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Clinical paper

Drowning related out-of-hospital cardiac arrests: Characteristics and outcomes☆

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ABSTRACT

Aim: There are few studies on drowning-related out-of-hospital cardiac arrest (OHCA) in which patients are followed from the scene through to hospital discharge. This study aims to describe this population and their outcomes in the state of Victoria (Australia).
Methods: The Victorian Ambulance Cardiac Arrest Registry was searched for all cases of OHCA with a precipitating event of drowning attended by emergency medical services (EMS) between October 1999 and December 2011.
Results: EMS attended 336 drowning-related OHCA during the study period. Cases frequently occurred in summer (45%) and the majority of patients were male (70%) and adult (77%). EMS resuscitation was attempted on 154 (46%) patients. Of these patients, 41 (27%) survived to hospital arrival and 12 (8%) survived to hospital discharge (5 adults [6%] and 7 [12%] children). Few patients were found in a shockable rhythm (6%), with the majority presenting in asystole (79%) or pulse-less electrical activity (13%). An initial shockable rhythm was found to positively predict survival (AOR 48.70, 95% CI: 3.80–624.86) while increased EMS response time (AOR 0.73, 95% CI: 0.54–0.98) and salt water drowning (AOR 0.69, 95% CI: 0.01–0.84) were found to negatively predict survival.
Conclusions: Rates of survival in OHCA caused by drowning are comparable to other OHCA causes. Patients were more likely to survive if they did not drown in salt water, had a quick EMS response and they were found in a shockable rhythm. Prevention efforts and reducing EMS response time are likely to improve survival of drowning patients.

1. Introduction

Drowning is a common cause of unintentional death and disability making it a major public health problem. In 2004, the World Health Organisation (WHO) Global burden of disease estimated 388,000 drowning deaths occurred worldwide. These figures may underestimate the burden of drowning, because they do not include deaths from disasters or transportation as well as non-fatal drowning. Globally the highest mortality from drowning is seen in children and in males.[1,2] In Australia, the age-adjusted rate of drowning-related deaths is estimated at 1.9 per 100,000, with the highest rates of death and hospitalisation seen in children under 5 years of age[3]. In children, aged 1–3 years, drowning is also the leading cause of unintentional death by injury.[2]

Out-of-hospital cardiac arrest (OHCA) precipitated by drowning occurs in the prehospital environment and management at the scene can dramatically improve patient outcomes.[4] There have been a small number of studies conducted on drowning-related OHCA,[5–8] reporting varying rates of survival, however most of these studies are case series or small cohorts and none have been conducted in Australia. Larger cohort studies are required to identify risk factors for the prevention of drowning and to establish predictors of survival.[9] The WHO recommend that research into the burden and risks of drowning worldwide be a priority.[2] This study aims to describe the characteristics of drowning OHCA in an Australian cohort and to identify independent predictors of survival.

2. Methods

This study was an analysis of prospectively collected data from the Victorian Cardiac Arrest Registry (VACAR). VACAR is approved as a quality assurance initiative by the Victorian Department of

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Health Human Research Ethics Committee (HREC) and the collection of patient outcomes is approved by the ethics committees of participating Victorian hospitals. This study was approved by the Research Committee of Ambulance Victoria and Monash University Human Research Ethics Committee.

The study setting is Victoria, Australia which has a population of 5.5 million, 75% of whom live in the capital city of Melbourne.[10] In the state of Victoria, professional and volunteer lifeguards perform over 750 rescues from water each year, with an age-adjusted rate of drowning of 1.5 per 100,000 population.[3,11]

Ambulance Victoria (AV) is the sole provider of emergency medical services (EMS) in the state. AV delivers a two-tiered EMS system, with advanced life support paramedics and mobile intensive care ambulance paramedics. Fire fighters and volunteer community emergency response teams provide a first response in select areas of Victoria. EMS response times were recorded from the receipt of the call for help to the arrival of the first EMS resource on scene. Patients were managed according to the Ambulance Victoria clinical practice guidelines which are based on recommendations by the Australian Resuscitation Council.[12,13]

Cases were identified and data was extracted from the VACAR. Adults and children (<18 years) with drowning recorded as the precipitating event for their cardiac arrest between October 1999 and December 2011 were included. Cases of drowning where cardiac arrest did not occur were not included in this study. Cases where trauma was the likely cause of OHCA (i.e. witnessed bridge suicides) were also excluded. VACAR collects standardised OHCA data according the Utstein definitions[14] and hospital outcomes for all cardiac arrest patients who are attended by EMS in Victoria.

