Accuracy of The Axillary Temperature Screening Compared to Core Rectal Temperature.

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Abstract

Purpose

To compare the sensitivity of axillary and rectal temperature in infants who presents to the emergency department with a recent history of fever in order to implement an early diagnostic modality to reduce risk of sepsis, urgency in antibiotic administration and decrease the need for delayed hospital admission.

Methods

A single-centre prospective nested control study of 201 patients who presents with a recent history of fever. Infants Up to 12 months of age were included. Any patient with the following comorbidities were excluded: (1) Haematological malignancy (2) immunocompromised (3) hyperthyroidism (4) recent administration of antipyretics medications and (5) congenital anal or rectal malformation. Demographic characteristics such as age and gender, weight, mean axillary and rectal temperatures were documented. Fever is defined as rectal temperature > 38 C as opposed to > 37.4 in the axillary method. Pearson's correlation between axillary and rectal temperatures was determined.

Results

The mean age was 6.1 ± 3.5 months. The study had 111 (55.2%) males and 90 (44.8%) females. The mean weight was 7.4 Kg ± 2.1 Kg. The mean (SD) rectal-axillary temperature difference was 0.8°C ± 0.7°C which was statistically significant (P < 0.001The sensitivity, specificity, positive predictive and negative predictive values of the axillary method for fever > 37.4 were 79.34% (95% CI [73-84.9]), 14.3% (95% CI [0.36–57.9]), 96.2% (95% CI [95-97.2]) and 2.4% (95% CI [0.4–13.5]), respectively. On the other hand, the sensitivity, specificity, PPV, NPV of the rectal temperature method for fever > 38 were 99.5% (95% CI [97.1–99.9]), 100% (95% CI [54–100]), 100% and 85.7% (95% CI [45.9–97.6]), respectively.

Conclusion

the axillary temperature measurement method is not as accurate as the rectal temperature method for the detection of fever in infants with a recent history of fever. The rectal method remains highly important for accurate and prompt diagnosis.

Introduction

Fever is a paramount vital sign that indicate illness in infants (1, 2). Accurate temperature measurement is important especially in infants where higher likelihood of sepsis and hospital admission is a concern (3). Core body temperature is considered the gold standard measure in establishing the diagnosis of fever represented by either the oral or the rectal routes. The most reliable site of core body

temperature measurement is the pulmonary artery due to its closest to the thermoregulatory center. The bladder, oesophagus and trachea are also other means of measure. Despite being tremendously accurate, these methods are invasive and not feasible in standard settings. (4) Multiple other measures have been also used as alternatives to detect fever such as axillary, tympanic and forehead methods due to their readily availability, no risk of perforation, non-invasiveness and little need for patient cooperation, feasibly and easy utilization. (5) Although they pose a wide range of advantages, controversy remains ongoing with regards to their reliability in detecting fever especially in febrile infants.

A considerable amount of literature showed a concern on the accuracy of axillary method due to poor sensitivity as opposed to rectal temperature which cannot be used interchangeably (3, 6-11). Some pediatricians also suggest that AT is accurate enough in detecting fever (2, 12, 13). However, it has been shown that a high number of false negative results have been reported when the AT method is used especially in infants according to the current standard practice. Despite the controversy, WHO recommend the use of the AT method because of hygiene, safety and perforation risk in the rectal method. Furthermore, recent NICE and paediatrics Italian society guidelines update also recommend against routine use of rectal temperature method and encourage the use of AT measurement in children below the age of five despite the ongoing controversy (14-17).

In the present study, we will prospectively compare the sensitivity of AT and RT in infants who presents to the emergency department in Al-Yamamah Hospital, Riyadh with recent history of fever in order to implement a proper diagnostic approach to reduce risk of sepsis, urgency in antibiotic administration and decrease the need for delayed hospital admission. We hypothesize that the AT is significantly unreliable to detect fever in febrile infants due to high false negative rate.

