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THE ROLE OF PARAMEDICS IN RESPONDING TO DROWNING AND NEAR-DROWNING EMERGENCIES

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Abstract

Background: Drowning and near-drowning pose significant public health challenges worldwide, causing substantial morbidity and mortality. Early and effective prehospital care by paramedics is crucial in improving survival and neurological outcomes. This review examines the role of paramedics in the initial management, rescue, and advanced interventions for drowning emergencies.

Methods: A comprehensive literature review was conducted, focusing on epidemiology, pathophysiology, prehospital assessment, rescue techniques, airway management, ventilation, resuscitation protocols, advanced interventions, and special population considerations relevant to paramedic care in drowning and near-drowning situations.

Results: Paramedics play an essential role in rapid extrication, airway securing, oxygenation, and ventilation, prioritizing rescue breaths before chest compressions due to the hypoxic nature of drowning. Advanced airway management, fluid resuscitation, and appropriate transport decisions are pivotal. Cervical spine immobilization is reserved for suspected trauma cases. Emerging technologies and evolving protocols continue to enhance prehospital care quality.

Conclusions: Effective paramedic interventions focused on early airway management and oxygenation significantly impact drowning outcomes. Continued research, training, and technological integration are necessary to optimize prehospital drowning care and reduce mortality and neurological sequelae.

Keywords

Drowning; Near-drowning; Paramedics; Prehospital care; Airway management; Emergency medical services; Cardiopulmonary resuscitation; Pediatric drowning; Hypoxia.

INTRODUCTION

Drowning and near-drowning present critical public health challenges worldwide and constitute significant causes of accidental injury and mortality. Drowning is defined as a process resulting in primary respiratory impairment from submersion or immersion in a liquid medium, causing asphyxia and potential fatality if not promptly managed. Near-drowning refers to survival after suffocation caused by submersion, with or without subsequent medical sequelae. These events predominantly affect vulnerable populations, including children under five years, males, and individuals in low- and middle-income countries, posing a considerable global burden (Liu et al., 2025).

The epidemiology of drowning and near-drowning illustrates their vast impact, with estimated global drowning deaths exceeding 230,000 annually, accompanied by millions of years of life lost (YLLs) due to premature mortality. Despite a decline in drowning mortality and incidence rates in recent decades, attributable to growing awareness and preventive measures, these reductions are unevenly distributed globally. Low socioeconomic status countries bear a disproportionate share of drowning-related deaths, especially in regions such as South Asia and Oceania, where environmental exposure and limited access to safety resources prevail. The multifactorial risk determinants, ranging from insufficient supervision, alcohol use, occupational hazards, to climatic factors, all compound the complexity of controlling drowning fatalities (Franklin et al., 2020).

Within this context, the role of prehospital care, particularly that of paramedics, emerges as pivotal in influencing drowning outcomes. Early, effective intervention by paramedics at the scene can substantially alter the trajectory from potential mortality or neurological disability towards survival with intact neurological function. Critical early management encompasses rapid extrication, airway and breathing priority, provision of rescue breaths, oxygen administration, stabilization of circulation, and prevention of secondary injuries such as hypoxia-induced cerebral damage. Contemporary guidelines emphasize initial ventilations before chest compressions to reverse hypoxemia in drowning victims, and advanced airway techniques adapted to the drowning scenario are utilized by skilled paramedic providers. This bridge of care from the drowning site to definitive hospital management is crucial for minimizing hypoxic injury and optimizing survival chances, underscoring the integral function of trained paramedics in drowning emergency responses (Gianfrancesco & Sternard, 2025).

Understanding drowning and near-drowning through their definitions, epidemiological scope, global health implications, and the vital importance of prehospital interventions sets the foundation for exploring the specific contributions and operational frameworks by which paramedics address these life-threatening emergencies. This knowledge supports the development of evidence-based protocols and resources aimed at enhancing prehospital drowning care, ultimately reducing mortality and the long-term burden of this preventable cause of death (Szpilman & Morgan, 2021).

METHODS

This review utilized a systematic approach to gather and synthesize evidence regarding the paramedic role in drowning and near-drowning emergencies. Relevant studies, guidelines, and expert consensus statements published in peer-reviewed literature were identified through database searches including PubMed, EMBASE, and gray literature sources up to 2025. Search terms included combinations of “drowning,” “near-drowning,” “paramedic,” “prehospital care,” “airway management,” “resuscitation,” and “emergency response.” Data extraction focused on epidemiological trends, pathophysiological mechanisms, prehospital assessment and rescue techniques, airway and ventilation management, cardiopulmonary resuscitation protocols, advanced paramedic interventions, transport considerations, and special populations such as pediatric and geriatric patients. Evidence quality and relevance were appraised to support practice recommendations and identify gaps for future research.

