Chapter 49

RESUSCITATION GUIDELINES

NICHOLAS T. TARMEY, FRCA,* AND R. SCOTT FRAZER, FFARCSI†

*Lieutenant Colonel, Royal Army Medical Corps, Department of Critical Care, Ministry of Defence Hospital Unit Portsmouth, Queen Alexandra Hospital, Southwick Hill Road, Portsmouth PO6 3LY, United Kingdom
†Colonel, Late Royal Army Medical Corps, Consultant in Anaesthesia, Queen Elizabeth Hospital, Mindelsohn Way, Birmingham B15 2WB, United Kingdom

INTRODUCTION

Cardiorespiratory arrest following trauma occurs in 1% to 4% of patients transported to major civilian trauma centers, where it is associated with a very poor overall prognosis.[1–4] Resuscitation from cardiorespiratory arrest in the military setting presents a unique challenge, with a number of important differences from civilian practice. The military population suffers a high incidence of blast and penetrating trauma as the cause of arrest,[5] and care is often delivered in a range of hostile environments. The military setting may also have significant constraints on medical resources, limiting the extent of available treatment. In enduring operations, however, resources may sometimes exceed those available to the civilian sector.

Traumatic cardiorespiratory arrest (TCRA), defined as the loss of central pulses and respiratory effort following trauma, represents the final common pathway before death due to exsanguination, pneumothorax, cardiac injury, brain injury, or asphyxia.[6] In the case of exsanguination, a period of profound hypotension with nonpalpable pulses may precede cardiac standstill, although these two phases may be indistinguishable on initial examination.

There is a lack of robust evidence for the optimal management of TCRA, in both civilian and military settings. In the absence of widely accepted, evidence-based guidelines, military practice has been guided by a combination of generic guidelines for cardiac arrest, limited civilian guidelines on prehospital resuscitation, and guidelines for resuscitative thoracotomy. A recent observational study from a United Kingdom (UK) field hospital in Afghanistan has provided some additional evidence on predictors of survivability following TCRA.[7] Although survival is rare for these patients, as in civilian practice, good outcomes can be achieved with timely, appropriate interventions, but these require access to significant resources. This chapter will review the evidence for current guidelines and, in the context of experience from current conflicts, suggest modifications to these guidelines for military TCRA.

EXISTING GUIDELINES

Cardiac Arrest Guidelines

Currently, the only internationally recognized guidelines for the treatment of cardiac arrest are those produced by the European Resuscitation Council and adopted by both the Resuscitation Council (UK) and the American Heart Association.[6] Although the core adult resuscitation algorithm (Figure 49-1) offers simplicity and standardization, it was produced principally for cardiac arrest from primary cardiac causes, not from trauma (the pediatric algorithm is also shown, in Figure 49-2, for reference). Consequently, the guidelines are mostly based on evidence from nontrauma resuscitation and place the greatest emphasis on early defibrillation for ventricular fibrillation or pulseless ventricular tachycardia, cardiac rhythms rarely encountered in TCRA.[7]

The 2010 update of the European Resuscitation Council guidelines does, however, include a useful discussion of TCRA in the "Special Circumstances" section.[8] Here, the authors recognize the lack of robust evidence for the treatment of TCRA and make a number of recommendations relevant to military resuscitation, including:

- Undertake only life-saving interventions at the scene, with immediate transfer to the nearest hospital.
- Do not delay transfer for unproven interventions such as spinal immobilization.
- Standard cardiopulmonary resuscitation (CPR) should not delay the treatment of reversible causes.
- Chest compressions are still considered "the standard of care in cardiac arrest irrespective of aetiology," but they are of limited value in hypovolemia and cardiac tamponade.
- Pericardiocentesis is not recommended, because it is usually ineffective and delays thoracotomy.
- For tension pneumothorax, anterior or lateral thoracostomy is more effective than needle decompression and quicker than inserting a chest tube.
- For assisted ventilation, it may be useful to limit tidal volumes and respiratory rate in order to reduce the effect of raised intrathoracic pressure on venous return.
- The role of vasopressors in TCRA remains unclear.