The primary outcomes of this study were survival to hospital (pulse present on arrival at hospital) and survival to hospital discharge. Univariate analysis was performed using Chi-square with Fisher's exact test and non-parametric data was compared using the Mann–Whitney significance test. Multivariate logistic regression was performed to predict factors related to outcomes. The variables assessed in the multivariate analysis were age (continuous variable), gender (males versus females), public location (home versus public location), salt water (salt water versus other), witnessed (yes versus no), bystander CPR (yes versus no), EMS response time (continuous variable) and shockable rhythm (yes versus no). Statistical calculations were performed on IBM® SPSS® Statistics 20.0. *p*-Values less than 0.05 were considered significant.

3. Results

3.1. Characteristics of all drowning related OHCA cases

Ambulance Victoria attended 336 (260 adults) drowning incidents that resulted in OHCA between October 1999 and December 2011, representing 0.6% of all OHCA attended. The characteristics of these cases are provided in Table 1. The median age of patients was 41.0 years (interquartile range [IQR] = 17–65) and the majority of patients were 18 years or older (77.4%) and male (70.5%). A greater number of cases occurred in the warmer seasons, particularly in summer (45.2%).

Incidents took place in the ocean (35.1%), inland waterways (25.0%), pools (17.0%) and bathtubs (12.2%). Patients drowned in fresh (41.4%), salt (35.1%) or chlorinated (16.1%) water. Only 12.2% of incidents occurred at home, with children more likely to drown at home compared to adults (35.5% versus 5.4%, $p < 0.001$).

Only 17.9% of drowning-related OHCA were documented as witnessed. Those that were witnessed were more likely to receive bystander CPR (59.3% versus 34.4%, $p < 0.001$), and have EMS resuscitation attempted (73.3% versus 40.2%, $p < 0.001$). Less than half (37.8%) of patients received bystander CPR before EMS arrival, with children (<18 years) twice as likely to receive CPR as adults (66.2% versus 30.6%, $p < 0.001$).

Table 1
Baseline characteristics of all drowning OHCA patients.

Number	336
Age (years; median [IQR])	41.0 (17–65)
Child (<18) (%)	76 (22.6)
Female (%)	99 (29.5)
Home (%)	41 (12.2)
Bystander CPR (%)	127 (37.8)
Body of water (%)	
Ocean	118 (35.1)
Inland waterways	84 (25.0)
Pool	57 (17.0)
Bathtub/spa/pond/bucket	52 (15.5)
Unknown	25 (7.4)
Type of liquid (%)	
Fresh	139 (41.4)
Salt	118 (35.1)
Chlorine	54 (16.1)
Unknown	25 (7.4)
Primary suspected cause of drowning (%)	
Presumed drowning	330 (98.2)
MVA	3 (0.9)
Suicide	3 (0.9)
Initial rhythm (%)	
Asystole	302 (89.9)
PEA	21 (6.3)
VF	10 (3)
Unknown	3 (0.9)
Season (%)	
Summer	152 (45.2)
Autumn	60 (17.9)
Winter	43 (12.8)
Spring	81 (24.1)
Witnessed (%)	60 (17.9)
EMS Response time (min; median [IQR])	8.0 (6–12)
EMS Resuscitation attempted (%)	154 (45.8)
Transported to hospital (%)	89 (26.5)

CPR, cardiopulmonary resuscitation; MVA, motor-vehicle accident; PEA, pulse-less electrical activity; VF, ventricular fibrillation; EMS, emergency medical service, IQR (inter quartile range).

3.2. Characteristics and outcomes of cases receiving attempted EMS resuscitation

EMS resuscitation was attempted in 154 cases (45.8%; 32.3% adults versus 80.3% children), the characteristics of these cases are presented in Table 2. Compared to patients where resuscitation was not attempted, patients who received an attempted EMS resuscitation were younger (26 years versus 55 years, $p < 0.001$) and more likely to have received bystander CPR (84.3% versus 20.8%, $p < 0.001$).

Where EMS resuscitation was attempted, 89 patients (57.8%) were transported to hospital. Return of spontaneous circulation (ROSC) was achieved before arrival at hospital for 45 (29.2%) patients, 44 (28.6%) were transported with ongoing CPR, and 64 (41.6%) were declared deceased at the scene. Few patients who did not achieve ROSC before arrival at hospital survived to discharge (2.0% versus 22.7%, $p < 0.001$). Only 12 (7.8%) patients receiving attempted EMS resuscitation survived to hospital discharge, two-thirds of whom were children and half drowned in pools (Table 3). All of the survivors were discharged from hospital to home, except one who was discharged to a rehabilitation facility.

