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Prehospital Trauma Compendium: Prehospital Management of Adults with Traumatic Out-of-Hospital Circulatory Arrest – A Joint Position Statement and Resource Document of NAEMSP, ACS-COT, and ACEP

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ABSTRACT

The National Association of Emergency Medical Services Physicians (NAEMSP), American College of Surgeons Committee on Trauma (ACS-COT), and American College of Emergency Physicians (ACEP) believe that evidence-based, pragmatic, and collaborative protocols addressing the care of patients with traumatic out-of-hospital circulatory arrest (TOHCA) are needed to optimize patient outcomes and clinician safety. When the etiology of arrest is unclear, particularly without clear signs of life-threatening trauma, standard basic and advanced cardiac life support (BCLS/ACLS) treatments for medical cardiac arrest is appropriate. Traumatic circulatory arrest may result from massive hemorrhage, airway obstruction, obstructive shock, respiratory disturbances, cardiogenic causes or massive head trauma. While resuscitation and/or transport is appropriate for some populations, it is appropriate to withhold or discontinue resuscitation attempts for TOHCA patients for whom these efforts are non-beneficial. This position statement and resource document were written as an update to the 2013 joint position statements.

NAEMSP, ACEP, and ACS-COT recommend:

- EMS resuscitation of adults with TOHCA should:
  - Prioritize prompt identification of patients who may benefit from transport to definitive care at trauma centers when safe and appropriate.
  - Emphasize the identification of reversible causes of traumatic circulatory arrest and timely use of clinically indicated life-saving interventions (LSIs) within the EMS clinician's scope of practice. These include:
    - External hemorrhage control with direct pressure, wound packing, and tourniquets
    - Airway management using the least-invasive approach necessary to achieve and maintain airway patency, oxygenation, and adequate ventilation.
    - Chest decompression if there is clinical concern for a tension pneumothorax. Empiric bilateral decompression, however, is not indicated in the absence of suspected chest trauma.
    - External chest compressions may be considered but only secondary to other LSIs.
    - Epinephrine should not be routinely used, and if used should not be administered before other LSIs.
  - If point-of-care ultrasound (POCUS) demonstrates no evidence of cardiac motion, this may have utility in TOHCA management for prognostication.
  - Emphasize that placement of cardiac monitors and/or use of POCUS should occur after indicated LSIs have been appropriately performed
- Conditions where resuscitation attempts should be withheld, include TOHCA patients with:
  - Injuries that are incompatible with life (e.g., decapitation, hemi-corpectomy, incineration, open skull injury with extruding brain matter).
  - Evidence of prolonged circulatory arrest (e.g., rigor mortis, dependent lividity, decomposition).
  - Advance care planning documents that indicate Do Not Resuscitate (DNR)/ Do Not Attempt Resuscitation (DNAR)/Allow Natural Death medical orders.
- Conditions where resuscitation attempts are discontinued for TOHCA patients should recognize:
  - Mechanism of injury should not be used as the sole determinant to discontinue resuscitation efforts**.**
  - Electrical rhythm should not be used as the sole determinant to discontinue resuscitation efforts. Of note, non-shockable rhythms (Pulseless Electrical Activity/Asystole) are

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associated with an extremely low likelihood of return of spontaneous circulation (ROSC) or survival with neurologic recovery.
    - There is insufficient evidence to support any specific universal standardized time-based cutoffs to discontinue resuscitation efforts based on the duration of resuscitation or transport times to definitive care. EMS decisions to transport or discontinue resuscitation should be locally determined based on EMS and trauma system resources and proximity.
- Implementation of protocols for TOHCA should consider:
    - Risks and benefits of resuscitation attempts and transport for public safety and EMS clinician safety.
    - Individual patient cost and organ donation should not be a factor in EMS clinical decision-making on-scene.
    - Local provisions for specific clinical resources (e.g. regional trauma capabilities), environmental (e.g. avalanche, etc.), or population-based situations are important and require active EMS physician oversight in collaboration with local trauma system stakeholders.

Introduction

In 2003, and updated in 2012-2013, the National Association of Emergency Medical Services Physicians (NAEMSP) and the American College of Surgeons Committee on Trauma (ACS-COT) published a joint position statement for withholding and discontinuing resuscitation attempts of patients in circulatory arrest caused by trauma (1–4). Traumatic out-of-hospital circulatory arrest (TOHCA) occurs much less frequently than medical arrest and portends a worse prognosis (5–8). Despite historically dismal outcomes, many EMS systems have seen survivorship from TOHCA improve over the past twenty years, in some cases doubling the number of TOHCA survivors (6, 7). For other EMS systems, survivor rates remain unchanged despite the implementation of trauma-focused protocols (9, 10). The reasons behind increased survival rates are likely multifactorial; in part due to improvements in prehospital and in-hospital trauma care and the implementation of prehospital discontinuation of resuscitation protocols. However, a cross-sectional analysis of prehospital TOHCA care in the United States (U.S.) highlighted wide variability in the management, with an open call for unified guidance. Only 45.7% of 35 state EMS protocols reviewed had a TOHCA protocol and 48.5% addressed discontinuation of resuscitation after TOHCA (11). This project aims to provide guidance for EMS system oversight in the management of TOHCA.

The EMS algorithms for TOHCA should be simple, evidence-based based, and adaptable to local populations, geography, and resources. When the etiology of arrest is unclear, particularly without clear signs of life-threatening trauma, standard basic and advanced cardiac life support (BCLS/ACLS) treatments for medical cardiac arrest may apply. This position statement and resource document provide guidance to optimize clinical management while balancing the reasonable use of system resources and considering the effects of on-scene and in-transit care on public safety (12–14).

To address the withholding and discontinuation of resuscitation attempts in TOHCA we aimed to review the literature and develop recommendations relevant to this topic(s). To best inform the development of recommendations, we organized our literature review into the following content areas:

1. Indicated Life Saving Interventions (LSIs) during resuscitation attempts
2. Conditions for withholding and discontinuing resuscitation attempts
3. Implementation considerations

Methods

Search Strategy

We performed a structured search of the literature using guidance developed for the NAEMSP Trauma Compendium. The search strategy was amended to identify literature relevant to EMS and TOHCA. We searched the National Library of Medicine *via* PubMed for articles published before December 22, 2022. The final search strategy is provided in the Supplemental Table and the search was completed on December 22, 2022. Non-English and non-human subjects' literature were excluded as part of the search strategy. Articles were screened using Covidence (Melbourne, Australia), which was also used to electronically eliminate duplicates.

