

**Epidemiology of drowning incidents among children at Sultan Qaboos University
Hospital Muscat, Oman**

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Abstract

Objectives: To study the epidemiology of drowning among children cases reported at Sultan Qaboos University Hospital in Oman.

Methods: We conducted a retrospective study of the patients who were presented at emergency department with the history of drowning over a period of 10 years from January 2008 to December 2017. Patients with age 1 to 18 years were included in the study. The data including demographics, timing and location of drowning, season, adult supervision, swimming ability, medical risk factors, duration of submersion, on spot resuscitation, emergency medicine department assessment, hospital management and outcome were collected from electronic hospital information system using a preformed proforma. Outcome was categorized into either full recovery, severe neurological injury or brain death based on the pediatric cerebral performance category (PCPC). A good outcome represents to a score of 1-3 points and PCPC

of 4-6 points corresponds to poor outcome. We calculated correlation for all variables with the outcome by using chi square and fisher exact tests. P value of <0.05 is taken as significant value.

Results: A total of 74 patients were included in the study. Of them, 54 (73%) were male, children of less than six years of age were 47 (63.5%). More than 50% of drownings happened in outside swimming pool, 21 (28.4%) of patients were unsupervised during incident and 39 (52.7%) required cardiopulmonary resuscitation. Out of all studied subjects, 3 (4%) were brain dead and 2 (2.7%) developed severe neurological injury. On univariate analysis, the following variables were statistically significant ($p < 0.05$) predicting the poor outcome like lack of adult supervision, duration of submersion >10 minutes, asystole, Glasgow Coma Scale <8, temperature <35c, PH <7, anion gap >20, blood glucose >10 mmol/L, abnormal chest x-ary findings, rewarming, cardiopulmonary resuscitation, intubation, inotrope support and pediatric intensive care unit admission.

Conclusion: This study suggests that children especially male below 6 years of age without swimming ability need strict supervision next to body of water. Furthermore; preventive measures might include raising community awareness about the risk factors of drowning, commencing public CPR lessons and strict pool safety regulation by related authorities.

Keywords: Drowning, Emergency Medicine, Pediatric Intensive Care, Oman

Introduction

Drowning is a neglected public health problem and significant cause of disability and death among children. It constitutes the 3rd major cause of accidental injury killer and 7 % of all injury related death globally.¹⁻² Approximately 80% of drownings are preventable and it is the serious cause of death especially in children among low and middle income countries.¹⁻³ According to

centers for disease control and prevention (CDC) drowning is the fifth leading cause of accidental death and causing two drowning related deaths every day in children less than 14 years in United States.⁴ Drowning is reported by, Donson et al, as the 5th major cause of accidental death in South Africa in 2010.⁵ In Bangladesh, about 50 drownings happened per day, with most of the drownings (80%) occurring in fresh water.⁶

The present definition of drowning is proposed by world congress on drowning and World Health Organization (WHO) in Amsterdam 2002 as, “Drowning is the process of experiencing primary respiratory impairment from submersion in liquid medium”. This definition nullifies all previous definitions of drowning like dry drowning, wet drowning, near drowning, active or passive drowning, silent drowning, and secondary drowning.⁷

Drowning shows three age related peaks each resulting in, children younger than five years, in adolescents and in elderly. The usual places of drowning in children are swimming pools, bath tubs, buckets and natural bodies of water. Epilepsy, medical illness and use of alcohol or illicit drugs are risk factors for drowning in children and adolescent.⁸ Peden MM et al: study showed lack of parent’s education, infants left unsupervised, children under 5 especially male are factors that showed the significant risk for drowning.⁹

Oman is situated on the southeastern edge of Arabian Peninsula covering almost all of the eastern sea coast of Arabian Peninsula. With such a vast sea coast drowning cases are natural to happen.¹⁰ According to Public Authority for Civil Defense and Ambulances (PACDA) Oman, the number of drowning related death is on the rise in Oman with 113 cases in 2015 to 286 cases in 2016. Most of drowning incidents happened in wadis and involved victims are those who not able to swim.¹¹ Sultan Qaboos University Hospital is a government institution and a teaching hospital situated within the campus of the Sultan Qaboos University Muscat. Hospital has 600 beds capacity and wide catchment area. Our study aimed to determine the epidemiology

of drowning among children cases reported at Sultan Qaboos University Hospital (SQUH) in Oman.

