U. S. NAVAL SUBMARINE MEDICAL CENTER
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MEMORANDUM REPORT NO. 68-10

PORTABLE CLINICAL SUCTION DEVICE FOR USE IN HYPERBARIC CHAMBERS

MF011.99-9003 23 May 1968

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SUMMARY PAGE

THE PROBLEM

To develop a simple, effective and reliable suction apparatus which will not present a fire hazard in hyperbaric chambers.

FINDINGS

A light-weight, readily portable instrument was developed which meets all the requirements for operation in hyperbaric chambers.

APPLICATIONS

The simplicity and effectiveness of this instrument have made it not only useful for hyperbaric chambers but also for other routine clinical applications of suction.

ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Work Unit MF011.99-9003—Physiological Effects of Long Duration Habitation in Hyperbaric Air and Artificial Environments. The present report was approved for publication on 23 May 1968 and has been designated Submarine Medical Center, Submarine Medical Research Laboratory Memorandum Report No. 68-10. This is Report No. 4 on the Work Unit listed above.

PUBLISHED BY THE NAVAL SUBMARINE MEDICAL CENTER

ABSTRACT

A new portable clinical suction device has been developed which operates on compressed gas. Its performance equals that of typical electric rotary aspirators and far exceeds the performance of conventional Venturi devices or foot-powered pumps. It can achieve 27 in./Hg. vacuum, has no moving parts, requires little maintenance and incorporates a suction tip, off-on trigger, vacuum control and vacuum release in an easily handled pistol grip.

