Emergency Anaesthesia for Multiple Trauma

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Trauma anaesthesia management is a challenge because we must deal with a critical ill patient with unclear history, injuries and physiologic status. ATLS® protocol is a useful tool in assessing and managing patients with complex and life threatening injuries. Rapid sequence of intubation is the preferred approach for airway control. Many factors combine to increase tracheal intubation difficulty in the trauma patient. Fluid management is especially challenging because of rapid, unpredictable changes in volume status and incomplete pre-operative resuscitation. For severely injured, the damage control resuscitation approach is intended to minimize exacerbating the multifactorial trauma-induced coagulopathy by replacing lost blood with plasma and platelet-containing products (haemostatic resuscitation) instead of using early and large amounts of crystalloids and RBCs (hypotensive resuscitation). This strategy encapsulates also the established concept of damage control surgery in the scope to rapid control the haemorrhage.

Keywords: difficult intubation, rapid sequnce of intubation, damage control resuscitation

Introduction

Injury is responsible for 5 million deaths per year all over the world and is the leading cause of death for young people under 40 years, representing an acute and unexpected event. Anesthesia for multiple trauma is one of the highest challenge of our specialty, because we must treat critically ill patients with unclear history, injuries and physiologic status. Also, the surgical diagnosis is usually unknown at the time of incision, as is the nature of the procedure being undertaken. We often do not have the time to place the desired invasive monitors and seldom have time to perform complete volume resuscitation. Nevertheless, we must anesthetize, paralyze, monitor, and resuscitate these patients, while the surgeon search for occult bleeding sources and resection of injured hollow viscus.

Trauma management needs rapid systematic assessment and research, based on Advance Trauma Life Support (ATLS®) protocol [1]. The main objectives of ATLS® are:

- To treat the greatest threat to life first;
- To apply the indicated treatment even when a definitive diagnosis is not yet established;
- A detailed history is not necessary to begin evaluation and treatment.

In the primary survey, the mnemonic ABCDE (Airway, Breathing, Circulation, Disability and Exposure of patient) is used to remember the order of assessment with the purpose to treat first that kills first. The scope is to stabilize the vital functions of the patient. Therapeutic efforts proceed in parallel with the diagnostic stages of ATLS. In the second survey, the patient is evaluated from head to toe (eg. radiographs, laboratory tests, invasive diagnostic procedures) to reveal all the traumatic lesions and decide the best therapeutic management (definitive care).

Usually, the trauma patient is seen by an anaesthesiologist for surgery to secure airway, exploratory thoracotomy or laparotomy associated with major bleeding, decompressive craniotomy, vascular injuries of extremities, unstable orthopedic fractures.

In this article we review the basics of trauma anaesthesia management, including preoperative evaluation, airway and hemodynamic management, monitoring, induction and maintenance. New trends in management of severely injured patients with massive transfusion — damage control resuscitation — will be discussed.

Preoperative evaluation and preparation

In severe multi-system trauma, patients will often require several surgical interventions and, as such, induction of general anesthesia is typically necessary to facilitate care. In patients with isolated orthopedic injuries, regional anesthesia becomes a viable consideration. The anaesthetic plan should take in to account many factors: the incertitude of traumatic injuries, the presence of full stomach, the hemodynamic instability in response to anaesthetic drugs, unknown history of the patient.

The anaesthesia evaluation of the acute trauma patient must always begin with the ABC: assessment of airways (A), breathing (B) and circulation (C). This sholud be adequate before proceeding further.We must determine with the surgeons the nature and extent of all injuries, and obtain as much history from the patient, family, or observers as possible [2]. The AMPLE mnemotechnic formula can be used:

- A – allergies;
- M – medications;
- P – past medical history;
- L – last meal;
- E – event leading to injury and environment.

A rapid and complete clinical examination is required to identify occult injuries. We should assess the mental status, focal neurologic signs, skin color (pallor, icter, cyanosis), breath and cardiac sounds, signs for difficult intubation (facial trauma with hematoma), arterial pressure and pulse rate, etc.

