hands-on practice in safe environments such as full-scale simulators, task trainers, and simulated patients (actors). The philosophy is that microsimulators in the same way as chess computers (i.e., microsimulators for chess playing) can provide the learning access to a vast amount of more or less seldom cases that can be dealt with dynamically. This aspect becomes particularly more important if the learners have limited access to "real" cases where they can be taught in an apprenticeship manner.

The issue of access to only a very limited number of clinically challenging problems (and consequently the lack of cognitive and psychomotor practice) is evident in the case of the training of the US Army Combat Medics (the so-called 91W program). The 91W program is a condensed 16-week course, with the first part being a standard EMT-B education. Due to a variety of reasons, with some being quite obvious during peacetime, the equivalent of clinical encounters, bedside learning, and clinical sessions is very limited. Therefore, the US Army decided to train to up to 8000 each year with extensive use of full-scale human patient simulators, a variety of task trainers such as IV arms and CPR manikins, and finally days in a simulated battlefield with both portable simulators and humans with wound make up.

The US Army is now introducing microsimulation as an integrated part of the training of the army combat medics in order to achieve a number of benefits: a) to strengthen the cognitive training by focusing more on deep learning (by doing!) rather than more superficial learning types that can be the result of classroom teaching only, b) to use less intensive time during practical exercises for more self-directed learning, and c) to free resources during the practical exercises in order to increase the instructor-to-student ratio during psychomotor and field training exercises. The military microsimulators are based on systems used in prehospital and in-hospital care as well as by the Red Cross in many countries for training in First Aid (in the military environment the target for the latter technology is the equivalent of First Aid – called Self Aid and Buddy Aid). The immediate implementation of the military microsimulators will be at the combat medic level, but the technology has been developed to be scaled up and down to be used for all group of personnel from emergency physicians to EMT-Bs, combat medics, and nurses. The majority of the cases will focus on trauma care, but a large number of cases will also be aimed at the EMT-B education, including ALS and other aspects of acute medicine as well as several cases aimed at CBRNE (chemical, biological, radiation, nuclear, explosions) related patients.

Rapid Preparation of Reserve Military Medical Teams Using Advanced Patient Simulators

Guy Lin,¹ Yabav Oron,¹ Ron Ben-Abram,¹ Dafna Barsuk,² Haim Berkenstadt,² Amitai Ziv,² Amir Blumenfeld¹

¹IDF-Medical Corps Trauma Branch and the ²National Medical Simulation Center (M.S.R.), Chaim Sheba Medical Center, Tel-Hashomer, Israel

Learning Objectives: To discuss the advantages of the use of advanced patient simulators in the training of reserve medical personnel.

Primary prehospital medical treatment for trauma casualties has unique features in the military setting. The environment is sometimes hostile, and tactical situations together with the feasibility of evacuation are major considerations. Most of our reserve medical teams are not working routinely in this environment. In many debriefings, we recognize gaps in patients' evaluation, diagnosis of deterioration in the patient respiratory or hemodynamic condition after the initial treatment, and need for rapid evacuation. We believed that training with advanced patient simulators could improve these tasks.

Many reserve medical teams were recruited for the medical support of the "Defensive Shield" operation (April 2002). The reserve teams were composed of physicians having all kinds of expertise and medics having various non-medical professions. A questionnaire revealed that 72% of reserve staff rarely treat trauma patients. Forty-seven percent define themselves as not good enough in trauma management. Moreover, reserve forces are usually trained for a high-intensity conflict, being prepared for prolonged evacuation time, and are not accustomed to the nearness of trauma centers to the battle zone.

Every military physician has ATLS certification. Complementary training is usually done by traditional methods such as simple manikins and living animal models. These models fit for technical skills and familiarity with the equipment, and less for diagnosis and decision-making. Team training is usually done by "fake" patients with less attention to individual performance. Advanced patient simulators give the opportunity to integrate all these skills.

Recruitment of reserve medical teams for medical support of battle zones adjacent to medical centers creates a need to assimilate rapid diagnosis and decision making (which interventions are more important than time?), together with refreshment of the critical skills of airway management and chest decompression.

During a 3-week period, 75 teams (90 physicians and 352 medics) were trained by advanced patient simulators in the Israeli Center for Medical Simulation (a collaboration of military and civilian systems).

We developed a scenario-based training adapted to specific missions. The basic program included an airway station (Airman manikin), head injury with difficulties in endotracheal intubation (Sim Man manikin), penetrating chest injury causing tension pneumothorax and hemorrhagic shock (Meti manikin), a multi-trauma pediatric patient (Pediasim Meti manikin), and a multi-casualty event. Video-screened debriefing was conducted by experienced ATLS instructors.

Feedback of trainees revealed overwhelming satisfaction. Reality of scenarios was evaluated as high by 95% of trainees. Eighty-seven percent said they are more ready for decision making in the care of combat casualties. Seventy-three percent felt they increased their knowledge and improved their skills.

Twelve trained medical teams have treated major trauma patients during the operation. They reported great contribution of advanced simulators training to the care of their patients: improved individual performance, self-confidence, and staff coordination.

Conclusion. Scenario-based training using HPS should be a leading system in the qualification of military medical teams. Rapid preparation for combat casualties care is feasible. This method of treatment should be developed, and the next step will be constructing a study for objective validation.

Selected References

- Ali J, Adam R, Josa D, et al. Effects of basic pre-hospital trauma life support program on cognitive and trauma management skills. *World J Surg* 1998; 1192-6.
- Ali J, Adam R, Pierre I, et al. Comparison of performance two years after the old and new (interactive) ATLS courses. *J Surg Res* 2001; 97:71-5.
- Ali J, Cohen RJ, Gana TJ, Al-Bedah KF. Effects of ATLS program on medical students' performance in simulated trauma patient management. *J Trauma* 1998; 44:588-91.
- Ali J, Gana TJ, Howard N. Trauma mannequin assessment of management skills of surgical residents after ATLS training. *J Surg Res* 2000; 93:197-200.
- Bond FB, Kostenbader M, McCarthy JF. Pre-hospital and hospital-based health care providers experience with a human patient simulator. *Prehospital Emerg Care*

2001; 5:284-7.

Blumenfeld A, Abraham RB, Stein M, et al. Cognitive knowledge decline after ATLS courses. *J Trauma* 1998; 44:513-6.

Devitt JH, Kurrek MM, Cohen MM, Cleave-Hogg D. The validity of performance assessment using simulation. *Anesthesiology* 2001; 95:36-42.

Issenberg SB, Megachic WC, Hart IR, et al. Simulation technology for health care professional skills training and assessment. *JAMA* 1999; 282:861-6.

Ziv A, Small S, Wolpe P. Patient safety and simulation based medical education. *Med Tech* 2000; 22:489-95.

