

POSTOPERATIVE TEMPERATURE CHANGES

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In the recovery room it is habitual to record the pulse rate, blood pressure and respiratory rate at regular intervals, to estimate the state of oxygenation by the color of the patient and to determine the rate of returning consciousness, to administer parenteral fluids and oxygen as required, and to measure fluid output from drainage catheters, and chest catheters. Vigorous measures are taken to promote a stir-up regime, aspirate secretions from the respiratory tract, and preserve adequate respiratory exchange, while at the same time making the patient as comfortable as the above prerequisites permit.

Often, in the postoperative period, the patient may remain lethargic even though the effects of the anesthetic drugs appear to have worn off. It may be difficult to obtain blood pressure recordings by means of the sphygmomanometer and the peripheral pulses may be difficult to palpate, with perhaps the pulsations of the carotid artery are full and bounding. The nail beds of the fingers and toes may be distinctly cyanotic, with perhaps the lips sharing in the dusky hue, though the functions of the respiratory and cardiovascular systems belie the presence of profound hypoxia. Or, more obviously, the patient will complain of being cold and will manifest gross shivering.

On the other hand, an increased respiratory rate associated with tachycardia and a flushing of the skin may be present. If persistent, these signs may be followed by profuse sweating, or twitching may supervene.

An explanation for these diverse signs and symptoms may be found by determining the body temperature of the patient. In the postoperative patient a recording from the rectum is more representative of body temperature than one recorded from the mouth, and it is considerably easier to obtain under normal circumstances than one recorded from the esophagus. If a body temperature alteration

has resulted primarily from surface temperature changes, the rectal temperature will differ little from the esophageal.

HEAT REGULATION

There is reason to believe that in the modern hospital the body temperature of patients having recently undergone operation may be altered frequently. To understand the factors involved, it should be recalled first that man has a most efficient homeostatic mechanism of body temperature regulation under normal circumstances. Heat produced within the body is dissipated chiefly through the respiratory tract by warming inspired air and by evaporation, and through the skin by radiation, conduction and convection, and by insensible water loss. There are fine and coarse mechanisms which can be called upon to maintain body temperature. Variations in skin blood-flow provide the finer adjustments—the cutaneous vessels dilate in warm environments and constrict in cool environments. In extremes of heat man reacts by sweating, and in cool atmospheres gross shivering occurs. Both the fine and coarse mechanisms in man are regulated reflexly through the nervous system and require the integrity of the central nervous system up to and including much of the hypothalamus.

The reflex arc may be as follows: thermal receptors in the skin provide afferent stimuli which flow to a central receptor area or areas, probably located in the hypothalamus;¹ this central receptor area probably is also responsive directly to changes in blood temperature in the order of 0.2 degree centigrade;² efferent arcs regulate shivering through the motor nerves and cutaneous vasoactivity and sweating through sympathetic fibers.

EFFECT OF ANESTHESIA

Anesthesia depresses and renders inefficient the temperature regulating mechanisms of the body.^{2,3} It is not known whether this action

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occurs as a result of suppression only of reflex mechanisms, or whether the central receptor area is affected also. Not only are the fine and coarse reflex actions which preserve the *milieu interieur* impeded, but spinal analgesia and general anesthesia produce extensive peripheral vasodilatation, measurable by the increases in skin temperature.⁴ This peripheral vasodilatation is conducive to the loss of heat if the ambient temperature surrounding the patient is reduced. Certain techniques employed in anesthesia—the nonbreathing and semiclosed—will increase the loss of heat from the body, whereas the closed technique will act to retain heat.⁵ With any technique of anesthesia, the normal mechanisms for losing heat through the skin and respiratory tract, and which compensate for normal heat production, are altered one way or another. The net result of the anesthetic state is that the temperature regulating mechanisms are held in abeyance so that the patient tends to become poikilothermic and at the mercy of environmental temperatures and other heat-altering mechanisms to which he may be exposed. The smaller the patient, the less is the total body mass and the greater the relative surface area, so that small subjects are prone to more frequent and extensive body temperature changes under anesthesia.^{3, 6} Because the temperature regulating mechanisms are obtunded and interfered with during anesthesia, body temperature alterations may persist into the postoperative period.

