

# Withholding or Termination of Resuscitation in Pediatric Out-of-Hospital Traumatic Cardiopulmonary Arrest

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ABBREVIATIONS: EMS, emergency medical services; ED, emergency department; CPR, cardiopulmonary resuscitation; PCPC, pediatric cerebral performance category; ROSC, return of spontaneous circulation.

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## ABSTRACT

This multiorganizational literature review was undertaken to provide an evidence base for determining whether or not recommendations for out-of-hospital termination of resuscitation could be made for children who are victims of traumatic cardiopulmonary arrest. Although there is increasing acceptance of out-of-hospital termination of resuscitation for adult traumatic cardiopulmonary arrest when there is no expectation of a good outcome, children are routinely excluded from state termination-of-resuscitation protocols. The decision to withhold resuscitative efforts in a child under specific circumstances (decapitation or dependent lividity, rigor mortis, etc) is reasonable. If there is any doubt as to the circumstances or timing of the traumatic cardiopulmonary arrest, under the current status of limiting termination of resuscitation in the field to persons older than 18 years in most states, resuscitation should be initiated and continued until arrival to the appropriate facility. If the patient has arrested, resuscitation has already exceeded 30 minutes, and the nearest facility is more than 30 minutes away, involvement of parents and family of these children in the decision-making process with assistance and guidance from medical professionals should be considered as part of an emphasis on family-centered

care, because the evidence suggests that either death or a poor outcome is inevitable.

## INTRODUCTION

In 2003, the National Association of EMS Physicians and the Committee on Trauma of the American College of Surgeons published guidelines for out-of-hospital withholding or termination of resuscitation for adult victims of traumatic cardiopulmonary arrest who met specific criteria.<sup>1</sup> Clinical criteria included absent pulse, unorganized electrocardiogram rhythm, fixed pupils (all at the scene), and cardiopulmonary resuscitation greater than 15 minutes. The recommendations did not extend to the pediatric population. Although many of the studies on which the recommendations were based included children, the vast majority of the involved subjects were adults. Studies published to that time that addressed the pediatric population in particular<sup>2,3</sup> and evaluated survival and functional outcome of pediatric blunt trauma victims with either full traumatic cardiopulmonary arrest or severe hypotension suggested that the prognosis for pediatric traumatic cardiopulmonary arrest victims is similar to that for adults. Given the emotional demands of withholding resuscitation from a child in the field, it was believed by both the leadership in pediatric trauma care and emergency medical services (EMS) that additional studies were warranted before including children in any

termination-of-resuscitation protocol. This literature review in pediatrics was undertaken to provide an evidence base for determining whether recommendations for out-of-hospital termination of resuscitation could be made. The project aims were to: (1) identify whether specific criteria exist that would support out-of-hospital withholding or termination of resuscitation for traumatic cardiopulmonary arrest victims; and (2) identify a specific time frame for any subset of pediatric trauma patients beyond which further resuscitative efforts are futile.

## MATERIALS AND METHODS

Organizational participants included the Committee on Trauma, Subcommittee on Emergency Services–Prehospital, and Pediatric Surgical Specialty Group of the American College of Surgeons; Committee on Pediatric Emergency Medicine of the American Academy of Pediatrics; National Association of EMS Physicians; and Pediatric Committee of the American College of Emergency Physicians. The initial review was completed in September 2008, and additional literature through 2011 was added to provide currency to the review. General guidelines for evaluation included:

1. Distinguish between blunt and penetrating trauma victims.
2. Define “pediatric patient” as 18 years of age or younger.
3. Determine location of arrest (out-of-hospital or emergency department [ED]).

Specific characteristics of the arrest were determined, if possible, as follows:

1. Distinguish between respiratory and cardiopulmonary arrest (from any cause).
2. Determine duration of witnessed arrest.
3. Determine duration of resuscitation to successful return of spontaneous circulation.
4. Determine outcome of children who had successful return of spontaneous circulation: did they survive to reach the hospital, survive to hospital discharge, and have long-term neurologic function?
5. Determine duration of resuscitation efforts in nonsurvivors.
6. Determine effects of epinephrine administration.
7. Determine outcome of thoracotomy when used.
8. Exclude special circumstances: drowning (warm or cold water), hypothermia, burns, electrocution (lightning, electric fence).
9. Determine any caveats with regard to survival to be an organ donor.

Methodology for the evidence evaluation was based on the 2000 Eastern Association for the Surgery of Trauma guideline “Utilizing Evidence-Based Outcome Measures to Develop Practice Management Guidelines: A Primer.”<sup>4</sup> Class I evidence is derived from prospective, randomized, controlled trials; class II evidence represents clinical studies in which data were collected prospectively or retrospective analyses that were based on clearly reliable data; and class III evidence is based on retrospectively collected data. A validity scale for class I was detailed by Jadad

et al in 1996.<sup>5</sup> Recommendations were classified as level 1, 2, or 3 according to the following definitions:

- Level 1: The recommendation is convincingly justifiable based on the available scientific information alone. This recommendation is usually based on class I data; however, strong class II evidence may form the basis for a level 1 recommendation, especially if the issue does not lend itself to testing in a randomized format. Conversely, low quality or contradictory class I data may not be able to support a level 1 recommendation.
- Level 2: The recommendation is reasonably justifiable by available scientific evidence and strongly supported by expert opinion. This recommendation is usually supported by class II data or a preponderance of class III evidence.
- Level 3: The recommendation is supported by available data but adequate scientific evidence is lacking. This recommendation is generally supported by class III data. This type of recommendation is useful for educational purposes and in guiding future clinical research.

Each article was assigned at least 2 reviewers. The assignments were known only to the project director. All articles were also reviewed by the project director, and evidence class was reconciled as needed.

## LITERATURE REVIEW

MedLine and PubMed were searched for the initial review through Ovid from 1980 to 2006. Subsequently, the review was updated with literature as recent as 2011. Search terms included traumatic cardiopulmonary arrest, blunt trauma, cardiorespiratory arrest, resuscitative thoracotomy, out-of-hospital cardiac arrest, out-of-hospital termination of resuscitation, cardiopulmonary resuscitation, emergency medical services, advanced life support, basic life support, outcome, survival, children, and adolescent. Article bibliographies were hand-searched for additional references. New citations were added and assigned as appropriate. Abstracts were included only if a companion manuscript was identified. Editorials, letters to the editor, and studies that included only adults were eliminated. Published papers that included only victims of drowning were ultimately eliminated after review, because the special circumstance of hypothermia and/or cold water drowning may alter resuscitation. Studies that included both adults and children were used if the children were evaluated separately or if data relevant only to children could be abstracted from the text. Studies that mixed traumatic arrests and arrests from other causes were used only if the trauma cohort was described independently. Only trauma patients who suffered a cardiopulmonary arrest rather than isolated respiratory arrest were included. Individual patients were included for review only if they could be tracked through the published paper such that some outcome (ie, at least survival to hospital discharge) could be determined. The arrest interval or time to resuscitation was defined, in a witnessed arrest, as the time between the occurrence of arrest and the time

that cardiopulmonary resuscitation (CPR) was instituted, whether by a bystander or professional. Resuscitation time was defined as the duration of CPR until either return of spontaneous circulation or death was declared.

