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Sex differences in the prehospital management of out-of-hospital cardiac arrest

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Abstract

Background—Sex differences exist in the diagnosis and treatment of several cardiovascular diseases. Our objective was to determine whether sex differences exist in the use of guideline-recommended treatments in out-of-hospital cardiac arrest (OHCA).

Methods—We included adult patients with non-traumatic OHCA treated by emergency medical services (EMS) in the Resuscitation Outcomes Consortium Prehospital Resuscitation using an IMpedance valve and Early versus Delayed (ROC PRIMED) database during 2007–2009. Outcomes included prehospital treatment intervals, procedures, and medications. Data were analysed using multivariable linear and logistic regression models that adjusted for sex, age, witnessed arrest, public location, bystander cardiopulmonary resuscitation (CPR), and first known rhythm of ventricular tachycardia/fibrillation.

Results—We studied 15,584 patients; 64% were male and median age was 68 years (interquartile range 55–80). In multivariable analyses, intervals from EMS dispatch to first rhythm capture (p=0.001) and first EMS CPR (p=0.001) were longer in women than in men. Women were less likely to receive successful intravenous or intraosseous access (OR 0.78, 95% CI 0.71–0.86) but equally likely to receive a successful advanced airway (OR 0.94, 95% CI 0.86–1.02). Women were less likely to receive adrenaline (OR 0.81, 95% CI 0.74–0.88), atropine (OR 0.86, 95% CI 0.80–0.92), and lidocaine or amiodarone (OR 0.68, 95% CI 0.61–0.75).

Conclusion—Women were less likely than men to receive guideline-recommended treatments for OHCA. The reasons for these differences require further exploration, and EMS provider education and training should specifically address these sex differences in the treatment of OHCA.

Keywords

Heart arrest; Prehospital emergency care

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Introduction

Out-of-hospital cardiac arrest (OHCA) is the most common cause of death from cardiac disease in the United States,[1] with 52.1 cases treated by emergency medical services (EMS) per 100,000 individuals annually.[2] The majority of patients with OHCA die before hospital admission.[3] To improve outcomes, the International Liaison Committee on Resuscitation, American Heart Association, and European Resuscitation Council provide guidelines for OHCA treatment.[4–6] These guidelines include cardiopulmonary resuscitation (CPR), intravenous (IV) or intraossesous (IO) access, medications, airway management, and defibrillation for shockable rhythms. Survival in OHCA is associated with several of these interventions, including high-quality CPR[3,7] and rapid defibrillation.[3,8]

Sex differences in the prehospital management of other forms of cardiac disease exist[9–12] and are associated with increased morbidity and mortality in women.[10,11] Similarly, important sex differences may occur in prehospital interventions for OHCA. In this study, we use the Resuscitation Outcomes Consortium (ROC) Prehospital Resuscitation using an IMpedance valve and Early versus Delayed (PRIMED) database to determine whether sex differences exist in prehospital treatment intervals, procedures, and medications among adults with OHCA. We hypothesise that women have longer prehospital treatment intervals and are less likely than men to receive procedures and medication.

Methods

Study Design

We performed a retrospective cohort study using the ROC-PRIMED database. This study was exempt from review by our Institutional Review Board.

Population and Setting

The ROC encompasses 11 regions in the United States and Canada serving approximately 23.7 million people.[13] During 2007–2009, adults with OHCA were enrolled in the ROC-PRIMED impedance threshold device trial.[14] In the current study, we included adults (≥18 years) with non-traumatic OHCA and complete sex and age data in the public-use ROC-PRIMED database from the National Heart, Lung, and Blood Institute. We excluded patients with arrest due to trauma or hemorrhage, those with prehospital "do not resuscitate" orders, and those considered legally dead, defined as "obvious death by legal legislation."[15]

Experimental Protocol

Variables obtained from the ROC-PRIMED database included sex, age, race, ethnicity, public arrest location, bystander- or EMS-witnessed arrest, bystander CPR, arrest rhythm(s), EMS time and events log, prehospital medications, and prehospital interventions. Because ages over 89 years were truncated into a single category in the database, an age of 90 years was used for all patients over 89 years old. A witnessed arrest was seen or heard by a bystander or EMS personnel. Prehospital return of spontaneous circulation (ROSC) was defined as ROSC at any time in the EMS events log following OHCA.