Pre-operative laboratories should include (if possible): lateral C-spine film, chest film, ECG, hematocrit, uri-

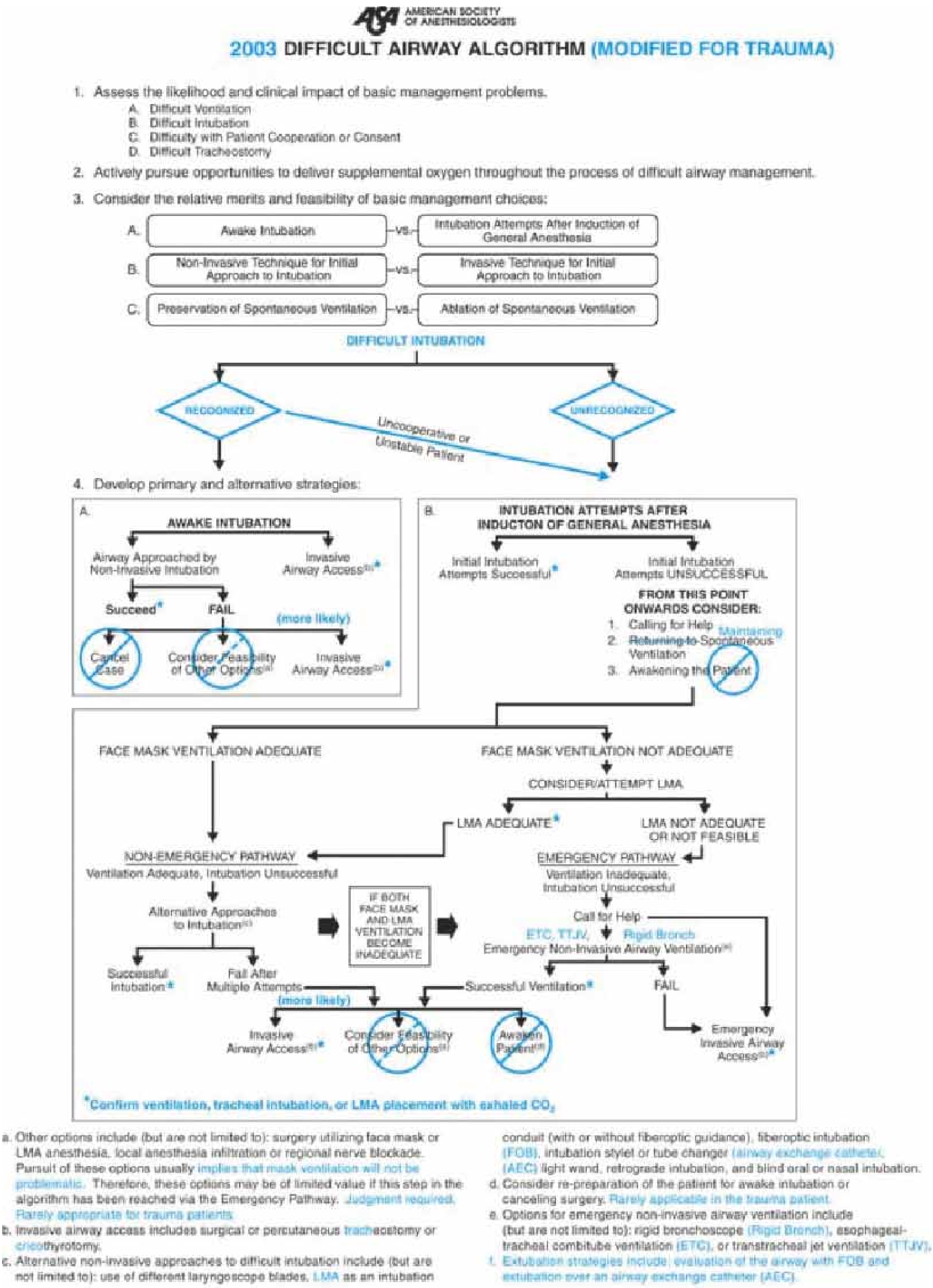

Fig. 1. 2003 Difficult Airway Algorithm (modified for trauma)

nalysis for blood, abdominal ultrasound (FAST – Focused Assessment by Sonography in Trauma). Other labs, such as CBC, coagulation profile, and electrolytes, may be ordered, but should not delay emergency surgery. Be sure the type and cross-match sample has been sent to blood bank immediately and verify blood products availability before incision.

The operating room should be warmed to 26–28°C well in advance. Check for adequate and functioning airway equipment (for difficult intubation also) and anaesthesia machine, drugs (including vasopressors), fluid warmers with high flow capability, monitors, cell-saver. When transporting to the O.R., always use supplemental oxygen, pulse oximetry, and other monitors as indicated. Finally, ensure that the neck is stabilized or C-spine is cleared before moving the patient

Airway and ventilatory management

The trauma patient may require tracheal intubation for airway protection, airway compromise, inadequate ventilation and oxygenation or surgery. Anesthesiologists are the most experienced physicians in the hospital at airway management, and are adept at planning for difficult intubations and dealing with unexpected problems that arise during airway procedures [3]. The presence of shock, respiratory distress, a full stomach, maxillofacial trauma, neck hematoma, laryngeal disruption, cervical spine instability and head injury all combine to increase tracheal intubation difficulty in the trauma patient.

