SOME EFFECTS OF INADVERTENT HYPOTHERMIA IN INFANT NEUROSURGERY

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IT has been pointed out that the surgical and anesthetic mortality rate in the first year of life is inordinately high for a group which comprises such a small percentage of the total surgical population.[1] One of the more complex of the inter-related factors contributing to this mortality rate is improper maintainence of fluid and electrolyte balance. It is generally agreed that this aspect of the infant's internal environment is most satisfactorily maintained by permitting him to select what he needs through complete oral intake.

Shortly after the installation of air conditioning in the operating rooms at University Hospital it was noted that a number of infants were slow in resuming normal activity and feeding patterns following surgery. It appeared that low body temperature during and immediately after operation might be causally related to this failure to recover normal activity. This study is an attempt to explore this relationship.

METHOD

In the selection of cases for this study the following criteria were met:

1. All patients were less than one year of age on admission to the hospital.

2. One of three operative procedures was performed; bilateral trephines, craniotomy for subdural membranes or ventricular and spinal-peritoneal shunts.

3. All patients were anesthetized utilizing an endotracheal tube and a nonrebreathing technique.

4. All operations were done in the same operating room.

5. All patients were offered fluids by mouth within three to four hours after return from the recovery room. (The usual recovery room stay was one and one-half to two hours.)

6. A satisfactory recovery was judged to be the acceptance of oral feedings within six hours of the termination of surgery and the continuation of a normal feeding pattern.

The study is divided into three distinct periods: First, the year prior to the installation of air conditioning when operating room temperatures ranged from 75 to 95 F. with no control of humidity. Second, a one-year period after the installation of air conditioning when temperatures ranged from 65 to 70 F., relative humidity was about 45 per cent and incomplete control of patient temperature was carried out. Third, a two and one-half year period when environmental conditions were similar to those of the second period but active control of patient temperature was attempted.

ANESTHETIC MANAGEMENT

Oral fluids were withheld for three to seven hours preoperatively. A cutdown was performed on almost all patients at this time and intravenous fluids administered until oral feedings were resumed. Preanesthetic medication consisted of atropine or scopolamine in appropriate doses intramuscularly 15 to 30 minutes prior to anesthesia. Older infants occasionally were given small doses of pentobarbital or secobarbital 30 to 60 minutes prior to anesthesia. Anesthesia was induced with ether or cyclopropane until tracheal intubation was accomplished. Maintainence of anesthesia was with nitrous oxide and added ether, trichlorethylene or halothane utilizing an Ayres "T" or a nonrebreathing valve. The infants were unclothed and the drapes were suspended above the body to permit easy observation of the infant and unencumbered respiratory movement of the thorax and abdomen. Blood loss was replaced as accurately as possible. Body temperature, (in Fahrenheit) when monitored, was recorded with a deep rectal probe. It was believed that unnecessary trauma would ensue if the probe were introduced into the infant esophagus. Temperature recording on

Received from the Department of Anesthesiology and Division of Neurosurgery, University Hospital, University of Maryland, Baltimore, Maryland, and accepted for publication March 18, 1960.

the ward was by rectal thermometer. The infants were warmed by surrounding them with warm water bottles.

Results

Of the 184 operative cases studied 168 met the established criteria. There were no deaths. Nineteen (11.3 per cent) of these patients had poor recovery of preoperative feeding patterns. Analysis of this group of patients (table 1) revealed that after elimination of obvious causes 11 infants (over half of the group) had unexplained feeding problems postoperatively. One baby, whose temperature was 102.2 F. on completion of surgery, had unexplained vomiting for some time. The ten remaining infants all had decreased body temperatures on completion of surgery. None of these infants accepted feedings in the six hours following surgery and all had a significant delay in resuming preoperative feeding patterns. There was no relationship between the anesthetic agents employed and the incidence of decreased body temperature during surgery.

When seen in the recovery room these infants were cool, slightly cyanotic, pale and very sluggish. Their level of activity was depressed and their cry weak. As they were warmed, activity slowly returned, but even after body temperature had returned to normal these babies were not as active for some time as those whose temperature had been maintained at or above normal.

