Emergence of Dive Paramedics: Advancing Prehospital Care Beyond DMTs

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Abstract

This article delves into the evolution of paramedic practice, particularly in the context of marine medicine, highlighting the emergence of dive paramedics and the augmentation of prehospital care. It emphasises the potential for qualified paramedics to pursue specialised training in marine paramedicine through postgraduate programmes, ultimately broadening their skill set.

Keywords: Ambulance, Out-of-hospital, Rescue, Training, Paramedic, Dive medical.

Introduction

Diver Medical Technicians (DMTs) are pivotal in delivering advanced prehospital care within the diving community. Paramedics have already demonstrated their competence in diverse prehospital care domains, such as flight paramedicine, critical care, and neonatal care. Specialised units like Hazardous Environment Response Teams (HERT) and Special Operations Response Teams (SORT) in the UK have further expanded paramedics' roles in rescue operations and safe extrication. This article underscores the potential benefits of introducing a comprehensive curriculum and specialised training for dive paramedics, accompanied by an expanded scope of practice.

Dive Paramedics: A Natural Progression Beyond DMTs for Prehospital Professionals

The Development of Dive Paramedics

Diver Emergency Medical Technicians (DMTs) consist of experienced divers who have successfully completed an accredited training program. This program equips them to provide initial first aid care until a marine medical doctor can assume responsibility. This article explores the expansion of paramedic training to incorporate marine medicine as an optional specialisation within the broader field of prehospital care.

When emergencies occur at sea, the initial response often involves the dispatch of a flight paramedic or a critical care paramedic aboard a helicopter or coast guard lifeboat. This can result in a significant time gap between the incident at sea and the commencement of dry bell or hyperbaric treatment, which may prove critical in dive-related emergencies.

Due to the distinct pathophysiological aspects and specialised hyperbaric treatment conditions inherent to marine environments, it is imperative to provide specific training for paramedics. Just as physicians are required to undergo training in hyperbaric medicine and certification as occupational diving doctors before practicing in marine settings, a similar expectation should be upheld within the emerging and independent field of paramedicine.

The Expanding Horizons of Paramedicine

In the realm of prehospital care, paramedics have carved out a niche that extends far beyond the traditional ambulance services. Whether it's the high-stakes environment of flight emergencies or the complex medical needs aboard cruise ships, paramedics have showcased their ability to operate both autonomously and within multidisciplinary teams. Their roles in the United Kingdom's Hazardous Area Response Teams (HART) and Special Operations Response Teams (SORT) further illuminate their versatility, not merely in clinical acumen but also in managing challenging maritime scenarios.

The Symbiosis of Paramedics and Marine Rescue Services

Recent collaborations between paramedics and the U.S. Coast Guard offer a compelling narrative of the benefits of such partnerships. The Coast Guard excels in rescue operations, but the addition of paramedics equipped with Advanced Life Support (ALS) capabilities has been a game-changer. This synergy has led to marked improvements in patient outcomes, particularly in marine emergencies.

The Maui County EMS Paradigm

A case in point is the partnership that commenced in October 2013 between Maui County EMS and the U.S. Coast Guard. Prior to this, the Coast Guard's response teams had limited medical training. The integration of a paramedic into these teams has not only elevated the level of medical care but also fortified the overall emergency response framework. [1]

The Imperative of Dive Paramedics

Given these promising developments, the next frontier in prehospital marine medical care is the conceptualisation and development of Dive Paramedics. This would involve collaborations with accredited bodies like the Australian Diver Accreditations Scheme (ADAS) and the International Marine Contractors Association (IMCA). The curriculum could be further enriched by incorporating advanced courses such as the Diving and Hyperbaric Medicine (DHM) Diploma offered by the Australian and New Zealand College of Anaesthetists (ANZCA).