The anesthesiologist should have a preformulated strategy for intubation of the difficult airway. Senior help should be sought early. In a 'cannot ventilate-cannot intubate' situation, a supraglottic airway should be temporary employed and, if ventilation is still unsuccessful, a surgical airway should be performed.

In 2003 the American Society of Anesthesiologist proposed a difficult airway algorithm adapted for trauma (Fig. 1) [4].

There are some particularities in traumatic patients: a difficult airway is frequently unrecognized, stopping the procedure to come back another day is seldom an option with trauma, a surgical airway may be the first/best choice in certain conditions, options for emergency non-invasive airway ventilation in case of difficult intubation include: laryngeal mask (LMA), Combitube®, fiberoptic or rigid bronchoscope intubation, transtracheal jet ventilation. Capnography should be used in every ventilated patient [4].

Indications for immediate endotracheal intubation in trauma patients are as follows:

1. Head injury with GCS <10;
2. Severe hemodynamic instability;
3. Airway obstruction;
4. Combative patient requiring sedation or analgesia;
5. General anaesthesia;
6. Chest trauma with hypoventilation (anterior flail chest >8 ribs);
7. Signs of respiratory failure: apnea >2–3 min, respiratory rate <10 or >29/min, PaO_2 <60 mmHg and $PaCO_2$ >55 mmHg.

Trauma patient who cannot maintain a patent airway/protected should have a cuffed tube placed in trachea. Rapid sequence of intubation (RSI) is the preferred approach in trauma patients. Sufficient and trained help should be available to provide in-line cervical spine stabilization, cricoid pressure (Sellick's manoeuvre) and administer medications to the patient. Direct laryngoscopy during manual in-line stabilization of the cervical spine has been shown to be safe and effective in patients with potentially unstable necks. Cricoid pressure assists the intubator by displacing the larynx posteriorly, and may help to prevent both gastric insufflation during bag-valve-mask ventilation and passive reflux of gastric contents during laryngoscopy.

The induction agents drugs are administered in rapid bolus, in dosage adapted to trauma patients due to hemodynamic instability. In classic RSI, the hypnotic used is thiopental in dosage of 4 mg/kg or less (1–2 mg/kg) in hypovolemic patient, followed by neuromuscular relaxant (succinylcholine – 1.5 mg/kg).

A better alternative in unstable patients is etomidate (0.1–0.3 mg/kg), which has a favorable hemodynamic profile. In doses less than 0.25 mg/kg, etomidate has minimal cardiodepressant effect, minimal respiratory depression, and very favorable effects on cerebral perfusion and the cerebral oxygen supply–demand ratio. For these reasons, etomidate is often the induction agent of choice in traumatized patients, especially those in shock, with unstable cardiopulmonary status, with multiple trauma, and/or with severe head injury, and in elderly patients with coexisting cardiovascular disease. Disadvantages are related to property of adrenocortical suppression and myoclonic activity [5].

Ketamine, 1–2 mg/kg IV, tends to maintain blood pressure by means of its sympathomimetic property, which also lends it a bronchodilating effect. However, its direct myocardial depression will be manifest in the hypovolemic patient who is already at maximum sympathetic stimulation. Furthermore, ketamine is contraindicated in traumatic brain injury because of its potential to increase ICP.

The patient with clinical signs of severe shock should not receive none of these hypnotic drugs. Intubation should be accomplished in this case with muscle relaxant, either alone or combined with a small dose of opioid (e.g., fentanyl 1–3 g/kg).

Succinylcholine (1.5 mg/kg) provides the best and fastest muscle relaxation to facilitate intubation, and is the preferred agent in any patient without a specific contraindication to its use (history of malignant hyperthermia, demyelinating neurologic disease prior to injury). Lethal hyperkalemia following succinylcholine administration is a risk in patients with neurologic deficits from spinal cord injury or with severe burns, but not until 24–48 hours following injury.

