Research

Pre-hospital advanced life support resuscitation training: A pilot of an evidence-based curriculum

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Abstract

Introduction

There is a broad evidence base to support advanced life support (ALS) education for healthcare professionals being structured, realistic and inclusive of a range of human factors. This paper outlines the results of a pilot ALS resuscitation course tailored for providers working in pre-hospital resource-limited settings. The focus on the pre-hospital ALS environment, team mix, techniques, skills and equipment are important because actions taken by pre-hospital healthcare professionals have a critical impact on the likelihood of patient survival.

Methods

A pre-hospital ALS course was piloted following research into the need for a course and development of a pre-hospital-specific curriculum, based on Australian Resuscitation Council (ARC) guidelines. There were 13 pilot courses run, involving 66 participants. Participants all worked in the pre-hospital environment and held qualifications ranging from a Certificate IV in Healthcare through to postgraduate paramedicine qualifications. The pre-hospital ALS course consisted of theory and practical elements, pre-reading and a pre- and post-course quiz. Feedback was sought from course participants and an expert panel was consulted on the findings.

Results

Participants and the Expert Panel indicated that a pre-hospital ALS course should follow current recommendations of the ARC and be delivered to persons with sufficient underpinning knowledge of ALS resuscitation. The course should include pre-reading on ALS protocols and a pre-test followed by one day of face-to-face teaching using equipment reflective of the pre-hospital environment. Scenarios should be relevant to the pre-hospital setting and involve varying numbers of responders. Participants should be assessed on a continual basis during the course.

Conclusion

To improve participant confidence in the delivery of ALS and maximise the likelihood of patient survival, pre-hospital ALS resuscitation education for pre-hospital providers should follow ARC guidelines, include pre-course reading and practical simulation that reflects participants' day-to-day employment.

Keywords:

paramedic; education; resuscitation; prehospital; advanced life support training

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Background

This paper reports the results of a pilot pre-hospital advanced life support (ALS) course based on previous research (1) which highlighted the unique challenges faced in pre-hospital environments including an unpredictable environment, limited resources, spatial constraints, suboptimal lighting and unpredictable bystander behaviour (2). Pre-hospital providers, working with first responders or in multidisciplinary teams, must typically move and perform resuscitation procedures on a narrow stretcher and in a moving vehicle. This contrasts with traditional training for managing cardiac arrests, which is usually delivered based in a hospital environment with standardised equipment, enough space and lighting, fixed beds and a team of known staff. Lyon and Sinclair (2) argued that a specifically designed national 'pre-hospital advanced life support course' would ensure the resuscitation standards of pre-hospital clinicians are maintained at the consistent and high level required.

The International Liaison Committee for Resuscitation (ILCOR), the European Resuscitation Council (ERC) and the Australian Resuscitation Council (ARC) all identify education as a key to improving outcomes from cardiac arrest (3-5). A literature review (6) identified the important components in resuscitation education as being: mode of delivery; assessment; simulation and equipment; human factors; and workplace implementation. Following best practice in the literature, the pilot pre-hospital ALS resuscitation course was delivered with a face-to-face component (1,7,8). Teaching was conducted in an environment similar to participants' workplaces to promote congruence between the education and the work environment (3,9). During this pilot course, competency assessment was considered but not formally performed, however assessment has been identified as an essential component of further pre-hospital ALS resuscitation courses in line with existing literature (5,10). Simulation was included in the course pilot because it has been reported to be a safe way to teach and practise skills without endangering real patients' lives (11-15). Human factors, known as non-technical skills, were included as a component of the course pilot, in particular leadership, teamwork and communication (10,16-19).

Methods

The one-day pilot pre-hospital ALS curriculum was developed following an online survey and interviews with pre-hospital healthcare professionals and first responders, and subsequent input from an expert panel, all with expertise in pre-hospital resuscitation (6). The expert panel were senior academics, ambulance managers or emergency medicine specialists with an identified track record of interest and expertise in pre-hospital resuscitation. Emergency medical care providers with at least a Certificate IV in Healthcare were eligible to participate in the pilot course. Participants, who were all frontline

responders, were recruited through an ambulance service and an industrial healthcare provider that was providing continuing professional education to its own and clients' staff. The course was delivered by the primary researcher on 11 occasions, and two paramedics who had assisted in earlier deliveries of the course on the other two occasions. The course consisted of theory lectures, case studies, video exemplars and practical resuscitation scenarios. It followed a defined curriculum, and all content was based on and consistent with ARC guidelines (20).