Pathophysiology of Drowning

The pathophysiology of drowning involves a complex cascade of respiratory, cardiovascular, neurological, and metabolic disturbances primarily initiated by the aspiration of water into the airways which leads to progressive respiratory impairment and systemic hypoxia. Drowning begins with an involuntary inspiratory effort that draws water into the upper respiratory tract, triggering reflex laryngospasm followed by airway obstruction and subsequent oxygen deprivation. This results in hypoxemia, the principal cause of morbidity and mortality in drowning, as it disrupts gas exchange, destroys pulmonary surfactants, and precipitates noncardiogenic pulmonary edema and acute respiratory distress syndrome (ARDS). The aspiration of water dilutes and alters surfactant function, leading to alveolar collapse and ventilation-perfusion mismatch, while the presence of fluid in the alveoli impairs oxygen diffusion at the alveolar-capillary membrane, causing systemic hypoxia and subsequent multi-organ effects. Electrolyte disturbances are generally minimal unless hypothermia intervenes, which, although sometimes neuroprotective, also increases the risk of cardiac arrhythmias (Armstrong & Erskine, 2018).

The respiratory impairment in drowning victims is characterized by airway obstruction initially due to laryngospasm, which may delay water entry but ultimately fails, leading to flooding of the lungs. Impaired oxygen diffusion triggers profound hypoxemia and subsequent brain hypoxia, leading to rapidly progressing cerebral edema and raised intracranial pressure. Respiratory failure culminates in apnea and asphyxial cardiac arrest. Additionally, the hypoxemia-induced myocardial stress leads to arrhythmias and reduced cardiac output. Cardiovascular compromise contributes importantly to clinical deterioration, with hypoxia-induced ventricular arrhythmias, pulmonary hypertension, and cardiomyopathy frequently seen. Neurologically, hypoxic-ischemic injury ensues within minutes of submersion, with loss of consciousness typically occurring within two minutes and irreversible brain injury within 4 to 6 minutes unless resuscitation is prompt. The release of excitotoxic neurotransmitters and free radicals during cerebral ischemia exacerbates neurological damage. Metabolically, drowning results in a cascade of acidosis initially respiratory, then progressing to metabolic acidosis that further impairs cellular function and contributes to systemic injury (J. J. L. M. Bierens et al., 2016).

The differences between saltwater and freshwater drowning are primarily related to the effects on pulmonary and systemic electrolytes. In saltwater drowning, the hypertonic seawater draws plasma into the alveoli, causing hemoconcentration and increased sinus fluid density, with higher concentrations of sodium, potassium, chloride, and magnesium in alveolar and sinus fluids compared to freshwater drowning. Freshwater, being hypotonic, diffuses into the pulmonary circulation leading to hemodilution. Despite these differences in fluid and electrolyte shifts, both types of drowning disrupt surfactant and alveolar function similarly, leading to noncardiogenic pulmonary edema and ARDS. Clinically, no significant differences in outcome have been conclusively demonstrated due to these electrolyte changes; hypoxemia and alveolar damage are the universal pathophysiological drivers regardless of water type. Forensic analysis can differentiate drownings using sinus fluid density and electrolyte concentration, with saltwater drowning cases showing significantly higher sinus density on imaging than freshwater cases (Vieira et al., 2024).

Recognition and Initial Assessment

Identifying drowning and near-drowning incidents in the prehospital setting is a critical responsibility of paramedics that requires vigilance and comprehensive assessment skills. Drowning can often be initially difficult to recognize, as the typical visual cues may be subtle or absent, particularly in cases of silent drowning or the instinctive drowning response. Silent drowning occurs when a victim is unable to call out for help due to airway obstruction or rapid incapacitation in water, resulting in a 'silent struggle' that can easily go unnoticed by bystanders or rescuers. This instinctive drowning response is characterized by involuntary and inefficient movements such as head sinking, gasping, arm flapping at the water surface, and an inability to call for help, which may be mistaken for normal swimming or distress unrelated to drowning. This presents a significant challenge in timely recognition and necessitates paramedics to maintain a high index of suspicion in water-related emergencies, especially when a person is found unresponsive near water bodies or with signs of respiratory distress. Studies underscore that drowning patients may not always present with obvious signs such as coughing, cyanosis, or visible water aspiration on scene, demanding an astute assessment approach by EMS providers (Dyson et al., 2013).

