same site.[98] The reason for this delay in recovery is the same as in diving and caisson recompression: that is, the re-solution of bubbles is slowed down in direct proportion to their loss of surface by compression.[104] For all practical purposes, recompression and not resaturation is the important factor in relief from decompression sickness per se, but elimination of the hypoxic effects depends upon resaturation of the blood with oxygen, which is of course rapidly effected.

2. Mechanical Effects of Recompression

The mechanical effects of recompression are as hazardous as under similar conditions in work at positive pressures. The patency of the eustachean openings and those of the several sinuses must be assured in order to prevent the injection of blood into the capillary bed of the mucosa lining the various cavities in question. As stated earlier,[105] the pressure necessary to rupture the capillary walls is quickly attained in descent, and damage ranging from petechial to massive hemorrhage has been observed regularly in individuals who have difficulty in clearing these passages.[98, 103]

During descent from altitudes at which oxygen must be used there is incurred a condition that is called "delayed acute aero-otitis media." It results from the charging of the middle ear with a high percentage of oxygen that is subsequently lost by absorption into the blood. If the nitrogen influx is not maintained at a proper rate, and it seems usually not to be unless the eustachean passage is intermittently opened, then a negative pressure develops in the middle ear, sealing the eustachean opening and eventually causing a varying degree of pain and discomfort, especially in individuals who are asleep. Practical prophylaxis has been shown by Bowen[106] to consist in removing the oxygen mask at air-breathing levels during descent, and prior to this, if feasible, ventilating the ear and sinuses with air during a "stage" descent, while interspersing oxygen breathing during halts at each stage. When difficulties of this nature arise in indoctrination and altitude-chamber work a more radical procedure can be applied. In this instance descent is made with air from even the highest levels since the time for descent can be made so short that supplementary oxygen need not be used. The ability to open the eustachean tubes must be assured before such maneuvers are attempted, yet it is surprising that with such rapid descent individuals having some difficulty at ordinary rates of descent will find less difficulty, presumably due to the continuous flow of gas into the ear.

3. Rate of Recompression

The rate of descent that can be effected is limited mainly by the several unquantitative variables and idiosyncrasies of sinus and ear ventilation, as suggested above and as described for divers and caisson workers. Recompression from 30,000

[104] J. B. H. Kuper, *Rept., Aviation Medicine Unit, Ind. Hyg. Research Lab., Natl. Inst. Health*, Bethesda, Md. (1942).

[105] C. L. Evans, *Starling's Principles of Human Physiology*. 8th ed., Lea and Febiger, Philadelphia, 1941.

ft. and above has been effected in the space of a minute routinely in the course of experimental work[106] without any untoward effect. With these rates of descent the compressional inflow effects described by Bean[92] should be apparent subjectively as well as objectively, yet no mention is made in the literature of such effects on descent from high altitudes. In a preliminary trial, continuous gas analysis of respired air indicated temporary carbon dioxide retention during rapid descent with a corresponding excess for several minutes following descent. The respiratory rate also showed an increment in the period immediately following the descent.[107] The data from experiments and experience with free fall in parachuting[98] indicate that mechanical effects are the only restricting factors in rapid descent. It is, of course, necessary to take into account the absolute pressure as well as the rate of descent because of the interval in which respirable air must be available. This is a real difficulty in parachuting from great heights because even in free fall the rate of descent is slow enough so that hypoxia may develop when an individual is jumping from 40,000 ft. About 2½ minutes elapse in free fall from this altitude, and an open chute descent would take 24½ minutes. Free fall is the method of choice until at least half an atmosphere of pressure is attained, not only from the point of view of avoiding hypoxia but also because of the excessively low temperatures at these heights.[98]

D. COMPARISON OF EFFECTS OF HIGH AND LOW ATMOSPHERIC PRESSURE

In the introduction to this chapter it was pointed out that the effects of barometric changes differed qualitatively as well as quantitatively in the ranges of absolute pressure above and below standard atmospheric pressure. The similarities and differences have been noted in the several sections. In the following lines a brief statement is made of the similarities and differences of effects on the physiology of normal individuals. The clinical and pathological features must be largely inferred from their physiological basis, and further detail should be sought in the several competent reviews, both classical and current, that are cited in the list of references.

The mechanical effect of pressure change on the ear and sinuses is qualitatively similar for both low-pressure and high-pressure atmospheres. The principal effect occurs on increase of pressure when for some reason pressure equalization by passage of air into the lumens cannot be effected. The main result is displacement of blood from the body into the capillary system of the tissues lining these cavities, with hemorrhage into the lumen. In the case of the middle ear, bursting of the drum also may result. A fall in pressure is usually not attended by severe effects but may result in driving blood out of the tissues within the cavity and forcing the ear drum outward. The construction of the normal passages connecting these structures with the exterior is mechanically adapted to relieve internal pressure readily.

[106] W. J. Bowen, *U. S. Naval Med. Bull.*, **44**, 247 (1944).

[107] Unpublished current work by the Aviation Medicine Unit, Ind. Hyg. Research Lab., Natl. Inst. Health, Bethesda, Md.