FACTORS INDUCING HYPERTHERMIA

Prior to the advent of air conditioning, operating rooms, particularly in the summer months, would have a high ambient temperature and high humidity, with the result that body temperature would increase during operation.⁷ Moreover, the application of heavy drapes would limit the potential loss of heat through conduction and convection. The operating room lights would radiate heat directly to the patient, increasing the tendency towards heat retention, and the closed systems of administering anesthesia would favor an increase in body temperature. Under extreme

circumstances compensatory sweating would occur, but only when the body temperature was elevated markedly. Frequently patients, and particularly children, would be admitted to the recovery room or return to the ward with all the stigmata of hyperthermia.

FACTORS INDUCING HYPOTHERMIA

Within recent years the situation described above has changed markedly. With the almost universal introduction of air conditioning into operating rooms, and with the need for surgeons and other operating room personnel who are heavily gowned to work in comfort, operating rooms are maintained at a relatively low ambient temperature of 68 to 72 F. The situation has become reversed for the patient: today he is exposed to ambient temperatures which favor the loss of body heat. Moreover, operating room lights are now constructed so that they do not radiate heat: and more and more semiclosed or nonbreathing techniques of anesthesia are being employed. In addition, major operations with body cavities exposed to the low ambient temperatures are going on for longer periods of time. Whole blood, which often comes directly from a refrigerator at 4 C., is being administered with greater frequency (500 ml. of cold blood administered over a period of 5 to 10 minutes will reduce body temperature an average of 0.5 to 1.0 degrees centigrade). Frequently body cavities, e.g., bladder, are exposed to cold irrigating solutions on repeated occasions. Over and above these situations, an increasing number of patients are being subjected purposefully to varying reductions of body temperature in the operating room to facilitate surgical procedures. The net result is that patients are returning to the recovery room with body temperatures below normal. In one average operating day recently, 15 consecutive patients between the ages of 6 months and 67 years returned from the operating rooms at Duke Hospital with rectal temperatures ranging between 33.8 C. and 36.5 C. (93.0 F. and 98.2 F.). These reductions in body temperature depend on numerous factors, but are more prone to be seen in infants and the geriatric patient.^{3, 4, 8}

POSTOPERATIVE CARE

Perhaps the most significant point about postoperative temperature changes is to recognize their presence: this demands the institution of techniques, intermittent or continuous utilizing a thermistor and recorder, whereby the body temperature of patients can be monitored. Knowledge that the body temperature is altered often will explain physiologic abnormalities that are present, such as a slow respiratory rate, cyanosis of the extremities, difficulty in obtaining the blood pressure, bradycardia, lethargy, and so on, and will permit corrective measures to be taken.

The question arises as to the significance which should be attached to hypothermia or hyperthermia in the postanesthetic period. Hyperthermia seldom is seen in the present-day recovery room. It may develop over a period of hours when massive areas of infection have been stirred up by operative intervention, it may follow certain intracranial procedures, and it may develop following episodes of severe hypoxia. Rarely, it may be associated with a delayed allergic or pyrogenic reaction to a blood transfusion or drug administration. As the patient recovers from anesthesia, the shivering of a "chill" may be associated with a rise in temperature, and it is important to differentiate this reaction from the shivering which accompanies the efforts of the patient to combat the presence of hypothermia. The recognition of a progressive rise in body temperature is important so that appropriate countermeasures may be taken if desired.

Much more common in the present recovery room is the patient with hypothermia. What is seen in the recovery room are manifestations of the rewarming phenomenon. As the patient recovers from anesthesia, the homeostatic mechanisms which have been held in subjection reassert themselves. There is no evidence to suggest that basic metabolic functions which have been altered by the initiation of hypothermia do not return to normal during the rewarming period. Animal experiments have shown that rewarming after two to 12 hours of hypothermia is not associated with significant changes in electrolytes, acid-base balance, blood sugar and amino acids, or the

lactic/pyruvate ratio.⁹ Urinary function, which may be impeded during hypothermia, returns to 75 per cent of control levels during the rewarming period, and completely to normal within 24 hours.¹⁰