Screening of Publications and Evidence Evaluation

We excluded studies that were not prehospital (e.g., emergency department (ED) setting only), not related to circulatory arrest, not related to trauma, singular case reports (case series were included), pediatric only, editorial/opinion articles, and those that involved only extenuating circumstances (e.g., avalanche, burn, choking, drowning, hanging, electrocution, etc.). Author AB performed the screening of titles and abstracts, full-text articles, and summarization of articles. Final articles were tagged by content areas (e.g., thoracostomy, thoracotomy, electrical rhythm, helicopter EMS, etc.) to facilitate organization. Additional articles were identified by manual review and snowball search of relevant bibliographies. Consensus documents from the European Resuscitation Council (ERC) (15), Australian Resuscitation Council (ARC), and New Zealand Resuscitation Council (NZRC) were also reviewed (16). A content expert panel was established with representatives from the NAEMSP, ACS-COT, and the American College of Emergency Physicians (ACEP) to discuss and evaluate evidence. The inclusion of specific LSI in this project is based on the frequency of scientific evidence encountered in the structured review of prehospital literature and expert panel consensus.

Results

The strategy identified 1,145 articles available for screening. We screened titles/abstracts and full-text articles relevant to TOHCA, resulting in 181 articles retained for consideration to inform this position statement and resource document (Figure 1). Literature regarding survival estimates in TOHCA based on mechanism (penetrating versus blunt) is summarized in Table 1. This table includes data from 63 articles since 1983, 59 observational studies, and four systematic literature reviews. Good neurological outcome was reported when available. Literature regarding associations of resuscitation time with TOHCA outcomes since the previous NAEMSP statement includes 12 articles and is summarized in Table 2.

Overall articles reviewed represented an international mix of observational retrospective cohorts. Types of EMS systems, population cohorts (e.g., out-of-hospital versus in-hospital traumatic arrest and medical versus traumatic arrest), traumatic mechanisms, EMS clinician training, prehospital interventions, and reporting varied significantly between articles or were not clearly defined. The authors emphasized more recent data, particularly those since the previous NAEMSP position statement. Figure 2 is a proposed algorithm that summarizes and synthesizes recommendations.

Discussion

EMS Resuscitation

Prioritize Prompt Identification of Patients Who May Benefit from Transport to Definitive Care at Trauma Centers When Safe and Appropriate. Emphasize the Identification of Reversible Causes of TOHCA and the Timely Use of Clinically Indicated LSIs within the EMS Clinician's Scope of Practice

Although death from trauma is often multifactorial, (77) studies suggest that TOHCA is often caused by traumatic

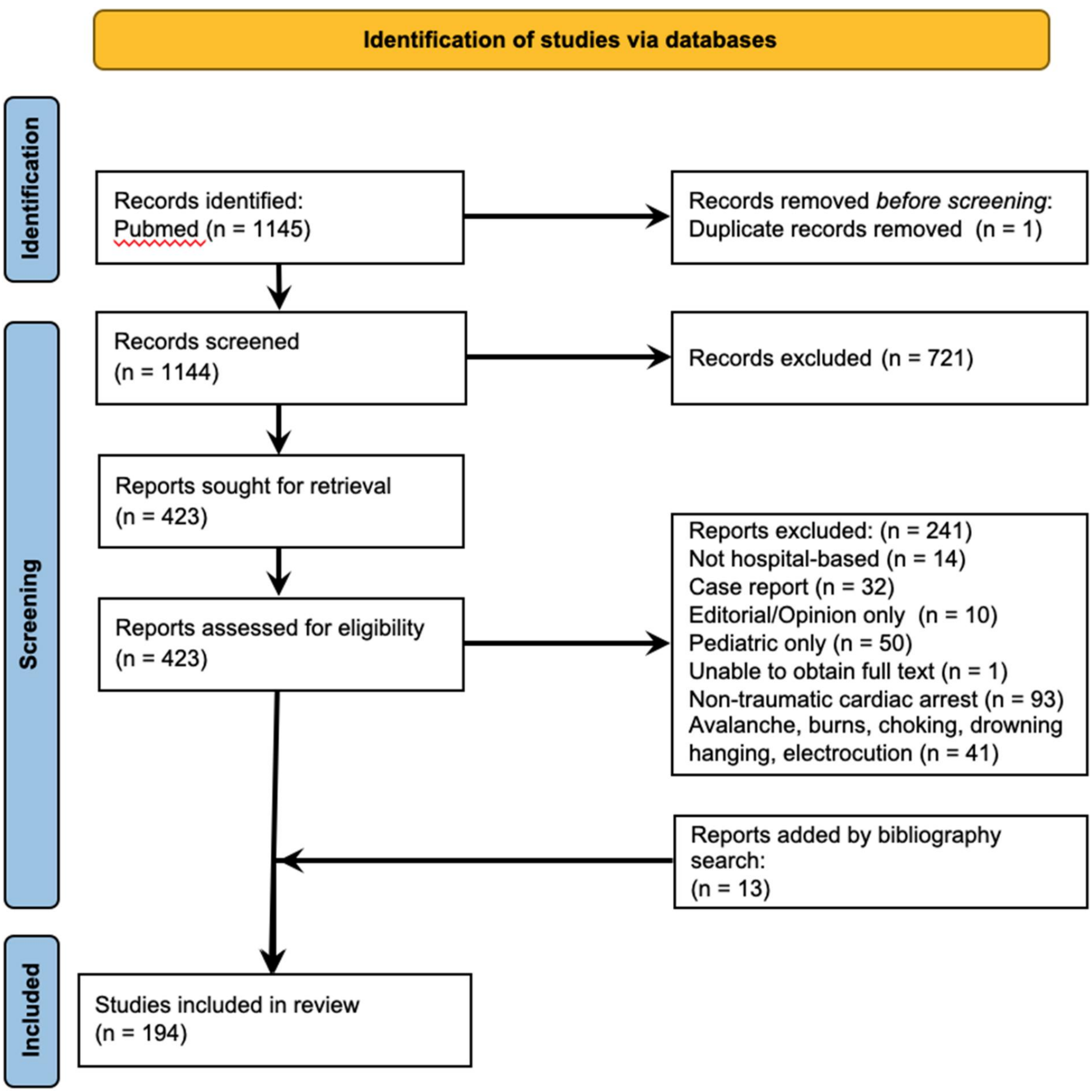

Figure 1. Literature review flow diagram.

Table 1. Survival estimates in TOHCA based on mechanism (penetrating versus blunt).

