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REPORTS OF ORIGINAL INVESTIGATIONS

# Predictive factors of maternal hypothermia during Cesarean delivery: a prospective cohort study

# Facteurs prédictifs d'hypothermie maternelle durant la Césarienne : une étude prospective de cohorte

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## Abstract

**Purpose** *Although perioperative hypothermia may increase maternal morbidity, active warming is infrequently performed to maintain normothermia during Cesarean delivery (CD). The aim of this prospective observational study was to determine the factors associated with maternal hypothermia in this setting.*

**Methods** *Women scheduled for elective or emergency CD were consecutively included in this study from November 2014 to October 2015. Maternal temperature was measured using an infrared tympanic thermometer on the patient's arrival in the operating room, at skin incision, and at the end of skin suture. Maternal hypothermia was defined by tympanic temperature < 36°C at the end of skin suture. Univariate analysis was performed, followed by multivariate logistic regression analysis, in order to determine the factors associated with maternal hypothermia at the end of the surgery.*

**Results** *Three hundred fifty-nine women were included and analyzed during this study. The incidence of hypothermia was 23% (95% confidence interval, 18 to 27) among the total population included. According to multivariate analysis, obesity, oxytocin augmentation of labour, and use of active forced-air warming were associated with a decreased risk of maternal hypothermia, while maternal temperature < 37.1°C on arrival in the operating room, maternal temperature < 36.6°C at skin incision, and an infused volume of fluids > 650 mL were significantly associated with maternal hypothermia. Both goodness of fit and predictive value of multivariate analysis were high.*

**Conclusion** *Several predictive factors for maternal hypothermia during CD were identified. These factors should be taken into account to help prevent maternal hypothermia during CD.*

## Résumé

**Objectif** *Bien que l'hypothermie périopératoire puisse accroitre la morbidité maternelle, le réchauffement actif peropératoire n'est pas fréquemment réalisé pour maintenir la normothermie durant la césarienne. L'objectif de cette étude prospective observationnelle était de déterminer les facteurs associés à l'hypothermie maternelle dans ce contexte.*

**Méthode** *Les patientes subissant une césarienne urgente ou programmée ont été consécutivement incluses entre novembre 2014 et octobre 2015. La température maternelle a été mesurée à l'aide d'un thermomètre tympanique infrarouge à l'arrivée au bloc opératoire, à l'incision, et à la fin de la fermeture cutanée. L'hypothermie maternelle était définie par une température auriculaire < 36°C à la fin de la fermeture cutanée. Une analyse univariée puis multivariée par régression logistique a été réalisée pour identifier les*

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*facteurs associés à l'hypothermie maternelle à la fin de la chirurgie.*

**Résultats** *Trois cent cinquante-neuf patientes ont été incluses et analysées. L'incidence de l'hypothermie maternelle était de 23% (intervalle de confiance à 95%, 18 à 27) dans la population incluse. En analyse multivariée, l'obésité, le déclenchement du travail par ocytocine, et le réchauffement actif par air pulsé étaient associés à une diminution du risque d'hypothermie maternelle, alors que la température maternelle < 37,1°C à l'arrivée au bloc opératoire et < 36,6°C à l'incision, et un volume de solutés administré > 650 mL, augmentaient significativement le risque d'hypothermie. La calibration et la valeur prédictive de notre analyse multivariée étaient élevées.*

**Conclusion** *Plusieurs facteurs prédictifs d'hypothermie maternelle durant la césarienne ont été identifiés. Ces facteurs devraient être pris en compte pour améliorer la prévention de l'hypothermie maternelle durant la césarienne.*

Perioperative hypothermia may lead to an increased risk of morbid cardiac events, postoperative wound infection, coagulopathy, intraoperative blood loss, transfusion requirement, and prolonged recovery.[1-4] Hence, maintaining normothermia during the intraoperative period is now a standard of care.[5]

During Cesarean delivery (CD), active warming techniques may lessen the decrease in maternal core temperature and the incidence of perioperative maternal hypothermia and shivering while improving maternal comfort.[6-14] Nevertheless, despite widespread availability of active warming devices in most obstetric theatres, in routine practice, they are used in < 20% of units responsible for parturients undergoing CD.[15,16] There is a current lack of specific recommendations regarding the prevention of perioperative hypothermia in women scheduled for CD,[5,17,18] which could partly explain the underuse of warming techniques in this setting.