## RESULTS

A total of 54 articles were retrieved for the initial review.<sup>2,3,6-57</sup> Of these, 35 were eliminated for the reasons described previously,<sup>6-40</sup> leaving 19 articles with potentially useful information.<sup>2,3,41-57</sup> An additional 23 articles were screened for the secondary review,<sup>58-81</sup> with 9 articles appropriate for inclusion.<sup>58,64-69,72,81</sup> There were 2 sets of patients included in 2 manuscripts each, and data was used only once.<sup>53,72,74,80</sup> There were 5 class II studies and 22 class III studies. From the 27 articles, there were 1114 patients who suffered an out-of-hospital traumatic cardiopulmonary arrest, with 60 surviving to hospital discharge (5.4%). Outcome data were available in 23 papers for 51 of these patients (Table 1): 29 suffered neurologic devastation and were either severely disabled or in a vegetative state,<sup>2,41,44-6,53,64,66,68</sup> 3 patients had moderate disability,<sup>3,42,66</sup> and 19 survived with a “good” or full neurologic recovery.<sup>3,42,66,68,69</sup> A separate evidentiary table provides data for cases of out-of-hospital traumatic cardiopulmonary arrest in children for which outcome was not reported (Table 2).<sup>56,59,72,81</sup>

A uniform system of describing disability was not used by all authors, although the most popular system was the pediatric cerebral performance category (PCPC) (Table 3).<sup>82</sup> Thirty-six patients suffered an out-of-hospital traumatic cardiopulmonary arrest from penetrating injuries, and at least 9 of them had a resuscitative thoracotomy in an ED; all of these patients died regardless of whether thoracotomy was performed.<sup>3,50-52,68</sup> Resuscitative thoracotomy was performed at the scene, in the ED, or in the operating room, for a total of 30 patients (combined blunt and penetrating trauma victims) who suffered an out-of-hospital traumatic cardiopulmonary arrest, and there were no survivors.<sup>3,50-52</sup> A few published papers mentioned children who were declared dead in the field, implying that the state or country has a do-not-resuscitate protocol for a subset of arrest victims.<sup>3,47,48,78,79</sup>

Cause of death, interval of arrest to CPR, and total resuscitation time for survivors were reported in a few papers. Specific anatomic causes of death were only rarely mentioned in published articles and included blunt trauma to the brain and spinal cord<sup>43</sup> and penetrating injuries to the head/brain, liver, spleen, heart, and aorta.<sup>50</sup> In a recent report, 78% of nonsurvivors had a traumatic brain injury.<sup>66</sup> It was difficult to abstract time to initiation of resuscitation and total resuscitation times for trauma patients from most papers. Information for arrests of all causes was available in a few. For example, interval to CPR was 2.3 minutes for survivors and 6.5 minutes for nonsurvivors in a Canadian study of 41 patients who had an unexpected cardiac arrest,<sup>48</sup> and median interval to initiation of CPR in a prospective study from California that included arrests

from all causes was 3 minutes (range, 0-5 minutes) among survivors and 13 minutes (range, 4-64 minutes) among nonsurvivors.<sup>53</sup> Reported survivor mean ED resuscitation time in one paper, exclusive of field resuscitation, was 11.4 minutes,<sup>42</sup> and survivor median resuscitation time in another report was 14 ± 2.5 minutes (in the ED).<sup>45</sup> One paper further described 5 survivors with a mean resuscitation time in the ED of 57.8 (standard deviation [SD], 25.5 minutes), and all had either severe disability or a vegetative state at discharge.<sup>41</sup> An outlier survivor in terms of resuscitation time had a good outcome with a combined 42 minutes of out-of-hospital and ED resuscitation.<sup>45</sup> In a study describing 56 pediatric patients with out-of-hospital traumatic cardiopulmonary arrest, 20 of the 56 trauma patients were revived by initial in-hospital CPR (return of spontaneous circulation [ROSC], ≥20 minutes), but only 1 patient whose outcome was not disclosed was eventually discharged from the hospital alive.<sup>58</sup> In 2010, a retrospective published review of pediatric out-of-hospital traumatic cardiopulmonary arrest documented 6 survivors out of a patient cohort of 30 patients.<sup>66</sup> CPR greater than 15 minutes and fixed pupils distinguished nonsurvivors from survivors, and adult criteria based on those of Hopson et al<sup>1</sup> correctly predicted 100% of those who died when all of the criteria were met. The mean duration of CPR was 42 minutes (SD, 28 minutes) for nonsurvivors and 7 minutes (SD, 3 minutes) for survivors. Three patients were discharged home with orders for outpatient rehabilitation services, and 3 patients required extensive rehabilitation and require 24-hour assistance with activities of daily living. A recently published multicenter cohort study of out-of-hospital pediatric cardiac arrest included 15 children with traumatic cardiopulmonary arrest (total, 138 patients), and 3 survived.<sup>67</sup> Although PCPC scores were used for survivors, it was not possible to determine outcomes for these 3 children. However, survivors from all causes had a median duration and interquartile range of CPR of 18.5 minutes (3.5–28.5 minutes) versus 41 minutes (24–54 minutes) for nonsurvivors.

A few papers addressed the use of epinephrine in out-of-hospital cardiopulmonary arrest in terms of survival, with some noting that survivors often needed no epinephrine. At least 3 authors associated more than 2 or 3 doses of standard dose epinephrine with death, although not necessarily among trauma victims, and 1 had survivors who had received up to 4 doses.<sup>35,41,53,67</sup>

The mean attempted resuscitation time in many studies averaged 30 minutes. Most child survivors of out-of-hospital traumatic cardiopulmonary arrest undergoing resuscitative efforts of this duration were neurologically devastated. The 3 patients who had moderate disability had ROSC after approximately 17 minutes of CPR.<sup>3,42,66</sup> Normal outcome was more often seen in trauma victims who had a perceived rapid ROSC, although an exact time in minutes was difficult to extract from the paper with the majority of survivors who had a normal neurologic status.<sup>68</sup>

A few papers made specific reference to organ donation, mentioning that sustained ROSC may serve as a bridge to possible organ donation and is necessary to prevent organ

**Table 1.** Evidentiary table for out-of-hospital traumatic cardiopulmonary arrest in children where outcome was reported.

