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x-ABC versus ABC: shifting paradigms in early trauma resuscitation

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SUMMARY

Exsanguinating hemorrhage is the most common cause of preventable death after trauma. Since the development of cardiopulmonary resuscitation, the airway, breathing and circulation (ABCs) have been applied to early resuscitation in different contexts including trauma. The ABCs have been a pivotal paradigm in the Advanced Trauma Life Support course since its development, but recent data have indicated that prioritizing the management of eXsanguinating hemorrhage (x-ABC) improves outcomes. In this review, we examine the history and evolution of the ABCs in the context of resuscitation research to the recent adoption of x-ABC in trauma.

THE ORIGIN OF THE ABCS

The shorthand airway, breathing and circulation (ABC) was originally popularized by Dr Peter Safar, pioneer of cardiopulmonary resuscitation. It was adopted by the American Heart Association in 1973 as a mnemonic device to help first responders remember the steps of cardiopulmonary resuscitation (CPR) for cardiac arrest.[1] Since its introduction in 1980, the Advanced Trauma Life Support (ATLS) course has formed the standard for the initial management of patients with trauma around the world including both military and civilian casualties.[2] The ABC mnemonic had become a mantra for early resuscitation and was a logical adoption of CPR principles translated to an established priority for standardizing care with the idea that injuries that lead to death the fastest should be addressed first. The ATLS course emphasizes that it teaches one safe way to manage patients with trauma and its implementation has been associated with improved survival in studies around the world.[3–5]

The development of CPR and ATLS did not stop after their conception. Multiple studies have found that structuring CPR to focus on cardiac compressions leads to improved outcomes in cardiac arrest.[6–9] For example, one European study randomized recertifying general practitioners and hospitalists to simulations using ABC versus CAB (circulation, airway, breathing) guidelines and found that those given the CAB guideline performed resuscitative cycles faster and delivered fewer extraneous rescue breaths.[7] This led to changes in national guidelines and educational programs in Europe and subsequently in North America. As cardiogenic rather than respiratory etiologies are the most common cause of cardiac arrest in adult patients,[10] this shift is aligned with current medical knowledge. Similarly, it is now well known that hemorrhage is the leading preventable cause of death in patients with trauma in both civilian and military settings.[11 12] The care of injured warfighters in Iraq and Afghanistan has led the way in adjusting the approach to the ABCs for patients with trauma, and civilian organizations are benefiting from the lessons learned in wartime.

ABCs in the military setting

The Committee on Tactical Combat Casualty Care (CoTCCC) establishes priorities for the initial management of injured warfighters. The concepts of ATLS set by the American College of Surgeons Committee on Trauma (COT) were primarily developed in civilian environments where trauma mechanisms are dominated by blunt injury and low velocity penetrating weapons. Mechanisms of injury during the wars in Iraq and Afghanistan were dominated by high-powered blast in the form of improvised explosive devices, which produce massive extremity trauma accompanied by exsanguinating hemorrhage. A study examining deaths on the battlefield (prehospital) by Eastridge and colleagues[13] showed that in Operation Iraqi Freedom and Operation Enduring Freedom, 73.7% of deaths were related to blast injury and 87.3% of injury mortality occurred before reaching a military treatment facility. Additionally, the most common causes of potentially survivable injuries were hemorrhage (90%) and loss of airway (8%). Notably, a study examining causes of death after patients reached a military treatment facility also found that hemorrhage was the second most common cause of death overall, and failure to control hemorrhage in the prehospital or early resuscitative phase was the most common cause of preventable in-hospital deaths.[14] As the importance of rapid hemorrhage control was increasingly recognized, there were more efforts to adapt damage control surgery, which at that time was well established in the civilian setting, to the unique challenges of the military setting including evacuation and transportation across multiple roles of care and continents.[15]

Based on elucidation of the mechanisms driving preventable deaths from combat trauma, the priorities for casualty management as espoused by the CoTCCC shifted from ABC to CAB with the highest priority placed on massive hemorrhage control and the use of tourniquets and hemostatic dressings.[16] In the Eastridge study, before the implementation of this approach (from the start of the study period in 2001 to initial fielding of tourniquets in 2005), the average incidence of death from extremity hemorrhage was 23.3 deaths per year, and from full implementation in 2007 to the end of the study period in

