Factors affecting survival after prehospital asystolic cardiac arrest in a Basic Life Support-Defibrillation system

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ABSTRACT

Objectives: Previous studies have shown a low but meaningful survival rate in cases of prehospital cardiac arrest with an initial rhythm of asystole. There may be, however, an identifiable subgroup in which resuscitation efforts are futile. This study identified potential field criteria for predicting 100% nonsurvival when the presenting rhythm is asystole in a Basic Life Support-Defibrillation (BLS-D) system.

Methods: This prospective cohort study, a component of Phases I and II of the Ontario Prehospital Advanced Life Support (OPALS) Study, was conducted in 21 Ontario communities with BLS-D level of care, and included all adult arrests of presumed cardiac etiology according to the Utstein Style Guidelines. Analyses included descriptive and appropriate univariate tests, as well as multivariate stepwise logistic regression to determine predictors of survival.

Results: From 1991 to 1997, 9899 consecutive cardiac arrest cases with the following characteristics: male (67.2%), bystander-witnessed (44.7%), bystander CPR (14.2%), call–response interval (CRI) ≤ 8 minutes (82%) and overall survival (4.3%) were enrolled. Of 9529 cases with available rhythm strip recordings, initial arrest rhythms were asystole in 40.8%, pulseless electrical activity in 21.2% and ventricular fibrillation or ventricular tachycardia in 38%. Of 3888 asystolic patients, 9 (0.2%) survived to discharge; 3 of these cases were unwitnessed arrests with no bystander CPR. There were no survivors if the CRI exceeded 8 minutes. Logistic regression analysis demonstrated that independent predictors of survival to admission were "CRI in minutes" (odds ratio [OR] = 0.87; 95% confidence interval [CI], 0.77–0.98) and "bystander-witnessed" (OR = 2.6; 95% CI, 1.5–4.4).

Conclusions: In a BLS-D system, there is a very low but measurable survival rate for prehospital asystolic cardiac arrest. CRIs of over 8 minutes were associated with 100% nonsurvival, whereas unwitnessed arrests with no bystander CPR were not. These data add to the growing literature that will help guide ethical decision-making for protocol development in emergency medical services systems.

Introduction

Sudden cardiac arrest accounts for 350 000 deaths annually in the United States.[1] Survival ranges from 1%–20%,[2–4] depending on the emergency medical services (EMS) system. Survival is related to initial rhythm, with relatively higher survival in the ventricular fibrillation (VF) group — especially if early defibrillation is performed. Survival is

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RÉSUMÉ

Objectifs : Des études antérieures ont démontré un taux de survie faible mais significatif dans certains cas d'arrêt cardiaque avec un rythme initial d'asystole en situation pré-hospitalière. Cependant, il pourrait y avoir un sous-groupe identifiable pour lequel les efforts de réanimation sont futiles. La présente étude a identifié les critères potentiels sur les lieux de l'incident permettant de prédire à 100 % les cas qui ne survivront pas en présence d'asystole au sein d'un système de soins immédiats en réanimation-défibrillation (SIR-D).

Méthodes : Cette étude de cohorte prospective, une composante du Ontario Prehospital Advanced Life Support Study (OPALS), fut menée dans 21 communautés ontariennes dotées d'un système de SIR-D, et incluait tous les arrêts chez les adultes dont l'origine présumée était cardiaque selon les Lignes directrices de Utstein. Les analyses comprenaient les tests descriptifs et univariés appropriés ainsi que l'analyse de régression logistique multivariée progressive pour déterminer les prédicteurs de survie.

