Journal of Nursing Informatics and AI in Global Practice and Research
Number 1, December 2023, The Official Association of Nursing in the Self-Governing Region of Valencia (Spain)
https://www.journurs-cecova.com/approach-to-care-in-fresh-water...

Approach to care in fresh water and salt water drowning patients: a systematic review

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Received: 5 September 2023 **Accepted:** 25 November 2023

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Conceptualization. MDG
Methodology. MDG
Validation. MDG
Formal analysis. MNV, MDG
Investigation. MNV, MDG
Resources. MNV, MDG
Writing — original draft preparation. MDG
Writing — review and editing. MNV, MDG

All authors have read and agreed to the published version of the manuscript.

KEY WORDS: Drowning, Fresh water, Salt water, Submersion, Immersion.

ABSTRACT

Introduction. Drowning is the third leading cause of unintentional death in the world, and the nursing approach differs according to the type of water in which the victim was drowning, fresh or salt water. The aim was to determine the physiological, pathological and treatment differences in near-drowning in different types of water.

Materials and methods: literature review. The databases used were "Google Scholar, Cinahl and Medline complete" via the José Planas virtual library at the European University of Valencia and the PubMed database.

Results. 11 articles were selected. The data in the materials selected was analysed, explaining the differences that exist between the cellular physiology of a person who has nearly drowned in fresh or salt water, the pathologies resulting from this accident and the relevant care and treatment.

Conclusions. When someone nearly drowns in fresh water there are more detrimental effects than nearly drowning in salt water.

INTRODUCTION

Drowning occurs when the respiratory tract is blocked by any type of liquid, due to submersion or immersion, resulting in hypoxia and subsequently causing death (Ahmadpour-Roudesari, 2019). It differs from “near-drowning” which is defined as a situation in which a person was close to death due to not being able to breathe (suffocation) underwater (Heller, 2019), but survived more than 24 hours after it occurred.

According to the First Aid and Injury Prevention Manual (Directorate National of Health Emergencies, 2016), first aid consists of the immediate measures taken on an injured, unconscious or suddenly ill person, at the site where the incident has occurred (scene) and until the arrival of health care (emergency service). These measures taken in the first moments are decisive for the evolution of the victim (recovery). When a person is close to drowning, first aid, immediate action and medical attention are essential, as they can prevent death. Once death is avoided, the patient is taken to a hospital emergency room where appropriate care and treatment are provided.

Classification

The classification of drowning is determined by two factors: the health consequence of drowning and the presence or absence of laryngospasm after drowning.

With regard to the first factor, the health consequences of drowning can be classified as follows (Aguilar, 1999):

- Fatal drowning (death by asphyxiation).
- Non-fatal drowning, also called near-drowning. In this case the person survives for 24 hours after suffocation from submersion in water.
- Secondary drowning. Triggers RDS which occurs between 15 minutes and 72 hours after immersion.

With regard to the second factor, whether or not there has been laryngospasm and therefore aspiration of water, we can differentiate between the following drownings (Pons, 2019):

- Dry drowning: attributed to laryngospasm that persists until death occurs due to anoxia. This accounts for 10-20% of cases.
- Wet drowning: water is aspirated into the lungs, which accounts for 80-90% of necropsy findings. (Pons, 2019)

The type of water that gets into the lungs is also a factor to be taken into account, so a distinction can be made between freshwater drowning in places such as swimming pools, pools, rivers, ponds and even bathtubs and buckets, and saltwater drowning in the sea or ocean. In the article by Ahmadpour-Roudesari (2019), it is evident that 90% of drowning cases occur in fresh water such as rivers and swimming pools, compared to only 10% in salt water.

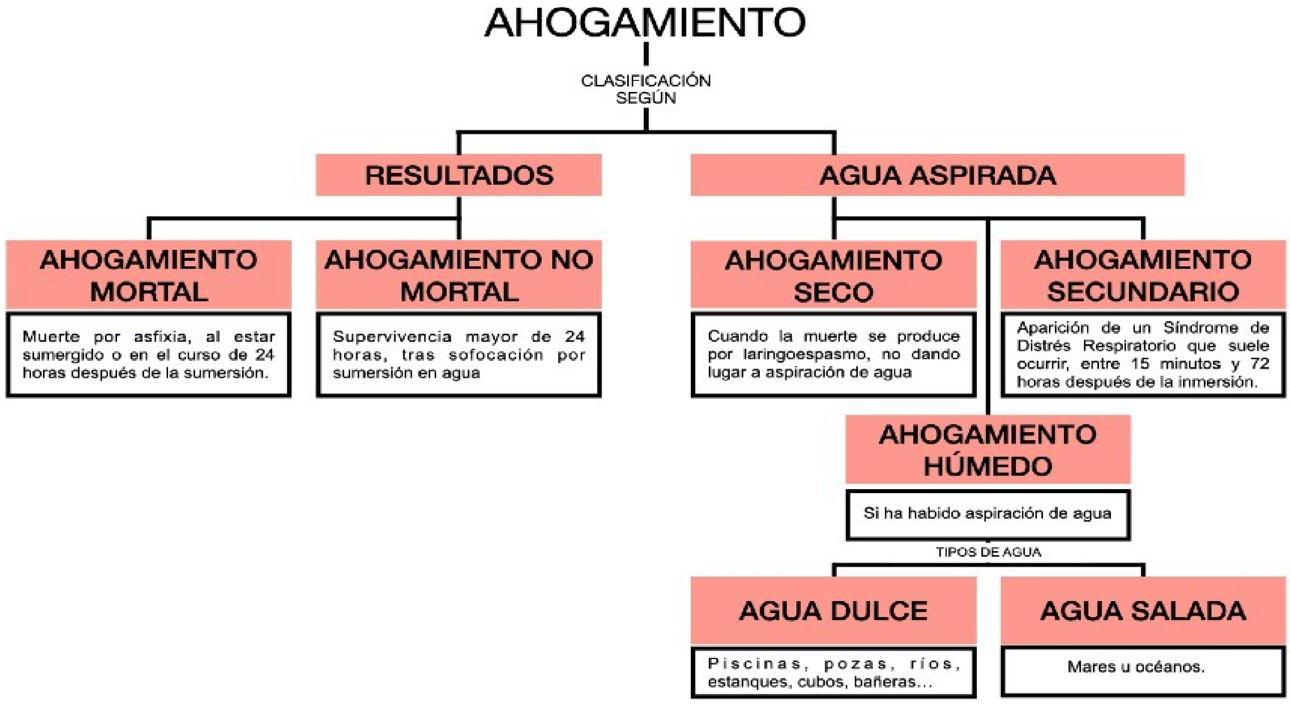

Figure 1: Classification of drowning. (Designed in-house)