The reported incidence of maternal hypothermia during CD varies considerably among studies, ranging from 48-91% when active warming measures are not used during the procedure.[8,10,12] Several pre- and / or intraoperative parameters may contribute to the decrease in maternal core temperature during the intraoperative period and, consequently, to the occurrence of maternal hypothermia. Nevertheless, these potential predictors of intraoperative maternal hypothermia remain unclear. Determining these factors would be of particular importance to help prevent maternal hypothermia during CD.

We therefore conducted a prospective cohort study to identify the predictive factors for intraoperative maternal hypothermia during CD.

## Methods

### Study design and patients

This prospective cohort study was conducted from November 1, 2014 to October 31, 2015 after approval from the Institutional Review Board (Comité de Protection des Personnes Sud-Est II, Groupement Hospitalier Est, IRB number 00009118). The methodology followed the recommendations of the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement.[19]

After receiving informed consent, women aged > 18 yr undergoing elective or emergency CD during the study period were consecutively enrolled. Exclusion criteria included refusal to participate in the study and CD performed as per the grade 1 classification described by Lucas *et al* —i.e., for immediate threat to life of mother or fetus with an ideal decision-to-delivery interval of < 30 min.[20]

### Protocol and definition of maternal hypothermia

Cesarean deliveries were performed under either neuraxial anesthesia (spinal anesthesia, combined spinal-epidural anesthesia, or extension of epidural analgesia to epidural anesthesia for labour) or general anesthesia in case of a contraindication to neuraxial anesthesia.

Once induction of anesthesia was achieved, a cotton blanket was placed over each patient's upper body. At the discretion of the attending anesthesiologist, an upper body forced-air warming blanket (Bair Hugger® Model 500; Augustine Medical, Eden Prairie, MN, USA) could also be placed over the patient's upper torso and arms using a warming unit set at 43°C.

In cases of CD performed under spinal anesthesia or combined spinal-epidural anesthesia, vasopressors were administered according to a standardized protocol. Immediately following intrathecal injection of the local anesthetic, a prophylactic infusion of phenylephrine 25 $\mu g \cdot mL^{-1}$ and ephedrine 1.5 $mg \cdot mL^{-1}$ was started via infusion pump at 20 $mL \cdot hr^{-1}$ on the closest port of the patient's dedicated intravenous line. In order to maintain the systolic blood pressure > 80% of baseline, the infusion rate was adjusted every minute until umbilical cord clamping and then every five minutes until the end of surgery. In cases of CD performed under epidural or general anesthesia, we did

not use a continuous infusion of vasopressors. Alternatively, we administered phenylephrine as intermittent boluses 50-100 μg to keep the systolic blood pressure at 80-100% of baseline, and / or if there was a significant decrease in maternal heart rate, we administered small boluses of ephedrine 3 mg (never > 15 mg) before umbilical cord clamping to avoid the risk of fetal acidosis.

Routine intraoperative monitoring consisted of electrocardiography, noninvasive arterial blood pressure, pulse oximetry, urinary output, and maternal temperature. Trained staff measured each patient's temperature using an infrared tympanic thermometer (AccuSystems Genius$^{TM}$ 2; Covidien, Mechelen, Belgium; accuracy ± 0.2°C) away from any heat-generating equipment. Maternal temperature was measured at three predefined time points: 1) on arrival in the operating room (prior to induction of anesthesia), 2) at skin incision, and 3) at the end of the skin suture. The same thermometer (maintained and calibrated in accordance with the manufacturer's guidelines) was used for all patients. Maternal hypothermia was defined as tympanic membrane temperature < 36°C at the end of the skin suture.