Participants were invited to complete a 50 stem-question (total 200 questions) pre- and post-course closed-book quiz addressing theoretical knowledge of pre-hospital resuscitation. Content validity of the quiz was confirmed by administration to six pre-hospital professionals, all of whom were paramedic educators. Reliability was tested by administration to a convenience sample of seven third-year undergraduate paramedic students who had each undertaken a university level ALS course in a prior semester. Internal consistency in the quiz was validated before use on the pilot course using the Cronbach Alpha (21,22) score ($\alpha=0.9$) indicating an acceptable level of consistency in the quiz. The seven students completed the quiz two days apart, without having completed the pilot ALS course and demonstrated no improvement between their first and second quiz attempts, with scores remaining at 72% for both quiz attempts ($M=144$, $SD=8.1$). Four of the students indicated they talked about resuscitation between their two attempts, and three indicated they read information about resuscitation.

The pre-hospital resuscitation quiz was based on the ARC Advanced Life Support 2 course quiz, amended for a pre-hospital environment. The theory lectures and case studies included in the pilot ALS course were delivered over approximately two hours (Table 1).

Six standardised interprofessional role-based hands-on scenarios, using mannikins, reflecting a realistic pre-hospital environment were delivered across the day. Participants on the course completed a feedback sheet which sought their views on each aspect of the course and the support provided by instructors. Participants also provided feedback on achievement of course objectives and their personal demographics.

Ethics approval

Written informed consent and a declaration of fitness to participate were obtained from all participants before course commencement. Research ethics approval was obtained from Edith Cowan University's Human Research Ethics Committee (approval number 14928).

Nine members of an expert panel with expertise in pre-hospital care were consulted on the analysis of the results. Six members provided written feedback, five participated in telephone

interviews and two participated in face-to-face discussions with the researcher.

Results

Thirteen pilot courses were delivered between September 2018 and December 2019. Sixty-six participants provided consent to participate; 71% were male (other demographic characteristics are shown in Table 2). The pilot course consisted of degree qualified (ie. Bachelor degree or postgraduate qualification) and non-degree qualified (Certificate IV or diploma qualification) participants. Ten participants on the pre-hospital pilot course had previously undertaken a standard Advanced Life Support 1 (ALS1) or Advanced Life Support 2 (ALS2) ARC course. Across all participants there was an almost equal proportion who had less than 4 years' experience, 5–9 years' experience or more than 10 years' experience in the pre-hospital environment.

In the pre-course quiz participants achieved a mean score of 133 out of 200 (SD=19) compared with 137 (SD=18) post-course. The scores were skewed slightly (0.3) towards an upper score, however they demonstrated a normal distribution using a Shapiro-Wilk test (23,24). A paired sample t-test showed that the pre- and post-course improvement was statistically significant ($t=-6.5$, $DF=65$, $p<0.01$). Internal

consistency of the quiz completed by course participants was calculated using the Cronbach Alpha (21,22) score ($\alpha=0.9$), which indicated a high level of consistency.

Participants with an undergraduate university degree or postgraduate qualification scored higher than non-degree participants. Non-degree participants achieved a mean score of 126 (SD=15) and degree participants scored 147 (SD=18) in the pre-course quiz. In the post-course quiz, non-degree participants achieved a mean score of 131 (SD=15), and degree participants scored 150 (SD=18). A two-sample t-test showed that there was a statistically significant difference between degree and non-degree participants in both pre-test scores ($t=-4.9$, $DF=36$, $p<0.01$) and post-test scores ($t=-4.3$, $DF=35$, $p<0.01$). There was also a statistically significant difference between pre-course and post-course knowledge quiz scores for both non-degree and degree participants. Non-degree participants achieved a mean pre-course and post-course quiz score of 126 (SD=15) and 131 (SD=15) respectively, which was statistically significant ($t=-5.6$, $DF=43$, $p<0.01$). Similarly, degree participants' scores increased from a pre-course mean of 147 (SD=18) to 150 (SD=18) post-course, which was statistically significant ($t=-3.3$, $DF=21$, $p<0.01$).