Key Outcome Measures

Our outcome measures were time to interventions (time to first cardiac arrest rhythm capture and time to first EMS CPR), procedure attempts and successes (IV or IO access and advanced airway placement), and medication administration [adrenaline (epinephrine), atropine, and lidocaine or amiodarone].

Analytic Methods

Summary statistics were calculated for each variable. Univariable analyses were performed to evaluate the relationship between sex and outcome measures. A multivariable linear regression model including age, public location of arrest, witnessed arrest, and bystander CPR was used to characterise the relationship between sex and prehospital treatment intervals. For prehospital procedures, multivariable logistic regression models were used to adjust for age, public location of arrest, witnessed arrest, bystander CPR, and first known rhythm of ventricular tachycardia or fibrillation. For medication administration, the models also included successful IV or IO access and successful oral endotracheal intubation (adrenaline and atropine models only). Because guidelines recommended that amiodarone or lidocaine be considered in refractory ventricular rhythms, prehospital ROSC was included in the model for amiodarone or lidocaine. All analyses were performed using Stata version 14.1 (StataCorp, College Station, TX).

Results

After excluding patients with traumatic arrest (n=100), exsanguination (n=39), missing sex (n=1,208), no cardiac arrest (n=43), "do not resuscitate" orders (n=199), legally dead (n=219), age <18 years (n=24), and missing age (n=29), we studied 15,584 adult patients with OHCA. Of those, 10,023 (64%) were male (Table 1). In multivariable analyses, the interval from EMS dispatch to first advanced life support (ALS) crew arrival was similar in men and women (p=0.438). However, intervals from dispatch to first capture of cardiac arrest rhythm and first EMS CPR were approximately 30 seconds longer in women (p=0.001 for both). Women and men were equally likely to receive a prehospital advanced airway (OR 0.94, 95% CI 0.86–1.02), but women were less likely to receive prehospital IV or IO access (OR 0.78, 95% CI 0.71–0.86; Table 2). Women were less likely to receive an IV access attempt (OR 0.77, 95% CI 0.70–0.85) and more likely than men to receive an IO access attempt (OR 1.47, 95% CI 1.31–1.66). When IV placement was attempted, it was less likely to be successful in women (OR 0.64, 95% CI 0.56–0.73). When IO placement was attempted, it was equally likely to be successful in women and men (OR 0.71, 95% CI 0.48–1.06). Women were also less likely to receive adrenaline (OR 0.81, 95% CI 0.74–0.88), atropine (OR 0.86, 95% CI 0.80–0.92), and lidocaine or amiodarone (OR 0.68, 95% CI 0.61–0.75; Table 3). These differences remained significant after adjusting for IV or IO access, endotracheal intubation, and prehospital ROSC (data not shown).

Discussion

Overall, women were less likely than men to receive timely prehospital CPR and rhythm capture, IV or IO access, and medications. Our data suggest that EMS providers are less adherent to guidelines[4–6] and less aggressive in their resuscitation of women with OHCA. Our results are similar to smaller study demonstrating that women were less likely to receive prehospital post-resuscitation care in alignment with guidelines.[16]

We found longer times to first EMS rhythm capture and first EMS CPR, but not in time to ALS crew arrival, in women with OHCA. Taken together, these findings suggest that ALS crews are dispatched with equal expedience for men and women but that EMS recognition of and intervention for OHCA is delayed in women. Reports from family, bystanders, or dispatch may bias EMS providers' expectations and initial actions in their assessment of patients. Similarly, ongoing bystander CPR or automated external defibrillator use may hasten EMS recognition of OHCA. Women with acute myocardial infarction experience different symptoms than men,[9] and women may also experience different symptoms preceding OHCA. Bystanders and EMS providers may be reluctant to unclothe women to place monitor pads on the chest, delaying cardiac rhythm analysis and defibrillation. The absolute differences in treatment intervals between men and women were less than one minute (Table 1), and the effects of these differences on clinical outcomes are unclear.

