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Abstract

Both epidural and general anesthesia can impair thermoregulatory mechanisms during surgery. However, there is lack of information about the effects of different methods of anesthesia on newborn temperature. The purpose of this study was to determine whether there are differences in newborn rectal temperature related to type of anesthesia. Sixty-three pregnant women were randomly assigned to receive general or epidural anesthesia. Maternal core temperature was measured three times with a rectal probe just before anesthesia, at the beginning of surgery and at delivery. In addition, umbilical vein blood was sampled for pH. The rectal temperatures of the babies were recorded immediately after delivery, and Apgar scores were determined 1, 5, and 10 min after birth. The duration of anesthesia and the volume of intravenous fluid given during the procedure (833 ± 144 *vs* 420 ± 215 mL) were significantly higher in the epidural group than in the general anesthesia group (P < 0.0001). Maternal rectal temperatures were not different in both groups at all measurements. In contrast, newborn rectal temperatures were lower in the epidural anesthesia group than in the general anesthesia group (37.4 ± 0.3 *vs* 37.6 ± 0.3°C; P < 0.05) immediately after birth. Furthermore, the umbilical vein pH value (7.31 ± 0.05 *vs* 7.33 ± 0.01; P < 0.05) and Apgar scores at the 1st-min measurement (8.0 ± 0.9 *vs* 8.5 ± 0.7; P < 0.05) were lower in the epidural anesthesia group than in the general anesthesia group. Since epidural anesthesia requires more *iv* fluid infusion and a longer time for cesarean section, it involves a risk of a mild temperature reduction for the baby which, however, did not reach the limits of hypothermia.

Key words: Rectal temperature; Newborn; Epidural anesthesia; General anesthesia; Cesarean delivery

Introduction

Body temperature is a well-controlled physiological parameter, and small deviations in core temperature provoke aggressive thermoregulatory mechanisms in an effort to maintain normothermia. However, all anesthetic drugs profoundly impair these mechanisms. Because of the core-to-peripheral redistribution of body heat that follows the induction of anesthesia, all patients are at risk for hypothermia (1).

Mild hypothermia causes numerous complications, including morbid myocardial outcomes, coagulopathy, and reduced resistance to surgical wound infections. Therefore, great caution has to be taken during anesthesia. However, the clinical situation is further complicated because core temperature is rarely measured during anesthesia and reductions in core temperature are usually not recognized by the anesthesiologist.

Over the past few decades, there has been a tremendous increase in the number of cesarean deliveries performed by section in most industrialized countries. Wide differences occur between countries, regions or even hospitals within the same region with similar socioeconomic profiles and patient characteristics (2,3). This suggests that cesarean section (CS) is probably often performed for non-medical reasons leading to an overall overuse of this surgical obstetric intervention. Indeed, it has been acknowledged that elective primary and repeat CS have contributed heavily to the rise in CS (4,5). In the US, for instance, the overall CS rates increased by 14% from 1998 to 2001 as a result of a 13% increase in medically indicated primary CS and a 53% increase in the rate of elective primary CS (4). Because of this global increase in CS rates, more attention is being paid to their outcomes.

Epidural or general anesthesias (GA) are the methods of choice for CS delivery. Both methods have advantages and disadvantages. Although regional anesthesia is the primary choice in most countries, it is still controversial in some aspects. There is also a great difference between countries, regions or even hospitals regarding the prefer-

ence for the method of anesthesia. In a study held at a university hospital in Turkey, only 44.5% of patients were preferentially submitted to regional anesthesia (6), as opposed to an 80% rate in the US (7). The effect of type of anesthesia on neonates is less clear, with some studies showing no difference in neonatal outcome between the two groups and others maintaining that neonatal outcome is better with regional anesthesia than with GA (8,9). In a recent extensive review, Afolabi et al. (10) concluded that "there was no evidence from that review to show that regional anesthesia is superior to GA in terms of major maternal or neonatal outcomes".

