Education and Practice

Recommendations on Ambulance Cardiopulmonary Resuscitation in Basic Life Support Systems

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ABSTRACT

Aim. Cardiopulmonary resuscitation (CPR) during ambulance transport can be a safety risk for providers and can affect CPR quality. In many Asian countries with basic life support (BLS) systems, patients experiencing out-of-hospital cardiac arrest (OHCA) are routinely transported in ambulances in which CPR is performed. This paper aims to make recommendations on best practices for CPR during ambulance transport in BLS systems. **Methods.** A panel consisting of 20 experts (including 4 North Americans) in emergency medical services (EMS) and resuscitation science was selected, and met over two days. We performed a literature review and selected 33 candidate issues in five core areas. Using Delphi methodology, the issues were classified into dichotomous (yes/no), multiple choice, and ranking questions. Primary consensus between experts was reached when there was more than 70% agreement. Questions with 60–69% agreement were made more specific and were submitted for a second round of voting. **Results.** The panel agreed upon 24 consensus statements with more than 70% agreement (2 rounds of voting). The recommendations cover the following: length of time on the scene; advanced airway at the scene; CPR prior to transport; rhythm analysis and defibrillation during transport; prehospital interventions; field termination of resuscitation (TOR); consent for TOR; destination hospital; transport protocol; number of staff members; restraint systems; mechanical CPR; turning off of the engine for rhythm analysis; alternative CPR; and feedback for CPR quality. **Conclusion.** Recommendations for CPR during ambulance transport were developed using the Delphi method. These recommendations should be validated in clinical settings. **Key words:** resuscitation; ambulance; cardiac arrest; consensus

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INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is a major cause of death globally, particularly in North America[1] and Asia.[2–5] Early and effective cardiopulmonary resuscitation (CPR) is an important factor that affects survival outcomes.[6] In North American and European models of advanced life support (ALS) emergency medical services (EMS) systems, resuscitation for OHCA is usually performed by providers (paramedics and physicians) on site. Resuscitations are often managed at the site where the patient experiences the event until the return of spontaneous circulation (ROSC) or death.[7,8] Typically, resuscitations are terminated prior to transport to the hospital if the treatment efforts are deemed futile. CPR during ambulance transport is less common and is often confined to patients with persistent ventricular fibrillation (VF) or who experience cardiac arrest en route.

In contrast, in basic life support (BLS) EMS systems, especially in Asian countries, most patients experiencing OHCA are transported to emergency departments (EDs) with active CPR in the ambulance en route.[2–5,9] This difference might be due to policies forbidding BLS providers to pronounce death on site, the perceived lack of ALS interventions on site, cultural/societal norms that expect active resuscitation/conveyance to the hospital, and local medico-legal issues.

Ambulance CPR can be defined as the provision of CPR to OHCA victims by EMS providers during transport to the hospital in a moving ambulance. In the context of this paper, we are referring to EMS systems with basic and intermediate service levels. Ambulance CPR is routine in such systems because they usually do not allow providers to terminate resuscitation at the scene unless there is ROSC. CPR is very challenging in a moving ambulance, and questions regarding the effectiveness of CPR and the safety of the EMS crew arise. There is also controversy surrounding best practices. The International Liaison Committee on Resuscitation (ILCOR), American Heart Association (AHA), and European Resuscitation Council (ERC) recommendations[7,8] are relatively silent on the best policies for ambulance CPR in BLS systems.

We aimed to provide recommendations on CPR during ambulance transport in BLS systems to avoid unsafe practices and to improve CPR quality and OHCA outcomes.

METHODS

Setting

The Asian Emergency Medical Services Council (AEMSC) was established in 2009 as a voluntary, participation-based group promoting education on and advocacy for EMS issues in the Asia-Pacific region. It has adopted the Pan Asian Resuscitation Outcomes Study (PAROS) as one of its core activities for the period between 2009 and 2014.[10] The PAROS clinical research network was inaugurated in 2010. More information about the PAROS network and the Asian EMS Council can be found at: www.scri.edu.sg/index.php/paros-clinical-research-network.

