Prehospital resuscitation in adult patients following injury: A Western Trauma Association critical decisions algorithm

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This is a recommended management algorithm from the Western Trauma Association (WTA) Algorithms Committee addressing prehospital resuscitation in adult patients following traumatic injury. The WTA develops algorithms to provide guidance and recommendations for particular practice areas but does not establish the standard of care.[1–3] Because there is a paucity of published prospective randomized clinical trials that have generated class I data to inform the overall algorithm, these recommendations are based primarily on the highest level of data available for specific injury types, prehospital transport characteristics and specific patient factors identified via structured literature search and expert opinion of the WTA members. The final algorithm is the result of an iterative process, including an initial internal review and revision by the WTA Algorithm Committee members, and then final revisions based on input during and after presentation of the algorithm to the full WTA membership.

The prehospital phase of care is an early period closest to the time of injury where resuscitation practices have been shown to be associated with differential outcome effects.[4–7] The algorithm and accompanying comments represent a safe and sensible approach that can be followed for crystalloid and blood product resuscitation in the prehospital setting. We recognize that there will be patient, personnel, situational factors, and new prehospital resuscitation data that may warrant or require deviation from the current recommended algorithm. We encourage prehospital providers and affiliated institutions to use this algorithm to formulate their own local protocols. The algorithm (Fig. 1) contains letters at decision points; the corresponding paragraphs in the text elaborate on the thought processes and cite pertinent literature. The annotated algorithm is intended to serve as a quick reference for prehospital providers and clinicians involved with prehospital resuscitation protocol creation/direction.

Initial Triage for Risk of Hemorrhage

Standard Prehospital Trauma Life Support or International Trauma Life Support guidelines should be followed whether the injured patient is being transferred from the scene of injury or interfacility transport. Initiation of intravenous access should be obtained during transport to minimize delay to definitive patient care. Patients without systolic hypotension (systolic blood pressure [SBP] < 100 mm Hg), tachycardia (heart rate [HR] > 110), or evidence/concern for hemorrhage should have their IV placed to "saline-lock" or can receive intravenous crystalloid fluids at "keep vein open" infusion rates (25–50 mL/h).[8] Those patients with hemodynamic instability with systolic hypotension (SBP <100 mm Hg) and tachycardia (HR > 110) or concern for hemorrhage should have intravenous resuscitation initiated. Hemorrhage control methods, including tourniquet placement, hemostatic dressings, and/or direct pressure, should also be performed simultaneously when feasible.[9] The intravenous resuscitation fluid blood pressure target will be based on mode of transport and whether blood products are available. Although evidence exists regarding the beneficial effects of balanced crystalloid solutions as compared with normal saline in critically ill ICU patients, the current algorithm is unable to recommend a specific prehospital crystalloid due to lack of strong evidence in this setting.[10]

Mode of Transport and Availability of Blood Products

Patients are most commonly transported by either ground ambulance or air medical services, which have advance life support capabilities en-route to definitive trauma care. In a small proportion of urban settings, basic life support transport (no intravenous resuscitation capability) performed by police has been demonstrated to result in improved outcomes in patients with penetrating injury.[11,12] Differences exist in the prehospital transport times, mechanism of injuries, injury severity, and provider training between ground and air medical transport patients. Increasingly, air medical transport services carry