Drills: Are They the Best Way to Prepare for a Mass Casualty Situation?

Moshe Michaelson, MD

Trauma Unit, Rambam Medical Center, Haifa, Israel

Learning Objective: To compare the types of drills available for training participants to respond to a mass casualty situation.

The key to success in a mass casualty situation (MCS) is to be prepared. The first step in preparedness is writing detailed standing orders. Standing orders should provide answers to all the problems that may arise during this difficult situation. However, writing standing orders is only part of the solution. A bigger task is to disseminate the information to all participants. There are a few tools to help us in this undertaking, and drills are one of the best. We discuss the types of drills available, with emphasis on the role each drill plays in achieving the goal of preparing the system to deal with an MCS. Attention is paid to cost-benefits and the ability of a single hospital to organize drills without outside help. At the end of the presentation, it will be clear whether drills are the best way to prepare for an MCS.

Friday, May 16, 2003

Simultaneous Afternoon Sessions

— Session A —

Update on New Drugs, Equipment, and Techniques in Trauma Care

Chair: Charles E. Smith, MD, FRCPC, Cleveland, Ohio, USA

What's New in Pulse Oximetry

Steven J. Barker, PhD, MD

Professor and Head, Department of Anesthesiology
University of Arizona, Tucson, Arizona, USA

Learning Objectives: This lecture will promote a better understanding of 1) how pulse oximeters work, 2) what they can and cannot measure, 3) the application of pulse oximetry to care of the trauma patient, and 4) current and expected new developments in the technology.

This lecture will review the theoretical background and recent developments in pulse oximetry, with emphasis on its use in trauma patients. The relationship of pulse oximetry to other monitors of patient oxygenation will be explored through a review of the physiology of oxygen transport. Clinical applications will be used to show both the value and the limitations of saturation monitoring.

Recent developments in pulse oximetry have been aimed chiefly at improving accuracy and reliability in the presence of various signal artifacts. These sources of error include patient motion, hypovolemia, shock, dyshemoglobinemias, and venous pulsations. Each of these artifacts and their potential remedies will be discussed in the context of the trauma patient.

Capnography in Trauma

Steven J. Barker, PhD, MD

Professor and Head, Department of Anesthesiology
University of Arizona, Tucson, Arizona, USA

Learning Objectives: This lecture will provide a better understanding of the mechanisms of CO₂ transport from the body, the relationship between arterial and end-tidal CO₂ tensions, and the use of the capnogram as a diagnostic tool. The attendee will be able to identify various abnormal capnogram shapes and use these to initiate and monitor treatment.

Capnography, the measurement of respiratory carbon dioxide, is effectively a minimum standard of care for general anesthesia. It is particularly important in the trauma patient, because the capnogram provides information not only about ventilation, but also about circulation and metabolism. This lecture will review the physiology of carbon dioxide transport, using this background as a guide to the interpretation of expired CO₂. The reasons for the difference between end-tidal and arterial carbon dioxide tensions will be discussed in detail, to show how this difference can be used as an important diagnostic tool.

We shall also review some basic capnogram waveforms and their clinical interpretation. This waveform can provide valuable diagnostic information, and it can also be used to monitor the progress of therapeutic interventions. We will see how the capnogram can even be used to measure the effectiveness of chest compressions during CPR. Unlike the pulse oximeter, which provides data on only one patient variable (arterial oxygenation), the capnogram provides an indication of metabolism, circulation, and ventilation simultaneously.

Neuromuscular Relaxant Pharmacology: An Update

Charles E. Smith, MD, FRCPC

Department of Anesthesia, MetroHealth Medical Center, Case Western Reserve University, Cleveland, Ohio, USA

Learning Objective: To discuss the scientific basis for choosing a neuromuscular relaxant for trauma patients.

Non-depolarizing relaxants bind to the acetylcholine (Ach) receptor at the post junctional nicotinic receptor and competitively prevent binding of Ach to the receptor. The ion channel is closed and no

current can flow. Depolarizers such as succinylcholine mimic the action of Ach and result in excitation of muscle contraction followed by blockade of neuromuscular transmission. Nonclassical mechanisms include prejunctional block, ion channel block, desensitization of receptors, perijunctional block, and tonic block of extraocular muscles.

Relaxants are used to facilitate tracheal intubation and provide skeletal muscle relaxation for surgery and mechanical ventilation. Other reasons are to reduce oxygen demand and intracranial pressure, abolish shivering, and as adjuncts to the treatment of tetanus, and status epilepticus.

Non-depolarizers are polar molecules. Potency is described by dose-response relationships. The ED₉₀ is the dose that produces 90% block (\pm SD). In practice, larger doses such as 3 x ED₉₀ are given to produce profound block initially. Smaller "repeat" doses or continuous infusions are then used to maintain block. Some muscle groups are more resistant than others with the dose-response curve shifted to right: e.g., diaphragm, larynx, eye muscles. Other muscle groups are more sensitive with the dose-response curve shifted to left: e.g., pharyngeal musculature that maintains upper airway patency. Monitoring of neuromuscular function is crucial in order to avoid complications from giving too much or too little relaxant.

Various factors influence the choice of relaxant such as onset, duration, side effects, histamine release, biliary or liver disease, renal function, hypothermia, age, and altered pharmacology due to drug-drug and drug-disease interactions (e.g., volatile agents, magnesium, muscular dystrophies, burns, motor neuron disease, myasthenia gravis, and sepsis). The table summarizes some important clinical information on neuromuscular relaxants for trauma.

Selected Neuromuscular Relaxants for Trauma

Agent	Intubating dose, mg/kg	Intubating time (min) ^	Duration (min)*	Comments
Succinylcholine	0.6-1.1	1	4-6	Side effects may contraindicate its use, e.g., hyperkalemia
Rocuronium	0.6-1.2	0.7-1.1	31-67	Nondepolarizer of choice for rapid sequence intubation. Mild vagolysis
Mivacurium	0.15-0.25	1.5-2.5	16-23	Metabolized by plasma cholinesterase. Histamine release
Vecuronium	0.08-0.10	2.5-3	25-40	Onset time delayed unless high doses (0.3-0.4 mg/kg) used. Cardiovascular effects unlikely
Cisatracurium	0.15-0.2	1.5-2	55-65	Potent stereoisomer of atracurium with organ independent elimination. Cardiovascular effects unlikely
Atracurium	0.4-0.5	2-2.5	35-45	Organ independent elimination. Histamine release
Pancuronium	0.06-0.10	2-3	65-100	Long acting. Associated with tachycardia and activation of the sympathetic nervous system

^ Average time to good-excellent intubating conditions ((80% block).

* Average time to 25% first twitch recovery.