Methods

This retrospective review study was conducted from January 2008 to December 2017 at emergency medicine department. We included patients with age 1-18 years who presented with history of drowning. The study was approved by the Sultan Qaboos University, College of Medicine and Health Sciences ethics committee (Reference: SQU – EC/254/17). Patient's data were retrieved from SQUH electronic medical record system by putting discharge code of near drowning, non-fatal drowning and fatal drowning. We extracted the following descriptive variables including demographic features, timing, season of the year, location of drowning, adult supervision, swimming ability, medical risk factors, duration of submersion, on spot resuscitation, transport to other hospital, emergency medicine department (EMD) assessment, in hospital management and outcome. Patient's outcome were categorized into either full recovery, severe neurological damage or brain death according to pediatric cerebral performance category (PCPC). A good outcome represents to a score of 1-3 points and PCPC of 4-6 points corresponds to poor outcome. Severe neurological damage indicates the patient stayed in a vegetative state. The data were presented in numbers and percentages. Association between groups were analyzed using Pearson's chi-squared and Fishers exact tests. A p-value of <0.05 is taken as statistically significant. Data were analyzed using STATA version 15 (STATA Corporation, College Station, TX, USA).

Results

A total of 74 patients chart reviewed and included in study. Out of them, 54 (73%) were male and children of less than six years of age were 47 (63.5%). Of the total study subjects, 69

(93.3%) discharge from hospital with full recovery, 3 (4%) were diagnosed as brain death, and 2 (2.7%) were developed severe neurological damage. Four groups of variables were evaluated to determine their relation to the outcome. The first group included patient's demographic such as age and sex. None of them associated significantly with good or poor outcome (Table 1). Second group included prehospital variables such as time and season of drowning, location of drowning, adult supervision, swimming ability, medical risk factors, duration of submersion, on spot resuscitation, and initial transfer to other hospital. Out of assessed variables, 38 (51%) of the drowning occurred in private swimming pool, 47 (63.5%) had no swimming ability, 2 (2.7%) children had diagnosed epilepsy, and 39 (52.7%) received on spot resuscitation by family member or EMS. Of the prehospital variables, lack of adult supervision ($p < 0.014$) and duration of submersion >10 minutes ($p < 0.001$) were statistically significant and correlated with poor outcome (brain death or severe neurological damage) (Table 2). Of the 4 children who had a worse consequences, all were swimming without the adult supervision. Of the study subjects, 5 children had duration of submersion > 10 minutes, out of them 2 were diagnosed as brain death, 2 were developed severe neurological injury and 1 was discharge from hospital with complete recovery. Third group included variables evaluated at the EMD such as, initial heart rhythm, GCS score, temperature, PH, anion gap, blood sugar, and chest x-ary. Of the variables assessed on arrival, asystole, GCS score < 8 , temperature $< 35^{\circ}\text{C}$, PH < 7 , anion gap > 20 , blood sugar > 10 , and abnormal chest x-ary findings (signs of aspiration) were found to correlate with poor outcome with statistical significance (Table 3). 2 children with drowning grave effects, both had initial sinus rhythm on arrival to EMD. Chest x-ary was done on all patients with 31 (42%) reported abnormal findings. Furthermore; chest x-ary of all children showed signs of aspiration who had a negative outcome. Fourth group included in hospital admission variables such as rewarming, cardiopulmonary resuscitation (CPR), intubation, inotropes, and PICU admission. In all, 6 (8%) patients were rewarmed, 4 (5.4%) required CPR,

10 (13.5%) patients were intubated, 4 (5.4%) received inotropic support and 17 (23%) were admitted to PICU. Of the variables assessed, CPR, intubation, need for rewarming, inotropes and PICU admission were statistically significant and correlated with poor outcome (Table 4).

Table 1. Demographic data.

