Polytrauma management has undergone tremendous evolution in the past decade in the assessment, diagnosis, treatment and team approach algorithms. This article aims to highlight the important changes in a concise manner.

**TRAUMA MANAGEMENT PRIORITIES—FROM ABC TO P-D-ABC-DE**

An important milestone marking the commencement of structured & organized major trauma management dates back to 1978 when the first ATLS Course was conducted to address the deficiency in major polytrauma management in the tragic small plane crash of the family of Dr Jim Styner (an orthopaedic surgeon of Nebraska of USA) in 1976. The classic management priorities can be modified from ABCDE to PD-ABCDE as indicated in Table 1.

With the emergence of new infectious diseases (SARS, avian flu & human swine flu) and the various blood-borne diseases, appropriate personal protective equipment (PPE) including the additional facial shield besides the regular mask, gown & gloves ought be taken prior to the trauma patient assessment. Initial assessment is important to determine the aggressiveness of treatment. Out-of-hospital traumatic cardiac arrests with unorganized electrocardiogram (ECG), fixed pupils (all at the scene), and cardiopulmonary resuscitation (CPR) greater than 15 minutes carry grave prognosis & termination of resuscitation can be followed.

Obstructed airway can kill in a short period while jeopardized ventilation follows as the next lethal condition resulting in cerebral, cardiac or other organ hypoxia even if death does not ensue.

After or while combating the "A & B", checking the "C" as the circulation to assess the hemodynamic status, to stop the external bleeding by compression treatment, start the IV lines, obtain blood for baseline point-of-care test (POCT) or laboratory assays as well as to blood
typing & screening to prepare for transfusion.

"D" stands for decompression of the intra-cranium as the next priority. Intracranial bleeding can kill but usually not as rapidly as the exsanguinating external or internal cavity (abdomen, pelvis or thorax).

"E" represents extremities. The most urgent extremity trauma is the massive external bleeding which can usually be controlled by direct compression. If the latter fails, cautious proximal tourniquet can be life-saving & does not cause significant risk to the nerve or limb tissues and the compression pressure and time control are vital to maximize the limb viability. [7-9] Arterial occlusion & compartment syndrome are the important & limb-threatening limb conditions, which can be managed immediately after the other life-saving operations (laparotomy, pelvic fixation & packing or thoracotomy) are settled or be performed simultaneously by the second operation team. Crush syndrome in entrapment injury especially related to earthquake with prolonged interval prior to extrication would warrant aggressive IVF replacement and NaHCO3 to help prevent ARF. [10-16] Early diagnosis of compartment syndrome & prompt fasciotomy are also important in both limb & renal salvage. [14]

DAM/DIM — FROM PLANS A&B TO THE EXPLICIT & STRATIFIED LEVELS 1 TO 5

The conventional Plans A&B for difficult airway management (DAM) have been confusing for being too non-specific & highly variable for Plan B. The modern trend is to spell out the escalation levels of the DAM/DIM choices in an explicit manner as in the ATLS Update in 2008. [3] Table 2 shows a practical & stratified approach to attain a quick decision & efficient team work. When difficult airway is anticipated such as injuries above the clavicles in volving the head & neck (cervical immobilization is required), the small mouth, receded chin, short neck, direct utilization of video-assisted airway management (VAAM) can be the first-line choice to shorten the intubation interval in the difficult airway with higher success rate. In case of very severe maxillofacial injuries with inaccessible oral passage, a surgical airway starting with cricothyrotomy will be life-saving. [17] Moreover, the conventional acronym of "LEMON (Look, Evaluate, Mallampati, Obstruction & Neck Movement" can be modified as "LEON" since Mallampati Classification is not applicable in emergency setting in the critical patients in supine position. [18] predefined DAM algorithm improves patient's outcome. [17]

The VAAM (video-assisted airway management: video-laryngoscopy or video-optical stylet) achieves higher intubation success in difficult airway. [19-21] It provides much better enlarged & close-up visualization of the laryngeal opening while maximizing the distance between the intubation clinician from the patient's mouth to reduce contact with blood splash during ETI. With a good viewing monitor, the assistants or supervisors can provide more efficient collaboration. Moreover, video-recording of the ETI can be enabled for training or quality assurance. [22]

If the expensive VAAM is not available, the more affordable LMA or iLM (intubating laryngeal mask airway) can also sustain ventilation and help achieve tracheal intubation. [23]

CT SCANNING IN HEMODYNAMIC INSTABILITY CAN BE THE TUNNEL TO DEATH

For the hemodynamically unstable patients, CT scanning in a distant radiology suite posing hazards
in transfer, monitoring & resuscitation can render the CT gantry as the tunnel to death.\[24\] Bed-side clinical assessment with radiology (XR pelvis & chest) & the highly versatile POCT USG to identify internal bleeding including hemoperitoneum, pericardial tamponade & hemothorax together with clinical correlation will expedite the diagnosis & shorten the time to definitive operation.