The median time taken for EMS to respond to the scene of survivors (5.9 min; IQR = 4–7) was significantly shorter compared to non-survivors (8.0 min; IQR = 6–11, $p = 0.026$). There were no survivors when the EMS response took longer than 12 min. The median age of survivors (3.0 years; IQR = 1–49) was not significantly different from non-survivors (26.6 years; IQR = 4–51, $p = 0.069$). Patients

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Table 2
Association between variables and survival to hospital discharge (EMS resuscitation attempted).

	Discharged alive	Died	Total	*p*-Value
Number (%)	12 (7.8)	142 (92.2)	154	
Age (years; median; [IQR])	3.0 (1–49)	26.5 (4–51)	26.0 (4–51)	.069
Child (<18) (%)	7 (11.5)	54 (88.5)	61	.233
Adult (≥18) (%)	5 (6.0)	79 (94.0)	84	
Gender				.320
Female (%)	5 (12.2)	36 (87.8)	41	
Male (%)	7 (6.7)	97 (93.3)	104	
Location (%)				.041
Home	5 (19.2)	21 (80.8)	26	
Public place	7 (5.9)	111 (94.1)	118	
Type of liquid (%)				.104
Salt	1 (2.1)	46 (97.9)	47	
Other	11 (11.2)	87 (88.8)	98	
Witnessed				.746
Yes (%)	4 (9.5)	38 (90.5)	42	
No (%)	8 (7.8)	94 (92.2)	102	
Bystander CPR				.510
Yes (%)	7 (7)	93 (93)	100	
No (%)	4 (10)	36 (90)	40	
EMS Response Time (min; median [IQR])	5.9 (4–7)	8.0 (6–11)	7.4 (6–11)	.026
Initial rhythm (%)				.022
VF/VT	3 (33.3)	6 (66.7)	9	
Non-shockable	8 (6.0)	126 (94.0)	134	
Pulse present at hospital (%)	10 (24.4)	31 (75.6)	41	<.001

CPR, cardiopulmonary resuscitation; EMS, emergency medical service; IQR, inter quartile range; VF, ventricular fibrillation; VT, ventricular tachycardia.

who drowned at home had a faster EMS response (6.5 versus 8.0 min, $p = 0.021$) and were more likely to survive than those who drowned in a public place (18.5% versus 5.9%, $p = 0.041$).

On EMS arrival, the majority of patients (79.2%) presented in asystole or pulse-less electrical activity (PEA) (13.0%). Only a small proportion presented in ventricular fibrillation (VF) (6.5%). Patients' outcomes by rhythm on EMS arrival are presented in Table 4. Only 3.3% of patients presenting in asystole survived to hospital discharge, compared to 20.0% of those in PEA and 30.0% of patients presenting in VF.

3.3. Predictors of survival

Multivariable analysis revealed no independent predictors for patients arriving at hospital with a pulse. Factors significantly associated with survival to hospital discharge were initial shockable rhythm (AOR 48.70, 95% CI 3.80 to 624.86) EMS response time (AOR 0.73, 95% CI 0.54 to 0.98) and salt water drowning (AOR 0.69, 95% CI 0.01 to 0.84).

4. Discussion

This is the only Australian study of drowning-related OHCA that follows patients from the emergency phone call through to discharge from hospital. Patients suffering OHCA caused by drowning survived to hospital discharge in 7.8% of cases. Patients were more likely to survive to hospital discharge if they did not drown in salt water, EMS responded quickly and they were found in a shockable rhythm. Cases frequently occurred in summer (45%) and the majority of patients were adults (77.4%) and male (70.5%).

Similar characteristics in drowning-related OHCA populations are reported elsewhere. A higher incidence of drowning in warm seasons has been previously described[3,6,15] and is probably related to increased exposure to water and activities at that time of the year. The male predominance is also commonly reported[7,16,17] and is likewise probably related to greater exposure. For example, an Australian survey of beach exposure and activity found that males had more exposure to the ocean and were more likely to engage in activities known to increase the risk of drowning such as swimming alone, in deep water and under the influence of alcohol.[18] The survey also found that males reported higher swimming confidence and the authors speculate that overconfidence may contribute to the risk of drowning.[18] Any efforts made to prevent drowning-precipitated OHCA need to target males in the warmer seasons.

It is not surprising that the number of witnessed cases in our cohort was so low (17.9%) given that previous studies have shown that drowning-related OHCA is witnessed less than half as often as cardiac aetiology OHCA.[6,7] Despite a comparable low rate of cases

Table 3
Characteristics of patients who survived to hospital discharge.