### Data collection

The following data were recorded for analysis: maternal age, body mass index, American Society of Anesthesiologists physical status, maternal comorbidities, obesity (body mass index ≥ 30 kg·m$^{-2}$), gestational age, elective or emergency CD (whether or not during active labour), CD decided during active labour, oxytocin augmentation of labour, primary or repeat CD, preeclampsia, placenta previa, premature rupture of membranes, duration of preoperative fasting for solids and fluids, mode of anesthesia, ambient temperature in the operating room, baseline maternal temperature on arrival in the operating room, maternal temperature at skin incision and at the end of the skin suture, use of active forced-air warming and / or fluid warmer during CD, time interval from arrival in the operating room to surgical incision, duration of surgery (from skin incision to the end of the skin suture), intraoperative blood loss, intraoperative blood transfusion, use of vasopressors, doses of vasopressors, and total volume of fluids administered during the surgical procedure.

### Statistical analysis

Statistical analysis was performed using MedCalc® version 12.1.4.0 for Windows (MedCalc Software, Ostend, Belgium).

For analysis, women with hypothermia (temperature < 36°C at the end of the skin suture) were included in the Hypothermia group, while those with a temperature ≥ 36°C at the end of the skin suture were included in the Non-hypothermia group.

The distribution of continuous variables was tested for normality using the Kolmogorov-Smirnov test. Continuous variables were expressed as mean (standard deviation [SD]) or as median [interquartile range (IQR)] and compared using Student's *t* test, Mann-Whitney *U* test, or paired Wilcoxon test, as appropriate. Categorical variables were described as number (percentage) and 95% confidence interval [CI] according to the Wald method and compared using $\chi^2$ test or Fisher's exact test, as appropriate. For each test, $P < 0.05$ was considered statistically significant.

Univariate and multivariate logistic regression analyses were used to identify variables associated with intraoperative hypothermia, producing odds ratios with 95% CI. For construction of multivariate models, all variables associated ($P < 0.1$) with intraoperative hypothermia in univariate analysis were subjected to a stepwise logistic regression analysis. For the purpose of the analysis, two logistic regression models were built. In the first model (model 1), the quantitative variables were expressed as continuous variables. In the second model (model 2), the quantitative variables were categorized as dichotomous variables according to their optimal threshold value. The optimal threshold value was determined by constructing receiver operating characteristic (ROC) curves for predicting maternal hypothermia, along with determining the corresponding Youden index. A variable was retained in the model if the associated two-sided *P* value was < 0.05. Then, after checking in multivariate analysis and adjustment with covariates, the variable was removed from the model if its associated *P* value was > 0.1. The goodness of fit of the models was assessed using the Hosmer-Lemeshow test, and their predictive value was evaluated using a ROC curve. The areas under the ROC curves were compared using the method developed by DeLong *et al.*[21]

## Results

The final analysis included 359 women. The flow diagram of patient enrolment and analysis is presented in Fig. 1.

In the total population, there was a significant median [IQR] decrease in maternal temperature between the patient's arrival in the operating room and skin incision (37.2 [36.9-37.5] °C *vs* 36.9 [36.5-37.2] °C, respectively; $P < 0.001$) and between incision and skin suture (36.9 [36.5-37.2] °C *vs* 36.4 [36.0-36.8] °C, respectively; $P < 0.001$).

Among the included patients, 81 (23%; 95% CI, 18 to 27) had maternal hypothermia, as defined by tympanic