Addressing the Complexity of Diving-Related Injuries

The burgeoning popularity of diving, both as a recreational activity and a profession, has led to an uptick in diving-related injuries. These injuries are not confined to amateur divers; even certified divers are not immune. Dive paramedics could fill this critical gap by providing specialised care for a range of medical emergencies, both general and diving-specific. [2]

The Nuances of Dive Medical Examinations

Dive medical exams, usually conducted by certified examiners, serve as a gateway to the underwater world. However, these exams are not infallible. The Queensland Government's scrutiny of past diving incidents revealed a troubling trend: individuals often failed to disclose pre-existing medical conditions. Dive paramedics could play a pivotal role here by conducting more comprehensive pre-dive assessments, thereby encouraging transparency, and enhancing safety.

The Uncharted Waters of Comorbidities in Divers

Dive paramedics would also be tasked with managing non-diving-related emergencies arising from comorbidities like cardiovascular issues, asthma, and epilepsy. Their training equips them to handle such emergencies adeptly, but the introduction of dive paramedics would necessitate a recalibration of their responsibilities to focus more on diving-related incidents.

The development of dive paramedics could be a watershed moment in marine medical care, offering a nuanced and specialised approach to emergencies in aquatic settings. Their role would be multifaceted, encompassing not just medical care but also preventive measures, thereby elevating the overall safety standards in diving and other marine activities.

Marine Specific Injury Examples

Marine Bites and Envenomation

One specific example of a diving-related incident that dive paramedics would handle is marine animal bites. Although severe marine bites are relatively rare, they do occur and, when poorly managed, can be life-threatening. Shark bites, for instance, are highly traumatic events that often puncture major arteries, leading to severe bleeding. Diver Medical Technicians (DMTs) are trained to apply tourniquets effectively, while divers can apply direct pressure until emergency assistance arrives. However, it is essential to note that there are over 2000 species of animals that are venomous or poisonous to humans in the marine environment. Swift administration of prophylactic antibiotics, anti-venom, and titrated opiate analgesics may significantly improve outcomes for individuals experiencing severe envenomation.

There are two broad categories of marine envenomation: topical jellyfish stings and penetrating venomous marine injuries (PVMI). The following tables will delve into envenomation and their respective treatment options.

JELLYFISH STINGS	SIGNS & SYMPTOMS*	IMMEDIATE TREATMENT	PARAMEDIC SCOPE
BLUEBOTTLE AND MINOR JELLYFISH	Localised intense pain for up to 2 hours. Erythematous eruptions.	Wash site with seawater and remove barbs. Immerse in hot water for 20 minutes. (Avoid vinegar)	Analgesia (oral) Provide advise to patient.
MAJOR BOX JELLYFISH	As above + Risk of CV collapse & death	Apply vinegar and remove barbs CPR (if required)	Analgesia (oral & IV) Cardiac monitoring Early interventions. Provide immediate advanced cardiac life support. Consider anti-venom. Transport to hospital.
OTHER BOX JELLYFISH	Irukandji syndrome; Tachycardia Agitation Hypertension Vomiting + Cramps Pulmonary Oedema Severe pain Cardiac injury Risk of CV collapse & death.	Apply vinegar and remove barbs. CPR (if required) usually basic life support.	Analgesia (oral & IV) Cardiac monitoring Early interventions. Provide immediate advanced cardiac life support. Consider anti-venom. Transport to hospital. Troponin tests for cardiac myopathy

Table 1. JELLYFISH STINGS, SIGNS & SYMPTOMS AND POTENTIAL PARAMEDIC TREATMENT SCOPE

PVMI	SIGNS & SYMPTOMS*	IMMEDIATE TREATMENT	PARAMEDIC SCOPE
VENOMOUS FISH	Puncture wounds Localised pain Secondary infection (uncommon)	Wash wound site Immerse in hot water for <90 minutes.	Irrigation and debridement Local or regional analgesia Ultrasound to check for spines Antibiotic treatment Hospital referral if; - XR required for retained spines - Surgery for repair of deep wounds - Wounds affecting joints or bones - Consider anti-venom
STINGRAY	Penetrating traumatic injury Localised bleeding Oedema Localised pain Risk of necrosis & secondary infection.	As above	As above + major haemorrhage control in the event of penetration of the trunk Early ACLS Transport to major trauma facility.
SEA URCHIN	Pain Retained spines	As above	As above + follow up assessments to check for retained spines & infection.
SEA SPONGE	Localised pain Itchiness Paranesthesia & numbness	Wash wound site	Analgesia (oral) Antihistamine

