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TECHNICAL NOTE

ALTITUDE RESISTANCE OF MEDICAL SUPPLY KITS

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Abstract: High altitude parachute operations involve exposition on low atmospheric pressure not only to the paratroopers but also the equipment they carry, including medical supplies. In most cases, manufacturers are not testing their products in high altitudes or providing such information. Therefore we challenged standard medical supplies with pressure profile depicting HALO operations to check if such pressure changes could have any adverse effects on their enclosures.

No direct damage was observed amongst particular items, although one of the containers broke under the pressure of the increased cargo volume. Some long-term observations may also indicate the need for repeated tests in order to ensure material endurance after multiple exposures.

Keywords: high altitude operations, medical supplies resilience

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INTRODUCTION

Special forces units are expected to perform high altitude parachute operations either in HAHO (High Altitude High Opening) or HALO (High Altitude Low Opening) modes. The relatively high altitude of such operations (up to 10 000m) raises some justified concerns about resistance of some medical supplies containing air inside their individual enclosures. An increase in altitude and associated decrease of atmospheric pressure causes gas expansion. The majority of medical supplies are either not tested to high altitudes or manufacturer states that they are safe up to 5000ft (1524m), which is a sort of an industry standard. Existing norms for the high altitude transport pressure resilience [1,4] usually call for 1500ft/4 752m of altitude. Available literature [2,3] is also focuses on such altitudes. Therefore, we cannot be sure if altitudes involved in high altitude parachute operations will not have an adverse influence on medical supplies carried by paratroopers. NATO test procedures described in [1] in Method III call for an even higher altitude of 40 000ft, but from the standpoint of parachute operation such testing would not be practical, because of altitude limitation for humans involved in HALO and/or HAHO operations. Therefore we decided to convey our own test by repeating typical high altitude parachute drop pressure profile.

MATERIAL AND METHODS

To assess the durability of the medical components exposed to high altitudes the following materials have been examined:

- military doctor's medical backpack;
- military paramedic's medical backpack;
- military medic's medical backpack;
- vacuum-packed military dressings put in a separate container.
- plastic laboratory container with infusion liquid bottles.

The backpacks were equipped in accordance tith Polish WTT (tactical-technical requirements) specification. Out of almost 100 items of content, our main focus was concerned on those either vacuum-packed or containing air and/or liquid or electric devices. Therefore, the following items were examined very thoroughly:

1. Haemostatic dressing (hermetically sealed).
2. Abdominal dressing (hermetically sealed).
3. Expansion gauze ((hermetically sealed).
4. Sterile thoracic penetration wounds dressing (hermetically sealed).
5. Lubricant sachets (sealed).
6. Endotracheal tube (air components: pilot balloon, cuff).
7. Laryngeal tube (proximal and distal cuffs).
8. IGel.

Fig. 1. Medical equipment in a decompression chamber.

Fig. 2. Rapid Decompression Chamber.

9. Manual suction pump (air container).
10. Bag Valve Mask (air bag).
11. Cricothyrotomy device: QuickTrach (a.o. syringe).
12. Hydrogel dressing 30x40cm (packed).
13. Hydrogel dressing 10cmx40cm (packed).
14. Hydrogel bottle 120ml.
15. Disinfection swabs (sealed).
16. Pressurized fluid administration set (containers).
17. Intraosseous set (a.o. syringe, containers).
18. Sphygmomanometer (air container).
19. Stethoscope (air spaces).
20. Backpack (the container).

Additionally, we put several infusion fluid bottles/packs accompanied by a selection of various medicament vials and disinfection liquids into a separate plastic lab container and performed another HALO simulation run under the same conditions.

The described tests were performed with the use of the Rapid Decompression Chamber in the Military Institute of Aviation Medicine in Warsaw, Poland. The chamber used for the experiment is depicted in Fig. 2.

The altitude profile used was standard speed increase altitude for 10 000m, then a 4-minute stay on this altitude followed by a 50m/s freefall simulation to an altitude of 1000m and standard speed fall (10m/s) until ground level. Different vertical rates of ascent were used to achieve steady pressure changes. The study only examined the impact of changes in air pressure on temperature. The temperature range was 18-21°C, and the study did not investigate the combined effects of low pressure and temperature at an altitude of 10,000 m. The altitude vs time profile is provided in Fig. 3.