Epidemiology

According to the World Health Organization (WHO, 2014) (WHO 2020), drowning is the third leading cause of unintentional injury death in the world, with data and figures showing that 236,000 people die each year – accounting for 7% of all injury-related deaths. Despite this, there is uncertainty surrounding the estimation of global drowning mortality, as the methods used to classify official drowning data exclude intentional drowning deaths such as suicide and homicide, as well as drownings resulting from catastrophic floods and water transport incidents.

Beyond this, there are also economic consequences, as in the United States, 45% of people who have drowned are in the most economically active segment of the population.

The National Drowning Institute (INA, 2021) states that in Spain "260 people have died from drowning in aquatic areas since the beginning of the year 2021"; June was the month with the highest number of people who died from this cause.

The WHO global report on drowning speaks about drowning as an important public health issue with a major impact on children and young people.

Drowning is preventable. Proven strategies at household, community and national levels range from basic swimming education and the installation of barriers to reduce the risk of water accidents, to the creation of safe spaces for children, e.g. day care centres, and learning lifesaving techniques. Hence, the WHO states that countries should take steps to improve data on drowning mortality and morbidity and establish a national water safety plan. (OMS, 2021).

In November 2014, the WHO published the first report exclusively on Drowning Prevention: An Implementation Guide. The guide builds on the global report on drowning and provides specific guidance on how to implement intervention to prevent drowning. (OMS, 2014). This was primarily aimed at governments to implement and adapt effective drowning prevention programmes.

The WHO (2021) cites the following as the main risk factors for drowning:

- Age: According to the global report on drowning, age is one of the main risk factors, generally linked to inattentive lapses in supervising children. Globally, drowning rates are highest among children aged 1-4. According to Richards' study (2019), children who cannot swim can submerge in < 1 minute, faster than adults.
- Sex: males are twice as likely to be at risk of non-fatal drowning as females, as they engage in more dangerous practices in the water.
- Access to water: e.g. people involved in fishing, or especially children living near ditches, ponds, swimming pools...
- Catastrophic floods: drowning accounts for 75% of all deaths caused by floods. They are more frequent in low- and middle-income areas.
- Travel by water: Boats are often overloaded, unsafe and lacking in safety equipment, and are sometimes piloted by people who have no boating experience and no knowledge of how to react in adverse circumstances.
- Other risk factors linked to drowning are socio-economic status, lack of higher education and living in a rural environment, leaving an infant unattended or with another child in the vicinity of the water, alcohol consumption near or in the water, certain diseases such as epilepsy, and tourists who are not familiar with the risks and particularities of local waters. In addition to these factors, Richards (2019) also includes people with Long QT Syndrome and people who engage in dangerous underwater breath-holding behaviour (DUBB) as risk factors.

Diagnosis

In many cases the diagnosis is obvious, as most people are in or near water. Resuscitation, if indicated, should precede completion of the diagnostic assessment. (Richards, 2019)

The diagnosis of drowning is as follows:

- Clinical assessment. Indication of imaging studies for concomitant injuries and pulse oximetry.
- Measurement of core temperature to rule out hypothermia.
- Assessment for causative or contributing disorders (e.g. seizure, hypoglycaemia, myocardial infarction, poisoning, injury).
- Ongoing monitoring as indicated for subsequent respiratory complications, as it sometimes takes up to 6 hours for respiratory symptoms and hypoxia to appear after immersion. (Richards, 2019)

A better or worse condition of the victim is determined after the diagnosis, depending on the water they have been submerged in and the progression of the physiological effects. The study of the physiology of drowning allows us to be familiar with the specific physiological stages that alter the sensitive ionic balance of the cell. (Ahmadpour-Roudesari, 2019)

Theoretically, fresh water is hypotonic, so near-drowning in this medium could cause hypervolaemia, dilutional hyponatraemia and haemolysis, whereas in salt water, hypovolaemia and hypernatraemia would occur.

Apart from these pathophysiologies produced by the ionic imbalance of the cell, the most immediate consequences following near-drowning are hypothermia, hypercapnia and metabolic acidosis. This can decrease myocardial contractility, increase pulmonary vascular resistance and produce cardiac arrhythmias. Renal alterations (acute tubular necrosis) may also occur, mainly due to hypoxia and acidosis triggered by asphyxia (Pons, 2019). These changes are mostly due to:

- Aspirating alveoli-occupying fluids that influence gas exchange.

- Aspirating fluids that destroy pulmonary surfactant, causing generalised alveolar collapse and atelectasis.

Regarding lung damage, Pons (2019) notes that there are no substantial clinical differences between freshwater and saltwater drowning. Although there is controversy, as Molyneux-Luick (1987) narrates that circulatory overload is believed to be the cause of pulmonary oedema in fresh water, unlike in salt water, as its hypertonicity causes damage to the lung parenchyma and fluid-filled perfused alveoli, causing intrapulmonary shunting.

Prognosis

Survival depends on the physical condition of the person, the duration of immersion and the amount of water inhaled. When the person survives, it is usually complete, but observation for several days is necessary to detect complications (Noble & Sharpe, 1963).

The most important determinants of neurological survival without serious sequelae are:

- Early rescue and the immediate establishment of basic life support, as the time factor is a crucial element.
- Delayed rescue and resuscitation are often lethal; CPR is the key to survival.
- The involvement of the CNS and/or cardiorespiratory failure is less common and implies greater severity, consequently worsening the prognosis.