However, there is a lack of experiments on the effects of different anesthesia methods on newborn temperature and its outcome. However, despite the shorter duration of anesthesia, the potential for mild maternal hypothermia still exists in both methods, and consequently a noticeable effect can also be expected on newborn body temperature (1,11-13). Concomitant effects of newborn hypothermia may be seen in the physical and metabolic status of the infant at birth and in the immediate postnatal period (14).

The purpose of the present randomized trial was to determine whether there is a difference in babies' rectal temperature related to type of anesthesia utilized. We, therefore, tested the hypothesis that neuroaxial anesthesia simultaneously decreases newborn temperature and Apgar score compared to GA.

Patients and Methods

The study was approved by the Ethics Committee and the patients gave written informed consent.

Patients

Seventy ASA physical status I pregnant women undergoing elective cesarean delivery participated.

Low-risk pregnant women aged 18 years or older, with 37 weeks of gestation or more, and undergoing elective scheduled cesarean delivery were eligible for enrollment. CS was medically indicated (e.g., previous CS) or was elective primary CS (due to patient preference but with no clear medical or obstetric indication). Pregnant women with a diagnosis of preeclampsia or eclampsia, with heart disease or taking any chronic medications other than prenatal vitamins or considered to have high-risk pregnancies were excluded.

Patients were divided into two groups respectively receiving general anesthesia (GA group, N = 30) or epidural anesthesia (EA group, N = 33), using sealed envelopes. Random permutation of 70 sequentially numbered, sealed, opaque envelopes, each containing a group name, was created by the computer. The envelopes were opened by the anesthesiologist before the surgery, after informed consent was obtained. Five patients in the GA group and 2 in the EA group were excluded from the study because

they did not accept the method of anesthesia at the end of randomization.

The groups were similar in regard to age (28 ± 4 *vs* 28 ± 3 years), weight (74.1 ± 14 *vs* 72.0 ± 8.29 kg) and height (162.1 ± 7.1 *vs* 161.5 ± 3.19 cm) variables.

Procedure

All women fasted for at least 8 h prior to the surgery. The intraoperative ambient temperature was maintained at 24°C in the operating room (OR). Mothers did not receive a period of prewarming prior to anesthesia and all infusion fluids were at room temperature in accordance with our routine practice.

On arrival in the OR, standard monitoring was applied with automated noninvasive blood pressure measurement, electrocardiography and pulse oximetry. Baseline data collection was started when the patient had been settled on the OR table in preparation for EA or GA.

General anesthesia

Patients in the GA group received standard rapid sequence induction with preoxygenation followed by 4-5 mg/kg thiopental and 100 mg succinylcholine. Cricoid pressure was used throughout induction and was released after correct placement of the tracheal tube had been confirmed. Anesthesia was maintained with up to 1.5% isoflurane and 50% nitrous oxide in oxygen. Neuromuscular blockade was maintained with 0.4 mg/kg atracurium.

Epidural anesthesia

All EA patients were prehydrated with 500 mL lactated Ringer's solution before induction of anesthesia. EA was performed with the patient in the sitting position at the L2-3 or L3-4 intervertebral space using a midline approach by loss of resistance to saline. The catheter was introduced 3 to 4 cm beyond the tip of the Tuohy needle in all patients. The needle was then removed, the catheter secured to the skin, and the patient placed in the supine position with left uterine displacement. Then, 12 mL 0.5% bupivacaine without epinephrine was injected after a test dose. Additional 4-mL doses of bupivacaine were injected into the catheter until a bilateral T4 block (pinprick) was established. CS was started soon after an adequate epidural block was established.

All patients were covered with sterile fields just after anesthesia. The time (minutes) from the beginning of anesthesia to surgery and delivery was recorded.

Measurements

Core temperature was measured with a rectal probe (Criticare 1100 4A, CSI, USA) inserted to a depth of 3 cm. The rectum was selected as the site for body temperature measurement because of the difficulties and hazards associated with direct tympanic temperature measurement (1,15,16) and because of the concerns and variability

associated with ear-based temperatures (1,17-20).