Table 2. PVMI, SIGNS & SYMPTOMS AND POTENTIAL PARAMEDIC TREATMENT SCOPE

Advanced Analgesic Techniques: The Efficacy of Nerve Blocks

The administration of analgesia is a critical component in the effective management of acute pain. While traditional methods such as oral and intravenous (IV) administration are prevalent, the utilisation of regional nerve blocks offers a targeted approach to pain management. Although nerve blocks are not ubiquitously employed in prehospital settings, existing literature indicates their efficacy [3]. Specialised training for dive paramedics could enable the incorporation of this advanced analgesic technique, thereby broadening the scope of marine medical care.

Cardiac Management: Anti-Venom as a Critical Adjunct

Immediate cardiopulmonary resuscitation (CPR) remains the quintessential life-saving intervention. However, in marine envenomation scenarios, the early administration of anti-venom has been shown to be pivotal in averting cardiac collapse [4][5]. The introduction of dive paramedics could augment existing protocols by facilitating Advanced Cardiac Life

Support (ACLS) and the timely administration of anti-venom, thereby enhancing the quality of emergency medical care in marine environments.

Musculoskeletal Injuries: Specialised Management of Dislocations

Dislocations, particularly of the shoulder joint, are a common occurrence among aquatic athletes and recreational divers, often resulting in acute pain and functional impairment [6]. Dive paramedics, with additional training in reduction techniques and radiological interpretation, could offer a more comprehensive approach to musculoskeletal injuries. The potential incorporation of portable diagnostic modalities, such as X-ray and ultrasound, could further elevate the standard of out-of-hospital care.

Near-Drowning Incidents: Addressing the Underreported Crisis

Near-drowning events are a significant yet underreported global health concern, with an estimated 500,000 cases occurring annually [7][8]. These incidents can result in severe physiological derangements, including hypoxia, acidosis, and hypothermia [9]. Specialised training for dive paramedics in early advanced treatment protocols, coupled with community engagement initiatives, could substantially mitigate morbidity and mortality rates.

Decompression Illness: A Multifaceted Clinical Entity

Decompression illness (DCI) encompasses two distinct clinical conditions: decompression sickness (DCS) and arterial gas embolism (AGE). While DCS is relatively rare, with an incidence of approximately one in 20,000 dives [10], timely diagnosis and intervention are imperative. Dive paramedics would necessitate specialised training to effectively assess, manage, and treat both DCS and AGE, including the administration of hyperbaric oxygen therapy and facilitating rapid transport to hyperbaric facilities. Priorities for managing DCS are outlined in Table 3.

DCS	Signs & Symptoms*	Timescale	Assessment & Treatment
Emergency	▪ Loss of consciousness ▪ Difficulty breathing ▪ Dizziness ▪ Obvious neurological deficit ▪ Altered level of consciousness ▪ Abnormal gait ▪ Weakness ▪ Bloody froth in mouth or nose ▪ Convulsions	Immediate or within 1 hour.	Neurological exam 100% oxygen Assisted ventilation Suction & aspiration reduction Cardiac monitoring ACLS
Urgent	▪ Unchanging severe pain ▪ Neurological deficit (during neurological examination)	Slow onset or progression over hours.	Neurological exam 100% oxygen Oral fluid hydration
Timely	▪ Vague pain ▪ Abnormal sensation	Onset progresses slowly over several days or not visible.	Neurological exam Diving history

Table 3. DCS severity, signs, symptoms and treatment.

Arterial gas emboli (AGE)

Arterial gas emboli (AGE) can develop when a diver remains underwater for an extended period, ascends too rapidly, or holds their breath during ascent. These conditions lead to changes in atmospheric pressure that cause gases within the lungs to either expand (in lower pressure environments) or contract (in higher pressure environments). Divers often become familiar with various pressure formulas, particularly the calculation of absolute pressure while submerged.