Study Design

Expert panel consensus was employed using the Delphi method. The study was exempted from institutional review board approval because there was no study intervention or use of patient information.

Study Participants

A panel consisting of 16 experts on EMS and resuscitation science was proposed, and its members were selected from the AEMSC executive committee.[9] Additionally, 4 experts were invited from the National Association of EMS Physicians (NAEMSP) of North America. The main criterion for expert selection was that the member should be a nationally/internationally recognized EMS researcher or EMS medical director. Countries and cities from which our panel experts came were as follows: Republic of Korea (Seoul, Daegu, Gwangju), Japan (Tokyo, Osaka, Kyoto), Taiwan (Taipei, Tainan), Singapore (Singapore), Thailand (Bangkok), Malaysia (Kuala Lumpur), and the United States (Atlanta, Georgia; Beaumont, Michigan; Wake County/Raleigh, North Carolina; Modesto, California).

Study Protocol and Data Collection

First, the expert panel was created. Second, a literature review and discussion of potential issues regarding CPR were undertaken. The literature review was performed by the experts without mandating a standardized review protocol. We chose 10 core areas from the discussion to design the Delphi questionnaire, namely, (1) the differences between Asian and non-Asian EMS; (2) the optimum duration for manual CPR at the scene; (3) the quality of manual CPR on a moving stretcher; (4) the number of crew members needed for good-quality CPR in an ambulance; (5) preventing crew injuries from falls during ambulance CPR; (6) alternative methods during ambulance CPR; (7) time intervals for automated external defibrillator (AED) rhythm analysis during ambulance transport; (8) measuring the quality of CPR during ambulance transport; (9) mechanical CPR devices as alternatives to manual CPR during ambulance transport; and (10) airway management and ventilation during ambulance transport. Third, the first round of the Delphi survey was completed to derive a primary consensus. Fourth, we shared the primary consensus with the expert panel and performed a second round of Delphi surveying via e-mail. As the final step, we summarized the final consensus (Fig. 1).

Each of the 10 core areas was independently reviewed by two experts at the meeting and was discussed in four small groups during the two-day consensus meeting. We designed a questionnaire from the literature review and discussion as the second step (see Appendix 1, available online). Of the 10 areas discussed, 5 areas were considered more important, and 32 candidate issues in these areas were included in the questionnaires. All of the participants voted in the first Delphi round using the questionnaires. The questionnaire consisted of dichotomous answers (yes/no), multiple choice questions, and ranking questions. In terms of the evaluation algorithm, primary consensus was considered reached when there was more than 70% agreement for dichotomous and multiple choice questions. This cutoff point was deemed appropriate because previous studies have reported using the same cutoff point and have also suggested that a minimum of 70% agreement is required for validity when using the Delphi method.[11–13] Dichotomous questions with 60–69% agreement were sent for a second round of voting. Likewise, multiple choice questions with 60–69% agreement were narrowed down to the top 3 options and were sent for a second round of voting. For ranking questions, the top 3 options were narrowed down for further voting.

During the second round of voting, questions with more than 70% of agreement were regarded as a secondary consensus. We summarized the issue lists from the primary and secondary consensus as the final step by reviewing them via e-mail to establish the recommendations on CPR during ambulance transport. The English language (without translation) was used as the working language in all of the processes and steps.

Statistical Analysis

Descriptive statistical analysis was performed for each question, and the agreement rates were calculated with frequencies and percentages. Questions with more than 70% agreement for "yes" were regarded as having received positive agreement, while those with more than 70% agreement for "no" were regarded as having received negative agreement. Both were considered to be consensus opinions.