Paramedics must also prioritize scene safety and risk assessment before initiating rescuing efforts to protect themselves from potential hazards at drowning sites. Water rescues may involve environmental risks including hazardous currents, unstable footing, underwater debris, presence of sharp objects, and varying water temperatures, each posing threats not only to the victim but also to the rescuers. A thorough risk assessment includes evaluating aquatic conditions such as tides, waves, water clarity, and weather, alongside identifying possible mechanisms of injury (e.g., trauma from submersion). Moreover, ensuring safe access and exit points for rescuers and victims is essential to facilitate rapid, effective intervention while minimizing secondary accidents. Guidelines emphasize that paramedics must often wait for specialized water rescue teams if the environment poses significant danger or if the rescuer is untrained for in-water retrieval, prioritizing their own safety to avoid adding to the casualty count (Jalalifar et al., 2024).

Prehospital Rescue Techniques

Prehospital rescue techniques for drowning prioritize rapid and safe extrication of the victim from the water with strict attention to airway management, breathing, and circulation. Since hypoxia is the primary cause of morbidity and mortality in drowning, rescuers emphasize early oxygenation and ventilation support. In-water rescue breathing is recommended only for trained rescuers due to the risks involved. Routine cervical spine immobilization is reserved for cases with suspected trauma to avoid delaying airway interventions. Advanced resuscitative measures such as noninvasive positive pressure ventilation and intubation may be used in the field by paramedics to stabilize airway and breathing before hospital transfer. These steps are essential to reduce hypoxic brain injury and improve survival chances (Gianfrancesco & Sternard, 2025).

Land-based rescue approaches often leverage the use of flotation devices and reaching aids to extend assistance while minimizing rescuers' exposure to water hazards. Water-based strategies involve direct approaches with rescue boards, fins, and tubes to reach and extricate drowning victims efficiently. Comparative studies highlight that using propelling or floating rescue equipment such as rescue boards significantly reduces rescue times and rescuer exertion, thereby improving efficiency and potentially reducing complications for both victim and rescuer. Additionally, emerging technologies like unmanned aerial vehicles (drones) have shown promise in rapidly delivering flotation devices to drowning victims, decreasing the time to first aid markedly in various sea conditions and enhancing safety for rescuers (Seguin et al., 2018).

The early role of bystanders and lifeguards is especially crucial in drowning incidents, often forming the first link in the emergency response. Many bystander rescues occur in hazardous conditions and involve untrained individuals, which carries risks for both rescuer and victim. Nevertheless, bystanders frequently contribute significantly to survival by immediate rescue and initiation of basic life support, including CPR. Studies demonstrate that victim survival improves markedly when bystanders provide prompt rescue and resuscitation before EMS arrival, underscoring the importance of public education and training in CPR and water safety. Lifeguards, equipped with specific training and rescue equipment, have demonstrated effectiveness in reducing drowning fatalities, with most successful rescues not requiring hospital care but emphasizing prevention and early interventions (Brander et al., 2019).

Paramedic Roles in Drowning Emergencies

Paramedics play a critical role in the response to drowning and near-drowning emergencies, functioning as a vital link in the chain of survival from the scene of rescue to advanced in-hospital care. Their responsibilities encompass rapid scene assessment and management, coordination with other emergency responders, and the prioritization of life-saving interventions focusing on airway, breathing, and circulation (ABC). Coordination among paramedics, lifeguards, fire services, and advanced life support teams ensures an effective, organized response that enhances patient outcomes. Early communication and collaboration improve resource allocation and timely transport to facilities equipped for specialized care such as mechanical ventilation or extracorporeal life support when required (Gianfrancesco & Sternard, 2025).

Scene management and extrication protocols are paramount in drowning emergencies, as the environment poses unique challenges and risks. Paramedics must ensure their own safety while employing techniques to rapidly remove victims from water with minimal delay to critical airway and breathing interventions. Extrication ideally involves near-horizontal positioning with the airway maintained above the body level to facilitate oxygenation and prevent further aspiration or vomiting. In cases where the victim is conscious or spontaneously breathing, a more vertical extraction may be preferable to support respiratory effort. These extrication decisions are guided by patient condition, environmental safety, and available personnel expertise. Routine cervical spine immobilization is reserved for incidents involving trauma risks such as diving injuries, to avoid delaying lifesaving airway management in typical drowning cases (Lari Siahkal et al., 2022).

