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Dubbink-Verheij, G.H.; Westerop, T.A.J.W.M. van; Lopriore, E.; Pas, A.B. te

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ORIGINAL ARTICLE



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Hypothermia during umbilical catheterization in preterm infants

Gerdina H. Dubbink-Verheij , Tjarda A. J. W. M. van Westerop, Enrico Lopriore and Arjan B. te Pas

Department of Pediatrics, Division of Neonatology, Leiden University Medical Center, Leiden, the Netherlands

ABSTRACT

Objective: To describe the effect of umbilical catheterization (UC) on skin temperature and cardiorespiratory status in preterm infants.

Materials and methods: In a prospective observational study of infants <32 weeks of gestation, the duration of UC, course of skin temperature, and cardiorespiratory status were registered. Hypothermia was defined as a temperature below 36.5 °C.

Results: UC was performed in 55 infants with a median (range) gestational age of 28 weeks (24–31) and birth weight of 1120 g (625–2091). Mean (SD) temperature first decreased 0.6 (0.6)°C during UC followed by a rise of 0.4 (0.4)°C after reaching the minimal temperature. Hypothermia already existed in 69% (38/55) of the infants before start of UC, which increased to 89% (49/55) during UC ($p = .001$). Duration of UC was not associated with the development of hypothermia during the procedure ($p = .48$). Heart rate (mean(SD)) significantly increased (162 (17) versus 152 (15); $p < .001$) and there was a trend toward an increase in supplemental oxygen (mean(SD)) (0.31 (0.17) versus 0.28 (0.13); $p = .78$), but both changes were only temporary.

Conclusion: Hypothermia was frequent in preterm infants before start of UC and increased during UC. Postponing UC until the infant has a normal temperature should be considered.

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KEYWORDS

Hypothermia; neonatal intensive care unit; preterm infant; procedures; umbilical catheterization

Introduction

Preterm infants treated in neonatal intensive care units (NICUs) are at increased risk of hypothermia due to increased evaporative heat loss, associated with a large skin-air temperature gradient [1]. Hypothermia present at admission is associated with increased neonatal mortality and morbidity [2–7]. Reducing the risk of hypothermia in the delivery room is therefore of paramount importance and can be achieved using several preventive measures. However, procedures performed in the NICU may also cause or contribute to the development of hypothermia, especially in preterm infants. Although umbilical catheterization (UC) is commonly performed soon after admission to the NICU, little is known about the effect of this procedure on body temperature.

Complications of preterm birth, such as respiratory distress syndrome (RDS), are most likely to occur in the first hours after birth. During these hours, hypothermia can worsen the cardiorespiratory condition of preterm infants. This is because the combination of the procedure and hypothermia can increase the

energy demand on the infant, leading to exhaustion [1,8]. When UC causes hypothermia or worsens existing hypothermia, the necessity of placing umbilical catheters soon after birth should always be weighed against the risk.

To audit our current practice in preventing hypothermia, we evaluated the effect of the UC procedure on skin temperature and cardiorespiratory status.

Materials and methods

We conducted a prospective observational study in preterm infants to evaluate the course of skin temperature during UC. The study was performed at the NICU of the Leiden University Medical Center, a tertiary care center in the Netherlands. All infants born with a gestational age below 32 weeks who received an umbilical (venous and/or arterial) catheter during the study period of 1 December 2015 to 30 September 2016 were eligible for the study. Only infants with no missing temperature values were included. This observational study was reviewed by

CONTACT Gerdina H. Dubbink-Verheij g.h.dubbink-verheij@lumc.nl Division of Neonatology, Department of Pediatrics, Leiden University Medical Center, J6-S, PO Box 9600, Leiden, the Netherlands; Now moved to: Department of Pediatrics, Haaglanden Medical Center, The Hague, the Netherlands

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the Ethics Review Committee of the LUMC. In concordance with Dutch laws and guidelines, a statement of no objection against execution of the study was issued by the Ethics Review Committee.