Trauma Resuscitation Guidelines

A number of sources of guidelines are available to military clinical staff; however, it must be recognized that even the currently published military

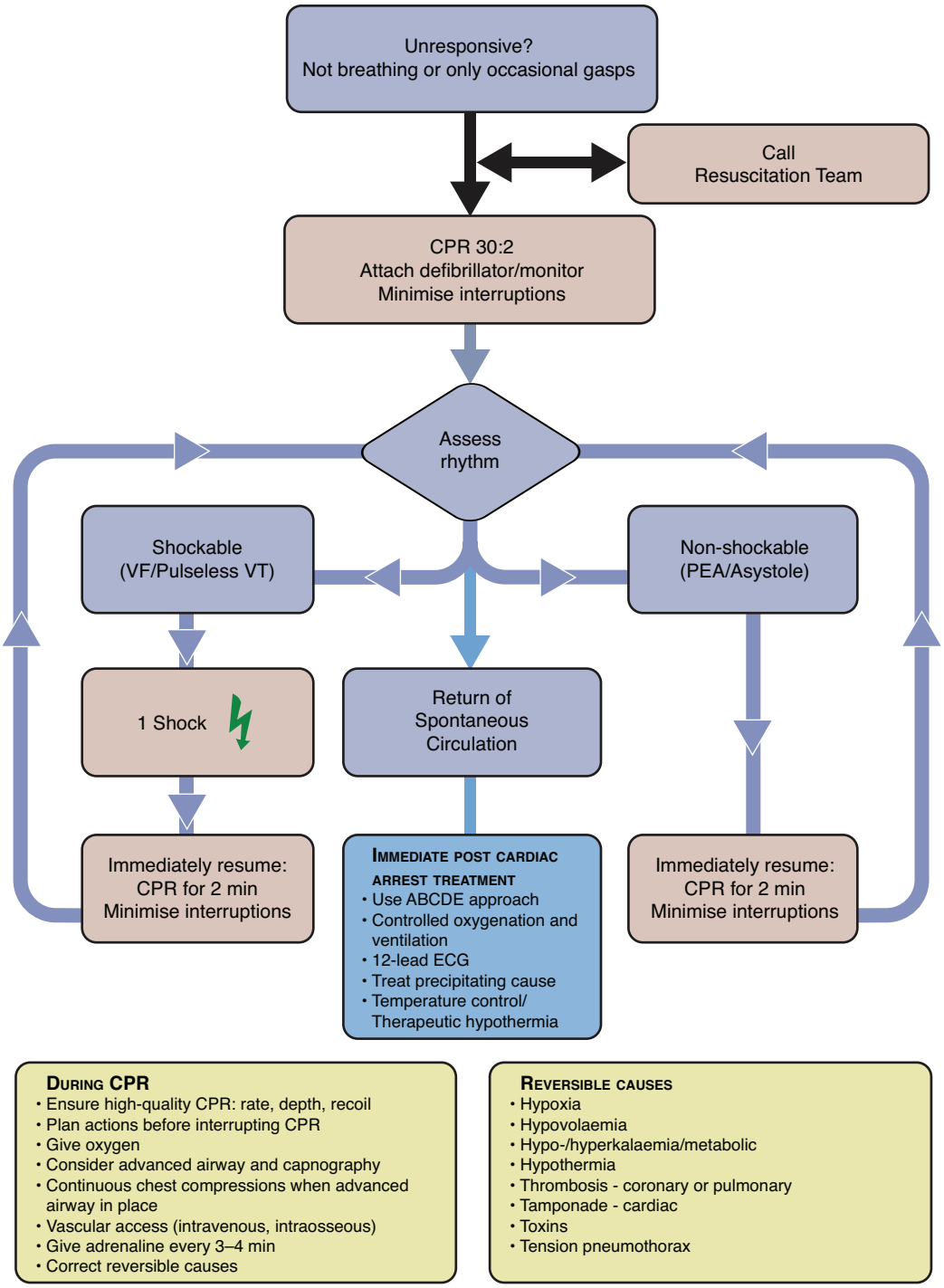

Figure 49-1. Adult Advanced Life Support algorithm. Copyright European Resuscitation Council—www.erc.edu—2012/003.
ABCDE: airway, breathing, circulation, disability, exposure
CPR: cardiopulmonary resuscitation
ECG: electrocardiogram
VF: ventricular fibrillation
VT: ventricular tachycardia
PEA: pulseless electrical activity
Reproduced with permission from: Nolan JP, Soar J, Zideman DA, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 1. Executive summary. *Resuscitation*. 2010;81:1232.