Résultats : De 1991 à 1997, 9899 cas d'arrêt cardiaque consécutifs furent inclus dans l'étude. Ceux-ci présentaient les caractéristiques suivantes : mâles (67,2 %), présence de témoin (44,7 %), témoin administrant la RCR (14,2 %), délai de réponse suivant l'appel <8 minutes (82 %) et taux de survie global (4,3 %). Parmi 9529 cas pour qui l'enregistrement du rythme était disponible, le rythme initial de l'arrêt était l'asystole (40,8 %), une activité électrique sans pouls (21,2 %) et une fibrillation ventriculaire ou une tachycardie ventriculaire (38 %). Parmi 3888 patients en asystole, 9 (0,2 %) survécurent après leur congé; trois de ces cas étaient des arrêts sans témoin et sans témoin administrant la RCR. Il n'y avait aucun survivant si le délai de réponse suivant l'appel dépassait 8 minutes. L'analyse de régression logistique a démontré que les prédicteurs indépendants de survie jusqu'à l'hospitalisation étaient «délai de réponse suivant l'appel en termes de minutes» (rapport de cotes [RC] = 0,87; intervalle de confiance [IC], 0,77–0,98) et «présence de témoin» (RC = 2,6; IC 95 %, 1,5–4,4).

Conclusions : Au sein d'un système de SIR-D, le taux de survie mesurable est très faible dans les cas d'arrêts cardiaques asystoliques en situation pré-hospitalière. Les délais de réponse suivant l'appel supérieurs à 8 minutes étaient associés à un taux de non survie à 100 %, tandis que les arrêts sans témoin et sans témoin administrant la RCR ne l'étaient pas. Ces données s'ajoutent à la littérature grandissante qui contribuera à guider les prises de décision éthiques pour la mise en place de protocoles au sein des systèmes de services médicaux.

much lower in the "non-shockable" (asystole and pulseless electrical activity [PEA]) group, and is particularly dismal in asystolic cardiac arrest.[5,6] Unsuccessful advanced life support (ALS) resuscitation in the field is a strong indicator that cardiac arrest cannot be reversed,[7] and transportation to the emergency department (ED) after failed ALS resuscitation is of no benefit.[8–12] In fact, it may expose the paramedic to increased occupational health risks such as needle-stick injuries and injuries secondary to motor vehicle collisions caused by running "lights and sirens."[13,14] As well, it may increase total costs to the system.[1516] For these reasons, there is an increased recognition of the need for protocols and guidelines for the termination of resuscitative efforts in the field.[17,18]

The National Association of Emergency Medical Services Physicians (NAEMSP) has published a position paper on prehospital termination of resuscitation for ALS systems.[19] The NAEMSP recommendations suggest that, in the population of out-of-hospital sudden cardiac deaths that are likely to be medical, field termination of resuscitation may be appropriate if: 1) a "full resuscitative effort" has been attempted, including definitive airway management, intravenous access and at least 20 minutes of treatment following Advanced Cardiac Life Support (ACLS) guidelines; 2) the patient's rhythm changes to or remains in a "terminal" rhythm of asystole or PEA; 3) the final decision to terminate is a consensus between the paramedic and the online physician; and 4) there is adequate education of the EMS personnel, respectful care of the dead, and counseling and support available for family and EMS personnel.

While some empirical data (mostly retrospective) exists for the development of resuscitation termination guidelines in ALS systems, there is little data to aid a similar process in Basic Life Support-Defibrillation (BLS-D) systems — this despite the fact that large geographical regions in Canada and the United States are covered by BLS-D systems. Some have suggested that a presenting rhythm of asystole has an extremely low survival rate and may be "unsurvivable," especially if unwitnessed.[5,6] Others have shown survival rates to be slightly higher.[20–22] The question is: Is there a subgroup of asystolic patients who have a 0% survival rate and can we easily identify this group in the field in order to develop practical and ethical prehospital resuscitation termination guidelines in a BLS-D system?

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The purpose of this study is to identify accurate and practical field criteria for predicting 100% nonsurvival when the presenting rhythm is asystole in a BLS-D system.