The procedure of umbilical catheterization was performed with the infant lying on the base of the open incubator. Measures to prevent hypothermia followed the local protocol and included the following:

1. the materials needed for catheterization were prepared before opening the incubator,
2. an infant radiant warmer or heat lamp was placed above the infant,
3. at least 80% of the body of the infant was covered with a sterile surgical cloth drape with a small central aperture, and
4. infants with a gestational age below 26 weeks – and some others, when the caregiver considered it necessary – were covered with an extra plastic isolation blanket with a central aperture underneath the sterile drape to conserve heat

The procedure was performed by caregivers with different level of expertise (residents, nurse practitioners, nurse practitioners in training, neonatologists or neonatal fellows). Inexperienced residents and nurse practitioners were supervised by a neonatologist or neonatal fellow.

The duration of the UC procedure was recorded. Starting time was defined as the moment the incubator was opened, and end of the procedure was defined as the moment the incubator was closed again. After the procedure an anteroposterior chest X-ray was performed to determine the position of the catheter(s). We also recorded the time the chest X-ray was made and the first time the umbilical catheter was used for medication or nutrition. Dates and times were reported by the assisting nurse or the performing caregiver. Hypothermia was defined as a skin temperature below 36.5°C, with 36–36.5°C as mild, 32–36°C as moderate, and below 32°C as severe hypothermia [9].

The following items of the procedure were recorded for every infant: type of umbilical catheter (venous catheter and/or artery catheter), malposition of the catheter, level of experience of the caregiver, and whether other procedures were performed during the time the incubator was open. Gestational age, birth weight, Apgar score, and ventilatory state (including fraction of inspired oxygen and peak inspiratory pressure), were also documented, as well as mortality, intraventricular hemorrhage (IVH) grade 2

or more [10], and RDS defined as the need for surfactant administration.

During UC, heart rate was measured using a Phillips IntelliVue monitor, and skin temperature was measured using a Phillips temperature sensor (Phillips Healthcare Nederland, Eindhoven, The Netherlands) attached with an adhesive hydrogel skin pad (Carefor-me, Dräger, Lübeck, Germany). The ventilatory state of the infant was measured by the ventilator Avea (CareFusion, Houten, the Netherlands). Heart rate, skin temperature, and ventilatory state were collected from start of the procedure until the catheter was used. Baseline characteristics of each infant and clinical data needed were distracted from the electronic patient dossier Metavision (iMD-soft, Leiden, the Netherlands).

Statistical analysis

Statistical analysis was performed with IBM SPSS Statistics version 23 (IBM Software, Armonk, NY, USA). Data are given as median or mean with SD or interquartile range (IQR) unless otherwise indicated. Temperature, heart rate and oxygen at the start and during catheterization were compared with the paired samples *t*-test. Association between the duration of the procedure and the occurrence of hypothermia, temperature decrease, heart rate increase, and increase in supplemental oxygen was determined using a Wald chi-square test. Association between the experience of the performing caregiver and the duration of the procedure was determined using a Kruskal–Wallis test. A Mann–Whitney U-test was used to compare the duration of insertion of an umbilical venous catheter only with duration of insertion of both umbilical catheters. A McNemar test was used to compare the proportion of hypothermia before and during catheterization. *p*-values below .05 were considered significant.

Results

Patient characteristics

During the study period, UC was performed in 100 infants, of which 58 were born below 32 weeks of gestation. In three infants, the temperature values during the procedure were not available. The remaining 55 infants were included in this study: their characteristics are shown in Table 1. 11% of these 55 infants were born below 26 weeks of gestation.

UC was started at median (IQR) 157 (85–335) min after birth. We attempted to place an umbilical venous

catheter (UVC) in all infants and, in addition, an umbilical-artery catheter (UAC) in 48/55 (87%). The procedure was successful in 40/55 (73%) of UVCs and in 36/48 (75%) of UACs. No additional interventions were performed on any infants during the UC procedure, with one exception when acute care for another infant had to be performed by the same caregiver during the period the incubator was open to allow for UC.

