BRIEF REPORT

# Portable Suction Unit Failure in a Rural EMS System

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**Abbreviations:**
ALS: Advanced Life Support
BLS: Basic Life Support
EMS: Emergency Medical Services
EMT: Emergency Medical Technician

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## Abstract

**Introduction:** Portable suction units used by EMS personnel are utilized infrequently and often are powered by batteries. Lack of use and inspection often results in failure of the device when it is needed. The purpose of this study was to examine the incidence of portable suction unit failure in a rural EMS system and to identify the reasons for failures.

**Methods:** A convenience sample was obtained through both random inspections by the staff of a regional EMS council and data from twice monthly checks reported by respective EMS agencies following a standard protocol for each unit. A standard protocol was used, including checking the vacuum level on each suction unit and inspecting the tubing, canister, and battery. Each inspector assessed whether the unit was capable of achieving 300 mmHg of suction within four seconds. Also, the unit was inspected for any signs of misalignment or dry rot of the gasket, kinking of suction hose, damage to the suction canister, weak/dead battery, or defective pump. Findings were recorded.

**Results:** Over a two-year period, 9,631 suction unit inspections were completed. There were 233 failures (2.4%) noted. The majority (126, 54.1%) were due to battery failure. Seventy-three units failed due to other reasons (not recorded, switch failure, battery not seated). Ten inspections failed due to incorrect assembly. Nineteen inspections failed due to defects with the suction canister. Five inspections failed due to kinked/disconnected suction tubing.

**Conclusion:** Only a relatively small percentage of inspections of suction units revealed failures (4.6% Advanced Life Support, 8.6% Basic Life Support) using the above-stated criteria. However, given the importance of airway management and potential complications associated with airway compromise, including aspiration pneumonia, hypoxia, and hemodynamic instability, this is of concern relative to the morbidity and mortality that could be related to airway failure. Due to the relative infrequency of use and the nature of portable suction units, the potential for lack of maintenance and deficiencies in routine inspection may impact the functional status of these devices in EMS agencies. Clearly, improved documentation of battery installation date, charging in accordance with manufacturer recommendations, and thorough inspection of the portable suction unit in its entirety will ensure readiness of these devices. Additionally, more rigorous documentation and analysis of inspections should be a focus of EMS agencies.

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## Introduction

Portable suction units used by Emergency Medical Services (EMS) personnel are used infrequently and often are powered by batteries.[1] Infrequent use and inspection may result in failure of the device when it is needed.[1] Adverse effects of suction unit failure may include aspiration as well as the inability to visualize the glottic opening during intubation attempts, which ultimately may increase morbidity and mortality. The aspiration of oral/gastric contents significantly increases the likelihood of developing pneumonia; aspiration of as little as 0.4 ml/kg of vomitus can cause significant pulmonary injury and is associated with high rates of both morbidity and mortality.[2] During resuscitations and emergent intubations, aspiration rates are estimated to range from 3% to 35%.[3] In addition to bypassing normal defenses, the endotracheal tube has the potential to damage the larynx, which also increases the risk for aspiration.[4] Many patients who require emergent airway interventions are at high risk for aspiration due to altered protective airway reflexes, such

| Suction Unit Brand | Number of Units Inspected | Number of Failures | Failure Rate[a] (%) | Brand's Share of Total Failures (%) |
|---|---|---|---|---|
| A | 4690 | 171 | 3.65 | 73.0 |
| B | 2579 | 32 | 1.24 | 13.7 |
| C | 78 | 3 | 3.85 | 1.3 |
| D | 863 | 12 | 1.39 | 5.2 |
| E | 957 | 10 | 1.04 | 4.3 |
| F | 273 | 2 | 0.73 | 0.86 |
| G (total of 8 different) | 85 | 3 | 3.53 | 1.3 |
| Total, All Brands | 9525 | 233 | | 99.66[b] |



**Table 1.** Suction Unit Failure Rate by Brand

[a]Higher failure rates in one particular brand may be reflective of a higher number of inspections of suction units containing that brand of battery.
[b]The total number of failures does not to add up as 100% as 106 inspection forms were excluded due to incomplete data.

as coughing, swallowing, and gagging as well as the presence of a full stomach. The mortality rate may be as high as 70% when a patient aspirates gastric contents.[3,5] Aspiration pneumonia increases hospital length of stay nearly 17 days and, in the US, increases costs by nearly $30,000 per patient.[4,5] In addition, asphyxiation may result when vomitus is viscous.[6] Adequate suctioning may decrease the potential for aspiration and its subsequent complications. The hypothesis was that there are a significant number of portable suction unit failures in a rural EMS system. The purpose of this study was to examine the incidence and causes of portable suction unit failure in a rural EMS system in the US.

## Methods

In 2008 and 2009, a convenience sample was obtained through random inspections by the staff of a regional EMS council and data reported by respective EMS agencies following a standard protocol for checking each suction unit twice monthly. The standard protocol included checking the vacuum level on each suction unit and inspecting the tubing, canister, and battery. The inspector assessed whether the unit was capable of achieving 300 mmHg of suction within four seconds. Also inspected were the gasket (for any signs of dry rot or misalignment), the suction hose for any signs of kinking, the suction unit canister (for any signs of damage), the battery, and the pump. The results were recorded (Appendix 1).

The regional EMS system is comprised of seven counties in western Pennsylvania, with a combined population of 639,641. Both basic and advanced EMS providers serve the region, including: 332 first responders; 2,916 Emergency Medical Technicians (EMTs)-Basic; 264 active EMT-Paramedics; 18 prehospital registered nurses; and 16 prehospital physicians. The region's EMS resources include 50 basic life support and 19 advanced life support agencies (both volunteer and paid). A total of 233 EMS vehicles answer a total of 109,082 calls per year.