RESULTS

Twenty experts participated in this study, including four North Americans (Table 1). From the literature review and panel discussion, the five areas from which

TABLE 1. Demographics of panel members who voted using the Delphi methodology

	Round 1		Round 2	
Variables	*N*	(%)	*N*	(%)
Total Country	20		18	
Asian (Korea, Malaysia, Japan, Taiwan, Thailand, Singapore)	16	(80.0)	14	(77.8)
Non-Asian (USA)	4	(20.0)	4	(22.2)
Gender				
Male	18	(90.0)	17	(94.4)
Female	2	(10.0)	1	(5.6)
Age, mean [range]	42.2	[33–58]	43.0	[36–59]
Profession				
Physician	20	(100.0)	18	(100.0)
Tiered EMS system				
Two tier, basic plus advanced life support	6	(30.0)	5	(27.8)
Single tier, basic/intermediate life support	12	(60.0)	11	(61.1)
Single tier, advanced life support	2	(10.0)	2	(11.1)
Urbanization level				
Rural plus urban	10	(50.0)	9	(50.0)
Metropolitan	10	(50.0)	9	(50.0)
Protocol for termination of resuscitation				
Yes	4	(20.0)	4	(22.2)
No	16	(80.0)	14	(77.8)

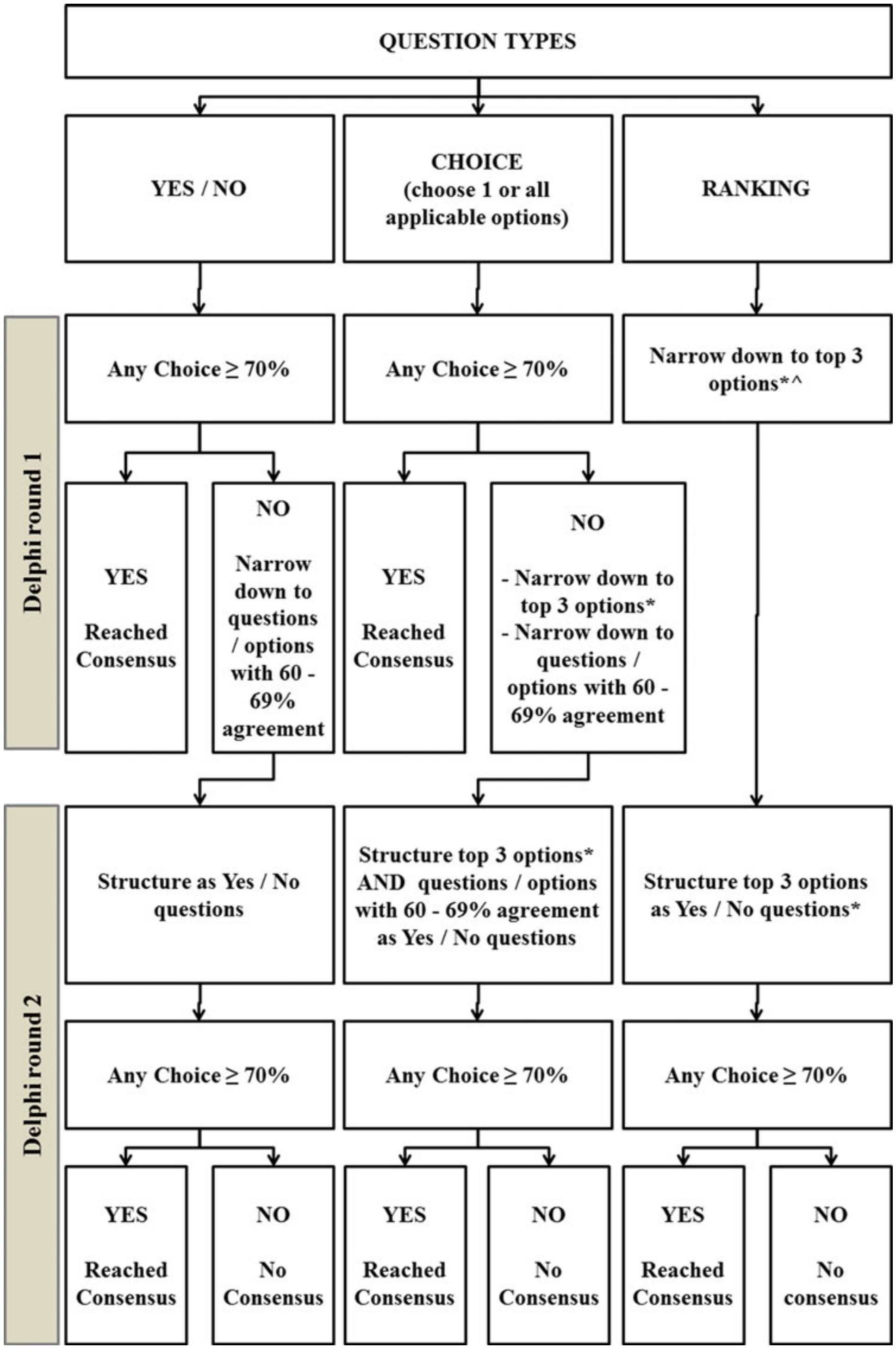

Figure 1. Consensus process evaluation algorithm using Delphi survey. *If there are two or more options ranked first or third, only the top two options will be considered for Yes/No questions in the following round of survey. ^For ranking questions, the narrowed down options will be determined using the median, and mean if required. *Delphi survey method*: All participants voted in the first Delphi round using the questionnaires consisting of dichotomous answers (Yes/No), multiple choice questions, and ranking questions. Primary consensus was considered reached when there was more than 70% agreement for dichotomous and multiple choice questions. Dichotomous questions with 60–69% agreement were sent for a second round of voting. Likewise, multiple choice questions with 60–69% agreement were narrowed down to the top 3 options and sent for a second round of voting. For ranking questions, the top 3 options were narrowed down for further voting. During the second round of voting, questions with more than 70% of agreement were regarded as secondary consensus.

the 33 issues were developed were as follows: (1) opinion on the length of time the crew stays on the scene; (2) opinion on on-site interventions and termination of resuscitation (TOR); (3) opinion on transport of cardiac arrest patients; (4) opinion on the quality of procedures administered in ambulances; and (5) opinion on the usefulness of mechanical compression devices (see Appendix 1, available online).