References

1. Bevan DR. Complications of muscle relaxants. *Semin Anesth* 1995; 14:663.
2. Smith CE, Grande CM, Wayne MA, ITACCS Consensus Panel, and International Review Committee. Rapid Sequence Intubation in Trauma. ITACCS, Baltimore, 1998.
3. Grande CM, Smith CE, Stene JK. Trauma anesthesia. In Longnecker DE, Tinker JH, Morgan GE, eds. *Principles and Practice of Anesthesiology*, 2nd edition. St. Louis, Mosby, chapter 81, 1997, pp 2138-64.

Acid-Base Balance in Trauma Resuscitation

Lewis J. Kaplan, MD, FACS

Associate Professor of Surgery, Director Emergency General Surgery, Yale University School of Medicine, Department of Surgery, Section of Trauma, Surgical Critical Care, and Emergency General Surgery, New Haven, Connecticut, USA

Learning Objectives: 1) To articulate the recent advances in trauma care over the past 3 years, 2) to enumerate the directly applicable changes in the trauma care paradigm, and 3) to construct an integrated plan to minimize iatrogenic acidosis and minimize transfusion needs in severely traumatized patients.

Military realities as well as civilian trauma (e.g., terrorist attacks of 9/11/01) have prompted a reexamination of trauma resuscitation tools and strategies. Traditional resuscitation strategies focused on hemorrhage control in conjunction with intense fluid resuscitation, including massive transfusion of blood and blood products as needed to clear lactate as an arbiter of hypoperfusion.¹ Recognition of the potential deleterious effects of this strategy prior to definitive hemorrhage control, limitation of the US blood banking system to meet demands, and heightened public and medical desires to avoid allogeneic exposures also promoted reevaluating the traditional resuscitation paradigm.

Several key factors have influenced the reshaped perspective in trauma resuscitation: 1) equivalent survivorship with low pressure resuscitation,² 2) laboratory evidence of reduced survivorship with high volume resuscitation,³ 3) acknowledgement of the presence and importance of hyperchloremic acidosis following massive resuscitation,⁴ 4) recognition of the interplay between metabolic acidosis and coagulopathy independent of hypothermia,^{5,6} 5) improved understanding of the relationship between starch-based resuscitation and coagulopathy,^{7,8} 6) accelerated interest in prehospital and military evaluation of hemoglobin-based oxygen carrier driven resuscitation, 7) the development and looming implementation of pro-

coagulants such as recombinant factor VIIa⁹ and a durable hemostatic dressing, and ¹⁰) elucidation of the key role of maintaining microcirculatory flow as a means of ameliorating regional hypoperfusion.

As a result, increases in starch-based resuscitation, including during the current war in Iraq, and reduced prehospital volume resuscitation are becoming more widely accepted. Multiple trials are being initiated to explore the benefits of procoagulant agents as well as the efficacy of HBOC resuscitation. However, the clear benefit from these changes is an altered acid-base profile from reduced chloride loading. Further data evaluation will allow us to understand the impact such a strategy will have on ICU length of stay, minute ventilation needs, and blood product transfusion.¹⁰

References

1. Cinat ME, Wallace WC, Nastanski F, et al. Improved survivorship following massive transfusion in patients who have undergone trauma. *Arch Surg* 1999; 134(9):964-8.
2. Dutton RP, Mackenzie CF, Scalea TM. Hypotensive resuscitation during active hemorrhage: impact on in-hospital mortality. *J Trauma* 2002; 52(6):1141-6.
3. Solomonov E, Hirsh M, Yahya A, et al. The effect of vigorous fluid resuscitation in uncontrolled hemorrhagic shock after massive splenic injury. *Crit Care Med* 2000; 28(3):749-54.
4. Kaplan IJ, Bailey H, Kellum J. The etiology and significance of metabolic acidosis in trauma patients. *Curr Op Crit Care* 1999; 5(6):458-63.
5. Roche AM, James MF, Grocott MP, Mythen MG. Coagulation effects of in vitro serial haemodilution with a balanced electrolyte hetastarch solution compared with a saline-based hetastarch solution and lactated Ringer's solution. *Anaesthesia* 2002; 57(10):950-5.
6. Patterson T, Bailey H, Kaplan IJ. Hyperchloremia induces acidosis, increases the strong ion gap, and impairs coagulation. *Crit Care Med* 2000; 28(12):A118.
7. Martin G, Bennett-Guerrero E, Wakeling H, et al. A prospective, randomized comparison of thromboelastographic coagulation profile in patients receiving lactated Ringer's solution, 6% hetastarch in a balanced-saline vehicle, or 6% hetastarch in saline during major surgery. *J Cardiothorac Vasc Anesth* 2002; 16(4):441-6.
8. Kaplan IJ, Bailey H, Walters W. Large volume resuscitation with hydroxyethyl starch in lactated ringers solution restores perfusion and minimally induces hyperchloremia without impairing coagulation. *Crit Care* 2001; 5(Suppl 1):S53.
9. Martinowitz U, Kenet G, Segal E, et al. Recombinant factor VII for adjunctive hemorrhage control in trauma. *J Trauma* 51(3):431-9.
10. Claridge JA, Schulman AM, Young JS. Improved resuscitation minimizes respiratory dysfunction and blunts interleukin-6 and nuclear factor-kappa B activation after traumatic hemorrhage. *Crit Care Med* 2002; 30(8):1815-9.

The Management of Massive Bleeds in Trauma by an Injury Site-Specific Agent (Recombinant Activated Factor VII)

U. Martinowitz,¹ L. Abaronson-Daniel,² G. Kenet,¹ B. Savitsky,² A. Lubezki,¹ G. Martonowits,³ G. Lin,³ A. Blumenfeld,³ and K. Peleg⁴
¹The National Hemophilia Center, ²The National Center for Trauma and Emergency Medicine Research, ³The Gertner Institute, Sheba Medical Center, Tel Hashomer, Ministry of Health and Sackler School of Medicine, ⁴Tel Aviv University, and ⁵Medical Corp, Israel Defense Forces (G.M. is the Surgeon General), Israel

Learning Objective: To discuss the use of recombinant activated factor VII as a hemostatic agent in trauma patients with massive hemorrhage.

Uncontrolled hemorrhage is a major cause of death in trauma patients, accounting for about 40-50% of the mortality in both military and civilian trauma. Most critically ill trauma patients develop profound multifactorial coagulopathy due to activation of coagulation with consumption of coagulation factors and platelets, activation of fibrinolysis (with fibrinogenolysis and hyperfibrinolysis in massive trauma), hemodilution, massive transfusions, hypothermia, and metabolic changes (acidosis, hypocalcemia, etc.). Introduction of a "site-specific" agent enhancing hemostasis only at the site of injury may decrease hemorrhagic mortality and morbidity in trauma patients. Such an agent, rFVIIa, has been used successfully for almost a decade in patients with hemophilia developing inhibitors to factor VIII or IX. rFVIIa activates the coagulation system on the membrane of activated platelets, adhered to the site of injury, upon complex formation with tissue factor that is exposed at that site. Hence, its action is compartmentalized, limited to the site of injury, without a systemic effect. The use of rFVIIa in trauma patients was avoided due to the theoretical risk of thrombotic complications. We performed a pig trauma study that supported the safety and efficacy of rFVIIa in this animal trauma model and, immediately after, a few exsanguinating trauma patients were treated successfully with rFVIIa, which led to ethical committee approval of this agent in patients suffering uncontrolled bleeding.