Authors	Number of Trauma Victims	Survivors	Outcome	Special Circumstances	Class
Hazinski et al, 1994 <sup>2</sup>	38	1	Severe disability (9.5-y-old functioning as nonambulatory 1-y-old)	Out-of-hospital intubation did not influence likelihood of reanimation	II
Suominen et al, 1998 <sup>3</sup>	28	1	Moderate disability	Run over by train, airway obstructed, spontaneous circulation within 17 minutes of the accident and after 5 minutes of resuscitation	III
Pitetti et al, 2002 <sup>41</sup>	53	1	Severely disabled (PCPC 4; see Table 3)	Survivors likely to be in sinus rhythm on arrival in ED, to have received fewer doses of epinephrine in ED	III
Kuisma et al, 1995 <sup>42</sup>	10	1	Partial disability, capable of self-care (Bloom III; see Table 3)	Mean resuscitation times for survivors and nonsurvivors was 11.4 and 30.6 minutes; bystander initiated CPR related to favorable outcome, survivor had ROSC in 17 minutes	III
Calkins et al, 2002 <sup>43</sup>	16	0			III
Ronco et al, 1995 <sup>44</sup>	26	1	Severely disabled (examined by a neurologist, no scoring system)	Median ED resuscitation time for both survivors and non-survivors was 30 minutes; only intact survivor was resuscitated prior to ED arrival	III
O'Rourke, 1986 <sup>45</sup>	10	2	Vegetative state		III
Thompson et al, 1990 <sup>46</sup>	28	2	Severely disabled		III
Tsai and Kalisen, 1987 <sup>47</sup>	6	0			III
Friesen et al, 1982 <sup>48</sup>	13	0		Interval between arrest and institution of active CPR was 2.3 minutes in survivors and 6.5 minutes in nonsurvivors	II
Sirbaugh et al, 1999 <sup>49</sup>	44	0			II
Sheikh and Culbertson, 1993 <sup>50</sup>	13	0		All had ED thoracotomy within 5 minutes of ED arrival	III
Beaver et al, 1987 <sup>51</sup>	17	0		All had ED thoracotomy after a mean of 22 minutes of conventional resuscitation	III
Powell et al, 1988 <sup>52</sup>	9	0		All had ED thoracotomy; all scene arrest patients died	III
Young et al, 2004 <sup>53</sup> (same as Brindis et al, 2011 <sup>80</sup> )	118	6	All severe disability or vegetative state (PCPC 4 or 5)	No survivor who had ED CPR >31 minutes had a good neurologic outcome	II
Patterson et al, 2005 <sup>54</sup>	59	0		No long term trauma survivors with use of either standard or high dose epinephrine	II
Martin et al, 2002 <sup>55</sup>	7	0		All patients in study had pulseless electrical activity at scene	III
Broides et al, 2000 <sup>57</sup>	7	0			III
Widdel et al, 2010 <sup>69</sup>	30	1	Good neurologic outcome	Survivor had 2 min of out-of-hospital CPR; aggressive resuscitation is rarely successful	III
Horisberger et al, 2002 <sup>65</sup>	16	0			III
Capizzani et al, 2010 <sup>66</sup>	30	6	2 with good neurologic outcome, 1 fair, 3 poor	CPR >15 min and fixed pupils were predictive of death or poor outcome	III
Fisher and Worthen, 1999 <sup>64</sup>	65	1	1 survivor in persistent vegetative state		III
Murphy et al, 2010 <sup>68</sup>	169	28	55% survived intact but 1/3 of these required no airway support	66 patients transferred from another hospital; no children survived if CPR was ongoing at ED arrival	III
<b>Total</b>	<b>812</b>	<b>51 (6.3%)</b>		29 (57%) severe disability; 3 (6%) moderate disability; 19 (37%) normal	

failure before harvesting.<sup>58</sup> However, it was noted by another group that it is ethically inappropriate to proceed with resuscitation solely to preserve organs, because the physician may be more committed to the potential well-being of an unknown recipient rather than the patient at hand or his or her family members. Traditionally, cadaveric organ transplantation operates under the “dead donor rule,” and organ recovery must not be

the direct cause of the donor’s death, a concept that is justified by the prohibition against the direct killing of innocent persons. Further, the added expense associated with organ preservation, until such time as decoupling has occurred and the family can be approached about donation, is generally the responsibility of the donor family. If the family decides to donate, future expenses will be born by the organ procurement organization

**Table 2.** Evidentiary table for out-of-hospital traumatic cardiopulmonary arrest in children where outcome was not reported.

Authors	Number of Trauma Victims	Survivors	Outcome	Special Circumstances	Class
Lin et al, 2007 <sup>58</sup>	56	1	Outcome not reported	20/56 patients revived in ED with ROSC all $\geq$ 20 min	III
Li et al, 1999 <sup>56</sup>	182	2	Unable to determine	National Pediatric Trauma Registry data, fewer than 2% of patients who were asystolic on admission were discharged alive	III
Moler et al, 2011 <sup>67</sup> (same as Moler et al, 2009 <sup>74</sup> )	15	3	Unable to determine	Median duration and interquartile range of CPR of 18.5 (3.5–28.5) min	III
Stockinger et al, 2004 <sup>81</sup>	49	3	Unable to determine		III
<b>Total</b>	<b>302</b>	<b>9 (3%)</b>			

on behalf of the recipient.<sup>83</sup> If the family declines the opportunity to donate, this added expense and burden is not offset by a perceived benefit to the family.<sup>44</sup>

**DISCUSSION**

Each year in the United States, 16,000 children suffer cardiopulmonary arrest.<sup>59</sup> Although inpatient results are improving, the outcome for pediatric traumatic out-of-hospital arrests remains poor, although newer evidence suggests that children and adolescents with out-of-hospital arrest from other causes are more likely to survive than adults.<sup>41,53,59-62,78,84</sup> Pediatric out-of-hospital deaths represent nearly one third of pediatric deaths in the United States,<sup>85</sup> and in 1 urban study, 2% of pediatric EMS calls were attributed to pediatric out-of-hospital arrests.<sup>63</sup> Some of the more current studies of out-of hospital arrest exclude trauma. Trauma is the leading cause of death from 1 through 21 years of age, and homicide or child abuse is the leading cause of trauma in children younger than 1 year<sup>86</sup>; therefore, the optimal management of pediatric out-of-hospital traumatic cardiopulmonary arrest deserves special attention and will be the primary focus of the recommendations based on this review. As many of the articles used for this review include pediatric arrests with multiple etiologies, making a few general observations about pediatric cardiopulmonary arrest is pertinent.

In a large 3-year prospective study of out-of-hospital arrests attributable to all causes in children younger than 12 years,<sup>53</sup> 8.6% of the children survived, one third of whom had a good

neurologic outcome. No patient who received more than 3 doses of epinephrine or more than 31 minutes of resuscitation in the ED survived. In a more recent review of the literature and science of pediatric resuscitation, Topjian et al reported that 5% to 10% of pediatric out-of-hospital arrest victims survive to hospital discharge, with 0% to 12% having good neurologic outcomes.<sup>59</sup> Indicators of potential for successful outcomes in pediatric out-of-hospital arrest include a witnessed arrest, the occurrence of early bystander CPR, an initial shockable rhythm, and return of spontaneous circulation within 20 minutes.<sup>84</sup> In the absence of these characteristics, a good outcome is extraordinarily unlikely. However, anecdotal reports of children who survive after a prolonged resuscitation exist and lend unease to including them in generalized protocols. Although the outcome of pediatric inpatient cardiac arrests, generally associated with primary cardiac disease, is better than for adults, the outcome for pediatric out-of-hospital resuscitation is substantially worse, because out-of-hospital arrests in children are more commonly caused by severe trauma, prolonged respiratory arrest, or septic shock rather than a primary cardiac etiology.<sup>59</sup> These etiologies imply a longer period of hypoxia before the actual arrest, with resulting brain and other organ damage. As noted previously, the mean resuscitation time in most pediatric studies was an average of 30 minutes. Most children with out-of-hospital traumatic cardiopulmonary arrest who received this duration of resuscitation and survived were irreversibly neurologically devastated.<sup>2,41,44-46,53,64,66,68</sup> Two of the 3 patients who suffered only moderate disability had ROSC after approximately 17 minutes of CPR.<sup>3,42</sup> Documentation of ROSC for the 19 children who had return to baseline or near-baseline status was reported for only 3 of the children as 2 minutes and less than 15 minutes.<sup>66,69</sup> In the series that quoted the largest number of intact survivors (n=16), the authors acknowledged that one third of survivors presented with a stable airway and did not require intubation for respiratory support. There was also a uniform distribution across all injury severity score groups for survivors, with more than half of those survivors having an injury severity score greater than 16. These findings caused the authors to reflect that almost half of the survivors had either an exceedingly rapid response to out-of-hospital CPR or out-of-hospital findings that may not have warranted CPR intervention at all.<sup>68</sup> In fact, it has been recognized that some children who undergo CPR in the out-of-hospital setting are