XR of cervical spine has been de-emphasized & can be delayed once H&N immobilization has been secured & priority to image the spine would be given to other life-saving procedures.\[3\]


DPL was widely used from the 1970s till early 2000s. Owing to its high false positive rate leading to 25 to 36 percent of non-therapeutic laparotomy,\[25,26\] not to mention the time & the skills taken to complete the procedure which cannot be repeated as necessary in contrast to USG, the advent of the more affordable USG models & more improving USG skill accuracy skills of good sensitivity (81%-93%) and high specificity (90%-98%)\[26-28\] and achieving 100% specificity in developing world,\[29\] DPL has virtually been substituted by USG in the late 2000s. Jansen has written the DPL Obituary (born 1965 & died 2005).\[30\]

**TRAUMA IMAGING–DIRECT WHOLE-BODY MDCT**

An important current controversy is on direct whole-body MDCT Vs stepwise imaging from plain XR to FAST USG followed by regional CT in major polytrauma with stable hemodynamics with CT performed outside the ED Trauma Room.

Wurmb’s study showed direct whole-body CT reduced the diagnostic interval from a median of 70 to 23 minutes & definitive management plan interval from another median of 82 to 47 minutes.\[31\] It carried an NNT (number needed to treat or to scan to identify one major injury warranting operation to reduce mortality) of 302 and an NNH of 1 777 (number needed to harm to produce one more fatal cancer per 10 mSv of additional radiation dose over regional CT usually around 9.2 mSv). Houshian identified about one-thirds (31.4%) of missed injuries needed operation.\[32\] Rieger also found MDCT had higher diagnostic accuracy than conventional imaging.\[33\]

In the retrospective multicentre study of the registry comprising of 1494 (32%) provided whole-body CT out of 4621 patients of the German Trauma Society, Huber-Wagner et al\[34\] showed that the relative reduction in mortality based on Trauma and Injury Severity Score (TRISS) and Revised Injury Severity Classification (RISC) Score were respectively 25% and 13%. Multivariate analysis identified that whole-body CT was a significant independent predictor for survival. The number needed to scan (NNT) was 17 based on TRISS and 32 based on RISC calculation. Whole-body CT is recommended as a standard imaging tool in the early resuscitation care in patients with severe polytrauma.

Though New CT technology can also decrease the radiation dose,\[35\] there is conflicting concern of the induced cancer rate and hence the irradiation ALARA (as low as reasonably achievable) principle together with the risk-benefit balance should be observed and the dilemma will require further research for delineation.\[36-38\]

**DYNAMIC MODEL (VS STATIC) IN SHOCK ASSESSMENT**

Shock assessment has transformed from the static model of classification by percentage of blood volume loss to the dynamic model of monitoring the response to initial IVF resuscitation with division into Rapid, Transient & non-responders to indicate the status of any on-going bleeding, volume loss, need for transfusion & operation as well as the possibility of non-hemorrhagic causes of tension pneumothorax & pericardial tamponade contributing to non-response as summarized in Table 3.\[3\]

<table>
<thead>
<tr>
<th>Response</th>
<th>Rapid</th>
<th>Transient</th>
<th>Non</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood loss</td>
<td>10%-20%</td>
<td>20%-40%</td>
<td>&gt;40%</td>
</tr>
<tr>
<td>On-going bleeding</td>
<td>Nil</td>
<td>Yes</td>
<td>Heavy/+possibility of Non-hemorrhagic shock causes</td>
</tr>
<tr>
<td>Replacement</td>
<td>Sufficient</td>
<td>Insufficient</td>
<td>Difficult to stop bleeding immediately</td>
</tr>
<tr>
<td>Need blood</td>
<td>low</td>
<td>high</td>
<td>Very high</td>
</tr>
<tr>
<td>Need operation</td>
<td>low</td>
<td>likely</td>
<td>High</td>
</tr>
</tbody>
</table>

The non-operative management (NOM)\[39\] in the rapid responders to be monitored in a critical care unit has been a common trauma practice in the past decade especially in the stable children (the majority involving the liver & spleen) with quick healing of the damaged organs.\[40,41\]

**DCR TO PREVENT LETHAL TRIAD OF TRAUMA**

Another new approach to combat the lethal triad
of trauma (hypothermia, coagulopathy & acidosis)\(^\text{[42-44]}\) related to massive transfusion in uncontrolled bleeding is the damage control resuscitation (DCR)\(^\text{[45-49]}\) comprising of three major components as in Table 4.

