A Retrospective Study of Near-drowning Victims Admitted to the Intensive Care Unit

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Abstract

A retrospective study was conducted to evaluate the outcome of near-drowning patients admitted to the intensive care unit (ICU) comparing seawater and freshwater drownings. A chart review was used to identify near-drowning patients admitted to ICU from 1 April 1989 to 1 May 1996 for biodata, physiological data and outcome. Seventeen near-drowning patients were admitted to ICU over a period of nearly 7 years. There were 3 deaths (17.6%) and 8 patients (47%) required cardiopulmonary resuscitation. Freshwater near-drowning occurred in 8 patients and saltwater near-drowning occurred in 9 patients. Nearly all (94%) the patients had a PaO_2/FiO_2 ratio <300 mm Hg. Pulmonary oedema was present on the chest radiographs of all patients. Mechanical ventilation was required for 8 patients (47%), and nearly all (94%) received prophylactic antibiotics. None of the patients developed pneumonia. Serum electrolytes and haemoglobin concentration were not grossly abnormal although, those with saltwater near-drowning had a significantly higher level of haemoglobin, sodium and urea compared to those with freshwater near-drowning. Patients that survived to hospital discharge had full neurological recovery and stayed an average of 4.5 days. We concluded that near-drowning victims that survive to be admitted to ICU have significant oxygenation defect with nearly half requiring ventilator-y support. Mortality is appreciable, but those that survive to hospital discharge had full neurological recovery.

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Key words: Electrolytes, Freshwater, Pneumonia, Pulmonary oedema, Saltwater, Survival

Introduction

Drowning victims suffocate from submersion. This may lead to immediate death or, if they survive, brain damage if significant cerebral hypoxia is present.[1] Aspiration of fluid occurs in 90% of cases which leads to hypoxaemia.[2] The volume and composition of fluid determines the physiologic basis of the hypoxaemia. Pneumonia may also develop if the water is grossly contaminated with bacteria.[3]

This study was conducted to examine the physiologic responses in fresh and seawater submersions, and the outcome from such tragedies that required intensive care unit (ICU) admission.

Patients and Methods

This is a retrospective study that examined all near-drowning victims admitted to the medical ICU of the National University Hospital, from 1 April 1989 to 1 May 1996. Biodata were collected along with laboratory investigations and chest radiograph reports. Hospital and ICU outcomes were determined, along with their presenting neurological status (Glasgow Coma Scale). Pneumonia was diagnosed based on new persistent infiltrates on chest radiograph, fever, leukocytosis, and increased sputum production.

Data are presented as mean ± standard deviation (SD). Continuous data were compared using t-test, and a P value of less than 0.05 was taken as significant.

Results

Seventeen cases were identified. There were 13 males and 4 females. The average age was 33 (±17 SD) years (range 12 to 70 years). Eight patients (47%) required cardiopulmonary resuscitation (CPR) (no data available on length of CPR) at recovery, with the majority surviving to hospital discharge (82%). There were 3 deaths. Eight patients (47%) required mechanical ventilation for a median period of 2 days. Pulmonary oedema was present in all patients, and 94% (17 patients) had a PaO_2/FiO_2 ratio <300 mm Hg at admission. There was no significant difference between those with freshwater versus saltwater near-drownings (153 ± 66 mm Hg vs 183 ± 116 mm Hg, $P = 0.26$).

Leukocytosis ($>12 \times 10^9/L$) was present in 9 patients (53%), with no positive blood cultures, and only 2 sputum cultures were positive with a light growth of *Staphy-*

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lococcus aureus. Antibiotics were prescribed on admission in nearly every patient (94%). No patient had an admission temperature of less than 35°C. Twelve patients had venous carbon dioxide levels of less than 20 mmol/L. No sodium bicarbonate was administered as treatment.

There were 8 (47%) freshwater near-drownings and 9 (53%) saltwater near-drownings. All freshwater near-drownings occurred in swimming pools. There was no information with regards to swimmers and non-swimmers. Two deaths were from freshwater drownings. One died from acute myocardial infarction (ECG and cardiac enzymes) and the other patient had significant cerebral oedema on computed tomographic (CT) head scan. The patient that died from saltwater drowning had a right thalamic infarct and became brain-dead. Admission Glasgow Coma Scale was less than 7 in 6 patients (35%) and recovered to 15 in the 3 patients that survived. Haemoglobin, electrolytes (sodium, potassium) and urea at admission are shown in Table I. Although the haemoglobin concentration, sodium and urea levels were significantly higher in those with saltwater near-drowning, the differences were not significant.