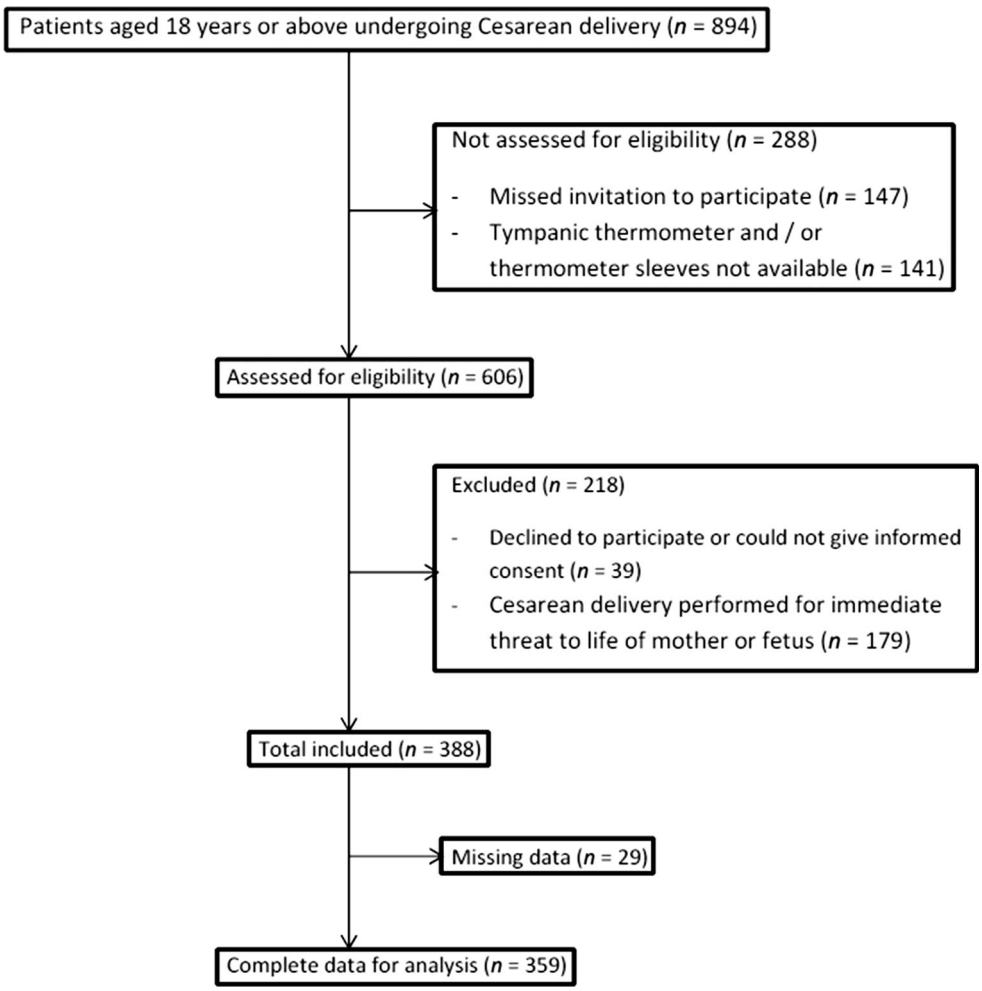


**Fig. 1** Flow diagram of patient enrolment and analysis

membrane temperature < 36°C at the end of the skin suture (Hypothermia group). In this group, the maternal temperature at the end of skin suture was within the range of 35-35.9°C in 79 patients and < 35°C in two patients. The Non-hypothermia group included the 278 remaining women with temperature ≥ 36°C at the end of the skin suture (Table 1).

Mean body mass index was significantly lower in the Hypothermia group compared with the Non-hypothermia group. Cesarean deliveries performed during labour, oxytocin augmentation of labour, and urgent CD were significantly more frequent in the Non-hypothermia group than in the Hypothermia group (Table 1).

There was a significant difference between groups with regard to the mode of anesthesia performed (Table 2). Spinal was the most frequent method in both groups (Non-hypothermia, 69% *vs* Hypothermia, 86%; $P = 0.004$), followed by epidural anesthesia (Non-hypothermia, 27% *vs* Hypothermia, 9%; $P < 0.001$). The median [IQR] dose of bupivacaine administered intrathecally for spinal or combined spinal-epidural anesthesia was 10 [9-10] mg in both groups ($P = 0.93$, between groups). All spinal and combined spinal-epidural anesthesia procedures were performed in the operating room. Conversely, epidural catheters were placed for labour analgesia and then used to extend epidural analgesia to epidural anesthesia in the delivery room immediately after the decision for CD. There was no significant difference between groups regarding the rate of CDs performed under general anesthesia (Non-hypothermia, 3% *vs* Hypothermia, 1%; $P = 0.69$). The total volume of fluids infused and the use of vasopressors during CD was significantly higher in the Hypothermia group than in the Non-hypothermia group. Maternal temperatures on arrival in the operating room as well as at skin incision were significantly lower in the Hypothermia group than in the Non-hypothermia group (Table 2). No fluid warmer was used in the included population.