Methods

Approval from the institutional review board (IRB) of King Fahad Medical City (KFMC) was obtained [1RB00010471]. Informed consent was waived due to nature of the study. Up to 12 months of age were included. The study was single-centre prospective nested control. Inquiry about the number of patients presented to the paediatric emergency department in Al-Yamamah hospital, Riyadh, Saudi Arabia with history of recent onset fever from February 2021 until September 2021 yielded a total of 201 patients. All 201 patients had to be confirmed to have fever in order to be included in the study. Patients who were afebrile despite the original subjective complain were excluded. The clinical ER triage sheets were evaluated by two investigators who managed to obtain all baseline characteristics variables. Any patient with the following comorbidities were excluded: (1) Haematological malignancy (2) immunocompromised (3) hyperthyroidism (4) imperforated anus (5) recent administration of antipyretics medications (6) congenital anal or rectal malformation. None of the reviewers were involved in any medical care for the patients included. Baseline characteristics such as age, gender, weight were noted. The temperature was measured for each patient using both the axillary and rectal methods at the same time. Fever is defined as RT > 38 C as opposed to >37.5 for AT (18). Nevertheless, several cut-off values

were considered for AT ranging from 37.2 °C to 37.5 °C to identify changes in the accuracy of temperature agreements between the two methods (19) .

Statistical Analysis:

Continuous variables with a normal distribution were represented as mean ± standard deviation (SD). Categorical variables were depicted as numbers and percentages. Test of normality checked by Kolmogorov Smirnov test. ROC (Receiver operating characteristics) was carried out to determine the sensitivity and specificity of axillary and rectal temperature test for robust and accurate measurement of fever. Cross tabulation was used to predict sensitivity, specificity, PPV and NPV when applicable. Paired sample t-test was used to compare the differences between temperature readings that are normally distributed. Pearson's correlation between axillary and rectal temperatures was determined. The degree of agreement was evaluated using the Bland-Altman method. $P < 0.05$ was considered statistically significant. 95% confidence interval (CI) and p-value were obtained for the independent variables. Data analysis was carried out by SPSS 25.0 (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.).

Results

The 201 infants who were considered for the analysis had a mean age of 6.1 ± 3.5 months. The study had 111 (55.2%) males and 90 (44.8%) females. The mean weight was 7.4 Kg ± 2.1 Kg. All infants underwent axillary followed by RT measurement upon triage in the emergency department. The (IQR) for age at triage was 6.12 months. Demographic characteristics of infants enrolled in the analysis are shown in Table 1. In order to establish the optimal cut-off/threshold values of axillary fever to determine the best sensitivity and specificity for the study test, we performed ROC analysis by plotting sensitivity against 100-specificity at different cut-off values of axillary temperature. By using, the value axillary temperature > 37.4 detect the positive case of axillary fever.

Table 1
Demographic characteristics of infants enrolled in the study (N = 201)

Variables	(Mean ± SD)
Age in months	6.1 ± 3.5
Male/Female	111/90
Weight (Kg)	7.33 ± 2.15
Axillary Temperature	37.9 ± 0.7
Rectal Temperature	38.7 ± 0.6

The mean (SD) rectal-axillary temperature difference was 0.8°C ± 0.7°C which was statistically significant ($P < 0.001$). The range of temperature difference from the mean was − 0.7°C to 0.9°C. The Bland-Altman

plot was constructed to show the level of agreement between each axillary and rectal readings (Fig. 2).

The sensitivity, specificity, PPV NPV of the AT for fever > 37.4 were 79.34% (95% CI [73-84.9]), 14.3% (95% CI [0.36–57.9]), 96.2% (95% CI [95-97.2]) and 2.4% (95% CI [0.4–13.5]), respectively. On the other hand, the sensitivity, specificity, PPV, NPV of RT method for fever > 38 were 99.5% (95% CI [97.1–99.9]), 100% (95% CI [54–100]), 100% and 85.7% (95% CI [45.9–97.6]), respectively. Some of the diagnostic parameters for the axillary methods based on different age groups are shown in Table 2.

Table 2
Sensitivity and PPV of the axillary method according to different age groups.

