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ORIGINAL ARTICLE

Performance of axillary and rectal temperature measurement in private pediatric practice

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Abstract

To better understand the role and reliability of axillary temperature measurements in clinical real life, axillary and rectal measurements in infants presenting in a private pediatric practice because of fever were compared. Prospectively, 169 infants (81 girls), median 9 (interquartile range 6–13) months of age, were examined at room temperature (20–24 °C). Two left and two right axillary, as well as two rectal measurements were taken with a digital thermometer and subsequently averaged. The median and interquartile range for axillary and rectal measurements were 36.9 (36.3–37.6) °C and 38.2 (37.4–38.9) °C, respectively ($p < 0.0001$). The limits of agreement in the Bland-Altman plots were 0.32 to 1.98 °C, with a mean bias of 1.15 °C. Axillary thermometers showed a good sensitivity for detecting rectal temperature > 38 °C (95%) but limited specificity (75%), with an area-under-the-curve of 0.95.

Conclusions: Axillary readings are always lower than rectal ones, the limits of agreement are quite wide. Axillary readings can be used for screening but critical measurements should be confirmed by more reliable methods.

What is Known
- *In infants and toddlers, temperature has been traditionally taken rectally.*
- *Axillary measurements are better accepted and are recommended in current guidelines.*

What is New
- *Axillary temperature was always lower than rectal temperature.*
- *The limits of agreement of axillary thermometers are wide.*
- *Axillary thermometers have a good sensitivity but limited specificity and are therefore adequate for fever screening.*

Keywords Children · Measurement · Fever · Infants · Thermometer

Abbreviations

CI	Confidence interval
IQR	Interquartile range
JT	Jan Teller
ROC	Receiver operating characteristics
SD	Standard deviation

Jan Teller and Reto Bernasconi contributed equally to this work.

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Introduction

Up to 30% of pediatrician visits are due to feverish illnesses [1–3]. In infants and toddlers, core temperature has been traditionally taken rectally. However, rectal measurement is to some extent invasive and can sometimes be poorly accepted by children and parents [4]. Newer measurement techniques, like auricular and forehead measurements, have a reduced reliability [5, 6]. A simple alternative used since years and recommended in current guidelines [4, 7], may be the axillary measurement. However, only a few studies were performed in the everyday clinical situation of a community pediatric practice. This investigator-initiated, non-commercially sponsored, observational prospective study aimed at comparing axillary and rectal digital measurements among a sample of infants presenting to their pediatrician because of a febrile illness.

Methods

Infants aged 1 to 24 months of age with no chronic illness presenting to the pediatric practice because of fever between September 1, 2013 and April 30, 2014 were eligible for participation. Repetitive temperature measurements were taken as part of routine quality assessment. After obtaining oral informed consent from the accompanying caregivers, a parent (under the control of their pediatrician and after receiving adequate instructions) took two axillary temperature measurements on the left and two measurements on the right arm. Subsequently, a pediatrician (JT) took two rectal temperature measurements. All measurements were taken at room temperature (20–24 °C) within a maximal timeframe of 5 min. Axillary and rectal temperatures were measured using a Microlife MT1961™ digital thermometer (Microlife, Widnau, Switzerland), appropriately cleaned. In addition to temperature values, age, gender, and diagnosis were annotated in anonymized form. For each location, two measurements were taken and averaged: right axilla, left axilla, and rectum. For study comparisons, the mean of the four axillary measurements was compared with the mean of the two rectal measurements.

Continuous variables are presented as median and interquartile range. The different repeated measurements were compared by means of a Friedman analysis of variance followed by a Dunn's multiple comparisons test. Dichotomous variables were analyzed with the Fisher's exact test. Agreement among axillary and rectal measurements was assessed by means of Bland–Altman plots, that depict the mean bias and its 95% limits of agreement [8]. Rectal temperature was considered as the reference and axillary temperature as the index test. Receiver operating characteristics (ROC) curve analysis was performed to identify the best threshold for detecting the presence of fever. A rectal temperature threshold of 38.0 °C, the most frequently used cut-off point for fever, was applied [5, 9–12]. However, in a sensitivity analysis, a rectal threshold of 38.5 °C was also explored [13]. Statistical significance was assigned at $p < 0.05$. In order to achieve a study power of 80%, setting an α error at 0.05 and assuming a difference between rectal and axillary measures of at least 0.5 °C (38.0 °C vs. 37.5 °C) as well as a standard deviation of 1.5 °C, $n = 126$ patients were needed. Taking into account a conservative drop-out or interruption rate of about 30%, we aimed at recruiting $n = 164$ participants.