According to the multivariate model in which quantitative measurements were considered continuous variables (model 1), five variables were independently associated with maternal hypothermia (Table 3). The total volume of non-heated fluids administered during the surgical procedure was an independent risk factor for

**Table 1** Preoperative characteristics of patients according to hypothermia

| Variable | Non-hypothermia ($n$ = 278) | Hypothermia ($n$ = 81) | $P$ value |
|---|---|---|---|
| Maternal age (yr) | 33 (5) | 33 (6) | 0.58 |
| Body mass index (kg·m$^{-2}$)* | 25.5 [22.6-30.5] | 24.1 [21.4-37.7] | 0.02 |
| ASA physical status | | | 0.38 |
| ASA I | 159 (57%) | 50 (62%) | |
| ASA II | 107 (39%) | 29 (36%) | |
| ASA III | 12 (4%) | 2 (2%) | |
| Maternal comorbidities | | | |
| Obesity* | 78 (28%) | 11 (14%) | 0.01 |
| Asthma | 25 (9%) | 9 (11%) | 0.72 |
| Diabetes mellitus | 21 (8%) | 6 (7%) | 0.85 |
| Hypertension | 5 (2%) | 0 (0%) | 0.59 |
| Hyperthyroidism | 2 (1%) | 0 (0%) | 1.00 |
| Hypothyroidism | 12 (4%) | 3 (4%) | 1.00 |
| Other comorbidities | 30 (11%) | 8 (10%) | 1.00 |
| Gestational age (weeks) | 38.4 [38.3-38.7] | 38.6 [38.3-38.9] | 0.98 |
| CD during labour* | 102 (37%) | 15 (19%) | 0.003 |
| Oxytocin augmentation of labour before CD* | 68 (25%) | 3 (4%) | 0.0001 |
| Duration of preoperative fasting for fluids (hr)* | 8 [4-12] | 10 [6-12] | 0.08 |
| Duration of preoperative fasting for solids (hr) | 13 [11-16] | 13 [10-15] | 0.31 |
| Repeat CD | 130 (47%) | 44 (54%) | 0.28 |
| Placenta previa | 9 (3%) | 0 (0%) | 0.22 |
| Premature rupture of membranes | 20 (7%) | 6 (7%) | 0.86 |
| Preeclampsia | 16 (6%) | 3 (4%) | 0.58 |
| Type of CD* | | | 0.005 |
| Elective | 137 (49%) | 55 (68%) | |
| Urgent | 141 (51%) | 26 (32%) | |

Values are presented as mean (standard deviation), median [interquartile range], or number (%)

* Variables tested in multivariate analysis ($P < 0.1$ in univariate analysis)

ASA = American Society of Anesthesiologists physical status; CD = Cesarean delivery

maternal hypothermia, while obesity, active forced-air warming during CD, increased baseline maternal temperature on arrival in the operating room, and increased maternal temperature at the start of CD were protective factors against hypothermia (Table 3).

After dichotomization of continuous variables (multivariate model 2), the volume of infused non-heated fluids > 650 mL, maternal temperature < 37.1°C on arrival in the operating room, and maternal temperature < 36.6°C at skin incision were significantly associated with intraoperative hypothermia (Table 4). Conversely, the following characteristics were associated with decreased odds of maternal hypothermia: obesity, use of active forced-air warming during CD, and oxytocin augmentation of labour before CD (Table 4).

The area under the ROC curve for the multivariate models to predict inadvertent maternal hypothermia during CD was 0.87 (95% CI, 0.83 to 0.90) for model 1 and 0.85 (95% CI, 0.81 to 0.88) for model 2 (Fig. 2). There was no statistical difference between these two areas ($P$ = 0.17). The results of the Hosmer-Lemeshow test were not statistically significant (model 1, $P$ = 0.99; model 2, $P$ = 0.32), corresponding to good model calibration.