Maternal rectal temperature was measured three times, just before anesthesia, at the beginning of operation and at delivery. In addition to maternal rectal temperatures, umbilical vein blood from the newborn was sampled for pH directly after birth. The rectal temperatures of the babies were also recorded immediately after birth and the Apgar scores of the infants were determined 1, 5, and 10 min after birth.

Statistical analysis

Differences between groups were compared using independent-samples *t*-tests, and "in-group" analysis of maternal rectal temperatures was performed by one-way ANOVA. Power analysis revealed that a sample size of 58 was required to detect differences, assuming a two-sided alpha of 0.05, power of 90%, and standard deviation of 0.4°C in body temperature. Data are reported as means ± SD and the level of significance was set at $P < 0.05$.

Table 1. Rectal temperatures of pregnant women during cesarean delivery.

Variable	General anesthesia (N = 30)	Epidural anesthesia (N = 33)
Rectal temperature before anesthesia (°C)	37.0 ± 0.5	36.8 ± 0.6
Rectal temperature at induction (°C)	36.9 ± 0.5	36.8 ± 0.5
Rectal temperature at delivery (°C)	37.0 ± 0.4	36.8 ± 0.5

Data are reported as means ± SD.

Table 2. Apgar scores, rectal temperatures and umbilical vein pH values of newborns and *iv* fluid volumes.

	General anesthesia (N = 30)	Epidural anesthesia (N = 33)
Apgar 1st min	8.5 ± 0.7 (7-10)	8.0 ± 0.9* (6-10)
Apgar 5th min	9.7 ± 0.5 (8-10)	9.6 ± 0.4 (9-10)
Apgar 10th min	9.9 ± 0.2 (9-10)	10.0 ± 0.0 (10-10)
Rectal temperature (°C)	37.6 ± 0.3 (36.7-38.1)	37.4 ± 0.3* (36.8-38.0)
pH	7.33 ± 0.01 (7.31-7.36)	7.31 ± 0.05* (7.24-7.38)
iv fluid (mL)	420 ± 215 (150-900)	833 ± 144* (500-1000)

Data are reported as means ± SD and range within parentheses. *$P < 0.05$ (Student *t*-test).

Results

The duration of surgery and the duration of anesthesia until delivery were significantly longer for the EA group. Anesthesia was induced within 18.7 ± 6 min after arriving to the OR for the EA group and within 11.6 ± 8.1 min for the GA group. Surgery was started 14.5 ± 7 min after the induction of EA and 1.1 ± 0.1 min after the induction of GA. Time to delivery was 8.0 ± 3.6 min for the EA group and 4.1 ± 1.3 min for the GA group, with a significant difference between groups regarding the time spent in the OR until delivery ($P < 0.001$).

Also, the volume of intravenous fluid given during the procedure was significantly larger in the EA group than in the GA group ($P < 0.001$).

Preoperative, preincision, and delivery mean maternal rectal temperatures were comparable in both groups. Also, "in-group" comparisons showed no difference between preinduction and delivery rectal temperatures (Table 1).

In contrast, newborn rectal temperature was lower in babies of the EA group than in babies of the GA group immediately after birth ($P < 0.05$). Furthermore, the umbilical vein pH value and Apgar scores at the 1st min were lower in the EA than in the GA group ($P < 0.05$; Table 2).

Discussion

Although mothers in the GA and EA groups did not have a significant difference in rectal temperatures over the course of the study, EA group newborns had lower body temperatures compared to the GA group. However, the scores of neither group were at the level of hypothermia.

In fact, both RA and GA markedly impair the normal precise regulation of core body temperature. Consequently, inadvertent peroperative hypothermia is common (21). The extent to which core temperature decreases during this phase depends largely on ambient temperature (22,23), the magnitude and duration of the surgical procedure (24), and the amount of unwarmed *iv* fluids given (25,26).

The present results indicate that mothers provided with usual care at 24°C room temperature did not have a change in core temperature until delivery in either group. Heat loss is greater during large than small surgeries, and greater heat deficits will develop during longer procedures (27,28). However, the duration of our survey was not long enough to observe this heat loss.