Study (Country)	# of survivors, n (%)*	Penetrating Trauma # of survivors, n (%)	Blunt Trauma # of survivors, n (%)	Good neurological outcome**	Study Type (Study Location)
Shimazu and Shatney. 1983(17)	7/267 (2.6%)	2/50 (4.0%)	5/217 (2.3%)	4/267 (1.5%)	Retrospective Observational (United States)
Aprahamian et al., 1985(18)	3/95 (3.2%)	–	–	–	Retrospective Observational (United States)
Wright et al. 1989(19)	0/67 (0.0%)	0/9	0/58	0/67 (0.0%)	Retrospective Observational (United States)
Rosemurgy et al., 1993 (20)	0/138 (0.0%)	0/42 (0.0%)	0/96 (0.0%)	0/138 (0.0%)	Retrospective Observational (United States)
Fulton et al., 1995(21)	6/245 (2.4%)	–	–	–	Retrospective Observational (United States)
Stratton et al 1998 (22)	9/879 (1.0%)	4/497 (0.8%)	5/382 (1.3%)	3/879 (0.3%)	Retrospective Observational (United States)
Battistella et al., 1999 (23)	16/604 (2.6%)	12 /300(4.0%)	4/304 (1.3%)	9/604 (1.5%)	Retrospective Observational (United States)
Coats et al., 2001(24)	4/39 (10%)	4/39 (10%)	–	1/39 (2.6%)	Retrospective Observational (United Kingdom)
Martin SK et al., 2002 (25)	4/110 (3.6%)	–	–	1/110 (0.9%)	Retrospective Observational (United States)
Cera et al., 2003(26)	53/195 (27%)	–	–	15/195 (7.7%)	Retrospective Observational (United States)
Pickens et al., 2005 (27)	14/184 (7.6%)	9/94 (9.6%)	4/90 (4.4%)	–	Retrospective Observational (United States)
Stockinger and McSwain 2004 (28)	15/558 (2.7%)	3/338 (0.9%)	12/192 (6.2%)	–	Retrospective Observational (United States)
Willis et al., 2005 (29)	4/89 (4.5%)	2 /18 (11.1%)	2/71 (2.8%)	–	Retrospective Observational (Australia)
Lockey et al., 2006 (30)	68/909 (7.5%)	9/114 (7.9%)	18/542 (3.3%)	–	Retrospective Observational (United Kingdom)
Huber-Wagner et al., 2007 (31)	130/ 757 (17 %)	–	–	- (9.7%)	Retrospective Observational (Germany)
Moriwaki et al., 2010 (32)	4/29 (14%)	4/29 (14%)	–	2/29(7%)	Retrospective Observational (Japan)
Davies and Lockey, 2011 (33)	13/71 (18%)	13/71 (18%)		11/71 (15%)	Retrospective Observational (United Kingdom)
Grasner et al., 2011 (34)	?/368 (7%)	–	–	- (2%)	Retrospective Observational (Germany)
Mollberg et al., 2011 (35)	1 /294(0.3%)	–	–	0/294 (0%)	Retrospective Observational (United States)
Moriwaki et al., 2011 (36)	13/477 (2.7%)	–	13/477 (3%)	–	Retrospective Observational (Japan)
Tarmey et al., 2011 (37)	4/52 (7.7%)	–	–	4/52 (7.7%)	Prospective Observational (United Kingdom Military in Afghanistan)
Deasy et al., 2012 (38)	6/175 (10%)	–	–	–	Retrospective Observational (Australia)
Zwingmann et al., 2012 (14)	238/5391 (4.4%)	69/1891 (3.6%)	74/2238 (3.3%)	27/2115 (1.3%)	Systematic Review and Metanalysis (Mixed)

(*continued*)

Table 1. Continued.

Study (Country)	# of survivors, n (%)*	Penetrating Trauma # of survivors, n (%)	Blunt Trauma # of survivors, n (%)	Good neurological outcome**	Study Type (Study Location)
Leis et al., 2013 (39)	11/169 (6.6%)	–	–	11/169 (6.6%)	Retrospective Observational • Mixed pediatric and adult(France)
Kleber et al., 2014 (40)	15/52 (29%)	5 /12(42%)	10/40 (25%)	4/52 (7.7%)	Retrospective Observational (Germany)
Faucher et al., 2014 (41)	15/540 (0.8%)	2 (29%)	71 (19%)	–	Retrospective Observational (France)
Chiang et al., 2015(42)	20/514 (3.9%)	–	–	13/514 (2.5%)	Retrospective Observational (Taiwan)
Seamon et al., 2015(43)	871/10,238 (8.5%)	674 (11%)	50 (2.3%)	408/6746 (6.0%)	Systematic Review and Metanalysis (Multiple)
Beck et al., 2016 (44)	9/527 (1.7%)	–	–	6/527 (1.1%)	Retrospective Observational (Australia)
Chien et al., 2016 (45)	9/396 (2.3%)	–	–	3/396 (0.8%)	Retrospective Observational (Taiwan)
Evans et al., 2016 (Epistry) (13)	92/1292 (7.1%)	19/417 (4.6%)	73/875 (8.3%)	–	Retrospective Observational (North America)
Evans et al., 2016 (PROPHET) (13)	145/1008 (6.3%)	9/336 (2.7%)	44/672 (6.5%)	24/1008	Retrospective Observational (North America)
Zwingmann et al., 2016(49)	507/1855 (27.3%)	–	–	164/1855 (8.8%)	Retrospective Observational (Germany)
Moore et al., 2016 (46)	106/1708 (6.2%)	- (9%)	- (3%)	18/1708 (1.1%)	Retrospective Observational (United States)
Barnard et al., 2017 (47)	53/705 (7.5%)	4/104 (3.8%)	49/601 (8.2%)		Retrospective Observational (United Kingdom)
Beck et al., 2017(48,49)	24/660 (3.8%)	–	–		Retrospective Observational (Australia)
Chiang et al., 2017 (50)	39/893 (4.4%)	14/212 (6.6%)	19/459 (4.1%)	17/893 (1.9%)	Retrospective Observational (Taiwan)
Claesson et al., 2017 (7)	53/1553 (3.4%)	–	–	–	Retrospective Observational (Sweden)
Duchateau et al., 2017 (51)	10/88 (11%)	1/11 (9.1%)	9/77 (11.7%)	9/88 (10.2%)	Retrospective Observational France
Irfan et al., 2017 (52)	10/410 (2.4%)	1/23 (4.3%)	9/383 (2.3%)		Retrospective Observational (United Arab Emirates)
Konesky et al., 2017 (53)	–	–	–	- (7.3%)	Retrospective Observational (United States)
Van Vledder et al., 2017 (54)	1/33 (3%)	1/33 (3%)	–	1/33 (3%)	Retrospective Observational (The Netherlands)
Djarv et al., 2018(6)	65/1774 (3.7%)	–	–	–	Retrospective Observational (Sweden)
Escutnaire et al., 2018(8)	49/3209 (1.5%)	–	–	–	Retrospective Observational (France)
Fukuda et al., 2018(55)	96/4382 (2.2%)	–	–		Retrospective Observational (Japan)
Tsutsumi et al., 2018 (56)	93/4313 (2.2%)	–	93/4313 (2.2%)		Retrospective Observational (Japan)

(*continued*)

Table 1. Continued.