Patients. Since mid-1999, more than 105 trauma, surgical, and medical patients suffering massive life-threatening bleeding have been treated with rFVIIa in Israel. We describe here the data of 36 trauma patients treated in 14 of the 22 hospitals in Israel. Patients were critically ill (ISS 25-75 in 86%), multi-transfused (see below), hypothermic, and acidotic and suffered profound coagulopathy (see below). Median age was 20 (range 14-65). Most were victims of terror (40%) and other violence (32%), which reflected the type of injury (46% penetrating, 11% blast, and the rest, blunt).

Results. The abnormal coagulation tests improved significantly within 15-20 minutes after administration of rFVIIa (PT shortened from 20.7 \pm 8.4 to 13.3 \pm 6.3 seconds [$P < 0.005$] and aPTT from 75 \pm 41 to 55.7 \pm 31.9 seconds [$P < 0.005$]). Cessation of bleeding was observed in 27/36 (75%) of the patients after administration of one to four doses of rFVIIa. Blood requirements decreased dramatically from 29.2 \pm 22.2 units of red packed cells given within 5.2 \pm 4 hours to 5.2 \pm 6.19 units given over the next 24 hours (2.2 \pm 2.5 in the survivors) ($P < 0.05$).

Twenty-two patients (61%) survived. The most common cause of death was exsanguination (8/14 [57%]) followed by sepsis (4/14 [28.5%]) and SIRS (2/14). Acidosis was found to be an independent risk factor for no response and mortality. There is also an impression that rFVIIa is less effective below pH of 7.1, but the number of patients is too small to reach conclusion. A trend for a better survival was found in patients who received higher first dose (median 120/ 98-138 [25-75 IQR] mcg/kg) vs. those who received 96/ 50-120(25-75 IQR) mcg/kg but larger numbers are required to evaluate this point.

Suggestions. rFVIIa seems to be a promising adjunct hemostatic agent in trauma patients suffering massive hemorrhage.

Future Perspectives. Recent evidence from clinical cases suggest that rFVIIa may have beneficial effect in traumatic brain injuries and blast lung injuries and may also improve and prolong survival upon prehospital administration (prolongation of the "golden hour"). Such preliminary evidence will be presented.

Damage Control Orthopedics

James C. Duke, MD

Associate Director, Department of Anesthesiology, Denver Health Medical Center;
Associate Professor of Anesthesiology, University of Colorado Health Sciences Center,
Denver, Colorado, USA

Learning Objective: To gain some understanding of the evolution in management of long-bone fractures in the multiply injured patient.

"Damage control" surgery began with packing of significant hepatic injuries when it was recognized that prolonged operative time resulted in exsanguinating, cold, acidotic, coagulopathic patients who often went on to die.¹ When hemorrhage was controlled, the patient was transferred to the ICU for further correction of these metabolic problems. The patient then received a planned reoperation once physiologic stabilization was achieved. Since that time, the techniques of damage control have evolved and been applied to other surgical disciplines, including orthopedic trauma.

The timing of long-bone fracture fixation has long been a topic of controversy. In selected patients, early total fracture care has benefits, including less pain, earlier mobilization, ease in nursing care, less fat embolization, fewer decubitus ulcers, as well as reduced pulmonary sequelae. However, controversy exists as to whether early total care may place certain patients with associated pulmonary or head injuries at risk for clinical deterioration. No randomized clinical trials exist with which to make the best clinical recommendations or to support a "standard of care." The best clinical data tend to be prospective and noncomparative, and recommendations are very general in nature.

"Damage control orthopedic" care has been adopted by many trauma centers as the preferred method of managing long-bone fractures in the multiply injured patient.^{2,4} Generally speaking, these patients are hemodynamically unstable and have multisystem injuries, and, in particular, pulmonary injuries. Damage control is practiced by employing temporary external fixation as a bridge to definitive operative repair. The orthopedic complication rate for delayed definitive fixation compares favorably with that of patients receiving early definitive fixation.

In conclusion, there is a clear benefit to early stabilization of long-bone fractures. Early intramedullary fracture fixation remains a desirable goal in the patient with only isolated femur fractures. However, certain multiply injured "borderline" patients with long-bone fractures should receive temporary external fixation. Many of the benefits of definitive intramedullary fixation, such as decrease in pain and requirement for analgesics, less fat embolization, and ease in nursing care will be conferred while limiting surgical trauma, fluid and blood resuscitation, and hypothermia in a vulnerable period.

References

1. Johnson JW, Gracias VH, Schwab CW, et al. Evolution in damage control for exsanguinating abdominal injury. *J Trauma* 2001; 51:261-71.
2. Scalea TM, Boswell SA, Scott JD, et al. External fixation as a bridge to intramedullary nailing for patients with multiple injuries and with femur fractures: damage control orthopedics. *J Trauma* 2000; 48:613-23.
3. Pape H-C, Giannoudis P, Krettek C. The timing of fracture treatment in polytrauma patients: relevance of damage control orthopedic surgery. *Am J Surg* 2002; 183:622-9.
4. Pape H-C, Hildebrand F, Pertsch S, et al. Changes in the management of femoral shaft fractures in polytrauma patients: from early total care to damage control orthopedic surgery. *J Trauma* 2002; 53:452-62.

— Session B —

Ethics: Organ Donation, End of Life Issues

Chair: Anne J. Sutcliffe, MB ChB, FRCA, Birmingham, UK

Managing Death and Dying

Anne Sutcliffe MB ChB, FRCA

Consultant in Anaesthesia and Critical Care, Queen Elizabeth Hospital, Birmingham B15 2TH, UK, and Honorary Senior Lecturer, University of Birmingham

Learning Objectives:

- To demonstrate that death is easier to accept if it is explained in terms that include not only medical but also religious and cultural concepts.
- To illustrate that traditional and brain stem death are more similar than commonly believed.

Death of a loved one is never easy to accept. This is particularly true following head injury, because the severity of external injury is often minimal in comparison to internal, invisible injury. The difficulty is even greater when the diagnosis of brain stem death is made in a warm, pink, "breathing" patient.

Unlike other medical diagnoses, death is final and is not amenable to further treatment. Treatment occurring at the time of death is stopped rather than withdrawn. Decisions to withdraw or withhold treatment imply that although treatment may have short-term physiological benefit, this benefit will not alter the underlying disease process and death is inevitable in days or weeks. In the case of brain stem death, treatment is neither possible nor of benefit.