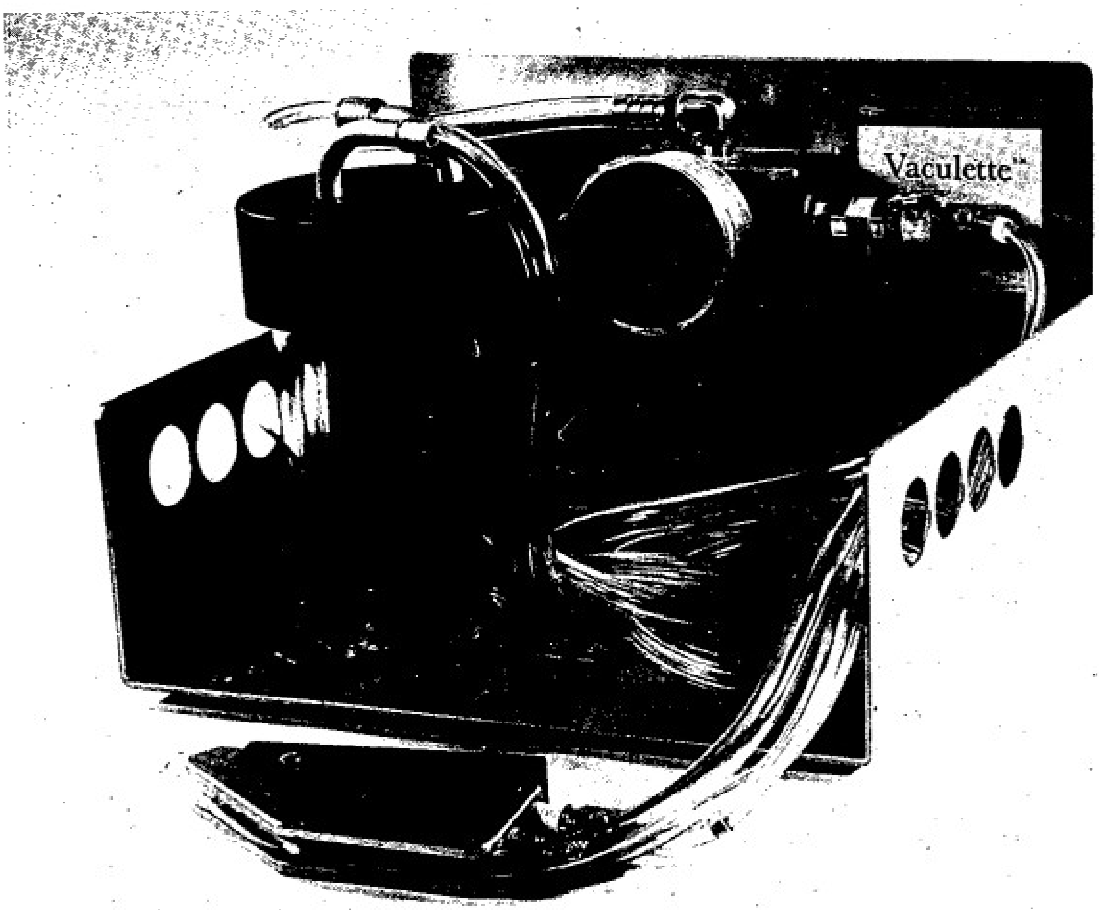

Figure 1.—Vaculette Suction Unit.

PORTABLE CLINICAL SUCTION DEVICE FOR USE IN HYPERBARIC CHAMBERS

INTRODUCTION

Aspiration of the naso-oropharynx and trachea to remove secretions, debris and vomitus is often essential to ensure adequate pulmonary ventilation. Under relatively controlled conditions in an intensive care unit or with a tracheostomy present, aspiration can usually be performed without difficulty. When the need for aspiration arises under conditions of emergency care and resuscitation, suction becomes a difficult task for a variety of reasons. The need for rapidity, the natural tendency for human error in emergencies, unsatisfactory patient position, lack of assistance and the mechanical inadequacy of portable suction devices all contribute to the problem.

Proper equipment design incorporating good mechanical and technical characteristics can be supplemented by good human engineering to enhance rapidity of use and decrease the probability of error and the need for assistance.

Rosen and Hillar have characterized the ideal clinical suction apparatus. A minimum vacuum of 25 in./Hg., free air flow of 25-30 l/min and rapid drawdown time to maximum vacuum to decrease the time required for adequate suctioning are all desirable.[1]

Currently available equipment fails, for the most part, to attain these goals. There are four basic types of portable aspirators in use today. The suction bulb, while inexpensive and reliable, creates insufficient vacuum and will not remove viscid secretions or adequate volume. Electric-powered, rotary aspirators provide adequate suction but require large heavy battery power packs or frequently overload already burdened ambulance electrical systems. The commonly used AMBU foot powered unit is very awkward for a single operator to use and provides only 11 in./Hg. suction. Gas-powered Venturi aspirators of the type so frequently incorporated in resuscitation apparatus for use in the hospital, ambulances, aid stations and the field are wasteful of oxygen and do not provide adequate suction. One commonly used portable unit can only attain 4 in./Hg. Such devices have been notoriously ineffective in removing any significant amount of viscid material or vomitus from the airway.

A new device has been developed to meet the need for a lightweight, portable suction apparatus.* It is capable of exceeding 25 in./Hg. vacuum, contains no moving parts, is modest in its consumption of compressed gas or oxygen and has proved reliable and easy to use. It has been designed specifically for portable resuscitation kits, litters, ambulances, and emergency life support and resuscitation carts. It also has general use within the hospital, emergency room and intensive care unit and may be used in hazardous locations where electric motors might be dangerous, e.g., hyperbaric chambers or coronary care units.

It is especially useful on litters when it is desirable to have suction immediately available for post-operative patients in transit between operating room, recovery room, intensive care unit and ward. The need for aspiration frequently arises at inopportune times made worse by the vagaries of hospital elevators.

DESCRIPTION

In a typical configuration for use on resuscitation carts or within the hospital, a block containing the air ejector and vacuum gauge is attached to a heavy aluminum chassis which also holds the collection bottle, hose and pistol grip (Fig. 1).

The basic apparatus is a one-stage air ejector powered by compressed gas with an input pressure which may vary from 40 to 75 psig. Maximum performance is attained with pressures approximating 50 psig.

This pressure value is provided by the vast majority of hospital wall oxygen systems and most resuscitator regulators.

* Corbin-Farnsworth Inc., Palo Alto, Calif.

Figure 2.—Pistol Grip of the Suction Unit which Contains the Off-On and Suction Control.

Figure 3.—Deep Suction Catheter Attached to the Pistol Grip Control.

The air ejector is attached to a 500 cc collection bottle which is equipped with an overflow valve to prevent suctioned material from passing into the air ejector. Should debris inadvertently enter the ejector, the mechanism tends to be self-purging and, in addition, is easily cleaned.