**Table 3.** Disability scoring systems.

1	Normal
2	Mild disability
3	Moderate disability
4	Severe disability
5	Coma or vegetative state
6	Brain dead
I	No disability, active life
II	Mild disability, active life
III	Partial disability, but capable of self-care
IV	Total disability, incapable of self-care

Pediatric Cerebral Performance Category (PCPC).<sup>57</sup>  
 Bloom Classification.<sup>92</sup>



unlikely to have been pulseless because of the difficulty of recognizing pulselessness in children.<sup>60,87</sup>

ED crowding in the United States is an emerging threat to patient safety and public health, particularly in safety net hospitals.<sup>88-90</sup> Although the effects of ED crowding on patient care and outcome are complex, transport of a nonviable patient from the field to the ED has the secondary effect of making the resources of the EMS personnel unavailable for those who might benefit from crucial immediate attention. A series of articles by Morrison et al validating the termination of resuscitation rule estimated that the frequency of out-of-hospital adult cardiac arrest transports to the ED could be reduced from 100% to 37.4% of calls, with no loss of viable patients, thus resulting in valuable resource and cost savings.<sup>91-93</sup> In addition to the cost concerns, the “lights and siren” run is associated with significant potential for injury to EMS personnel and the public.<sup>94-97</sup> Finally, the costs of supplies (often including precious blood products) and the emotional toll on ED providers who would not otherwise be exposed to the death, including the risk of post-traumatic stress disorder, are all important considerations that should not be ignored when choosing whether to transport a patient who is already dead or who will inevitably die (unpublished survey data; in process to submit for publication).

It is for these reasons that there is increasing acceptance of termination of resuscitation for adults when there is no hope for a good outcome.<sup>1,91,92,98-102</sup> Although the same justifications apply to children, especially in light of worse out-of-hospital resuscitation outcomes, children are routinely excluded from termination-of-resuscitation protocols, at least in the United States.<sup>1</sup> Approximately half of states have formalized termination of resuscitation in statute or protocol, but only a few apply them to children. In a recent Melbourne, Australian study of out-of-hospital arrest, there were 29 patients who had attempts at resuscitation discontinued in the field. Including the 7% of patients who had no attempts at resuscitation, this represented 20.6% who were declared dead at the scene by paramedics.<sup>79</sup>

Beyond the resource-saving benefits associated with termination of resuscitation, 2 small studies indicate that families of adult patients who die in the out-of-hospital setting may actually adapt better to their losses when there is cessation of futile resuscitative efforts in the field.<sup>103,104</sup> Many states have EMS protocols or statutes that allow do-not-resuscitate orders or a declaration of death in the field for adult victims with obvious signs of death, including decapitation, hemicorporectomy, lividity, rigor mortis, and decomposition, although even these states may exclude children from such protocols and procedures. The Resuscitation Outcomes Consortium reported that no EMS resuscitation was performed in 19% of children, and the Australian study reported that no EMS resuscitation was performed in 7%.

There remains a profound reluctance to stop futile resuscitative efforts when the patient is a child.<sup>98</sup> On the basis of the literature to date, the reluctance stems from provider and public ignorance of out-of-hospital arrest outcomes,<sup>26-7,29,104-106</sup>

fear related to inadequate preparation for communication with acutely grieving family members,<sup>26,107</sup> perceived determinants of family adaptation to loss, and concerns regarding legal liability for providers. The issue of whether or not families benefit from futile resuscitative measures in the field and ED has not been studied. The Institute of Medicine study, “Emergency Care for Children: Growing Pains”<sup>90</sup> corroborates that the provision of even routine emergency care for children provokes stress and anxiety for EMS providers because of lack of knowledge, training, and pediatric-specific experience.<sup>108,109</sup> Increased training and information is desired by EMS providers<sup>109</sup> and seems to mitigate the discomfort in some settings.<sup>26,29,110,111</sup>

There are no American studies of the needs of families of children at the scene of the death, although it is the time of the most tremendous shock and the time when EMS providers have the unique opportunity to positively affect the lives of the survivors forever. Most existing advice regarding the needs of families affected by the sudden, unexpected death of a child is based on extrapolations from the hospital setting or on anecdotal evidence. These recommendations are remarkably similar to recommendations regarding the care of families bereaved in other settings, particularly when the deceased is a child.<sup>46,47</sup>

Ethical concerns regarding the implementation of a termination-of-resuscitation policy deserve mention. Minority populations experience traumatic injuries disproportionately, including traumatic death. Any termination of resuscitation policy may, therefore, be viewed with distrust, particularly among minority populations. There are situations in which a family is remote from the scene of the arrest, and transport of the child to a hospital may allow family members more resources for grief counseling. EMS providers may be concerned about child abuse and prefer to transport.<sup>86</sup> New technologies for resuscitation after cardiopulmonary arrest from various causes are being considered and used at some hospitals, including extracorporeal membrane oxygenation.<sup>112,113</sup> This technology is expensive and may or may not lead to improved neurologic outcomes in trauma patients.<sup>114</sup> The ability of lay parents to grasp the risks and benefits of this extraordinary treatment option, providing informed consent when they are faced with an emergency life-or-death decision for their child, may be significantly compromised by the urgency of the process. The use of hypothermia as a treatment strategy after traumatic brain injury has also been attempted without a demonstrated survival advantage.<sup>115</sup> Preservation of circulation with the specific intent of organ preservation for transplantation is controversial. A specific area of debate that applies to this discussion includes the use of invasive procedures that are nonbeneficial to the donor. Health professionals should remain informed of advances in resuscitation that will allow a balanced discussion with those who will have decision-making authority for a given child.

This literature review and analysis has several limitations. The papers available for review are heterogeneous with respect to etiology of arrest, type of arrest (cardiopulmonary versus respiratory arrest), and location (out-of-hospital or ED), and

final outcome data are often lacking. One study used registry data that may repeat reports of some children previously mentioned in the other studies. There is now an effort to try to standardize data for out-of-hospital arrests that will be helpful going forward, but this information cannot be applied to this review.<sup>116</sup> One of the more recent reviews that applied this template excluded trauma patients.<sup>78</sup> Some of the references in the discussion that detail out-of-hospital cardiac arrest transports to the ED in adults may not necessarily translate to children. The original Hopson study has been reconfirmed, and one of the pediatric studies used the same criteria with consistent results,<sup>66,81</sup> but another group had several survivors when applying the same criteria to an urban population.<sup>72</sup> As mentioned, some children who undergo CPR in the out-of-hospital setting are unlikely to have been pulseless because of the difficulty of recognizing pulselessness in children.<sup>60,86</sup> Nevertheless, results of the current review suggest that survival for children suffering an out-of-hospital traumatic cardiopulmonary arrest attributable to blunt or penetrating trauma is poor and that many survivors live with devastating neurologic disability. Despite its limitations, the following conclusions can be proposed on the basis of the results of this review: (1) the retrospective analysis revealed a reported overall traumatic cardiopulmonary arrest survival rate of 5.4%; (2) more recent publications corroborate that a short (<20 minutes) ROSC is associated with improved survival but not necessarily a good outcome; (3) virtually all survivors who require resuscitation for >20 minutes are neurologically devastated, but a few children resuscitated under more favorable circumstances have returned to baseline; and (4) there are some clear markers that will help identify the rare child who might have a chance at a good outcome. In particular, survivors are likely to have a very short interval of arrest to CPR (<5 minutes), to have ROSC in the field within minutes of beginning CPR, and to have sinus rhythm on arrival in the ED. There is little evidence that epinephrine makes a difference in the outcome of trauma patients. Most children with out-of-hospital traumatic cardiopulmonary arrest who receive more than 20 minutes of resuscitation and survive are neurologically devastated. Those who do better receive resuscitation for only a few minutes.