Paramedics prioritize the ABC approach, with immediate focus on securing a patent airway, ensuring effective breathing, and maintaining circulation. Since drowning causes hypoxia primarily through airway obstruction by fluid and subsequent respiratory failure, airway management and ventilation are the most critical interventions. Rescue breaths are emphasized early in resuscitation, with guidelines recommending five initial rescue breaths before initiating chest compressions. This contrasts with standard cardiac arrest protocols that often prioritize chest compressions first, underlying the pathophysiologic importance of reversing asphyxia in drowning victims. Supplemental oxygen administration and advanced airway management, including endotracheal intubation when skill and resources permit, are integral to improving oxygenation and preventing secondary brain injury. Supraglottic airway devices are generally discouraged due to less reliable protection and aspiration risks in these patients. Continuous monitoring using pulse oximetry and capnography guides ongoing resuscitation efforts and ventilation adequacy(Mohamed, 2022).

Airway Management and Ventilation

Airway management and ventilation are critical components in the prehospital and emergency care of drowning and near-drowning patients. Immediate airway assessment and intervention are paramount, as hypoxia due to airway obstruction or pulmonary edema is the principal cause of morbidity and mortality in these emergencies. Early management at the scene involves rapid extrication, followed by immediate evaluation of airway patency, breathing effectiveness, and circulation. Rescue breaths should be administered promptly in apneic patients, as ventilation, rather than chest compressions alone, is the priority in drowning resuscitation. Current guidelines recommend initiating five rescue breaths before starting chest compressions to counteract hypoxia caused by water in the airways and alveoli, which makes ventilation more challenging at the outset. This approach contrasts with the usual two breaths used in standard basic life support protocols. In-water rescue breathing should only be performed by trained individuals and with caution to ensure rescuer safety. The Heimlich maneuver, once considered part of airway management in near-drowning, is no longer recommended due to lack of evidence of benefit and potential risk of harm. Cervical spine

immobilization is reserved for patients with trauma history to avoid unnecessary delays in airway management in the majority of drowning cases (McCallin et al., 2024).
Techniques for effective rescue breaths and ventilation in near-drowning must address the obstruction and water presence in the airway. Mouth-to-mouth or mouth-to-nose ventilation is generally employed, with the rescuer positioning the victim supine, opening the airway by extending the neck, and sealing their mouth to deliver positive pressure breaths. The ventilation rate recommended is about 12 to 16 breaths per minute, carefully timed to avoid gastric insufflation and further aspiration. The initial breaths tend to be more difficult due to water obstructing the airway and alveolar collapse, hence the recommendation for five initial breaths. If the patient is breathing but unconscious, positioning in the recovery position facilitates airway protection. If ventilation is ineffective or the patient remains apneic, advanced airway techniques are warranted to secure the airway and optimize oxygenation (McCallin et al., 2024).
Suction plays a significant but cautiously employed role in near-drowning emergencies. Suctioning of the airway may be necessary to remove aspirated water, mucus, and debris that impair ventilation and gas exchange. However, endotracheal suctioning should not be performed routinely but only when secretions visibly obstruct the airway, compromise ventilation, or when the patient cannot clear secretions independently. Excessive or deep suction can injure the alveolar-capillary membrane, promote pulmonary edema, and worsen hypoxia. The recommended suction pressure is between 80–120 mmHg (11–16 kPa) using appropriately sized catheters with suction duration limited to 15 seconds to minimize trauma. Passive drainage techniques, such as positioning the patient with the head lowered and allowing secretions to clear by gravity, may be preferable in some cases to reduce alveolar damage. Closed suction systems are favored in mechanically ventilated patients to prevent loss of lung recruitment. Suction interventions must be balanced carefully to maintain airway patency while minimizing additional lung injury in the sensitive pulmonary environment of drowning victims (Bhalotra & Thakur, 2018).
Regarding advanced airway devices, the use of supraglottic airway (SGA) devices and endotracheal intubation (ETI) are essential considerations in prehospital drowning care. Endotracheal intubation remains the gold standard for airway protection, assuring a secured airway and effective ventilation, especially in patients with compromised consciousness or inadequate spontaneous breathing. ETI is associated with better outcomes, including higher survival rates and improved neurological recovery compared to SGAs, particularly when performed by experienced providers in appropriate settings. SGAs may be considered as rescue devices when ETI is not feasible or delayed but are generally associated with less reliable airway protection and a higher risk of aspiration in drowning due to the presence of fluid in the airway. Guidelines generally discourage routine use of SGAs in drowning because of the aspiration risk and recommend early tracheal intubation when possible. The choice between these devices must consider provider skill, patient condition, and scene context, with ETI preferred for definitive airway management while SGAs serve as temporary or backup options (Dabkowski et al., 2024).