TABLE 1

Analysis of the Causes of Poor Postoperative Feeding

	No.
Feeding problems (vomiting) existing prior to surgery	2
Post meningitic, depressed bone marrow, malnutrition	1
Sensitivity to cow's milk	2
Postoperative convulsive seizures	2
Cardiac decompensation, postoperative	1
Unexplained, temperature 102.2 F.	1
Decreased body temperature, poor feeding, temperature data not reliable	2
Unexplained, temperature less than 97 F.	8
Total	19

The influence of operating-room temperature on body temperature and the resumption of feeding patterns is graphically shown in figure 1. Patients with obvious causes for poor postoperative feeding are not included.

In the first period (before air conditioning) there were 24 patients. Although no attempt was made to modify body temperature by cooling there were no patients with temperatures over 102 F. and only one with a temperature below 97 F. (94 F.). All these infants resumed a normal feeding pattern within six hours of surgery.

In the second, or immediate post-air-conditioning period, there were 38 patients. Five

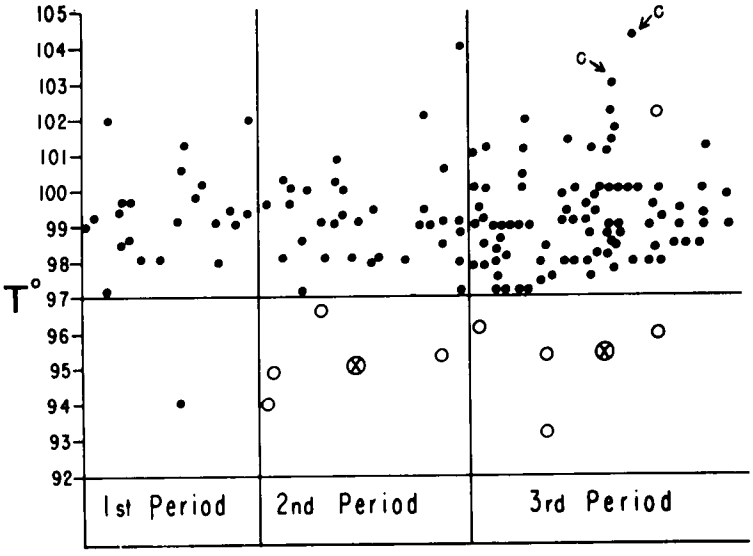

Fig. 1. Scattergram of immediate postoperative temperature showing temperature distribution as related to resumption of normal feeding pattern. Solid dots denote infants who ate well, circles denote infants who ate poorly. "C" denotes infants with poorly functioning cutdown.

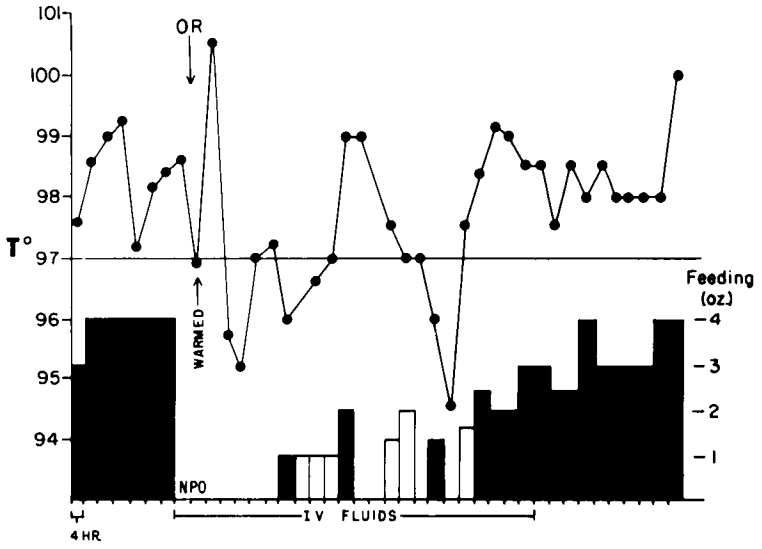

FIG. 2. Seven day postoperative temperature and feeding pattern of R. J., two and one-half months old, showing variations in feeding with fluctuations of body temperature. The solid bars represent feedings retained, the white bars represent feedings taken but vomited.

infants, whose temperatures were below 97 F., did not eat well. The remaining 33 had temperatures above 97 F. and ate satisfactorily. Two babies had fever (over 102 F.) due to inadequate intravenous fluid replacement but had no feeding problem.

There were 97 patients in the third period when temperatures were monitored during the operation and active warming of the infant was attempted. Despite our emphasis on the maintainence of temperature near normal, five patients were permitted to become cold. None of these accepted feedings within the first six hours after surgery. The other 92 babies all had temperatures above 97 F. and only one had difficulty establishing a normal feeding pattern postoperatively.