The suction tubing leads from the collection bottle to the pistol grip. The off-on control and suction control are incorporated into an instinctively held pistol grip (Fig. 2). Squeezing the trigger supplies oxygen or other compressed gas from the primary source to the air ejector. The amount of vacuum created, from 0 to 27 inches/Hg. depends on the pressure exerted on the trigger by the operator. A tapered nozzle, representing the barrel of the pistol, may be used as the oropharyngeal suction tip or will receive a standard catheter for deep suction. Releasing the trigger immediately causes the vacuum to drop to zero in the same manner as removing one's thumb from the T or Y connector between tubing and catheter of a conventional aspirator. Intermittent suction or release of caught tissue is thus easily controlled.

The pistol grip provides single hand control of the off-on trigger, degree of vacuum desired and manipulation of the suction nozzle or catheter. This permits the other hand to be used for positioning the patient or fine manipulation of a deep suction catheter (Fig. 3).

The combination of the trigger off-on control in the same hand as the suction tip or catheter, together with the very rapid increase in vacuum, permits insertion of the suction tip or catheter with the apparatus shut off. Squeezing the trigger builds up vacuum very rapidly during the manipulation or removal withdrawal phase. Oxygen is thus consumed only during the actual period of suctioning and not during the period of handling the catheter or inserting it. This results in a great reduction of gas consumption. This is important in ambulances and portable resuscitation kits which carry limited supplies of bottled oxygen.

Quick connect-disconnect fittings permit rapid removal and assembly of the clear polyvinylchloride oxygen tubing. The clear polyvinylchloride aspiration tubing itself snaps into the pistol grip and may be easily cleaned or discarded and replaced.

Various mountings and chassis may adapt the unit to its various applications. Attachment to a wall oxygen outlet or oxygen tank, placement on a shelf or bedside table, use in specialized life support systems or portable resuscitation kits are all within the device's capabilities.

RESULTS

The performance characteristics of a production unit of the new portable aspirator were determined using a mercury manometer, calibrated American Gas Meter Company Model 802 totalizing flowmeter and a stop-watch. Values represent the average of ten trials. Comparative performance of other aspirators were made with the same instrumentation and conditions (Table I). All aspirators were new as supplied by the manufacturers.

This new self-contained portable suction device exceeds the degree of vacuum attained by available foot pumps and Venturies and approximates that attained by electric rotary types. Free air flow rate and ability to suction a viscid test medium is superior. Using the factory provided collection jars, time required to attain an adequate clinical level of vacuum is less in the device described than in the electric rotary type (Fig. 4).

DISCUSSION

While air ejectors have been used for suction devices for many years,[2] they have never been able to attain the vacuum forces of electric rotary pumps. Within the past few years, increased understanding of fluid dynamics has elevated the state of the art in design of such devices. It is now possible to build devices which exceed the specifications of electric aspirators. In addition to increased portability, freedom from power lines or vehicular electrical systems, air ejectors have no moving parts, are virtually maintenance free and require no lubrication. There is no inherent electrical hazard with danger of inadvertent ground paths.

TABLE I

COMPARISON OF NEW GAS POWERED ASPIRATOR WITH CONVENTIONAL ELECTRIC ROTARY, FOOT POWERED AND GAS POWERED ASPIRATORS

	MAXIMUM VACUUM	FREE AIR FLOW THROUGH NO. 16 FR. RUBBER CATHETER	ASPIRATION TIME FOR 100 ml. UNIFORM PHISOHEX TEST MEDIUM THROUGH NO. 16 FR. RUBBER CATHETER
VACULETTE	27 in./Hg.	17 l./min.	46 Seconds
SORENSON 1/10th h.p. Electric Rotary Aspirator	28 in./Hg.	14.3 l./min.	64 Seconds
AMBU Foot powered aspirator	11 in./Hg.	10.6 l./min.	Unsatisfactory
EMERSON Venturi on Resuscitator	7.6 in./Hg.	8.0 l./min.	Unsatisfactory
STEPHENSON	6.2 in./Hg.	11.0 l./min.	Unsatisfactory