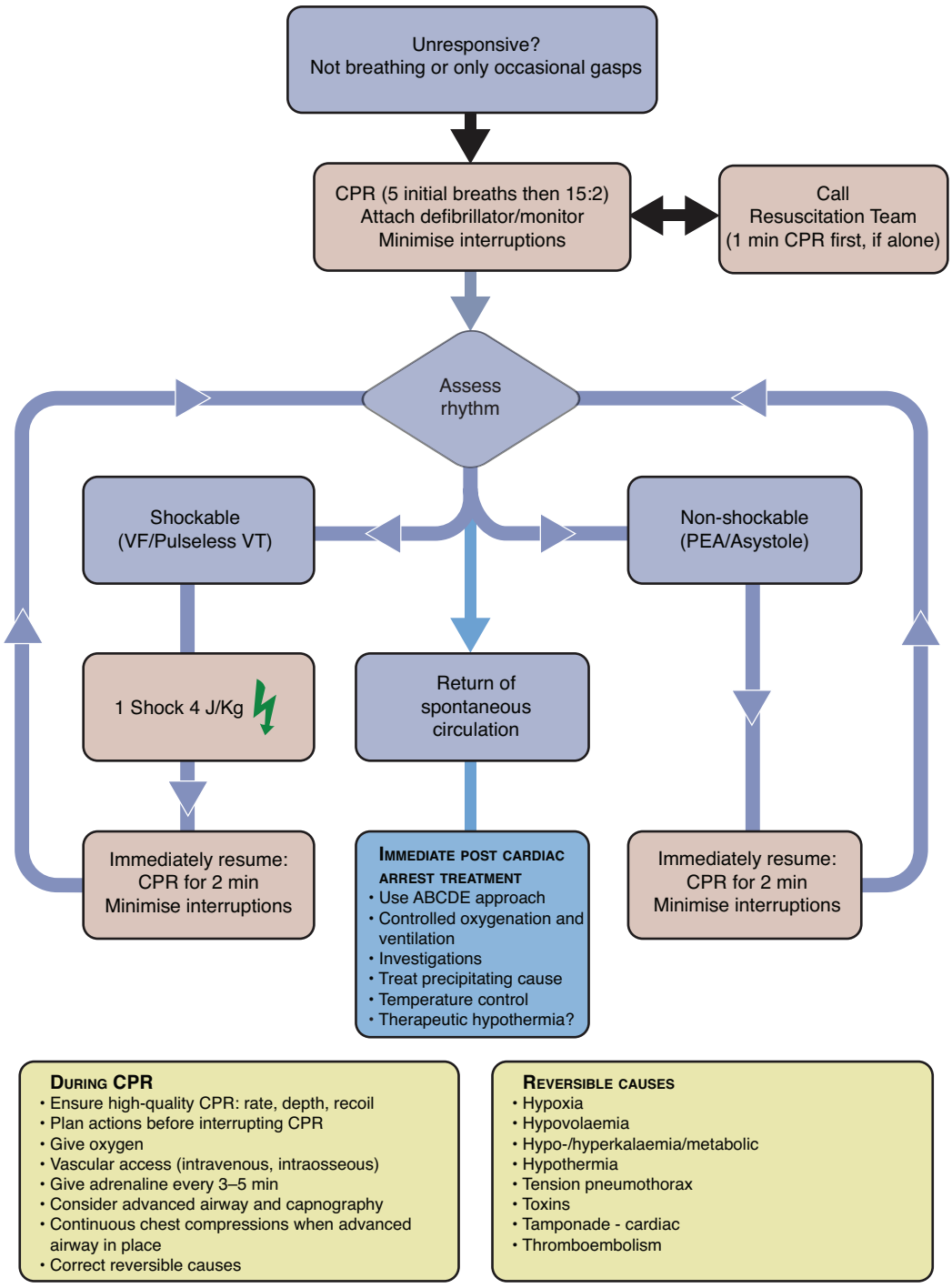

Figure 49-2. Pediatric Advanced Life Support algorithm. Copyright European Resuscitation Council—www.erc.edu—2012/003.
ABCDE: airway, breathing, circulation, disability, exposure
CPR: cardiopulmonary resuscitation
ECG: electrocardiogram
VF: ventricular fibrillation
VT: ventricular tachycardia
PEA: pulseless electrical activity
Reproduced with permission from: Nolan JP, Soar J, Zideman DA, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 1. Executive summary. *Resuscitation*. 2010;81:1249.

guidance is based on civilian data. Sources include the following:

The American College of Surgeons' Advanced Trauma Life Support (ATLS)

ATLS is a well-recognized approach to trauma resuscitation, aimed at members of a civilian emergency department trauma team.[9] Although the course provides a widely accepted paradigm for managing trauma patients, there is little specific guidance on the management of TCRA.

Battlefield Advanced Trauma Life Support (BATLS)

BATLS is a course designed by the UK Defence Medical Services (UK DMS) to provide standardized training in emergency trauma care for military practitioners.