Variables	No. of cases n = 74	Good outcome		Poor outcome		p value Chi-square test
		Full Recovery		BD or SND		
		n	%	n	%	
		69	93	5	7	
Age						0.868
Infant (1-12 m)	2 (2.7)	2		0		
Toddler (1-3 y)	30 (40.5)	27		3		
Preschool (4-6 y)	15 (20.3)	13		2		
School (7-14 y)	17 (23.0)	17		0		
Adolescent (15-18 y)	10 (13.5)	10		0		
Sex						0.667
Male	54 (73.0)	50		4		
Female	20 (27.0)	19		1		

BD or SND indicates brain death or severe neurological damage

Table 2. Relation of prehospital variables to drowning outcome.

Variables	No. of cases n = 74	Good outcome		Poor outcome		p value Chi-square test
		Full Recovery		BD or SND		
		n	%	n	%	
		69	93	5	7	
Timing of drowning						0.789
AM	6 (8.1)	6		0		
PM	68 (91.9)	63		5		
Season of drowning						

Summer	29 (39.2)	26	3	0.517
Autumn	18 (24.3)	8	0	
Winter	9 (12.2)	18	1	
Spring	18 (24.3)	17	1	
Location of drowning				0.087
Buckets	3 (4.1)	3	0	
Home swimming pool	6 (8.1)	5	1	
Outside swimming pool	38 (51.4)	36	2	
Wadis	5 (6.8)	4	1	
Lake / Ponds	5 (6.8)	4	1	
Sea	17 (23.0)	17	0	
Lack of adult supervision				0.014
No	53 (71.6)	52	1	
Yes	21 (28.4)	17	4	
Swimming ability				0.571
Pre swimming age	36 (48.6)	32	4	
Can swim	27 (36.5)	26	1	
Can't swim	11 (14.9)	11	0	
Medical risk factors				0.928
No	72 (97.3)	67	5	
Epilepsy	2 (2.7)	2	0	
Duration of submersion				<0.001
<10 min	65 (87.8)	64	1	
>10 min	9 (12.2)	5	4	
On spot resuscitation				0.090
No	35 (47.3)	35	0	
Yes, by family or EMS	39 (52.7)	34	5	
Initial transfer to other hospital				0.723
No	41 (55.4)	39	2	
Yes	33 (44.6)	30	3	

BD or SND indicates brain death or severe neurological damage; EMS, emergency medical services

Table 3. Relation of the assessment variable in the emergency department with drowning outcome.

Variables	No. of cases n = 74	Good outcome Full Recovery		Poor outcome BD or SND		p value Chi-square test
		n	%	n	%	
		69	93	5	7	
Initial Rhythm						
Sinus rhythm	71 (95.9)	69		2		<0.001
Asystole	3 (4.1)	0		3		
GCS Score						
<8	4 (5.4)	0		4		<0.001
>8	70 (94.6)	69		1		
Temperature C						
<35	8 (10.9)	4		4		<0.001
>35	66 (89.1)	65		1		
PH						
<7	3 (4.1)	0		3		<0.001
>7	71 (95.9)	69		2		
Anion Gap						
< 20	62 (83.8)	62		0		<0.001
> 20	12 (16.2)	7		5		
Blood sugar (mmol/dl)						
<10	65 (87.8)	64		1		<0.001
>10	9 (12.2)	5		4		
CXR						
Normal	43 (58)	43		0		0.024
Bilateral infiltrate	31 (42)	26		5		

BD or SND indicates brain death or severe neurological damage; CXR, Chest x-ary

Table 4. Relation of management variable in the hospital with drowning outcome.

Variables	No. of cases n = 74	Good outcome Full Recovery		Poor outcome BD or SND		p value Chi-square test
		n	%	n	%	
		69	93	5	7	
Rewarming						
No	68 (91.9)	67		1		<0.001
Yes	6 (8.1)	2		4		
CPR						
No	70 (94.6)	69		1		<0.001
Yes	4 (5.4)	0		4		
Intubation						
No	64 (86.5)	64		0		<0.001
Yes	10 (13.5)	5		5		
Inotropes						
No	70 (94.6)	68		2		<0.001
Yes	4 (5.4)	1		3		
PICU						
No	57 (77.0)	57		0		0.006
Yes	17 (23.0)	12		5		

BD or SND indicates brain death or severe neurological damage; CPR, Cardiopulmonary resuscitation; PICU, Pediatric intensive care unit.