Table 4. Damage control resuscitation (DCR)

<table>
<thead>
<tr>
<th>1. Permissive hypotension</th>
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<tr>
<td>2. Hemostatic resuscitation</td>
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<tr>
<td>3. Damage control operation / surgery (DCO / DCS)</td>
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Permissive hypotension\(^\text{[48]}\) aims to defer or restrict the fluid resuscitation until hemorrhage is controlled to minimize the risk of hydrostatic dislodgement of the temporary clots in bleeding vessels prior to operation to stop the internal bleeding. Consequently, a short period of suboptimal organ perfusion will occur with the target to maintain the vital organ perfusion (brain & heart) with a systolic BP of around 80-90 mmHg. Bickel et al has shown the reduced mortality (ARR of 8%) by delayed & small IVF replacement in penetrating torso trauma with shock.\(^\text{[50]}\) However, the atypical short pre-hospital time & very young age-mix render the study generalizability difficult. Cochrane review\(^\text{[51-53]}\) has not shown mortality difference between early & delayed fluid resuscitation. Yet, the permissive hypotension approach in the absence of head injury cannot be ignored until sufficient studies have identified the true effects.

Hemostatic Resuscitation targets at blood replacement by packed red cells together with high ratio of plasma & platelet concentrate at the early point when massive blood transfusion (MBT) is anticipated so as to diminish the coagulopathy & to improve survival.\(^\text{[54-59]}\) Early studies showed the inclusion of high ratio of FFP caused more ARDS & MOF.\(^\text{[50]}\) Subsequently study revealed the septic shock,\(^\text{[60]}\) ventilator-associated pneumonia (VAP), abdominal compartment syndrome (ACS), heart failure, liver failure & MOF rates were lower in MBT with high component ratios. Moreover, mortality\(^\text{[61-63]}\) & the total amounts of blood products transfused\(^\text{[61]}\) were both decreased with massive transfusion protocol (MTP). The current on-going researches are to identify the most optimal blood product ratios.\(^\text{[64]}\)

In the CRASH-2 PRCT involving 20,211 adult trauma patients in 274 hospitals in 40 countries,\(^\text{[63]}\) intravenous tranexamic acid (loading dose 1 g over 10 min followed by infusion of 1 g over 8 h) versus placebo showed significant mortality reduction with NNTs of 66.7 for all-cause and 125 for death due to bleeding. Besides, there were no significant changes in the mortality due to vascular occlusion, multi-organ failure and head injury. Moreover, tranexamic acid is relatively inexpensive. Consequently, it is safe and affordable to use this drug to reduce the risk of death in bleeding trauma patients. Future studies would be to identify the best therapeutic time window and dose.

**DCS TO FIX THE DERANGED PHYSIOLOGY**

Damage control surgery (DCS–Table 5)\(^\text{[30, 66-68]}\) aims to restore or optimize the physiology instead of definitive anatomical repair. It encompasses stopping bleeding by simple methods including temporary clamping, ligation, shunting or packing if definitive operation is not possible liked multiple & extensive liver lacerations or unduly prolongs laparotomy & raise the hypothermia risk. Next is the decontamination of the injured body cavities such as bowel perforation by temporary closure or resection without anastomosis. Third is the rapid closure surgical wounds by improvised or commercially available topical dressing (such as laparotomy incision with wide exposed surface area of the abdominal contents leading to hypothermia) to prevent abdominal compartment syndrome in laparotomy as well as to rewarmed & stabilize the patient before the follow-up operation 24-48 hours later.

There has been no randomized controlled trial to evaluate the DCS concept. A small study of major penetrating abdominal injuries showed a mortality reduction for treatment with contemporary DCS compared with historical controls (10% vs 42%).\(^\text{[50]}\) With the advent of the DCS & other improved trauma Management, the mortality of the United States servicemen wounded in Iraq and Afghanistan (2003 and 2009) was only 10% as compared with 24% in the first Gulf War (1990-1991) and Vietnam War (1961-1973).