Cardiopulmonary Resuscitation (CPR) in Drowning

Cardiopulmonary resuscitation (CPR) in drowning emergencies differs fundamentally from CPR performed in typical cardiac arrest cases largely because the primary cause of cardiac arrest in drowning is hypoxia secondary to respiratory failure rather than intrinsic cardiac pathology. In drowning, hypoxemia develops progressively as water aspiration impairs gas exchange, leading initially to respiratory arrest followed by cardiac arrest if ventilation is not promptly restored. Consequently, early resuscitation efforts prioritize airway and breathing over chest compressions. Current guidelines emphasize the crucial importance of initiating rescue breaths before chest compressions in drowning victims, contrasting with compression-only CPR recommended in adult cardiac arrests of cardiac origin. Specifically, for drowning victims who are apneic and unresponsive, five initial rescue breaths should be given to attempt oxygenation prior to commencing chest compressions. This differs from the typical two breaths before compressions in other cardiac arrests. In-water rescue breathing, performed only by trained rescuers when it is safe, may interrupt the progression to cardiac arrest. Once out of the water, rescuers should open the airway and administer rescue breaths ensuring visible chest rise before progressing to chest compressions if breathing or pulse is absent or unclear. The use of automated external defibrillators (AEDs) in drowning resuscitation is less frequently effective than in primary cardiac arrests since shockable rhythms such as ventricular fibrillation are uncommon, seen in only about 2% to 12% of drowning-related arrests. Nevertheless, AEDs should be applied promptly when available after initial ventilation and compressions are underway, as a primary cardiac cause of arrest cannot be excluded. Importantly, AED application should not delay or interfere with the priority of rescue breaths and chest compressions, which are critical to reestablish oxygenation and circulation in drowning victims. Vomiting is a common complication during resuscitation, and protective airway maneuvers must be employed to prevent aspiration during rescue attempts. Rescue protocols also recommend selective cervical spine immobilization only if there is a suspicion of trauma, as routine immobilization may delay airway management (J. Bierens et al., 2023).
Hypoxia in drowning victims is the principal determinant of mortality and neurological outcomes. The immediate management strategy centers on rapid oxygenation and ventilation to reverse hypoxemia and prevent secondary cerebral injury. Supplemental oxygen should be administered as early as possible, using modalities ranging from nasal cannula to high-flow oxygen delivery systems. Noninvasive positive-pressure ventilation or endotracheal intubation

may be required if oxygenation cannot be maintained adequately or if airway protection is compromised. In the prehospital emergency context, oxygenation efforts aim to prevent progression to cardiac arrest and limit hypoxic brain injury. Concurrently, hypothermia is common in drowning victims due to immersion in water, especially cold water, contributing to altered physiology and challenging resuscitation. Passive warming techniques include removal of wet clothing and insulation with blankets to reduce further heat loss. Active external warming employs heated blankets or forced warm air devices, while active internal rewarming methods, such as warmed humidified oxygen, warmed intravenous fluids, and, in severe cases, extracorporeal circulation techniques, are used in hypothermia with hemodynamic instability or cardiac arrest. Continuous monitoring of core temperature is essential for guiding rewarming interventions and assessing the risk of arrhythmias associated with hypothermia. Patient outcomes improve with careful, controlled rewarming and maintenance of adequate oxygenation. Early recognition and management of hypoxia and hypothermia in drowning patients are paramount to optimize survival and neurological prognosis, with advanced therapies reserved for refractory cases in specialized centers (Close & Yee, 2025).

Paramedics responding to drowning and near-drowning emergencies must carefully consider spinal injuries, particularly cervical spine involvement, given the potential for trauma, especially in diving-related incidents. Recent expert consensus and guidelines emphasize that routine cervical spine immobilization is not universally necessary in drowning patients; instead, it should be reserved for those with a history or clinical signs of trauma, such as axial loading of the spine from mechanisms like diving into shallow water or high-impact falls. The approach balances the need for spinal precautions against the critical priority of airway management since inappropriate spinal immobilization, especially rigid collars, may impede airway access and delay resuscitation efforts. In practical terms, paramedics should ensure rapid extrication and airway stabilization, using manual in-line stabilization of the head and neck when spinal injury is suspected. This is particularly vital in scenarios where trauma is evident or the patient is unconscious with an unclear mechanism of injury. Where possible, assessment tools such as neurological function tests (e.g., asking about spinal pain or motor function) are used to decide on immobilization. It is also recommended against routine use of rigid cervical collars in water rescues due to limited benefit and potential risks, including compromised airway management and increased intracranial pressure. In-water spinal precautions should only be attempted when the scene is safe and must not delay rescue or resuscitation efforts. The immobilization process benefits from coordinated team efforts, ideally with at least three trained rescuers to safely extricate and stabilize the patient from water (Breindahl, Bierens, et al., 2024).

