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Hypothermia and the Inhalation Therapist

by **William F. Donohue**

PART I

Hypothermia Owes Its Success To Lowered Oxygen Consumption

Across the nation an increasing number of inhalation therapists are treating patients who are being medically managed with the aid of modern hypo-hyperthermia equipment. In some hospitals, these machines are under the jurisdiction of the inhalation therapy department. Regardless of whether or not the inhalation therapist is responsible for this expensive piece of equipment, it behooves him to be aware of certain physiological changes which occur when it is employed to lower body temperature. Since this equipment is used mainly for cardiovascular surgery and neurosurgical patients, a basic knowledge of the theory behind the use of hypothermia will give us a wider background of knowledge concerning these patients.

The fundamental and most important effect of hypothermia is a decrease in the rate of all metabolic processes, with the quality of metabolic processes affected by marked reduction in general body temperature. Just as there is a range of temperatures, within the human body, there is also a range of temperatures between individuals; this range is approximately from 97° to over 99°F., and varies with such factors as exercise and environmental temperature. Body temperature remains fairly constant as long as heat production of the body equals heat loss. A decrease of body temperature occurs because heat loss is greater than the rate of heat production, heat being dissipated from the body by the processes of radiation, evaporation, and conduction.

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It is believed that the therapeutic use of cold was first discovered by inhabitants of colder climates and that possibly it was the first effective treatment for pain. The use of ice and snow therapeutically were recorded as far back as the eleventh century. Cold, as an adjunct in surgical amputations, is recorded in the sixteenth century. Baron Larrey, Napoleon's surgeon, rediscovered the value of lowered body temperature in surgical procedures during the French Army retreat from Moscow. In the nineteenth century, also, Bright used cold for its local anesthetic effects, considering the use of cold superior to narcotics, such as opium and morphine sulfate.

In the late 1930's, the work of Allen, as well as Fay and Henry, gave considerable impetus to hypothermia as a medical treatment. Limited knowledge of the physiology of hypothermia delayed its acceptance by the medical profession. Bigelow and his associates in 1950 provided some of the necessary physiological experimentation which hitherto had been lacking. One of their studies demonstrated that oxygen consumption was decreased during cooling and increased during rewarming. Bigelow discovered that circulation could be stopped for 15 minutes allowing the heart to be opened with complete recovery. Thus, Bigelow first suggested the use of hypothermia for cardiac surgery.

Swan has reported the use of hypothermia with 24 patients who underwent standard closed cardiac operations and 8 patients who underwent open-heart operative procedures. The patients in this study were deliberately hyperventilated throughout their operative procedure so that a state of mild respiratory alkalosis was maintained. Swan believes that ventricular fibrillation was avoided by keeping blood pH up by this technique.

Hypothermia was first applied to patients having neurosurgery about 1953 to improve conditions during surgery. Since this time, it has been used extensively both during neurosurgery and for the treatment of patients with severe neurological lesions. According to Batterell, and Lougheed, the advantages of hypothermia "in the surgical management of recently ruptured intracranial aneurysms include reduction of the oxygen demand of the brain and prevention of future cerebral damage from anoxia secondary to spasm of the affected artery." These investigators could attribute no cerebral dysfunction to the use of hypothermia.

Further review of the literature relative to hypothermia in neurosurgery reveals that reduction of body temperature lowers cerebral oxygen consumption and reduces brain blood flow. Hypothermia decreases the brain volume and lessens edema due to surgical trauma. Dangers of hypothermia with neurosurgical patients include "masking of infection either intracranially or extracranially, and masking of the signs of cerebral compression." Since pulmonary infections may also be masked, special attention must be paid to the chest.

External methods of inducing hypothermia include ice or cold water baths, ice bags, and cooling blankets which circulate cold water through their coils. The cold water bath is essentially a tub filled with water and crushed ice at a temperature of approximately 50°F. Cooling occurs quite rapidly because of the uniform distribution of cold over the body. With the ice bag method, in which the bags are distributed over the trunk and the inner and outer surfaces of the extremities, it is difficult to maintain the desired degree of hypothermia because the temperature of ice bags cannot be controlled. When the ice bags are removed, there may be an additional temperature drift downward if wet sheets are not removed from the bed.

When using cooling blankets, the circulating cold water containing anti-freeze solution is usually several degrees above the freezing point of water. In addition to inducing and maintaining hypothermia, these blankets may be used to restore the temperature to normal levels by altering the temperature regulating gauge so that the circulating solution is warmed. Skin burns may occur if the circulating solution is either too warm or too cold.

PART II

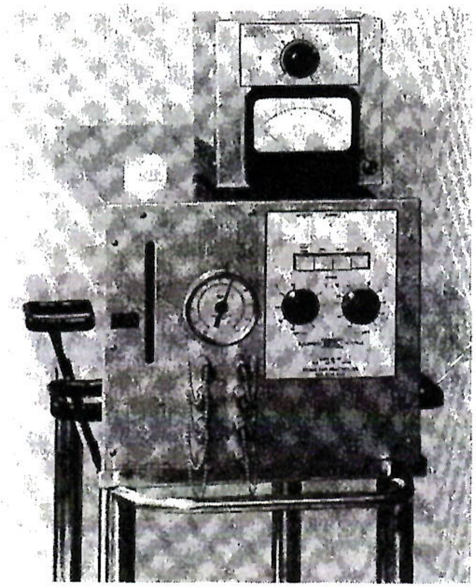
Vital Signs Of Hypothermic Patient Must Be Carefully Monitored.