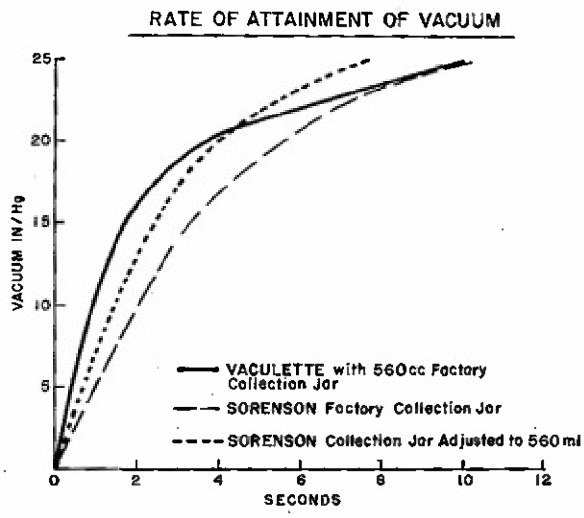

Figure 4.—Rate of Attainment of Vacuum.

In addition, this device may possess a significant physiologic advantage over electric or gas powered suction devices which are turned on prior to insertion of the catheter. All deep suction results in negative pressure in the lungs. The degree of negative pressure created and the probability of resultant atelectasis or decreased intrathoracic pressure resulting in increased systemic venous return and dilation of the vena cava and right heart are dependent on the suction created, the size of the catheter with respect to the tracheal diameter and related factors.[3] Radiographic demonstrations of this phenomena during suction have been made[4] and reductions in arterial oxygen saturation during suction are also well established.[5] It is clearly advantageous that suction not exist until the intended moment of actual aspiration and during withdrawal of the catheter. Some suction exists at the catheter tip even though the T or Y junction of an electric or gas powered suction apparatus may be open to the atmosphere.[6] The operator might possibly avoid activating the suction machine until the catheter is in position. However, many off-on switches cannot easily be reached by the person manipulating the catheter, and it is often difficult to completely compress and block many rubber or plastic catheters while positioning them.

The combination of a trigger switch to energize the suction apparatus and modulate vacuum together with the short time to achieve maximum vacuum may minimize undesirable intrapulmonary and intrathoracic negative pressures and their potential consequences in this new suction unit.

SUMMARY

The simplest clinical suction device for use in hyperbaric chambers is a value and tubing to utilize the pressure differential between the inside of the chamber and the atmosphere. This presents certain dangers, however, since the suction can far exceed that which is desirable, with resultant damage to tissue.

Electric rotary aspirators present a potential fire hazard. Evaluation of a new commercially available, gas-powered aspirator was therefore undertaken to determine its suitability for chamber use.

This portable clinical suction device has been recently developed and operates from compressed gas. Its performance equals that of typical electrical rotary aspirators and far exceeds the performance of conventional Venturi devices or foot powered pumps. It can achieve 27 in./Hg. vacuum, has no moving parts, requires little maintenance and incorporates a suction tip, off-on trigger, vacuum control and vacuum release in an easily handled pistol grip.

As long as the device is supplied with an input pressure of 50 psig over ambient pressure, it will function well.

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UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
U.S.Naval Submarine Medical Center, Submarine Medical Research Laboratory	UNCLASSIFIED
	2b. GROUP N/A

3. REPORT TITLE

PORTABLE CLINICAL SUCTION DEVICE FOR USE IN HYPERBARIC CHAMBERS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Interim report

5. AUTHOR(S) (First name, middle initial, last name)

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6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
23 May 1968	5	7

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. MF011.99-9003.04	Memorandum Report No. 68-10
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U.S.Naval Submarine Medical Center Box 600, Naval Submarine Base Groton, Connecticut 06340

13. ABSTRACT

A new portable clinical suction device has been developed, which operates from compressed gas. Its performance was evaluated and found to equal that of typical electric rotary aspirators and to far exceed the performance of conventional Venturi devices or foot-powered pumps. It can achieve 27 in./Hg. vacuum, has no moving parts, requires little maintenance and incorporates a suction tip, off-on trigger, vacuum control and vacuum release in an easily handled pistol grip.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Suction device, portable, clinical (compressed gas powered)						
Suction device for use in hyperbaric chambers						
Non-electrical, clinical suction apparatus						