Table I. ATLS® classification of blood loss based on initial patient presentation [1,7]

	Class I	Class II	Class III	Class IV
Blood loss* (ml)	Up to 750	750–1000	1500–2000	>2000
Blood loss (% blood volume)	Up to 15%	15–30%	30–40%	>40%
Pulse rate	<100	100–120	120–140	>140
Blood pressure	Normal	Normal	Decreased	Decreased
Pulse pressure (mmHg)	Normal or increased	Decreased	Decreased	Decreased
Respiratory rate	14–20	20–30	30–40	>35
Urine output (ml/h)	>30	20–30	5–15	Negligible
Central nervous system/mental status	Slightly anxious	Mildly anxious	Anxious, confused	Confused, lethargic
Fluid replacement	Crystalloid	Crystalloid	Crystalloid and blood	Crystalloid and blood

Table II. ATLS® responses to initial fluid resuscitation* [1,7]

	Rapid response	Transient response	Minimal or no response
Vital signs	Return to normal	Transient improvement, recurrence of decreased blood pressure and increased heart rate	Remain abnormal
Estimated blood loss	Minimal (10–20%)	Moderate and ongoing (20–40%)	Severe (>40%)
Need for more crystalloid	Low	High	High
Need for blood	Low	Moderate to high	Immediate
Blood preparation	Type and crossmatch	Type specific	Emergency blood release
Need for operative intervention	Possibly	Likely	Highly likely
Early presence of surgeon	Yes	Yes	Yes

* 2000 ml of isotonic solution in adults; 20 ml/kg bolus of Ringer's lactate in children

An alternative to succinylcholine in RSI is rocuronium, a non-depolarizing blocking agent, with medium duration of action and fast onset time of neuromuscular block in a dose of 1–1.2 mg/kg, achieving excellent intubating conditions in 60 sec. Recently, the rocuronium antagonist sugammadex has been introduced into clinical practice. With a dose of 16 mg/kg sugammadex, rocuronium-induced neuromuscular block reversal is faster than spontaneous muscular recovery after suxamethonium administration. Thus, rocuronium (1.2 mg/kg) has the potential to become the first-line neuromuscular blocking agent in emergency anesthesia.

After intubation is performed, correct tracheal tube placement is checked by capnography and auscultation [6]. Mechanical ventilation is made with low tidal volume (5–6 ml/kg) and low positive pressure to minimize arterial hypotension due to decrease venous return, the goal is SpO_2 >95%.

Monitoring

All trauma patients should have minimum noninvasive monitors before anesthesia induction: ECG, blood pressure measurement, pulse oximetry and capnography. Capnography is useful in conjunction with arterial blood gas determination, as changes in the gap between $PetCO_2$ and $PaCO_2$ will indicate changes in alveolar dead space, which reflect changes in volume status. In addition, all trauma patients should have a Foley catheter with urometer for frequent measurement of urine output as a sign of end-organ perfusion. Core temperature probe (rectal or esophageal) is also important, as hypothermia is frequent associated with severe trauma.

At least two large bore IV (14–16G) cannula are necessary for fluid replacement in multiple trauma patients. The intravenous lines should be well fixed to avoid dislocation during anesthesia induction and maintenance. If access cannot be obtained initially because of hypovolemia, fluids can be given through an intra-osseous needle inserted into the marrow of the tibia. This method has been particularly successful in children.

A radial arterial catheter is very useful for all laparotomies, thoracotomies, craniotomies or peripheral injuries associated with significant blood loss. Invasive arterial pressure monitoring is required in unstable hemodynamic patients due to hemorrhage, fluids shifts and to adequate guide the vasopressors drugs.

Central venous access is desirable in any case involving large blood loss or transfusion. The internal jugular approach is preferable, although the subclavian may also be used with great caution to avoid pneumothorax. The femoral approach is contraindicated in the patient with potential intra-abdominal hemorrhage, but may be used for isolated limb injuries or traumatic brain injury [2].

Maintaining adequate organ perfusing blood pressure is one of the major goals of resuscitation. Early use of invasive/mini-invasive cardiac output monitoring devices (pulmonary artery catheter, PiCCO®, Flotrac®, echocardiography) are necessary for the assessment and management of the hemodynamic status of the hypotensive severe trauma patient.

Hemodynamic management

Initial evaluation

Multiple trauma patients are virtually always hypovolemic on initial evaluation by the clinician and the hemorrhage is

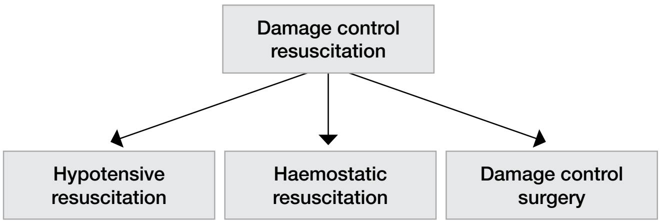

Fig. 2. Components of damage control resuscitation [16].

the most common etiology, the blood loss is often ongoing or even worsening during anaesthesia. The anaesthesiologist should clinically assess the extent of traumatic haemorrhage using a combination of mechanism of injury, patient physiology, anatomical injury pattern and the patient's response to initial resuscitation. In addition, the anaesthetic agents often worsen the "functional" volume status by increasing intravascular capacity. Volume status must be continually monitored and fluid therapy adjusted in response to ongoing changes.