[10] BATLS adapts civilian practice for the military setting by applying emerging medical evidence and practical military experience from recent conflicts. A key feature of BATLS is the military paradigm of <C>ABC, where catastrophic external hemorrhage, represented by <C>, is dealt with before attending to the airway, breathing, and circulation. For military TCRA, the main advice offered by BATLS concerns the appropriateness of attempting resuscitation for these patients. The 2008 BATLS manual makes the following recommendations:

- It is appropriate to start resuscitation for witnessed TCRA, particularly when hypovolemia is the underpinning cause and volume is rapidly restored.
- It is not appropriate to start resuscitation for TCRA in the case of blunt trauma with absent vital signs at the scene of injury.
- It is not appropriate to start resuscitation for TCRA in the case of penetrating trauma with absent vital signs for 5 minutes at the scene of injury.

Clinical Guidelines for Operations (GCOs)

CGOs, published by the UK DMS, represent current policy for emergency medical care in the military setting.[11] The main areas of TCRA guidance within CGOs relate to triage (Figure 49-3) and resuscitative thoracotomy (Figure 49-4). According to the CGOs, the triage status of a military TCRA victim varies according to the presence of effective enemy fire: if enemy fire is present the casualty is considered dead, but if enemy fire is absent it may be appropriate to commence basic life support.