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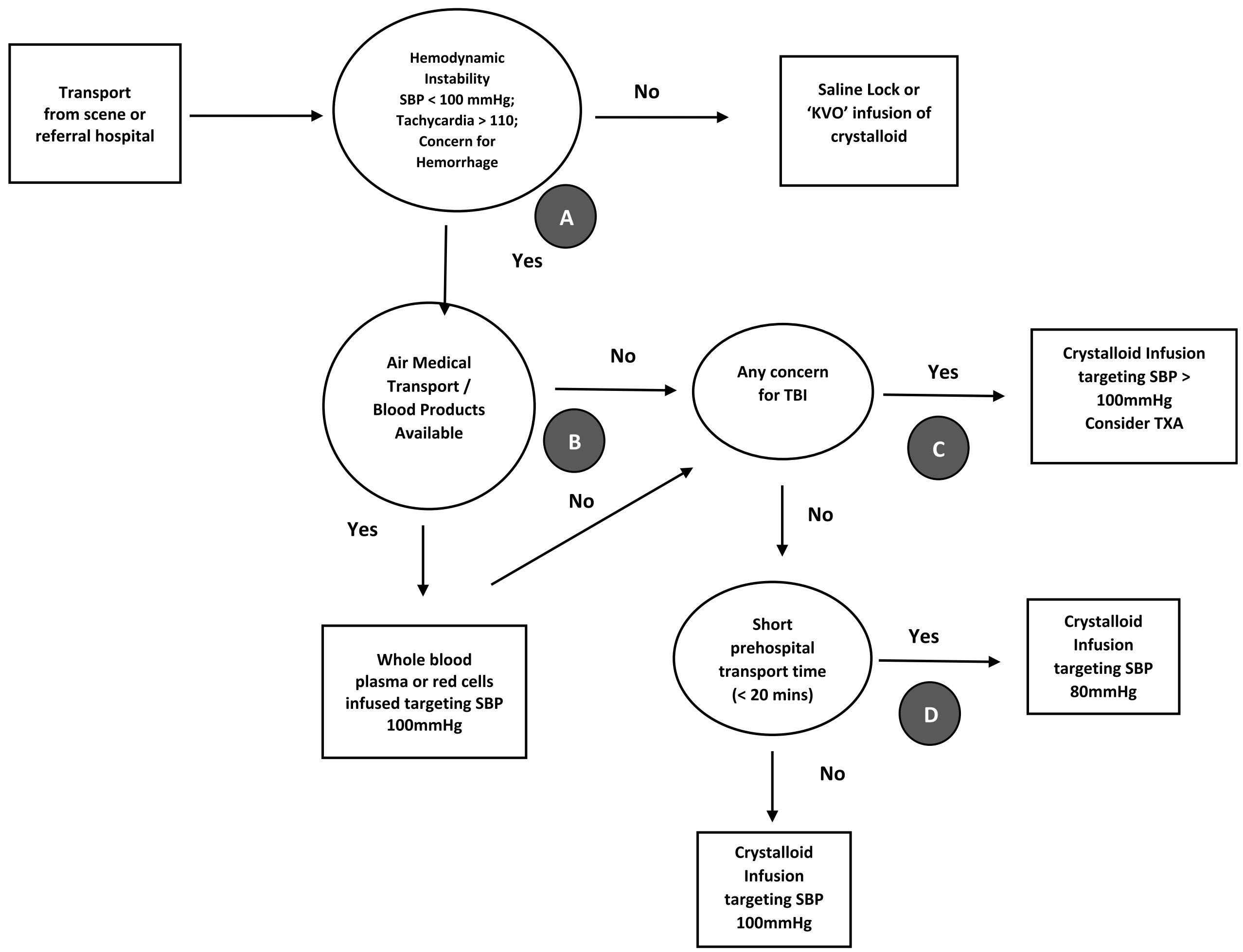

Figure 1. A Western Trauma Association critical decisions algorithm for prehospital resuscitation in adult patients following injury.

blood components for resuscitation because they have the capabilities to appropriately store and monitor blood products at their respective bases and during transport. In both military and civilian settings, packed red blood cell transfusion, when initiated early after injury, has been shown to be associated with a survival benefit for air medical transport patients.[4–6] Prehospital plasma has similarly been demonstrated to be safe[13] and reduce mortality when provided in the prehospital arena in patients at risk of hemorrhagic shock.[7] Cold-stored whole-blood transfusion has become increasingly common for civilian in-hospital resuscitation[14–17] and is even available in a small number of trauma systems across the country in the prehospital setting.[18,19] Studies are in progress to determine the potential benefits of cold-stored whole blood in both the in-hospital and prehospital environments. In those transport systems where whole blood or blood components are available, blood product transfusion should be initiated in those with hemodynamic instability or in those patients with concern for hemorrhage targeting an SBP of 100 mm Hg. Crystalloid infusion should not be provided prior to blood product infusion in these patients. Once all prehospital blood products have been transfused and continued hemodynamic instability or concern for hemorrhage exists, crystalloid resuscitation may be initiated with blood pressure targets based on concern for traumatic brain injury (TBI) and prehospital time.

Concern for TBI

For those air medical or ground transport patients without blood products available who are at risk of hemorrhage, crystalloid infusion should be initiated once IV access is obtained. Prehospital hypotension in patients with TBI should be minimized as it is associated with detrimental outcome.[20,21] Evidence suggest that there is no threshold blood pressure level that is safe and that outcomes are linearly associated with prehospital systolic blood pressure.[22] In patients with concern for TBI based on mechanism of injury, Glasgow Coma Scale score, or external signs of injury, crystalloid infusion should target a systolic blood pressure greater than 100 mm Hg.

Preliminary unpublished data presented from a recent completed randomized trial which focused on prehospital tranexamic acid (TXA) in patients with concern for TBI demonstrated benefit in patients with documented brain injury.[23] Tranexamic acid should be considered in this cohort of patients based upon the current evidence available. No evidence for prehospital TXA in those at risk of hemorrhage exists currently but clinical trials will be completed in the near future.