Duration of umbilical catheter procedure

The median (IQR) duration of the UC procedure was 30 (24–44) min. There was no difference in duration when a UVC alone was placed or both a UVC and a UAC (43 (15–50) versus 30 (25–41) min; $p = .78$). The duration from start of the procedure until the catheter was used (including waiting time for the chest X-ray to be performed and time needed to reposition catheters if necessary) was 74 (57–110) min.

There was a trend toward decrease in duration of UC when the level of experience of caregivers was higher ($p = .06$; Table 2).

Effect of umbilical catheterization on infant temperature, heart rate and need for oxygen

The mean (SD) skin temperature at the start of UC was 36.1 °C (0.7) and decreased significantly to a minimal temperature of 35.5 °C (0.7) during the procedure ($p < .001$), leading to a mean decrease of -0.6 °C (0.6) (Table 3).

This decrease was followed by an increase of 0.4 °C (0.4) to a temperature of 35.9 °C (0.7) at the end of the procedure. Hypothermia occurred in 49/55 (89%; Table 3) infants during the procedure (mild 9,

moderate 40, severe 0). In 38/55 (69%), hypothermia already existed before the start of the procedure and in 11/55 (20%) hypothermia was new and developed during the procedure ($p = .001$; Figure 1). When hypothermia already existed, the temperature decreased further during the procedure with a mean (SD) of -0.5 °C (0.5). 13/16 (81%) infants with mild hypothermia at the start developed moderate hypothermia during the procedure. No differences were found between temperature at the start of UC, temperature decrease and minimal temperature during UC, and hypothermia before and during UC in infants born below 26 weeks compared to infants born at 26 weeks and older.

The course of temperature during the first 40 min of umbilical catheterization is shown in Figure 2. The lowest temperature value was reached at a different time point in each infant. Figure 2 includes mean temperatures of 55 infants at $t = 0$ min and of 22 infants

Table 3. Temperature values and hypothermia during umbilical catheterization.

	N = 55
Temperature at start of UC	36.1 (0.69)
Minimal temperature during UC	35.5 (0.70)
Temperature decrease during UC	0.6 (0.6)
Hypothermia during UC	49/55 (89)
Mild	9/49 (18)
Moderate	40/49 (82)
Severe	0/49 (0)

Data are represented as mean (SD) or n/N (%). UC umbilical catheterization.

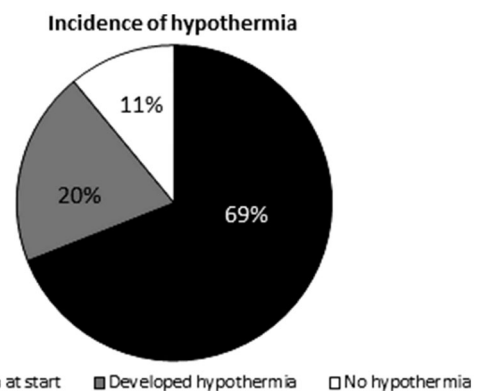


Figure 1. Incidence of hypothermia at start and during umbilical catheterization.

Table 1. Patient characteristics.

Patient characteristics (N = 55)	
Gestational age (weeks)	28 (24–31)
Birth weight (g)	1120 (625–2091)
Apgar score at 5 min	8 (0–10)
Mortality, n (%)	1 (2)
IVH $\geq$ grade 2, n (%)	10 (18)
RDS, n (%)	53 (96)
Mechanical ventilation during catheterization, n (%)	14 (25)

Data are represented as median (range) unless otherwise specified. IVH: intraventricular hemorrhage, RDS: respiratory distress syndrome.

Table 2. Duration of umbilical catheterization.