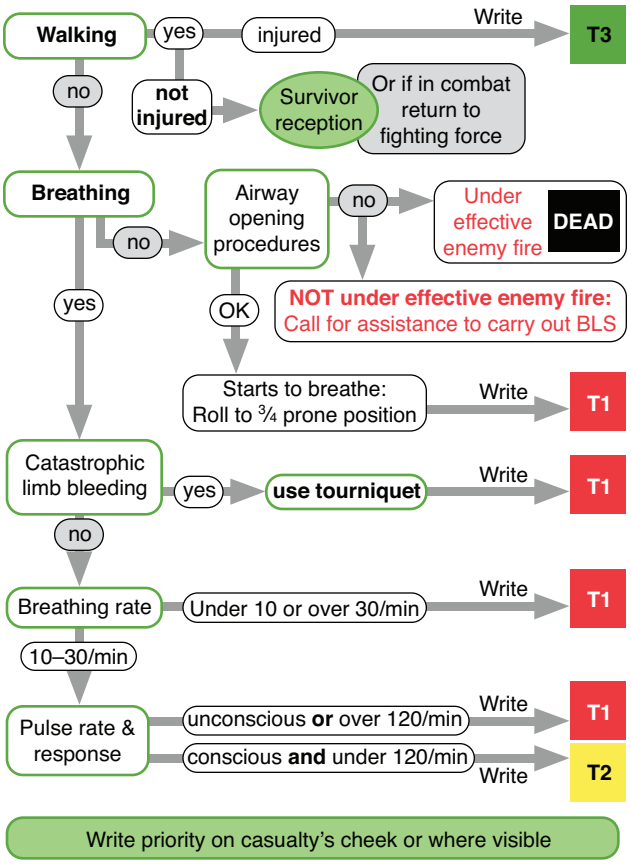

Figure 49-3. Triage flowchart for incident management. The NATO triage categories of T1, T2, and T3 indicate treatment priorities as follows: T1: immediate, T2: urgent, and T3: delayed.
Reproduced from: *Clinical Guidelines for Operations*. London, England: Defence Concepts and Doctrine Centre, 2008: Section 2: 51. Joint Doctrine Publication 4-03.1.

Guidance within CGOs on the use of resuscitative thoracotomy reflects recommendations made by the American College of Surgeons Committee on Trauma in 2001.[12] The committee states that for TCRA due to blunt injury, thoracotomy may be considered only if signs of life were present on arrival in the emergency department. For TCRA due to penetrating trauma, thoracotomy may be considered if signs of life were present until 5 minutes before presentation. Again, this guidance is based on civilian data and guidelines.

Prehospital Resuscitation Guidelines

In 2003 the US National Association of EMS Physicians and the American College of Surgeons published guidelines on withholding resuscitation for prehospital

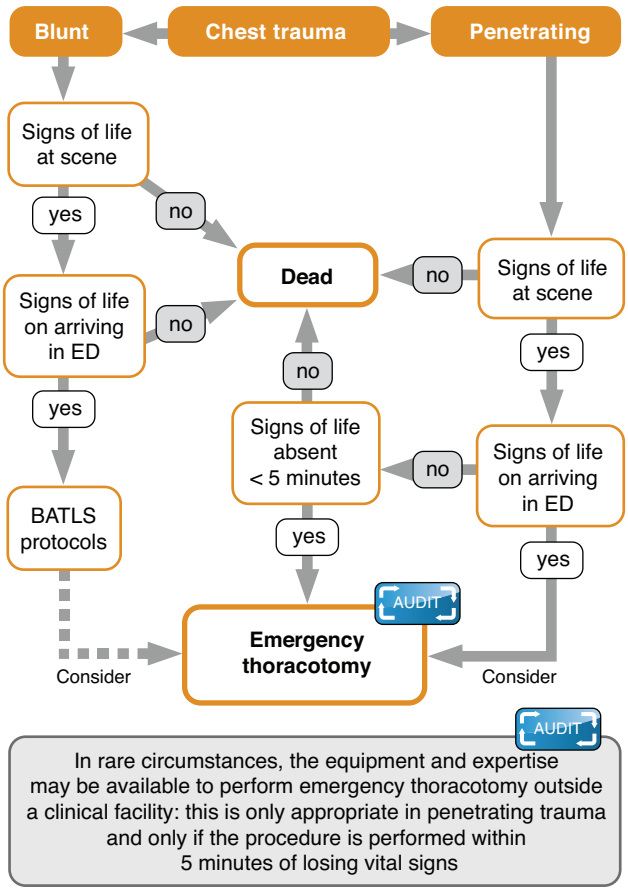

Figure 49-4. Emergency thoracotomy treatment guidelines flowchart.
ED: emergency department
Reproduced from: *Clinical Guidelines for Operations*. London, England: Defence Concepts and Doctrine Centre, 2008: Section 3: 16. Joint Doctrine Publication 4-03.1.