Although most of the recommendations in this statement are at a level 2 or 3 based on the evidence, the decision to withhold resuscitative efforts in a child under specific circumstances (decapitation or dependent lividity, rigor mortis, etc) is reasonable. However, in other circumstances, because of the potential for ambiguity and miscommunication, if there is any doubt as to the circumstances or timing of the traumatic cardiopulmonary arrest, under the current status of limiting termination of resuscitation in the field to persons older than 18 years in most states, resuscitation should be initiated and continued until arrival to the appropriate facility. The decision in these instances should not be left to EMS providers with different levels and variety of training, expertise, experience, and communications skills (even with remote input from the medical

director, who is not on-site) to ensure a consistent message is delivered to parents and families of these children. If the patient has arrested and resuscitation has already exceeded 30 minutes and the distance to the nearest facility is more than 30 minutes away, involvement of parents and family of these children in the decision-making process with assistance and guidance from medical professionals should be considered as part of an emphasis on family-centered care, because evidence suggests that either death or a poor outcome is inevitable.

## TREATMENT CONCLUSIONS BASED ON EVIDENCE

1. The withholding of resuscitative efforts should be considered in pediatric victims of penetrating or blunt trauma with injuries obviously incompatible with life, such as decapitation or hemicorporectomy (Level 2).
2. The withholding of resuscitative efforts should be considered in pediatric victims of penetrating or blunt trauma with evidence of a significant time lapse following pulselessness, including dependent lividity, rigor mortis, and decomposition (Level 2).
3. Initiation of standard resuscitation should be considered for a cardiopulmonary arrest patients in whom the mechanism of injury does not correlate with a traumatic cause of arrest unless (1) or (2) above applies (Level 2).
4. Initiation of standard resuscitation should be considered in cardiopulmonary arrest victims of lightning strike or drowning in whom there is significant hypothermia unless (1) or (2) applies (Level 2).
5. Immediate transportation to an ED should be considered for children who exhibit witnessed signs of life before traumatic cardiopulmonary resuscitation and have CPR ongoing or initiated within 5 minutes in the field, with resuscitation maneuvers including airway management and intravenous or intraosseous line placement planned during transport (Level 2).
6. Following blunt and penetrating trauma in victims in whom there is an unwitnessed traumatic cardiopulmonary arrest, a longer period of hypoxia may be presumed to have occurred, and an acceptable duration of CPR (including bystander CPR) of less than 30 minutes may be considered with medical director input (Level 3).
7. If there is any doubt as to the circumstances or timing of the traumatic cardiopulmonary arrest, under the current status of limiting termination of resuscitation in the field to persons older than 18 years in most states, resuscitation should be initiated and continued until arrival to the appropriate facility (Level 3).
8. The inclusion of children in state termination-of-resuscitation protocols should be considered, including children who are victims of blunt and penetrating trauma who have or in whom there is EMS-witnessed cardiopulmonary arrest and at least 30 minutes of unsuccessful resuscitative efforts, including CPR (Level 2).

## FUTURE POLICY AND PROTOCOL GUIDANCE

1. Termination-of-resuscitation protocols for children based on the evidence should be developed and implemented under the guidance of the EMS system or state EMS medical director. Online medical control may be needed to determine the appropriateness of termination of resuscitation in individual children.
2. Policies and procedures for termination-of-resuscitation protocols must include notification of the appropriate law enforcement agencies and notification of the medical examiner or coroner for final disposition of the body.
3. EMS providers should receive education regarding communication with families and assistance with how to direct families to community and grief resources. EMS providers should have immediate access to resources for their own debriefing and counseling. Families of the deceased should have immediate access to culturally and linguistically appropriate care, counseling, and resources, including access to clergy, social workers, and other counseling personnel.
4. EMS, medical control, and ED providers should have access to resources for their own debriefing and counseling after the death of a child.
5. Adherence to policies and protocols governing termination of resuscitation should be monitored through a quality review system.
6. A more formal study evaluating out-of-hospital traumatic cardiopulmonary arrest that includes long-term neurologic and functional outcome should be performed to clarify expectations for intact survival in children and legitimize the inclusion of children in termination-of-resuscitation protocols.
7. Research is vitally needed regarding the acceptance of termination-of-resuscitation protocols by families of children sustaining out-of-hospital traumatic cardiopulmonary arrest to determine the potential emotional effects of both termination of resuscitation and failure to initiate resuscitative efforts when futility of such efforts is apparent.
8. There is a need for more research/study of infants/children/adolescents from diverse racial, ethnic, cultural, and socioeconomic populations to determine whether disparities in resuscitative care or outcomes exist.
9. Engagement of, partnership with, and collaboration with local communities and advocacy groups, perhaps through a community-based participatory research concept, may prove helpful in developing protocols and providing community health education programs about this subject.

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*The recommendations in this statement do not indicate an exclusive course of treatment or serve as a standard of medical*

*care. Variations, taking into account individual circumstances, may be appropriate.*

All policy statements from the American Academy of Pediatrics automatically expire 5 years after publication unless reaffirmed, revised, or retired at or before that time.

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**REFERENCES**

1. Hopson LR, Hirsh E, Delgado J, Domeier RM, McSwain NE, Krohmer J. Guidelines for withholding or termination of resuscitation in prehospital cardiac arrest: joint position statement of the National Association of EMS Physicians and the American College of Surgeons Committee on Trauma. *J Am Coll Surg.* 2003;196(1):106-112.
2. Hazinski MF, Chahine AA, Holcomb GW, et al. Outcome of cardiovascular collapse in pediatric blunt trauma. *Ann Emerg Med.* 1994;23(6):1229-1235.
3. Suominen P, Räsänen J, Kivioja A. Efficacy of cardiopulmonary resuscitation in pulseless paediatric trauma patients. *Resuscitation.* 1998;36(1):9-13.
4. Eastern Association for the Surgery of Trauma, Ad Hoc Committee on Practice Management Guideline Development. Utilizing Evidence-Based Outcome Measures to Develop Practice Management Guidelines: A Primer. Chicago, IL: Eastern Association for the Surgery of Trauma; 2000. Available at: [www.east.org](http://www.east.org). Accessed June 30, 2011.
5. Jadad AR, Moore RA, Carroll D, et al. Assessing the quality of reports of randomized clinical trials: is blinding necessary? *Control Clin Trials.* 1996;17(1):1-12.
6. Brady WJ, Hennes H, Wolf A, Hall KN, Davis M. Pattern of basic life support ambulance use in an urban population. *Am J Emerg Med.* 1996;14(3):250-255.
7. Suominen P, Silfvast T, Korpela R, Erosuo J. Pediatric prehospital care provided by a physician-staffed emergency medical helicopter unit in Finland. *Pediatr Emerg Care.* 1996;12(3):169-172.
8. Rosenberg NM, Klein E, Gittelman MA, Nozicka CA, et al. When to start and when to stop. *Pediatr Emerg Care.* 2001;17:126-129.
9. Svenson JE, Nypaver M, Calhoun R. Pediatric prehospital care: epidemiology of use in a predominantly rural state. *Pediatr Emerg Care.* 1996;12(3):173-179.
10. Young KD, Seidel JS. Pediatric cardiopulmonary resuscitation: a collective review. *Ann Emerg Med.* 1999;33(2):195-205.
11. Svenson JE, Spurlock C, Nypaver M. Pediatric firearm-related fatalities: not just an urban problem. *Arch Pediatr Adolesc Med.* 1996;150(6):583-587.
12. Morris MC, Nadkarni VM. Pediatric cardiopulmonary-cerebral resuscitation: an overview and future directions. *Crit Care Clin.* 2003;19(3):1-22.
13. Svenson JE, Spurlock C, Nypaver M. Factors associated with the higher traumatic death rate among rural children. *Ann Emerg Med.* 1996;27(5):625-632.
14. Zaritsky A. Recent advances in pediatric cardiopulmonary resuscitation and advanced life support. *New Horiz.* 1998;6(2):201-211.
15. Innes PA, Summers CA, Boyd IM, et al. Audit of paediatric cardiopulmonary resuscitation. *Arch Dis Child.* 1993;68(4):487-491.
16. Quan L, Wentz KR, Gore EJ, Copass MK. Outcome and predictors of outcome in pediatric submersion victims receiving prehospital care in King County, Washington. *Pediatrics.* 1990;86(4):586-593.
17. Torphy DE, Minter MG, Thompson BM. Cardiorespiratory arrest and resuscitation of children. *Am J Dis Child.* 1984;138(12):1099-1102.

