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Safety and Accuracy of Volumetric Infusion Pumps in a Hyperbaric Chamber

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Buck, J, Alexander J. Safety and accuracy of volumetric infusion pumps in a hyperbaric chamber. J Hyperbaric Med 1987; 2(2):93–95.—The use of a safe and accurate infusion pump is critical in a hyperbaric chamber for patients who are dependent on insulin, heparin, and powerful cardiovascular drugs. To be certain that infusion pumps performed safely and accurately, pumps and batteries were tested at 1, 3, and 6 ATA.

infusion pumps, hyperbaric chambers

Introduction

With the recent proliferation of hyperbaric chambers and treatment of critically ill patients in chambers, adaptation of equipment to chamber use is becoming increasingly important. The following study was undertaken to determine which infusion pumps would function in a hyperbaric environment, in addition to testing their accuracy under hyperbaric conditions. Thus, three infusion pumps, the 350 Controller, the 960 IMED, and the 928 IMED, were tested at 1, 3, and 6 ATA. In addition, Gates and Yuassa batteries were tested, as well as Ivex and IMED bubble-trap filters.

Methods

Tests were performed in the treatment lock of a 9 × 26-ft chamber. The equipment was set up next to a port so that direct visualization could be made during the tests. All observers were on the outside of the chamber. Fluids were colored with green food coloring to better visualize drops that were collected into graduated containers marked in 10-ml increments.

The IMED 960 was set at an infusion rate of 60 ml/h, the IMED 928 at 125 ml/h, and the 350 Controller at 20 ml/h. Separate Gates and Yuassa batteries, as well as a fuse, were exposed to observe their reactions to the increased pressure.

The chamber was subsequently pressurized to 30 fsw for 1 min, 60 fsw for 1 min, 100 fsw for 1 min, 140 fsw for 3 min, 165 fsw for 1 min, 190 fsw for 2 min, and subsequently decompressed to 165 fsw for 30 min, then to 75 fsw for 13 min, subsequently to 60 fsw for 2 h 15 min. During compression, the

temperature reached a maximum of 110°F. At the end of the exposure, the temperature had dropped to 45°F; the total time of exposure being approximately 4 h. After decompression of the chamber, the equipment was observed for signs of damage.

Results

Infusion accuracy was determined on the 3 units. The 350 Controller, which is regulated via a drip chamber, did not function after the drip chamber became filled with fluid, which occurred immediately compression began. It was thus considered to be inadequate for hyperbaric exposure.

The IMED pumps do not use a drip chamber for flow monitoring and control and thus were satisfactory. The 960 was noted to infuse within 1 ml of accuracy (at 60 ml/h); the 928 within 5 ml of accuracy throughout all exposures (125 ml/h).

The separate batteries were also examined. The exposed Gates battery separated and leakage occurred, and the Yuassa battery developed cracks in several places in its casing but did not leak fluid.

In the bubble filters used in the infusion systems, the Ivex filter was noted to trap bubbles well with no air bubbles found distal to the trap. The IMED filter, however, did allow bubbles to pass through it, and these were noted distal to the trap. It is also of note that condensation was seen in the exposed fuse.

Batteries were subsequently removed from the IMED 960 and 928 pumps. These were both Yuassa batteries, and in contradistinction to the one that was left separate; neither of the batteries in the pump units showed any defects. It is of note that these batteries are of the lead acid-starved electrolyte type.

After the initial exposures, repeat shallower exposures were done with an observer inside the chamber which was compressed to 60 fsw for 30 min and subsequently brought up to 30 fsw for 30 min. Again, the 350 Controller unit was noted to alarm secondary to loss of the air-fluid interface. However, when the observer emptied some of the fluid out of the chamber, thus reestablishing the drip monitor, the pump was noted to function but only at low infusion rates (20 ml/min) without changes at 2 ATA. At higher rates (99 ml/min), the drip chamber tended to empty, allowing the tubing to fill with air. Thus, this piece of equipment was not satisfactory for hyperbaric usage. Both the 928 and 960 IMED pumps infused rapidly, responding accurately to changes in flow rates, and no problems were noted during phases of compression or decompression. An IMED 965 was also tested to a depth of 60 fsw and functioned properly during this limited evaluation.

Conclusions

By simulating a profile that would commonly be used in the care of critically ill patients requiring intravenous infusion, it was determined that the IMED

960 and 928 performed well under these conditions. However, the battery should be checked frequently for cracks because one out of three Yuassa batteries exposed developed this problem. The 350 Controller unit was not considered to function adequately under hyperbaric conditions, mainly because of the use of a drip chamber which monitors the infusion rate and thus requires an air-fluid interface.

Testing of equipment before its use on patients in the hyperbaric environment should be done on a routine basis because equipment design is not specific for this type of use. Malfunction during actual patient care can place patients at considerable risk, both for air embolism and for marked cardiovascular instability, if powerful vasoactive or cardiotonic drugs are infused at a rapidly changing rate.