Study (Country)	# of survivors, n (%)*	Penetrating Trauma # of survivors, n (%)	Blunt Trauma # of survivors, n (%)	Good neurological outcome**	Study Type (Study Location)
Barnard et al., 2019 (5)	10/304 (3.8%)	–	–		Retrospective Observational (United Kingdom)
Chen et al., 2019 (57)	10/463 (2.2%)	0/12 (0%)	7/406 (1.7%)		Retrospective Observational (Taiwan)
Manley et al., 2019 (58)	1/82 (1.2%)	1/82 (1.2%)	–	–	Retrospective Observational (United States)
Aoki et al., 2019 (59)	52/5204 (1.0%)	–	52/5204 (1.0%)		Retrospective Observational (Japan)
Kim et al., 2020 (60)	1608/8546 (18.6%)	36/255 (14.1%)	1535/8291 (18.5%)	70/8546 (0.8%)	Retrospective Observational (Korea)
Jun et al., 2020 (61)	713/8237 (8.7%)	–	–	–	Retrospective Observational (Korea)
Tran et al., 2020 (62)	131/? (3.7%)	–	–	–	Systematic Review & Metanalysis (Multiple)
Alqudah et al., 2021 (9)	18/755 (2.4%)	–	–	8/755 (1.1%)	Retrospective Observational (Australia)
Do et al., 2021(63)	6 /111 (5.4%)	–	–	1/111 (0.9%)	Retrospective Observational (Vietnam)
Houwen et al., 2021 (64)	36/915 (3.9%)	10/151 (6.6%)	26/764 (3.4%)	17/915 (1.9%)	Retrospective Observational (The Netherlands)
Savary et al., 2021(65)	8/287 (2.8%)	–	–	8/287 (2.8%)	Retrospective Observational (France)
Naito et al., 2021 (66)	239/5336 (4.5%)	–	–	–	Retrospective Observational Japan
Almond et al., 2022 (67)	0/44 (0%)	0/18 (0%)	0/26 (0%)	0/44 (0%)	Retrospective Observational (United Kingdom)
Benhamed et al., 2022 (68)	67/4922, (1.4%)	–	–	39/4922 (0.8%)	Retrospective Observational (France)
Doan et al., 2022(69)	147/1497 (9.8%)	–	–	–	Retrospective Observational (Australia)
Lee et al., 2022(71)	461/13631 (3.4%)	–	–	131/13631 (1.0%)	Retrospective Observational (13 Asian Countries)
Kitano et al., 2022 (72)	288/3883 (7.4%)	–	288/3883 (7.4%)	98/3883 (2.5%)	Retrospective Observational (Japan)
Vianen et al., 2022 (73)	(3.8%)	–	–	(1.4%)	Systematic Review and Metanalysis (Multiple)

*Survivor defined as alive at 30 days or at discharge.
**Good neurological outcome defined as Cerebral Performance Category (CPC) 1 or 2 or Glasgow Outcome Scale (GOS) 4 or 5.

brain injury, hemorrhage, tension pneumothorax, or hypoxia (40, 76, 78). All EMS interventions should focus on mitigating common and reversible factors that result in TOHCA and may include external hemorrhage control, airway management, and chest decompression. Moreover, non-LSI EMS procedures should not delay timely transportation to definitive care at designated trauma centers when indicated (79).

Based on the structured review of prehospital literature, airway management, thoracostomy, epinephrine, external chest compressions/defibrillation, and point-of-care ultrasounds (POCUS) were identified for further discussion. Of note, the deployment of prehospital physicians, more commonly found in EMS systems with air medical resources and EMS systems outside North America, brings a larger scope of practice including diagnostics and therapeutics which, in most circumstances, are not used by non-physician EMS clinicians. In one systematic review and meta-analysis, the presence of prehospital physicians was associated with almost a two-fold increase in survival (6.1% with prehospital physicians versus 2.4% without prehospital physicians) and more favorable neurological outcomes for those that did survive (57% with prehospital physicians versus 38% without prehospital physicians) (73). However in-depth discussion of the role of

Table 2. Associations of time with TOHCA outcomes.