Treatment

The victim's condition depends on how quickly the physiological effects of submersion have progressed and then on how quickly treatment is applied.

Richards (2019) states that treatment aims to correct cardiac arrest, hypoxia, hypoventilation, hypothermia and other physiological stress. Treatment starts with resuscitation, the correction of oxygen levels, carbon dioxide and intensive respiratory support.

The treatment to be provided should be instantaneous, "so in the emergency room there is a double priority of maintaining respiration and circulation" (Molyneux-Luick, 1987). No time should be wasted clearing the airway, although this is still under debate. Noble & Sharpe (1963), state that there is no point in maintaining a completely clear airway if the myocardium is not supplied with oxygen.

Some of the treatments carried out in the emergency department coincide in both situations (freshwater drowning and saltwater drowning), but others depend on the type of pathology that has caused the drowning.

Nursing care

In his study of clinical notes regarding near-drowning, Bruce (1984) points out some of the intensive nursing care techniques to be performed, such as bathing care, fluid balance and other recordings, the intelligent observation of signs, skin care, chest percussion, etc. Others are hypothermia control, dehydration control, hyperventilation control and drug administration, which were controversial. Of equal importance is the treatment regime of psychosocial support for the family unit, due to possible feelings of guilt for the drowning.

GOALS

To determine the differences in the treatment and care provided for a person who has almost drowned in fresh water and a person who has almost drowned in salt water, determining the existence of physiological differences between freshwater and saltwater drowning, and differentiating pathologies depending on the type of water in which the person has almost drowned.

MATERIAL AND METHODS

Type of study

Systematic literature review of peer-reviewed articles on near-drowning in different types of water, and the related physiology, pathophysiology, treatment and care.

Eligibility criteria

The PICO format was used for the research question. Although there are different strategies, this is the best known for structured clinical questions. It comprises four components: patient, intervention, comparison and outcomes.

P. Person in need of emergency health care, following near-drowning in fresh or salt water.

I. Nursing staff provide different treatments depending on various different factors.

C. Not applicable.

O. Treatment and/or care for the patient depending on whether the near-drowning took place in fresh or salt water.

After applying the method, the following research question resulted: Do patients who drown in fresh water and/or salt water receive the same care and/or treatment?

Inclusion and exclusion criteria

Firstly, the criteria for inclusion in the bibliographical search were as follows:

- Results based on the study of people who nearly drowned in different kinds of water.
- Document of any kind.
- Order of relevance
- Manuals related to the prevention of drowning and first aid.
- Reports on drowning.
- Articles published in any language and in specific date ranges.
- Secondly, the exclusion criteria to be taken into account in this search were based on discarding those documents that:
- Did not provide useful information for the goals of this study.
- Did not meet the inclusion criteria defined in the previous section.
- Articles repeated in two different databases.

Search strategy

The following table shows the search strategy with the descriptors and Boolean markers used in the different databases.

Table 1: Mesh and Desc search strategy. (Designed in-house)

MEDLINE Y CINAHL	Drowning AND Salt water OR Fresh water AND Nurse* AND Care*
GOOGLE SCHOLAR	Drowning AND Treatment AND Fresh water OR Salt water NOT Prehospital
PUBMED	Drowning AND Critical AND Care

Sources of information

The databases used were: Google academic, PubMed and Cinahl and Medline, via the José Planas virtual library at the European University.

Source of information Cinahl and Medline

The first database search was done at the José Planas Library and the MEDLINE and CINAHL databases were selected. The terms “drowning”, “salt water”, “fresh water”, “nurse*” and “care*” were used. We also used the Boolean operators AND and OR as shown in the image. A total of 26 search results were obtained, of which 6 were of interest.

Figure 2: Search results from the José Planas Library

Source of information Google Scholar

The second search was carried out in Google Scholar, using the terms “drowning”, “treatment” and “emergencies” to specifically address the subject of the study. In addition, in the advanced search, at least one of these two words had to appear in the articles: “salt water” OR “fresh water”. Another criterion to be highlighted was that the word "prehospital" should not appear in the article, as this study is aimed at treatment in the hospital service. The Boolean operators used were AND and OR. 17 search results were obtained, of which 4 were of interest.

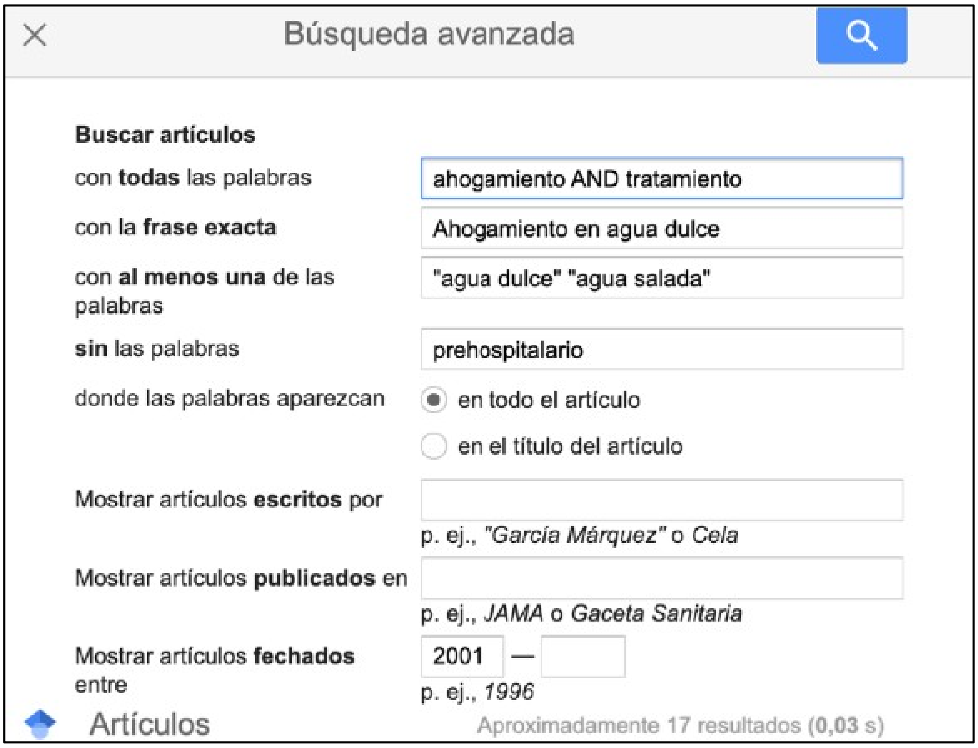

Figure 3: Search results from the José Planas Library

Source of information PubMed

Finally, the PubMed database was used. In this database, the words to be searched were “near-drowning”, “critical” and “care”. The Boolean marker AND was used between each of the words. The only screening was that the text should be free full text. 78 search results were obtained, of which 3 were of interest.