Table I summarizes estimated blood loss based on initial presentation. Table II presents the three types of response to initial fluid resuscitation, whereby the transient responders and the non-responders are candidates for immediate surgical bleeding control [1,7].

If treatment for hypovolemic shock fails, consideration should be given to addressing non-haemorrhagic causes of shock, including: tension pneumothorax, neurogenic shock, cardiogenic shock or septic shock.

Management of severe injured patients with massive transfusion — Damage control resuscitation

Trauma resuscitation strategies have change considerably over the recent years, due to advances in civilian and military medicine. From the entire trauma admissions, only 3–8% of patients are severely injured and massive transfused; the mortality of this patients range from 40 to 70%. Timing of intervention is important and hemorrhagic deaths occur very early, usually within the first 6 hours of admission. Rapid and early treatment can improve survival and outcome, the role of the anaesthetist as member of trauma team beeing essential [8,9].

Standard resuscitation practice for multiple trauma, supported by ATLS® guidelines, recommends initially infusion of 1–2 l crystalloids, preferably Lactate Ringer's (LR) solution (3:1 ratio of volume replacement to lost blood with crystalloid solution). Resuscitation continues with repeated boluses of LR and use of packed red blood cells (RBC) for serious bleeding patients and a systematic search and repair of surgically correctable sources of hemorrhage [1]. The goal is to support blood pressure, urine output and to reverse metabolic derangements associated with blood loss. This resuscitation method is an appropriate policy for 90% of trauma patients who are not in shock and are hypercoagulable after injury. However, for the approximately 10% of patients who are the most severely injured, are in haemorrhagic shock and coagulopathic, this attitude could be harmful because might interfere with haemostatic mechanism, exacerbating blood loss and traumatic coagulopathy [10]. In this population of most severe traumatic patients, recent strategies of care developed by military experience focus on optimal timing and modulation of the metabolic, inflammation and coagulation pathways. The technique to achieve this is called "damage control resuscitation" (DCR) and addresses the entire lethal triad (reversal of acidosis, prevention of hypothermia and coagulopathy) immediately the patient is assessed in emergency department in concert with aggressive surgical hemostatic interventions [11]. Another definition of DCR is: systematic approach to major trauma combining the catastrophic bleeding, airway, breathing and circulation paradigm with of series of clinical techniques from point of wounding to definitive treatment in order to minimize blood loss, maximize tissue oxygenation and optimize outcome [12].

DCR concept

Traumatic coagulopathy is a hypocoagulable state that occurs in the most severely injured. There are multiple factors that may contribute to this coagulopathy, which evolve over time. Immediately after injury, hypoperfusion may cause coagulopathy as a result of increased anti-coagulation and hyperfibrinolysis via increased activated protein C production, tissue plasminogen activator and a concomitant decrease in plasminogen activator inhibitor concentrations and thrombin activatable fibrinolysis inhibitor [13]. This specific process has been termed the Acute Coagulopathy of Trauma-Shock (ACoTS). Mathematical models have determined that hemodilution occurs after patients are given excessive crystalloids and red blood cells (RBCs) worsening shock-induced hypocoagulation. The development of hypothermia, hypocalcaemia and acidosis can each further contribute to worsening of this initial coagulopathic state [14].

Therefore, in patients with severe traumatic injury the goal is to minimize iatrogenic resuscitation injury, prevent worsening of the presenting traumatic shock and coagulopathy, and to obtain definitive hemostasis. Once this is achieved the next immediate goal is to rapidly reverse shock, hypocoagulation, intravascular volume depletion, and maintain appropriate oxygen delivery and cardiac output [15].

DCR combines three major components: hypotensive resuscitation and haemostatic resuscitation with damage control surgery (Fig. 2) [16]. The foundation for this approach starts in pre-hospital environment, where intravenous fluid administration is restricted to a volume sufficient to maintain a radial pulse. The term "haemostatic resuscitation" describes the very early use of blood and blood products as primary resuscitation fluids, to treat intrinsic acute traumatic coagulopathy and to prevent the development of dilutional coagulopathy. Damage control resuscitation is designed to proceed hand in hand with damage control surgery. The sequential strategy of operation is undertaken simultaneously with resuscitation efforts, with close communication and cooperation between surgeon and anaesthetist.

