SYSTEMATIC REVIEW

Airway Clearance Using Suction Devices in Prehospital Combat Casualty Care: A Systematic Review

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Abbreviations:
DTIC: Defense Technical Information Center
ISO: International Organization for Standardization
OIF: Operation Iraqi Freedom

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Abstract

Airway management is at the forefront for combat medics dealing with battlefield trauma. For military service members, compromised airways are the second leading cause of potentially survivable death on the battlefield, accounting for one in ten preventable combat deaths. Effective suction is a critical component of airway clearance. However, currently available devices are too heavy and bulky to be carried by combat medics and are insufficiently powered. The industry has not responded to the need, with companies continuing to produce models using 1970s technology. A literature review was completed with the assistance of a librarian. The databases searched included: Biomedical Research Database (BRD), Computer Retrieval of Information of Scientific Projects (CRISP), Federal Research in Progress (FEDRIP), Defense Technical Information Center (DTIC), Pub Med/Medline, and OVID. Additionally, a Google Scholar search was performed to identify nonstandard sources. After screening, a total of 40 articles were used. There were no randomized controlled trials or other high-quality evidence that addressed the issues; there was limited peer-reviewed literature on the use, effectiveness, adverse effects, and safety of suction for use in combat casualty care. A review of the available literature revealed no standards, either proposed, validated, or accepted, for the safety or avoidance of adverse effects for portable suction device use in combat casualty care. Similarly, there are no accepted standards to guide the safe use and anticipated adverse effects of suction for use in prehospital combat or emergency care. Nevertheless, there are meaningful data that can be extracted from the few studies available combined with non-clinical studies, narrative reviews and case reports, and expert opinions.

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Introduction

Loss of patent airway is the second most common cause of potentially preventable deaths that occur in tactical and combat environments.[1-6] The proximate cause can be direct trauma to the airway structures or indirect from traumatic shock or brain injury and the subsequent loss of airway protective reflexes. Fluid and debris from blood, secretions, or environmental contamination (eg, mud and gravel) can complicate the situation. In these situations, skilled airway management personnel determine survivability; specific interventions often make the critical difference in survival for patients with actual or impending airway compromise. Managing the airway in typical emergencies can be challenging; the combat medic (or a similar corpsman) faces an additional level of difficulty. Hazardous or confined spaces and hostile actions inherently limit the ability to intervene with an artificial airway or assisted ventilation.

Paramount in airway management is clearing the airway of fluid or debris, and it is often the first step in the resuscitation of the compromised patient.[7,8] The primary tool utilized for this necessary first step is medical suction. In fixed facilities such as hospitals, this is provided by installed "wall" suction, which are powered by large industrial-grade pumps. In the field where initial combat casualty care takes place, suction can be provided by battery- or human-powered devices. Placing the patient on their side or in the prone position can promote airway drainage at the expense of patient care access (the supine position allows for most

patient care procedures). The airway may be cleared manually by the combat medic's fingers as a last resort (or when a large chunk of debris is accessible), but this poses a risk to the operator's fingers should the patient bite down.

There is limited information on the types, if any, of portable suction units carried by combat medics in the far-forward combat area.[9] Information suggests that battery-powered suction devices are simply too heavy to be carried in the combat medic's aid kit.[10] Manually powered devices, while lightweight, offer limited capability and require the use of a hand or foot to operate, limiting efficiency of the provider. Fielding data from military logistics agencies on the number and types of suction units employed in the field are not available, and prior experience suggests that even if obtained, the data will show the total purchases rather than where, when, and how the devices were fielded.

The focus of this review is to critically appraise the available evidence supporting the need for portable suction for use in combat casualty care with emphasis on the use, effectiveness, adverse effects, and safety of the device and to perform a narrative descriptive review that can inform practice.