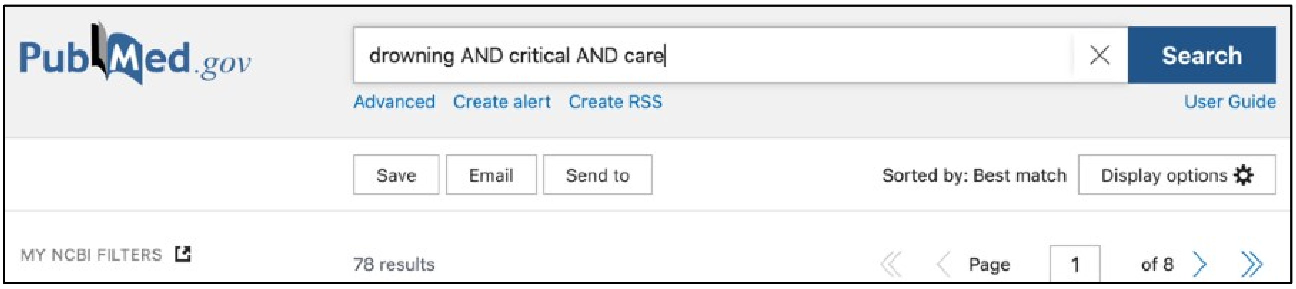

Figure 4: Search results from the PubMed database

The following table shows a summary of the search in each of the databases.

Table 2: Summary of databases and search strategies. (Designed in-house)

DATABASE	Cinahl and Medline	Google scholar	PubMed
Search strategy	Drowning AND salt water OR fresh water AND nurse* AND care*	Near-drowning AND treatment	Drowning AND critical AND care
Screening for inclusion	Full text in Cinahl Apply equivalent subjects	The words “Near-drowning in fresh water” are in the whole article. Include quotations	Free full text
Screening for exclusion	Date range not defined	Prehospital Date range not defined	
Date range	1964-2022	2001-2022	Not defined
Total results	25 results	17 results	78 results
Results of interest	6 results	2 results	3 results

Flow Chart. Flow chart showing the search in peer-reviewed literature

11 articles were obtained from the databases consulted. Below is a flowchart for each one of the databases used.

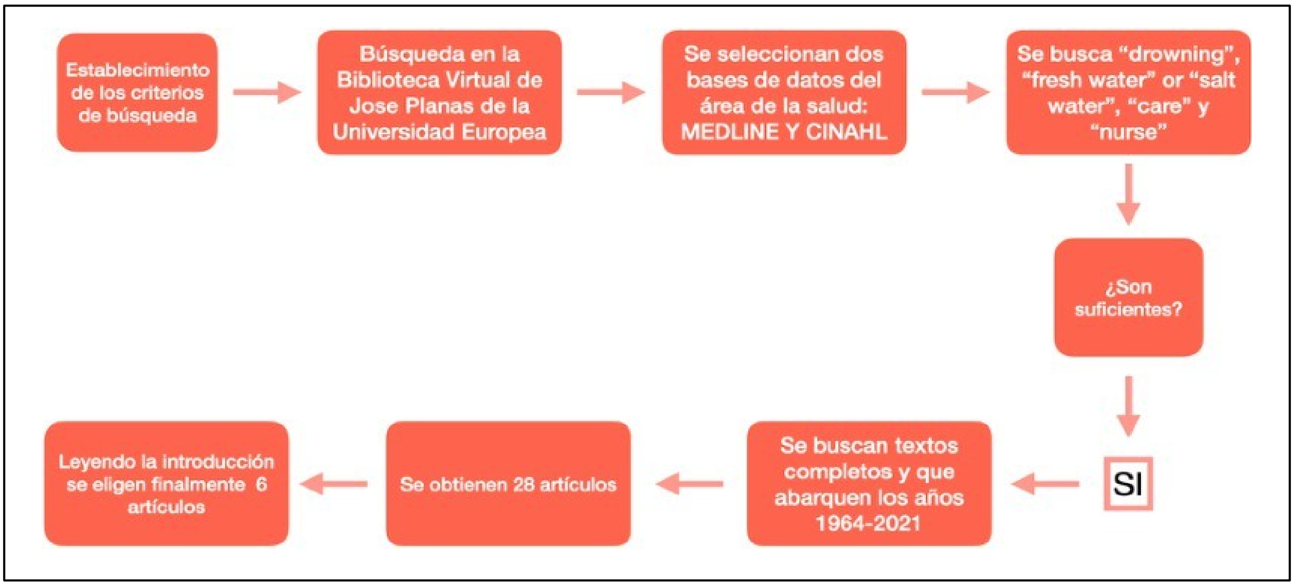

Figure 5: Detailed flowchart of the Cinahl and Medline databases at the José Planas library. (Designed in-house)