Inspections of 88 EMS agencies were conducted twice monthly by trained members of the regional EMS council staff to ensure that consistent inspection practices were followed. A new vacuum gauge was used for the inspections, as was a standardized form designed specifically for inspection of the suction unit (Appendix 1, online only). At a minimum, all inspectors were trained as EMT-Basics.

Fourteen different brands of suction unit were inspected. Failure rates were described by brand and by EMS service type. To attempt standardization, the rate of inspections for each battery was reviewed in the context of all batteries. The standardization was based on the frequency of inspection. Standardization of the number of failures relative to the brand of battery was evaluated. Higher failure rates in one particular brand might have been reflective of a higher number of inspections of suction units containing that brand of battery.

Because no human subjects were involved, this study was exempt from Institutional Review Board review.

## Results

Over a two-year period, 9,631 suction unit inspections were completed. Two hundred thirty-three failures were noted. There were no cases of multiple failures in one unit.

The highest failure rate, 3.85%, occurred in suction unit Brand C, followed by 3.65% for Brand A (Table 1). With respect to EMS service type, the highest suction unit failure rate, 8.68%, occurred in Basic Life Support (BLS) agencies as shown in Table 2. Suction unit failure rates by brand of battery (Figure 1) indicated highest rates for Brands C, A, and G. Overall, battery failure accounted for the greatest number of suction unit failures: 126 (54%) (Figure 2). Additional reasons for suction unit failure were: other, 73 (31%) (ie, not recorded, switch failure, battery not seated; defects with the suction unit canister); 19 (8%) incorrect assembly; 10 (4%); and kinked or disconnected tubing 5 (2%).

## Discussion

The inspection process identified two serious issues: (1) the failure of a number of suction units due to battery failure, with one brand of battery having a significantly higher rate of failure; and (2) the inspection logs of many EMS agencies were insufficient to provide detailed information on the following parameters: (a) date on which the battery was placed into service;



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| EMS Service Type | Average Suction Unit Failure Rate (%) | Range of Failure Rate (%) |
|---|---|---|
| Quick Response Service | 2.11 | 0-12.5 |
| Basic Life Support | 8.68 | 0-100 |
| Advanced Life Support | 4.66 | 0-33.3 |



**Table 2.** Suction Unit Failure Rate by EMS Service Type

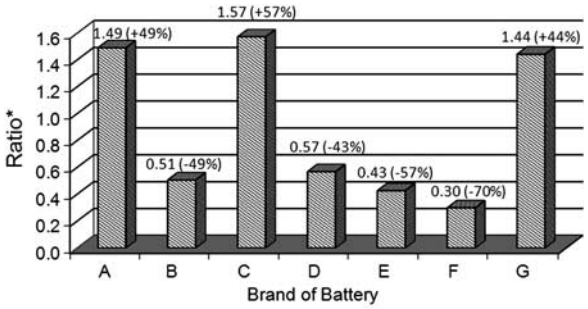


**Figure 1.** Standardized Ratio of Failures by Brand of Battery

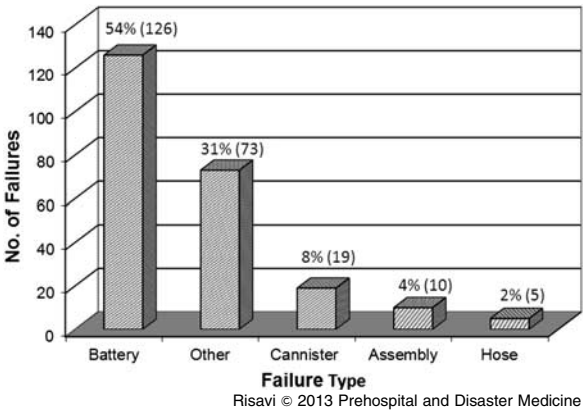


**Figure 2.** Suction Unit Failures by Type

(b) frequency and duration of charging; and (c) whether batteries (with removable battery packs) were rotated among portable suction units. No similar studies have been reported.

The regional EMS council, through a quality improvement initiative, has replaced a number of portable suction units, and is in the process of replacing additional units. A total of 54 new units were distributed in 2009, and 21 new units were distributed in 2010. Each new portable suction unit has a unique identifier for both the battery and the unit. This ensures tracking of each battery in those units with removable battery packs.

The failure rate of suction units in BLS agencies was twice that of ALS agencies. This is a concern because many BLS agencies rely on volunteers, with limited staffing. Due to the relative infrequency of use and the nature of portable devices subjected to the prehospital environment, the potential for lack of maintenance and deficiencies in routine inspection may significantly impact the functional status of portable suction units in EMS agencies.[7] Pennsylvania Department of Health regulations require all licensed EMS agencies to participate in quality assurance/quality improvement activities as directed by the regional EMS council. This includes unannounced inspections of EMS agencies and their equipment, and inspection of logs relating to the use and inspection of portable battery-powered suction units. Education of EMS agencies regarding documentation of new battery installation, frequency of charging, and inspection is also being emphasized to facilitate a more thorough assessment of portable suction units to maintain constant readiness. Those EMS agencies not complying with quality assurance/quality improvement initiatives, or continuing to have persistent failure rates, are subject to potential disciplinary action by the Department of Health.

## Conclusion

A relatively small percentage of suction unit inspections resulted in failure (4.6% ALS, 8.6% BLS). However, given the importance of suctioning in airway management and potential complications associated with airway compromise, this is a significant concern relative to possible morbidity and mortality. Further study of EMS agency inspection methods and the frequency of such methods appears warranted.

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