Average length of stay in hospital was 4.5 (±2.3 SD) days. All patients that survived to hospital discharge had a normal neurological examination.

TABLE I: ADMISSION VALUES OF SODIUM, POTASSIUM, UREA AND HAEMOGLOBIN COMPARISON BETWEEN FRESH AND SALTWATER NEAR-DROWNING VICTIMS

	Freshwater	Saltwater	*P* value (one-sided t-test)
PaO_2/FiO_2 ratio (mm Hg)	153 ± 66	183 ± 116	0.26
Sodium (mmol/L)	135 ± 4.1	149 ± 5.4	<0.001
Potassium (mmol/L)	3.46 ± 0.49	3.86 ± 0.81	0.13
Urea (mmol/L)	3.68 ± 1.06	4.69 ± 0.84	0.022
Haemoglobin (g/dL)	13.4 ± 1.34	15.0 ± 0.79	0.005

Discussion

Drowning or near-drowning may occur because the person does not know how to swim or stay afloat. Alternatively, a cardiac or neurological condition develops while the patient is in the water or leads to the person falling into water resulting in an inability to swim or stay afloat. Victims may also be trapped underwater. Prognosis depends on the cause of the drowning, the length of hypoxaemia, and subsequent resuscitation if they survive the hypoxaemia. As a result of hypoxaemia, brain damage may occur. Furthermore, aspiration of water would lead to pulmonary oedema and potential infection if the water is contaminated with bacteria. Freshwater aspiration causes atelectasis from surfactant dysfunction, and this hypotonic water is rapidly absorbed. Seawater is hypertonic and may pull additional fluid into the lungs.[5] Most of our patients had abnormal oxygenation (PaO_2/FiO_2 <300 mm Hg), with 47% requiring mechanical ventilation. There was no significant difference in oxygenation impairment between fresh and saltwater near-drownings. An alternative to mechanical ventilation is continuous positive airway pressure (CPAP) mask,[6] although patients with impaired neurological function may be better managed with tracheal intubation.

Aspiration of large volumes of water may lead to changes in blood volume and serum electrolytes. Hypotonic freshwater and hypertonic saltwater lead to opposite changes.[1] In freshwater drowning, acute hypervolaemia with dilution of electrolytes may occur. However, hypotonic plasma may also lead to membrane disruption and release of haemoglobin and potassium into the serum. In saltwater drowning, hypovolaemia with concentration of electrolytes may occur. In our patients, there were no serious abnormalities in the serum electrolytes or marked haemoconcentration or dilution, although the haemoglobin, sodium and urea concentrations were significantly higher in the group with saltwater near-drownings. This may indicate that our patients did not aspirate a significantly large amount of water during their submersion. Similarly, in a review of 91 victims, Modell et al[2] reported that there were no significant changes in serum electrolytes and haemoglobinafter fresh, sea or brackish water near-drownings.

Seawater or riverwater is more likely to contain contaminants and bacteria leading to pneumonia. Overall, the incidence of pneumonia is low, especially if mechanical ventilation is not required. As such prophylactic antibiotics are seldom required, although the majority of our patients received them with no subsequent evidence of pneumonia. The commonly described pathogens are usually Gram-negatives, anaerobes, and staphylococci, although *Haemophilus influenzae* and *Streptococcus pneumoniae* have also been described.[7,8]

In our study, there were 3 deaths (17.6%) and 47% presented with circulatory arrest requiring cardiopulmonary resuscitation. A study from the Netherlands has documented a mortality of 24%.[3] However, mortality rates are difficult to compare, as the circumstances surrounding the event will determine the outcome, which may vary from series to series.

Hypothermia was not a problem with our patients as we live in a tropical climate. Others have described hypothermia as a risk factor for infections.[9] However, hypothermia may also be protective for cerebral function especially for children.[10] If hypothermia is present, re-warming should not induce shivering as oxygen demands would be increased.

In summary, we have presented our study of 17 near-drowning victims who were admitted to the ICU and

showed little difference between fresh and seawater near-drownings. Hypoxaemia was a ubiquitous finding along with pulmonary oedema. Pneumonia per se was not seen. Electrolyte abnormalities were not a major concern in our group of patients.

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