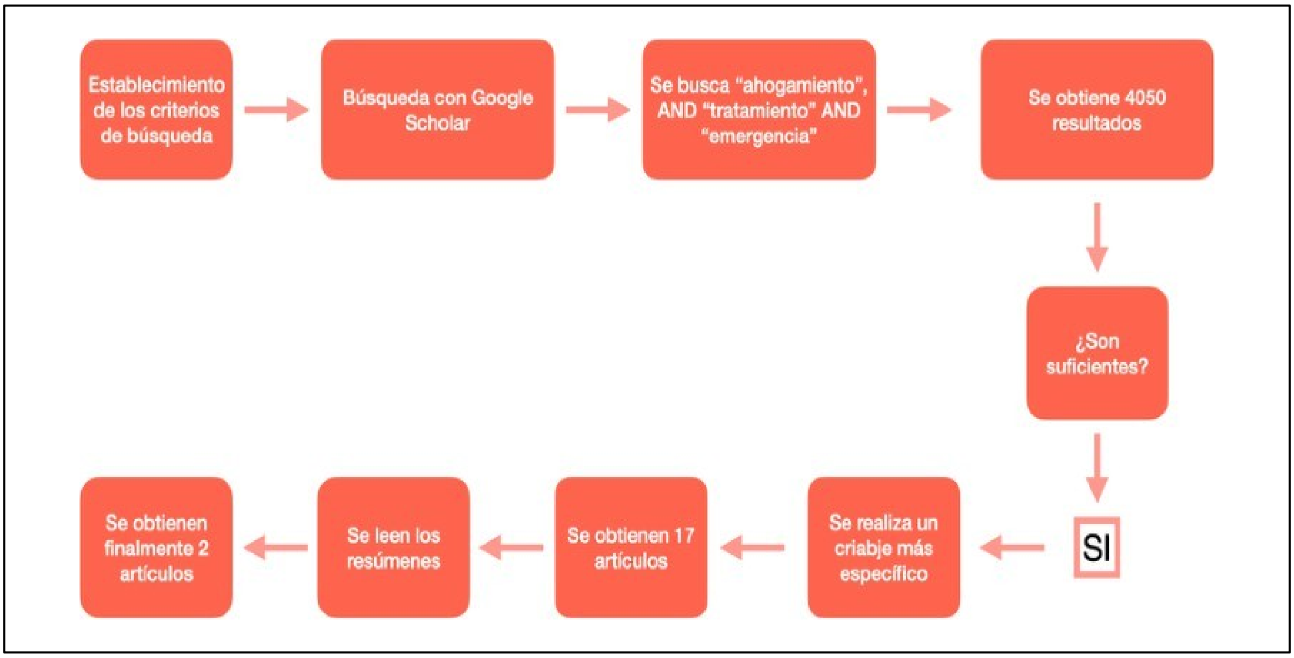

Figure 6: Detailed flowchart of the Google Scholar database

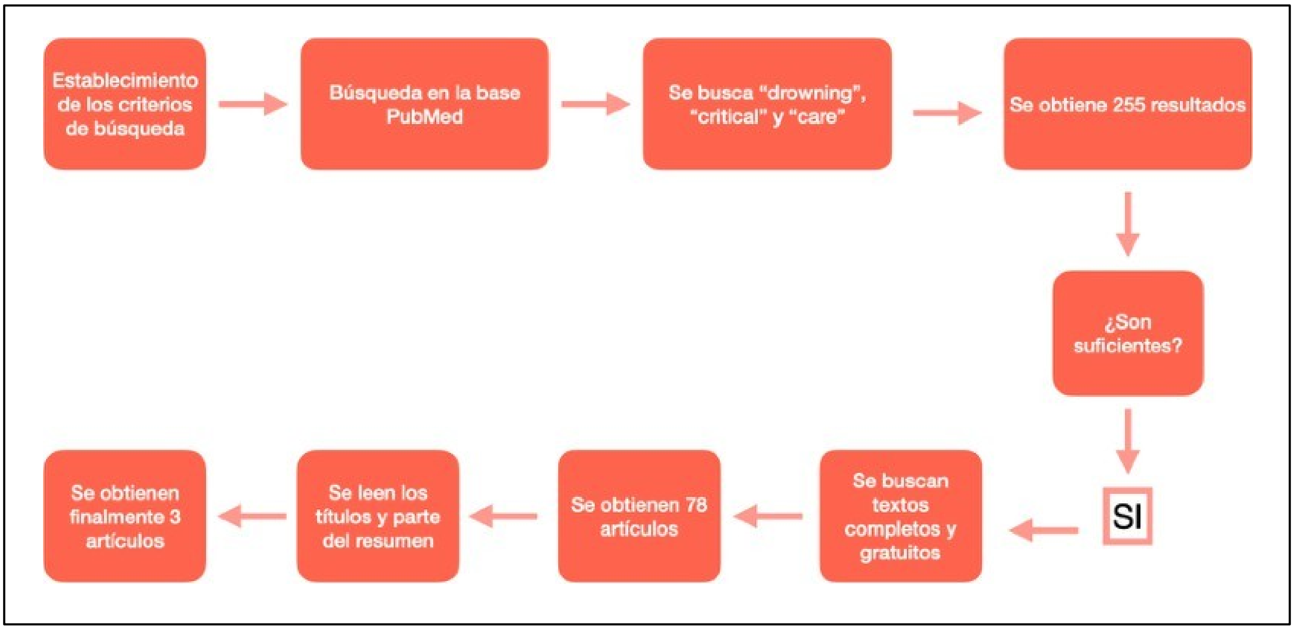

Figure 7: Detailed flowchart of the PubMed database (Designed in-house)

RESULTS

11 articles were selected for the review, in accordance with the goals established. The most relevant aspects of each one are presented below:

Table 3: Documents used in the study SOURCE: (designed in house)

Type of document	Title of article	Authors	Year	Goal it relates to		Results	Conclusions
Journal article	*Drowning physiology and the effective factor on drowning in Guilan's beaches and swimming pools*	Mojaba Ahmadpour-Roudesari	2019	Secondary goal	Cell physiology	The study of cell physiology provides insight into the specific steps that disrupt the ionic balance of the cell.	The sequence of events is different: • Fresh water: hypotonic to blood • Salt water; hypertonic.

Newspaper article	Water-sports injuries the old and the new	Marilee Molyneux-Luick	1978	Main goal	Care and treatment	• Monitoring blood gases and blood pH.
						• Maintaining cardiac output.
						• Assessing CNS function.
						• Providing:
						  • Observation of PEEP to prevent complications.
						  • Administer diuretics, isoprotenerol, antibiotics and steroids.
							Victims who have nearly drowned may drown again unless caregivers are aware of the proper precautions to take.