Methods

A literature search was performed for information regarding airway management in prehospital combat casualty care, currently available suction devices, and safety guidelines used. All cited literature is from peer-reviewed journals and other citable sources. Most of the literature review was completed with the assistance of a librarian. The databases searched included: Biomedical Research Database (BRD; US DoD; Virginia USA); Computer Retrieval of Information of Scientific Projects (CRISP; NIH; Bethesda, Maryland USA); Federal Research in Progress (FEDRIP; NTIS; Springfield, Virginia USA); Defense Technical Information Center (DTIC; Fort Belvoir, Virginia USA); Pub Med/Medline (NIH; Bethesda, Maryland USA); and OVID (Ovid Technologies; New York USA). Additionally, a Google Scholar (Google Inc.; Mountain View, California USA) search was performed to identify nonstandard sources. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used in conducting this review (Table 1[11]).

Keywords included in search filters were: "oropharyngeal airway clearance," "prehospital combat casualty care airway management," and "airway suction devices." Various combinations of the following keywords were utilized as well: suction, vacuum, aspiration, catheter, airway, oropharyngeal, nasopharyngeal, tracheal, safety, and adverse effects. Boolean combinations and fuzzy logic were used as allowed by the search engines.

Selection Criteria, Data Abstraction, and Methodological Quality

Two authors screened all articles and abstracts independently for relevance which were included in the writing of this review. Author one (PJ) has five years of experience in drug delivery and medical device design. In addition, PJ worked on projects relevant to airway management for two years. Author two (RAD) is a professor of military and emergency medicine who has been focusing on airway management techniques for eight years.

Articles and abstracts were included if they: (1) explained the need, use, adverse effects, or safety of suction devices, or the need for suction device improvement in prehospital combat casualty care situations; and (2) focused on adult patients. Exclusion criteria for articles and abstracts included: (1) not including the keywords mentioned in the search strategy; (2) studies that did not consider portable suction devices; and (3) studies that focused solely on hospital use without relevance to prehospital or combat environments. Articles were considered high quality if they were published in a high impact factor, peer-reviewed journal and included most or all of the inclusion criteria. Moderate-level literature referred to articles that included descriptions or explanations required to explain the need for airway suction devices but did not necessarily meet all of the inclusion criteria.

Study Characteristics

A total of 4,512 unique sources were identified between all databases. Of those, 212 search results were considered for evaluation. Based on the inclusion and exclusion criteria mentioned, 172 search results were excluded upon initial screening (Figure 1).

Source documents were extracted from 1980-present and analyzed for title content. If relevant, the article was reviewed in detail. Secondary references prior to 1980 were selectively utilized based on the title and likelihood of topical relevance. Specific sources searched include, but are not limited to:

- Committee on Combat Casualty Care (CoTCCC);
- Medical literature using Medline or equivalent with search terms including: *Suction, Vacuum, Aspiration, Airway/Airway Management, Airway Obstruction*, and modifier terms including safety, efficacy, and performance;
- Engineering literature using Academic Search (EBSCO; Ipswich, Massachusetts USA), or equivalent, using similar search terms as above;
- Defense Technical Information Center (DTIC);
- Retrievable information form conferences and meetings focused on combat casualty care, prehospital care, and airway management;
- Government standards, including Federal Drug Administration (FDA; White Oak, Maryland USA); and
- Industry and government standard clearinghouses, including International Organization for Standardization (ISO; Geneva, Switzerland).

Results

Overview

There were no randomized, controlled trials or other high-quality evidence to perform a systematic review. There was, however, adequate moderate-level peer-reviewed literature and expert opinions and guidelines available to perform a narrative descriptive review that could inform practice.

Anatomic and Physiologic Considerations in Suction

Suction is the employment of negative pressure through a catheter directed into the upper airway of a patient.[12] The catheter can be passed through the oral or nasal cavity into the pharynx and supraglottic region.[2] If advanced further, it can pass either into the upper esophagus or through the glottis and into the trachea.[2] In most cases of combat casualty care, the suction catheter will remain in the upper airways, as clearance of this structure is the primary goal.[4] Advancing the suction catheter beyond the glottis is not considered desirable when performing upper airway suction and may be detrimental if a gag reflex occurs.[4] In selected clinical situations, there is a need to perform tracheal suction through an endotracheal tube or similar airway device. This procedure is generally reserved for casualties undergoing lengthy evacuation, as may occur in prolonged care situations. Gastric suctioning is not considered a prehospital procedure and is unlikely to be performed by a combat