Before the course, participants were provided with links to ARC resuscitation guidelines. Forty percent of participants

Table 1. Pre-hospital resuscitation quiz and theory course content

Pre-hospital resuscitation quiz topics	Theory lectures and case studies
Airway management (two questions)	Pre-hospital cardiac arrest in perspective
ALS algorithm (nine questions)	Causes of cardiac arrest in the pre-hospital environment
ALS medications (six questions)	Team based ALS resuscitation
Cardiac arrest in perspective (two questions)	Human factors in resuscitation
Causes of cardiac arrest (one question)	Post-resuscitation care and transport
Decisions relating to resuscitation (two questions)	Decisions relating to resuscitation
Defibrillation (one question)	Hot debriefing including supporting bystanders
Hot debriefing (four questions)	
Human factors (three questions)	
Infection control (one question)	
Legal aspects of resuscitation (one question)	
Rhythm recognition (13 questions)	
Return of spontaneous circulation (ROSC) (two questions)	

Table 2. Participant demographic profile (n=66)

Gender	Qualification						
	Non-degree qualified			Degree qualified			Total
	Certificate IV	Diploma	Bachelor	Graduate certificate	Graduate diploma	Master	
Female	42%	11%	42%	0%	5%	0%	100%
Male	62%	11%	15%	1%	9%	1%	100%
Total	56%	11%	23%	1%	8%	1%	100%

indicated they completed the pre-reading. Participants who did the pre-reading achieved a pre-course quiz mean score of 135 (SD=20) and those who did not had a mean score of 134 (SD=19), with no statistical difference between those who did and those who did not do the pre-reading ($t=0.25$, $DF=50$, $p=0.80$). All but one of the expert panel members agreed that pre-course reading should be mandatory before future courses and suggested that the test be delivered in an open book format and submitted before the course to ensure a minimum level of knowledge is achieved.

Over 90% of course participants identified the content and presentation of theory aspects of ALS as being excellent or good (Figure 1). Participants indicated more time could have been spent on patient assessment. One member of the expert panel recommended that additional theory on transport to a cardiac catheterisation laboratory session be included in the course.

Almost all (98%) course participants identified practical skills sessions, including rhythm recognition, team mix and numbers, and the varying pre-hospital environments used in practical scenarios as being excellent or good (Figure 2). The expert panel agreed that the practical scenarios included in the pilot course were appropriate for a pre-hospital ALS course.

There were six identified learning outcomes for the pilot pre-hospital ALS course, and all pilot course participants reported that the learning outcomes were either fully or partially met (Table 4). This result compares favourably to recent findings from standard ALS1 courses, where 1609 respondents indicated that ALS1 course outcomes were fully or partially met 96–99% of the time (25). All but three of the course participants indicated that the course was entirely relevant to their practice, with the other three indicating it was partially relevant. Of the participants who indicated the course was partially relevant, one was a medical practitioner, one a registered nurse and one a non-degree participant. The expert panel indicated that the course learning outcomes were relevant and appropriate for a pre-hospital ALS course.

Ten participants had previously undertaken an ARC ALS course. Seven indicated that the pilot pre-hospital course was more relevant than the ARC course previously attended, with three (one a medical practitioner, one a registered nurse and one a paramedic) indicating it had the same relevance. None of the participants indicated that the pilot course was less relevant than the ARC course previously attended. Feedback was sought from all course participants in relation to course curriculum and content (Figure 2). Respondents indicated that length, content including the quiz, as well as scenarios were appropriate for a pre-hospital ALS course (Figure 3).

Figure 1. Participant feedback on theory lectures (n=53)

Figure 2. Participant feedback on practical sessions (n=52)

Discussion

The aim of this research was to pilot a pre-hospital (ie. resource-limited) ALS resuscitation course based on a curriculum developed from previous research (1,6) and determine whether it met the needs of participants in relation to their regular working environment. Overall, the course appeared to have met participant needs, with all participants indicating the course learning objectives were fully or partially met.

Current ALS courses require a pre-course open book quiz to be completed as a means of establishing a baseline of participants' theoretical knowledge. The course pilot included a modified closed-book version of this quiz, with additional pre-hospital-specific questions. Like current ARC ALS courses, pre-reading was also included in the pilot course. Only 40% of participants

indicated they undertook the course pre-reading and whether participants completed the pre-reading or not, did not appear to make any difference to their pre-course quiz results, with both pre-reading and no pre-reading groups scoring less than 80% on the quiz, which the ARC regards as a minimum knowledge threshold before starting an ALS course. The low scores achieved by all participants in the knowledge quiz suggests a need to make pre-reading mandatory and to test knowledge in an open-book format.