Age group	N (%)	Sensitivity (%, 95% CI)	PPV (%, 95% CI)
< 3 Months	34 (21.4)	90.4 (76.9–97.2)	95 (94.4–95.3)
3–6 Months	47 (23.4)	76.6 (62–88)	100
> 6 Months	111 (55.2)	76.4 (67.1–84.1)	95.3 (92.8–97)
*Statistically significant at 5% level			

Discussion

Fever is a very common complaint that is encountered almost daily in any emergency department (20). Accurate temperature measurement is crucial in order to minimise risk of sepsis in infancy. Despite explicit research about the safety and accuracy of AT measurement method, limited published data about how accurate the AT method compared to RT in detecting fever is available for infants. Moreover, AT has been widely used for fever screening in paediatric emergency departments due to safety, hygiene and convenience for patients, families and the nursing staff. However, a concern regarding high false-negative rates (21) especially when the heart rate is elevated renders paediatricians to doubt the accuracy of AT and require the use of core temperature measurement such as the rectal method. The sensitivity of the AT compared to RT has not been investigated extensively in the infants age group. In addition, information about the association between infant age groups and level of AT sensitivity is minimal. Most published data were merely on newborns and neonates (10, 22-26). Our study explicitly investigates the accuracy of AT measurement compared to the gold standard RT. We believe that AT screening carries a substantial risk of missing the diagnosis of febrile infant. To our knowledge, this is the first study to delineate the importance of specifically using RT for any infants who presents to the emergency department with a recent history of fever.

The relationship between the RT and AT was assessed using the Bland-Altman analysis. It shows a mean difference of 0.8 °C with a 95% CI range of ± 1.5 °C which indicates a large difference between the two methods. The difference is considered significant due to a narrow range of normal temperature between 36.5-37.5 °C (18). The febrile infants would be more likely to be missed if the difference was up to 1.5 °C

with such a narrow normal range for AT allowing them to succumb to complications. The first to show poor agreements between AT and RT was a meta-analysis done by Craig et al (27), pooled mean rectal-axillary temperature measurements difference was 0.25 °C for mercury thermometers (95% CI, -1.5-0.65) and 0.85 °C (95% CI, 0.19- 1.9) for the electronic thermometer. The latter reflects a similar result found in our study for the electronic thermometer. The majority of studies included in the pooled analysis of the electronic thermometer were performed on young children other than neonates allowing for more consistency to our findings. Although the mercury thermometer seems to provide a more accurate agreement between the two methods, it's no longer being used due to fear of mercury toxicity and has been replaced by a more convenient and safer digital thermometer (28). Furthermore, a recent study by Teller et al(29) performed on children < 24 months presenting with fever also discovered a rectal-axillary mean difference of 1.1°C with 95% limit of agreement between 0.32-1.98 °C which confirm our findings.

Jones et al (30) conducted a study on 573 children under the age of five on Gambia, West Africa. They found 98% sensitivity of AT for the detection of fever. Although the sensitivity is extremely high, the authors argues that the reason for is due to the high prevalence of tropical infectious diseases such as malaria in Africa. Tropical infectious diseases are well known to present with a high-grade fever allowing for a higher likelihood of detection by the axillary method. On the contrary, several other studies performed on infants report a various sensitivity to our study (73% (2), 81% (31), 64% (28), 62% (32), and 49%(21)). The reason for this variation might be attributed to the measurement device that has been used, the different age groups enrolled, different ambient temperatures or children weight difference for height. It has been shown in multiple subgroup analysis that neonatal fever was detected with a high sensitivity by the axillary method resembling similar findings to our study (11, 32). Thus, a potential effect on accuracy is possible when considering the age factor.

Our analysis suggests that AT is less sensitive at detecting fever >35.4 °C upon patient triage in the emergency department. It may miss approximately 20% of infants with rectal hyperthermia. Shine et al (33) performed a comparison analysis exactly similar to our study and found nearly comparable results (29% false negative rate using AT). Subgroup analysis suggests that the AT is quite sensitive for infants <3 months as opposed to markedly decreasing sensitivity for infants in the older age groups. The latter finding was also reported in another studies (11, 33). An explanation for this difference may be related to body weight. Children with a low weight for height seems to have less wider range between the two methods compared to children with an average weight for heigh. Another explanation is a possible difference in the physiological mechanisms of thermoregulation for each age groups. Further investigation into this aspect should be sought for future studies.

To allow for a more convenient temperature measurement for families and healthcare providers, several lower than the normal cut-off value may be considered for AT measurement ranging from 37.2 °C to 37.4/ 37.5 °C. Lowering the cut-off value for the diagnosis of fever would substantially decrease the false negative rate. AT of 37.4/ 37.5 °C, 37.3 °C, 37.2°C showed a sensitivity of 79%, 83%, and 86% respectively.