Study	Study population	Findings	Notes
Morikawa et al. 2010 (32)	Case series observational study in a large urban population of Japan investigating 29 patients with TOHCA from penetrating trauma.	There was a longer time interval from collapse to arrival at the emergency department for patients without ROSC or who died in the emergency department than those who did not.	Those with shorter intervals from collapse to the hospital were associated with better outcomes. Among discharged patients ($n = 4$) the longest time interval from collapse to arrival to the ED was 26 min.
Morikawa et al. 2011 (36)	Retrospective analysis of 477 blunt TOHCA patients in Japan from a single center's registry over 10 years.	Shorter interval from collapse to hospital arrival for patients who had ROSC or did not die in ED ($p < 0.05$)	This study reports the longest interval from collapse to ED arrival as 47 min in amongst patients who survived to discharge ($n = 13$).
Lin et al. 2013 (74)	Retrospective analysis of 420 TOHCA patients over six years in Taiwan.	The odds of ROSC sustained for two hours or greater ($n = 63$) was not impacted by response time < 5 min, time at scene < 8 min, or transport time < 5 min (OR 0.6, 1.0, 1.1 and 95% CI 0.3-1.1, 0.6-1.8, and 0.6-1.8, respectively).	Within a study with time intervals mostly under 20 min, there was no difference in sustained ROSC by response, scene, or transport time.
Beck et al. 2017 (48)	Retrospective analysis of 660 TOHCA adult patients from the Victorian Ambulance Cardiac Arrest Registry on whom resuscitation was attempted over a six-year period.	Response time was significantly longer for patients not achieving ROSC ($n = 501$) and a higher proportion of patients with prolonged downtime (88% versus 12%) did not achieve ROSC ($p < 0.001$).	Longer response times and prolonged downtime were associated with not achieving ROSC.
Djarv et al. 2018 (6)	Retrospective analysis of 1774 TOHCA patients from a 16-year population-based Swedish registry.	30-day survivors ($n = 65$) had shorter median time from collapse to call, start of CPR, defibrillation, and arrival of EMS compared to non-survivors.	Shorter time to medical care associated with better survival at 30 days. All interval medians were less than 15 min in this study.
Konesky et al. 2018 (53)	124 adult TOHCA patients over a five-year period in an upstate New York trauma system.	Prolonged time between injury and arrival to the ED predicted failure of CPR (OR 0.4, 95% CI $0.2 - 0.8$)	The authors conclude that rapid transport to the ED is an important contributor to survival of TOHCA.
Chen et al. 2018 (57)	Multi-institutional 5-year database in Taiwan with analysis of 463 TOHCA patients with no ROSC in the field who had resuscitation in the ED.	Patients with 30-day survival ($n = 10$) had significantly shorter median response and transport times (4.5 versus 9 and 2 versus 5 min, respectively).	Transport, response, and scene times were all under twenty minutes in this system.
Jun et al. 2020 (61)	5-year nationwide data in Korea from OHCA database including 8326 TOHCA patients without ROSC.	Cardiac arrest to ED arrival interval was shorter in the sustained ROSC group compared to the non-sustained ROSC ($p < 0.001$); the same relationship was suggested with survival to discharge ($n = 713$) versus non-survival ($p = 0.076$).	A shorter cardiac arrest to ED arrival time interval is associated with better outcomes.
Naito et al. 2021 (66)	Retrospective analysis of 5336 adult trauma patients who had prehospital CPR from Japan Trauma Data Bank over 14 years.	Median transport time of 11 min with cohort survival 4.5%, and when excluding prehospital ROSC survival falls to 1.2%. Uses binomial log-linear regression to create model testing transport time as dichotomous variable (less or greater than/equal to 15 min).	Used statistical modeling from study population to estimate survival as below 1% after 15 min of transport time within this population. There is unclear internal and external validity of this model at the time of this writing.
Lee et al. 2022 (71)	Retrospective analysis of 124 TOHCA patients presenting to single center ED, mostly blunt, over five-year period in Taiwan.	ROSC group had a shorter CPR time average compared to non-ROSC group; prehospital time and prehospital CPR were not significantly different.	Implies prolonged prehospital CPR may be associated with worse outcomes.
Kuo et al. 2022 (75)	411 patients from a single level I trauma center in Taiwan arriving in TOHCA.	Duration at scene not significantly associated with outcomes, however ED survival group had a shorter transport interval than ED mortalities ($p = 0.04$). Patients receiving more than twenty minutes of CPR were less likely to have ROSC or ED survival ($p < 0.001$).	Shorter transport intervals and CPR duration were associated with better outcomes in this study.
Ohlen et al. 2022 (76)	Retrospective analysis of 284 adult TOHCA patients at a single center in Sweden.	Survivors who had thoracotomies ($n = 12$) had a shorter median interval from intervention to last sign of life.	Implies shorter prehospital course and more expedient trauma center intervention may portend better outcomes.

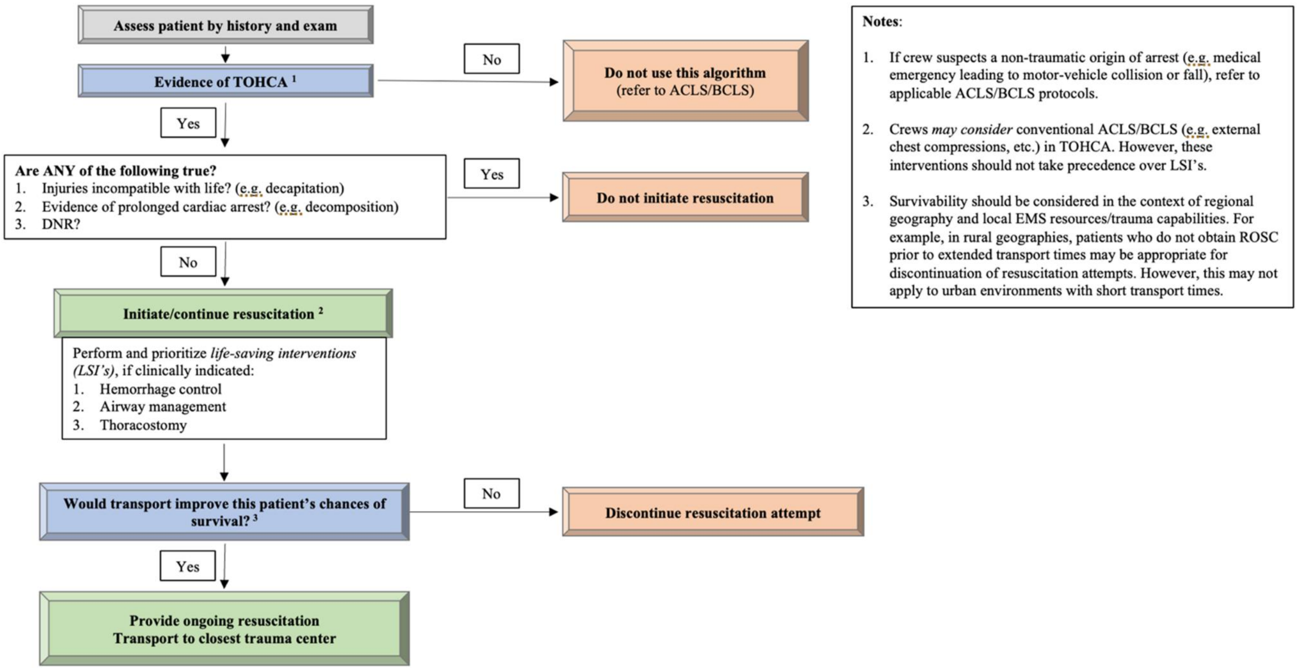

Figure 2. Treatment of TOHCA Algorithm.

prehospital physicians and associated advanced procedures (e.g., thoracotomy, and prehospital resuscitative endovascular balloon occlusion (REBOA)) are beyond the scope of this position statement.

Airway Management

Airway Management Using the Least-Invasive Approach Necessary to Achieve and Maintain Airway Patency, Oxygenation, and Adequate Ventilation

The 2021 NAEMSP Prehospital Trauma Airway Management position statement and resource document provides a comprehensive resource for airway management (80). If an airway is patent, then breathing should be assessed. If an airway is not patent, airway positioning maneuvers should be attempted followed by interventions to secure the airway as indicated (81). A 2023 evidence-based guideline addressing prehospital airway management by Jarvis et al., recommends that bag-valve-masks, supraglottic airways, or endotracheal intubation may be used to manage unsecured airways in trauma patients but not specifically the TOHCA subgroup of patients. The guideline goes further to state that the optimal airway management modality should be determined by the individual trauma patient circumstances (82).

