DECOMPRESSION TESTING OF AIRCREW

BY

WG. CDR. H. N. DUTTA

Assistant Professor of Pathology, AFMC

Decompression testing is a laboratory procedure in which a person is subjected to a medically controlled "altitude environment at ground level," known as the "decompression chamber" or "altitude chamber," where the ills of the flier under diminished atmospheric pressure, can be evaluated without subjecting him to the actual in-flight hazards and where accurate monitoring can be accomplished without difficulty.

The present day "decompression chamber" is a modern version of the "evacuation pump" of Robert Boyle, who in 1659 first studied the reactions of animals subjected to reduced atmospheric pressures and suggested that air contained something necessary to life which he called a "vital quintessence" and that bubble formation contributed to the animal's death [2].

Man is designed to live comfortably only in the relatively dense atmosphere near the earth. He has lived in and has become accustomed to the atmospheric pressure of 14.7 lbs. per square inch on his body since time immemorial and his whole physiological activities have been conditioned to function optimally at his environment.

Physically he is not aware of this constant outside weight or *compression* of the atmosphere. If this compression or pressure is removed, the entire structure explodes outwards. This is exactly what happens as altitude increases and the atmosphere thins out, eventually dissipating into space which has practically no weight or pressure whatsoever. This is then known as the "decompression" of atmospheric pressure. This decompression is one of the greatest hazards at high altitudes, because it is attended in human beings with a symptom-complex known as "decompression sickness" or "altitude dysbarism" or "aero-embolism" or "bends," which is thought to be due to the occurrence of bubbles in the tissues and blood stream, as a result of the barometric-pressure reduction, which allows the dissolved gas in the tissues (mainly the Nitrogen) to come out of solution. The manifestations of this "sickness" are varied and range from minor transient pains or itching to severe agony and/or collapse. But individual reactions to reduced atmospheric pressure are variable and can alter to a certain degree in one person from time to time. Other factors affecting their onset are environmental temperature, altitude of residence of the man and the amount of work he does at the reduced pressure.

Symptoms of decompression sickness do not usually occur immediately on exposure to reduced barometric pressure. Time is, therefore, an important variable. High altitude decompression sickness is not seen below 23,000 ft. (307 mm Hg) and rarely below 30,000 ft. (225 mm Hg) but it occurs at increasing frequency at greater altitudes above 30,000 ft.

The decompression test :

The actual testing of aircrew can be described under three *headings* viz :—

a) Pre-test procedure
b) The test proper
c) Post-test procedure

Pre-test procedure

It consists of a medical examination of the air-crew to exclude any pathological conditions, specially of the heart, lungs, throat and tonsils. The patency of the eustachian tubes and the appearance of the tympanic membrane are noted. The body heights and weights (without tunic and shoes) of the subjects are also recorded.

The personnel are briefed regarding the test-procedure, fitting of the helmet, oxygen mask and the oxygen supply inside the chamber. (Matches, lighters and fountain pens are to be left outside before entering the chamber).

Test-procedure in the altitude-chamber :

The main oxygen control is in the "Open" position. The first part of the ascent to 6,000 ft. and return to ground level is for checking the patency of the eustachian tubes. Any aircrew experiencing any difficulty during this preliminary test-run are excluded from the main test, the schedule of which laid down by the IAF,[3] is as follows :—

1. Climb to 6,000 ft. @ 3,000 ft/min.
2. Remain at 6,000 ft. for 1 min.
3. Descend to ground level @ 3,000 ft./min.
   Oxygen regulator turned on to "*Normal.*"
4. Climb to 20,000 ft. @ 3,000 ft/min.
   Oxygen flow turned to "*High.*"
5. Climb to 30,000 ft. @ 2,000 ft/min.
6. Climb to 37,000 ft. @ 1,000 ft/min.
7. Remain at 37,000 ft. for 5 *mins.*
8. Descend to 30,000 ft. @ 3,000 ft/min.
9. Remain at 30,000 ft. for 30 to 40 minutes.
10. Descend to ground level @ 3,000 ft/min.

During the test-proper, the occurrence of the following reactions in the aircrew calls for *immediate descent :* "chokes," neuro-circulatory failure or collapse, severe

bends, severe abdominal cramps, severe aero-dontalgia and evidence of C. N. S. involvement (i. e. nausea, vomiting, frontal headache and clouding of vision).