Damage control resuscitation principles [17]:

- Rapid recognition of high risk for trauma-induced coagulopathy (massive transfusion prediction);
- Permissive hypotension;
- Rapid definitive surgical control of bleeding;
- Prevention/treatment of hypothermia, acidosis, and hypocalcaemia;
- Avoidance of hemodilution by minimizing use of crystalloids;
- Early transfusion of red blood cells: plasma: platelets in a 1:1:1 unit ratio;
- Use of thawed plasma and fresh whole blood when available;
- Appropriate use of coagulation factor products (rFVIIa) and fibrinogen containing products (fibrinogen concentrates, cryoprecipitate);
- Use of fresh RBCs (storage age of <14 days);
- When available thromboelastography to direct blood product and the haemostatic adjunct (anti-fibrinolytics and coagulation factor) administration.

Identification of patients who require DCR

Because less severely injured trauma patients may theoretically manifest hypercoagulability, identification of candidates for damage control resuscitative techniques must be based on rapidly obtainable clinical parameters. In combat settings, in which roughly 95% of casualties present with a penetrating trauma mechanism, certain patterns of injury can reliably predict the need for massive transfusion and damage control surgical and resuscitative techniques [18]:

- patients with multiple proximal amputations (particularly thigh level);
- truncal hemorrhage combined with a proximal amputation;
- abdominal evisceration with hypotension;
- liver laceration with haemorrhage;

pelvic fracture with overwhelming blood loss.

Other measurable parameters that have been suggested as predictors of massive transfusion requirements include [19,20,21]:

- base deficit >6;
- international normalized ratio >1.5;
- systolic blood pressure < 90 mmHg in combat trauma patients and <110 mmHg in civilian trauma patients;
- hemoglobin <11 g/dl ;
- temperature <35–36°C;
- weak or absent radial pulse.

1. Permissive hypotension

The normal patient response on traumatic bleeding is activation of coagulation cascade with clot formation, hypotension and vascular spasm. Efforts to restore normal circulatory function by aggressive replacing intravenous fluids was seen as important in preventing haemorrhagic shock. Uncorrected haemorragic shock leads to ischaemia, progressive organ dysfunction and finally irreversible organ failure and death. Pre-hospital resuscitation strategies can effect care of the hemorrhaging trauma patient, as well.

The identification that fluid resuscitation may interfere with haemostatic mechanisms by "popping the clot" and haemodilution, led to a reevaluation of this accepted approach. Permissive hypotension or "hypotensive" or "balanced" resuscitation is a strategy to restrict fluid administration until haemorrhage is surgically controlled, while accepting a limited period of sub-optimum end-organ perfusion. The systolic blood pressure should be kept between 80–90 mmHg.

Clinical evidence to support this strategy is debatable and is based on several studies. Bikell et al. showed a statistically significant 8% absolute reduction in mortality for hypotensive patients with penetrating torso trauma assigned to delayed (in the operating theatre) compared with pre-hospital or emergency room fluid resuscitation. However, the atypical short pre-hospital time and very young age-mix render the study generalization difficult [22]. Another randomized trial of patients who had sustained mainly blunt trauma showed no difference in mortality between the delayed and immediate resuscitation groups, but included patients with relatively minor injuries and had many protocol violations, rendering the comparisons and conclusions meaningless [23]. A smaller randomized trial of patients with either blunt or penetrating trauma showed no difference in mortality between controlled fluid resuscitation and conventional therapy, but also the study had many methodological problems [24]. The Cochrane review has not shown mortality difference between early and delayed fluid resuscitation.

In patients with uncontrolled haemorrhage, particularly in the context of penetrating torso trauma, a strategy of permissive hypotension, together with expert resuscitation and rapid control of haemorrhage, might be more appropriate. The permissive hypotension is more applicable to the management of penetrating trauma, which is often characterized by the presence of major vascular injuries, than to blunt injuries.

Despite the lack of evidence, actual guideline recommendations for clinical practice point towards judicious administration of intravenous fluids.

The management of polytrauma patients with head injuries requires special attention. The importance of maintaining cerebral perfusion pressure is well recognized; thus permissive hypotension is currently contraindicated in this setting.

2. Haemostatic resuscitation

Clinical military experience suggests that coagulopathy may be present at the time of admission before significant resuscitative fluid has been given, as a consequence of acidosis-induced coagulation factor dysfunction, coagulation factor consumption, and hypothermia-induced failure of platelet activation. Failure to recognize and immediately address the trauma-induced coagulopathy found in severely injured patients could be linked to delayed laboratory measurements (in OR or ICU) after dilution with crystalloid and RBCs.