Results

One-hundred sixty-nine infants (81 girls, 88 boys), 1 to 23 months of age, were included. Baseline characteristics of study participants are depicted in Table 1.

Figure 1 shows the median and interquartile range (IQR) for temperature measurements obtained by the two investigated measurement locations. The mean of the four axillary measurements was always lower than that of the two rectal measurements (Fig. 1), in median by 1.1 °C (IQR 0.83–1.43, $p < 0.0001$).

The first (median 36.9 °C, IQR 36.3–37.5 °C) and second (median 37.0, IQR 36.3–37.6 °C) left axillary measurements, as well as the first (median 36.7 °C, IQR 36.3–37.5 °C) and

Table 1 Baseline characteristics of the 169 patients included in the study. For continuous data, median and interquartile range are given. Categorical data are presented as absolute number and percentage

N	169	
Age (months)	9	[6–13]
Gender, females:males	81:88	(48%:52%)
Rectal temperature ≥ 38.0 °C	102	(60%)
Rectal temperature ≥ 38.5 °C	48	(28%)
Reason for consulting		
- Fever	93	(55%)
- Fever and cough	69	(41%)
- Fever and dyspnea	3	(1.8%)
- Fever and vomiting	3	(1.8%)
- Fever and earache	1	(0.6%)
Diagnosis		
- Unspecified viral infection	98	(58%)
- Upper respiratory tract infection	29	(17%)
- Obstructive bronchitis	16	(9.5%)
- Otitis media acuta	9	(5.3%)
- RSV bronchiolitis	5	(2.9%)
- Acute gastroenteritis	4	(2.4%)
- Pneumonia	2	(1.2%)
- Streptococcal angina	1	(0.6%)
- Urinary tract infection	1	(0.6%)
- Other	4	(2.4%)

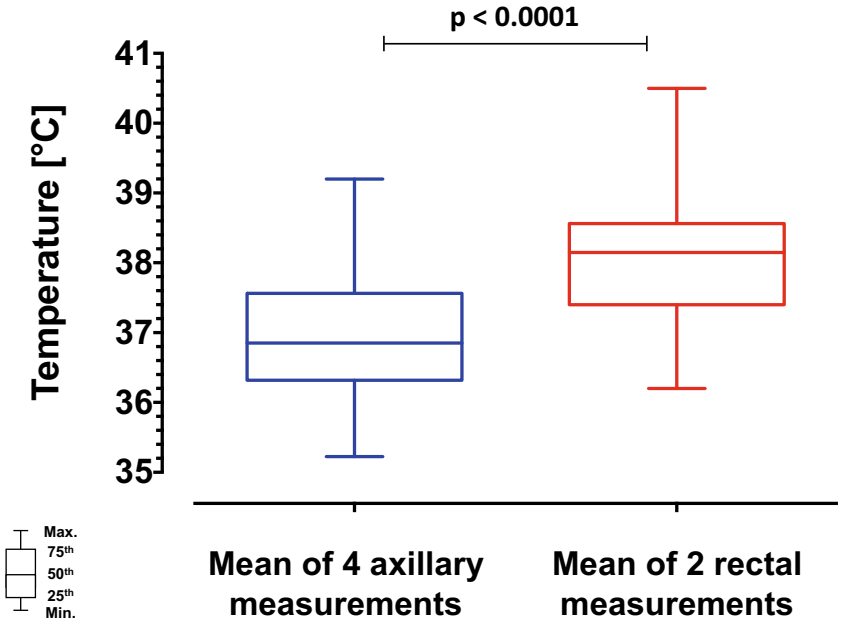

Fig. 1 Box plots depicting the mean of the four axillary and the mean of the two rectal measurements. The mean of the four axillary measurements (median 36.9 °C, interquartile range 36.3–37.6 °C) was always lower than that of the two rectal measurements (median 38.2 °C, interquartile range 37.4–38.9 °C)

second (median 36.9 °C, IQR 36.3–37.7 °C) right axillary measurements were not significantly different. The mean of the two left (median 36.9 °C, IQR 36.3–37.5 °C) and the mean of the two right (median 36.9°, IQR 36.3–37.6 °C) axillary measurements were not significantly different. Also, all other possible paired comparisons among the axillary measurements were not significantly different. The first (median 38.1 °C, IQR 37.3–38.6 °C) and second (median 38.2 °C, IQR 37.4–38.6 °C) rectal measurements were not significantly different. Coefficients of variation of both axillary (2.3%) and rectal (2.3%) measurements were low, demonstrating good reproducibility.