The rate of descent will depend on the severity of the signs and symptoms and the altitude at which they disappear on descent. Where the symptoms are such as to endanger life, descent should be very rapid ignoring ear or sinus symptoms, because a clean rupture of the ear-drum is preferable to the complications which might follow such severe reactions. The medical officer-in-charge is personally to supervise each run after satisfying himself as to the general fitness of the subjects. Usually a subject has only *one* run in the chamber. If he has no symptoms or minor symptoms only, he is *passed* fit for the duties. If the symptoms are more severe, he may be failed or the medical officer may decide that a second run (after an interval of 2 days to one week) should be given before classification or categorization.

Post-test procedure : (Observation after decompression testing)

Immediately after the run, the various symptoms and observations made during the run are cross-checked with the aircrew. Personnel are kept under observation for 2 to 4 hours after undergoing the test. During this period, pulse rate, B. P. and any subjective symptoms are recorded *every half hour*. The appearance of the tympanic membranes are also noted.

Any aircrew showing abnormal reactions during the run or during this 4 hours period of observation, are to be kept under further medical observation for at least 24 hours in the SSQrs/emergency room. During this period records are to be made of the individual's signs and symptoms especially (i) frontal headache, (ii) nausea, (iii) giddiness, (iv) mottled skin, (v) vomiting, (vi) undue apprehension, (vii) half-hourly pulse and respiratory rate, (viii) B. P. reading, (ix) urinary output, (x) E. C. G. or E. E. G. recording if available. Further investigations e. g. haematocrit findings, C. S. F. examination, serum Na and K etc., are necessary. Aircrew should also be instructed to report to the Medical officer the occurrence of any abnormal reactions appearing within 24 hours after the run.

Post-decompression shock :

This is a rare condition of neuro circulatory failure which may be encountered after any of the severe forms of decompression sickness especially after 'chokes'. It may occur without a previous history of any symptoms at altitude. Symptoms are usually observed within a period of upto 1—6 hours. Occasionally they may manifest later.

Cardinal symptoms of impending decompression shock are frontal headache, nausea, hypotension, increased pulse rate, undue apprehension and clouding of consciousness. It is akin to a surgical or traumatic shock. There is profound haemo-concentration with peripheral circulatory failure, pulmonary oedema and development of small amount of serous effusions. There is a marked rise of body temperature (105°—

106°F) and leucocytosis in this syndrome[2]. Albuminuria and oliguria have also been reported in many cases. Blood-stained semi-solid faeces may be passed very rarely by some patients. Death is usually from cardiac or respiratory failure.

The condition, if encountered, should be *treated* urgently and *energetically*. The patient is to be admitted immediately to the nearest hospital, *oxygen should be given at once*, stimulants and intravenous fluids being administered, if necessary, enroute, to maintain the volume of the circulating fluid and electrolyte balance.

Morphia and *other respiratory depressants are definitely contraindicated.*

Assessment (Classification).

The assessment of the test results is based mostly on the extent, severity and persistence of limb pains i. e. "bends" with a view to simplify interpretation of these pains they are categorized in the following manner :—

(i) *Severe* — Severe pains necessitating premature termination of the test.

(ii) *Moderate* — Persistent low grade pain throughout the test.

(iii) *Mild* — Slight pain of *limited distribution* with a tendency to diminish in extent and severity during the test.

The actual criteria for deciding whether or not a candidate passes the test are as follows :—

a) *Pass :* No symptoms or mild symptoms.

b) *Fail :* Moderate to severe "bends", "chokes," severe abdominal pain, collapse or C. N. S. involvement.

Note : As far as is known, decompression test results do not reflect the general physical fitness of a candidate or aircrew, but merely indicate that he may be at special risk, when engaged in high altitude operational flight. In the absence of other medical factors, the test cannot, and should not, therefore, be used to justify the lowering of the medical category.

Precautions for decompression testing :

There are certain precautions which have to be taken for decompression testing. These are as follows :—

Group (A) : Decompression chamber runs are *not* to be performed *within 48 hrs*, of the following :

(i) Full recovery from minor acute illness e. g. gastritis, enteritis or acute upper respiratory disorders like common cold.

(ii) Minor injury.

(iii) Inoculation by any vaccine.

(iv) Tests for susceptibility to decompression sickness or hypoxia.

Group (B): Chamber tests are *not* to be repeated on aircrew showing the following reactions :—

(i) Severe bends necessitating premature descent.

(ii) Chokes.

(iii) CNS involvement.

(iv) Neuro-circulatory collapse

(or decompression collapse or post-decompression shock).

Group (C): At anytime when a subject is in the chamber immediate *medical attention* and medical facilities must be available at hand. The medical officer in charge should have within the immediate vicinity an "*Emergency Room*" with full facilities for management of a case of chamber reaction.