After two days of meetings and discussions, 10 issues were agreed upon during the first round of Delphi surveying. In the second round, 14 additional issues were agreed upon with more than 70% consensus agreement (Table 2). There was positive agreement for 18 issues and negative agreement for 6 issues. A total of 24 consensus statements were reviewed via e-mail and were accepted by the expert panel. No agreement was reached on 18 issues (Table 3).

DISCUSSION

There are very few data on the optimal methods of providing CPR and other resuscitative measures during ambulance transport. During ambulance transport, CPR is usually performed using the traditional method, with the provider standing at the patient's side. In Asia, resuscitation en route is commonly performed by a team of three providers. Providers and their equipment are infrequently restrained. These recommendations are helpful in highlighting the difficulties faced with CPR during ambulance transport, to guide EMS directors in designing more feasible and more effective protocols in their systems.

The Length of Time an Ambulance Crew Should Stay On-site

We recommend that the decision regarding the length of time an ambulance crew stays on site should be driven by protocol (treatment and response to treatment), rather than by elapsed time alone. The medical literature suggests that patients who achieve ROSC prior to arrival at the hospital are more than 30 times more likely to survive than are those who arrive in the emergency department with ongoing resuscitation efforts.[14–16] The movement of patients in cardiac arrest will decrease the effectiveness of cardiac compressions and place the patients and providers at risk for motor vehicle crashes.[17] Procedures such as inserting an advanced airway are also difficult within the setting of a moving ambulance.

However, efforts directed at resuscitation on site in a BLS setting are limited by the situation, environment, and interventions available, as well as by pressure to transport patients to the hospital. In many BLS settings, the EMS crew is not allowed to pronounce death or decide to terminate resuscitation efforts. There are also societal, cultural, and policy expectations that patients will be transferred to hospitals. The advent of extracorporeal membrane oxygenation (ECMO) for cardiac arrest also means that there are additional interventions available in hospitals that are not available in the field. Thus, a balance is required between "stay and play" and "scoop and run."