TABLE 1. Top Identified Knowledge and Research Gaps Related to Prehospital Resuscitation

Topic or Research Knowledge Gap	Algorithm Section
1. Vital sign definition of hemodynamic instability	A
2. Specific crystalloid fluid and target administration method	A
3. Cold stored group O whole blood benefits as compared with standard prehospital component resuscitation such as packed red blood cells	B
4. TBI and hemorrhagic shock combined management	C
5. Prehospital TXA administration and specific injured cohort who benefits	C
6. Patient cohorts who benefit from prehospital hypotensive or controlled resuscitation	D

Prehospital Transport Time

Urban as compared with suburban or rural trauma patients differ in demographics, mechanisms of injury, and prehospital transport times.[24] Time of transport to definitive trauma care has been demonstrated to effect outcome in those patients with significant injury and those at risk of hemorrhage.[25–27] High-level randomized evidence exists demonstrating that patients with penetrating torso injury in an urban setting have improved survival with delayed crystalloid infusion (resuscitation starting in the operating theater) as compared with immediate crystalloid infusion (prehospital resuscitation) group.[28] In this randomized trial, patients in the delayed group had a median SBP of 72 mm Hg in the prehospital setting and prehospital transport times were less than 15 minutes on average. A more recent randomized pilot trial demonstrated that a "controlled resuscitation strategy" is safe and was associated with improved survival in blunt injured patients.[29] In this study, crystalloid infusion was provided in 250-mL boluses targeting an SBP of 70 mm Hg and mean prehospital transport times were less than 20 minutes. In those patients who have an estimated transport time of less than 20 minutes, crystalloid infusion should be provided targeting an SBP of 80 mm Hg. In those patients with estimated prehospital transport times greater than 20 minutes, crystalloid infusion targeting an SBP of 100 mm Hg should be provided.

Areas of Controversy and Existing Knowledge Gaps

The vital sign definition which constitutes hemodynamic stability is not well defined and may vary by the age and comorbidities of the respective patient (Table 1). As prehospital resuscitation guidelines vary with different crystalloid fluids and volumes typically transfused, we remained nonspecific regarding type of crystalloid fluid and elected to recommend systolic blood pressure targets rather than attempt to recommend volumes and infusion rates. Specific crystalloid fluids and whether they be provided as bolus or blood pressure targets remains inadequately characterized in the literature for prehospital injured patients.

The highest level of evidence for hypotensive resuscitation in the prehospital environment was demonstrated in patients who suffered penetrating torso trauma in an urban setting with short transport times.[28] The current algorithm additionally includes blunt injured patients also with short transport times and similarly targets an SBP of 70 mm Hg based on data from a single pilot clinical trial.[29] There is no high-level evidence whether blunt injured patients with short transport times would benefit from prehospital hypotensive or controlled resuscitation.

There is a paucity of literature providing guidance on the management of combined patient with TBI and hemodynamic instability/hemorrhagic shock. Whether TXA should be provided in the prehospital arena for either TBI or in patients with concern for hemorrhage remains similarly poorly characterized. Publication of clinical trial results providing more definitive guidance for TXA in the prehospital arena for both these populations will be coming in the near future. Similarly, evidence of the benefits of cold-stored whole-blood resuscitation in the civilian population as compared with standard prehospital resuscitation are currently lacking. For this resource to become available in the prehospital arena commonly, high-level evidence will be required showing its benefit for those severely injured. Studies are ongoing to address this important information currently.

SUMMARY AND CONCLUSIONS

Interventions or management practices following injury that occur in the prehospital phase of care, closest to the time of injury, have significant potential to improve outcomes. Prehospital resuscitation following injury represents one such practice that continues to evolve. Growing evidence has accumulated regarding the negative effects of overly aggressive crystalloid resuscitation and the benefits of early, prehospital blood product transfusion in those with significant injury and risk of hemorrhage.[6,7,30] The current algorithm attempts to unify the highest-level evidence available to promote safe, effective prehospital resuscitation care.

AUTHORSHIP

All authors meet authorship criteria for this article as described below. All authors have seen and approved the final article as submitted. The first author (J.L.S.) had full access to all data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. J.L.S., M.J.M., K.I., E.E.M. participated in the conception and design. J.L.S. and K.I. participated in the acquisition of data. J.L.S., M.J.M., K.I., E.E.M. participated in the analysis and interpretation of data. All authors participated in the article preparation and editing.

DISCLOSURE

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