Journal of Hyperbaric Medicine, Vol. 3, No. 3, 1988

A Functional Suction Apparatus Within the Monoplace Hyperbaric Chamber

L. K. Weaver

Critical Care Medicine, LDS Hospital, Eighth Avenue and C Street, Salt Lake City, UT 84143

Weaver LK. A functional suction apparatus within the monoplace hyperbaric chamber. J Hyper Med 1988; 3(3):165–171.—Most hyperbaric oxygen (HBO) treatments in the United States are delivered within the monoplace chamber. Patients who require HBO may have nasogastric (NG) tubes, thoracostomy tubes, or wound drains that require suction, which has not been well documented during monoplace HBO therapy. This paper describes a method of providing suction during HBO therapy within a Sechrist monoplace hyperbaric chamber. An Ohio vacuum regulator with a 1.4-liter suction receptacle canister was mounted on a stainless steel bracket that attaches to the hyperbaric chamber hatch in a manner similar to the Sechrist 500A ventilator. The vacuum regulator and canister were configured so that the 500A ventilator could be mounted on the hatch and still allow access to all i.v. pass-throughs. A vacuum regulator is adjusted to the desired degree before compression. The hose that typically connects the vacuum regulator to the wall outlet is passed out of the chamber via an i.v. pass-through. It is not necessary to connect the unit to the wall vacuum because when chamber pressure exceeds 5 psi there is an adequate gradient from inside to outside the chamber to drive the vacuum regulator. The vacuum regulator can be turned on or off by turning a 3-way stopcock open or closed. The vacuum regulator should not be turned to "full" as this could expose the suctioned part to an extreme vacuum; rather it should be regulated to the desired level by the variable suction knob. This system has proved satisfactory suction for NG drainage, surgical drains, and oropharyngeal suctioning in a patient who could not swallow.

hyperbaric; hyperbaric oxygen; suction apparatus; monoplace hyperbaric chamber

Introduction

The majority of patients treated with hyperbaric oxygen (HBO) therapy receive this therapy in monoplace HBO chambers (1). Patients who are treated with HBO may have nasogastric (NG) tubes, thoracostomy tubes, or wound drains that require suction, either intermittently or continuously. Others who operate monoplace chambers either cap-off surgical drains or NG tubes or place a glove or bag around the tube to collect passive drainage. Chest tubes are used with Heimlich valves that are not applied to suction. Inadequately drained NG tubes may be an increased risk of aspiration of gastric contents, particularly during decompression. Similarly, for surgical drains, it may be important to not interrupt continuous suction during HBO treatment. Chest

tube drainage may be inadequate if removed from suction, which could lead to a tension pneumothorax, a serious complication worsened by decompression.

At this time, no medical equipment manufacturer in the United States offers a suction apparatus designed or adapted for use in the monoplace hyperbaric chamber. Drager offers an optional suction unit with its HTK 1200 monoplace hyperbaric chamber (Dragerwerk AG, Lübeck-Travemünde, FRG). Therefore, I sought to develop an adjustable suction apparatus for patients treated within the monoplace hyperbaric chamber. This suction apparatus uses the pressure gradient which exists between the hyperbaric chamber and the ambient environment.

Materials and Methods

An Ohmeda vacuum regulator (#306-1008-880, Ohmeda, Madison, WI) was chosen because of its relative compact size and availability. This vacuum regulator was disassembled to verify that there was no evidence of oxygen-incompatible substances such as grease, thus avoiding any potentially combustible products before placing it into the HBO chamber (2).

The reassembled vacuum regulator was mounted on one end of a stainless steel plate attached to the hatch of the chamber. On the opposite end of the plate, a 1.4-liter suction receptacle canister (#43423-01, Sorensen Research Co., Salt Lake City, UT) was added (Fig. 1). The mounting plate was cut and grooved so it could be held in the chamber hatch as the ventilator block is. The Sechrist 2500B monoplace chamber hatch has two grooved bushings which accept the Sechrist 500A hyperbaric ventilator block. These bushings were extended (Fig. 2) so that both the suction apparatus and ventilator could be mounted in the hatch simultaneously (Fig. 3). A similar configuration could be applied to any monoplace hyperbaric chamber.