Discussion

Globally the maximum drowning rates are among children 1-4 years followed by children 5-9 years. Drowning accounts for 43% of deaths among children aged 1-4 years in Bangladesh and 57% of drowning incidents happened in same age group in Saudi Arabia.¹²⁻¹³ This study showed most of the drowning occurring in children of toddlers age group followed by school going children. Moreover, results showed a trend (not statistically significant) for poor drowning outcome in children < 6 years. Increased prevalence of drowning in this age groups could be due to children are trying to explore the world and their cognitive abilities are not correspondent to recognize dangers especially when left unsupervised. The study showed a sex difference of male to female ratio > 2:1 which is in line with World Health Organization (WHO) yearly report on drowning published in 2014.² Majority of worse drowning outcome occurred in male population in comparison to the females. This might be related to that boys are more physically active and having risk taking behavior compare to girls.¹⁴

Maximum drowning incidents occurred in afternoon and evening time of summer followed by autumn and spring. This seasonal difference is similarly reported in these regional studies.^{13,15} More than half of our study population submersion occurred in swimming pools followed by sea, wadi and pond respectively. Furthermore; in all children with outcome in the form of brain death or severe neurological damage, 3 patients drowning happened in swimming pool, 1 in wadi and other one in pond. These results were comparable with drowning incidents reported by PACDA and with reference studies^{8,16} but is in contrast with study done in china, where 72% of the children drownings occurred in natural water bodies.¹⁷ The climate of Muscat features a hot and humid with long and very hot summer. Hot weather may leads to increase outgoing and water related activities. Increased access to water is risk factor for drowning. This may in part explain the quite high incidence of drowning in artificial or natural water bodies. It

is paramount advice to parents to take care of their children while going to the swimming pool, wadis or sea. One of the four submersion occurred where accompanying person was not around or busy in other work and above sixty percent of the victims have no swimming abilities. Out of them, 4 victims had brain death or severe neurological damage. These results explained the lack of strict safety precautions near body of water and poor adult supervision associated with worse consequences.

Overall outcome of drowning patients are dependent on optimal prehospital care.¹⁸ Transport to hospital with definite care as early as possible and performance of CPR at scene or during transport correlated with good outcome (although not statistically significant). This might be related to the vigilance during transport is not optimal and inadequate knowledge of general population regarding the basic life support. Al – Shaqsi et al; reported in there study almost 55% of surveyed population did not know how to perform CPR.¹⁹ Multiple efforts made by experts is the field, to develop individual prognostic factors to predict the drowning negative outcome, unfortunately there are no validated guidelines in the literature.²⁰⁻²¹ However, published prognostic factors include drowning duration >10 minutes, delayed rescue at the scene, need for CPR in the emergency department, depth of coma (GCS score <4), poor neurological response to therapy, initial arterial pH of less than 7.0, and initial blood sugar level of greater than 12 mmol/L.²⁰⁻²² Our studies results are matching with other studies²¹⁻²⁵ regarding the predictive values of prehospital variables, initial EMD and in hospital management with harmful effects of drowning.

Proper understanding of submersion injuries pattern is vital for the development of preventive measures against drowning. Developed countries did significant research and hence developed much improved preventive measures. In doing so they took strict legislative measures and did comprehensive health awareness campaigns.²⁶ The outcome of overall preventive strategies

suggested by studies in the developed countries is sometimes difficult to implement in developing countries due to the lack of resources. Generally their recommendations include fencing of water bodies and to improve public awareness regarding the drowning.²⁷

Limitation

To the best of our knowledge, this is the first study with deep insight on drowning at institutional level. There were limitations. First limitation, the study was conducted at one tertiary care hospital, therefore findings might not be generalized to the whole population. Therefore, it is need to collaborate with other hospitals and related institutional bodies to work on this subject in future. Second limitation, due to retrospective study, it was difficult to comprise different factors the might have affected the prevalence of drowning like parents education, home and private swimming pool safety measures. Third limitation, follow up of discharged patients with severe neurological damage were missing.

Conclusion

This study suggests that children especially male below 6 years of age without swimming ability need strict supervision next to body of water. Furthermore; preventive measures might include raising community awareness about the risk factors of drowning, commencing public CPR lessons and strict pool safety regulation by related authorities.

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