2011, this dropped to 3.5 deaths per year, equating to an 85% reduction in mortality.[13] The CoTCCC developed the MARCH-PAWS algorithm (Massive bleeding, Airway, Respiration, Circulation, Hypothermia/Head injuries, Pain, Antibiotics, Wounds, Splinting) which emphasizes control of massive bleeding in both care under fire and tactical field care setting followed by prioritizing airway, respirations, circulation/resuscitation and head injury while avoiding hypothermia. Following MARCH and after stabilization, pain control, antibiotics, wound care and splinting of fractures are prioritized (figure 1). Many of these concepts were translated to civilian prehospital medicine where the use of tourniquets, which were once disparaged by ATLS, and hemostatic dressings are now common. The term x-ABC was created to indicate addressing exsanguinating hemorrhage first.

ABCs in the civilian setting

As the critical nature of early hemorrhage control is being translated from battlefield to civilian medicine, there has been increasing civilian literature supporting this approach. Davis *et al* published medical examiner reports from Miami-Dade County evaluating prehospital deaths.[11] Out of a total of 512 deaths during 1 year, 146 deaths (28.5%) were deemed to be potentially survivable and the majority of these were caused entirely by hemorrhage (54.1%) (table 1). The majority of hemorrhage-related deaths resulted from chest injury. The second leading cause of potentially preventable death was neurotrauma occurring in 28.1% of deaths. Overall, death from brain injury was most commonly occurring in 59% of deaths, but only about 14% of these deaths were considered potentially preventable.

While the etiologies of trauma differ between civilian and military settings, these findings of preventable causes of death are remarkably similar to those of Eastridge *et al* who analyzed death on the battlefield during the period from 2001 to 2011.[13] This study was also based on medical examiner reports and revealed that 87.3% of all mortality occurred prior to arrival at the medical treatment facility. 24.3% of deaths were deemed potentially preventable, 91% were largely associated with hemorrhage and the site of lethal hemorrhage was truncal in 67% of deaths. These studies both show that the greatest opportunity to improve survival in trauma patients is to treat hemorrhage as early as possible, preferably in the prehospital setting.

Table 1 Causes of death and anatomic regions injured in potentially survivable patients (n=146)[11]

Cause of death	n (%)
Hemorrhage	79 (54.1)
Neurotrauma	41 (28.1)
Hemorrhage+neurotrauma	15 (10.3)
Asphyxia	9 (6.2)
Asphyxia+neurotrauma	2 (1.4)

Time to early resuscitative intervention (TERI) has been shown to be a critical predictor of survival. The group from Pittsburgh combined data from the Prehospital Air Medical Plasma trial and the Study of Tranexamic Acid during Air and ground Medical Prehospital transport trial.[17] Using logistic regression, the authors found that every 1 min delay in TERI was associated with a 2% increase in the odds of both 24-hour and 30-day mortality. They found statistically significant benefits in 24-hour and 30-day survival with earlier delivery of red blood cells, plasma and tranexamic acid (table 2)

One area of debate that remains relates to the sequence of care in hypotensive patients with a GCS <8, which may be caused solely by hemorrhagic shock. ATLS has traditionally emphasized that these patients should be intubated for airway control first. However, intubation is not a benign intervention. Multiple retrospective and prospective observational studies have shown associations of early intubation with increased mortality.[18–25] Although differences in the compared populations in these studies, particularly initial GCS makes interpretation difficult, there is extensive evidence that hypovolemia combined with the removal of sympathetic drive and vasodilatation with induction medications can lead to severe hypoperfusion.[20 21 26–28] In a prospective observational EAST multicenter trial, Ferrada and