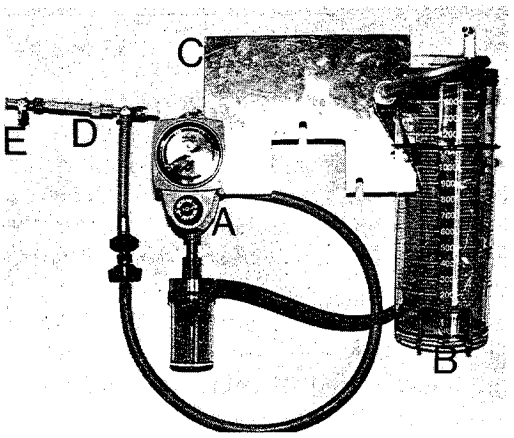

FIG. 1—The Ohio vacuum regulator (*A*) and Sorensen suction canister (*B*) mounted on a bracket (*C*) configured so that the assembly fits onto the Sechrist 500A ventilator block mounting bushings in the hatch of the Sechrist 2500B hyperbaric chamber. *Note* the Cobe pass-through (*D*) connected to the vacuum hose of the Ohio unit. The 3-way stopcock (*E*) regulates the degree of vacuum once the chamber is pressurized.

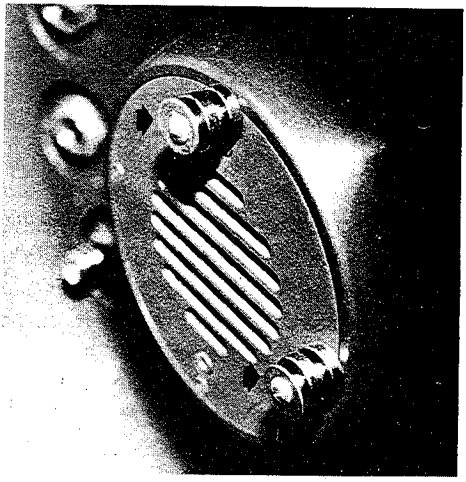

FIG. 2—The ventilator block mounting bushings (*arrowheads*) extended to accept both the suction assembly and the ventilator block simultaneously.

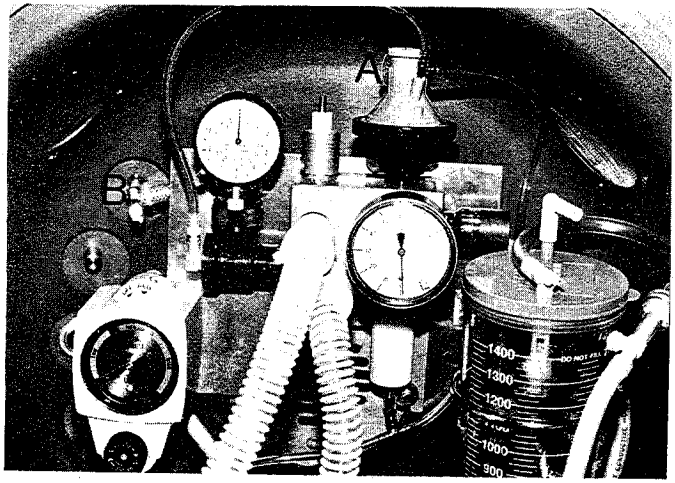

FIG. 3—Configuration of the suction assembly and Sechrist 500A ventilator when used simultaneously. A Bird micronebulizer (*A*) has replaced the standard Bird 500-cc nebulizer. The vacuum hose of the Ohio unit runs behind the assembly and exits the chamber via a Cobe pass-through (*B*).

The vacuum hose that normally connects the vacuum regulator to the hospital vacuum (on the wall) was cut. To the severed end, a 3-way luer-lock stopcock was attached and secured with Tygon ties. The female luer-lock was then attached to the luer-lock (male) on an i.v. pass-through (HBO pass-through, #041-600-500, Cobe, Lakewood, CO) to exit the chamber hatch. The

Cobe one-way backcheck valve must be removed. Another 3-way stopcock was connected to the Cobe pass-through on the outside of the chamber hatch.

For testing, the latex suction tubing that connects the suction receptacle canister to the item to be suctioned was occluded. The system was mounted in the hatch as specified, and the chamber was pressurized. The vacuum regulator was turned to "full" or to "regulate" before closing the hatch.