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Section/Topic	#	Checklist Item	Reported on Page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title Page
ABSTRACT			
Structured Summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3–4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	4
METHODS			
Protocol and Registration	5	Indicate if a review protocol exists, if and where it can be accessed (eg, Web address), and, if available, provide registration information including registration number.	N/A
Eligibility Criteria	6	Specify study characteristics (eg, PICOS, length of follow-up) and report characteristics (eg, years considered, language, publication status) used as criteria for eligibility, giving rationale.	5–6
Information Sources	7	Describe all information sources (eg, databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4–5
Study Selection	9	State the process for selecting studies (ie, screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data Collection Process	10	Describe method of data extraction from reports (eg, piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	N/A
Data Items	11	List and define all variables for which data were sought (eg, PICOS, funding sources) and any assumptions and simplifications made.	N/A
Risk of Bias in Individual Studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	N/A
Summary Measures	13	State the principal summary measures (eg, risk ratio, difference in means).	N/A
Synthesis of Results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (eg, I^2) for each meta-analysis.	N/A
Risk of Bias Across Studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (eg, publication bias, selective reporting within studies).	N/A
Additional Analyses	16	Describe methods of additional analyses (eg, sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study Selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	4, Figure 1
Study Characteristics	18	For each study, present characteristics for which data were extracted (eg, study size, PICOS, follow-up period) and provide the citations.	N/A
Risk of Bias within Studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see Item 12).	10
Results of Individual Studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	N/A
Synthesis of Results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	11–12
Risk of Bias Across Studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional Analysis	23	Give results of additional analyses, if done (eg, sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			
Summary of Evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (eg, health care providers, users, and policy makers).	13

Table 1. PRISMA 2009 Checklist[11] *(continued)*

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Section/Topic	#	Checklist Item	Reported on Page #
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (eg, incomplete retrieval of identified research, reporting bias).	13–14
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (eg, supply of data); role of funders for the systematic review.	N/A

Table 1. *(continued).* PRISMA 2009 Checklist[11]

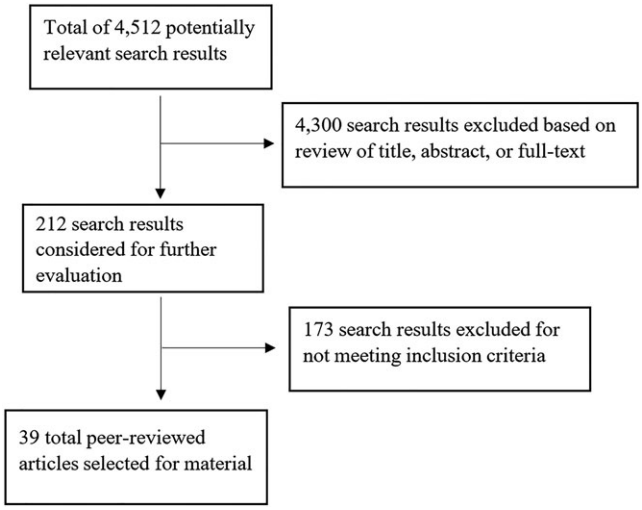

Figure 1. Flow Chart Depicting the Literature Review Process.

medic in Role 1 (closest to the fighting).[13,14] However, it is a procedure expected in Role 2 ("clearing station" staffed by a medical company of physicians, nurses, and medics), Role 3 ("full service" medical facility encountered on the battlefield), and possibly during prolonged care.[13,14]

The tissues exposed to suctioning include all the structures of the oro- and nasopharynx, glottis structures, trachea, and esophagus.[7] These aerodigestive tracts possess multiple functions and varied structures, each with unique characteristics relevant to suction safety. When damaged, forces generated during ordinary suctioning may be enough to cause additional injury.[5] Solid structures such as the teeth are impervious to the effects, while softer, mucous-membrane covered tissues can be affected.[5] The vascularity of the aerodigestive tract is especially susceptible, as most soft tissue structures are well-supplied by superficial capillaries, while larger vessels lie deeper but can also be exposed.[2]

Since the technique of oropharyngeal suction is ideally visually guided, anatomy plays a role in creating pockets of visual obstruction. The nasal vestibule, lateral cheeks, subungual space, and deeper structures of the hypo- and posterior pharynx are all difficult to visualize.[2] Large amounts of secretions and debris (often what initially causes the need for suction) can obscure sensitive tissues.[14] Deeper structures such as the trachea and esophagus are commonly cannulated blindly, which has additional safety implications.