Using Bland-Altman plots to compare the mean of all axillary measurements with the mean of all rectal measurements, the 95% limits of agreement were 0.32 to 1.98 °C, with a mean bias of 1.15 (SD ± 0.42) (Fig. 2).

According to the ROC analysis (Fig. 3), the best threshold in detecting rectal temperature ≥ 38.0 °C was 36.5 °C for the axillary measurements, with a sensitivity of 95.1% (95% CI 88.9–98.4%) and a specificity of 74.6% (95% CI 62.5–84.5%), the area under the curve being 0.95 (95% CI 0.92–0.98, $p < 0.0001$). The best threshold (to apply on axillary readings) in detecting rectal temperature ≥ 38.5 °C was 37.0 °C, with a sensitivity of 91.7% (95% CI 80.0–97.7%) and a specificity of 71.9% (95% CI 63.0–79.7%), the area under the curve being 0.93 (95% CI 0.89–0.98, $p < 0.0001$).

Discussion

In this study, digital axillary measurements were always lower than rectal measurements, in median by about 1.1 °C. This

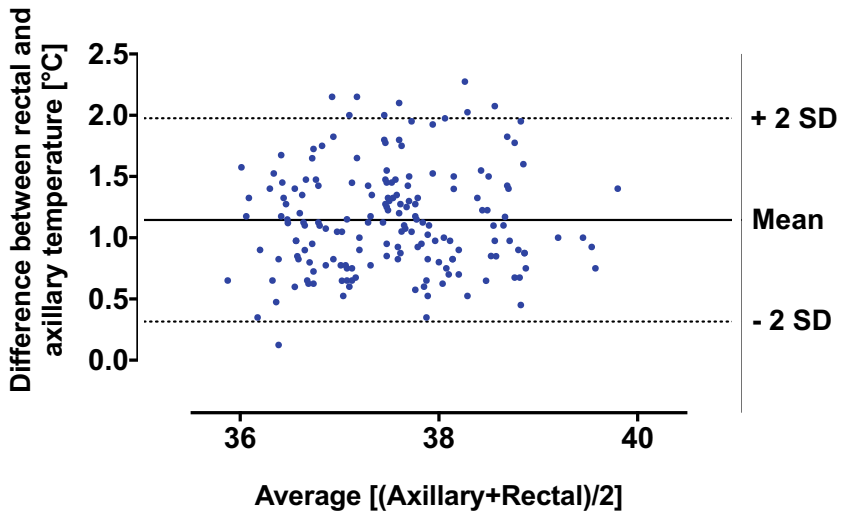

Fig. 2 Bland-Altman plots, displaying the difference between the axillary and rectal measurements against their average. Ideally, the data should be distributed around a mean bias of zero across the range of means (solid line): the smaller the scatter, the greater the agreement. The mean bias was 1.15 (SD ± 0.42) and the 95% limits of agreement (dotted lines) ranged from 0.32 to 1.98 °C. No tendency over the range of differences can be appreciated