Performing caregiver	Number of catheterizations	Duration of umbilical catheterization
Resident	30	35 (30–46)
Nurse practitioner	1	23 (–)
Nurse practitioner in training	1	40 (–)
Neonatologist or fellow	16	25.5 (15–32)
Supervised inexperienced caregiver	7	43 (26–50)

Duration is represented as median (IQR) in minutes.

at $t=40$ min, because in 33 infants duration of the procedure was <40 min.

The duration of UC was not associated with temperature decrease ($p=.87$) or with the development of hypothermia during the procedure ($p=.48$).

Mean (SD) heart rate at the start of UC was 152 (15) beats/min, maximum heart rate 162 (17) ($p<.001$) and heart rate at end of UC was 149 (17) beats/min ($p=.20$). Mean (SD) supplemental oxygen at start of UC was 0.28 (0.13), maximal supplemental oxygen during UC was 0.31 (0.17) ($p=.06$), and supplemental oxygen at end of UC was 0.28 (0.13) ($p=.78$). The duration of UC was not associated with increase in heart rate ($p=.10$) or increase in supplemental oxygen ($p=.97$).

Discussion

During UC in preterm infants, body temperature temporarily decreases and heart rate temporarily increases with a trend toward a temporary increase in supplemental oxygen. In this study, hypothermia occurred in 89% of infants during UC. A large proportion of these infants was already hypothermic before the procedure (78%), suggesting that not all infants had been rewarmed adequately before UC was started. No association was found between the duration of the procedure and the development of hypothermia.

To our knowledge, this study is the first to investigate development of hypothermia during UC. Although Fleming et al. [11] report that the temperature at the start and end of UC did not differ in their study, they do not report the temperature during the procedure itself. Ghyselen et al. [12] investigated the

temperature decrease during the insertion of another central venous catheter, which is a peripherally inserted central catheter (PICC). Their study showed that the temperature of infants undergoing this procedure without a wrapping bag generally dropped to hypothermic levels. However, a polyethylene bag was effective in maintaining the temperature at a normal level.

Dongara et al. [13] investigated the duration of insertion of 72 PICCs and 72 UVCs after randomization for the type of catheter. The mean time needed for PICC insertion was 34.1 min (SD 34.7) and 28.3 min (SD 17.2) for UVC insertion. These durations are comparable with the median duration of 30 min we needed to perform UC. In our study, there was a trend toward a longer duration when inserting a UVC only, compared with a UVC and a UAC during the same procedure. However, only 7 infants were given a UVC alone. This group is therefore too small to accurately represent all procedures with only a UVC. Fleming et al. [11] investigated whether bedside ultrasonography would be a more efficient and accurate method for determining umbilical catheter position compared with chest X-ray. The mean time to usage of the catheter was 75 min in 15 infants with ultrasound-guided placement and 139 min in 16 infants with confirmation of position by chest X-ray after standard placement. Despite waiting for confirmation of the position by chest X-ray in our study group, the median duration of 74 min from the start of the procedure to use of the UVC is only a few minutes longer than the duration reported in the ultrasound-guided group of Fleming et al. [11].

Our study has some limitations. The skin temperature of the infants was measured, possibly not giving a reliable reflection of the core temperature. However, in infants with birth weight <2001 g moderate to strong correlation ($r=0.50$ – 0.77) was described by Helder et al. [14] with a 0.27°C (0.03 – 0.51) lower skin temperature (measured at the abdomen as in our department) compared with rectal temperature. Performing caregivers were informed about the registration of the duration of the procedure, possibly leading to a feeling of time pressure and shorter procedures during the study period. The duration from the end of the procedure until use of the catheter is variable, due to different levels of urgency for use of the catheter or logistical reasons causing delay. These reasons were not structurally registered. Another limitation of this study is that variations in temperature, heart rate and oxygen during UC were not compared with the same variations in a control

