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To whom it may concern

The UCLA Center for Prehospital Care was requested to participate with SSCOR, Incorporated on a bench research project involving three different suction units.

The study was conducted on February 6, 2004. Mr. Scott Eamer and myself were the principals conducting the study. This project was given consent from the UCLA Institutional Review Board

The preliminary results of the study are attached for your review.

If you have any questions regarding this study, please do not hesitate to contact my office.

Sincerely,

Baxter Larmon, PhD, MICP
Professor Medicine
UCLA School of Medicine
Director
UCLA Center for Prehospital Care

Demystifying the 30 Liter Per Minute Standard in Portable Suction

A study done in conjunction between UCLA Center for Prehospital Care and SSCOR, Inc. using jointly developed methods to test the validity of the 30 liter per minute standard for airflow in battery operated portable suction units.

Methods

The study was conducted at the UCLA Center for Prehospital Care comparing a battery powered hand held suction unit reaching 10-12 liters per minute airflow at the end of a suction catheter against two conventional portable suction devices reaching over 30 liters per minute airflow at the end of a suction catheter.

A solution of simulated vomitus was mixed according to section 59.9 of the ISO standard for Medical Suction Equipment, ISO Standard 10079-1. The vomitus solution consists of 10 grams of food grade xanthum gum dissolved in 1litre of distilled water and adding 100 grams of 1mm diameter glass beads having a specific gravity of 2,55. The vomitus was mixed 12 hours prior to the tests and stored at room temperature. Each portable suction unit was timed to see how long it took to remove 200cc of vomitus solution from a reservoir. This test is again based on the ISO Standard for Medical Suction Equipment, ISO Standard 10079-1. In section 59.9, the standard requires equipment intended for pharyngeal suction to evacuate 200cc of simulated vomitus in not more than 10 seconds. Each suction unit performed the suction test three times, and the results were averaged.

Description of Devices used in the Study

The two conventional portable suction units used in the study were determined by asking three EMS dealers what their most popular selling units are. The top two suction units were used in the study. The two top suction units were off the shelf devices, capable of reaching over 30 liters per minute airflow and over 500mmHg at the end of a suction catheter. Both conventional portable suction units were connected to the same Bemis 1200cc Hi-Flow canister and lid with a hydrophobic filter and float valve, a 72" length of standard patient connecting tube (9/32" ID), and a typical Yankauer type suction catheter (.259 ID) for the test.

The battery powered hand held suction unit was capable of reaching 10-12 liters per minute and over 500mmHg at the end of the suction catheter. The vacuum pump in this device was connected directly to a 300cc collection canister through a hydrophobic filter. The catheter (.320 ID) is affixed to the canister. In this configuration, the distance from the vacuum pump to the tip of the suction catheter has been shortened from the 6'11" distance in the conventional setup to 9.5".

Description of Test Fixture

Components

- Liquid-Level-Sensor (LLS) operating switch system with two 6" sensing probes, electronic control board, relay and 120vac. power cord.
- 4 Digit, 1/100 sec. 120V AC Timing Indicator with 12V DC control relay.
- 4 Outlet junction box with 8 way terminal strip connector.
- 500 mL. Graduated polycarbonate beaker.
- Beaker stand.
- Laminated particle-board stand.
- 1 Flexible connecting lead terminating with a 2 pin Molex Plug.
- 1 Flexible connecting lead terminating with a 2 pin Receptacle.

Operation

- Fill the beaker with VOMITUS to the 300cc level, and then raise it to encompass the two probes and the catheter tip. Slide the beaker stand directly under the beaker. The tip of the catheter and its two side holes will then be just below the 100cc graduation as predetermined by the fixed height of the beaker stand.
- Remove the Pump plug from the Molex receptacle on the PC board and insert it into the receptacle on the flexible lead. Insert the plug on the flexible lead into the Molex receptacle on the PC board.
- Connect the main power cord to a 120vac. 60Hz. 15 amp power supply receptacle and the green "Power On" light will operate.
- Depressing the On/Off switch immediately starts the pump and timer and the liquid level rapidly drops. When the liquid level drops to the 100mL graduation both the pump and the timer will stop. The timer then indicates the elapsed time taken for the difference in volume as read from the beaker graduations.
- Reset the timer and switch off the Suction Unit.

