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Inadvertent perioperative hypothermia induced by spinal anesthesia for cesarean delivery might be more significant than we think: are we doing enough to warm our parturients?

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Neuraxial anesthesia is currently the anesthetic technique of choice for cesarean delivery. A recent report estimates that approximately 94% of all cesarean deliveries in the United States are performed using this technique.¹ Significant strides have been made in improving the safety of spinal anesthesia by raising awareness about adverse effects such as hypotension, inadequate intraoperative anesthesia and inadequate postoperative analgesia, and developing strategies for their prevention. However, there is still significant work to be done. Two publications in this month's *Anesthesia & Analgesia* have highlighted inadvertent perioperative hypothermia as one area where further work is needed.^{2,3} Inadvertent perioperative hypothermia, the unintentional cooling of a patient's core temperature to less than 36°C, has long been a recognized complication of general anesthesia. However it is also common in women receiving spinal anesthesia for cesarean delivery, with the incidence reported as high as 91%.⁴ In the general surgical population, inadvertent perioperative hypothermia is associated with adverse outcomes, which include increased blood loss, higher surgical site infection rates, higher rates of myocardial ischemia and prolonged hospitalization.^{5–7} In the obstetric patient population, neonatal hypothermia, which may result from maternal hypothermia, is associated with an increase in respiratory distress syndrome, hypoglycemia and neonatal mortality, particularly in preterm and very low birth weight infants.⁸ While the adverse surgical outcomes of hypothermia have not been adequately evaluated in the obstetric patient population, active warming techniques aimed at preventing inadvertent perioperative hypothermia have been associated with reduced maternal shivering, improved maternal thermal comfort, reduced neonatal hypothermia and improved neonatal acid base status.^{9,10} The implementation of enhanced recovery after surgery protocols, which include perioperative active warming as a component, has shortened hospitalizations in women who deliver by scheduled cesarean with spinal anesthesia.¹¹

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The high incidence of perioperative hypothermia in women receiving spinal anesthesia for cesarean delivery should not be surprising. Spinal anesthesia significantly impairs autoregulation by inhibiting the vasomotor and shivering responses and causes a thermal redistribution from the core to peripheral tissues.¹² Dermatomal distribution is a significant predictor of hypothermia in patients receiving spinal anesthesia, with higher dermatomal spread increasing the risk.¹² Furthermore, spinal anesthesia is not always associated with significant thermal discomfort despite patients experiencing core hypothermia by mechanisms that still remain unclear.¹³ Spinal anesthesia blocks tonic cold sensory input from the lower limbs to thermoregulatory centers which may then be perceived as relative warmth by patients.¹³ It also appears that the administration of intrathecal morphine, currently regarded as the gold standard for postoperative analgesia for cesarean delivery, may further exacerbate inadvertent perioperative hypothermia.¹⁴

Despite the high incidence of inadvertent perioperative hypothermia, routine core temperature monitoring is uncommon. In patients receiving neuraxial anesthesia for general surgical procedures, only a third of clinicians reported routinely monitoring intraoperative core temperature.¹⁵ In the United Kingdom, only 27% of obstetric units routinely monitored intraoperative maternal core temperature.¹⁶ Infrequent use likely reflects the fact that traditional techniques to measure core temperature are inappropriate for an awake mother undergoing surgery adjacent to her bladder.¹⁵ However, the availability of new noninvasive devices which utilize the zero heat flux principle and show good correlation with other core temperature monitoring sites could be more suitable in this patient population.¹⁷ In this issue of *Anesthesia & Analgesia*, du Toit *et al* used an ingestible temperature sensor, and described with high resolution the pattern of the hypothermic insult following spinal anesthesia for cesarean delivery.² In this observational study, active warming measures were not routinely used, and patients experienced a mean reduction in intestinal temperature by 1.30 °C, most likely due to redistribution hypothermia.² The median time to the lowest intestinal temperature was approximately 1h from spinal placement, and in 75% of patients intestinal temperatures continued to fall even after leaving the operating room (OR).² It took a median of 4.5 hours for intestinal temperature to recover to baseline, and in 29 % of patients, the temperature did not return to baseline during the 8 hours duration of the study. These findings suggest that a significant proportion of patients continue to experience hypothermia in the postanesthesia care unit (PACU) and beyond, when active warming measures may have ceased. Since temperature is typically included in PACU discharge criteria, hypothermia may delay PACU discharge. Even more concerning is the level of hypothermic exposure, with patients sustaining a median of approximately 2 degree-hours of hypothermic exposure following spinal anesthesia.² In the general surgical patient population, the intraoperative duration of hypothermic exposure is a significant predictor of intraoperative blood transfusion requirements.¹⁸ The severity of the hypothermic insult resulting from a single shot spinal anesthetic suggests that obstetric patients may be at risk of adverse outcomes comparable to those seen in the general surgical population. However there is a lack of data investigating adverse surgical outcomes related to hypothermia in the obstetric population. Furthermore, almost all studies investigating active warming techniques stop data collection in the PACU, and therefore do not cover the entire duration of spinal anesthesia induced hypothermia.