Results

When the chamber was pressurized to approximately 5 psi, there was an adequate gradient to operate the vacuum regulator to full suction (200 to 300 mmHg). The vacuum regulator could be turned on and off merely by opening and closing the outside 3-way stopcock. However, at higher chamber pressures (>10 psig), there was enough suction to collapse the latex suction tubing with the vacuum regulator turned to on. Therefore, if the vacuum regulator was turned to regulate instead of on and the degree of vacuum was regulated (by turning the variable adjustment control) before compression, an appropriate degree of suction could be applied. If full vacuum was set with the regulator variable adjustment control, a suction gradient of 200 to 300 mmHg could be maintained. However, if the vacuum regulator were turned to full the suctioned item would be exposed to the gradient of pressure from inside to outside the chamber, which is much too high for patient use.

This system has been used at our center to provide continuous or intermittent suction to NG tubes, to suction surgical drains, and to provide oral suction for a cooperative patient who had difficulty swallowing her own secretions. We have not yet had the opportunity to use this suction unit with chest tubes but have no reason to believe it would not function adequately.

Discussion

This system of providing suction to patients treated within a monoplace hyperbaric chamber is appealing because it uses a standard hospital vacuum regulator and easily mounts in the monoplace chamber hatch.

The need to provide suction to patients will increase as HBO therapy is applied to a growing patient population with NG tubes, chest tubes, and surgical drains.

Several points deserve emphasis. First, it is paramount that the vacuum regulator never be turned to the full position. This can be prevented by placing a screw in the control knob to act as a stop (Fig. 4). In the full position, the vacuum regulator exposes the suctioned item to the maximum "wall" suction which, in the case of a chamber pressurized to 2.0 to 2.8 ATA, is many times the gradient available from the usual hospital wall outlet. Next, the vacuum regulator should be adjusted to the desired level or gradient of vacuum *before* beginning treatment. This can be accomplished by connecting the outside hatch 3-way stopcock (open position) to the hospital wall vacuum

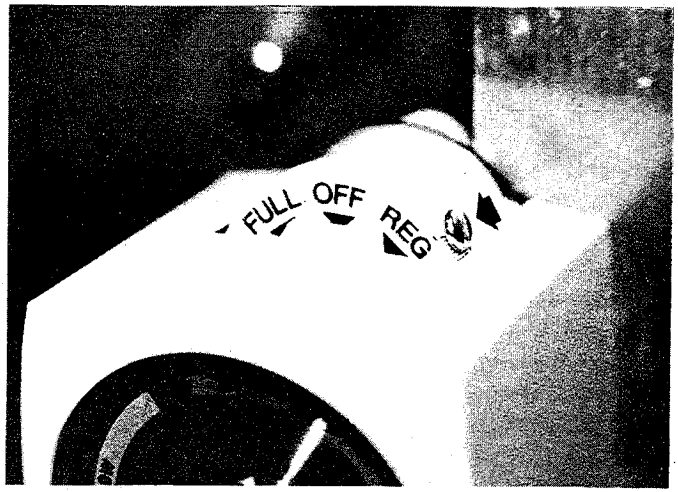

FIG. 4—Screw (*arrowhead*) placed into the Ohio vacuum on-off control for a safety feature that prevents the regulator from being turned to full on (*see* Discussion).

by a vacuum hose made especially for this purpose. Then the vacuum regulator may be adjusted by turning the adjustment knob the appropriate amount. When the chamber is pressurized to the desired treatment level, the vacuum regulator can be turned on and off by turning the 3-way stopcock located outside the chamber hatch, and can be adjusted to any value between on and off by putting the handle of the 3-way stopcock in a position midway between on and off. The degree of vacuum can be read off the dial of the vacuum regulator located in the chamber.

If the patient requires suction continuously (before the chamber is pressurized), the outside hatch stopcock is positioned to the open position and the open lumen connected to a vacuum regulator powered by the hospital vacuum source. This places two vacuum regulators in series and works quite well. Once the chamber is pressurized to >5 psi, the wall vacuum regulator may be turned off because there is now an adequate gradient available to drive the vacuum regulator located inside the chamber (e.g., a patient has a tube thoracostomy and is receiving positive pressure ventilation, has adult respiratory distress syndrome with a reduced thoracic compliance, and may reaccumulate a pneumothorax unless continuous suction can be provided).