Limitations:

Several limitations in our study should be taken into consideration. Almost all patients included in the study are febrile and the design of the study is prospective nested control. It may have an impact on increasing the sensitivity level. However, that was not observed in our analysis and the result reflects similar findings from other studies. Furthermore, the measurement of temperature may be affected by subjective techniques performed by the nursing staff. Some patients were excluded from the study due to a lack of rectal temperature readings.

In conclusion, the axillary temperature measurement represents a poor screening method and should not be considered accurate enough as an alternative to the rectal temperature method for the detection of fever in infants with a recent history of fever. The rectal method remains highly important for accurate and early diagnosis in the clinical context of suspected underlying infectious or inflammatory processes.

Abbreviation

Axillary temperature (AT), Rectal temperature (RT), Positive predictive value (PPV), Negative predictive value (NPV) and Confidence interval (CI).

Declarations

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Conflict of Interest: The authors declare no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. IRB [1-056C]. IRB registration Number with KACST, KSA: H-01-R-012. IRB registration number U.S. Department of HHS IORG: 1RB0001047.

Informed consent: Informed consent was waived due to the nature of the study.

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Figures

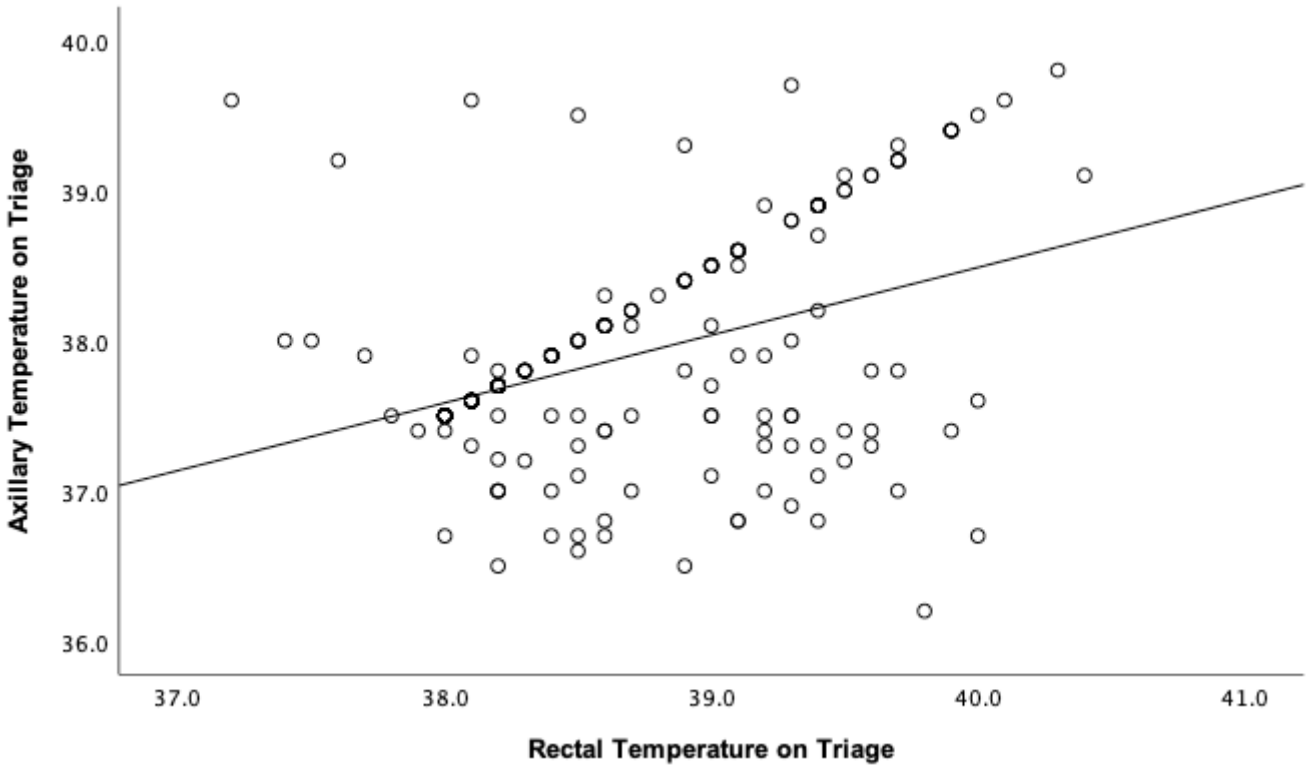

Figure 1

Scatterplot of rectal and axillary temperatures in the pediatric emergency department triage setting (n=201). (Pearson's correlation R=0.4, P<0.001).