Rewarming the patient following hypothermia may be accomplished by: (1) immersion in tepid or warm water; (2) application of warm water bags or blankets; (3) use of diathermia; and (4) natural rewarming by air with or without a heat cradle. A transitory fall in rectal temperature has been observed during the rewarming period when external methods are used to induce and maintain hypothermia. During rewarming by the external methods, skin temperature rises rapidly and peripheral blood flow through the muscles and the superficial areas of the body is increased.

Blood temperature, as it passes through these superficial areas, initially falls because of the coolness in these areas. Therefore, the temperature of venous blood returning to the heart is reduced, and this produces a drop in cardiac temperature. This transitory drop in cardiac temperature slows the heart further and reduces cardiac output, and may lead to cardiac arrest or ventricular fibrillation.

Shivering in patients cooled by external methods represents the body's attempts to restore homeostasis and conserve body heat. It is characterized by peripheral vasoconstriction, during which the rate of heat production may increase to 400% above normal. Sustained shivering is accompanied by an increase in temperature, circulation rate, and oxygen consumption. Thus, the purpose for which hypothermia was initiated is defeated and may cause additional injury to the patient. Shivering, which usually ceases at rectal temperatures of approximately 92° to 86° F., is followed by persistent muscular rigidity. Shivering will become evident again as the patient reaches these temperatures during the rewarming period.

Research on the effects of hypothermia on the heart rate and blood pressure indicate a fall of both of these during treatment. There is, however, a marked peripheral vasoconstriction when hypothermia is initiated which causes a transitory rise in both heart rate and blood pressure. During this period of transitory increase, the rectal temperature does not begin to drop. Patients must be observed during the induction of hypothermia for an increased apical rate and an elevation in the blood pressure. The therapist can expect both of these to be elevated for a period of 10-20 minutes. Any elevation beyond 20 minutes as a maximum should be reported, as this may be indicative of increased intracranial pressure. As the treatment is continued or intensified, the rectal temperature begins to fall accompanied by a slowing of the heart beat and a decrease in blood pressure, usually from a reduction in all metabolic processes. As the temperature begins to fall, the heart rate becomes slower and arrhythmias may occur. Auricular fibrillation is common at body temperatures of 86°F. When rectal temperatures reach 78°F., the blood pressure may fall precipitously accompanied by ventricular fibrillation and cardiac arrest. Thus, the rate and character of the pulse and the rate and character of the apical heart rate become important indicators of cardiovascular functioning and should be accurately described and recorded.



An example of the refrigerated blanket type hypothermia apparatus.

Photo courtesy Gorman-Rupp Industries, Bellville, Ohio

It is important to remember that slowing of heart rate, and consequently pulse beat, occur with increased intracranial pressure, as well as hypothermia. The important distinction to be made is that both the blood pressure and the pulse rate decrease simultaneously with hypothermia, while with the increased intracranial pressure, the blood pressure is increased and the pulse rate is decreased or decreasing.

The therapist must observe the depth, character, and rate of respiration plus the color of the patient for pallor or cyanosis indicative of insufficient respiratory exchange of gases. Positioning in bed is very important in the case of neurosurgical patients in hypothermia because of the reduced levels of consciousness and the inability to expectorate mucus, which may lead to pulmonary complications. Since these complications may be masked, frequent suctioning is necessary. In addition, these patients should be turned frequently to permit further maintenance of respiratory functioning.

The therapist should remember that the degree of hearing in these patients is not known. Therefore, talking about the patient near his bed should be avoided and explanations of treatments should be offered.

In most hospitalized patients, an oral or rectal temperature will supply adequate information relevant to the course of disease. In hypothermia, as cooling proceeds, there has to be a reasonably reliable index of heart temperature because it is the temperature of this organ which will largely determine the onset of ventricular fibrillation. During cardiovascular and neurosurgical operative procedures, the temperature is often monitored with the aid of an esophageal thermometer. It has been demonstrated that a rapid change in esophageal temperature can be induced by the rapid transfusion of cold blood.

As far as oxygen is concerned, the important question is whether the oxygen available to the tissues is adequate to meet their demands. Effective oxygen transport depends upon adequate pulmonary ventilation, the transfer of oxygen across the lung capillaries, the capillary blood flow in the tissues, the dissociation of hemoglobin, the tissue partial pressure of oxygen, and an adequate activity of the tissue oxidative enzyme.

During surgical hypothermia, the transfer of oxygen across the pulmonary capillaries is controlled without difficulty by the anesthesiologist. The situation may be reversed, however, when the patient is returned to the ward and still having his temperature regulated via hypothermia. It is for this reason that the inhalation therapist is frequently called to minister to these patients. Further, there is a tendency towards retention of CO_2 at low temperatures, and this is governed by the increase in carbon dioxide solubility and the inadequacy of spontaneous ventilation. It is because of this that the therapist usually has orders to administer frequent I.P.P.B. treatments to these patients.

The hypothermic heart seems especially sensitive to a low pH, which may increase its irritability and the tendency to ventricular fibrillation. In 1953, Swan et al suggested this factor in their course of studies on the metabolic problems of hypothermia. Since then, it has been customary for physicians to advise moderate over-ventilation with the object of raising the blood pH and lowering pCO_2. The inhalation therapist should remember, when administering positive pressure, that hyperventilation must not be overdone because at low temperatures less CO_2 is produced than normally, so that it is rather easy to lower pCO_2 excessively.

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