Methods

This was an observational cohort study in which data was extracted from Phase I and Phase II of the Ontario Prehospital Advanced Life Support (OPALS) Study, which took place in 21 Ontario communities with a BLS-D level of care. The details of the methodology of the OPALS Study have been published previously.[23–25] The OPALS Study is a multiphase, before–after controlled clinical trial. It looks at all eligible cardiac arrest patients seen during 3 distinct phases. Phase I (36 months) represents the baseline status after the introduction of automatic defibrillation programs. Phase II (12 months) assesses survival after the introduction of "rapid defibrillation" (defibrillation <8 min 90% of the time). Therefore, both Phase I and Phase II would be considered BLS-D systems. Phase III (36 months) will assess survival after the introduction of "full ALS programs."

OPALS studied urban or suburban Ontario communities with populations ranging from 16 000 to 750 000 (total, 2.7 million). All had 911 telephone service, and medical control was provided by 11 base hospitals. All paramedics were BLS certified and had graduated from a 1-year community college program (or equivalent). There were no ACLS providers or ALS paramedics in the system during the study period. All ambulance dispatch information was obtained from a central computerized ambulance response information system. Patient encounters were documented on standard ambulance call report forms.

All arrests of presumed cardiac etiology during a 7-year (1991–1997) period were examined. Case definitions followed the Utstein Style Guidelines. Exclusion criteria were: age less than 16 years, trauma, decomposition or rigor mortis and arrests that were clearly noncardiac (e.g., drowning, poisoning, hypothermia).

The primary outcome measure for the study was survival to hospital discharge, which was verified by review of the hospital records or an interview with the family physician. Other outcomes of interest were return of spontaneous circulation (ROSC) and survival-to-hospital admission. All survivors to hospital discharge of asystolic arrest had their cases reviewed by a panel of 4 EMS physician experts and 2 emergency physicians. The diagnosis of asystole was confirmed by consensus, and the circumstances around the survival were discussed and verified or the case was not considered an "asystole save." The functional level of survivors was also reviewed where possible. Cerebral Performance Category (CPC) scores were available for Phase II survivors.

Asystolic arrests were analyzed to determine survival rates in relation to age, gender, witness status, bystander cardiopulmonary resuscitation (CPR) status and call–response interval (CRI) (analyzed both as a continuous variable and as a categorical variable: ≤8 min vs. >8 min). CRI was defined as the time elapsed between call received and vehicle stopped.

Descriptive and univariate test statistics (Student's *t*, chi squared, Fisher's exact) were used to characterize asystolic arrest. Multivariate stepwise logistic regression analysis was undertaken to determine independent predictors of survival to hospital admission.

Results

From January 1, 1991, to December 31, 1997, there were 9899 arrests of presumed cardiac origin. The predominant arrest rhythm was asystole in 3888 (40.8%) cases, VF or ventricular tachycardia (VT) in 3621 (38%) and PEA in 2020 (21.1%). There were 370 cases that did not have a rhythm strip tracing identifying the original arrest rhythm.

Compared with the total arrest group, asystolic arrests were more likely to be unwitnessed (70.8% vs. 48.4%) and less likely to be associated with bystander CPR (8.1% vs. 14.2%). The overall survival rate was 4.3%, but only 9 (0.2%) of 3888 asystolic arrest victims survived. Table 1 shows that asystole survivors made up 2.1% (9/428) of all survivors. Figure 1 illustrates the breakdown of asystolic arrest survival in relation to witnessed and bystander CPR status. Interestingly, 3 of the 9 survivors had unwitnessed arrest and no bystander CPR. None of the survivors re-

Table 1. Comparison of all patients (*N* = 9899) enrolled in a 1991–1997 prospective cohort study conducted in 21 Ontario communities with a BLS-D system with those in the study whose predominant arrest rhythm was asystole (*N* = 3888)

Characteristic	All cases *n* (%)	Asystole *n* (%)
Mean age, yr	68	69
Male	6645 (67.1)	2404 (61.8)
Witnessed arrest	4421 (44.7)	1033 (26.6)
EMS witnessed	681 (6.9)	103 (2.6)
Bystander CPR	1404 (14.2)	315 (8.1)
CRI ≤ 8 min*	7435 (82.0)	2990 (80.4)
ROSC	1075 (10.9)	102 (2.6)
Survived to admission	824 (8.3)	67 (1.7)
Survived to discharge	428 (4.3)	9 (0.2)

BLS-D = Basic Life Support-Defibrillation; CRI = call–response interval; ROSC = return of spontaneous circulation
* Missing data. CRI available for 9064 patients, including 3720 asystole patients.