## Discussion

In this study, almost a quarter of the women who underwent a CD presented with hypothermia, as defined by maternal tympanic membrane temperature < 36°C at the end of the skin suture. This result should encourage anesthesiologists to monitor maternal core temperature before and during CD, since maternal hypothermia may lead to several complications,[1-4] including a significant

**Table 2** Intraoperative surgical and anesthetic data according to hypothermia

| Variable | Non-hypothermia ($n$ = 278) | Hypothermia ($n$ = 81) | $P$ value |
|---|---|---|---|
| Mode of anesthesia* | | | 0.03 |
| Spinal anesthesia | 193 (69%) | 70 (86%) | |
| Epidural anesthesia | 75 (27%) | 7 (9%) | |
| Combined spinal-epidural anesthesia | 2 (1%) | 3 (4%) | |
| General anesthesia | 8 (3%) | 1 (1%) | |
| Intraoperative ambient temperature (°C) | 22.1 (0.5) | 22.1 (0.4) | 0.46 |
| Use of active forced-air warming* | 26 (9%) | 6 (7%) | 0.06 |
| Interval from arrival in the operating room to incision (min)* | 19 [13-23] | 20 [17-26] | 0.06 |
| Duration of surgery (min) | 34 [28-41] | 35 [29-49] | 0.15 |
| Intraoperative blood loss (mL) | 350 [200-600] | 300 [200-600] | 0.95 |
| Total volume of fluids infused (mL)* | 575 [400-1,000] | 750 [500-1,000] | 0.02 |
| Use of vasopressors* | 214 (77%) | 76 (94%) | 0.001 |
| Total dose of ephedrine (mg)* | 15 (14) | 21 (14) | <0.001 |
| Total dose of phenylephrine (μg)* | 234 (226) | 334 (223) | 0.0005 |
| Intraoperative blood transfusion | 2 (1%) | 1 (1%) | 0.54 |
| Patient temperature on arrival in the operating room (°C)* | 37.2 [37.0-37.6] | 36.8 [36.5-37.1] | <0.001 |
| Patient temperature at skin incision (°C)* | 37.0 [36.7-37.3] | 36.5 [36.3-36.7] | <0.001 |
| Patient temperature at end of skin suture (°C) | 36.5 [36.2-36.9] | 35.7 [35.5-35.8] | <0.001 |

Values are presented as mean (standard deviation), median [interquartile range], or number (%)

* Variables tested in multivariate analysis ($P < 0.1$ in univariate analysis)

**Table 3** Parameters independently associated* with perioperative maternal hypothermia during Cesarean delivery

| Variable | Adjusted odds ratio | 95% confidence interval | $P$ value |
|---|---|---|---|
| Total volume of fluids infused (per 100 mL) | 1.13 | 1.05 to 1.21 | 0.001 |
| Patient temperature on arrival in the operating room (per °C) | 0.09 | 0.03 to 0.26 | <0.001 |
| Patient temperature at skin incision (per °C) | 0.22 | 0.09 to 0.51 | <0.001 |
| Use of active forced-air warming | 0.15 | 0.05 to 0.48 | 0.001 |
| Obesity | 0.26 | 0.11 to 0.62 | 0.002 |

*Multivariate model 1 in which the quantitative measurements are considered as continuous variables

**Table 4** Parameters independently associated* with perioperative maternal hypothermia during Cesarean delivery

| Variable | Adjusted odds ratio | 95% confidence interval | $P$ value |
|---|---|---|---|
| Total volume of fluids infused > 650 mL | 2.16 | 1.18 to 3.95 | 0.01 |
| Patient temperature on arrival in the operating room < 37.1°C | 3.77 | 1.95 to 7.31 | <0.001 |
| Patient temperature at skin incision < 36.6°C | 4.04 | 2.11 to 7.75 | <0.001 |
| Use of active forced-air warming | 0.28 | 0.10 to 0.78 | 0.01 |
| Obesity | 0.28 | 0.12 to 0.64 | 0.002 |
| Oxytocin augmentation of labour before Cesarean delivery | 0.20 | 0.06 to 0.68 | 0.01 |

*Multivariate model 2 in which the quantitative measurements are categorized as dichotomous variables

increase in blood loss,[3] the main cause of maternal death worldwide.[22]

In our study, maternal temperatures on arrival in the operating room and at skin incision were identified as strongly predictive of maternal hypothermia. These results are in agreement with those previously reported in surgical patients, for whom baseline temperature prior to anesthesia and temperature at the start of the operation were among