In diving-related and trauma-associated drowning, paramedics must maintain heightened vigilance for spinal injuries, as these cases often involve considerable axial forces or blunt trauma. Special considerations include the potential for concomitant fractures, intracranial hemorrhage, or other multisystem trauma, making rapid and precise clinical assessment essential. Management in these cases prioritizes maintaining cervical spine neutrality during airway interventions and extrications, while recognizing that delays in oxygenation and ventilation can significantly worsen outcomes. The balance between spinal immobilization and airway management is a complex clinical challenge; airway interventions such as jaw-thrust maneuvers are preferred over head tilts to open airways while maintaining neck stability. In drowning victims with suspected spinal injury, manual spinal stabilization and use of flotation or extrication devices that support spinal alignment are critical. Attention must also be paid to environmental factors that complicate rescue and immobilization, such as water current, surf conditions, and temperature, which affect both patient safety and efficacy of interventions (Breindahl, Bierens, et al., 2024).

Advanced Prehospital Interventions

Advanced prehospital interventions play a crucial role in improving outcomes for drowning patients. One key intervention is noninvasive positive-pressure ventilation (NIPPV), which has shown efficacy in treating moderate acute respiratory distress syndrome (ARDS) stemming from near-drowning. Studies indicate that paramedics can deploy devices such as nasal or full-face positive pressure ventilators to improve oxygenation and reduce the need for invasive mechanical ventilation, particularly in fresh-water drowning cases. However, seawater drowning patients may be more difficult to treat with NIPPV due to greater pulmonary insult. Early airway support optimizes oxygen delivery and may prevent progression of hypoxic injury during transport to definitive care (Ruggeri et al., 2016).

Intravenous access and judicious fluid management are essential components of prehospital care in drowning emergencies. Many drowning victims are intravascularly volume-depleted and exhibit hypotension, often exacerbated by hypothermia and increased intrathoracic pressure from positive pressure ventilation. Paramedics should establish IV access promptly, with intraosseous routes as alternatives if intravenous access is challenging. Fluid resuscitation should use warmed isotonic crystalloid solutions to support circulation without causing fluid overload, mindful that excessive fluids can worsen noncardiogenic pulmonary edema common in these patients. The fluid management strategy aims to optimize preload and cardiac output while minimizing the risks of exacerbating lung injury (Polderman & Varon, 2015).

Pharmacological interventions in the prehospital setting focus primarily on addressing arrhythmias and hypotension. Drowning victims may develop bradyarrhythmias or other dysrhythmias secondary to hypoxia and myocardial depression. Advanced cardiac life support (ACLS) protocols guide the use of medications such as epinephrine, atropine, and amiodarone, but it is critical to recognize that the effectiveness of some drugs is reduced in hypothermic patients with core temperatures below 30°C. Vasopressors may be employed cautiously to manage refractory hypotension, and fluid resuscitation must be balanced accordingly. Endotracheal administration of medications is generally discouraged, with intravenous routes preferred when possible. Throughout, maintaining adequate ventilation and oxygenation remains paramount, as effective resuscitation in drowning emergencies hinges on reversing hypoxia-induced cardiac dysfunction and preventing secondary organ injury (Gianfrancesco & Sternard, 2025).

Transport and Interfacility Coordination

Transport and Interfacility Coordination in drowning and near-drowning emergencies is a critical component of paramedic care, requiring rapid decision-making to ensure timely arrival at definitive care facilities capable of advanced interventions. Criteria for rapid transport hinge primarily on the severity of the patient's condition, including the presence of respiratory distress, altered consciousness, hypothermia, cardiovascular instability, or failure to respond to initial resuscitation measures. Paramedics must prioritize immediate transport for patients exhibiting significant respiratory compromise, cardiac arrest, or deteriorating neurological status, as even brief submersion can result in delayed pulmonary edema or severe hypoxia that worsens rapidly. Studies and guidelines emphasize that any patient with even brief submersion should be transported emergently for hospital assessment, regardless of initial apparent stability, owing to the unpredictable clinical course post-submersion. Helicopter Emergency Medical Services (HEMS) may be dispatched in geographically remote or critically ill drowning cases to reduce response and transport times, facilitating early advanced care including airway management and critical care interventions (Breindahl, Wolthers, et al., 2024).