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ceived bystander CPR. Table 2 shows that CRI (as a continuous variable), bystander- and EMS-witnessed arrests were significantly associated with improved survival to admission. Six of the 9 asystole survivors to discharge had ROSC in the field (Table 3). Three patients who arrived in the ED pulseless (despite 12–14 min of CPR) were subsequently resuscitated and survived to hospital discharge.

Multivariate logistic regression analysis showed that CRI (OR = 0.87; 95% confidence interval [CI], 0.77–0.98) and bystander witness (OR = 2.6; 95% CI, 1.53–4.4) were associated with survival to admission. There were too few survivors to identify predictors of survival to discharge.

Figure 2 shows that 9 asystolic arrest victims survived to hospital discharge, but none survived if the CRI was greater than 8 minutes. Six survivors were from OPALS Phase I. All 6 were discharged home, but CPC scores are unavailable for these patients. The 3 survivors from OPALS Phase II underwent formal CPC testing. One was classified as CPC 1 ("good" cerebral performance) and 2 were classified as CPC 3 ("severe cerebral disability").

Discussion

This study is the largest to date that looks at outcomes of asystolic arrest in a BLS-D system. It confirms that there is a very low (0.2%) but measurable survival rate, and suggests that the only modifiable factor associated with improved survival to discharge was CRI. In this study, CRI