18. Zaritsky A, Nadkarni V, Getson P, Kuehl K. CPR in children. *Ann Emerg Med.* 1987;16(10):1107-1111.
19. Copass MK, Oreskovich MR, Bladergroen MR, Carrico CJ. Prehospital cardiopulmonary resuscitation of the critically injured patient. *Am J Surg.* 1984;148(1):20-26.
20. Alpers A, Lo B. When is CPR futile? *JAMA.* 1995;273(2):156-158.
21. Christensen DW, Jansen P, Perkin RM. Outcome and acute care hospital costs after warm water near drowning in children. *Pediatrics.* 1997;99(5):715-721.
22. Eisenberg M, Bergner L, Hallstron A. Epidemiology of cardiac arrest and resuscitation in children. *Ann Emerg Med.* 1983;12(11):672-674.
23. Gallagher EJ, Lombardi G, Gennis P. Effectiveness of bystander cardiopulmonary resuscitation and survival following out-of-hospital cardiac arrest. *JAMA.* 1995;274(24):1922-1925.
24. Lewis JK, Minter MG, Eshelman SJ, Witte MK. Outcome of pediatric resuscitation. *Ann Emerg Med.* 1983;12(5):297-299.
25. Ludwig S, Ketrick RG, Parker M. Pediatric cardiopulmonary resuscitation. *Clin Pediatr (Phila).* 1984;23(2):71-75.
26. Hall WL, Myers JH, Pepe PE, Larkin GL, Sirbaugh PE, Persse DE. The perspective of paramedics about on-scene termination of resuscitation efforts for pediatric patients. *Resuscitation.* 2004;60(2):175-187.
27. O'Marcaigh AS, Koenig WJ, Rosekrans JA, Berseth CL. Cessation of unsuccessful pediatric resuscitation – how long is too long? *Mayo Clin Proc.* 1993;68(4):332-336.
28. Rosenberg NM, Schunk JE, Bolte R, Goepf JG. Initiation/termination of cardiopulmonary resuscitation. *Pediatr Emerg Care.* 1997;13(4):282-284.
29. Scribano PV, Baker MD, Ludwig S. Factors influencing termination of resuscitative efforts in children: a comparison of pediatric emergency medicine and adult emergency medicine physicians. *Pediatr Emerg Care.* 1997;13(5):320-324.
30. Bonnin MJ, Pepe PE, Kimball KT, Clark PS Jr. Distinct criteria for termination of resuscitation in the out-of-hospital setting. *JAMA.* 1993;270(12):1457-1462.
31. Gray WA, Capone RJ, Most AS. Unsuccessful emergency medical resuscitation – are continued efforts in the emergency department justified? *N Engl J Med.* 1991;325(20):1393-1398.
32. Hallstrom AP, Cobb LA, Swain M, Mensinger K. Predictors of hospital mortality after out-of-hospital cardiopulmonary resuscitation. *Crit Care Med.* 1985;13(11):927-929.
33. Rosemurgy AS, Norris PA, Olson SM, Hurst JM, Albrink MH. Prehospital traumatic cardiac arrest: the cost of futility. *J Trauma.* 1993;35(3):468-474.
34. Shimazu S, Shatney CH. Outcomes of trauma patients with no vital signs on hospital admission. *J Trauma.* 1983;23(3):213-216.
35. Schindler MB, Bohn D, Cox PN, et al. Outcome of out-of-hospital cardiac or respiratory arrest in children. *N Engl J Med.* 1996;335(20):1473-1479.
36. Lopez-Herce J, Garcia C, Dominguez P, et al. Characteristics and outcome of cardiorespiratory arrest in children. *Resuscitation.* 2004;63(3):311-320.
37. Lopez-Herce J, Garcia C, Rodriguez-Nunez, et al. Long-term outcome of paediatric cardiorespiratory arrest in Spain. *Resuscitation.* 2005;64(1):79-85.
38. Pasquale MD, Rhodes M, Cipolle MD, Hanley T, Wasser T. Defining “dead on arrival”: impact on a Level I trauma center. *J Trauma.* 1996;41(4):726-730.
39. Bodai BI, Smith JP, Blaisdell FW. The role of emergency thoracotomy in blunt trauma. *J Trauma.* 1982;22(6):487-491.
40. Engdahl J, Axelsson A, Bang A, Karlson BW, Herlitz J. The epidemiology of cardiac arrest in children and young adults. *Resuscitation.* 2003;58(2):131-138.
41. Pitetti R, Glustein JZ, Bhende MS. Prehospital care and outcome of pediatric out-of-hospital cardiac arrest. *Prehosp Emerg Care.* 2002;6(3):283-290.
42. Kuisma M, Suominen P, Korpela R. Paediatric out-of-hospital cardiac arrests—epidemiology and outcome. *Resuscitation.* 1995;30(2):141-150.
43. Calkins CM, Bensard DD, Partrick DA, Karrer FM. A critical analysis of outcome for children sustaining cardiac arrest after blunt trauma. *J Ped Surg.* 2002;37(2):180-184.
44. Ronco R, King W, Donley D, Tilden SJ. Outcome and cost at a children's hospital following resuscitation for out-of-hospital cardiopulmonary arrest. *Arch Pediatr Adolesc Med.* 1995;149(2):210-214.
45. O'Rourke PP. Outcome of children who are apneic and pulseless in the emergency room. *Crit Care Med.* 1986;14(5):466-468.
46. Thompson JE, Bonner B, Lower GM. Pediatric cardiopulmonary arrests in rural populations. *Pediatrics.* 1990;86(2):302-306.
47. Tsai A, Kalisen G. Epidemiology of pediatric prehospital care. *Ann Emerg Med.* 1987;16(3):284-292.
48. Friesen RM, Duncan P, Tweed WA, Bristow G. Appraisal of pediatric cardiopulmonary resuscitation. *CMAJ.* 1982;126(9):1055-1060.
49. Sirbaugh PE, Pepe PE, Shook JE, et al. A prospective population-based study of the demographics, epidemiology, management, and outcome of out-of-hospital pediatric cardiopulmonary arrest. *Ann Emerg Med.* 1999;33(2):174-184.
50. Sheikh AA, Culbertson CB. Emergency department thoracotomy in children: rationale for selective application. *J Trauma.* 1993;34(3):323-328.
51. Beaver B, Colombani PM, Buck JR, Dudgeon DL, Bohrer SL, Haller JA Jr. Efficacy of emergency room thoracotomy in pediatric trauma. *J Ped Surg.* 1987;22(1):19-23.
52. Powell RW, Gill EA, Jurkovich GJ, Ramenofsky ML. Resuscitative thoracotomy in children and adolescents. *Am Surg.* 1988;54(4):188-191.
53. Young KD, Gausche-Hill M, McClung CD, Lewis RJ. A prospective population-based study of the epidemiology and outcome of out-of-hospital pediatric cardiopulmonary arrest. *Pediatrics.* 2004;115(1):157-164.
54. Patterson MD, Boenning DA, Klein BL, Fuchs S, Smith KM, Hegenbarth MA, Carlson DW, Krug SE, Harris EM. The use of high-dose epinephrine for patients with out-of-hospital cardiopulmonary arrest refractory to prehospital interventions. *Ped Emerg Care.* 2005;21(4):227-237.
55. Martin SK, Shatney CH, Sherck JP, Ho C, Homan SJ, Neff J. Blunt trauma patients with prehospital pulseless electrical activity (PEA): poor ending assured. *J Trauma.* 2002;53(5):876-881.
56. Li G, Tang N, DiScala C, Meisel Z, Levick N, Gabor K. Cardiopulmonary resuscitation in pediatric trauma patients: survival and functional outcome. *J Trauma.* 1999;47(1):1-7.
57. Broides A, Sofer S, Press J. Outcome of “out of hospital” cardiopulmonary arrest in children admitted to the emergency room. *IMAJ.* 2000;2(9):672-674.
58. Lin Y-R, Wu H-P, Huang C-Y, Chang Y-J, Lin C-Y, Chou C-C. Significant factors in predicting sustained ROSC in paediatric patients with traumatic out-of-hospital cardiac arrest admitted to the emergency department. *Resuscitation.* 2007;74(1):83-89.
59. Topjian AA, Berg RA, Nadkarni VM. Pediatric cardiopulmonary resuscitation: Advances in science, techniques and outcomes. *Pediatrics.* 2008;122(5):1086-1098.
60. Donoghue AJ, Nadkarni V, Berg RA, et al; Can AM Pediatric Arrest Investigators. Out-of-hospital pediatric cardiac arrest: an epidemiologic review and assessment of current knowledge. *Ann Emerg Med.* 2005;46(6):512-522.
61. Gerein RB, Osmond MH, Stiell IG, Nesbitt LP, Burns S; OPALS Study Group. What are the etiology and epidemiology of out-of-hospital pediatric cardiac arrests in Ontario, Canada? *Acad Emerg Med.* 2006;13(6):653-658.