Recommendations for end-of-life care in the intensive care unit deal mainly with patients in whom treatment is withdrawn.¹ Nevertheless, they contain useful guidance for management of the brain-dead patient. Communication with families is essential. It may help them to accept death if they are able to understand the similarities between traditional and brain stem death. This implies that the staff supporting them must also be clear about how its current medical concepts fit into religious, societal, and cultural concepts of death.

Brain stem death has been an accepted diagnosis for approximately 20 years but is still challenged by some doctors² and religious groups.³ Others see it as a means to the end of developing the organ transplantation programme. In Japan, it is possible to choose how the declaration of death is made.⁴

For the following reasons, I believe traditional death and brain stem death are more closely related than many people appreciate:

- Traditional death depends on recognisable features such as absence of respiration and a pulse. Some religions, e.g., Judaism, require that breath has left the body, based on medicine as it was practiced in ancient times. In fact, unsuccessful cardiopulmonary

resuscitation is always associated with brain stem death and this is the reason the patient does not breathe and the heart does not beat.

- Life and death are a continuum marked by the acquisition of mandatory certificates at given points of time. Death in all its forms is a process, not an event, as suggested by the legal requirement to state a time of death. This time describes the time the diagnosis is made, not the time when the process reached a point where medical death can be diagnosed.
- The diagnosis of death has always described the death of the organism as a whole, not the whole organism.
- All diagnoses of death require that preconditions are met. Hypothermia is an exclusion criterion for both traditional and brain stem death.

Further Reading

1. Truog RD, Cist AFM, Brackett SE, et al. Recommendations for end-of-life care in the intensive care unit: The Ethic Committee of the Society of Critical Care Medicine. *Crit Care Med* 2001; 29:2332-48.
2. Taylor RM. Reexamining the definition and criteria of death. *Semin Neurol* 1997; 17:265-70.
3. Lazar NM, Shemia S, Webster GC, et al. Bioethics for clinicians: 24. Brain Death. *CMAJ* 2001; 164:833-6.
4. Morioka M. Reconsidering brain death. A lesson from Japan's fifteen years of experience. *Hastings Center Report* 2001; 31:41-6 (www.lifestudies.org/reconsidering.html).

Diagnosing Brain Stem Death: After 30 Years, Couldn't We Do Better?

Dr. Gerlinde Mandersloot

Royal London Hospital, London, United Kingdom

Learning Objectives: To assess the changes and progress in medical technology, philosophy, and ethics relating to brainstem death.

The development of medical technology in intensive care medicine dramatically increased the complexity of cases over the past 30 to 40 years. The ability to maintain ventilation and circulation artificially, and the advances made in organ transplantation, showed that meaningful life could be maintained even though these organs had failed. Therefore, the concept of cessation of cardiorespiratory function as the defining criteria for death had to be revised.

The (re)definition of death—"irreversible loss of the capacity for consciousness, combined with the irreversible loss of the capacity to breathe"—has largely been accepted throughout the western world, since its inception in the 1960s. The debate surrounding brain (stem) death initially involved mainly clinicians, lawyers, philosophers, and religious leaders. This concept of death has been accepted in the United Kingdom and United States without much public debate, but in the last 20 years it has seen extensive public debate in Denmark, Germany, and also Japan. It remains interesting to note that worldwide the public voice was not heard as much in this debate as in the one on when "life" begins.

Although clinical diagnosis remains at the heart of the diagnosis of brain stem death, some countries specify additional special tests. These may be required by law as an essential component of the diagnosis, or left to the discretion of the clinicians to be used as an additional decision-making tool. The special investigations also vary from country to country and include EEG, vascular flow studies, CT scanning, and MRI. Little work has been done to objectively assess the contribution and validity of these investigations.

Also, the point of death remains a varying one. For example, in the United Kingdom, the time of death is recorded as the time when the first set of clinical tests confirm brain stem death, in Denmark it is recorded as the time when the heart stops.

Although brain stem death has gained increasing acceptance over the last 30 years, many questions surrounding the philosophical concept of what death is and when it occurs, the diagnostic criteria, and confirmatory tests required still remain.

Bibliography

- Beecher HK. A definition of irreversible coma. Report of the ad hoc committee of the Harvard Medical School to examine the definition of brain death. *JAMA* 1968; 205:337-40.
- Working Group of Conference of Medical Royal Colleges and their Faculties in the United Kingdom. *The criteria for diagnosing brainstem death*. *J R Coll Phys (Lond)* 1995; 29:281-2.
- Pallis C, Harley DH. *ABC of brainstem death*, second edition. London, BMJ Publishing Group, 1996.

Improving Organ Donation Rates

Walter Mauritz, MD, Paul Sporn, MD, Emanuel Sporn, MD¹

¹Department of Anesthesia and CCM, Trauma Center, "Lorenz Boehler", ²Department of Anesthesia and CCM, KA "Rudolfstiftung", ³Department of Surgery, University of Vienna, Vienna, Austria, EU

Learning Objectives: To describe the current state of organ donation, as well as medical, organizational, financial, and legal approaches to improve donation rates.

Methods. Medline searches for "organ donation rates", "organ transplantation" (by organs), and "donation rate improvement" from 1994 – 2003. Internet search for "transplant statistics". With a few exceptions, only data from the US and the EU were used.

Results. There is a serious worldwide shortage of transplantable organs. The maximum donation rate is estimated to be 50/mill.pop./yr; 35/mill.pop./yr is considered optimal. Most centers achieve only a fraction of this value, and many patients die on the lists. Different strategies have been employed to improve donation rates:

- Medical: "Expanded donor criteria": kidneys from elderly donors, non-heart-beating donors, donors with renal disease; livers from hepatitis C-positive donors, from aged donors (>70 yr!!); lungs from older donors (>55 yr), from smokers with >20 "pack yrs" (!), hearts from poisoned donors, and various organs from donors with a history of cancer have been used with good results. "New techniques": split liver transplantation, xenotransplantation (?). All these options increase the rate of available organs by a considerable margin.
- Organizational: Increasing awareness of medical staff that organ donation is an option, improving the request process, and improving donation logistics have all resulted in increased donation rates.
- Financial: In some countries (e.g. Turkey, India), organs may be bought, which gives acceptable long-term results but higher rates of HIV- and hepatitis B-infected recipients. This is illegal in the EU and US, yet some ethically acceptable financial incentives (e.g., reim-

bursement for funeral expenses) are discussed.