There is little objective evidence for the recommendation on the transportation of patients with cardiac arrest who do not achieve ROSC on site. However, the consensus reached in our study recommends transportation immediately, after 3–4 cycles of CPR at the scene, including defibrillation if indicated and advanced airway management.

On-site Interventions and Termination of Resuscitation

Based on our consensus, CPR, defibrillation, mechanical CPR, and supraglottic airways are considered effective interventions in the field for OHCA. The importance of CPR and defibrillation in the field for OHCA has been established in several studies.[18,19] However, it is important to recognize that there are no conclusive data to support or refute the effectiveness of mechanical CPR or supraglottic airways for the management of OHCA in the field. For instance, a literature review of mechanical CPR vs. manual CPR found that although mechanical CPR improves the quality of CPR, it does not improve survival, and it might even have a negative impact on neurological outcomes.[20] It is also still unclear whether survival from OHCA is improved by the use of endotracheal intubation (ETI), instead of supraglottic airway (SGA) devices or basic airway management.[21,22] However, SGA devices are known to be easier and faster to insert by lower-level providers, such as EMTs. Hence, although our expert panel recommended that these interventions should be attempted on scene before transporting the patient, EMS directors should bear in mind the existing evidence when considering these recommendations.

We recommend that online medical control be used for decisions regarding on-site TOR and that the family should be asked for consent (verbal or written) before on-site TOR. Currently, there are evidence-based guidelines that providers can use to identify patients who are undergoing futile resuscitation and to terminate resuscitation on-site without needless transport.[23,24] However, our panel could not agree on whether the NAEMSP BLS and ALS TOR guidelines were applicable in their local settings, especially in Asia. These guidelines also do not take into account family wishes or consent. Local EMS systems should develop their own guidelines/protocols for on-site resuscitation and termination of obviously futile cases, with consideration for local and cultural settings.

TABLE 2. Consensus statements showing agreement from Delphi survey rounds 1 and 2

Consensus statements	No. of respondents in agreement[a] N	%	Established in round
(A) Length of time crew stays on scene			
1 The decision regarding the length of time ambulance crew stays on scene should be driven by protocol (treatment and response to treatment) rather than by time elapsed alone	16	80.0	1
2 Three to four rounds of CPR should be given prior to transport	15	83.3	2
3 Crew should stay at scene for at least a minimum period (not more than 20 min) for rhythm analysis and defibrillation	17	94.4	2
4 Advanced airways such as ETI and SGA should be established at scene before transport	ETI: 14	70.0	1
	SGA: 18	90.0	
(B) On-scene interventions and termination of resuscitation			
1 CPR, defibrillation, mechanical CPR, and supraglottic airways are considered effective interventions for OHCA in the field	CPR: 20	100.0	1
	Defibrillation: 20	100.0	
	Mechanical CPR: 16	80.0	
	SGA: 15	75.0	
2 Online medical control is useful for deciding on-scene TOR	16	80.0	1
3 Family should be asked for consent (verbal or written) before on-scene TOR	16	88.9	2
(C) Transport of the cardiac arrest patient			
1 Cardiac arrest patients should be transported to a specialty hospital or cardiac arrest center, rather than to any of the nearest hospitals	18	90.0	1
2 Availability of prehospital interventions, assurance of good quality EMS care/training/skills, clinical prognosis, social/cultural context, and acceptability of on-scene TOR should be used to guide decision to transport cardiac arrest patient prior to ROSC	Prehospital: 20	100.0	1
	EMS care: 20	100.0	
	Clinical prognosis: 18	90.0	
	Social: 17	85.0	
3 Two to three crew members are required at the back of the ambulance for manual CPR	18	100.0	2
4 Using a seat-belt restraint system is the best way (effective and easy to implement) to ensure crew safety during transport	13	72.2	2
(D) Quality of procedures administered in the ambulance			
1 Mechanical CPR is a better alternative to manual CPR in the ambulance	20	100.0	1
2 Straddle CPR should <u>not</u> be the recommended technique for CPR in a moving ambulance	14	77.8	2
3 The engine should not be turned off when analyzing rhythm	15	75.0	1
4 If the ambulance makes a routine stop (e.g., traffic light), one analysis/shock should be allowed	16	88.9	2
5 For patients with a new VT/VF (change of rhythm) en route, the ambulance should stop for analysis and defibrillation	16	88.9	2
6 For patients with persistent/recurrent VT/VF, the ambulance may stop more than once during transport to analyze rhythm	13	72.2	2
7 Live video feedback is <u>not</u> the best method (effective and easy to implement) to measure quality of CPR in the ambulance	14	77.8	2
8 ETI is <u>not</u> the best method (effective and easy to implement) for ALS airway management.\	14	77.8	2
(E) Usefulness of mechanical compression devices			
1 Mechanical CPR should be the recommended technique for CPR in a moving ambulance	15	83.3	2
2 Mechanical compression devices may be useful in all situations, regardless of duration of transfer from scene to ambulance or duration of transport	Transfer: 17	85.0	1
	Transport: 15	75.0	
3 Provided that there is good quality CPR on the scene by first responders, a mechanical device may be brought in by a second tier responder	19	95.0	1
4 A battery-driven automatic chest compressor is the ideal mechanical CPR device for use in ambulances	16	88.9	2
5 A gas-driven automatic chest compressor is <u>not</u> the ideal mechanical CPR device for use in ambulances	16	88.9	2