Overall, women were less likely than men to receive IV or IO access. IV access attempts were less successful in women; however, IO attempts were equally successful in men and women. A prior study showed that inpatient nurses perceived IV insertions as more difficult in women than men, although there was no difference in success rate.[17] EMS providers' perceived and actual difficulty placing IV catheters in women may contribute to women being less likely to receive IV attempts and IV success. These findings suggest that EMS providers' training and skills in IV access in women with OHCA should be increased. Alternatively, initial or early IO access for patients with OHCA should be considered.

Women were also less likely than men to receive guideline-recommended medications.[4–6] The largest sex difference was observed in administration of lidocaine or amiodarone, possibly because guidelines only recommend that these medications be considered in refractory ventricular rhythms. In contrast, the smaller sex difference in adrenaline may occur because adrenaline is a standard component in the algorithm for all cardiac arrest rhythms. Similar sex differences in EMS protocol adherence have been demonstrated in chest pain and STEMI, with women less likely to receive prehospital electrocardiograms and aspirin.[11,12] Importantly, our data suggest that sex differences in prehospital medication administration are not driven primarily by differences in IV/IO access.

Despite including over 15,000 patients with OHCA, our study has several limitations. First, our analyses were limited to data in the ROC-PRIMED dataset. Race was unknown for 76% of patients and thus not included in our analyses. Prehospital practices might differ between ROC sites, and we were unable to account for clustering. Second, the R^2 values for our models were low, suggesting that additional unmeasured variables affect our outcomes. Third, data were collected in ten ROC-PRIMED sites from 2007–2009. Our findings may not be generalisable to other EMS systems and geographic areas. Similarly, EMS practices may have changed in the years since data were collected. One notable change in guidelines was the removal of atropine for the treatment of pulseless electrical activity and asystole in 2010.[18,19]

Conclusion

Important sex differences exist in the prehospital care of patients with OHCA. Women experience longer times to CPR and cardiac rhythm capture, and they are less likely to receive IV/IO access and medications. The reasons for these differences should be explored further, and EMS provider education and training should specifically address sex differences in the treatment of OHCA.

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Table 1

Demographic and clinical characteristics.

	Men (n=10,023)	Women (n=5,561)
Age (years) *	66 (54–78)	72 (57–83)
Witnessed arrest	5,235 (52%)	2,557 (46%)
Public location	1,867 (19%)	468 (8.4%)
AED applied	234 (2.3%)	87 (1.6%)
AED shock delivered	108 (1.1%)	31 (0.6%)
Bystander CPR	3,804 (38%)	1,982 (36%)
First known rhythm of VF/VT	2,881 (29%)	863 (16%)
An rhythm of VF/VT	4,341 (43%)	1,598 (29%)
Dispatch to ALS crew arrival (minutes) *	8.0 (5.7–11.1)	8.0 (5.6–11.1)
Dispatch to first EMS CPR (minutes) *	8.5 (6.7–11)	8.8 (6.9–11.3)
Dispatch to first EMS rhythm captured (minutes) *	10.1 (8.2–12.9)	10.5 (8.5–13.3)
Prehospital interventions		
IV attempt	8,890 (89%)	4,707 (85%)
IO attempt	717 (7.2%)	587 (11%)
IV or IO success	8,891 (89%)	4,727 (85%)
Advanced airway	8,060 (81%)	4,412 (80%)
Adrenaline	8,255 (83%)	4,472 (81%)
Atropine	6,676 (67%)	3,704 (67%)
Amiodarone or lidocaine	2,226 (22%)	686 (12%)

* Data presented as median (interquartile range)

AED = Automated external defibrillator; CPR = Cardiopulmonary resuscitation; VF/VT = Ventricular fibrillation/ventricular tachycardia; ALS = Advanced life support; EMS = Emergency medical services

Table 2

Predictors of attempted and successful prehospital procedures in multivariable regression models.