The best strategy for preventing inadvertent perioperative hypothermia is unknown. A recent meta-analysis demonstrated that active warming with either forced air warming devices or by the administration of warmed fluids in women having an elective cesarean delivery under neuraxial anesthesia reduces the maximum fall in temperature and the incidence of hypothermia when compared with passive warming techniques.¹⁰ Active warming techniques also increased maternal thermal comfort and reduced the incidence of shivering.¹⁰ Furthermore, active warming reduced neonatal hypothermia and improved umbilical artery cord pH suggesting that active warming may also have neonatal benefits.¹⁰ However the benefit of single active warming strategies on maternal core temperature investigated to date has been modest, with most studies reporting no more than 0.2–0.5 °C temperature difference between the warming and control groups.⁴ Multimodal warming techniques in theory may be more efficacious, but interestingly a combination of intraoperative forced air warming and warmed IV fluid administration showed limited efficacy in reducing hypothermia following spinal anesthesia for cesarean delivery, with hypothermia developing in 64 % of patients in the warming group compared to 91 % of patients in the control group.⁴ In this issue of *Anesthesia & Analgesia*, Munday et al. assessed the efficacy of another multimodal active warming strategy in women who received spinal anesthesia with intrathecal morphine.³ In this study, the addition of 20 min of whole body preoperative forced air warming to intraoperative warmed intravenous fluid administration did not significantly reduce the incidence of inadvertent perioperative hypothermia or the rate of decline of intraoperative core temperatures compared to fluid warming alone, but the study did not include a control group not receiving any warming modality.³ In fact, 48% and 64 % of patients in the combined and single modality groups respectively were hypothermic on admission to PACU, and 68% and 80 % respectively required warming in PACU, confirming the findings of du Toit et al. that core temperatures continue to decline in the postoperative period.^{2,3} This study only applied forced air warming preoperatively, and did not continue it intraoperatively. While preoperative warming has been proposed as an effective strategy for preventing hypothermia particularly in short surgical procedures under general anesthesia,¹⁹ the study by Munday and colleagues suggests that its efficacy is limited in women undergoing cesarean delivery under spinal anesthesia. Combining preoperative and intraoperative forced air warming with warmed IV fluids may be more effective. In fact, of all the studies investigating active warming techniques in the cesarean delivery population, the study that showed the greatest difference in maternal core temperature between the active and passive warming groups (1.1 °C) was a study that combined preoperative and intraoperative forced air warming with warmed IV fluid administration.²⁰ This study however was in patients receiving epidural anesthesia, and there are no similar studies to date in patients receiving spinal anesthesia.

Studies have also not adequately addressed the impact of the OR ambient temperature on the incidence and severity of inadvertent perioperative hypothermia in the mother and neonate and the ideal temperature for its prevention. Despite the World Health Organization recommending a minimum delivery room temperature of 25°C to reduce neonatal hypothermia, the feasibility of instituting this temperature intraoperatively has not been investigated.²¹ In the general surgical patient population receiving spinal anesthesia, ambient OR room temperature is not a predictor of hypothermia.¹² However in women having

cesarean delivery, one study has demonstrated that a higher ambient OR temperature of 23°C when compared with 20°C, in combination with other maternal warming measures, modestly reduced neonatal and maternal hypothermia, but resulted in no significant reduction in neonatal adverse outcomes.²² Discomfort was however reported by surgeons with the higher OR temperature.

In order to improve the detection and prevention of inadvertent perioperative hypothermia in the obstetric patient population having cesarean delivery under spinal anesthesia, current core temperature monitoring practices and temporary management guidelines will need to be updated. In the past, the lack of reliable core monitoring sites was highlighted as a barrier to temperature measurement in awake patients.¹⁵ However, the availability of newer less invasive temperature monitoring devices which correlate with core temperature could improve compliance with temperature monitoring in awake patients. With improved perioperative core temperature monitoring, patients who continue to experience hypothermia particularly in the postoperative period can be identified and receive active warming measures. In fact, as we become more aware of the duration of inadvertent perioperative hypothermia, continuing active warming into the postoperative period may compliment preoperative and intraoperative warming techniques.

Inadvertent perioperative hypothermia occurs commonly in women having a single shot spinal anesthesia for cesarean delivery, but this may only be the tip of the iceberg. The study by du Toit et al. suggests that we might be significantly underestimating the magnitude and duration of this insult. Our current warming strategies appear to have limited efficacy in isolation, and a combination of modalities initiated preoperatively, and continued intraoperatively and postoperatively might be needed. We need to focus our research efforts on investigating the mechanisms that contribute to inadvertent perioperative hypothermia in obstetric patients, developing effective strategies to reduce its incidence, identifying patients at greater risk for hypothermia, and determining the impact of inadvertent perioperative hypothermia on adverse maternal and neonatal outcomes. Studies also need to extend the duration of temperature monitoring well beyond the early recovery period. Efforts aimed at preventing inadvertent perioperative hypothermia in the obstetric patient population could have far reaching implications that extend outside the OR.

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