Effective communication with receiving facilities during transport is vital to prepare for immediate and specialized post-resuscitation care. Paramedics must provide accurate clinical information including vital signs, Glasgow Coma Scale scores, duration of submersion, resuscitation efforts performed, and presence of hypothermia or cardiac arrest. Early notification allows emergency departments and intensive care units to mobilize resources such as extracorporeal life support (ECLS) teams and to prepare for advanced airway management or cardiopulmonary support. Communication protocols often include a structured handover ensures continuity of care and optimizes outcomes (Breindahl, Wolthers, et al., 2024).

Extracorporeal life support (ECLS), including extracorporeal membrane oxygenation (ECMO), plays an emerging and vital role in the management of severe drowning cases complicated by refractory hypoxemia, cardiopulmonary failure, or profound hypothermia. ECLS provides cardiopulmonary support by oxygenating blood outside the body, allowing time for lung and cardiac recovery. Its use is particularly indicated in patients with cardiac arrest unresponsive to conventional resuscitation or in those with severe respiratory failure. The evidence base, though derived mainly from observational studies and registry data, indicates that ECLS can significantly improve survival rates in select drowning victims. ECLS also facilitates active rewarming in hypothermic patients, and centers with the necessary infrastructure provide protocols for rapid deployment. Survival outcomes are better when ECLS is instituted early and when patients do not require prolonged CPR before cannulation (Burke et al., 2016).

Post-resuscitation care focuses on meticulous monitoring and management of complications such as acute respiratory distress syndrome (ARDS), pneumonia, and multi-organ dysfunction resulting from hypoxia and ischemia during submersion. Respiratory support continues with careful ventilation strategies to minimize further lung injury while addressing oxygenation deficits. Neurological assessment is integral, involving serial examinations to detect early predictors of outcome. Tools like the Glasgow Coma Scale and brainstem reflex assessments guide prognostication. Studies show that neurological status at 24 hours post-resuscitation, specifically the presence of purposeful movements and normal brainstem functions, strongly predicts survival with good neurological outcome versus severe deficit or death (Zhou et al., 2022).

Special Populations

Pediatric drowning presents distinct challenges due to anatomical, physiological, and developmental differences. Children are particularly vulnerable to drowning due to their proportionally larger head size, smaller airway diameter, and lower functional residual lung capacity, which contribute to rapid hypoxia onset. The presence of pre-existing conditions such as developmental delays or dysmorphic syndromes additionally increases risk and complexity of management. Upon rescue, immediate correction of hypoxia is paramount, as hypoxic injury dictates prognosis. More than half of pediatric drowning cases require supportive ventilation or cardiopulmonary resuscitation, with successful early CPR closely linked to improved outcomes. Paramedics must hence be proficient in pediatric airway management and resuscitation techniques. Clinical assessment commonly involves neurological evaluation using scales like the Glasgow Coma Scale and respiratory parameter monitoring to guide therapy, including oxygen supplementation ranging from low-flow delivery to invasive ventilation in severe cases. Fluid resuscitation and shock management may also be necessary, with careful monitoring for cardiac dysfunction necessitating echocardiography and inotropic support. Importantly, integration of care from prehospital through ICU stages remains suboptimal, and paramedics play a critical role in initial stabilization and rapid transport while coordinating with receiving facilities. Preventative measures, including parental education and community awareness, also intersect with the paramedic's role as frontline responders in pediatric drowning incidents (Raess et al., 2020).

Geriatric drowning patients experience additional complexities due to advanced age-related physiological changes and multimorbidity, often complicating the presentation and outcomes. Older adults drowned constitute about one-tenth of drowning cases and have higher incidences of cardiac arrest at presentation. Comorbid conditions such as cardiovascular disease, dementia, and pulmonary disorders frequently coexist, predisposing to drowning via precipitating medical events like seizures or cardiac ischemia. These comorbidities also influence the response to resuscitation and contribute to delayed recovery or increased mortality. The interaction of frailty and chronic illnesses impacts trauma and drowning outcomes, underscoring the necessity for paramedics to consider these factors in their clinical assessment and management plans. Acknowledging that high proportions of geriatric patients within healthcare centers correlate with increased mortality highlights the resource strain and challenges in providing optimal care. Paramedics must be adept in early recognition of underlying medical events and comorbidity screening, ensuring rapid intervention and appropriate triage to trauma or critical care centers equipped to handle complex elderly patients (Boland et al., 2025).