[a] Total number of attendees was 20 in the first round and 18 in the second round.

CPR, cardiopulmonary resuscitation; ETI, endotracheal intubation; SGA, supraglottic airway; OHCA, out-of-hospital cardiac arrest; TOR, termination of resuscitation; EMS, emergency medical service; ROSC, return of spontaneous circulation; ALS, advanced life support; VT/VF, ventricular tachycardia/ventricular fibrillation.

TABLE 3. Issues on which consensus could not be reached

Statements	Respondents N	%
Crew should "stay and play" longer until return of spontaneous circulation		
Yes	6	(33.3)
No	11	(61.1)
IV adrenaline (epinephrine) is an effective intervention for out-of-hospital cardiac arrest in the field		
Yes	12	(66.7)
No	6	(33.3)
Hypothermia is an effective intervention for out-of-hospital cardiac arrest in the field		
Yes	11	(61.1)
No	7	(38.9)
NAEMSP BLS and ALS termination of resuscitation (TOR) guidelines are applicable in my local EMS setting		
Yes	9	(50.0)
No	9	(50.0)
The treatment capability of the hospital is the most important factor to determine which hospital the cardiac arrest patient should be transported to		
Yes	11	(61.1)
No	7	(38.9)
Medical control clinical judgment is the most important factor to determine which hospital the cardiac arrest patient should be transported to		
Yes	6	(33.3)
No	12	(66.7)
The paramedics' clinical judgment is the most important factor to determine which hospital the cardiac arrest patient should be transported to		
Yes	10	(55.6)
No	8	(44.4)
Improving ambulance design (to reduce risk of injury) is the best way (effective and easy to implement) to prevent crew from falling down when performing CPR during transport		
Yes	12	(66.7)
No	6	(33.3)
Family should be allowed at the back of the ambulance during transport		
Yes	9	(50.0)
No	8	(44.4)
Using CPR feedback devices is the best way (effective and easy to implement) to improve manual CPR in the ambulance		
Yes	11	(61.1)
No	7	(38.9)
Improving ambulance design is the best way (effective and easy to implement) to improve manual CPR in the ambulance		
Yes	9	(50.0)
No	9	(50.0)
Changing the number of crew members required is the best way (effective and easy to implement) to improve manual CPR in the ambulance		
Yes	8	(44.4)
No	10	(55.6)
End tidal CO_2 is the best method (effective and easy to implement) to measure quality of CPR in ambulance		
Yes	11	(61.1)
No	7	(38.9)
Real-time CPR feedback is the best method (effective and easy to implement) to measure quality of CPR in ambulance		
Yes	9	(50.0)
No	9	(50.0)
Laryngeal tube is the best method (effective and easy to implement) for ALS airway management		
Yes	6	(31.6)
No	13	(69.4)
Intubating laryngeal mask airway is the best method (effective and easy to implement) for ALS airway management		
Yes	8	(44.4)
No	10	(55.6)
For patients with initial asystole or PEA, the ambulance should not stop at all to analyze rhythm		
Yes	8	(44.4)
No	9	(50.0)
For patients with initial asystole or PEA, the ambulance should stop only if the AED (during its programmed analysis every 2 minutes) advises a shock		
Yes	11	(61.1)
No	7	(38.9)
For patients with VT/VF, the ambulance should stop only if the AED (during its programmed analysis every 2 minutes) advises a shock		
Yes	12	(66.7)
No	6	(33.3)
Mechanical compression devices may be considered only if there are 2 or more providers		
Yes	9	(50.0)
No	8	(44.4)