• Legal: The "Final Rule" was introduced in Hawaii in 1998; it states that "all hospitals are required to notify organ procurement organizations of all deaths and imminent deaths" in order to remain eligible for Medicare and Medicaid reimbursement. Donor referrals increased by 50%. Some EU countries use a "Presumed Consent" policy, thus avoiding the often difficult request process. This results in heart and lung transplantation rates that are at least twice as high as those from comparable EU countries. Conclusions. Many different strategies have been developed and tested. Each transplant center or organ procurement organization has to find the best way to deal with the local situation. With the right combination of techniques, an optimal donation rate should be possible to achieve.

Managing the Donor

Linda E. Pelinka, MD, 1 and Emanuel Sporn, MD2

¹Department of Anesthesia and Critical Care Medicine, Lorenz Boebler Trauma Center, and ²Clinical Department of Transplantation, Surgical University Clinic of Vienna, Vienna, Austria, European Union

Learning Objectives: To review the pathophysiologic changes that occur after brain death and the clinical actions necessary to maintain the brain-dead, heart-beating donor.

The most important limitation in organ transplantation is donor availability. For many patients with end-stage organ disease, the brain-dead, heart-beating donor is the only potential source from which to gain a healthy organ. Many available organs are lost to transplantation because of insufficient knowledge of the pathophysiology of brain death and because of inadequate management of the potential donor.

Pathophysiologic Changes. A brief parasympathetic phase is followed by intense catecholamine release, associated with increased systemic vascular resistance, myocardial work, and oxygen consumption. Subsequently, cardiac output and blood pressure drop and ischemic tissue injury is enhanced because of the inotropic and chronotropic condition of the heart is impaired. Loss of antidiuretic hormone secretion causes diabetes insipidus, which is associated with hypernatremia, hypokalemia, hypocalcemia, and hypomagnesemia. Damage to the hypothalamus causes hypothermia. Plasminogen activator release causes disseminated intravascular coagulopathy.

Aims of Therapy

Ventilatory management: Lower FiO_2 as much as possible while keeping $\text{pO}_2 > 100$ mmHg and keep peak end-expiratory pressure < 10 cm H_2O . Keep pH around 7.4.

Blood pressure: Maintain normovolemia by administration of crystalloids and colloids, and keep systolic blood pressure between 100-120 mmHg for sufficient organ perfusion. Administer inotropes if systolic blood pressure remains < 100 mmHg. Dopamine is the inotrope of choice. Add norepinephrine if necessary and reserve vasopressin as a last resort. Administer nitroprusside for systolic blood pressure > 150 mmHg. Central venous pressure should be 8-12 cm H_2O .

Coagulopathy: Maintain hematocrit $> 30\%$ in multiple organ donors and $> 24\%$ in other donors. Replace clotting factors with fresh frozen plasma and platelets. INR should be < 1.5 and platelets $> 50,000$.

Electrolytes: Replace 0.9% saline with 0.45% saline and 5% dextrose water when sodium > 136 mEq/L. Treat diabetes insipidus with a 4 μg bolus of desmopressin acetate; repeat every 4 hours if necessary. Urinary output should be approximately 1 ml kg^{-1} hr^{-1} .

Kidney function: Administer furosemide if urinary output < 1 ml kg^{-1} hr^{-1} and systolic blood pressure and central venous pressure are normal.

Blood sugar: Treat hyperglycemia with continuous insulin infusions.

Body temperature: Keep body temperature between 36-38°C. Warm/cool the patient and the infusions, and increase/decrease room temperature to prevent hypothermia/hypothermia.

Conclusion. Correct management of the brain-dead, heart-beating donor is based upon extensive knowledge of the pathophysiology of brain death and continuous monitoring of the potential donor to meet the aims of therapy.

References

- Zaroff JG et al. Consensus conference report: *maximizing use of organs recovered from the cadaver donor: cardiac recommendations*, March 28-29, 2001, Crystal City, Virginia. *Circulation* 2002; 106(7):836-41.
- Prognosis, diagnosis, and issues of organ transplantation in the vegetative state and brain death. *Current Opinion in Critical Care* 1997; 3:110-4.
- Sporn P, Sporn E. *Diagnosis of brain death and management of organ donors*. In Valentin R, Karnik A, eds. 4th Refresher Course on Intensive Care Med, ISBN 3-7011-7469-5. Publisher Leykam Graz, Austria, 2003, pp 33-8 (in German).

Non-Heart-Beating Donors

Maureen McCann, MD

Medical Director, Neurotrauma ICU, R Adams Cowley Shock Trauma Center, Baltimore, Maryland, USA

Learning Objectives: 1) To review the process of establishing a NHBD program, 2) to present the data showing utilization of NHBD programs, and 3) to discuss legal/ethical issues surrounding NHBD.

History. In the year 2000, we associated organ donation with patients who had sustained catastrophic neurological injuries that resulted in the declaration of brain death. When brain death has occurred, consent for donation can be granted, and the patient can be taken to the operating room on full ventilatory support for the organ recovery operative procedure. This procedure is performed on the brain-dead (legally dead) patient while organ perfusion is maintained from the donor's beating heart and mechanical support of ventilation. This is not the way organ donation has always taken place. Prior to 1968, there were no formal guidelines for the determination of brain death. In 1968, the Harvard Criteria for the Determination of Brain Death were set forth to facilitate the declaration of brain death at the hospital level. This began the era of organ transplantation with which we are currently familiar.

Prior to 1968, organ donations took place following the withdrawal of life-sustaining measures and the resulting cessation of all cardiac and pulmonary function. A family could choose to consent to donation after cardiac death (legal death) was declared. As the patient expired, effects to the organs during the dying process negatively impacted the outcomes of early organ donations. With the advent of the Harvard Criteria in 1968, organ donations from brain-dead donors became more prevalent. The ability to perfuse the organs until the last

moments of the operative procedure in a brain-dead donor made the outcomes of the donations more successful. The issue of optimal perfusion, coupled with little research into the mechanism of recipient rejection of transplanted organs, made the brain-dead organ donation protocols the norm for the next 30 years.

As the mid-1990s approached, public education efforts in the field of organ donation had reached a point whereby families of neurologically devastated patients often approached the hospital staff regarding donation options. This family-led initiative has prompted transplant professionals to revisit the option of non heart-beating organ donation for those families who wished to withdraw life-sustaining measures from patients who did not meet the strict criteria of brain death. Often times these families were initiating the discussion of organ donation, and the hospital was not in a position to provide the autonomy for this decision to the family. The development of non-heart-beating organ donation policies has empowered these families to make health care decisions on behalf of their loved ones.

The Transplant Resource Center (TRC) of Maryland approved its policy and procedure for non-heart-beating organ donation in January 2000. The first hospital policies followed soon after, at The Johns Hopkins Hospital (2/2000) and the University of Maryland Medical Center (4/2000). There are now 10 active NHBD policies in Maryland hospitals (of the 35 hospitals in TRC's service area).