Haemostatic resuscitation targets at blood replacement by packed RBCs together with high ratio of plasma and platelet concentrate (1:1:1) at the early point when massive blood transfusion (MT) is anticipated. The scope of this attitude is to diminish the coagulopathy and to improve survival.

This recommendation is based on several large adult military and civilian retrospective studies, both single and multicenter, in penetrating and blunt injury massive transfusion populations, which mostly indicate that when groups of equal severity of injury are compared, a high ratio of plasma and platelets to RBCs, (approximating a median 1:1:1 unit ratio) is associated with improved survival [25,26,27,28]. A few of these studies have documented that this survival benefit was associated with decreased death from haemorrhage. Since the majority of these reports are retrospective and subject to bias, particularly survivorship bias, they must be interpreted with caution. The preponderance of the current literature indicates that patients in haemorrhagic shock at high risk of death or who require massive transfusion benefit from increased ratios of plasma and platelets to RBCs. Conversely, DCR should not be performed in patients who are not in hemorrhagic shock or who are not at high risk of massive transfusion.

The risks of plasma and platelet use must be considered with increased use. Plasma transfusion has been associated with increased risk of allergic reactions, transfusion-associated acute lung injury (TRALI), transfusion-associated cardiac overload and acute respiratory distress syndrome (ARDS) [28]. In addition, platelet transfusion has been associated with bacterial contamination, deep venous thromboembolism (DVT) and febrile reactions. For patients with severe traumatic injury and haemorrhagic shock the apparent survival benefit with increased plasma and platelet transfusion far exceeds the rare risks of transfusion reactions While the risks of plasma and platelet use should always be acknowledged, these risks should be placed in perspective with the potential benefits of improved survival when increased amounts are transfused early to patients with severe traumatic haemorrhage.

The haemostatic resuscitation ends when active haemorrhage is definitively controlled.

3. Damage control surgery

It is now recognized that severely injured trauma patients, who are still alive at the point of medical intervention, are now more likely to die from the metabolic consequences of the injury rather than the completeness of the immediate surgical repair to their damaged organs. The concept of damage control surgery (DCS) is arising from the fact that the massively injured patient lacked the physiological reserve to survive the rigours of complex and prolonged definitive or reconstructive surgery. The aim of damage control surgery is to stop haemorrhage, minimize contamination and temporary closure or cover of the abdomen. After surgery, the patient is rapidly transferred in ICU to continue the resuscitation care started in emergency department and surgery. Planned re-operation to restore anatomy and achieve definitive repair is carried out on return to normal physiology. DCS is only applicable to a minority of trauma patients and is associated with potential morbidity and should be employed judiciously. If used too liberally may be no better or even worse than immediate definitive surgery [30].

DCS approach comprises five stages:

1. Patient selection. The decision to adopt this strategy in trauma patient should be reached early, in order to avoid the development of the vicious circle. It has been identified key factors in patient selection for DCS [31,32].
   - Physiological criteria:
     - hemodinamic instability (SBP <70 mmHg);
     - hypothermia <34°C;
     - severe metabolic acidosis (pH <7.1);
     - resuscitation and operative time >90 min;
     - massive transfusion (>10 units packed RBCs);
   - Complex injury pattern:
     - ISS >25;
     - high energy blunt trauma;
     - multiple torso penetration;
     - major abdominal vascular injury with multiple visceral injuries;
     - multi-regional injury with competing priorities.
2. Intraoperative stage. Priorities are haemorrhage control, limiting contamination. Haemorrhage is controlled by temporary clamping, packing, shunting or ligation and hollow viscus injuries are either closed or resected without anastomosis. Definitive vascular repair by grafting or anastomosis is not considered a DCS procedure. Contamination control is often achieved by tape closure of the ends of the injured hollow viscus. Anastomoses and stomas are not fashioned in DCS. Pre-emptive strategies to prevent compartment syndromes such as fasciotomies and laparostomy are employed. On completion of the procedure, the abdomen is temporarily closed using an improvised or commercially available topical negative pressure dressing, which saves time, helps to minimize the risk of intra-abdominal hypertension, and facilitates observation of the volume and nature of drainage from the abdomen. For long bones fracture, external fixators are used. Operating time should be as short as possible, usually less than an hour.

Active warming is important and theatre temperature should be 26°C.