The participants' t-test showed that the variation in quiz results between degree and non-degree participants was statistically significant, suggesting that those with a degree were better prepared for the course. The expert panel suggested that because of the level of in-depth knowledge required for ALS, the course may be better aimed at participants with a university degree, and a separate pre-hospital intermediate life support

Figure 3. Course feedback (n=54)

Table 4. Achievement of learning outcomes (n=52)

Learning outcomes	Fully met	Partially met	Not met	Total
Management of the patient in cardiac arrest in the pre-hospital setting using the ARC cardiac arrest algorithm	92%	8%	0%	100%
Identify and treat the pre-hospital reversible causes of cardiac arrest using a structured team-based approach	88%	12%	0%	100%
Recognise non-life sustaining cardiac rhythms, delivering appropriate safe defibrillation therapy when indicated	85%	15%	0%	100%
Lead and be a constructive member of a pre-hospital resuscitation team	92%	8%	0%	100%
Plan the management and safe extrication and transfer/care of the post-resuscitation patient	88%	12%	0%	100%
Recognise life extinct and conduct hot debriefing on scene	87%	13%	0%	100%
Overall learning needs	85%	15%	0%	100%

(ILS) course be developed for those without a degree. Quiz scores improved between the start and end of the course in both degree and non-degree participants, and this result was found to be statistically significant. This result suggests that the pre-hospital resuscitation course, with no external influences, directly improved pre-hospital resuscitation knowledge.

The duration of the face-to-face component of current ARC courses is one (ALS1) and two (ALS2) days. There does, however, not appear to be any peer-reviewed literature recommending the ideal duration of an ALS course. Feedback from participants and the expert panel suggested that one day for the pre-hospital course was appropriate given the focus on shockable and non-shockable rhythms. Both participants and the expert panel suggested that specialist resuscitation situations would require more time.

The pilot pre-hospital ALS course covered elements unique to the pre-hospital environment including multidisciplinary teams working with first responders, varying numbers of responders and varying locations. Feedback from participants suggested that interdisciplinary education and contextualisation for the pre-hospital environment was a key benefit of the course. The expert panel agreed with this finding, in particular it indicated a strong preference for interdisciplinary education that is also well established in the literature (26-30). Information from the ARC indicates that all but 1% of participants on ALS1 courses were nurses and doctors (25). This pilot course included interdisciplinary teams of health professionals, trained first responders and lay persons as would be typically found in the pre-hospital environment. It could therefore be argued that the course was less monoculture in nature and more accurately reflected the pre-hospital environment when compared to a standard ARC course. There is, however, further work required to compare the impact of pre-hospital ALS courses with single cohorts of participants against multidisciplinary groups of participants.

Following best practice as identified in the literature, the pilot pre-hospital ALS course had a face-to-face element (1,7,8) including lectures and case studies. Participant satisfaction with the theory elements of the pilot course was similar to that of standard ALS1 courses. In 12-month post-course feedback from 1,687 ALS1 participants, 98% of respondents rated the causes of cardiac arrest lecture and ALS algorithm lecture as excellent or good (25). The expert panel also agreed that a face-to-face element was critical in a pre-hospital resuscitation course.

The pilot course, like current ARC ALS courses, assumed technical skill capability of each participant and focussed on skill application in the pre-hospital environment. In line with the literature (3,9) simulation was used to embed pre-hospital resuscitation skills. The objectives for the pilot pre-hospital course focussed less on technical skill and more on human factors, including teamwork and communication, in an environment and culture in which the participants typically

work. If participants do not have a baseline level of technical skill capability and need to focus on this, scenarios may be challenging in relation to embedding higher-level ALS human factor skills. The expert panel suggested that a two-phase approach incorporating an ILS course could be considered with a first phase focussing on technical skills to ensure a baseline level of knowledge before an ALS course being undertaken. Almost all course participants (98%) identified the practical skills component as being excellent or good.

Existing literature has identified that human factors are an important component of healthcare (10,31) and the pilot pre-hospital ALS course addressed team communication and team leadership in the pre-hospital setting. The quiz, where both groups had a three and 6% improvement in their theoretical knowledge of human factors, and feedback from participants indicated that incorporating human factors into scenarios were a valued component of the course.