Equation 1.a

$$Pabs\ (bars) = \frac{Depth\ (msw) + 1}{1}$$

Equation 1.b

$$Pabs\ (bars) = \frac{Depth\ (fsw) + 1}{33}$$

Figure 1. Equation to calculate absolute pressure [11]

- = pressure
- = absolute
- ( ) = 33
- = meter sea water
- = feet sea water

A simplified method for recreational divers is for every 10 meters of sea water the pressure increases the density of the gases by a multitude of one.

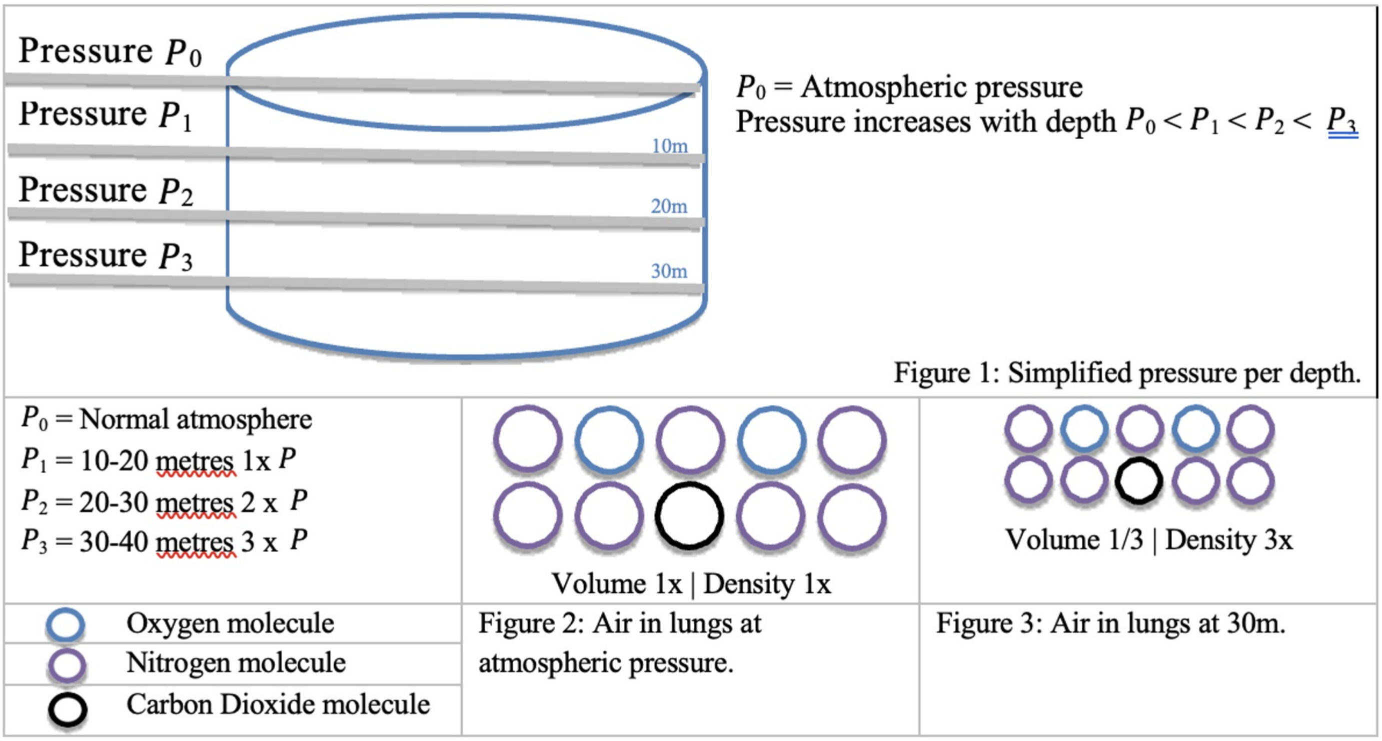

Figure 1: Simplified pressure per depth.

Figure 2: Air in lungs at atmospheric pressure.

Figure 3: Air in lungs at 30m.