The importance of careful temperature control even on the ward is emphasized in figure 2. This 2½-month-old baby was in serious difficulty with a bizarre and inexplicable feeding pattern for 76 hours after surgery. Only when the problem was recognized and his temperature maintained at normal levels did he eat satisfactorily.

Discussion

As the use of generalized body hypothermia has become an accepted technique, the opinion has prevailed that a fall in body temperature of several degrees is relatively innocuous and, indeed, in many instances may be beneficial. Rigid temperature control in the neonatal and premature nursery has been considered by some as old-fashioned.[2, 3] Silverman, Fertig and Berger [4] found that small infants, whose temperatures were permitted to drop, showed an increase in mortality rate in the first five days of life. In pediatric anesthesia practice emphasis has been placed on the avoidance of hyperpyrexia to prevent operative and postoperative complications.[5, 6] Recently, however, the concern has been expressed that hypothermia in infants and small children during anesthesia may be a double-edged sword.[7-9] This study adds further evidence that this may be true.

The infant under one year of age who is permitted to become cold does not recover normal activity or feeding pattern promptly. After the elimination of obvious causes of poor postoperative feeding there remained a significant number of infants who did not eat well. These infants had temperatures below 97 F. at the end of surgery. On the other hand, almost all infants whose body temperatures remained above 97 F. had a prompt return of normal feeding and activity. Even those with frank hyper-pyrexia did well. Two infants whose temperatures had reached 104 F. owing to a malfunctioning cutdown (fig. 1) ate readily—perhaps even greedily—as if to compensate for dehydration. It is our belief that the administration of adequate amounts of intravenous

fluids will prevent marked elevation of temperature even in the artificially-warmed infant.

Inadvertent hypothermia in this age group occurs with startling rapidity unless temperature is recorded and artificial warming is instituted throughout the course of anesthesia. Surface cooling by convection and radiation is probably the principal route of heat loss in the infant whose higher ratio of body surface to body mass makes him an extremely efficient radiator. Depression of heat production and of the immature heat control centers, dilation of the peripheral vascular bed by anesthetic drugs, and the exposure of large vascular surfaces in turning a craniotomy flap all will speed surface cooling. Direct blood-stream cooling is produced by the administration of fluids at room temperature and blood at refrigerator temperature. The reported [10] respiratory heat loss when breathing cool, dry gases will occur when anesthesia is maintained by a nonrebreathing technique.

It is our belief that, in addition to the depression of central nervous system activity by cold, these babies have become over-anesthetized. As body temperature falls the increased solubility of anesthetic gases and vapors will result in an increased content of these agents in the tissues. Thus, at the end of operation the cold baby may well be deeply anesthetized and the elimination of anesthetic drugs will be significantly prolonged. This represents the greatest danger of inadvertent and unrecognized hypothermia. In planned, induced hypothermia this effect is expected and corrected by reducing the anesthetic concentration in the inhaled mixture.

Our findings may seem at variance with the majority of the reports on the merits of hypothermia. Patients with decreased body temperatures are said to "do better" and to show less postoperative stress. However, these reports are concerned with planned and controlled hypothermia in patients over one year of age, whereas our study concerns unplanned and unrecognized hypothermia in infants under one year of age.

Summary and Conclusions

A study was made of 168 operative experiences in infants in which the causes of poor postoperative feeding patterns were investigated. Of these patients 19 (11.3 per cent) had difficulty re-establishing a normal feeding pattern. Over half of these patients had unexplained feeding difficulties and associated reduced body temperatures following surgery. Ten of the 11 infants with body temperatures below 97 F. (R.) *did not* follow a satisfactory feeding pattern postoperatively, whereas almost *all* those infants with temperatures above 97 F. *did* have a satisfactory feeding pattern. We believe that inadvertent and unrecognized hypothermia in infants during surgery is an important cause of poor postoperative recovery of activity and feeding patterns. Continuous recording of temperatures during surgery is essential in this age group to detect the rapid drop of body temperature seen in air-conditioned operating rooms. Warming of infants during anesthesia will prevent inadvertent hypothermia and the associated postoperative feeding problems. Serious hyperthermia is not a problem in infants under one year of age *if* adequate hydration is maintained in the operative period. Rigid control of body temperature in these infants will obviate the problems presented by either extreme.

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