Damaged or injured tissue presents additional concern as the local resistance to the forces applied can convert marginally viable to dead tissue. In rare cases, suction can inadvertently amputate avulsed tissues and perforate exposed blood vessels, causing significant hemorrhaging.[12] Damage from trauma can also expose deeper structures to damage, and in extreme cases, result in profound iatrogenic injury. Insertion of a suction cannula into the cranium through a large basilar skull or cribriform plate fracture is one rare but serious example.[4]

If applied continuously for many minutes to hours, suction can cause local tissue ischemia and necrosis. This is a potential problem in nasogastric suctioning (gastric mucosa) and tracheobronchial suctioning (tracheal mucosa).[15,16] This was a common complication of gastric suctioning until techniques and devices became common to limit suction duration (ie, intermittent-suctioning).

Locally, suctioning can cause an increase in secretions secondary to tactile stimulation, though this effect is generally mild.[17] Stimulation of sensitive tissues can result in a reflex arc such as sneezing (nasal cavity), gagging (posterior tongue), coughing (trachea), or bronchospasm (bronchi).[17] Additional reflexes include vagal stimulation with bradycardia and hypotension, and tachycardia.[17] Elevations in intracranial pressure can also occur. Hypoxia may result from coughing, bronchospasm, reflex hypopnea, the direct effect of the cannula (airway obstruction), or the evacuation of therapeutically hyper-oxygenated air and its replacement with room air.[17]

For an awake patient, suctioning can range from mildly uncomfortable to painful.[17,18] Catheter stiffness, force applied, and suction strength are among the factors that determine the degree of patient discomfort.[17] Carroll in 2003 noted:

> There is little research to guide the clinician in selecting appropriate levels of negative pressure for various suctioning procedures. For example, a review of published guidelines for airway suctioning found suggested levels of 50 to 100mmHg for infants, 80 to 120mmHg for children, and 100 to 150mmHg for adults. However, none of these recommendations are evidence-based. Additionally, these generic recommendations do not take into account the type of suctioning (eg, tracheobronchial or oropharyngeal), the clinical indication, or the particular catheter used or flowrates desired. To date, there has not been significant additions to the literature base on this topic.[19]

Suction in the prehospital combat casualty environment can be used to evacuate fluids other than for airway clearance as well; it can be used in virtually any part of the body. An example of applications outside the upper airway region includes evacuating blood for better visualization of a bleeding site or draining and decompressing a pneumohemothorax.[16] However, no substantive peer-reviewed literature was found to support these alternative applications of medical suction.

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Evidence of Need for Suction in Combat Casualty Care

Airway obstruction occurs when a build-up of bodily fluids (ie, vomit, blood, saliva, or bile) and debris (ie, broken teeth and fracture bones) accumulates at the oropharynx and/or nasopharynx, blocks airway passages, and prevents ventilation.[12] As little as one-fourth of a mouthful of vomitus fluid (approximately 0.4mL/kg) is enough to cause serious airway obstructions.[12] In combat scenarios, airway obstruction due to maxillofacial injuries is the third leading cause for preventable combat casualties.[4,5,20] In these situations, suctioning and intubating the patient can be difficult due to deformed facial features resulting from injuries such as fractures, swollen tongues, or debris blocking the airway.[21] These presentations are challenging for combat medics who receive relatively limited training related to intubation procedures.[20]

Aspiration of as little as 25mL of vomitus is capable of causing significant pulmonary aspiration injury, and massive aspiration poses a mortality rate as high as 70%.[22,23] Delaying suction can increase the exposure risk of aspiration as well as immediate obstruction-related hypoxia.[22] Fluid- and debris-obscured visualization of key anatomic landmarks makes laryngoscopic tracheal intubation virtually impossible, so the availability and performance of controlled suction is essential.