Notably in the Prospective Observational Prehospital and Hospital Registry (PROPHET), patients who received supraglottic airway or endotracheal intubation had decreased survival odds compared to those receiving bag-mask ventilation (13). Several studies demonstrate that prehospital endotracheal intubation is not associated with survival-to-discharge outcomes (5, 6, 62). Further, the insertion of advanced airways on scene may result in unnecessary transport delays. Therefore, in the absence of evidence that invasive airways are time-critical LSIs in this population, they should likely be deferred until after transport, if at all.

Chest Decompression

Chest Decompression If There is Clinical Concern of Tension Pneumothorax

Chest decompression should be performed for TOHCA patients with suspicion of a tension pneumothorax if it is within the EMS clinician's scope of practice. In one small case series of TOHCA patients, 49% (18/37) underwent chest decompression (17 tube thoracostomy, 1 needle thoracostomy decompression), resulting in ROSC in 4/18 (22%) patients (83). All four patients had clinical signs of a tension pneumothorax (e.g., decreased air entry, hyper-resonant thorax, tracheal deviation, high airway pressure pressures during ventilation, subcutaneous emphysema) and did not have external signs of chest injury. In a larger series of 909 patients, where all patients received bilateral decompression, 6/909 (0.7%) subsequently achieved ROSC (30). In more recent studies, the use of trauma-based resuscitation protocols increased the frequency of prehospital decompression. However, this was not associated with increased ROSC or survival to discharge (65, 84). In Germany, the judicious use of prehospital chest tube insertion was a strong predictor for survival (31). Thus, for TOHCA patients with suspected tension pneumothorax, decompression is recommended, however, there is insufficient evidence to support routine empiric bilateral decompression in the absence of suspected chest trauma. Further discussion of the treatment of tension pneumothorax is addressed in a companion manuscript to this paper.

External Chest Compressions

External Chest Compressions Should be Secondary to Other LSIs

External chest compressions are a cornerstone of the management of medical cardiac arrest though their utility in TOHCA is less clear. External chest compressions may cause additional thoracic injury (85), have no theoretical clinical benefit, and are resource intensive. External chest compressions may delay transport to definitive trauma care or interfere with interventions that can be life-saving. While external chest compressions have been associated with good neurologic outcomes for TOHCA in some EMS systems (31), other studies show that prolonged cardiopulmonary resuscitation (CPR) on-scene for TOHCA is associated with worse outcomes. In addition, several retrospective cohort studies demonstrate that external chest compressions are not effective for TOHCA unless the underlying cause of the arrest is simultaneously and rapidly addressed (20, 23, 85, 86). Thus, in TOHCA external chest compressions should be considered only after reversible causes of arrest are addressed and should not delay transport for more definitive care.

Epinephrine

Epinephrine Should Not be Routinely Used

Epinephrine is routinely utilized for medical cardiac arrest, however, its use in TOHCA is not well established. In two large Asian retrospective studies, epinephrine administration was associated with increased prehospital ROSC, but not necessarily increased survival (42, 59). Furthermore, several studies suggest lower survival rates in TOHCA cohorts who received epinephrine (6, 52, 76). In a 2021 metanalysis, epinephrine administration was not significantly associated with prehospital ROSC (OR:4.67, 95% CI: 0.66-32.81) or short-term survival (OR 1.41, 95% CI: 0.53-3.79) (87). Overall, there is not sufficient evidence to support the routine use of epinephrine for TOHCA.

Point-of-Care Ultrasound (POCUS)

If POCUS Demonstrates no Evidence of Cardiac Motion, This May Have Utility in TOHCA Management for Prognostication

Although POCUS is not widely used in the prehospital setting, it may have some utility in TOHCA management. In a meta-analysis of seven studies with 710 total cases of prehospital or in-hospital TOHCA, among 369 patients without cardiac activity by POCUS there were zero who survived to discharge and only one patient achieved ROSC (88). A different meta-analysis of TOHCA patients demonstrated one of the most important predictors of survival was cardiac motion on ultrasound (OR 33.91, 1.87-613.42 (62)). Further study is needed to substantiate the implications of these findings and whether the delay in obtaining POCUS negatively impacts the potential benefit of other interventions.

Withholding Resuscitation Attempts

Conditions Where Resuscitation Attempts Should be Withheld, Include TOHCA Patients

- ***With injuries that are incompatible with life (e.g., decapitation, hemi-corpectomy, incineration, etc.).***
- ***With evidence of prolonged cardiac arrest (e.g., rigor mortis, dependent lividity, decomposition, etc.).***
- ***With signed advance care planning documents that indicate Do Not Resuscitate (DNR)/ Do Not Attempt Resuscitation (DNAR)/Allow Natural Death medical orders.***

Our literature search did not reveal sufficient evidence regarding when resuscitation attempts should be withheld, thus the following section consists of suggested considerations for EMS system oversight in the management of TOHCA.

Discontinuing Resuscitation Attempts

Mechanism of Injury Should Not be Used as the Sole Determinant to Discontinue Resuscitation Efforts

Patients with TOHCA are often grouped into two broad categories based on the mechanism of injury: blunt and penetrating trauma. Mechanism of injury has long been thought to play a large role in survival from TOHCA with penetrating trauma thought to be more survivable than blunt trauma, although the evidence is unclear. The reviewed literature is summarized in Table 1.

Numerous studies based in the U.S. (23, 27, 46) and internationally (Australia (29), France (41), Taiwan (42, 50), Japan (32, 36), and the Netherlands (64)) have noted increased survival in penetrating TOHCA versus blunt TOHCA. In a seminal meta-analysis of 72 studies including TOHCA patients who underwent an ED thoracotomy, patients suffering penetrating thoracic injury were found to have an 11.7% rate of neurologically intact survival, compared to just 2.4% of patients with blunt injuries. In contrast, numerous studies have demonstrated similar rates of survival in penetrating and blunt trauma (14, 53, 89). These findings are corroborated in studies out of Asia, Australia, and the United Kingdom (47, 69, 70, 73). Compared to international cohorts, the U.S. has a proportionately higher incidence of high-velocity penetrating trauma (e.g., fire-arm wounds) versus low-velocity penetrating trauma (e.g., knife wounds); however, mortality rates are overall similar for fire-arm related penetrating trauma (90). In a 2020 systematic review and meta-analysis of 53 studies and over 37,000 patients, the authors concluded that "mechanism of injury was not an important prognostic factor in for survival" (62).