Resuscitation equipment should comprise of the following :—

Bed with blankets, stethoscope, sphygmomanometer, ophthalmoscope, percussion hammer, hard-rubber oral airway, tongue forceps, sterilized syringes and needles, adrenaline, nor-adrenaline, niketha-mide, caffeine, aminophylline, atropine, sutures and needles, scalpel, forceps, portable sterilizer, sterile gauze and sponges, tincture iodine, intravenous fluids (plasma, dextran and 5% glucose solution) and transfusion sets, instrument pack for treating cardial arrest by cardiac massage.

Recompression Chamber

This can be used for treatment of a severe case of post decompression shock if facilities are available.

Value of decompression testing

This can be described under *four* broad headings :—

1. Selection
2. Training
3. Diagnostic Aid
4. Research.

1. Selection of Aircrew

The decompression testing aids in the selection of "bend-resistant" personnel for high altitude flying i. e., persons who will be able to withstand the effects of low barometric pressures, with particular reference to the development of symptoms of

aero-embolism. Susceptibles or unsuitable personnel can thus be eliminated at the recruiting or training stage.

The tests have revealed that younger the individual the less susceptible he is to "bends" and fat individuals and persons of older group are generally prone to "bends" [2].

Veteran pilots with their valuable experience are not to be judged incapable of flying at high altitude but are to be considered *less* suitable for a high altitude flying career in a modern jet fighter aircraft.

Decompression testing is, therefore, a practical compromise solution of the high altitude problem, where the use of selected personnel has shown that such men can function efficiently for several hours at very high altitudes.

2. Training of Aircrew

The decompression chamber has been used in the training of airmen since Paul Bert trained Tissandier and his companions prior to their ill fated balloon flight in 1875.

Just as primary training in stick-rudder-throttle technique is essential to pilot, so also the primary training in oxygen technique is essential to the high altitude crew. Hence the decompression chamber is used nowadays in the education of the aircrew in the effects of reduced barometric pressure, specially the importance of oxygen at high altitudes and the symptoms of acute *hypoxia*, because it is an important and continuing threat to flight safety and crew effectiveness.

It is also used at the same time to indoctrinate high altitude fliers in the correct use of oxygen equipment or any other special equipment that may be necessary to combat these effects e. g. demonstrations to the aircrew of the effectiveness of pressure breathing and pressurized clothing, such as pressure jerkins and pressure suits, following loss of cabin pressure as in explosive decompression.

Training is necessary to prevent *hyperventilation*, because the difficult part of partial pressure suit indoctrination is learning to breathe properly at high mask pressure. Considerable practice is necessary in order to learn the reversal of the active and passive phase of respiration and to regulate the rate to 6 to 7 respirations per minute. There is a universal tendency to breathe too rapidly i.e., to hyperventilate at altitude or when pressure breathing, specially in apprehensive individuals. The decompression testing thus enables aircrew to receive practical training in pressure breathing equipment, following simulation of a failure of the aircraft pressure cabin. It also allows experience of hypoxia and the testing of oxygen equipment and tolerance to high altitude as well.

3. Diagnostic Aid

The decompression chamber can be used to aid diagnosis as it becomes more readily available and as clinicians become more familiar with its potentialities. Its use has been aptly demonstrated by Berry and King[1] in aircrew patients of the USAF, with ENT problems, head injuries, spontaneous pneumothorax or pulmonary blebs, pulmonary resection, hypoxia, hyperventilation, cardiac problems and chamber reactions. In all these problem cases each "flight" was tailored to the individual case and closely simulated the actual conditions surrounding the referred incident.

Thus, the chamber test can be used as another diagnostic tool for the disposal of problem aero-medical cases.

4. Research

Finally, decompression testing of aircrew can be extended to its use as a research tool for better understanding of the bio-physico-chemical changes occurring at the cellular level e.g. the life-span of the erythrocytes in high altitude fliers, whether it is decreased or increased, the effect of hypoxia on the leucocytes and the immunological process, the effect of hypoxia on blood lipids in man, the effect of hypoxia on taste and smell[4] and on the fibrinolytic activity of the blood at high altitude. These are some of the few important problems in medicine, on which there is very little information available at the moment.

There may also be other justifications for both fundamental and applied research aimed at a better understanding of human performance capabilities and limitations and at improving the design and reliability of the equipment that is essential to flying safety and aircrew effectiveness.

Summary

1. The nature and procedure for decompression testing of aircrew and the precautions to be taken for chamber runs have been described.

2. The importance of decompression testing of aircrew in selection, training and education in flight physiology and protective equipment as well as an aid to diagnosis and future research has been briefly recorded.

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