				Secondary goal	Cell physiology	• In fresh water: haemodilution, rarely hyponatraemia and hyper volaemia. • In salt water: hypovolaemia.	
				Secondary goal	Complications and pathologies	• In fresh water: secondary drowning, pulmonary oedema. • In salt water: intrapulmonary shunting. • In both cases: hypoxaemia, pulmonary oedema and metabolic acidosis. In addition to risk of circulatory arrest, infection secondary to aspiration, electrolyte and fluid balances, cerebral oedema and occasionally renal failure.	
Journal article	*Drowning: Its Mechanism and Treatment*	C.S. Noble, M.D and Noble Sharp, B.A.	1963	Main goal	Treatments	Intravenous solutions • In fresh water: If sodium level is below 110mEq/l: 1000 cc of 3% saline. If there is a calcium deficiency: to be corrected with calcium gluconate. • Salt water: 5% dextrose: never saline. Blood or plasma transfusion.	The current concept is that asphyxia is complicated by haemodilution in freshwater and haemoconcentration in saltwater.

Type of document	Title of article	Authors	Year	Goal it relates to		Results	Conclusions
				Secondary goal	Cell physiology	• Fresh water: Haemodilution Haemolysis High potassium levels Low calcium levels Rarely hyponatremia. • Salt water: Haemoconcentration Hypernatremia High calcium levels High potassium levels	Treatment of near-drowning obtained from a review of the literature is described, with emphasis on cardiac massage, intravenous therapy and ongoing observation.
				Secondary goal	Complications and pathologies	In both fresh and salt water: asphyxia. In fresh water: high potassium levels and low calcium levels may be a significant factor in ventricular fibrillation. Haemolysis may cause renal tubular nephrosis.	
Journal article	*Study of drowning in fresh and salt water*	Mohamadreza cuya, Nasrin Ramezan i, Golnaz Peyravi	2019	Secondary goal	Cell physiology	Fresh water leads to rapid absorption into the blood from the gastrointestinal tract due to the low osmotic pressure of blood: Increased volume and thus haemolysis. In salt water: the same osmotic pressure as blood; there is an increase in sodium and chlorine.	Possible complications that may occur are due to the ingestion of abundant water.
Journal article	*Intensive care after fresh water inmersion accidents in children*	Pfenninger, J & sutter,M.	1982	Main goal	Care and treatment	Fresh water: • Respiratory monitoring • Monitor blood pressure. • Maintain body temperature between 35.5 and 36.5o with ice packs, wet sheets and ventilation. • Restriction of fluid intake. • Administration of barbiturates and dexamethasone. • Depending on lung pathology; PEEP, IMV or CPAP. Other care: keep head elevated, appropriate sedation, administer antacids (sodium bicarbonate) through nasogastric tube, early nutrition, strict surveillance for bacterial infections.	NIC methods should be defined to improve minimal iatrogenic complications.
Journal article	Ahogamiento y casi ahogamiento	Posada A. & Augusto, C.	2005	Secondary goal	Cell physiology	Fresh water: hypervolaemia, haemodilution, haemolysis and hyperkalaemia, alveolar collapse, atelectasis, hypoxemia and impaired ventilation-perfusion. Salt water: Hypovolaemia, haemoconcentration, hypermagnesemia and hypercalcemia.	The importance of prevention in the majority of drownings and teaching said prevention.
				Secondary goal	Care and treatment	• 5% glucose perfusion during transport. • Assess level of consciousness using the Glasgow scale. • Monitor pulse, perfusion and blood pressure. • Central catheter in extremely hypothermic patients. • Administration of insulin.	

Type of document	Title of article	Authors	Year	Goal it relates to		Results	Conclusions
				Secondary goal	Complications and pathologies	Depending on the organ or system affected • CNS Convulsions • Pulmonary system: hypoxia, hypercapnia, pulmonary acidosis, atelectasis, pulmonary oedema, bronchoaspiration of gastric contents, diffuse lung injury: pulmonary haemorrhage, bronchoaspiration of irritants, pneumonia. • Circulatory system: supraventricular arrhythmias and PR lengthening, QRS widening and ST-segment depression in hypothermia. • Renal alterations: acute renal failure, acute tubular necrosis, hypotension and hypoxia. • Other alterations: fever, leukocytosis, coagulation disorders secondary to sepsis and haemolysis and rarely major changes in haemoglobin and haematocrit. Depending on time: • Short-term complications. Encephalopathies: due to massive release of catecholamines, hyperglycaemia is common even in non-diabetic patients. Pneumonia or pulmonary access due to ingestion of contaminated water. Severe hypothermia due to immersion in cold water. Convulsions after immersion. Long-term complications: The main long-term damage is neurological. Other damage includes minimal brain dysfunction, spastic quadraplegia, extrapyramidal syndrome, cortical atrophy, and peripheral neuro muscular damage. In addition to ARDS, persistent anoxic-ischemic encephalopathy, aspirational pneumonia, lung abscess, pneumothorax, pneumomediastinum, pneumopericardium and lung shock. Myoglobinuria or haemoglobinuria, renal failure due to acute tubular necrosis, coagulopathy (especially associated with hypothermia), sepsis, empyema and barotrauma secondary to high ventilator pressures.	
Journal article	*Brain Resuscitation in the Drowning victim*	Alexis A. Topjian et al.,	2012	Secondary goal	Complications and pathologies	• Lung damage and acute respiratory distress syndrome (ARDS). • Hypothermia has an additional effect on glucose homeostasis by decreasing insulin sensitivity and the amount of insulin secreted by the pancreas.	Systematic evaluation of potential resuscitative therapy specific to asphyxia cardiac arrest (ACA) is needed if treatment for drowning is to be available.
				Secondary goal	Care and treatment	• Glycaemic control: avoidance of hypoglycaemia, hyperglycaemia and rapid fluctuation of glucose levels. • Hypothermia control: improved neurologically intact survival with the use of moderate therapeutic hypothermia.	
Journal article	*Distinction between saltwater drowning and freshwater drowning by assessment of sinus fluid on post-morten computed tornography*	Kawasumi, Y.et at.,	2016	Secondary goal	Complications and pathologies	The result of pleural effusion in salt water is characterised by an elevated sodium and potassium content. The density of sinus fluid in the spheroid and maxilla is higher in fresh water than in salt water.	The density of sinus fluid is higher in saltwater drowning than in freshwater drowning while there is no significant difference in volume.