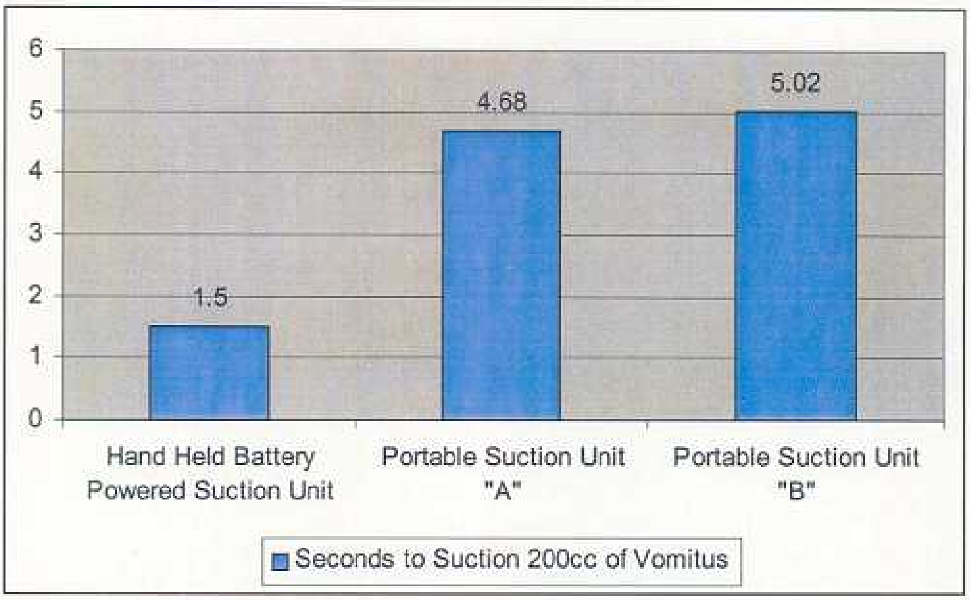
Study

1. Each device was inspected prior to the test to ensure it was operating according to the manufacturers specifications.
2. All of the batteries on the suction units were fully charged after an overnight charge prior to the tests.
3. The tests were conducted at room temperature.
4. The device was attached to the test fixture
5. The ISO vomitus material was placed into a container
6. Each device was turned on and the time required to evacuate the 200cc of vomitus was measured
7. This was done three times for each unit

Results

Three measurements were taken from each device, the average time to suction 200cc of vomitus is presented:

- The average time for the hand held battery powered suction unit to evacuate 200cc of vomitus was 1.50 seconds
- The average time for the portable suction unit "A" to evacuate 200cc of vomitus was 4.68 seconds.
- The average time for the portable suction unit "B" to evacuate 200cc of vomitus was 5.02 seconds.



Discussion

There are many standards for portable suction that require a portable suction unit to provide a free airflow of 30 liters per minute at the delivery tube. The standard does not mention the capacity nor the type of canister to use when conducting the test. Changing the type and size of the canister may dramatically affect the airflow readings of a suction device. The AHA Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care state that a portable suction unit provide vacuum and flow adequate for pharyngeal suction. This standard makes no mention of numerical specifications, nor does it attempt to describe what is adequate vacuum and flow for pharyngeal suctioning.