62. Rodriguez-Nunez A, Lopez-Herce J, Garcia C, Dominguez P, Carrillo A, Bellon JM; Spanish Study Group of cardiopulmonary arrest in Children. Pediatric defibrillation after cardiac arrest: initial response and outcome. *Crit Care*. 2006;10(4):R113-R120.
63. Babl FE, Vinci RJ, Bauchner H, Mottley L. Pediatric pre-hospital advanced life support care in an urban setting. *Pediatr Emerg Care*. 2001;17(1):5-9.
64. Fisher B, Worthen M. Cardiac arrest induced by blunt trauma in children. *Pediatr Emerg Care*. 1999;15(4):274-276.
65. Horisberger T, Fischer JE, Fanconi S. One-year survival and neurological outcome after pediatric cardiopulmonary resuscitation. *Intensive Care Med*. 2002;28(3):365-368.
66. Capizzani AR, Drongowski R, Ehrlich PF. Assessment of termination of trauma resuscitation guidelines: are children small adults? *J Pediatr Surg*. 2010;45(5):903-907.
67. Moler FW, Donaldson AE, Meert K, et al; Pediatric Emergency Care Applied Research Network. Multicenter cohort study of out-of-hospital pediatric cardiac arrest. *Crit Care Med*. 2011;39(1):141-149.
68. Murphy J, Jaiswal K, Sabella J, Vinson L, Megison S, Maxson R. Prehospital cardiopulmonary resuscitation in the pediatric trauma patient. *J Ped Surg*. 2010;45(7):1413-1419.
69. Widdel L, Winston KR. Prognosis for children in cardiac arrest shortly after blunt cranial trauma. *J Trauma*. 2010;69(4):783-788.
70. Bardai A, Berdowski J, van der Werf C, et al. Incidence, causes, and outcomes of out-of-hospital cardiac arrest in children. *J Am Coll Cardiol*. 2011;57(18):1822-1828.
71. Berens RJ, Cassidy LD, Matchey J, et al. Probability of survival based on etiology of cardiopulmonary arrest in pediatric patients. *Pediatr Anesth*. 2011;21(8):834-840.
72. Pickens JJ, Copass MK, Bulger EM. Trauma patients receiving CPR: predictors of survival. *J Trauma*. 2005;58(5):951-958.
73. Stratton SJ, Brickett K, Crammer T. Prehospital pulseless, unconscious penetrating trauma victims: field assessments associated with survival. *J Trauma*. 1998;45(1):96-100.
74. Moler FW, Meert K, Donaldson AE, et al. In-hospital versus out-of-hospital pediatric cardiac arrest: a multicenter cohort study. *Crit Care Med*. 2009;37(7):2259-2267.
75. Hickey RW, Cohen DM, Strausbaugh S, Dietrich AM. Pediatric patients requiring CPR in the prehospital setting. *Ann Emerg Med*. 1995;25(4):495-501.
76. Richman P, Vadeboncoeur T, Chikani V, et al. Independent evaluation of an out-of-hospital termination of resuscitation (TOR) decision rule. *Acad Emerg Med*. 2008;15(6):517-521.
77. Seamon M, Fisher C, Gaughan J, et al. Emergency department thoracotomy: survival of the least expected. *World J Surg*. 2008;32(4):604-612.
78. Atkins D, Everson-Stewart S, Sears G, et al. Epidemiology and outcomes from out-of-hospital cardiac arrest in children. The Resuscitation Outcomes Consortium Epistry-Cardiac Arrest. *Circulation*. 2009;119(11):1484-1491.
79. Deasy C, Bernard S, Cameron P, et al. Epidemiology of paediatric out-of-hospital cardiac arrest in Melbourne, Australia. *Resuscitation*. 2010;81(9):1095-1100.
80. Brindis SL, Gausche-Hill M, Young K, et al. Universally poor outcomes of pediatric traumatic arrest. A prospective case series and review of the literature. *Pediatric Emergency Care*. 2011;27(7):616-621.
81. Stockinger ZT, McSwain NE Jr. Additional evidence in support of withholding or terminating cardiopulmonary resuscitation for trauma patients in the field. *J Am Coll Surg*. 2004;198(2):227-231.
82. Fiser DH. Assessing the outcome of pediatric intensive care. *J Pediatr*. 1992;121(1):68-74.
83. American Academy of Pediatrics, Committee on Hospital Care, Section on Surgery, and Section on Critical Care. Pediatric organ donation and transplantation. *Pediatrics*. 2010;125(4):822-828.
84. Kleinman ME, de Caen AR, Chameides L, et al; The International Liaison Committee on Resuscitation. The International Liaison Committee on Resuscitation (ILCOR) consensus on science with treatment recommendations for pediatric patients: pediatric basic and advanced life support. *Pediatrics*. 2010. [DOI: 10.1542/peds.2010-2972A].
85. Martin JA, Kung H-C, Mathews TJ, et al. Annual summary of vital statistics. *Pediatrics*. 2008;121(4):788-801.
86. American Academy of Pediatrics, Committee on Child Abuse and Neglect and Committee on Bioethics. Forgoing life-sustaining medical treatment in abused children. *Pediatrics*. 2000;106(5):1151-1153.
87. Tibballs J, Russell P. Reliability of pulse palpation by healthcare personnel to diagnose paediatric cardiac arrest. *Resuscitation*. 2009;80(1):61-64. [Epub 2008 Nov 6].
88. Trzeciak S, Rivers EP. Emergency department overcrowding in the United States: an emerging threat to patient safety and public health. *Emerg Med J*. 2003;20(5):402-405.
89. Cowan RM, Trzeciak S. Clinical review: Emergency department overcrowding and the potential impact on the critically ill. *Crit Care*. 2005;9(3):291-295.
90. Institute of Medicine, Committee on the Future of Emergency Care in the United States Health System, Subcommittee on Pediatric Emergency Care. *Emergency Care for Children: Growing Pains*. Washington, DC: National Academies Press; 2007.
91. Verbeek PR, Vermeulen MJ, Aii FH, Messenger DW, Summers J, Morrison LJ. Derivation of a termination-of-resuscitation guideline for emergency medical technicians using automated external defibrillators. *Acad Emerg Med*. 2002;9(7):671-678.
92. Morrison LJ, Visentin LM, Kiss A, et al. Validation of a rule for termination of resuscitation in out-of-hospital cardiac arrest. *N Engl J Med*. 2006;355(5):478-487.
93. Morrison LJ, Visentin LM, Vermeulen M, et al; TOR Investigators. Inter-rater reliability and comfort in the application of basic life support termination of resuscitation clinical prediction rule for out of hospital cardiac arrest. *Resuscitation*. 2007;74(1):150-157.
94. Maguire BJ, Huntingt KL, Smith GS, Levick NR. Occupational fatalities in emergency medical services: a hidden crisis. *Ann Emerg Med*. 2002;40(6):625-632.
95. Maguire BJ, Huntingt KL, Guidotti TL, Smith GS. Occupational injuries among emergency medical services personnel. *Prehosp Emerg Care*. 2005;9(4):405-411.
96. Centers for Disease Control and Prevention. Ambulance crash-related injuries among emergency medical services workers—United States, 1991-2002. *MMWR Morb Mortal Wkly Rep*. 2003;52(8):154-156.
97. Clawson JJ, Martin RL, Cady GA, Maio RF. The wake-effect-emergency vehicle-related collisions. *Prehosp Disaster Med*. 1997;12(4):274-277.
98. O'Brien E, Hendricks D, Cone DC. Field termination of resuscitation: analysis of a newly implemented protocol. *Prehosp Emerg Med*. 2008;12(1):57-61.
99. Bailey ED, Wydro GC, Cone DC. Termination of resuscitation in the pre-hospital setting for adult patients suffering nontraumatic cardiac arrest. National Association of EMS Physicians Standards and Clinical Practice Committee. *Prehosp Emerg Care*. 2000;4(2):109-195.
100. Pepe PE, Swor RA, Ornato JP, et al. Turtle Creek Conference II. Resuscitation in the out-of-hospital setting: medical futility criteria for on-scene pronouncement of death. *Prehosp Emerg Care*. 2001;5(1):79-87.
101. Richman PB, Vadeboncoeur TF, Chikani V, Clark L, Bobrow BJ. Independent evaluation of an out-of-hospital termination of resuscitation rule. *Acad Emerg Med*. 2008;15(6):517-521.
102. Sasson C, Hegg AJ, Macy M, Park A, Kellermann A, McNally B; CARES surveillance Group. Prehospital termination of resuscitation