Type of document	Title of article	Authors	Year	Goal it relates to		Results	Conclusions
Journal article	*Latrogenic salt water drowning and the hazards of a high central venous pressure*	Paul E Marik	2021	Secondary goal	Complications and pathologies	• Consequences of volume overload: pulmonary oedema, myocardial oedema, increased abdominal pressure, gastrointestinal disturbance (malabsorption, bacterial translation and hepatic congestion). • Renal failure: increased chloride. • Coagulopathies.	When PVC>3 there is an increased risk of renal failure, respiratory failure, gastrointestinal dysfunction and death across a broad spectrum of clinical disorder.
Journal article	*Use of surfactant in the management of near-drowning in fresh water: acasestudy.*	Lusi Maldonad, Maribel Niño, Oneivic Chavéz and Edith Fernandez.	2006	Main goal	Care and treatment	Basic resuscitation measures. More specific management: fluid restriction, furosemide and mannathiol on occasion, in addition to mechanical ventilation when breathing is spontaneous. Maintain intracranial pressure below 20. Surfactant lavage to maintain alveolar surface tension and decrease alveolar collapse for rapid and effective improvement of oxygenation.	The effects of surfactant lavage in various different pathologies are described, showing its efficacy in reducing alveolar collapse and improving oxygenation indices.
				Main goal	Pathologies and Complications	• Immediate consequence: hypoxia, hypercapnia and metabolic acids. • Surfactant lavage results in a pulmonary oedema due to the rupture of alveolar cells. • Brain damage due to hypoxia. • Ventricular arrhythmias and cardiac arrest. • Coagulation disorders and haemolysis.	
				Secondary goal	Cell physiology	Hypotonic freshwater fluid leads to passage across the alveocapillary membrane resulting in: • Hypervolaemia • Haemodilution • Haemoptysis • Hyperkalemia	

Newspaper article	*Near drowning: a successful treatment*	Elizabeth Bruce	1984	Main goal	Care and treatment	• Endotracheal intubation to facilitate control of hyperventilation.
						• Control of dehydration: furosemide.
						• Control of hypothermia: lowering core temperature to 30 degrees reduces intracranial pressure.
						• Drug therapy:
						  • Furosemide
						  • Barbiturates are controversial
						  • Steroids: dexamentasone
						  • Cimetidine
						  • Pancuronium or D-Tubocurare
						• Intensive nursing care: attention to fluid balances, physiotherapy, skin care and intelligent observation for signs of deterioration of essential systems.
							Resuscitation should be initiated immediately and should not be abandoned for so long that the person appears to be clinically dead after 10 minutes or more.

Tables are provided below to summarise the goals that have been established.

Main goal

Differences in the treatment for fluid therapy depending on whether the near-drowning was in fresh or salt water.

Table 4: Fluid therapy according to the salinity of the water in which a person has nearly drowned. (Designed in-house)

Fresh water	**Salt water**
If sodium level is below 110mEq/l: 1000 c/c of 3% saline solution for 3 to 6 hours	5% dextrose: never saline solution
If there is a calcium deficiency: to be corrected with calcium gluconate.	Blood or plasma transfusion.
A blood transfusion might become necessary later on	Venesection might be necessary later on

Secondary goal

Physiological differences between near-drowning in fresh or salt water.

Table 5: Summary table of physiological differences in near-drowning. (Designed in-house)

Characteristics		**Fresh water**	**Salt water**
Salinity		Hypotonic	Hypertonic
Blood concentration		Haemoconcentration	Haemodilution
Volume		Hypervolaemia	Hypovolaemia
Electrolite levels	Sodium	Low	High
	Potassium	High	High
	Calcium	Low	High

DISCUSSION

Interpretation of the results

Treatment and care of a person who has nearly drowned in fresh water and a person who has nearly drowned in salt water.

With regard to the first goal concerning the treatment of freshwater drowning and saltwater drowning, there is a great deal of controversy.

In fluid therapy, there are opposing ideas: on the one hand, Molyneux-Luick (1978) points out that treatment with fluid therapy is unfounded. He argues that hypertonic intravenous solutions should not be administered to patients who have aspirated fresh water, nor hypotonic intravenous solutions to patients who have aspirated salt water. He states that the electrolyte balance that a victim may suffer could correct itself, and that if it is not able to correct itself, it is because the person will subsequently die. Furthermore, Topjian et al. (2012) state that clinically relevant electrolyte changes are rare because the amount of water ingested is usually small. On the other hand, Noble & Sharpe (1963) add in their article the different appropriate intravenous therapy solutions according to the water aspirated.

In relation to drugs there is also particular controversy concerning the use of barbiturates and steroids. Although Bruce (1964) stated in his article that there was still controversy in the use of barbiturates, Pfenninger & Sutter (1982) stated that they were treatments of choice to prevent brain damage and hypoxia, thus avoiding variation in intracranial pressure values.

As for the administration of steroids, such as dexamethasone, they are useful in preventing the inflammation of patients' lungs, due to the inspiration of fluids. And while many studies claim a significant improvement in oxygenation, ventilation and the reduction of pulmonary oedema, other experts such as Molyneux-Luick (1978) agree with this, but reject routine use.

Regarding the airway, Noble & Sharpe (1963) state in their article that the prevailing opinion is that no time should be wasted clearing the airway, but this is subject to debate. The argument against clearing the airway immediately is that there is no point in creating a perfect airway while the myocardium is failing from lack of oxygen. Even a small amount of oxygen from the air reaching the vital centres in the first few seconds can achieve what pure oxygen and generous ventilation cannot achieve one or two minutes later, because even a small volume of oxygen can rapidly increase haemoglobin saturation. Molyneux-Luick (1987) agrees with this statement; "in the emergency room there is a double priority, maintaining respiration and circulation".