However, certain factors may be of importance in the rewarming period. The first of these is the ability of the patient himself to institute rewarming. There is evidence that the newborn, and indeed infants under 6 months of age, have poorly developed mechanisms for initiating rewarming.¹¹ Not only are they prone to lose heat, but they usually require a warm environment to regain it. There is also danger in allowing the body temperature of an infant to remain below 34 C. (93.2 F.) for a prolonged period. The syndrome known as sclerema may develop and progress to an irreversible outcome.^{6, 11} Therefore, when moderate hypothermia is present in an infant postoperatively, active measures to combat it should be undertaken. A warm atmosphere approaching body temperature with a high humidity⁹ should be made available. An Isolette will provide these features, although if the patient has received ethyl ether, care should be taken to make certain that breakdown products of this drug do not accumulate in the apparatus due to exposure to the hot metal heating element.¹²

In older children and adults, hypothermia usually induces peripheral vasoconstriction and varying degrees of shivering during recovery from anesthesia. It has been suggested that patients who have received thiopental are more prone to develop active shivering movements, and that perhaps suppression of adrenal function may be the etiologic factor.¹³ Support for this thesis is gained from the fact that shivering movements are also common following halothane anesthesia, during which adrenal function is not stimulated. However, the ability of the patient to shiver rests more likely with the alacrity with which reflex functions are restored and the necessity of the patient to utilize them.

The act of shivering is undesirable in some patients because oxygen utilization (and therefore demand) is increased greatly. In postoperative patients in whom respiratory or cardiac reserve is low, shivering can place a

dangerous burden on the organs responsible for preserving physiologic function. It is wise to administer oxygen to all such patients. The shivering itself sometimes can be minimized by placing several warm blankets in close contact with the patient.

The peripheral vasoconstriction which accompanies the patient's efforts to rewarm himself may produce a cyanosis of the nailbeds and sometimes of the lips and ears. Due to the reduced peripheral circulation, a capillary stagnation occurs and unoxygenated blood collects in these areas. Brisk rubbing of the extremities will cause a reduction of the cyanosis and permit a differentiation between this condition and that due to generalized hypoxia. As the patient warms, the nailbeds become more normal in color.

As the patient's temperature returns towards normal, the reflex peripheral vasoconstriction becomes less marked. At this time the systolic blood pressure may be reduced to relatively dangerous levels. This phenomenon has been called "rewarming shock."¹⁴ Under these circumstances the capacity of the circulating bed has increased, so that what was a satisfactory blood volume to maintain an adequate blood pressure has now become less than adequate. As patients are being rewarmed postoperatively, the possibility of this situation arising should be kept in mind, and whole blood administered to combat the deficit.

Occasionally, as a patient is rewarming himself, an overshoot may occur and the body temperature may become elevated beyond the normal. The importance of this is in its recognition, so that efforts to promote warming are not carried on indefinitely.

The purposeful initiation of hypothermia in the postoperative period may be difficult if the homeostatic mechanisms to preserve body temperature are active at the time the decision is made to reduce body temperature. The postoperative patient who has recovered from anesthesia will resist attempts to reduce his body temperature by violent shivering. The administration of chlorpromazine will reduce the shivering reflex to some extent, but it is difficult to prevent shivering until the body temperature has fallen below 34 to 33 C. (93.2 to 91.5 F.). It is suggested that, if

it is believed desirable to maintain a state of hypothermia in the patient postoperatively, this decision be made and implemented while the patient is still anesthetized so that the body temperature reduction may be accomplished while the compensatory reflex mechanisms are still in abeyance. If the body temperature is maintained below 34 C. (93.2 F.) in the postoperative period, shivering will not be a serious complication.

SUMMARY

Postoperative temperature changes are prone to occur in patients because the normal homeostatic mechanisms which preserve the constancy of body temperature are inactivated by anesthesia. Moreover, anesthesia produces peripheral vasodilatation, so that in today's air-conditioned, cool operating rooms the patient is likely to lose body heat. As a result of these and other factors, a majority of patients have a reduced body temperature in the postanesthetic period. Recognition of this state is important so that compensatory measures may be taken when required, and so that certain signs and symptoms associated with hypothermia may be recognized for what they are.