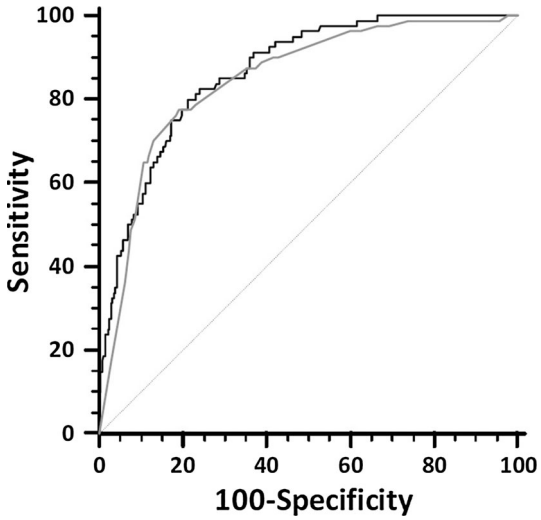


**Fig. 2** Receiver operating characteristic curves of the multivariate logistic regression models 1 (solid black line) and 2 (solid grey line) to predict intraoperative maternal hypothermia during Cesarean delivery. The discontinuous line indicates the line of identity (area under the curve = 0.5)

the most important factors associated with intraoperative hypothermia.[23,24] Hence, reducing the normal core-to-peripheral tissue temperature gradient by warming such patients before induction of anesthesia (active prewarming) would be particularly important in this setting to minimize the consequent redistribution hypothermia. Thus, several studies reported that starting active prewarming with warmed intravenous fluid and / or forced-air warming at least 15 min prior to induction of anesthesia and surgical incision was effective for preventing hypothermia.[7,9,11,13,25,26] Our results suggest starting active warming as soon as possible prior to induction of anesthesia in women with a core temperature < 37.1°C on arrival in the operating room. Importantly, the time spent in hospital and the location of the patient prior to CD, unfortunately not recorded in our study, could have an impact on maternal temperature on arrival in the operating room and thus on maternal hypothermia. For instance, patients undergoing elective CD are most likely kept in a preoperative area with a fairly standard temperature which they may not modify. In contrast, labouring women are most likely admitted in a suitable labour room for perhaps a prolonged period of time where they have elected to modify the temperature to their desired comfort level.

In our cohort, active forced-air warming was performed only during CD and in < 10% of patients in both groups. In fact, despite widespread availability of intravenous fluid warmers and active forced-air warmers in the obstetric operating rooms, these devices are not widely used in routine practice in patients undergoing CD.[15,16] The protective role of active forced-air warming started during CD to prevent the decrease in maternal temperature remains controversial.[7,9,10,12,14,27] This may be related to discrepancies between study designs as concerns anesthesia techniques and warming modalities. In their recent meta-analysis, Sultan *et al.*[6] reported that forced-air warming was associated with a lesser decrease in maternal temperature compared with control groups receiving no active warming, however, without a significant decrease in the incidence of maternal hypothermia. In our study, multivariate analysis showed that applying forced-air warming over the upper torso and arms using a warming unit set at 43°C was effective for preventing maternal hypothermia, although started after induction of anesthesia. Hence, our results suggest that starting forced-air warming during CD remains at least somewhat beneficial for reducing the risk of maternal hypothermia. Consequently, this should be encouraged in clinical practice, even if no active prewarming is performed to prevent redistribution hypothermia.

Another predictive factor for maternal hypothermia was the infusion of > 650 mL of unwarmed fluids during the CD. Yi *et al.* previously reported that an infusion of more than one litre of unwarmed fluid tripled the risk of intraoperative hypothermia during surgical procedures performed under general anesthesia.[23] During CD, intravenous fluid coloading is advocated at the time of spinal anesthesia, in combination with infusion of vasopressors, to prevent maternal hypotension.[28] Hence, women may receive 1-3 L of crystalloid fluids intraoperatively and, consequently, may be significantly cooled.[25,29] In our cohort, the mean volumes infused were substantially < 1,000 mL in both groups, and no fluid warmer was used. Avoiding maternal cooling related to large crystalloid infusions may be achieved, either by limiting the volume of intraoperative fluids infused during CD whenever possible or by using fluid warmers when a large amount of fluid (> 500 mL) is nonetheless required.[5,25]