Controversies regarding the use of antibiotics.

We know that secondary infection can follow aspiration or inhalation of water into the lungs. Molyneux-Luick (1978) recommends broad-spectrum antibiotics when there is complete consolidation of lung tissue by atelectasis or when sputum cultures show the presence of an ineffective organism; although in this same study Molyneux-Luick (1978) states that the physician will not generally prescribe antibiotics if patients' lung X-rays show spongy nodular infiltrates. Nor will they order antibiotics for fever alone, since fever without infection is common after near-drowning. Unlike in the article by Topjian et al. (2012), where antibiotic therapy is advised for patients with fever. Similarly, however, the routine use of antibiotics is controversial.

Reizine et al. (2021) discuss patients who have nearly drowned in fresh water and the high multi-resistance created by micro-organisms in pneumonia, whereas in salt water, they state that the micro-organisms found in respiratory samples are mostly bacteria with a low rate of antibiotic resistance.

There are physiological differences in a person's organism depending on whether the near-drowning is in fresh or salt water.

There is a difference of ideas in relation to haemodynamics and electrolyte balances that can be caused by immersion in water, as several articles such as Posada & Augusto (2005), Cuya, Ramezani, & Peyravi (2019) and Molyneux-Luick (1978) all state that these physiological changes do exist. Topjain et al. (2012), however, state that most people do not aspirate enough fluid to cause clinically relevant changes in blood volume. Furthermore, changes in electrolytes due to the small amount of water ingested are also rare.

Pathologies depending on the type of water in which the person has nearly drowned.

Many of the pathologies caused by the different kinds of water coincide; according to Posada & Augusto (2005) one of the complications of the pulmonary system is pneumonia, affirmed by Topjian et al. (2012), who state that even though submersion-associated pneumonia is unknown, findings from case series suggest rates of between 30-50%.

Another common pathology is hypothermia, which according to Posada & Augusto (2005) is caused by immersion in cold water. Bruce (1984) states that the core temperature should be lowered to 30°C in order to reduce intracranial pressure. However, Pfenniger & Sutter (1982) state that body temperature should be maintained between 35. 5 to 36. 5o, recommending active cooling with ice packs, wet sheets and ventilation. Posada & Augusto (2005) recommend the administration of warm, humidified oxygen and warm intravenous fluids. Less common techniques such as peritoneal lavage, chest tube lavage, oesophageal rewarming tubes and extracorporeal procedures are used in extreme cases.

Reizine (2021) says that the effect of water temperature on near-drowning outcomes seems to be under debate. The study by Quan et al. showed better neurological outcomes among patients who nearly drowned in water > 16 °C, while the study by Claesson et al. assessing survival at 1 month showed no association between water temperature and survival.

Conn (1997) argues that cooling by immersion can cause death in several different ways, but paradoxically it protects the brain from hypoxia. Water temperature is crucial, as the rapidity of cooling and death are directly related and this cooling situation precedes the development of bradycardia and subsequently cardiac arrest. The best method for warming patients with immersion hypothermia remains controversial, with the caveat that no warming effort should be initiated unless the body temperature is below 30°C. Treatments highlighted in his article are warm baths, perfusion of warm fluid into the rectum by gastric lavage and the use of vapours, although the latter is controversial due to the low specific heat of gases.

Finally, ventricular fibrillation. Fainer (1963) reports a case in which dogs were the protagonists. They developed ventricular fibrillation during immersion in fresh water, but this had not been observed in humans. This is unlike the article by Noble & Sharpe (1963), which confirms that for a person who has nearly drowned in fresh water, high potassium levels and low calcium levels may be a significant factor in causing ventricular fibrillation. He agrees with Conn (1997) in that a body temperature below 32°C could cause spontaneous ventricular fibrillation.

Limitations

One of the limitations found in this study is that most of the articles found refer to drowning in common and do not differentiate whether near-drowning has occurred in fresh or salt water, except for other articles whose title defines the type of water.

CONCLUSIONS

The care of a freshwater near-drowning case includes the administration of antacids via a nasogastric tube, early nutrition, and close monitoring for bacterial infections. Common care for a person who has nearly drowned in fresh or salt water is attention to fluid balances, physiotherapy (postural changes), skin care and intelligent observation for signs of the deterioration of essential systems.

Common treatments for freshwater drowning and saltwater drowning are: monitoring blood gases and pH, monitoring pulse, perfusion and blood pressure, monitoring glycaemia, hypothermia and dehydration, maintaining cardiac output, assessing CNS function, providing observation of PEEP, CPAP and IMV to prevent complications, and administering diuretics, isoprotenerol, antibiotics, sodium bicarbonate, insulin and steroids (dexamethasone). Furthermore, in freshwater near-drowning fluid intake and the administration of barbiturates should be restricted, intracranial pressure should be kept below 20 and surfactant lavage applied. Regarding fluid therapy in near-drowning in fresh water, if the sodium level is below 110mEq/l: 1000 c/c, 3% saline for 3- 6 hours and if there is a calcium deficit it should be corrected with calcium gluconate.

For fluid therapy in near-drowning in salt water, 5% dextrose is administered (never saline) and blood or plasma transfusion.

The physiological effects in near-drowning in fresh water include haemodilution, haemolysis, rarely hyponatraemia, hypocalcaemia, hyperkalaemia and hypervolaemia. The physiological impairments in near-drowning in salt water are haemoconcentration, hypernatraemia, hypercalcaemia, hypomagnesaemia, hyperkalaemia and hypovolaemia.

The pathologies encountered when a person nearly drowns in fresh water are metabolic acidosis, hypercapnia, hypoxia, risk of circulatory arrest, infection secondary to aspiration, cerebral oedema, atelectasis, possible ventricular fibrillation, renal damage and pulmonary oedema. The pathologies encountered when a person nearly drowns in salt water are metabolic acidosis, hypercapnia, hypoxia, risk of circulatory arrest, infection secondary to aspiration, cerebral oedema, intrapulmonary shunt, pleural effusion and gastrointestinal disturbance.

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