Hospital care is required in five to ten percent of airway obstructions that occur on the field.[24] For six percent of all soldiers killed in action during the Vietnam War, airway obstruction was identified as the leading cause of death.[25] More recent conflicts, notably Operation Iraqi Freedom (OIF), have shown an increase in primary injuries to the airway.[25] In OIF, 27% of wounded-in-action military personnel suffered injuries only to the head, neck, or airway structures.[25] This increase in airway trauma is likely due to the excellent torso protection of body armor and a subsequent diversion of injuries towards less-armored areas such as the neck and face. The Registry of Emergency Airways at Combat Hospitals study (REACH) shows that prehospital cricothyrotomy is performed ten-times more often on the battlefield as compared to civilian trauma systems (5.8% versus 0.5%).[13] A recent study highlights the high incidence of combat airway injury in combat maxillofacial trauma.[26] In these and other trauma cases, airway management requires a low threshold for airway stabilization to include tracheal intubation and cricothyrotomy or tracheostomy.[26] A likely major reason for this dramatically higher rate of surgical airways is poor visualization of the injured airway in conjunction with current inadequate suction devices available on the battlefield.

Evidence of Need for Portable Suction Devices

Over the last dozen years, the combat experience has clearly demonstrated that airway obstruction was the second leading cause of preventable combat casualty deaths, and between six to ten percent of these deaths could have been circumvented with adequate airway management.[27] Because of vastly improved body armor and the enemy's shift towards direct fire and improvised explosive devices, the injury pattern today is much different than in previous wars. Until the 1990s, truncal injuries dominated; since then, the trend has shifted toward exposed limbs and the head and neck.[28]

Combat situations can be highly variable scenarios with many confounding mission, field, and environmental factors such as extreme temperatures, different tactical conditions, difficult terrains, and combat search and rescue (CSAR) operations.[29] Airway suction devices should be capable of performing under these various environmental parameters and should be assessed in various conditions, such as high altitude, vibration, extreme temperatures, excess humidity, and strong magnetic field.[30] In mass-casualty scenarios, a suction device that can be operated without any or minimal prior medical training is highly preferred.[21] Due to the diverse terrains and tactical situations, the device must be durable, easy to transport, and easy to sterilize.[1] Tubing for the suction device must be clear to allow for constant monitoring of the suction process and any clogging of the device. Large-bore tubing is preferred so as to suction viscous fluids containing a considerable amount of debris.[31] In addition, combat-ready suction devices must differ from their civilian counterparts by being compact, rugged, operable in complete darkness, and without emitting a detectable signal (ie, reduced infra-red and noise signatures).[13,32-34] The ideal design guidelines needed for a field-use portable suction unit as suggested by the Walter Reed Army Institute of Research (WRAIR; Silver Spring, Maryland USA) are listed in Table 2.[1] Because of factors such as portability, battery life, vacuum pressure, combat medic training, and terrain constraints, there is controversy as to whether airway management should be composed of tracheal intubation through the mouth or cricothyrotomy (surgical cannulation through the neck).[24,35] Since both techniques require visualization for success, suction plays an important role in either case. Even alternative airway techniques that are inserted without direct visualization of the upper airway structures (eg, supraglottic devices) would benefit from the application of suction to reduce the risk of aspiration.

Device Guideline	Value
Total Volume	Less than or equal to 1229.03cm^3
Weight	Less than or equal to 300g
Dimensions	Less than or equal to 76.2 x 101.6 x 127mm
Peak Pressure	90-200mmHg
Fluid Volume	200-400mL in first use

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Table 2. Suction Device Guidelines as Suggested by Mark F. Costello[1]

Discussion

To highlight the infrequent use of prehospital suction devices, Kozak, et al surveyed 51 paramedics to determine equipment used and training received for medical aid on the field.[29] Reportedly, suction equipment was utilized in only 50% of advanced airway procedures and was carried for medical aid on the field less than 25% of the time.[29] It seems the available off-the-shelf devices do not possess the proper balance of trade-offs between portability, effectiveness, and cost to provide sufficient airway management in tactical care.[36,37] Currently used suction pumps are too heavy, have bulky dimensions, and have limited battery life before requiring recharge. A *Consumer-Reports*-style product review was previously conducted by the authors. It reviewed currently available portable suction devices and their parameters.[37,38] Of the 34 devices included in the report, not one met all criteria required to withstand the rigorous parameters of combat environments, and only a handful of devices were compliant with the aspiration needs in combat casualty situations.[37,38] Proposed specifications for an improved suction device are proposed in Table 3[37] in comparison to the Laerdal Compact Suction Device (Laerdal; Stavanger, Norway), which is the current state-of-the-art device available on the market.[37] Based on these specifications, a group led by Akhter, et al is currently developing an improved suction device