TCRA.[4] Based on a number of observational studies, the guidelines were aimed at limiting futile care and recommended that treatment should be withheld or withdrawn in the case of:

- blunt trauma with asystole at the scene,
- penetrating trauma with asystole and no signs of life at the scene,
- 15 minutes of unsuccessful CPR, or
- anticipated transfer time of more than 15 minutes.

The acceptance of these guidelines has been limited, however, by subsequent reports of a number of TCRA victims who survived despite meeting these criteria for withdrawal of care. Therefore, while these guidelines offer useful information on factors associated with poor outcome, it is not recommended that they be strictly applied in all cases of TCRA, especially not military TCRA.

EVIDENCE FOR MILITARY TRAUMATIC CARDIORESPIRATORY ARREST

Although there is little published evidence for the management of military TCRA, a recent observational study from a UK field hospital in Afghanistan provided some evidence on indicators of survivability.[7] Over a period of 6 months, the hospital received 52 adult patients who suffered TCRA beginning either in the field (29 patients), during helicopter transport to hospital (16 patients), or in the hospital (7 patients). Four of these patients survived to Role 4 hospital discharge and were neurologically intact.

In contrast to civilian studies of TCRA, these patients were principally injured by blast and fragmentation injuries, and the cause of arrest in over 80% of patients was exsanguination—a mechanism normally associated with very poor outcomes in civilian studies. Despite the prevalence of this cause of arrest, the overall rate of survival, at 8%, was broadly in keeping with civilian studies.

Comparing survivors with nonsurvivors, the following factors were identified as potential predictors of survival:

- **Arrest beginning after transfer to hospital.** Three of the four survivors arrested in hospital and one arrested during helicopter transfer. Although 5 of 29 patients who arrested on the ground achieved return of spontaneous circulation (ROSC), none of these patients survived to hospital discharge.
- **Electrical activity on electrocardiogram (ECG) during arrest.** All four survivors had some electrical activity on ECG during arrest—three were in sinus-based rhythms and one had an agonal rhythm. Only 1 of the 29 patients with asystole achieved ROSC, and this person did not survive to discharge.
- **Cardiac movement on ultrasound during arrest.** When performed in the emergency department as part of the initial assessment of a TCRA victim, brief ultrasound examination of the heart appeared to be a useful tool in assessing salvageability. All six of the patients with cardiac activity on ultrasound during

arrest exhibited ROSC, with two surviving to discharge. In the other patients ultrasound was not performed because equipment or skilled ultrasound practitioners were unavailable. Conversely, ROSC was not achieved in any of the 18 patients without cardiac activity on ultrasound.

Importantly, these results were achieved in a well-established field hospital with an advanced prehospital service, rapid access to blood products and emergency surgery, and a well-organized critical care air-evacuation service. In total, over 900 units of packed red blood cells and fresh frozen plasma were used on these 52 patients, with each survivor requiring an average of 47 units of blood and 45 units of plasma.

Resuscitative thoracotomy may also have contributed to the survival of these patients. All four of the survivors received a thoracotomy, during which a number of important interventions were made. In addition to open-chest CPR, pericardial tamponade was released in one patient, and at least two other survivors were treated with direct compression of the descending thoracic aorta, while distal control of hemorrhage was achieved.

AREAS OF CONTROVERSY

The traditional paradigms of resuscitation from cardiac arrest may be challenged in a number of controversial areas, particularly in the context of TCRA. Three of these areas are discussed below.

Epinephrine and Other Vasopressors

The use of epinephrine (adrenaline) is well established in the European Resuscitation Council guidelines, where a bolus dose is recommended every 3 to 5 minutes. However, the guidelines themselves state that this suggestion is not supported by any robust human studies, and that although epinephrine may increase coronary and cerebral perfusion pressure during CPR, it may also impair microcirculation and contribute to post–cardiac-arrest myocardial dysfunction.[6] Recent work has shown a deleterious effect, with the use of vasoconstrictors being associated with increased mortality in trauma patients.[13] In military TCRA, the priority must be aggressive volume resuscitation with blood and blood products. Although epinephrine and other vasopressors may have a role, their use should not be a priority and excessive doses should be avoided.