Finally, there is a growing body of literature indicating blunt TOHCA cohorts may even have better survival rates than penetrating TOHCA cohorts. In 2016, Evans et al., analyzed two registries from the Resuscitation Outcomes Consortium (ROC) and found blunt TOHCA patients fared *better* than penetrating TOHCA patients (8.3% vs. 4.8% in the Epistry Registry and 6.5% vs. 3.2% in the PROPHET registry) (13). These data are supported by studies from France (51, 68), Korea (60), and Australia (48, 79) and the US (13, 53).

Overall, these data are too heterogeneous to make definitive recommendations regarding the withholding or discontinuation of resuscitation in TOHCA based solely on the mechanism of injury alone. Instead, these decisions should be based on a more nuanced approach that considers both the type of injury sustained as well as other clinical factors in deciding to withhold or discontinue resuscitation. Therefore, we recommend against using the mechanism of injury as the sole determinant in the decision to initiate or discontinue resuscitation efforts in TOHCA.

Electrical Rhythm Should Not be Used as the Sole Determinant to Discontinue Resuscitation Efforts. Of Note, Non-Shockable Rhythms (PEA/Asystole) Are Associated with an Extremely Low Likelihood of ROSC or Survival with Neurologic Recovery. The management of medical cardiac arrests has primarily been differentiated by the initial rhythm being shockable (ventricular tachycardia (VT) or ventricular fibrillation (VF)) or non-shockable (PEA or asystole). However, except for circumstances where a medical arrest may result in trauma, it is important to acknowledge the fact that traumatic cardiac arrests have significant differences in patient population and underlying pathophysiology whereby the underlying cardiac activity may not adequately represent survival (8). While asystole and PEA are described more commonly as the initial rhythms in TOHCA compared to shockable rhythms (5, 91, 92), investigations evaluating the prognostic value of the initial rhythm have been limited to cohort studies that did not account for the potential confounding impact of response time or duration of cardiac arrest (38, 39, 69).

Like medical cardiac arrest, shockable rhythms have been consistently linked with improved outcomes in TOHCA cohorts. Patients with TOHCA and shockable rhythms have demonstrated survival rates >30% (6, 18, 39, 42, 93). A 2020 meta-analysis of 53 studies with over 37,000 trauma patients found shockable rhythms were associated with increased odds of survival (OR 7.29; 95% CI 5.09-10.44) (62). A follow-up 2022 study found a more modest, yet still significant, odds of survival (aOR 1.12; CI 1.03-1.21) in shockable TOHCA (73). Shockable rhythms should be treated as a possibly reversible etiology of cardiac arrest and thus defibrillated per BCLS/ACLS guidelines (94).

The data on the survival of TOHCA patients found in PEA is more mixed. Some studies have demonstrated near-universal fatality with an initial PEA rhythm (18, 25, 95, 96). Multiple other studies have demonstrated a modest cohort of survivors with survival rates ranging widely from 2.6 to 7% (5, 23, 26, 36, 38, 39, 48, 64). In a 2003 study, PEA was shown to be predictive of survival when compared to asystole (26). Similarly, near-universal fatality with asystole was demonstrated in early TOHCA studies (18, 22, 23, 26, 32, 96). On the other hand, a small and early outlier study from Denver, Colorado found a survival rate of 19% (5/26) in asystolic TOHCA. Notably, all of these patients had pericardial tamponade at the time of an ED thoracotomy (97). Furthermore, recent cohort studies have demonstrated trauma patients with asystole have survival rates ranging from 2.4% to 13.5% (36, 38, 48) and even neurologic recovery rates of 2.7% (39). This surprising rate of neurologic recovery after asystolic TOHCA is likely inflated as their study population excluded patients without attempted resuscitation. Although survivors are noted, they are rare and the likelihood of a patient achieving ROSC, survival, or neurological recovery was significantly less for those with asystole versus shockable rhythms and PEA (39, 69). In addition, the variability in PEA survivability may be related to the inherent heterogeneity of PEA. For example, a narrow-complex tachycardic PEA may confer a better prognosis than a wide-complex bradycardic PEA, but such nuance may not be captured in research samples.

Overall, while the data on primary electrical rhythm and survival in TOHCA is heterogeneous, there is a clear trend that shockable rhythms portend the greatest likelihood of survival and asystole the least likely. However, recent studies demonstrate a small but modest cohort of survivors with various non-shockable rhythms, including asystole. Thus, although we do not recommend that electrical rhythm be used alone as a sole criterion for withholding or discontinuing resuscitation efforts, presenting rhythm may be strongly considered among other clinical factors when EMS medical directors and other trauma-system stakeholders collaborate to develop local TOHCA resuscitation guidance.

There is Insufficient Evidence to Support Any Specific Universal Standardized Time-Based cutoffs to Discontinue Resuscitation Efforts Based on the Duration of Resuscitation or Transport Times to Definitive Care. EMS Decisions to Transport or Discontinue Resuscitation Should be Locally Determined Based on EMS and Trauma System Resources, and Proximity. In any life-threatening trauma, there is a finite amount of time when medical interventions can make a meaningful difference. Logically, reductions in patient downtime, EMS response time, EMS transport times, and total time of resuscitation would optimize survival outcomes. Evidenced-based literature review represents a heterogeneous group of observational studies that are not well designed to make generalized time-based recommendations (Table 2). However, there are some broad overall trends. For TOHCA, there is an association between a shorter time interval between collapse and presentation to a hospital and achieving a positive outcome, such as ROSC or survival (32, 36, 61). Prolonged downtime is unsurprisingly associated with failure of resuscitation (48, 53). Prolonged resuscitation or CPR in the field is also associated with less survivorship and ROSC (57, 70, 75). Similarly, shorter transport (57, 75) and response times (6, 39, 48) were in some studies associated with positive outcomes, but this was not universally noted (74).

Time of resuscitation as an independent predictor for the outcome of resuscitation has not been well studied. Further, time has typically been studied as a dichotomous or categorical rather than continuous variable, with subjective time intervals chosen by the authors based on study design (48, 57, 74). In the absence of data, the Australian and New Zealand Committee on Resuscitation (ANZCOR) 11.10.1 guidelines recommend the continuation of basic or advanced life support interventions for up to 10 min after potentially reversible causes have been addressed, after which resuscitation attempts should be stopped if there is no ROSC (16). The 2021 ERC guidelines do not make any specific time-based prehospital cutoff guidelines (15). The current Western Trauma Association guidelines recommend ED Thoracotomy (EDT) (also termed resuscitative thoracotomy (RT)) if the patient arrives in the ED with less than 10 min of prehospital CPR for blunt trauma, less than 15 min of CPR for penetrating trauma, and less than 5 min of CPR for patients with penetrating trauma to the neck or extremity (98). Notably, this recommendation is made in the absence of high-quality evidence. Moreover, Western Trauma Association guidelines for EDT are intended only for in-hospital guidance based on the duration of witnessed downtime and attempted resuscitation. Since there is no universal consensus or evidence based on how long resuscitation attempts should continue after TOHCA, EMS decisions to transport or discontinue resuscitation should be locally based on EMS and trauma system resources, and proximity.