The reasons the battery powered hand held suction unit significantly outperformed the conventional suction units are:

- There is less dead space in the canister to evacuate. The battery powered hand held suction device has a custom canister with a capacity of 300cc. The conventional suction units use the standard 1200cc suction canister.
- The fluid path in the battery powered hand held suction device is shorter than the fluid path on the conventional units. The fluid path on the battery powered hand held device is approximately 9-1/2" while the fluid path on the conventional suction unit consists of the standard 6' of patient tubing and a standard 11" Yankauer type suction catheter.
- The fluid path in the battery powered hand held suction device is wider than the fluid path on the conventional units. The patient tubing has an inside diameter of .281 (9/32") while the inside diameter of the fluid path of the battery powered hand held suction device is .320.

The later two points can be explained by Poiseuille's Equation [1] which states the rate at which fluid passes through the tube increases proportionately to the fourth power of the diameter of the tube. The effect of tube length on fluid passage is linked to the concept of laminar flow. When fluid flows through a tube it travels in layers, or "streamlines," of concentric circles of equal distance from the side of the vessel. These circles are a function of the degree to which molecules of the fluid opt to adhere to the wall of the tube. The longer fluid is in contact with the sides of the tube, the more the molecules of the fluid may adhere to the side of the vessel, and the more sluggish the flow. There have been numerous other studies that have reached the same conclusion, including studies conducted by James T. Vandenberg [2] who concluded a larger diameter system suctions faster than the standard tubing and connection ports currently used.

Additional tests were performed with the battery powered hand held suction device. A 36" piece of bubble tubing (.275 inside diameter) with a standard Yankauer suction tip was attached to the end of the catheter of the hand held suction unit. The average time necessary to evacuate the 200cc of vomitus from the reservoir was 3.00 seconds, still better than the conventional 30 liter per minute suction units.

Limitations of the study

We used ISO solution to simulate vomit. Although an international standard, this solution may not accurately represent what an EMS professional will see in the field when suctioning a patient.

Conclusion

While the hand held battery powered suction unit does not meet the 30 liters per minute suction standard, it significantly out performed the two conventional portable suction units that do meet the standard. Further investigation needs to evaluate the standards for suction and set actual performance criteria.

[1] The **Poiseuille's Equation** (or the **Hagen-Poiseuille law** is the physical law concerning the voluminal laminar stationary flow Φ_V of incompressible uniform viscous liquid (so called Newtonian fluid) through a cylindrical tube with the constant circular cross-section, experimentally derived in 1838, formulated and published in 1840 and 1846 by Jean Louis Marie Poiseuille (1797-1869), and defined by:

$$\Phi_V = \frac{dV}{dt} = v_s \pi r^2 = \frac{\pi r^4}{8\eta}\left(-\frac{dp^\star}{dz}\right) = \frac{\pi r^4}{8\eta}\frac{\triangle p^\star}{l} ,$$

where *V* is a volume of the liquid, poured in the time unit *t*, v_s median fluid velocity along the axial cylindrical coordinate *z*, *r* internal radius of the tube, p^* the preasure drop at the two ends, η dynamic fluid viscosity and *l* characteristic length along *z*, a linear dimension in a cross-section (in non-cylindrical tube). The law can be derived from the Darcy-Weisbach equation, developed in the field of hydraulics and which is otherwise valid for all types of flow, and also expressed in the form:

$$\Lambda = \frac{64}{Re} , \qquad Re = \frac{2\rho v_s r}{\eta} ,$$

where *Re* is the Reynolds number and ρ fluid density. In this form the law approximates the *friction factor*, the *energy (head) loss factor*, *friction loss factor* or *Darcy (friction) factor* Λ in the laminar flow at very low velocities in cylindrical tube. The theoretical derivation of slightly different Poiseuille's original form of the law was made independently by Wiedman in 1856 and Neumann and E. Hagenbach in 1858 (1859, 1860). Hagenbach was the first who called this law the Poiseuille's law.

[2] Vandenberg, James T; Large-Diameter Suction Tubing Significantly Improves Evacuation Time of Simulated Vomitus; American Journal of Emergency Medicine Volume 16. Number 3. May 1998