- in cases of refractory cardiac arrest. *JAMA*. 2008;300(12):1432-1438.
103. Delbridge TR, Fosnocht DE, Garrison HG, Auble TE. Field termination of unsuccessful out-of-hospital cardiac arrest resuscitation: acceptance by family members. *Ann Emerg Med*. 1996;27(5):649-654.
  104. Edwardsen EA, Chiumento S, Davis E. Family perspective of medical care and grief support after field termination by emergency services personnel- a preliminary report. *Prehosp Emerg Care*. 2002;6(4):440-444.
  105. Marco CA, Larkin GL. Public education regarding resuscitation: effects of a multimedia intervention. *Ann Emerg Med*. 2003;42(2):256-260.
  106. Marco CA, Larkin GL. Cardiopulmonary resuscitation: knowledge and opinions among the U.S. general public State of the science fiction. *Resuscitation*. 2008;79(3):490-498.
  107. Compton S, Madgy A, Goldstein M, Sandhu J, Dunne R, Swor R. Emergency medical service providers' experience with family presence during cardiopulmonary resuscitation. *Resuscitation*. 2006;70(2):223-226.
  108. Seidel JS. Emergency medical services and the pediatric patient: are the needs being met? II. Training and equipping emergency medical services providers for pediatric emergencies. *Pediatrics*. 1986;78(5):808-812.
  109. Zaritsky A, French JP, Schafermeyer R, Morton D. A statewide evaluation of pediatric prehospital and hospital emergency services. *Arch Pediatr Adolesc Med*. 1994;48(1):76-81.
  110. Glaeser PW, Linzer J, Tunik MG, Henderson DP, Ball J. Survey of nationally registered emergency medical services providers: pediatric education. *Ann Emerg Med*. 2000;36(1):33-38.
  111. Stevens SL, Alexander JL. The impact of training and experience on EMS providers' feelings towards pediatric emergencies in a rural state. *Pediatr Emerg Care*. 2005;21(1):12-17.
  112. Posner JC, Osterhoudt KC, Mollen CJ, Jacobstein CR, Nicolson SC, Gaynor W. Extracorporeal membrane oxygenation as a resuscitative measure in the pediatric emergency department. *Pediatr Emerg Care*. 2000;16(6):413-415.
  113. Yamamoto LG, Young LL. Acute-onset dysrhythmia heralding fulminant myocarditis and refractory cardiac arrest treated with ED cardiopulmonary bypass and extracorporeal membrane oxygenation. *Am J Emerg Med*. 2007;25:348-352.
  114. Ayad O, Dietrich A, Mihalov L. Extracorporeal membrane oxygenation. *Emerg Clin North Am*. 2008;26:953-959.
  115. Hutchison JS, Ward RE, Lacroix J, et al. Hypothermia therapy after traumatic brain injury in children. *N Engl J Med*. 2008;358(23):2447-2456.
  116. Nichol G, Rumsfeld J, Eigel B, et al. Essential features of designating out-of-hospital cardiac arrest as a reportable event: a scientific statement from the American Heart Association Emergency Cardiovascular Care Committee; Council on Cardiopulmonary, Perioperative, and Critical Care; Council on Cardiovascular Nursing; Council on Clinical Cardiology; and Quality of Care and Outcomes Research Interdisciplinary Working Group. *Circulation*. 2008;117(17):2299-2308.