**Table 5. DCS**

<table>
<thead>
<tr>
<th>1. Bleeding control</th>
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<tbody>
<tr>
<td>2. Decontamination</td>
</tr>
<tr>
<td>3. Quick body cavity closure to rewarmed patient</td>
</tr>
<tr>
<td>4. Planned re-operation for definitive repair when physiology normalized</td>
</tr>
</tbody>
</table>

**MAJOR PELVIC FRACTURE—A PRE-DEFINED MANAGEMENT PROTOCOL TO IMPROVE SURVIVAL**

Major pelvic disruption with shock carries high mortality.\(^\text{[69,70]}\) There is no head to head comparison of whether transcatheter angiographic embolisation (TCAE)\(^\text{[70]}\) first is superior to external pelvic fixation (EPF)\(^\text{[67]}\) or the
converse but an explicit & pre-defined protocol improves the survival outcome.\cite{70}

Pelvic binder followed by EFP, pre-peritoneal packing (Pre-PPP) & TCAE\cite{67,68} +/- venous stenting\cite{68,69} can be a reasonable approach since trauma surgeons are usually in-house of the hospital in contrast to the interventional radiologists owing to more common man-power limitation in the latter specialty in the locality.

Pelvic circumferential compression devices (PCCD) can promptly reduce the pelvic volume to create the tamponade effect to reduce bleeding.\cite{74,75} However, prolonged use can cause skin & tissue damage in the 3 common forms of PCCD including Pelvic Binder(R), SAM-Sling (R) and T-POD (R) and timely switch to EPF is essential.\cite{76} EPF apposes the fracture sites to help control the bone marrow bleeding & prevent expansion of the pelvic volume to enhance the consequent pressure effect of pre-peritoneal pelvic packing (Pre-PPP) to compress the venous & potentially the arterial bleeders. Pre-PPP is a novel management for mechanically unstable pelvic fractures in critically injured patients.\cite{77} This rapid method to control pelvic fracture-related hemorrhage may reduce the need for emergent TCAE & decrease the blood product need as well as the mortality in the high-risk pelvic fractures.\cite{79}

TCAE targets at arresting arterial bleeding by injecting gel-foam or as a permanent procedure by metallic coils in case of A-V fistula or pseudo-aneurism. Venous stenting controls hemorrhage through the large ruptured veins such as the iliac veins. Interventional TCAE is an efficient & effective procedure for hemostasis of arterial bleeding detected on MDCT in pelvic fractures as contrast (or blood) blush. It should be incorporated into the early clinical Management protocol.\cite{79}

**PREVENTION**

While the golden hours of trauma resuscitation are very exciting & appealing,\cite{80} prevention is actually more important. Though the concept of golden hours is pervasive, Newgard et al\cite{81,82} showed there was no association between the any EMS intervals and mortality in severely injured patients. Trunkey\cite{83}, the renowned trauma surgeon, is certainly one of the major advocates on trauma prevention. He had identified motor vehicle crash, homicide, burns, alcohol and drug abuse were the major issues.

Simple devices such as the helmets continue to be important to reduce head and maxillofacial injuries and death in bicyclists & related activities whereas the safety belts decreases mortality in motor vehicle crashes, not to mention the tremendous reduction in financial burden.\cite{89,90} While drunk driving persists as an important cause for trauma mortality,\cite{91} drugged driving is another emerging problem with high prevalence rate of 18.5%, 13%, 12.3% and 10% among the injured drivers of the respective Italian,\cite{92} Swedish,\cite{93} Belgian\cite{94} and Hong Kong\cite{97} studies. Education, legislation and law enforcement are the 3-pronged public health approach to control the harm.

Trauma care quality indicators comprise of 3 levels from the prehospital, in-hospital to post-hospital.\cite{98} In the prehospital & in-hospital levels, the aim is to achieve the secondary injury prevention to allay the trauma severity by reducing the impact force such as by the safety devices mentioned above and safe car & road design as well as to limit the trauma complications by prompt EMS and medical treatment. Tertiary prevention targets at injury recurrence while primary prevention focusses on occurrence elimination.

Trauma resuscitation & the subsequent operation may not be able to save lives or fully restore the body functions (brain or limb), leaving not only death, permanent disability, scars, pain but burden in all forms including & not limited to physical, psychological, financial and social. Injury prevention has to receive an escalated recognition and higher resources. In a nutshell, proficient trauma care is not confined to the golden hours of resuscitation, but begins with efficient pre-hospital bystander and ambulance services and continues with the in-patient critical care followed by high quality rehabilitation programme reinforced by future prevention for the injured and primary prevention for the at risk groups. While operation is the definitive care for trauma, prevention is the best therapy!

**LIMITATIONS**

This article evolves from evidences, consensus (clinical practice guide), concepts, beliefs and daily practice to address the needs of the trauma victims with an aim to provide a reasonable approach while emphasizing on prevention. It is by no means the only single or best approach as the authoritative or authoritarian trauma management commandments. The span of this article also restricts the more in-depth deliberation on the controversial points of each issue. Continuing researches will elucidate the evolving truths in trauma care with an outcome-based approach!

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