Intubation, Ventilation, and Chest Compressions

Securing a definitive airway and performing intermittent positive-pressure ventilation (IPPV) and external chest compressions have been considered fundamental to resuscitation from cardiac arrest. In TCRA, however, these procedures may prove detrimental if applied incorrectly. Compressing an empty heart (in the case of hypovolemia) is ineffective and may interfere with other, more useful procedures.[8] In addition, IPPV may increase intrathoracic pressure, further reducing venous return to the heart.[14] A pragmatic approach for military TCRA is emphasizing the restoration of circulating blood volume ahead of chest compressions and limiting the frequency and tidal volume of invasive ventilation until circulation is restored. Early thoracotomy may assist in this context by minimizing the effect of IPPV on intrathoracic pressure and hence venous return, as well as allowing the correction of reversible causes (eg, tamponade) and allowing internal cardiac massage to be performed.

Capnometry as a Guide to Resuscitation

In addition to its role in guiding IPPV and preventing hyperventilation, capnometry may also prove useful as evidence of residual cardiac output in an apparently pulseless patient. This is the subject of current research by the UK DMS, with the aim of providing a guide to the salvageability of future TCRA patients.

SUMMARY

A summary of the treatment priorities for the military TCRA patient is shown in Figure 49-5. Key points are as follows:

- Although survival from military TCRA is rare, good outcomes are possible, especially in the context of in-flight or in-hospital arrest when there is organized ECG activity, cardiac movement on ultrasound examination, and a persisting end-tidal CO_2 trace.
- Resuscitation from military TCRA demands a large amount of healthcare resources, including blood products and rapid access to emergency surgery.

