

## Rectal, Axillary or Skin Temperature in Newborns?

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### Abstract

**Background:** Hypothermia in newborns is strongly associated with increased morbidity. Despite its importance, where and how temperature should be measured is not still clearly defined.

**Aim:** To compare sites and instruments for measuring temperature in newborns to estimate differences and limits of agreement.

**Patients:** Sample: 107 healthy term newborns. The temperature was measured in three different body sites (forehead, axilla and rectum), using three different thermometers.

**Results:** Mean  $\pm$  DS rectal temperature was  $36.9 \pm 0.4^\circ\text{C}$ , mean axillary temperature was  $36.5 \pm 0.4^\circ\text{C}$ , mean skin temperature was  $36.1 \pm 0.4^\circ\text{C}$ . The mean rectal-axillary temperature difference was  $0.3^\circ\text{C}$  (limits of agreement  $-0.30$  to  $0.92$ ); the mean axillary-skin difference was  $0.35^\circ\text{C}$  (limits of agreement  $-0.45$  to  $1.17$ ); the rectal-skin difference was  $0.67^\circ\text{C}$  (limits of agreement  $-0.05$  to  $1.40$ ). All the differences between methods are statistically significant. Infants born after a cesarean section had a slightly lower temperature than after vaginal delivery.

**Conclusions:** Observed values of temperature depend on site and type of thermometer used.

Since the measure in different sites produces different results, it seems necessary to define an objective way to assess it. The core-peripheral temperature difference may detect a thermal stress.

**Keywords:** Newborn; Temperature; Cold stress; Reproducibility of results; Skin

### Introduction

An association between neonatal hypothermia and increased morbidity both in healthy neonates and in low birth weight infants has been known since several years [1,2]. Despite its importance, several controversies exist regarding body temperature in neonates. Firstly, the normal temperature range in newborn is not clearly defined, and depends on where and how it is measured. The World Health Organization (WHO) reports the normal "core" temperature to be above  $36.5^\circ\text{C}$ , while temperatures of  $36$  to  $36.4^\circ\text{C}$  are labeled as mild hypothermia, those  $32$  to  $35.9^\circ\text{C}$  as moderate and those  $<32^\circ\text{C}$  as severe hypothermia. According to the WHO, axillary temperature is better than the rectal temperature because of hygiene, safety and ease [3]. In newborns, the presence and degree of hypothermia is an item in assessment of disease severity in several scores such as Clinical Risk Index for Babies II (CRIB) [4] and Score of Neonatal Acute Physiology Perinatal Extension II (SNAPPE) [5], and an item recorded also by the Vermont Oxford Network (VON), but surprisingly its detection method and site are not specified. Although the measurement of rectal temperature was widely considered to be the gold standard for the newborn [6,7], it is slower and more invasive than other alternatives, and because of its risks and drawbacks, the American Academy of Pediatrics (AAP), the National Institute for Health and Clinical Excellence (NICE) and the Italian Pediatric Society (SIP) recommend avoiding rectal temperature and recommend the axillary site instead [8-10].

Because of the recent recall of mercury thermometers [11], companies have increased the range of equipment commercially available for the clinician, specifically reserved for different body site (rectal, skin, axillary), including less invasive methods. Few and conflicting data are available on the performance of thermometers in neonates, and on the exchangeability of temperatures obtained in different sites [12-16]. New Italian guidelines from the Ministry of Health [17] recommend to monitor newborn's temperature immediately after birth, but axillary thermometer could interfere with

mother-infant bonding and breastfeeding, while infrared forehead measurement would not, because of its lack of body contact. Given all these uncertainties, the aim of the study was to compare different instruments for measuring temperature in different sites of the body in a sample of newborns at birth, to estimate differences and limits of agreement.

### Patients

We studied a sample of 107 healthy (i.e not requiring any special care) term newborns. All these newborns had an uneventful delivery, and followed the usual routine of care of our hospital: for the first two hours after delivery, mother and baby were transferred in a post-delivery room with a controlled temperature of  $24^\circ\text{C}$ . During this observation period, the babies stayed with their mothers, covered with clothes after being bathed and dried. After this time mothers and infants were transferred to the ward, where we carried out the measurements.