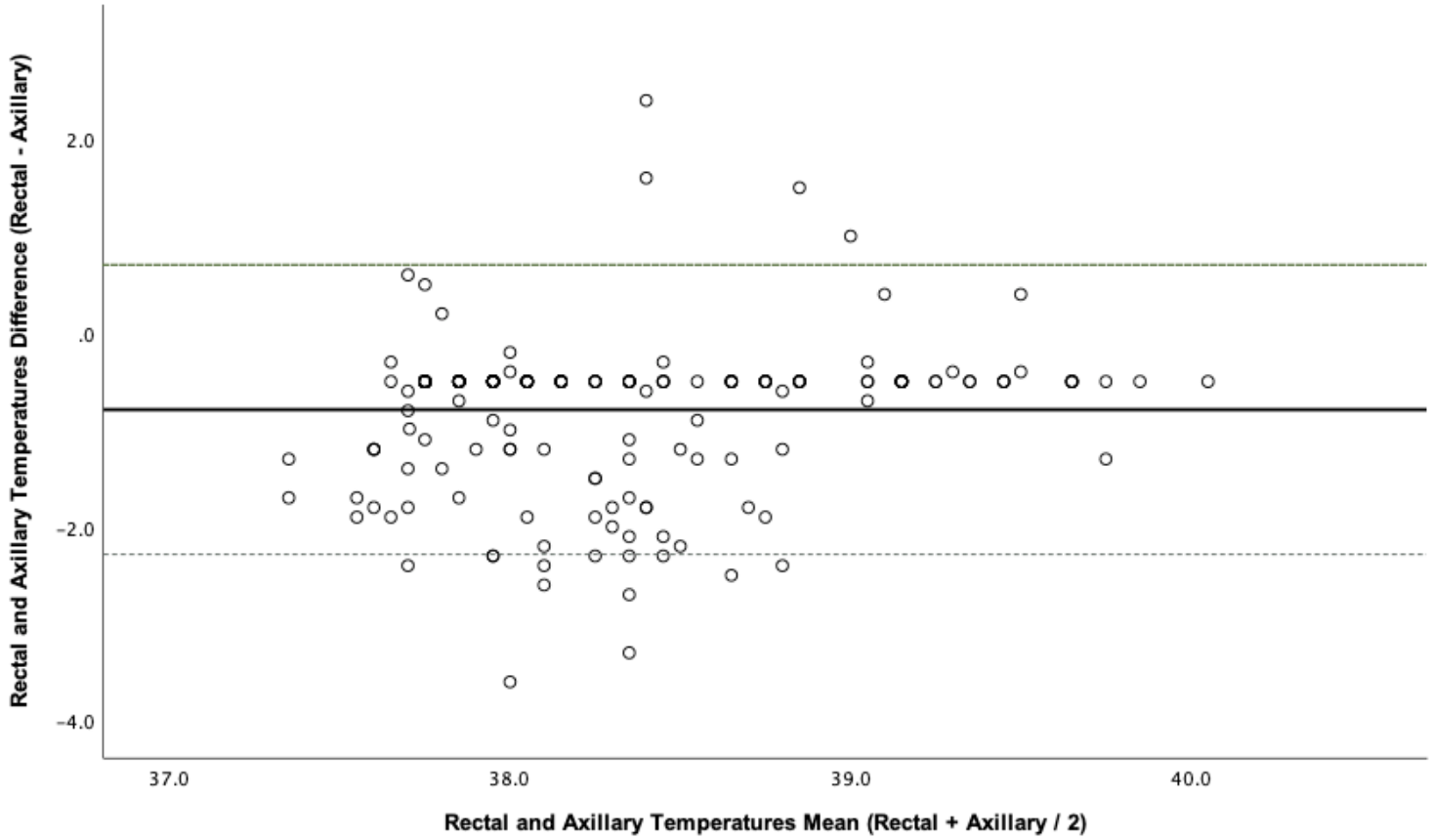

Figure 2

Scatterplot of the Bland-Altman method for rectal and axillary temperatures measurements in pediatric emergency department triage. The solid line illustrates the mean difference of both rectal and axillary and the dashed lines illustrate the 95% agreement limits.