After altitude exposure, the medical supply kits used in the experiment were thoroughly examined for cracks or breakage of containers.

RESULTS

No damages in any type of medical supplies have been visually detected. Although during the high-altitude exposure we have observed significant increases in the volume of the above-listed items, none of them resulted in destruction of the medical equipment. However, the plastic lab container broke at 10 000m after 2 minutes of exposure, due to the pressure caused by increased cargo volume (mainly infusion bottles). Although in the beginning only one crack was noted, after having been removed from the shelf after several months, the item practically fell into pieces. Normally, it would experience years of shelf life without any problem.

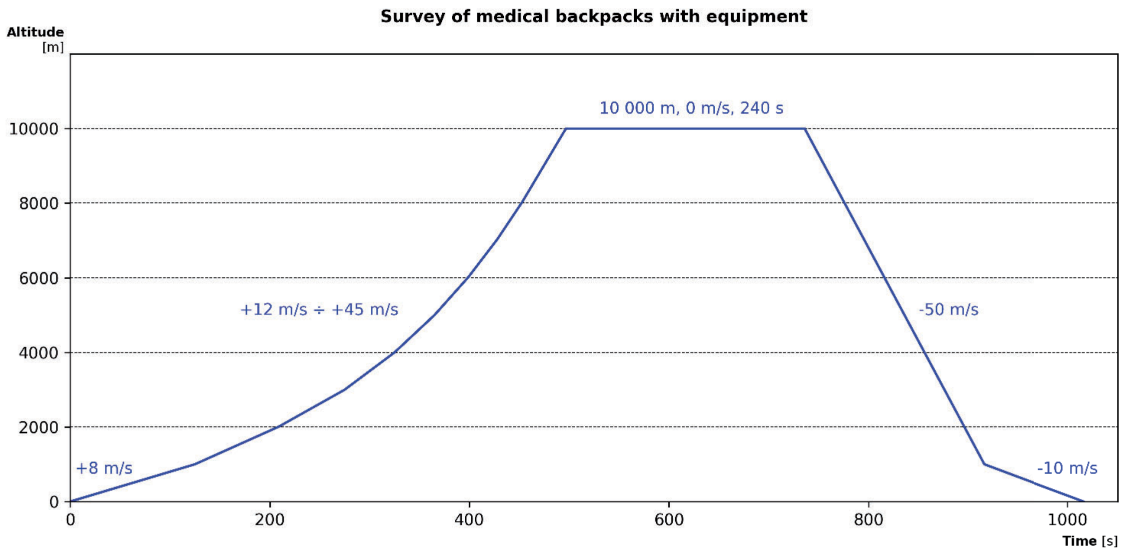

Fig. 3. Altitude vs time profile.

Fig. 4. Broken container.

DISCUSSION AND CONCLUSIONS

The medical equipment showed no damage after a single exposure to high altitude, whether it was a bottle, a vacuum-packed item or an air container. Therefore, it might be considered safe to rely on during the (mostly Special Operations Forces) mission beginning with the HALO jump.

Of course, we also proved that the medical kits involved in the experiment is compliant with both civilian norms and Method I and II described in NATO standard mentioned.

However, within 6 months after exposure, a significant breakage in the plastic lab container exposed to mid-mission rupture was observed, which may indicate the occurrence of micro-strain damages.

This, in our opinion, requires further examinations. Currently, we are conducting the study with multiple high altitude exposures applied to the medical equipment in the hypobaric chamber. Hopefully, this will answer the question: should the medical equipment used in high altitudes be, for safety reasons, treated as single-use? We should find out soon.

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AUTHORS' DECLARATION:

Study Design: Magdalena Kozak, Krzysztof Kowalczuk. **Data collection:** Magdalena Kozak, Dariusz Rękawik, Marek Kasprzak, Katarzyna Sowa. **Manuscript preparation:** Magdalena Kozak, Krzysztof Kowalczuk.

The authors declare no conflict of interest.

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