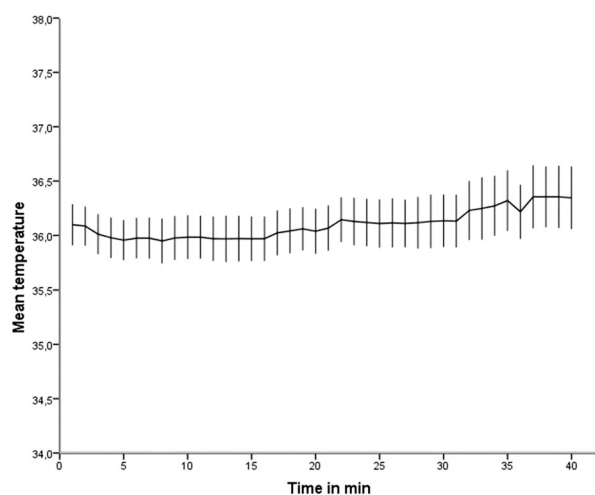


Figure 2. Course of temperature during first 40 min of umbilical catheterization. At $t=0$ $n=55$, at $t=40$ $n=22$. Error bars represent 95% confidence interval.

group of preterm infants without catheterization. We therefore cannot rule out the possibility of comparable variations in preterm infants without UC. However, we expect these parameters, especially skin temperature, to be more stable in infants kept in their incubator without undergoing procedures.

During UC 20% of infants developed hypothermia. To prevent its harmful effects, all efforts were made to keep the temperature of the infant stable during catheterization. This can be achieved by the use of warm gel mattresses and auxiliary heat lamps, and by closing the incubator as soon as the procedure is finished [1]. Wrapping preterm infants in a plastic bag after birth can also prevent hypothermia [15]. Wrapping the infant in a plastic bag with a hole at the level of the umbilicus during the procedure of UC may also be helpful to keep the temperature stable. The use of measures to prevent heat loss in our population is likely to have limited the decrease in temperature and to have led to the rewarming of the infant during the procedure, as shown in Figure 2. However, these measures could not prevent a drop in temperature during the first minutes of the procedure. This drop frequently caused or worsened hypothermia in infants. Tsai et al. [16] report that insertion of a PICC was associated with higher rates of catheter-related complications when the procedure lasted longer than 60 min, compared with instances when it was shorter than 30 min. Limiting the time needed to perform UC may also have beneficial effects. However, we found no correlation between the duration of the procedure and the development of hypothermia or temperature decrease. We generally observed a drop in temperature at the beginning of the procedure. However, the temperature was stabilizing and sometimes rising again in the latter part of the procedure, indicating that a longer duration will not necessarily lead to ongoing temperature decrease. Limiting the duration of the procedure may be more challenging in institutions where trainees perform catheterizations. In our study, a trend toward longer duration of the procedure when performed by less experienced caregivers was observed.

Hypothermia shortly after birth is a frequently observed problem in preterm infants and needs to be avoided. Although UC was performed a median of 2 h and 37 min after birth in our study, 69% of infants were still hypothermic at the moment the procedure started. To achieve intravenous administration of glucose and amino acids within the first hour of life, performing UC during the first “golden hour” of neonatal preterm life is advocated [17,18]. However, as shown

in this study, UC may lead to inadequate rewarming of infants who are already hypothermic after birth. For hypothermic infants, we suggest considering postponing the procedure of UC until the infant has a normal temperature if it is possible to give the infant alternative intravenous access during waiting time that can be inserted more quickly. In these cases, UC is not essential and may even be a harmful step in the first hour(s) of life.

In conclusion, hypothermia is a common condition in infants. It develops during UC in one in five very preterm infants catheterized after birth. In even more infants, however, hypothermia is already present at the start of the procedure, and frequently worsens temporarily during catheterization. Efforts have to be made to prevent the development of hypothermia during catheterization. Moreover, the rewarming of infants after birth needs to be optimized and time should be allowed for this in order to limit the presence of hypothermia after birth even before undergoing procedures at the NICU.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Gerdina H. Dubbink-Verheij  <http://orcid.org/0000-0003-0734-2233>

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