### Methods

For each infant, the temperature was measured by the same nurse in three different body sites (forehead, axilla and rectum), using three different thermometers specifically designed for each site, at two hours of life. Rectal temperature was assessed by digital thermometer Chicco Artsana; axillary temperature by electronic thermometer

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Kendall Filac 3000, and forehead skin temperature by infrared thermometer Thermofocus 01500 Tecnimed. For the purpose of this study, we defined hypothermia following WHO definitions [3]. Data are expressed as means (SD). For each infant, we calculated the difference between temperature recordings (rectal-axillary; rectal-forehead; axillary-forehead); paired data Student t test was used for between-group comparisons. The limits of agreement between methods were calculated according to Bland and Altman as the mean ( $\pm 2$  SD) of the differences between the three measurements [18]. All calculations were carried out with the statistical package Stata 11.

## Results

Mean birthweight was 3321 g (SD 452 g, range 2210- 4440 g), mean gestational age 38 (SD 1,38 weeks, range 37-41 weeks); 22 infants (20%) were delivered by cesarean section (CS). Mean (DS) rectal temperature was 36.9°C (0.4), (range 35.9- 37.6); mean axillary temperature was 36.5°C (0.4) (range 35.1-37.5); mean forehead skin temperature was 36.1°C (0.4), range 35.4-37.2). Depending on the method and site of measurements, the number of neonates deemed hypothermic was different (Table 1). The comparison between techniques in individual infants are reported in Figure 1; the mean difference between rectal and axillary temperature was 0.31°C (limits of agreement -0.30 to 0.92); the mean difference between axillary and forehead temperature was 0.35°C (limits of agreement -0.45 to 1.17); and that between rectal and skin temperature was 0.67°C (limits of agreement -0.05 to 1.40). All the differences between methods were statistically significant ( $P < 0,001$ ). We never observed a difference between rectal and axillary/forehead temperature greater than 2°C, which could indicate ‘cold stress’ [20]. Temperatures depended on birth weight for all methods ( $p < 0,003$ , by correlation analysis), a kilogram of weight being associated with about 0.3 degrees increase for rectal and axillary temperature, and about 0.15 degrees for skin temperature. Temperature was different by mode of delivery, as measured by all methods: rectal mean temperature in cesarean sections (CS) was 36.6°C (0.3) , in vaginal deliveries was 36.9°C (0.3); axillary mean temperature in CS was 36.2°C (0.4) vs 36.6°C (0.3); skin mean temperature was 36.0°C (0.3) in CS, vs.36.2°C (0.3) in vaginal deliveries. ( $P < 0.05$  for all comparisons). Frequency different degrees of hypothermia according to mode of delivery is shown in Table 1. No adverse events were observed and all the thermometers were judged safe and easy to use by nurses.

## Discussion

We found that the observed values of temperature depend on site of measurement and related type of thermometer used.

In the past, rectal temperature was considered the gold standard to measure core temperature, but due to its drawbacks it is not presently recommended as the routine method of assessing this parameter by scientific societies [8,9,10].

For each couple of measurements, we plotted the difference vs. the mean value (so called Bland-Altman plot) [18]. This technique is generally used to assess the agreement between methods purported to measure the same thing. In this case however, the differences are due to two different sources of variability: that between sites, and that between