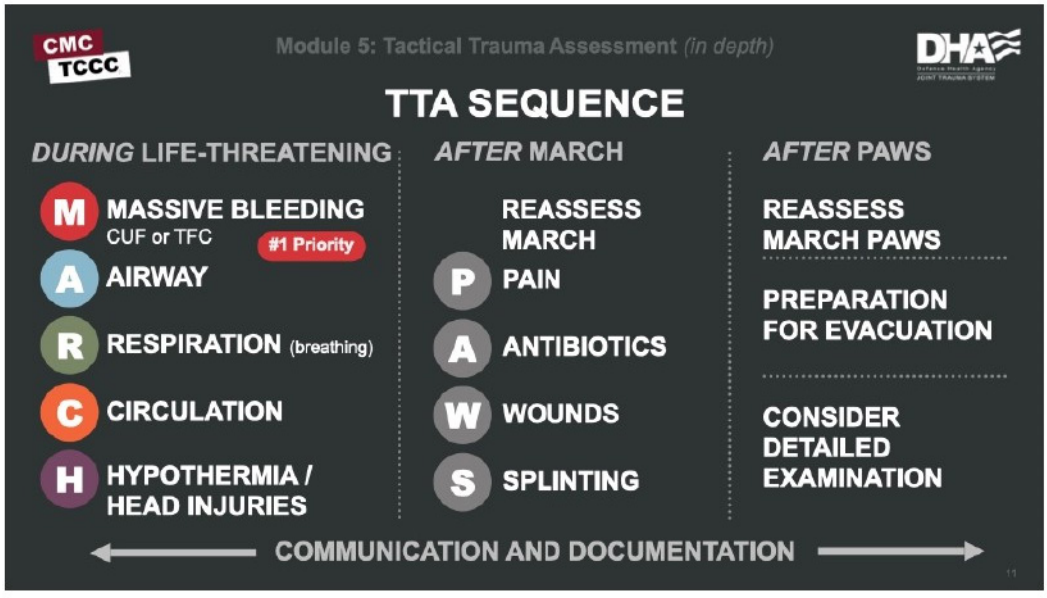

Figure 1 MARCH-PAWS algorithm.[16] Within this algorithm, the CoTCCC is now considering testing responsiveness to resuscitation prior to assessing respiration in hypotensive casualties because death due to tension pneumothorax in non-intubated patients is rare whereas death due to exsanguination is common. CUF, Care Under Fire; DHA, Defense Health Agency; TFC, Tactical Field Care; TTA, Tactical Trauma Assessment.

Table 2 Association of TERI on mortality among individual resuscitative intervention components among patients receiving an early resuscitative intervention[17]

	aOR*	95% CI	P
pRBCs			
30-day mortality	1.015	1.001 to 1.029	0.04
24-hour mortality	1.047	1.001 to 1.086	0.02
Plasma			
30-day mortality	1.021	1.001 to 1.042	0.04
24-hour mortality	1.044	1.007 to 1.083	0.02
TXA†			
30-day mortality	1.042	1.003 to 1.083	0.04
24-hour mortality	1.073	1.013 to 1.137	0.02

*Adjusted odd per 1 min increase in TERI.
†Only available as prehospital intervention.
pRBC, packded red blood cells; TERI, time to early resuscitative intervention.

colleagues[29] demonstrated that for patients requiring intubation within the first 30 min of arrival, those who were treated with a CAB approach (circulation/resuscitation prioritized) compared with ABC had higher postintubation SBP despite lower preintubation SBP, fewer experienced cardiac arrest requiring CPR, and they had a lower 24-hour mortality (11% vs 69%). Other 'C' interventions such as early initiation of vasopressin (which is depleted in hemorrhagic shock) have also been shown to be of benefit when moved to an earlier stage of resuscitation compared with standard care.[30]

Breeding *et al* published a literature review inclusive of four studies evaluating CAB versus ABC in patients with trauma in shock.[31] Overall, patients treated with intubation before blood transfusion experienced a higher mortality (78% vs 50%, $p<0.05$). Intubation prior to blood transfusion was associated with hypotension, which was independently associated with higher mortality. They proposed the algorithm shown in figure 2.