Overview of the Process of NHBD. The process is designed for patients who require life-sustaining medical therapies, typically related to (but not limited to) devastating neurological injuries. A family must independently decide to withdraw life-sustaining therapies. Following this decision, there may be discussion of organ donation. The option of organ donation may be presented to the family collaboratively by a coordinator from the Transplant Resource Center of Maryland and the attending physician or nurse from the hospital. If the family consents to donation, an ethics consult is obtained. The purpose of the ethics consult is to validate the family and staff level of understanding of the process and the decision to withdraw life-sustaining measures. If the ethics consult is complete, and the ethics consultation reveals a clear understanding of the NHBD process, then arrangements can be finalized to carry out the donation.

The process includes serologic studies of the potential organ donor, further evaluation of organ function, and identification of suitable recipients for the donated organs. The family would then be given the opportunity to attend the withdrawal of life-sustaining measures. Experience has shown us that many families (90%) opt to "say goodbye" in the comfort of the familiar surroundings of the intensive care unit. In these cases, the patient is transferred to the operating room for the withdrawal process. The patient is provided comfort measures that are "normal and customary" per hospital policy. At the time of asystole, ventricular fibrillation, or PEA, the patient is declared dead by a hospital attending physician. The Transplant Resource Center of Maryland protocol mandates that, in accordance with the recommendation from the Institute of Medicine (an independent medical review board that reviews new/changed procedures for administering health care), an additional 5 minutes must pass following the declaration of death and the initiation of the recovery of organs for transplantation (if hospital policy mandates a longer waiting time, the hospital policy takes precedence).

Key Points

- The NHBD protocol will be initiated only in those cases where the patient's family has consented to donation but the patient does not meet brain death criteria and/or the family has chosen to withdraw mechanical and medical support but wishes the patient to be a donor.
- The TRC does not endorse discussion of donation until after the patient's family understands and accepts the patient's terminal condition and has decided to discontinue support measures. Any donation discussion should include a TRC coordinator in collaboration with the attending physician and/or nurse and family support staff.
- No invasive procedures within this policy will be started without informed consent/permission from the legal next-of-kin.
- No member of a hospital transplant service may be involved with any portion of the informed consent process for organ/tissue/eye donation.

Indications for Implementation of NHBD Protocol

1. Patients whose injuries are not survivable and who are predicted to suffer a cardiac arrest and death may be classified as potential non-heart-beating organ donors. These patients may potentially donate their kidneys, liver, pancreas, heart valves, and tissue.
2. Non-heart-beating organ donors are those patients with severe brain injuries or illness resulting in a terminal condition, who do not meet the criteria of brain death and have inadequate respiratory effort for maintaining oxygenation.
3. Family members must be informed about, and understand, that an irreversible condition exists. The family members have decided to discontinue life support independent of a decision about organ donation. In some circumstances, family members may have previously consented to organ donation and wish to discontinue support when brain death does not occur.
4. Non-heart beating donor candidates must:
 - be deemed medically suitable.
 - have legal next-of-kin available to provide informed consent.
 - have the release of the medical examiner office.

Procedure

1. The patient is being medically managed and supported in an ICU setting.
2. The patient is identified as a potential donor and referred as such to the TRC according to established procedures.
3. The TRC coordinator performs the established evaluation process to determine initial medical suitability for donation, according to established TRC policies.
4. The family is informed by medical staff of grave prognosis and given time to adjust and prepare for the imminent death. The TRC does not endorse discussion of donation at this time.
5. The family is informed by medical staff of the options available in cases where a patient does not meet brain death criteria, including "do not resuscitate" (DNR), "no medic," and/or discontinuation of artificial support measures.
6. The family chooses to implement a DNR status and/or discontinuation of artificial support measures. Documentation of DNR and discharge life support must be present in the hospital chart before any other steps are initiated.
7. The TRC coordinator presents the case to the medical examiner's office (MEO), according to established policies.
8. Once it is determined that the patient is a NHBD candidate, the family is informed of the option of donation by the TRC coordinator, with the physician and a hospital witness in attendance. The family is completely informed of all aspects of the

donation and recovery process, including the time frame/limit for death to occur. A written informed consent is obtained for organ and tissue donation, according to established TRC policies. The consent must be witnessed and signed by a hospital staff member. The TRC coordinator writes a detailed note in the patient's hospital record regarding the consent process.

9. All necessary laboratory and diagnostic testing is performed according to established TRC policies.
10. The operating room staff is notified of the pending NHBD recovery. Space and OR nursing staff availability will be determined. Anesthesia services will not be required for the customary withdrawal of care. Arrangements for continuous palliative care should be made should donation be precluded.
11. Once all necessary evaluation, organ placement arrangements, and recovery arrangements have been completed, and all members of the organ recovery team are in place, withdrawal of care will take place in accordance with individual hospital policies. The physician may order, as part of his/her usual and customary practice, ongoing pain relief, if in the physician's belief it is medically and ethically necessary. No member of the TRC or the transplant team/center is present for or involved with this portion of the process.
12. The patient's vital signs are closely monitored and recorded every 5 minutes from the time the ventilator/pressor support is discontinued. The patient will be pronounced dead by the physician of record or intensivist designee after 5 minutes of asystole as measured by 1) the absence of electrical activity, and 2) the absence of an arterial pulse waveform, and 3) the absence of ventilatory efforts. Should death not occur within 60 minutes after discontinuing life support, the patient is returned

to the intensive care unit or a private room for ongoing palliative care. After declaration of death, surgical recovery of organs occurs according to standard procedures as directed by the transplant recovery surgeons.

Thank you to Charlie Alexander, RN, BSN, CPTC, Director, Development and Donor Services Center, TRC of Maryland, for the use of the above prepared information

Living Donors

Jane McNeill, MB CbB, FRCA
The Royal London Hospital, London, UK

— Session C —

Trauma Airway Management: Hands-On Skills Station

Andreas Thierbach, MD Mainz, Germany
Jeffrey Berman, MD, Chapel Hill, North Carolina, USA
James M. Rich, MA, CRNA, Dallas, Texas, USA
Freddy Lippert, MD, Copenhagen, Denmark
Marvin A. Wayne, MD, FACEP, Bellingham, Washington, USA
William C. Wilson, MD, San Diego, California, USA

Saturday, May 17, 2003

Simultaneous Morning Sessions

— Session A —

Pediatrics

Co-Chair: Gail E. Rasmussen, MD, Meridian, Mississippi, USA
Co-Chair: Jeffrey M. Berman, MD, Chapel Hill, North Carolina, USA

Emergency Airway Management in the Pediatric Trauma Patient

Gail E. Rasmussen, MD
Adjunct Clinical Faculty, Department of Anesthesiology, University of Mississippi Medical Center, Jackson, Mississippi, USA

Learning Objectives: To review emergency airway management in the pediatric trauma patient. The lecture will include discussion of the difficult airway algorithm and alternative airway devices and cervical spine immobilization.