Drowning in special environments further complicates rescue and management efforts due to varying hazards and physiological impacts. In swimming pools, children under nine represent the most vulnerable group, often linked to lack of supervision and absence of lifeguards, particularly in private pools. About 20% of drownings involve individuals older than 40, where underlying comorbidities or unexpected medical events can precipitate drowning. Natural bodies of water such as lakes, rivers, and oceans present additional risks, including strong currents, underwater obstacles, variable depths, and exposure to aquatic life. Industrial settings or extreme temperature waters pose physiological stressors like cold shock, arrhythmias, hyperthermia, or hypothermia that can precipitate drowning even before submersion. Paramedics responding in these diverse contexts must adapt their techniques for extrication and initial care, manage temperature-related complications, and anticipate multisystem organ involvement. Preventative strategies emphasize environmental controls such as pool fencing, lifeguarding, and public education and recognition of unique hazards intrinsic to each setting to reduce incidence and enhance survival (Chan et al., 2018).

Future Directions

Current evidence base and limitations regarding the role of paramedics in drowning and near-drowning emergencies highlight the critical importance of early airway management, oxygenation, and rapid extrication to improve patient outcomes. Paramount in prehospital care is prioritizing airway and breathing over chest compressions due to the hypoxic nature of drowning injuries. Rescue breaths and supplemental oxygen are essential interventions, with current guidelines recommending five initial rescue breaths before chest compressions in apneic patients. Paramedics have an advanced role in maintaining oxygenation and hemodynamic stability, often utilizing noninvasive positive-pressure ventilation or endotracheal intubation, especially in severe cases. Evidence also supports cervical spine immobilization only when trauma is suspected, optimizing prompt resuscitation efforts without delay. Despite these advances, significant gaps remain in the evidence base. Most drowning incidents present with nonshockable rhythms, limiting the utility of defibrillation, and the prehospital setting often challenges providers with environmental and logistic hurdles. The variability in prehospital triage, time intervals, and advanced airway management reflects a need for standardized protocols and further quality data. Additionally, there is a paucity of large-scale prospective studies assessing long-term neurological outcomes relative to specific prehospital paramedic interventions, thus constraining evidence-based refinements in care pathways (Popp et al., 2021).

Areas for future research and innovation are therefore paramount in enhancing paramedic response to drowning emergencies. Investigations must focus on optimizing airway management techniques tailored to drowning physiology, improving prehospital triage systems to identify patients who would benefit most from advanced interventions, and integrating decision-support tools to enhance rapid assessment and transport to specialized centers. Research into the timing and efficacy of mechanical ventilation methods in the field, alongside pharmacologic adjuncts or neuroprotective strategies during resuscitation, would fill critical knowledge gaps. Further exploration of improved training modules for paramedics and first responders, including simulation-based education to better address rare but catastrophic drowning scenarios, is also urgent. Epidemiological studies analyzing temporal metrics such as response times, transport delays, and their correlation to survival and neurological outcomes would help define best practices. Finally, more comprehensive databases capturing prehospital interventions and outcomes would provide a rich resource to inform evidence-based guidelines and quality improvement initiatives (Thom et al., 2023).

In terms of emerging technologies and interventions, several promising innovations show potential to transform paramedic response to drowning. Sensor-based drowning detection systems employing heart rate monitors, oxygen saturation sensors, and motion detectors aid in early identification of victims in distress, potentially enabling faster dispatch of EMS. Autonomous robotic technologies equipped with image processing and camera systems are being developed to assist in pool rescue scenarios, reducing response times and the burden on human rescuers. Wearable alert devices integrating biosensors provide continuous monitoring and can trigger flotation aids automatically, preventing submersion injuries. Furthermore, artificial intelligence (AI) and machine learning algorithms are being explored to analyze video surveillance and environmental data for predictive drowning risk, which could augment situational awareness for paramedics and lifeguards. Advances in portable extracorporeal life support devices and improved airway management tools adapted for field use also represent areas of innovation likely to improve outcomes in severe drowning cases. Integration of these technologies into EMS protocols, alongside thorough validation studies, will be critical to realize their benefits in real-world emergency settings (Jalalifar et al., 2024).

CONCLUSION

Paramedics serve as a critical link in the chain of survival for drowning and near-drowning victims. Their ability to promptly assess, safely extricate, and manage airway and ventilation distinguishes patient outcomes, with emphasis on reversing hypoxia through rescue breaths and supplemental oxygen administration. Advanced prehospital interventions, including noninvasive ventilation and endotracheal intubation, further improve survival rates. The selective use of spinal precautions and coordinated transport enhances the overall care continuum. Despite advancements, there remain notable challenges such as environmental hazards, variable protocols, and limited prospective outcome data. Targeted research and innovations in training, technology, and triage systems are essential to further strengthen paramedic response and reduce the global burden of drowning-related death and disability.

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