Ascending from a depth of 20 meters doubles the volume of air molecules, and at 30 meters, it triples. This rapid expansion of gases within the lungs can lead to the rupture of lung tissue, resulting in pulmonary barotrauma. It also allows gas bubbles, typically nitrogen, to enter the arterial circulation. Divers prevent this by equalising and conducting safety stops, during which they wait for 3-5 minutes every 5 meters to allow their body to acclimatise to the changing pressure exerted on internal gases.

Existing comorbidities, especially lung conditions like asthma, cysts, COPD, tumors, scar tissue, or infections, can increase a diver's susceptibility to AGE. Unfortunately, divers often underreport these conditions on pre-dive questionnaires. Having accessible dive paramedics conduct assessments offers a more convenient point of contact than a marine medical doctor, potentially revolutionising the management of these risks.

Depending on the location of the embolus, it can lead to various symptoms, similar to any arterial blockage. Paramedics are skilled at diagnosing and treating a range of clots, including recognising ECG changes if the blockage occurs in cardiac arteries. Additionally, there's a solid understanding of the pathophysiology of pulmonary embolism and stroke within paramedicine, making the expansion of this knowledge a logical and practical progression of the profession.

Recreational trauma

Apart from professional divers, many recreational divers, including those who are relatively inexperienced, engage in diving activities. Improper conduct during diving can result in serious injuries, such as head or spine injuries from head-first dives. These injuries require specialised care, particularly in terms of immobilisation and transportation in cases of spinal cord injury (SCI). Such injuries are not limited to open water environments and can occur in pools as well [12].

Other traumatic injuries that may occur include maxillofacial injuries and fractures or dislocations of long bones. While paramedics can reduce dislocations, it's crucial to ensure that fractures are not overlooked before returning the patient to activity. The expertise and training of the paramedic play a crucial role, underscoring the need for adequate training [13].

The multidimensional role of Paramedics in maritime rescue and safety operations

Paramedics involved in water rescue operations serve roles that extend beyond clinical skills; they are problem solvers, critical thinkers, and proficient scene managers on land. In water rescue activities, additional training is essential to ensure the maritime safety of the medical team and to conduct safe patient extrication. In March 2022, the NSW police conducted a joint training program to assist paramedics in gaining nautical awareness and enhancing marine safety. In Poland and Germany, paramedics are already specialising in maritime navigation and sea rescue operations.

Picture 1. Paramedics training with NSW Police — Port Stephens Marine Area Command [14]

Picture 2. The G1512W Maritime Medical Rescue Team in the Port of Ustk [15]

To what extent can paramedics make a difference in diving emergencies?

Diving-related emergencies present unique health risks, etiology, and rescue conditions, which can vary significantly depending on whether the diving occurs in a pool, lake, or open waters. Paramedics, with their comprehensive training in managing various rescue operations and providing advanced clinical care, have the potential to significantly reduce mortality risks and enhance overall diver and marine safety. Clinical evidence from the U.S. demonstrates better patient survivability when paramedics collaborate with coast guards [1].

It's essential to recognise that many diving emergencies require successful resuscitation at the site, with patient transport occurring typically after the return of spontaneous circulation (ROSC) and stabilisation. Dive Medical Technicians (DMTs) already provide this prehospital care, making it an area of paramedicine that warrants further attention and research for advancement. Paramedics can play a pivotal role in advancing prehospital care by developing training programs and defining the scope of practice for dive paramedics and marine paramedicine.

Conclusion

In conclusion, while the development of a comprehensive curriculum and scope of practice for dive paramedics may take time, the progress of marine paramedicine is already underway. Paramedics should consider entering this field as researchers and clinicians, as they are ideally positioned to bring healthcare to patients across all environments, including land, air, and sea. Dive Medical Technicians are already proficient in advanced first aid skills, and Dive Paramedics could further advance this field by introducing more sophisticated medical technology and treatments, potentially reducing the overall burden on healthcare systems.

Endnotes

[1] DMT accreditation is through Australian Diver Accreditations Scheme (ADAS) or International Marine Contractors Association (IMCA).

[*] The signs and symptoms listed in all tables are non-exhaustive lists, and other symptoms may be present, requiring discussion in the development of the curriculum for dive paramedics.

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