In the context of prehospital civilian trauma management, the Tulane group published their experience with instituting a prehospital advanced resuscitative care bundle in hypotensive penetrating trauma patients.[32] The bundle includes 2 units of red blood cells, 2 g of calcium and 2 g of tranexamic acid administered at the scene of the trauma or during transport to the trauma center. Patients, treated in this manner, were compared with a historical control group treated with a traditional ABC bundle, including intubation. The groups were similar with respect to demographics and physiology at the scene but only one patient in the x-ABC cohort was intubated prehospital versus all of the patients in the ABC group. On arrival in the ED, the x-ABC group had a significantly higher systolic blood pressure and GCS and lower ED shock index. More ABC patients died in the ED and their in-hospital mortality was higher.

Overall whether prehospital or in hospital, exsanguinating patients in the civilian center do better if intubation is avoided and resuscitation is prioritized. One could make the argument that stopping bleeding and resuscitating these patients is the best treatment of airway by restoring circulation and cerebral perfusion. At the 2023 ATLS symposium, updating guidelines to reflect an x-ABC approach was proposed.[33] We may soon see ATLS guidelines that align with those of the CoTCCC.

CONCLUSIONS

Exsanguination is the leading cause of preventable death after trauma and better understanding of this has led to a transition in military and civilian practice to an x-ABC approach from the traditional ABC approach. In prehospital and early in hospital trauma resuscitation, airway and breathing should not be prioritized in the absence of significant anatomic injury or severe hypoxia. In patients with trauma with exsanguinating hemorrhage, all efforts should be focused on the earliest possible arrest of hemorrhage with tourniquets and hemostatic dressings combined with blood product resuscitation and immediate transfer to the operating room for torso hemorrhage control.

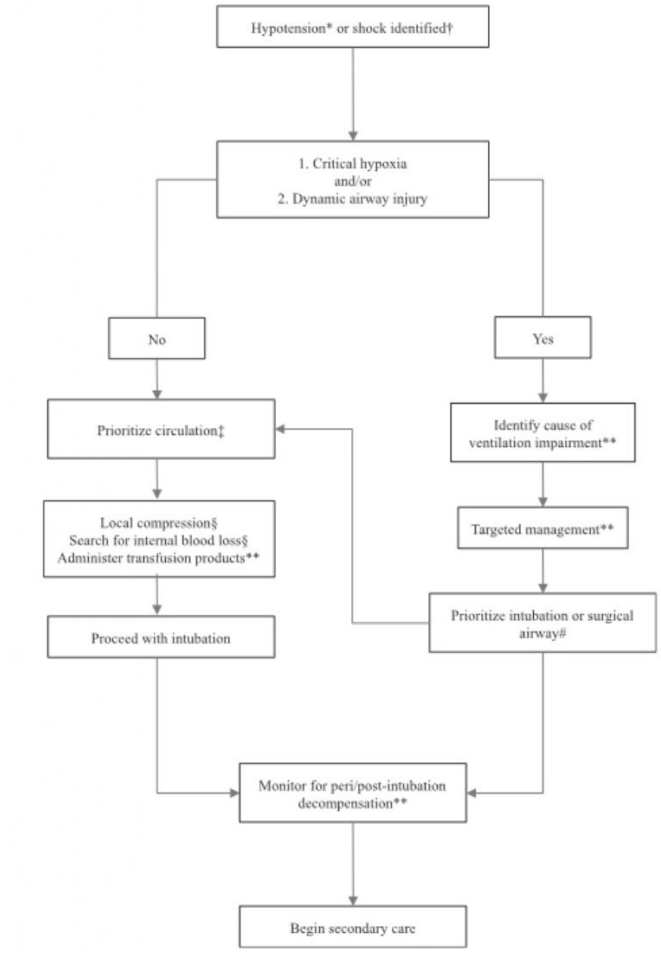

Figure 2 Algorithm for the management of hypotensive trauma patients.[31] This algorithm emphasizes that in those with critical hypoxia or loss of airway due to anatomic injury, airway remains the priority. These defects can be ruled out in a matter of seconds and once they are, hemorrhage control and resuscitation should become the priority.

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