The use of scenarios in the pilot course allowed for theory, skills and human factors to be consolidated and practised in a physically and psychologically safe environment without risk to actual patients (11-15). The pilot course included, as recommended by the literature and past phases of this research (6), equipment commonly used in the pre-hospital environment and response teams were varied to reflect those commonly encountered in the pre-hospital environment. The move towards interprofessional teamwork has been recommended in the literature (10,16-19). Feedback from participants identified that teaching a standardised ALS approach which could be applied in any pre-hospital situation was beneficial.

It is important that participants complete assessment and receive feedback during educational courses (5,10). The pilot course did not formally assess participants' competency. Continual assessment is the approach taken in the ALS1 course and it may be appropriate to adopt the same approach for a pre-hospital ALS course in the future.

Education courses should be taught by professionals who are knowledgeable in the content and accreditation supports robust course governance and quality control (3-5). Feedback from participants and the expert panel suggested that a pre-hospital ALS course should be taught by Australian Health Practitioner Regulation Agency registered pre-hospital professionals, who have undertaken an ARC instructor course, or are accredited by a state ambulance service.

Limitations

The findings of this research, while valuable, must be considered in light of several limitations and potential systematic and non-systematic errors (32). There was potential that the statistical analysis is flawed because there was a small sample of participants (ie. sampling error). The small number

of participants was necessary due to the maximum allowable number of participants in each course and could be addressed through further courses across a wider cohort of participants.

Representation from a range of pre-hospital providers from Certificate-IV to those with postgraduate qualifications ensured a cross-section of results was obtained from the pilot courses. Additionally, feedback from an expert panel was sought to supplement and confirm information collected from course participants.

There also exists the potential for bias due to self-selection (33). Some participants in the course were part of a five-day continuing development course, and while participants could elect not to participate in the research, they were required to participate in the resuscitation component of their course. Other course participants already had an interest in pre-hospital resuscitation so could provide a biased view in relation to the content. This potential bias was addressed by including participants from a range of backgrounds, and also seeking the input from an expert panel. In future research this limitation could be addressed by making the course optional for participants.

Response bias (34) is another potential limitation of this research. The course feedback form focussed on the perceptions and personal experiences of participants and this could have resulted in response bias, addressed by asking questions in different formats and in different Likert scales. Different respondents may have had different experiences and subsequently provided different views about the ALS course.

The primary researcher, who is an operational paramedic, has experience of pre-hospital ALS and may have unintentionally influenced the analysis resulting in experimenter expectancy bias (35,36). Expectancy bias was managed by relying on the feedback from participants in developing the findings and discussing the findings with the expert panel who were independent of the data collection and training. Future research could address expectancy bias by having a wider range and greater number of trainers.

This research has identified what could be included in a pre-hospital ALS course based on a pilot project. This means the research does not yet confirm whether the suggested inclusions would improve patient outcomes. To determine whether patient outcomes are improved would require a longitudinal study, using patient data which is readily available, and which could be de-identified and linked back to the education undertaken by the responders.

Conclusion

Previous research found that the pre-hospital environment typically involves unique challenges including an unpredictable environment, limited resources, spatial constraints, suboptimal

lighting and unpredictable bystander behaviour. There are recommendations from the Australian Resuscitation Council for the provision of ALS education, however there currently does not appear to be any Australian peer-reviewed recommendations for specific pre-hospital ALS education. This research sought to, based on previous work, pilot a pre-hospital ALS course to determine if it had the potential to improve the knowledge and skills of pre-hospital professionals working in resource-limited environments.

The findings of the pilot ALS course suggested that a pre-hospital specific ALS course improved participants' confidence and skills for resuscitation in a resource-limited environment. This finding is important because the course may better prepare pre-hospital responders for real events. The findings of the course pilot suggested a pre-hospital ALS course should align with current ARC guidelines and include online pre-course readings and a quiz. Further work is required to determine entry points for a pre-hospital ALS course. This research suggested the ALS course should have a face-to-face element that includes lectures, case studies, skills and scenarios based on pre-hospital ALS situations. A pre-hospital ALS course, taught by ARC-approved instructors, should be generic to teach the principles of ALS, including human factors, in the pre-hospital environment which can then be transferred to the participants' typical work environment.

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Competing interests

The authors declare no competing interests. Each author of this paper has completed the ICMJE conflict of interest statement. Professor Grantham and Mr Gale are members of the Australian Resuscitation Council. Professor Sim, Associate Professor Beatty and Mr Reid have no competing interests.

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