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Specification Criteria	Values or Statement	Laerdal Compact Suction Device
Physical Specifications		
Weight Range (overall device)	<1kg, <0.5kg for man-pack version.	1.5 to 1.95kg
Dimensions - overall device (length, height, depth), including canister	30 x 10 x 10cm	18.5 x 26.2 x 8.13cm
		and 23.6 x 19.1 x 23.6cm
Canister Capacity (mL), Volume markings on canister?	1000mL, 500mL for man-pack version	300mL and 500mL
Performance Specifications		
Directional Performance	Functions in all orientations	N/A
Vomit Flowrate (removal)	3L/min	30L/min
Vacuum Pressure Range (measured at catheter tip)	0-550mmHg	50-550mmHg
Device operational temperature, humidity, moisture exposure range	Based on military standards pertinent for medical devices	N/A
Device operational atmospheric pressure range	Airworthy/safe to fly based on military standards	Certified to use in aircrafts
Engineering Design Specifications		
External AC/DC input power range	120 VAC/12-24 VDC nominal	12V
Battery Type (rechargeable or disposable)	Both	Rechargeable
Max noise level (dB), overall device	≤ 69dBA	≤ 70dB
Suction Tube Diameter	1.27-1.91cm ID	0.48cm ID

Table 3. Proposed Specifications for a Portable Suction Device for Use in Prehospital Combat Casualty Care by De Lorenzo, et al[37]

for prehospital combat casualty care situations that will be lightweight and portable, among other things.[39]

Limitations

Despite the criticality and importance of airway management, there is a paucity of high-quality evidence on the techniques of suction. A 2009 Cochrane (London, UK) review on suctioning of patients revealed limited scope of data that applied almost exclusively to tracheal suction of intubated patients in the intensive care unit.[40] Practice guidelines from 2001 on hyperoxygenation, hyperinflation, use of a ventilator circuit adaptor, and subglottic suctioning were validated. In the review, new evidence was identified with respect to indications for suctioning, open suction versus closed suction systems, use of medications, and infection control. Unfortunately, the applicability to suctioning of the upper airway in combat casualty care cannot be extended. To date, there are no high-quality reports focusing on prehospital or emergency care in the Cochrane database.

Currently available ISO standards that cover suction devices encompass the universal need for medical suction devices; ISO 10079 represents good manufacturing practices, safety standards, and design implications that would all likely be transparent to the clinician. Nevertheless, the standard contains a number of relevant patient safety requirements for portable suction devices that may or may not apply to the combat casualty care environment. This standard represents a minimum standard for portable manual and electrically powered suction devices. There is little indication in the standard that these minimums are satisfactory patient safety parameters for either prehospital or combat casualty care use. Adding combat-specific testing mechanisms to current ISO standards for suction devices would be ideal and have been suggested in a report written by Robert De Lorenzo, et al.[37]

Conclusions

This descriptive narrative review highlights the need for the development of an efficient suction device for use on the field in prehospital combat casualty care situations by medics with minimal training. There are no randomized controlled trials or other high-quality evidence that address the issue of acute airway clearance using suction; there is limited peer-reviewed literature on the need for, use, adverse effects, and safety of suction. A review of the available literature reveals no standards, either proposed, validated, or accepted, for the safety or avoidance of adverse effects portable suction devices pose in combat casualty care. Similarly, there are no accepted standards to guide the safe use and anticipated adverse effects of suction for use in prehospital or emergency care. The few studies available combined with the non-clinical studies, narrative reviews, case reports, and expert opinion in the literature suggest airway suction devices for prehospital combat casualty care should be lightweight, portable, and easy to use for field medics with minimal training in airway management.

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