Implementation Considerations

Risks and Benefits of Public Safety and EMS Clinician Safety

Public Safety. The use of lights and sirens (L&S) saves an estimated 42 s to 3.8 min but is associated with significant traffic-related fatality rates for first responders, civilians, and patients (12). A 2022 NAEMSP position statement recommends limiting L&S operations to situations where these modest time savings are expected to have a clinically significant impact (12). For TOHCA, critical hospital-based time sensitive interventions may justify the small amount of time saved with L&S transport. Policies regarding the use of L&S transport for TOHCA patients must weigh survival likelihood against the risks that L&S operations pose to EMS clinicians and the surrounding public.

EMS Clinician Safety. Safety for EMS clinicians is a core tenet of the practice of EMS medicine. All TOHCA resuscitation attempts should be aborted in the setting of excessive environmental hazards or risk of interpersonal violence to EMS clinicians. Conversely, there may be scenarios where withholding or discontinuing resuscitative attempts may pose a higher risk to EMS clinicians' safety than continuing with transport to the nearest appropriate receiving facility. This is highlighted in a 2017 survey of 3,500 EMS clinicians from the Chicago, Illinois EMS system where 86% of respondents identified scene safety as a barrier to discontinuing resuscitative attempts (99). Of those respondents, 68% specifically cited safety concerns related to feeling threatened by family members. Although EMS clinician communication skills training in death notification and de-escalation may mitigate challenging scenarios with family and bystanders, there may be certain circumstances where transportation to the hospital will provide additional resources not available in the field (e.g., social workers, chaplains, and family advocates) or help mitigate threats to safety on scene.

In addition, the circumstances of traumatic events and the physical appearance of the patient can be more distressing to EMS clinicians than might be the case for victims of cardiac arrest due to non-traumatic causes. Sensitive, non-intrusive screening, and, if necessary, debriefing resources for EMS clinicians involved in TOHCA resuscitation attempts should be made available as needed.

Individual Patient Cost and Organ Donation Should Not be a Factor in EMS Clinical Decision-Making on-Scene

Cost. Financial and opportunity costs of providing care to TOHCA patients should be cautiously considered during the development of TOHCA resuscitation protocols. These discussions should consider the cost of ineffective resuscitation attempts rather than the cost of resuscitation per patient (20, 35, 100–102). In addition, there is a theoretical, and at times tangible, concern that resource allocation from one patient with a time-critical disease comes at the cost of another (3). When developing TOHCA protocols, cost of care should be considered within the context of patient survivability rather than perceived economic value judgments.

Organ Donation. The potential that TOHCA patients might serve as potential organ donors may be another question that arises during the discussion of TOHCA resuscitation practices. There is limited analysis of organ donation outcomes from patients after TOHCA. In studies evaluating rates of successful organ donation in cohorts of mostly in-hospital traumatic cardiac arrest patients, the successful organ donation rate is 1.4% to 8.9% (58, 68, 100, 103). Organ donor eligibility is significantly less for those patients with TOHCA when compared to medical arrest (100) and in some cases limited to corneas only (20). Although organ donation may be considered after resuscitation attempts, current data shows that organ procurement following TOHCA is infrequent. To avoid conflict of interest, the primary objective of resuscitation attempts in TOHCA should be the survival of the patient, not the potential donation of their organs. Thus, organ donation should not be a factor in EMS clinical decision-making in on-scene direct patient care.

Local Provisions for Specific Clinical Resources (e.g. Regional Trauma Capabilities), Environmental (e.g. Avalanche etc.), or Population-Based Situations Are Important and Require Active EMS Physician Oversight in Collaboration with Local Trauma System Stakeholders

Systems of EMS care vary significantly based on geography (e.g., proximity to a regional trauma center, urban/rural, etc.), type of EMS system (e.g., aeromedical, ground, etc.), type of local trauma system/resources, regulatory factors (e.g., the authority of EMS clinicians to pronounce death in the field), and responding clinician scope of practice (e.g., Emergency Medical Technician (EMT), Paramedic, Nurse, Physician, etc.). Additionally, local trauma system intention to treat TOHCA patients in various contexts can vary considerably. This variation is reflected in the substantial heterogeneity found in primarily observational studies comparing these system-level characteristics. All these factors present significant limitations on the ability to develop universally applicable criteria to guide decisions on whether to withhold or discontinue resuscitative efforts for TOHCA in the field. Thus, local, or regional protocols for withholding or discontinuing resuscitation in TOHCA should consider the potential impact of these system-level factors on the marginal benefit of specific interventions in the field and the appropriateness of rapid transport to the closest trauma center or other hospital.

Conclusion

Patients with TOHCA generally have low survivability, but achievement of ROSC with neurologic recovery and survival is possible for some patients. Except when death is obvious, there are no singular criteria on which EMS agencies should base decisions to initiate, withhold, or discontinue resuscitative efforts in the field for adult TOHCA. Within the scope of practice of their local EMS clinicians, resource availability, and other operational and geographical considerations, EMS agencies may incorporate multiple variables including mechanism of injury, presenting cardiac rhythm, duration of arrest, proximity to definitive care, and public safety implications when developing prehospital protocols to guide withholding or discontinuation of resuscitation attempts in TOHCA patients. Further research is needed to better define factors that are more objectively predictive of survival or death, including duration of arrest, proximity to definitive care, and the role of prehospital clinical interventions on TOHCA outcomes.

External Review

This document was created by NAEMSP, ACS-COT, and ACEP and was subject to review and approval by each participating organization.

Updating Procedure

Pursuant to NAEMSP Standards & Clinical Practices Committee procedures and practices, this position statement and resource document will be reviewed and updated five years after its publication. Applicable NAEMSP review and revision practices that are current as of the time of the review will be followed. At a minimum the review process should include a search and synthesis of any new and relevant evidence that is published since the printing of this document.

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AMB developed plan for literature review and evidence extraction. AMB, NG, CI, AN and TL participated in data analysis. All authors wrote the initial draft of the manuscript and participated in editing. All authors assume full responsibility for the collection of the data.

Declaration of Generative AI in Scientific Writing

The authors did not use a generative artificial intelligence (AI) tool or service to assist with preparation or editing of this work. The author(s) take full responsibility for the content of this publication.

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