Predictor variables	Outcome variables							
	Prehospital advanced airway attempt	Prehospital advanced airway success - all patients	IV attempt	IV success - attempts only	IO attempt	IO success - attempts only	IV or IO attempt	IV or IO success - all patients
Female sex	0.85 (0.77–0.93)	0.94 (0.86–1.02)	0.77 (0.70–0.85)	0.64 (0.56–0.73)	1.47 (1.31–1.66)	0.71 (0.48–1.06)	0.87 (0.78–0.98)	0.78 (0.71–0.86)
Age (per 10 years)	1.00 (0.97–1.03)	1.04 (1.01–1.06)	1.01 (0.98–1.04)	1.11 (1.07–1.15)	0.87 (0.84–0.90)	1.12 (1.00–1.26)	0.94 (0.90–0.97)	0.99 (0.96–1.02)
Witnessed arrest	1.05 (0.95–1.15)	1.07 (0.98–1.16)	1.36 (1.23–1.50)	0.91 (0.79–1.04)	0.94 (0.83–1.05)	0.85 (0.57–1.28)	1.36 (1.20–1.53)	1.16 (1.05–1.28)
Public location	1.02 (0.88–1.17)	0.96 (0.85–1.08)	1.09 (0.93–1.27)	1.22 (0.99–1.52)	0.65 (0.53–0.79)	0.61 (0.40–1.08)	0.94 (0.78–1.12)	0.96 (0.83–1.12)
Bystander CPR	1.19 (1.08–1.31)	1.28 (1.17–1.39)	1.06 (0.96–1.18)	1.20 (1.04–1.38)	1.07 (0.95–1.21)	1.52 (0.99–2.32)	1.19 (1.05–1.35)	1.27 (1.14–1.40)
VF/VT first rhythm	1.06 (0.94–1.19)	1.02 (0.92–1.13)	1.73 (1.51–1.98)	1.80 (1.49–2.18)	0.63 (0.53–0.74)	0.71 (0.43–1.18)	1.65 (1.40–1.95)	1.66 (1.45–1.90)
Cases incuded	15,441	15,413	15,483	13,545	15,483	1,296	15,483	15,483
R^2	0.0025	0.0030	0.0165	0.0193	0.0208	0.0192	0.0139	0.0129

IV = Intravenous; IO = Intraosseous; CPR = Cardiopulmonary resuscitation; VF/VT = Ventricular fibrillation/ventricular tachycardia

Table 3

Predictors of prehospital medication administration in multivariable regression models.

	Outcome variables		
Predictor variables	**Adrenaline**	**Atropine**	**Amiodarone or Lidocaine**
Female sex	0.81 (0.74–0.88)	0.86 (0.80–0.92)	0.68 (0.61–0.75)
Age (per 10 years)	1.00 (0.98–1.03)	0.99 (0.97–1.01)	0.99 (0.96–1.02)
Witnessed arrest	0.78 (0.72–0.86)	0.79 (0.74–0.85)	1.49 (1.35–1.64)
Public location	0.78 (0.70–0.88)	0.78 (0.71–0.86)	1.15 (1.02–1.29)
Bystander CPR	1.23 (1.13–1.35)	0.91 (0.84–0.97)	1.20 (1.09–1.32)
VF/VT first rhythm	0.70 (0.63–0.77)	0.44 (0.40–0.47)	8.40 (7.64–9.25)
Cases included	15,421	15,420	15,420
R^2	0.0114	0.0338	0.1936

CPR = Cardiopulmonary resuscitation; VF/VT = Ventricular fibrillation/ventricular tachycardia