REFERENCES

1. Burton, A. C., and Edholm, O. G.: Man in a Cold Environment. Baltimore, Williams & Wilkins, 1955.
2. Pickering, G.: Regulation of body temperature in health and disease, *Lancet* 1: 1, 1958.
3. Harrison, G. C., Bull, A. B., and Schmidt, H. J.: Temperature changes in children during general anaesthesia, *Brit. J. Anaesth.* 32: 60, 1960.
4. Foregger, R.: Surface temperatures during anaesthesia, *ANESTHESIOLOGY* 4: 392, 1943.
5. Clark, R. E., Orkin, L. R., and Roventine, E. A.: Body temperature studies in anesthetized man; effect of environmental temperature, humidity, and anesthesia system. *J. A. M. A.*, 154: 311, 1954.
6. Stephen, C. R., Dent, S. J., Hall, K. D., Knox, P. R., and North, W. C.: Body temperature regulation during anaesthesia in infants and children, *J. A. M. A.* 174: 1579, 1960.
7. Bigler, J. A., and McQuiston, W. O.: Body temperatures during anaesthesia in infants and children, *J. A. M. A.* 146: 551, 1951.
8. France, G. C.: Hypothermia in newborn: body temperatures following anaesthesia, *Brit. J. Anaesth.* 29: 390, 1957.

9. Fisher, B., Fedor, E. J., and Lee, S. H.: Re-warming following hypothermia of two to twelve hours; some metabolic effects, *Ann. Surg.* 148: 32, 1958.
10. Moyer, J. H., Morris, G., and De Bakey, M. E.: Hypothermia; effect on renal hemodynamics and on excretion of water and electrolytes in dog and man, *Ann. Surg.* 145: 26, 1957.
11. Bower, B. D., Jones, L. F., and Weeks, M. M.: Cold injury in newborn: study of 70 cases, *Brit. Med. J.* 1: 303, 1960.
12. Mendenhall, M. K., Jenicek, J. A., and Bryant, J. M.: Thermal decomposition of ether in infant incubator, *J. A. M. A.* 173: 651, 1960.
13. Smith, R. M., Bachman, L., and Bougas, T.: Shivering following thiopental sodium and other anesthetic agents, *ANESTHESIOLOGY* 16: 655, 1955.
14. Blair, E., Montgomery, A. V., and Swan, H.: Posthypothermic circulatory failure; physiologic observations on circulation, *Circulation* 13: 909, 1956.

CORDOTOMY One hundred and three cordotomies were performed on 75 patients. Permanent relief of pain was achieved in 62 per cent of these patients. The commonest cause of intractable pain was cancer and the operation was most successful in this group. Sensory examination was performed during the course of the cordotomy since local anesthesia was used in most cases. Failure usually was related to inadequate incision but anatomic and physiologic factors were also considered. An operative mortality of 10.7 per cent occurred in this series. One stage bilateral cordotomies were associated with the highest of neurologic complications. The optimum time for cordotomy is soon after the occurrence of severe and intractable pain. (*Frankel, F. A., and Prokop, J. D.: Value of Cordotomy for the Relief of Pain, New Engl. J. Med.* 264: 971 (May 11) 1961.)

INTUBATION COMPLICATIONS In a series of 450 cases it was found that 44 per cent of patients on direct questioning admitted to postintubation sore throat, whereas less than 5 per cent volunteered this information. Throat complications were greater in the female patient, and in those in whom head movement occurred during intubation and surgery. The prone position was also associated with a greater incidence. The influence of endotracheal tube lubrication was investigated. The lowest incidence of com-

plications occurred with single applications of an anesthetic cream on the tubes. (*Gard, M. A., and Cruickshank, L. F. G.: Factors Influencing Incidence of Sore Throat following Endotracheal Intubation, Canad. Med. A. J.* 84: 662 (Mar. 25) 1961.)

HEAD INJURY Brain specimens of 14 rabbits, on which closed injury to the head had been inflicted experimentally, followed by cervical vagosympathetic block, were subjected to histological examination. Concussion was accompanied by increased capillary permeability with subsequent development of cerebral edema. The vago-sympathetic block regulated the increased permeability of the capillaries and contributed to a more rapid disappearance of brain edema. (*Icanota, L. A.: Effect of Vago-Sympathetic Procaine Block upon the Morphological Changes in Closed Brain Injuries, Eksper. Khir.* 3: 28, 1960.)

NASOTRACHEAL TUBES In children, the same size tubes that are used for orotracheal intubation can be used for nasotracheal intubation. Even large adenoids are said not to interfere. Advantages are the free oral cavity and less danger of kinking. There is no increase in complications compared to oral intubation. (*Koerner, M.: Nasotracheal Intubation in the Child, Der Anaesthetist* 10: 109 (Apr.) 1961.)