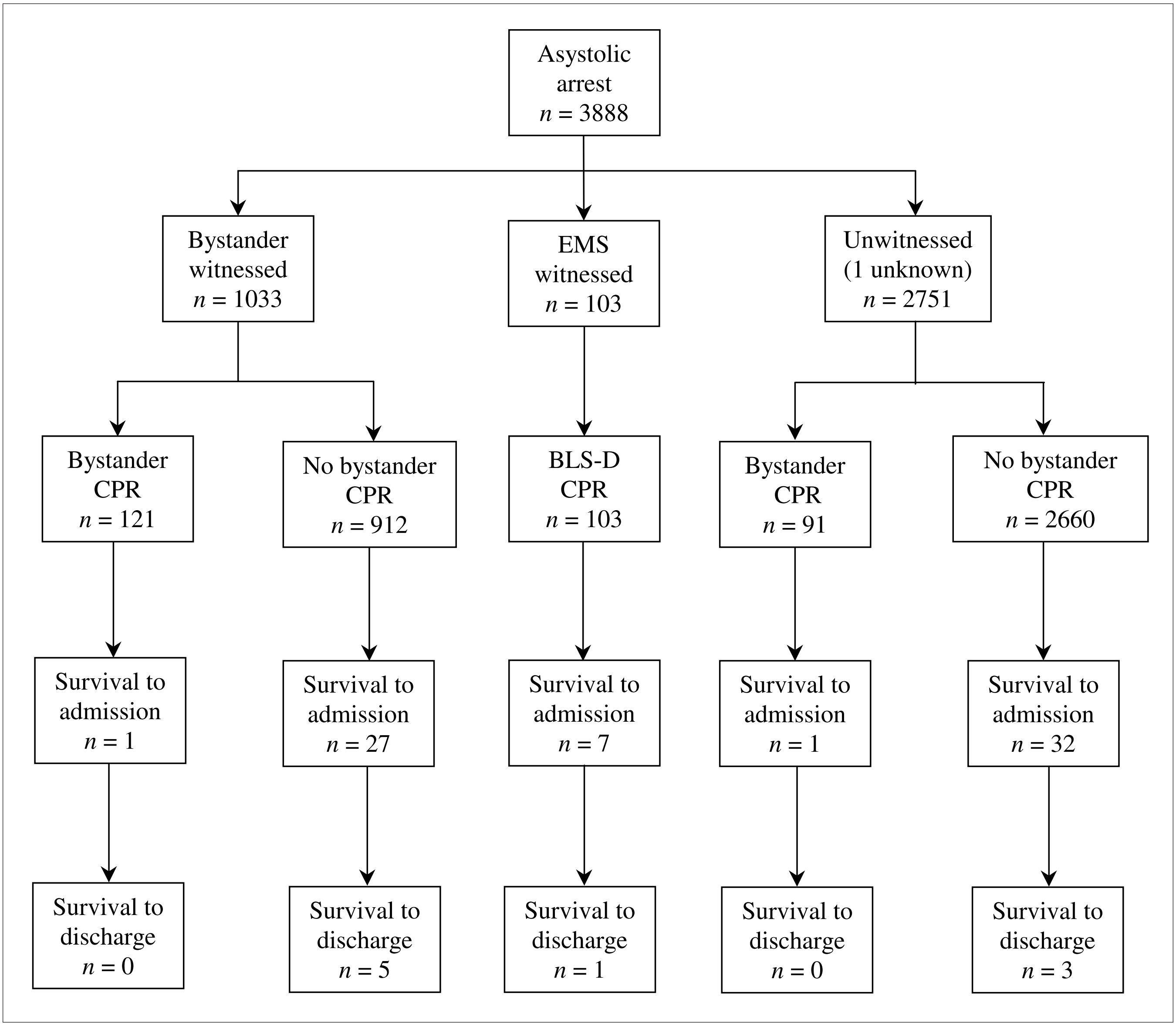

Fig. 1. Survival to discharge of asystolic arrests in relation to witnessed and bystander CPR status

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greater than 8 minutes was associated with 100% mortality.

A strength of this study was that each survivor's case was reviewed by a group of EMS experts and emergency physicians. By consensus, they confirmed the diagnosis of asystole (vs. bradycardia or PEA) and reviewed the circumstances around the resuscitation to confirm that each was indeed an asystole survivor.

Interestingly, no survivors to discharge received bystander CPR. In fact, patients who died at the scene were more likely to have received bystander CPR than patients who were admitted to hospital, but this was not statistically significant and was likely a chance finding. Previous authors have suggested that CPR may play a role in sustaining VF or VT. Without CPR, cardiac arrest rhythms may deteriorate more rapidly to asystole. If this is true, patients who received CPR yet were in asystole on EMS arrival may have had longer arrest times and, therefore, worse outcomes. Another important observation is that several patients survived to hospital discharge despite suffering a non-witnessed asystolic arrest and having no bystander CPR. Previous studies have suggested these factors predict 100% nonsurvival.[20,21]

These data should help guide ethical EMS protocol development and system design. Specifically, this study can help decision-makers develop field resuscitation termination guidelines for BLS-D systems. Much of rural Canada and the US have BLS-D systems in which CRIs are greater than 8 minutes. Perhaps if the presenting rhythm is asystole in this context, resuscitation efforts and transport may be futile.

The concept of medical futility is important to this argument. According to Schneiderman and colleagues,[26] futility involves both quantitative and qualitative aspects. A quantitative approach defines futility as an intervention that has a very low chance of being successful. Schneiderman and colleagues have defined this chance as less than 1%.[26] Others, on the other hand, have pointed out the difficulties in this approach.[27,28] Most EMS physicians have supported the position that no potentially salvageable patients should be jeopardized in the setting of cardiac arrest.[29]

A qualitative approach also considers patient quality of life after the intervention.[26] A previous study suggested that survivors of prehospital cardiac arrest have generally good quality of life outcomes,[30] although this has not been correlated with the presenting rhythms. In this study, 7 of the 9 survivors were discharged home rather than to an institution. Of concern, however, is that 2 of the 3 survivors who had formal CPC testing were classified as having a severe cerebral disability. No conclusions can be drawn from this because these numbers are so small.