CO_2, carbon dioxide,; ALS, advanced life support; PEA, pulseless electrical activity; AED, automated external defibrillator; VT/VF, ventricular tachycardia/ventricular fibrillation.

Transport of the Cardiac Arrest Patient

There is little evidence supporting a defined number of ambulance providers for the provision of quality CPR. The study of Martin-Gill et al. found no difference in the delivery of quality CPR among 2-, 3-, and 4-person crews of paramedics in a cardiac arrest simulation.[25] It is important to note, however, that this study was not conducted under actual field conditions, and more evidence is needed to confirm the effects of ambulance crew configurations on the management of cardiac arrest patients. Another study found that there was no association between the outcomes after OHCA and the number of advanced life support-trained personnel at the scene. However, this was a report on the staffing of ALS providers, so it might not be applicable to BLS systems.[26]

The optimal number of CPR providers is frequently limited by operational constraints. The typical staff of an ambulance in many Asian EMS systems consists of a driver and 2 crew members, who may be BLS or ALS trained or both. Olasveengen et al. demonstrated that CPR quality deteriorates during transport.[27] Significant hands-off time was found, regardless of whether the ambulances were staffed by BLS or ALS personnel.[28] Wang et al. concluded that many of the reasons were operator related and not ambulance related.[29] Fatigue can reduce the quality of compressions over time and can affect cases with long transport times.[30] Although more evidence is needed, the consensus is that the number of ambulance crew members might affect the quality of CPR. We recommend that 2–3 crew members be required at the back of the ambulance for good-quality manual CPR.

Ambulance crews can experience difficulties in keeping balance in moving ambulances, and thus they might provide inadequate CPR for patients. Movement, especially during acceleration and deceleration, can increase the risk of falls and injuries. Prior studies have also revealed significant mortality for ambulance personnel during ambulance crashes.[17] Using a seatbelt restraint system is the best way to ensure crew safety during transport. This is especially true in a restrained, forward-facing seat. However, using a lap belt while seated in the ambulance will typically not allow the crew member to perform adequate CPR for a patient on a stretcher. Thus, there is an unresolved dilemma regarding the use of manual CPR in a moving ambulance.

The Quality of Procedures Administered in the Ambulance

Our consensus is that mechanical CPR is a safer alternative to manual CPR in the ambulance. The consensus recommends mechanical CPR, rather than straddle CPR, to improve safety during ambulance CPR. As discussed in the "On-site Interventions and Termination of Resuscitation" section, previous studies have shown both positive and negative associations between mechanical (versus manual) CPR and survival outcomes.[31,32] These studies usually compared on-site compression by mechanical devices to manual CPR for OHCA. There have been no reports on clinical outcomes with mechanical CPR during ambulance transport. Hence, the recommendation for mechanical CPR was made in consideration for ambulance crew safety, rather than clinical outcomes. Straddle CPR, in which the crew straddles the patient on the stretcher, can increase stability, but it does not reduce the risk of falls or injuries.