	Age (years)	Body of water	Bystander CPR	Initial rhythm	Transported with ROSC/CPR	Days in hospital	Discharge location
1.	Paediatric	Unknown	CPR	Asystole	ROSC	5	Home
2.	1	Bathtub	None	Unknown	ROSC	3	Home
3.	1	Pool	CPR	Asystole	CPR	39	Home
4.	1	Unknown	CPR	Asystole	ROSC	Unknown	Home
5.	1	Pond	CPR	PEA	CPR	13	Home
6.	2	Pool	Unknown	Asystole	CPR	0	Home
7.	3	Pool	None	PEA	CPR	37	Home
8.	14	Pool	None	VF	ROSC	13	Home
9.	25	Ocean	CPR	PEA	ROSC	38	Rehab
10.	49	Pool	CPR	VF	ROSC	141	Home
11.	50	Pool	CPR	VF	ROSC	10	Home
12.	61	River	None	PEA	ROSC	49	Home

CPR, cardiopulmonary resuscitation; ROSC, return of spontaneous circulation; PEA, pulse-less electrical activity; VF, ventricular fibrillation.

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Table 4
Outcomes of drowning OHCA patients by initial presenting rhythm (EMS resuscitation attempted).

	Number	Died at scene	Transported under CPR	Transported with ROSC	Discharged alive
Asystole (%)[a]	122	53 (43.4)	38 (31.1)	30 (24.6)	4 (3.3)
PEA (%)	20	6 (30.0)	5 (25.0)	9 (45.0)	4 (20)
VF (%)	10	5 (50.0)	1 (10.0)	4 (40.0)	3 (30)
Unknown (%)	2	0	0	2	1
Total (%)[a]	154	64 (41.6)	44 (28.6)	45 (29.2)	12 (7.8)

CPR, cardiopulmonary resuscitation; ROSC, return of spontaneous circulation; PEA, pulse-less electrical activity; VF, ventricular fibrillation.
[a] Outcome unknown for 1 patient in asystole.

being witnessed for children and adults (18.8% versus 16.0%) in our cohort, children were more likely to receive bystander CPR (66.2% versus 30.6%). This may have occurred because children are easier to rescue than adults, typically having a lower body weight and bathing in shallow flat waters. To increase the number drowning-related OHCAs that are witnessed and the opportunity for bystanders to provide CPR, the appropriate supervision of children and the dangers of adults swimming alone should be promoted.

Children also had higher rates of EMS attempted resuscitation (80.3% versus 32.3%) which is probably explained by the above mentioned bystander CPR rates and an AV guideline which allows paramedics to withhold resuscitation for adults who present in asystole and are estimated to have been in OHCA for greater than 10 min.[12] There were also significant differences in the location and types of water where drowning-related OHCA occurred between adults and children. For children, prevention efforts need to focus on the home and for adults the focus should be on oceans, inland waterways and pools.

Our study confirmed and found new predictors of survival in drowning-related OHCA. Salt water has not previously been shown to negatively predict survival[9,20] and additional research is needed to explore this further. A fast EMS response and a shockable rhythm are known to be predictors of survival for all aetiologies of OHCA.[21–24] When compared to cardiac aetiology, drowning OHCA patients are more often found in asystole and have a significantly longer EMS response.[6,7] More patients may have been found in shockable rhythms if their drowning OHCA was witnessed and they had a shorter EMS response.

While there has been recent debate over the timing of search and rescue efforts and subsequent resuscitation of submerged individuals, it is clear that early rescue and basic life support are the key to survival and long-term quality of life in OHCA due to drowning.[25–31] Submersion duration is unknown for the majority of our cohort given that only 17.9% of drowning OHCAs were witnessed. However there were no survivors when the EMS response took longer than 12 min. Only 32.3% of adults received attempted resuscitation and it is not known if the remainder would have benefitted from attempted resuscitation or a guideline to direct resuscitation efforts for drowning.

The limitations of this study largely relate to the retrospective nature of the data collection. Complete information on each of the patients was not always available and information on the neurological outcomes of survivors was not collected. Patients who were revived before EMS arrival were not included and neither were those where an ambulance did not attend.

5. Conclusion

Patients suffering OHCA caused by drowning survived to leave hospital in 7.8% of cases, which is comparable to survival rates of other causes of OHCA. The majority of patients were adult males and incidents often occurred in summer. An initial shockable rhythm, shorter EMS response time and non-salt water drowning were found to be the only independent predictors of survival. Prevention efforts and reducing EMS response times are likely to improve the survival of drowning patients.

Conflicts of interest

All authors work for organisations (Ambulance Victoria and Life Saving Victoria) that respond to drowning incidents and promote drowning prevention in Victoria.

Uncited reference

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