A practical consideration in this discussion is public acceptance and expectations. Public perception of cardiac arrest resuscitation may be influenced by popular television shows, which depict unrealistically high survival rates.[31,32] A recent study showed that 96% of family members were willing to accept the decision to terminate unsuccessful resuscitation in the field.[33] This study, however, involved ALS paramedics and ride-along emergency medicine residents as part of the crew; therefore its conclusions may not be valid in a BLS-D system. Obviously, before any field termination guidelines are implemented, paramedics require training in grief counseling, and the public requires substantial involvement and education.[19]

Cost-effectiveness and resource allocation are also important considerations. It has been estimated that the US spends $500 million dollars annually for the transport and continued resuscitation of clinically dead patients.[16] Another $500 million in intensive care unit costs are generated by patients who survive to admission but not to discharge.[16] Costs specifically related to the EMS system are

Table 2. Association of patient characteristics of those patients who survived to hospital admission compared with those who did not survive to be admitted (univariate analysis)

Characteristic	Survival to admission (n = 67)	Nonsurvival to admission (n = 3821)	p
Mean age, yr	66	69	0.06
Male	51%	62%	0.06
Bystander witnessed	42%	26%	0.004
Bystander CPR	3%	8%	0.121
EMS witnessed	10%	3%	0.0001
CRI ≤ 8 min	88%	80%	0.13
Mean response interval, min	5.6	6.4	0.03

CPR = cardiopulmonary resuscitation; EMS = emergency medical services

Table 3. Characteristics of patients whose predominant arrest rhythm was asystole who survived to discharge (*N* = 9)

Characteristic	No.
Mean age	68
Male	5
Bystander witnessed	5
EMS witnessed	1
Bystander CPR	0
EMS CPR	1
ROSC in field	6
Estimated mean time from response to ROSC, min	5.2

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unknown; however, because most EMS costs are fixed (i.e., salaries, ambulances, communication systems), the marginal cost of one more resuscitation may not be high. Futile resuscitation does carry important opportunity costs that must be considered, such as not being able to respond to a concurrent treatable emergency.

This study did not analyze actual costs. However, a retrospective analysis of our data shows that a policy of terminating resuscitation in asystolic arrest victims when EMS response times were greater than 8 minutes would have led to 730 fewer resuscitations with no change in survival. The mean cost per resuscitation in a similar patient group is US$764.[16] Thus, the projected savings with the policy described above would be at least US$500 000 over the study time period. This level of saving, generalized to the entire continent and extended over time, would be significant and could be achieved without jeopardizing a single survival.

Other ethical considerations include the potential occupational health and safety hazards of "lights and sirens" responses, which have been shown to increase the risk of ambulance collisions.[13,14] Needle-stick injuries are also more likely to occur in a moving ambulance in the stressful situation of a continued resuscitation.

Study limitations

This study took place in a BLS-D system; therefore, its findings cannot be extrapolated to an ALS situation. Although a recent meta-analysis suggests that intubation and intravenous drugs may improve cardiac arrest survival in general,[4] it is unknown whether they do so in the subgroup of asystolic patients. Perhaps OPALS Phase III (ALS) data will clarify this question. Another limitation is that our study population had relatively low bystander CPR and overall survival rates. Therefore, the conclusions reached may not be applicable to BLS-D systems that are associated with significantly higher bystander CPR and survival rates. Finally, our findings may not be generalizable to BLS-D systems using automatic external defibrillators (AEDs) that analyze rhythms as either "shockable" or "non-shockable." It is possible that there may be differences in the diagnosis of asystole when it is made by an AED vs. a BLS-D paramedic using a monitor-defibrillator.