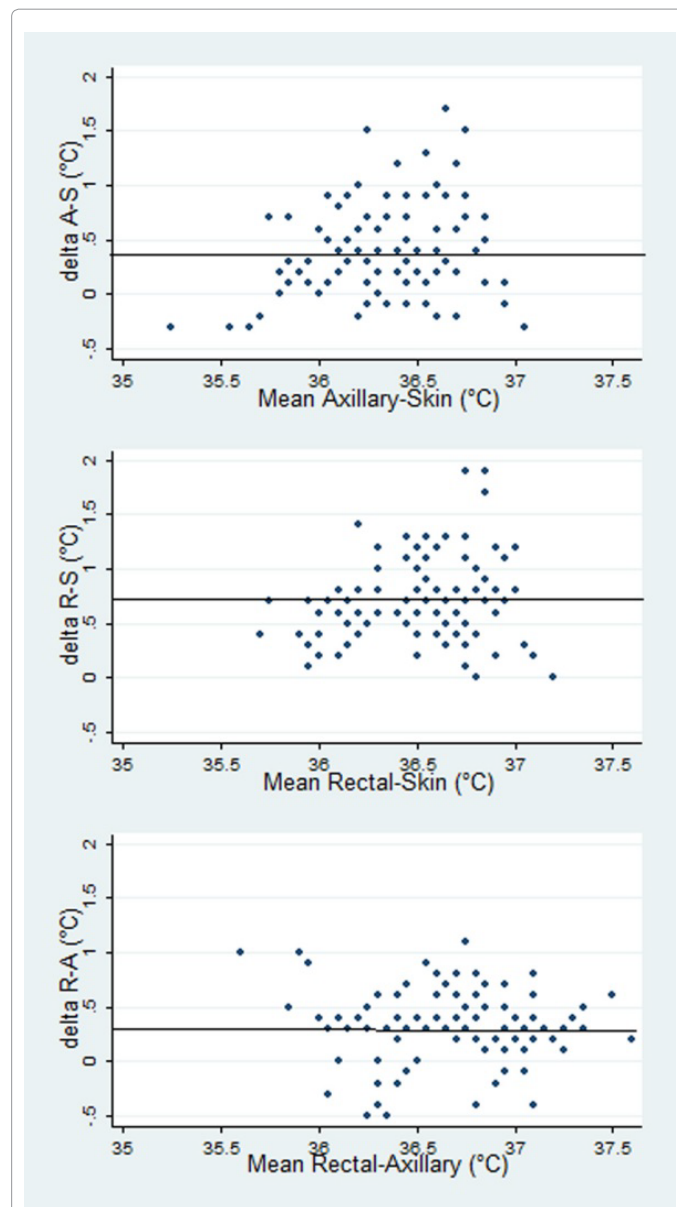


Figure 1: Comparison between techniques in individual infants.

Site	Hypothermia Grade	Cut-Off Value (°C)	All Newborns N= 107*	Vaginal Delivery N= 85*	Cesarean Section N=22*
Rectum	Moderate	<36	1 (1)	1 (1)	0 (0)
	Mild	36-36.4	19 (18)	11 (13)	8 (36)
Axilla	Moderate	36	7 (6)	2 (2)	5 (22)
	Mild	36-36.4	35 (32)	27 (32)	8 (36)
Skin	Moderate (periferal cut-off)	<35.5	2 (2)	0 (0)	2 (9)
	Moderate	<36	32 (30)	24 (28)	8 (36)
	Mild	36-36.4	51 (47)	44 (51)	7 (31)

\*The column reports numbers and percentages.

Table 1: Different measurement sites and percent of patients deemed hypothermic according to different cut-off values.

thermometers, specifically designed for a site. Thus, the limits of agreement are inflated by a systematic difference that probably reflects a biologic phenomenon (e.g., that the forehead is really colder than the rectum). In this study a clear gradient of temperature was observed between rectal, axillary and skin temperature. The difference between axillary and rectal temperature is in agreement with the results of a meta-analysis carried out some years ago comparing sites of measurement, [19] and with traditional wisdom in Italy, that suggests “half a degree” difference between rectal and axillary values, and with some [13,14] but not all [16] studies. As for the difference between forehead and rectal temperature, the same discrepancies occur [15,16]. There are few data on this issue regarding neonates. Unlike Uslu et al. [16], De Curtis et al. [15] found no difference between rectal and infrared skin temperature, in stable preterm and term neonates, at mean age of 15.7 days. The agreement between the two methods could be due to the thermo-neutral environment where preterm infants were maintained. It has been found that preterm infants have a smaller core-surface temperature gradient because of their relative lack of thermal insulation by body fat [13,20]. It is of interest that we found that infants born after a cesarean section had a slight but persistent lower temperature than those after vaginal delivery. The lower temperature in cesarean section is probably due to several causes, including temperature in the operating theatre, and, for elective cesarean sections, the absence of labor, that leads to a reduction in non-shivering thermogenesis in brown adipose tissue [21]. Effects of anaesthetics on the mother’s body temperature were also considered to be responsible [22], but all our CS were carried out in epidural, not general anaesthesia. In conclusion, since the measure of temperature in different body sites produces different results, it is necessary to define a standard way to assess it and to define which is the optimal temperature range in newborns. For an early detection of hypothermia and the related risks, a dual site (axillary-skin) measurement could be useful. A growing concern about Sudden Unexpected Postnatal Collapse (SUPC) requests even more attention on the early post natal period, including temperature measurement in the first hours immediately after birth. Infrared forehead temperature measurement is a non invasive method which does not interfere with infant-mother bonding and breastfeeding, therefore offering a clear advantage over other methods while maintaining a precision comparable to other methods, once the ‘baseline’ difference between methods is taken into account.

#### Author Contributions

GP wrote the first draft of the manuscript. IM and LG contributed to manuscript preparation. GP and LG carried out statistical analyses and prepared tables and figure. All Authors contributed to the overall project design, instrument preparation, acquisition of data, interpretation of the results, and critically revised the paper, and have seen and approved the submission of this version of the manuscript.

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