Rhythm analysis and shock delivery during ambulance transport is another issue without objective evidence. As most BLS ambulances use AEDs, there is a theoretical risk that engine movement artifacts might be misinterpreted as VF. However, in practice, turning off the engine would result in significant transport delays. We suggest that to analyze the rhythm during transport, the engine need not be turned off. For patients in persistent VF, the ambulance should be allowed to stop more than once during transport to allow for analysis of the rhythm. Delays in rhythm analysis during ambulance transport could lead to prolongation of VF and an increase in myocardial metabolic demand. Nevertheless, this consideration should be balanced with the desire to avoid delays in transport and obstruction of traffic. Thus, we suggest that opportunistic analysis should be undertaken at traffic lights. We do not recommend a regular or periodic stop for AED rhythm analysis during ambulance transport in the Asian EMS context. Rapid lane changes and deceleration to stop the ambulance might put the crew at risk for collisions, so they should not be encouraged. In the BLS context, to use the AED mode, providers should stop the ambulance to be able to "analyze" and then shock if advised. This recommendation is in contrast to the recommendation to ALS crews, which can read the rhythm and give manual shocks on the move.

Continuous and effective chest compression is a key to better outcomes for OHCA during ambulance transport. Chest compression can be divided into three components: quality per compression, quantity, and continuity. Each component should be measured to evaluate the total quality of chest compressions. It seems reasonable to collect relevant variables regarding each component, depending on the purpose of measuring CPR quality, such as ongoing feedback during CPR, quality improvement, and clinical trials.[33] While commercially available defibrillators and standalone devices have the ability to measure the quality of chest compressions, the accuracy or precision of the devices during transportation should also be verified. Video recording could be useful for detecting the factors affecting CPR quality, although its value has yet to be proved. ETI has not been shown to improve survival for OHCA,[22,23] and its implementation in a BLS system requires a large investment in training and resources. Our consensus is that ETI is not recommended as the best airway management in this EMS setting.

The Use of Mechanical Compression Devices

Our consensus suggests the usefulness of mechanical CPR in patients during ambulance transport. These devices can also be used as a second-tier method when high-quality manual CPR is provided initially by a first responder. Mechanical devices can constitute a useful alternative to manual CPR, in terms of safety for the ambulance crew.

LIMITATIONS

There are several limitations we wish to highlight. First, the experts were selected from the AEMSC and the NAEMSP by invitation, so their opinions might not be representative of general opinion. Most of the participants worked in east and south Asian EMS systems, with some from North American systems. These origins might not be representative of the wider international EMS community (e.g., we did not consult experts from European systems). The small number of experts who were consulted and who attended the original meeting is also a limitation. In addition, the panel discussions on CPR during ambulance transport took place over two days and were followed by two Delphi surveys conducted via e-mail. Thus, the evidence reviewed might subsequently be overtaken by new research. Finally, these recommendations cannot be generalized to different local environments, regulations, protocols, and service levels of EMS systems (e.g., ALS systems).

CONCLUSION

Recommendations for CPR during ambulance transport in BLS systems were developed using the Delphi method. We agreed on several critical issues for the safe performance and high quality of CPR during ambulance transport. Our main recommendations are as follows: (1) the EMS crew should stay and treat for more than 3–4 cycles of CPR at the scene; (2) advanced airways should be established prior to transport; (3) online medical control for TOR should be considered; (4) seat belts for improving provider safety should be implemented; and (5) mechanical CPR can be considered as an alternative to manual CPR.

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SUPPLEMENTARY MATERIAL AVAILABLE ONLINE

Appendix 1: Questionnaire—Delphi Survey Rounds 1 and 2. Available at www.informahealthcare.com/pec.