A decrease in temperature during anesthesia initially develops from a core-to-peripheral redistribution of body heat (26-28). Redistribution of core temperature is due to the fact that anesthetics inhibit the tonic vasoconstriction that normally maintains a large core-to-peripheral temperature gradient. Core temperature then decreases linearly at a rate determined by the difference between heat loss and production. As is the case for GA, redistribution of body heat is the major initial cause of hypothermia in patients receiving epidural anesthesia. However, redistribution

during neuraxial anesthesia is typically restricted to the legs (29). In the present study, the mean maternal rectal temperature of the EA group was slightly lower than that of the GA group but the difference was not statistically significant. The patients were covered with fields immediately after anesthesia and during surgery. Therefore, a decrease in temperature related to vasodilatation in the legs in the EA group was not expected.

It is important to note that the average duration of our survey was not long enough for the redistribution of core temperature, especially in the GA group. The trial was started when the patients entered the OR and ended at delivery. We suggest that, because of this short period of time, we did not observe a decline in temperature in either group of mothers. Thus, it is not possible to assign the difference in baby temperature to the anesthetics.

Insler and Sessler (29,30) reported that heating intravenous fluids does not warm patients, but does prevent fluid-induced hypothermia in patients given large volumes of fluid. The only reasonable explanation for the difference in temperature between EA and GA babies was the volume of *iv* fluids infused at room temperature, which was larger in the EA group.

The other associated explanation was the application of anesthesia and the surgical time, which were significantly longer in the EA group than in the GA group. A fetus generates considerable heat that must be dissipated to its mother. Because heat flows only down a temperature gradient, the temperature of the fetus is usually slightly higher than that of the mother. Fetal temperature is thus directly related to maternal temperature, and therefore maternal hypothermia is likely to be associated with hypothermia in newborn infants (14). In the present study, the tendency to a lower rectal temperature in EA babies was more significant among those who were in contact with their mothers for a longer period of time before delivery compared to the GA group.

Babies born to mothers who were under GA remained warmer than those born to EA mothers. The clinical importance of this difference remains unclear. However, it is interesting to note that umbilical vein pH was also significantly lower in EA babies. This observation suggests that even a very mild temperature change is not entirely benign.

There are some conflicting results regarding the Apgar scores of babies born to mothers submitted to different anesthesia applications. Three studies (31-33) documented the mean Apgar score at 1 min of babies born to mother submitted to EA or GA and reported that scores were significantly lower among babies delivered by mothers submitted to GA. However, Kolatat et al. (32) and Kavak et al. (34), when comparing spinal with general anesthesia, noted that there was no difference in mean Apgar score at 1 min. A similar trend was noticed with Apgar scores at 5 min in two studies (31-33) comparing EA with GA, which reported significantly lower scores among babies in the GA group. However, when comparing the Apgar score at 5 min of babies born to mothers submitted to spinal anesthesia and to GA, Kolatat et al. (32) and Kavak et al. (34) did not find any differences between groups. In our study, the 1st-min Apgar scores were lower in babies from the EA group, but were similar in the two groups at the 5th and 10th min. This indicates the fast recovery of the thermoregulation mechanisms of babies immediately after delivery.

The limitations of this study should be noted. Both the investigators and the patients were aware of group assignment, simply because it would be impossible to hide the type of anesthesia from either the investigators or the patients. However, all our findings were objective and thus intrinsically resistant to bias. It is therefore unlikely that full blinding, even if technically possible, would alter our conclusions.

In accordance with our routine clinical practice, all fluids were at room temperature and the EA group was given 500 mL crystalloid solution before EA application. This could be also accepted as a limitation of the study. However, the aim of this trial was to determine the possible inadvertent hypothermia of newborns related to anesthesia. Therefore, we did not modify our routine practice to test the result.

We suggest that, because of the shorter duration of cesarean delivery, maternal hypothermia does not occur. But since EA needs more *iv* fluid infusion and a longer period of time compared to GA, it involves a risk of a mild decline in baby temperature.

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