The most immediate concern in the management of the pediatric trauma patient begins with the ABCs of resuscitation with airway assessment and assurance of adequate oxygenation. Without adequate oxygenation and effective ventilation, all other resuscitative efforts will be ineffective. Pediatric patients also force our hands more quickly than adults because the apnea-to-hypoxia interval is so much shorter and we are forced to intervene more quickly. Airway management in the trauma setting differs from other scenarios because of the need for cervical spine stabilization and immobilization, which may restrict options for intubation. The differences between adult and pediatric cervical spine injury will be delineated. One must recognize the need for airway intervention in the setting of respiratory distress and impending respiratory failure. This is often overlooked in the initial resuscitation, where there may be more concern for establishment of IV access than airway control.

After initial assessment and relief of anatomic obstruction, patients who do not resume spontaneous ventilation and those with altered levels of consciousness (Glasgow Coma Scale score of 8 or less) will need more definitive airway protection and probably intubation. One must have the proper airway equipment available and checked before this is undertaken. Also, alternative airway adjuncts should be available should intubation prove difficult (including LMAs, jet ventilation equipment, and equipment for cricothyroidotomy).

The trauma patient also poses an increased risk for aspiration of stomach contents because they are considered to be full stomachs. GI prophylaxis is optimal if time allows before undertaking a rapid sequence induction with cricoid pressure. The use of succinylcholine and its relative contraindications in the pediatric patient will be discussed. In the trauma setting, regardless of the age of the patient an anticholinergic agent is recommended (i.e., atropine, 5-10 mcg/kg, up to a maximum of 0.4 mg, or glycopyrrolate, 0.1 mg/kg) prior to induction. There has also been the recommendation, particularly in head trauma, to pretreat with 2 mg/kg of intravenous lidocaine prior to intubation. The sedative-hypnotic selected depends on the hemodynamic stability of the patient and the presence or absence of raised intracranial pressure (ICP). The top three choices include propofol, thiopentothal, and etomidate, depending on the particular circumstance of the patient.

Once endotracheal intubation has been accomplished, confirmation of correct placement is essential, via auscultation. Tracheal rings can be visualized via bronchoscopy and the presence of carbon dioxide determined on capnogram or with an attachable CO₂ detector.

The pediatric trauma patient has several unique aspects in clinical practice that must be taken into consideration in the successful management of the emergency airway and ultimately the resuscitation.

References

- McAllister JD, Gnauck KA. Rapid sequence intubation of the pediatric patient: fundamentals of practice. *Ped Clin North Am* 1999; 46:1249-84.
Gausche M, Lewis RJ, Stratton SJ, et al. A prospective randomized study of the effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome. *JAMA* 2000; 283:783-90.
O Kelly SW, Reynolds PI, Colitto M. The use of fiberoptic endoscopy and laryngeal mask airway in securing the traumatized airway in the pediatric patient. *Am J Anesth* 1995; 22:152-3.

Sedation/Analgesia/Anesthesia for Diagnostic Studies and Treatment Outside the Operating Room

James E. Fletcher, MD
Department of Anesthesia, University of North Carolina, Chapel Hill, North Carolina

Learning Objectives: 1) To review pain management strategies for children with trauma-induced pain and 2) to consider various sedatives, analgesics, and anesthetic agents and the implications of their use on assessment procedures.

In addition to experiencing the pain directly caused by trauma, children who have suffered injury may have to undergo procedures that provoke anxiety and pain as part of their diagnostic workup or treatment. The nature of the injury, ranging from an isolated fractured long bone to a semiconscious head injury with chest contusion, will affect the strategy chosen to manage the patient's comfort and cooperation. Similarly, the proposed intervention will determine the use of anxiolytics, analgesics, sedatives, and anesthetics.

Diagnostic studies may involve painful procedures such as tapping of the peritoneal cavity or invasive radiology such as angiography. Immobility is important for noninvasive radiology such as CT or MRI, particularly in the latter instance. Alternatively, a therapeutic intervention such as placement of a chest drain or fixation of a broken limb will require analgesia to facilitate cooperation.

Central to any such intervention is an assessment of the patient's cardiorespiratory system, including keen attention to either pre-existing or trauma-induced compromise of the airway or circulating blood volume.

Pain should be assessed frequently in the pediatric population, as children are reluctant to report pain. The pain experience includes sensory qualities—where, when, how much—and motivational-affective qualities—emotional, aversive ("hurt"), and pain-reducing behavior. Parental guidance is useful in understanding the child's pain and distress behaviors. Children who have difficulty communicating, such as those with cognitive deficits or who do not speak English, are particularly difficult to assess. Age-specific methods of assessment are available. The pain language used by the child should be determined (e.g. "hurt", "booboo"). Self-reporting is preferred in most children over 4 years of age; for those above age 7 years, a numerical pain scale may be used. Observation of body posture, activity, and facial expression may also help, although some apparently "normal" behavior may represent a coping mechanism for pain.

Sedation, anesthesia, and systemic analgesia represent a spectrum of CNS depression, which has the potential to compromise the airway and cardiovascular system, while also providing humanitarian relief of suffering and facilitating successful diagnostic studies and treatment. "Conscious sedation" involves the use of CNS depressants to produce inattention, anxiety, and analgesia. The essential feature of this technique is that the patient remains conscious and able to respond to a mild stimulus—ideally, a voice. Once consciousness is lost, the child has lapsed into a state of light anesthesia, with its accompanying risks. As it is not possible to predict the effect of medication and the interaction of the medication with the patient's medical state, full resuscitative equipment and expertise must be available at all times when sedation is administered.

Often, sedative/analgesic drugs can be combined usefully with local anesthetic techniques. Options include IV (PCA) opioids, oral analgesics/sedatives, inhalation of nitrous oxide, ketamine, behavioral techniques, epidural local anesthetics and opioids, NSAIDs. Each drug has a specific profile of anxiolysis, analgesia, and sedation, as well as specific pharmacological features such as speed of onset and duration of action, which affect selection. Because of this, the non-analgesic, slow onset/offset sedative chloral hydrate is relatively unhelpful in comparison to morphine or fentanyl, combined with midazolam. Often, behavioral techniques can be combined with pharmacological methods. However, opioid analgesics and local anesthetics remain the cornerstone of procedural pain management. Sedative/anxiolytics should be reserved for non-painful procedures, as they will not relieve pain, while making assessment more difficult. All drugs should be given incrementally to effect.

Pediatric Prehospital Care

Dr. Charles D. Deakin
Consultant Anaesthetist, Southampton University Hospital, Southampton, UK

Learning Objectives:

- To understand injury patterns in children.
- To understand how differences in paediatric anatomy and physiology relate to injury patterns.
- To understand the principles of prehospital trauma care in children.