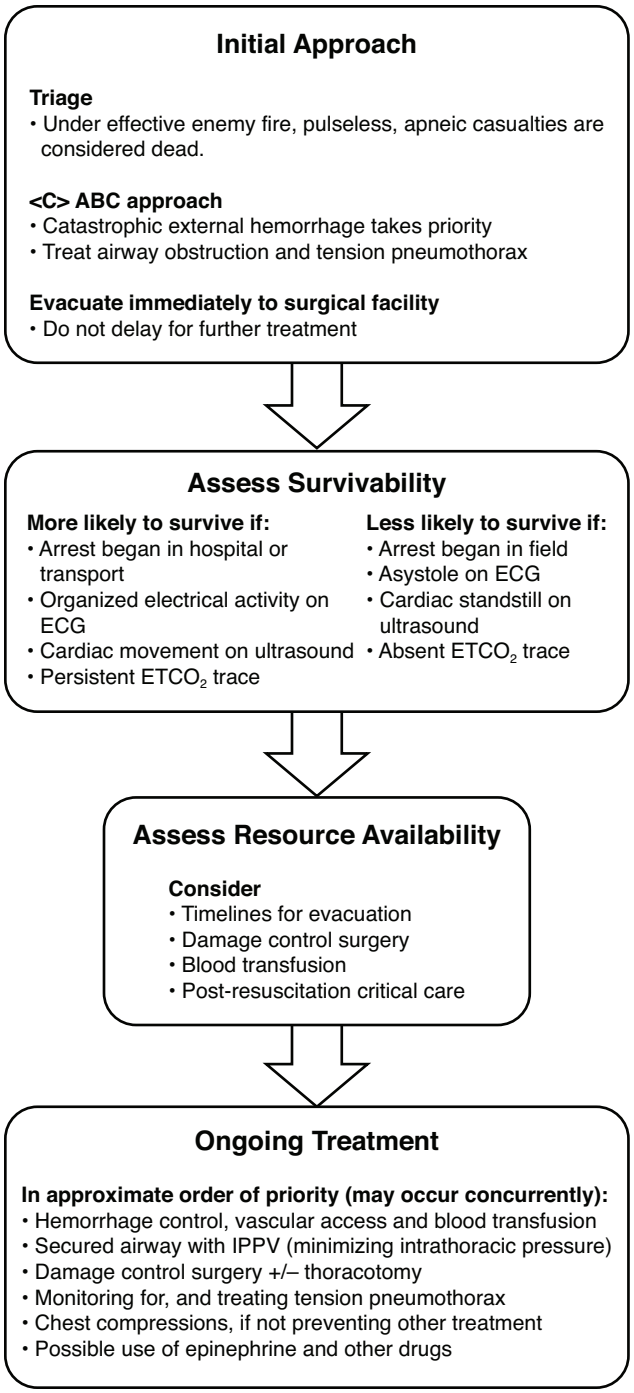

Figure 49-5. Summary of management of traumatic cardiorespiratory arrest.
ECG: electrocardiogram
$ETCO_2$: end-tidal carbon dioxide
IPPV: intermittent positive-pressure ventilation

- Restoration of circulating volume, immediate transfer for surgery, and the correction of reversible causes (including catastrophic hemorrhage, tension pneumothorax, and cardiac tamponade) should take priority over the use of vasopressors and possibly also external chest compressions. Resuscitative thoracotomy may also be emerging as a recommended approach in this situation.

REFERENCES

1 Rosemurgy AS, Norris PA, Olson SM, Hurst JM, Albrink MH. Prehospital traumatic cardiac arrest: the cost of futility. *J Trauma.* 1993;35:468–473.

2. Battistella FD, Nugent W, Owings JT, Anderson JT. Field triage of the pulseless trauma patient. *Arch Surg.* 1999;134:742–745.

3. Fulton RL, Voigt WJ, Hilakos AS. Confusion surrounding the treatment of traumatic cardiac arrest. *J Am Coll Surg.* 1995;181:209–214.

4. Hopson LR, Hirsh E, Delgado J, et al. Guidelines for withholding or termination of resuscitation in prehospital traumatic cardiopulmonary arrest. *J Am Coll Surg.* 2003;196:475–481.

5. Hodgetts TJ, Davies S, Russell R, McLeod J. Benchmarking the UK military deployed trauma system. *J R Army Med Corps*. 2007;153:237–238.

6. Nolan JP, Soar J, Zideman DA, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 1. Executive summary. *Resuscitation.* 2010;81:1219–276.

7. Tarmey NT, Park CL, Bartels OJ, Konig TC, Mahoney PF, Mellor AJ. Outcomes following military traumatic cardiorespiratory arrest: A prospective observational study. *Resuscitation.* 2011;82:1194–1197.

8. Soar J, Perkins GD, Abbas G, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 8. Cardiac arrest in special circumstances: Electrolyte abnormalities, poisoning, drowning, accidental hypothermia, hyperthermia, asthma, anaphylaxis, cardiac surgery, trauma, pregnancy, electrocution. *Resuscitation.* 2010;81:1400–1433.

9. American College of Surgeons Committee on Traum. *ATLS, Advanced Trauma Life Support for Doctors*. 8th ed. Chicago, IL: American College of Surgeons; 2008.

10. *Battlefield Advanced Trauma Life Support*. London, England: UK Defence Medical Services; 2008. Joint Service Publication 570.

11. *Clinical Guidelines for Operations*. London, England: Defence Concepts and Doctrine Centre, 2008. Joint Doctrine Publication 4-03.1.

12. Practice management guidelines for emergency department thoracotomy. Working Group, Ad Hoc Subcommittee on Outcomes, American College of Surgeons—Committee on Trauma. *J Am Coll Surg.* 2001;193:303–309.

13. Sperry JL, Minei JP, Frankel HL, et al. Early use of vasopressors after injury: caution before constriction. *J Trauma.* 2008;64:9–14.

14. Ho AM, Graham CA, Ng CS, et al. Timing of tracheal intubation in traumatic cardiac tamponade: a word of caution. *Resuscitation.* 2009;80:272–274.