In the present study, obesity and oxytocin augmentation of labour were associated with a decreased risk of hypothermia. These results are not surprising since oxytocin acts on uterine contractions and thermoregulation[30] while increased body mass index is associated with a reduced incidence of hypothermia in surgical patients.[23,31] In fact, redistribution hypothermia (reduction in maternal temperature during the first hour of anesthesia) may be inversely proportional to the percentage of body fat.[32]

Core hypothermia during CD performed under spinal, epidural, or general anesthesia is mainly related to core-to-peripheral redistribution of body heat.[25] General anesthesia impairs thermoregulation by synchronously reducing the thresholds for vasoconstriction and shivering, and

neuraxial anesthesia also interferes with central thermoregulatory control while preventing vasoconstriction and shivering in blocked areas.[25] These mechanisms lead to a rapid decrease in core temperature during the first hour following the induction of anesthesia.[25] Our novel study analyzes the potential impact of anesthetic technique on hypothermia during CD. The type of neuraxial anesthesia was related to the occurrence of maternal hypothermia in univariate analysis, with an increased proportion of spinal anesthesia and a decreased proportion of epidural anesthesia in the Hypothermia group *vs* the Non-hypothermia group. Nevertheless, according to multivariate analysis, we did not find any influence of the type of neuraxial anesthesia on the incidence of maternal hypothermia. Furthermore, the lack of a relationship between maternal hypothermia and general anesthesia can be related in part to the low rate of general anesthesia performed in our cohort when compared with neuraxial anesthesia techniques. This premise should be confirmed in further trials.

While there is some evidence that intraoperative hypothermia may contribute to perioperative morbidity in the general surgical population,[1-4] there is a lack of data in the literature as to the potential consequences of maternal hypothermia during CD on perioperative maternal and neonatal outcomes. Further research is needed to assess the relationship between hypothermia during CD and perioperative morbidity.

Several limitations of this study need to be considered. First, this was a single-institution study dependent on local patterns relating to the experience of our medical team and intraoperative procedures. Other factors may also act on the intraoperative decrease in maternal temperature and on the incidence of maternal hypothermia during CD and cannot be excluded. For example, in our institution, ambient temperature remains almost constant, around 22 (0.5)°C. Hence, we were unable to find any significant difference in ambient temperature between the Hypothermia and Non-hypothermia groups herein. In contrast, a recent randomized-controlled trial showed a beneficial effect of increasing ambient temperature to 23°C (*vs* 20°C in the control group) on the incidence of maternal hypothermia.[33] External validation is therefore required to assess the generalizability of our findings. The second limitation was the definition of maternal hypothermia based on a tympanic temperature of $< 36$°C. Most studies defined perioperative hypothermia as a core temperature $< 36$°C.[6,8,10,12] Tympanic temperature measurement is largely used in clinical practice[16] because it is a noninvasive convenient tool that is quick to use in awake patients. We used a new generation of infrared tympanic thermometer with good reliability for assessing core temperature.[34] Furthermore, the same thermometer (with disposable sleeves) was used for all patients in order to enhance the reproducibility of the measurements. Another limitation of our study was the lack of standardization in our department concerning the use of forced-air warming to prevent hypothermia. This may be viewed as a potential source of bias for the interpretation of our results and could be at least partly due to the absence of specific recommendations concerning the use of forced-air warmers during CD.

In conclusion, this observational prospective study identified several predictive factors of maternal hypothermia during CD. Obesity, active forced-air warming, and oxytocin augmentation of labour were independently associated with a decreased risk of hypothermia, while baseline maternal core temperature $< 37.1$°C on arrival in the operating room, maternal core temperature $< 36.6$°C at the start of CD, and an infused volume of fluids $> 650$ mL during the surgical procedure were independent risk factors for maternal hypothermia. Strategies for the prevention of maternal hypothermia should focus on these factors, and further studies are required to assess their effectiveness in women undergoing CD. In particular, further studies should seek to determine the optimal warming strategy (prewarming, combination of fluids, and air warming) for preventing maternal hypothermia during CD.

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