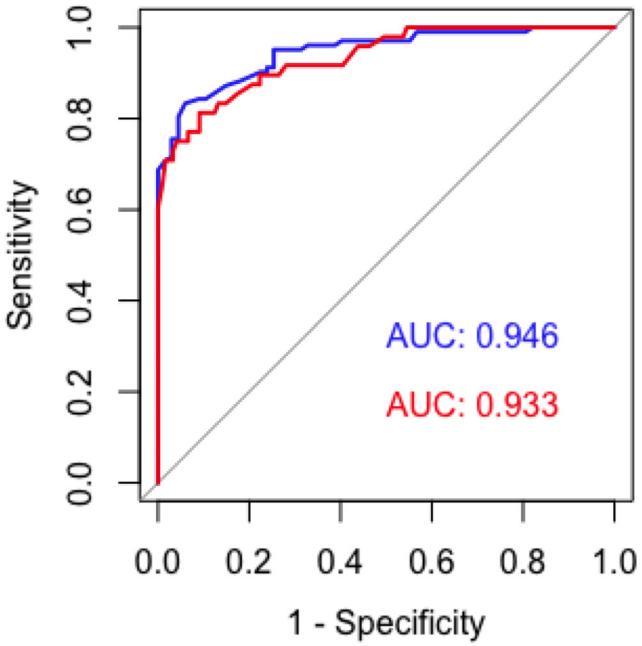

Fig. 3 The receiver operating characteristic (ROC) curves for a rectal fever threshold of 38.0 °C (blue) and 38.5 °C (red) are shown. They graphically depict the diagnostic ability of the axillary temperature measurement in discriminating febrile and afebrile infants. The areas under the curve (AUC) are 0.95 for a rectal temperature threshold of 38.0 °C and 0.93 for a threshold of 38.5 °C, respectively

finding confirms previous work with mercury and digital thermometers [14–16]. Second, limits of agreement were wide, well larger than the 0.5 °C often deemed as acceptable. However, they were narrower than those detected for auricular and forehead thermometers [5]. Third, a receiver-operating-curve analysis detected a quite low axillary temperature threshold to detect fever, as defined as rectal temperature ≥ 38.0 °C. Unsurprisingly, this threshold implied a good sensitivity but a low specificity. Taken together, these results suggest that axillary temperature measurements are adequate for fever screening and may perform better than auricular and forehead measurements [5].

Interestingly, the traditional tenet that axillary (i.e., peripheral) temperatures are about 0.5 °C lower than rectal (i.e., central) temperatures [17] is questioned by the current results, which suggest a bigger discrepancy in everyday clinical life. This may have several explanations. First, while that difference applies to the general population, we analyzed exclusively infants ≤ 24 months of age. This population has a bigger area/volume ratio, which may predispose to greater warmth dissipation (conduction, radiation, convection, evaporation). Second, this work was not a study on temperature values in an unselected general population, but on temperature measurement among ill infants presenting with suspicion of a feverish illness. Third, this result may also be explained by limitations of study performance: it is theoretically conceivable that too much time elapsed between the two measurement locations, allowing the temperature to decrease over time. However, this is extremely unlikely: (1) measurements were first taken axillary, then rectally; (2) no significant differences were detected between the four axillary measurements; (3) examination rooms were warm (20–24 °C). Anyway, this finding is not completely surprising, since previous studies among children already found differences up to 0.98 °C [14, 15, 18], that are not so far away from the 1.1 °C detected in the current study among infants.

This study has several strengths. First, it was performed in a private pediatric practice, thus mirroring the most frequent situation encountered in everyday clinical life. Second, repeated measurements were performed, showing good reproducibility of both axillary and rectal measurements. Third, this study included children consulting for feverish illnesses, i.e., the population of greatest interest when assessing temperature measurement techniques and devices.

This study also has some limitations. First, the insertion depth of the rectal thermometer was neither assessed nor standardized. However, measurements were performed by a pediatrician, both warranting appropriateness and safety. Second, this study included only infants ≤ 24 months of age. Thus, these results cannot be automatically generalized to older children or adults. Third and similarly, since only outpatients consulting their general pediatrician were included, a generalization to inpatients, emergency department visits, or home measurement by parents should be avoided. Finally, no patient with recurrent fever syndromes (a possibly different situation) was included in this study (Table 1) [19].

In conclusion, this study showed that axillary temperature measurements with a digital thermometer do not accurately mirror rectal temperature. However, having a good sensitivity, they can be used for fever screening in private pediatric practice. Together with previous works [5], these data show that we still not dispose about reliable non-invasive temperature measurement techniques in infants ≤ 24 months and rectal temperature measurement remains important when accurate measurements are needed. Most of all, temperature readings should be interpreted in the global clinical context [5].

Authors' contributions - Study concept and design: JT, SAGL
- Consent, Recruitment, Study execution: JT
- Statistical analysis: RB, SAGL
- Review of the literature, Preparation of the figures, Drafting of the manuscript: RB, SAGL
- Critical revision of the manuscript: GDS, SAGL
- Approval of the final manuscript: JT, RB, GDS, SAGL

Compliance with ethical standards

Conflict of Interest The authors declare that they have no conflict of interest.

Research involving human participants and/or animals This project was performed in the context of a routine quality assessment. All

procedures performed were in accordance with ethical standards as laid down in the 1964 Helsinki declaration.

Informed consent Caregivers received information on the study and (anonymous) study participation and had to give oral consent in order for their children to be enrolled in the study. Since only infants < 24 months of age were included, children assent was not required.

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