3. ICU stage. In the critical care unit attempts continue at correcting the physiological consequences of the injury and its associated metabolic failure. Active rewarming measures continue with air-warming devices, fluid warmers and an overall warm ambient environment. Perfusion must be restored to the body tissues with adequate resuscitation fluids, minimizing the acidosis and the oxygen debt from the anaerobic metabolism. Coagulopathy is corrected by administration of fresh frozen plasma, cryoprecipitate and platelets as necessary. Early return to the operating theatre ("second look") is indicated if there is obvious ongoing surgical bleeding or if abdominal compartment syndrome develops. The endpoints of resuscitation are:
   - hemodynamic stability, no vassopresors;
   - normoxia, normocarbia;
   - lactate level < 2 mmol/l;
   - normothermia;
   - normal coagulation;
   - urine output >1 ml/kg/h.
4. Scheduled definitive surgery (day 5–10 after trauma – "window of opportunity"). This is dictated by improvement in the patient's physiological status and requires often more than one surgical specialty. The following indices are often used to guide re-operation: base deficit >-4 mmol/l, lactate <2.5 mmol/l, core temperature >35°C and an INR <1.25. At this stage anastomoses are fashioned, stomas raised with reconstruction of digestive tract, vascular repairs performed, fascial closure of the abdomen, internal bone fixation, closure of open wounds. Also, we should think of tracheostomy in case of prolonged mechanical ventilation and jejunal tube placement.
5. Secondary reconstructive surgery (>3 weeks after trauma). In this stage, after the resolution of edema and immunosuppression, reconstructive interventions can be performed like: ligamentary reconstruction, articulary prosthesis replacement, nerves reconstruction, bone reconstruction after craniotomy, etc.

DCS has become an important part of trauma surgeon armamentarium and is currently viewed as a component of DCR and should not be applied in isolation. Combining DCR with DCS may lead to early correction of physiological status, which in classical DCS occurred in ICU stage and thus allow a longer DCS surgical window. Thus, it can be stated that "surgery does not follow resuscitation, it is a part of resuscitation" [33].

Maintenance of anaesthesia

Selection of safe drugs and dosages is particularly difficult in the injured patient whose volume status may not be accurately known. Although many factors must influence the choice of induction and maintenance agents in the trauma patient, the most important one is usually the volume status.

After anesthetic induction is complete and the airway is secured, we have tested his response to drugs in a very significant way. We should therefore use the patient's response to induction to guide our choice of maintenance agents. In the unstable, hypovolemic patient it is better to use narcotics in association with muscle relaxant at decreased doses (intravenous anaesthesia). It has the advantage of good hemodynamic stability, but with the cost of high rate of intraoperative awareness. Volatile anesthetic (balanced anaesthesia) may be added in the very stable patient with no continuing hemorrhage. Be prepared to change the maintenance technique at any time during anaesthesia as the patient's condition and responses may change.

Exacerbation of hypotension should not be a contraindication to anaesthesia, however, but only a sign that it should be used with caution. Deep anaesthesia makes it easier to assess the patient's fluid volume over the reminder of the resuscitation because hypovolemia will cause an immediate decrease in blood pressure in the patient in whom catecholamine release has been blocked.

In most of cases we do not intend to awake and extubate the multiple trauma patient at the end of surgery. The patient is transferred in ICU for completion of resuscitation and optimization of end-organ perfusion. In addition, the patient needs good analgesia during transport to ICU or remote diagnostic procedures (CT scan/MRI/angiography).

Conclusions

The anaesthetic management of multiple trauma patients is very complex, requiring a good collaboration with trauma surgeon and other members of trauma team. To minimize anaesthetic risk in the trauma victim, the anaesthetist should know as much as possible about the extent of traumatic lesions and be aware about the exact surgical procedure and associated risks. The anaesthetic plan have to take into consideration the resuscitation status and any co-existing diseases the patient may have choosing the optimal anaesthetic medications and monitoring devices. Fluid management is especially challenging because of rapid, unpredictable changes in volume status and incomplete pre-operative resuscitation. The anesthesiologist is vital in overseeing the process of fluid resuscitation to optimize hemostasis and long-term survival. Another critical role of the anesthesiologist is prevention of a second hit caused by recurrent shock or incomplete resuscitation.

Appling the damage control resuscitation principles in case of severely injured patients it is now clearly lifesaving in many patients with multisistemic trauma. This approach derived from advances in combat casualty care is intended to minimize exacerbating the multifactorial trauma-induced coagulopathy by replacing lost blood with plasma and platelet-containing products (haemostatic resuscitation) instead of using early and large amounts of crystalloids and RBCs (hypotensive resuscitation). This strategy encapsulates also the established concept of damage control surgery in the scope to rapid control the haemorrhage. Although there are still unanswered questions regarding DCR, many trauma centers have adopted this concept, and it is quickly becoming a common resuscitation approach in severely injured patients.

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