It is expected that O_2 will escape through the outside hatch 3-way stopcock when the chamber is pressurized and the stopcock is open. If the resulting sound is distracting, it can be reduced by attaching latex tubing and running it out of the chamber area or, just as simply, by connecting the tubing to the hospital wall vacuum regulator and adjusting it to low continuous suction (approximately 80 mmHg). This escaping gas originates from a bypass valve

in the vacuum regulator and does not represent the mass movement of gas from the suctioned item.

This system can be used safely if set up in the manner described and if the caution about never operating the vacuum regulator in the full on position is adhered to.

Endotracheal (ET) suction can be provided, but at an increased risk. To accomplish this, the suction catheter would have to be inserted into the ET tube and left in that position. A unit similar to the Ballard suction system (Ballard Trach Care Closed Tracheal Suction System, Ballard Medical Products, Midvale, UT) would have to be incorporated. The suction catheter would have to remain inserted through the ET tube lumen for the duration of an HBO treatment (2 to 2.5 h including compression and decompression time). Increased flow resistance would result, even with large ET tubes, resulting in the potential for auto-peep (3). This could have an adverse clinical consequence, including hemodynamic compromise, pulmonary barotrauma, and alveolar hypoventilation (with an increased risk of CNS O_2 toxicity if hypercarbia ensues) (4). Furthermore, if the vacuum regulator is inadvertently left on continuously instead of only turned on for brief durations (>15 s), the patient could experience profound hypoxemia (5, 6). It is for these reasons that ET tube suction in the monoplace chamber is not recommended.

The Sechrist 500A hyperbaric ventilator will mount on the hatch of the Sechrist 2500B monoplace chamber if configured in the manner described, with one change. The 500-cc Bird nebulizer must be removed from the side of the ventilator block, because there is inadequate space for it and the suction canister. The one-way entraining valve is then positioned there. A Bird micronebulizer (Bird, Palm Springs, CA) is placed on the top of the block, and the gas line that drove the 500-cc nebulizer plugs into the Bird micronebulizer (Fig. 3). We typically operate the ventilator without filling the nebulizer with sterile water. However, with patients who have mucus or blood in the airways or who have airflow obstruction, nebulized gas may be advantageous. Relocation of the suction canister and use of the 500-cc Bird nebulizer is then recommended.

Conclusions

A method of providing suction to patients treated in the monoplace hyperbaric chamber has been presented. An available hospital vacuum regulator is placed within the chamber and driven by the gradient of pressure provided by the pressurized chamber. Intermittent, continuous, and variable suction can be used. The vacuum regulator should never be turned to full but rather adjusted to the appropriate degree (the pre-HBO amount) before chamber pressurization. With proper configuration, the vacuum regulator, suction canister, and the Sechrist 500A ventilator can be mounted simultaneously in the chamber hatch. This system has been used to suction NG tubes, surgical

drains, and for oral suction in a cooperative patient who could not swallow. I caution against using this system with endotracheal tube suction because of potential risks to the patient, including the effects of auto-peep, alveolar hypoventilation, and the potential for severe hypoxemia if the suction were inadvertently left on continuously.

I thank C. Gregory Elliott, M.D., C. DuWayne Schmidt, M.D., and Terry Clemmer, M.D. for reviewing the manuscript. A special thanks to Keith Green and Pat Petersen for preparing the manuscript.

References

1. Myers RA. Functional hyperbaric chamber facilities. Summary of questionnaires compiled by Maryland Institute of Emergency Medical Services (MIEMSS), April 1986.
2. Weaver LK. Tycos pressure infuser: some precautions before using in the chamber. Pressure 1987; 16(6):15.
3. Pepe PE, Marini JJ. Occult positive end-expiratory pressure in mechanically ventilated patients with airflow obstruction. Am Rev Respir Dis 1982; 126:166.
4. Clark JM. Oxygen toxicity. In: Bennett PB, Elliott DH, eds. The physiology and medicine of diving, 3rd ed. pp. 229–230. London: Baillière Tindall, 1982.
5. Caldwell SL, Sullivan KN. Artificial airways. In: Burton GG, Hodgkin JE, eds. Respiratory care: a guide to clinical practice, 2nd ed. Philadelphia: JB Lippincott, 1977:519.
6. Greenway L, King J, Napoli L, et al. The effect of Ballard Closed Tracheal Suction System (BCTSS) on desaturation and saturation recovery time [Abstract]. Respir Care 1986; 31(10):988.