Conclusions

In a BLS-D system, there is a very low but measurable survival rate of prehospital cardiac arrest when the presenting rhythm is asystole. Unwitnessed arrest with no bystander

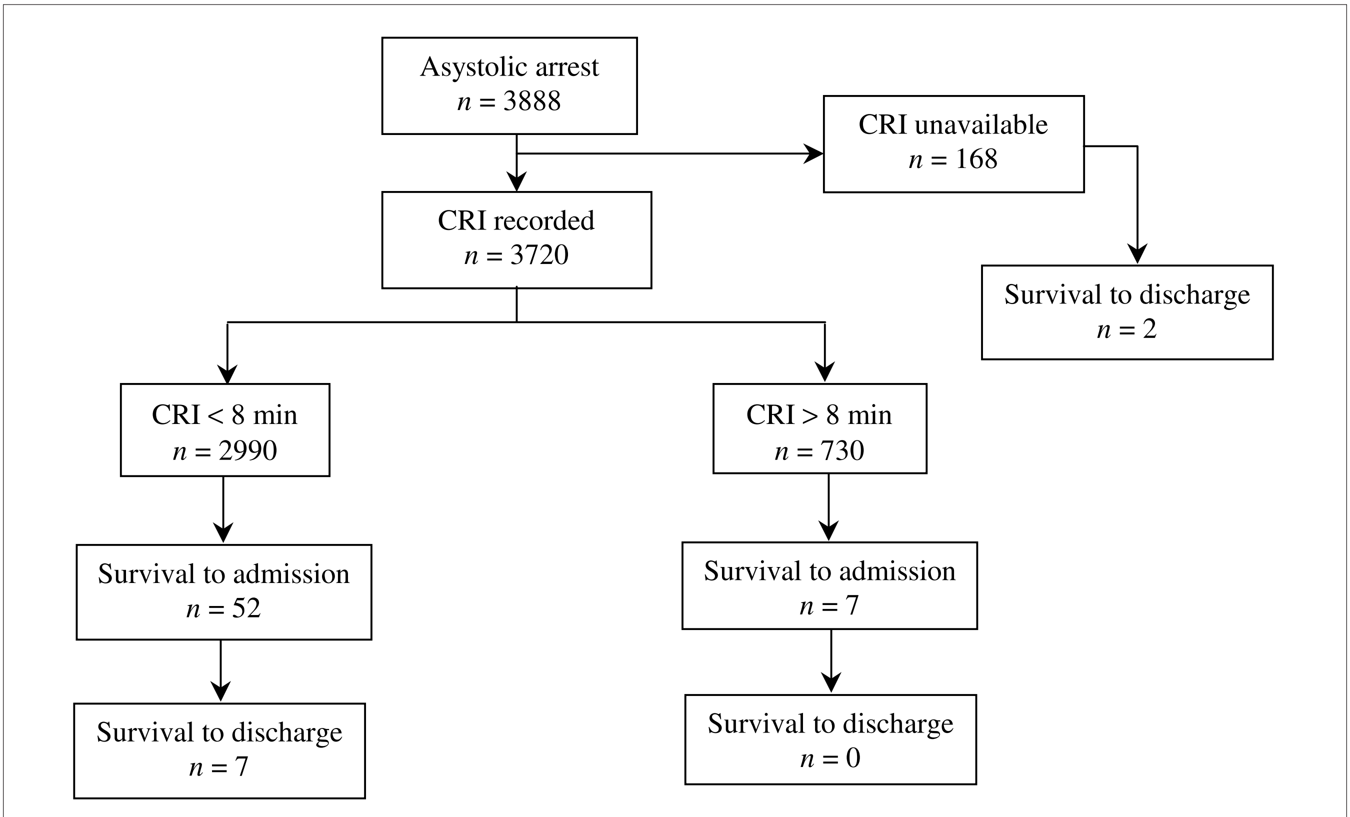

Fig. 2. Call–response interval (CRI) vs. survival to discharge in patients with asystolic arrest

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CPR did not predict 100% nonsurvival, but a CRI of greater than 8 minutes did. These data add to the growing literature that will help guide ethical decision-making for protocol development and system design in EMS systems.

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