Original Article

Comparison between temporal and rectal temperature measurement

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ABSTRACT

Introduction: Various digital thermometers for non-invasive use have been used increasingly in Danish hospitals, including the temporal artery thermometer (TAT). However, previous studies have concluded that the accuracy of the TAT is unsatisfying for paediatric, surgical, cancer and intensive care patients. The purpose of this study was to compare the accuracy of the TAT with that of a conventional rectal thermometer (REC) within acutely admitted medical patients at an emergency department.

Methods: This was a prospective, comparative study. For two months, 381 patients were included. At a maximum interval of seven minutes, the temperature was measured first with a temporal artery thermometer and then with an REC. The measurements were analysed in a Bland-Altman plot, and the sensitivity and specificity of the TAT were calculated.

Results: The differences between the TAT and the REC ranged from −1.7 °C to 1.7 °C. The mean of the difference was drawn in the Bland-Altman plot through 0.17 with a standard deviation of ± 0.47. The sensitivity and specificity were calculated to 67% and 96%, respectively.

Conclusions: Based on this study, we do not recommend the use of the TAT as an alternative to an REC for non-invasive measuring of the body temperature in acutely admitted medical patients.

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Trial registration: Study procedures were approved by the local ethical committee and submitted to www.clinicaltrials.org (NCT01817881).

In Denmark, rectal measurement of body temperature is considered equivalent to an invasive measure [1]. However, in addition to patient discomfort [2], the privacy requirements of rectal temperature measurement are inherently more resource demanding than non-invasive methods. This is particularly problematic during the initial triage in the emergency department (ED) before the patient is admitted to a hospital bed. The body temperature is used systematically combined with saturation, respiration rate, blood pressure and pulse to create an early warning score used to rate, evaluate and identify critical diseases in patients [3]. Hence, body temperature contributes to establishing parameters for diagnosis, treatment and evaluation of care and treatment.

Over the past ten years, various digital thermometers for non-invasive use have been used increasingly in Danish hospitals, including the temporal artery thermometer (TAT). Because of its ease of use and disinfection, the TAT is a convenient alternative to rectal measurements, which matches the functional demands of the ED.

However, despite local incidences in which TAT measurements incorrectly identified patients as normothermic, in-house non-published research and recent systematic reviews and meta-analyses [4, 5] concluding that the TAT is not sufficiently accurate to replace rectal temperature measurement, TAT is still being used. This has raised concern of potentially compromised patient safety and need of renewed attention to the use of TAT as an alternative to rectal measurements.

Current literature on the use of non-invasive temperature measurements [4, 5] is primarily based on studies performed on surgical, intensive care unit or paediatric patients. Only few studies have been performed on adults (≥ 75 years) at the ED presenting with a medical issue [6, 7]. These studies found that TAT had a low diagnostic accuracy. Similar results were found more recently in cancer patients [8] and in a geriatric cohort [9]. The latter study argued that TAT measurements should be used only in special circumstances when rectal or oral measurements are impractical.

To renew attention to this important topic and to add to generalisability, we designed a study using our previously collected but unpublished data with the aim of comparing temporal and rectal measurements of body temperature in adults (≥ 18 years) presenting with medical issues at our ED.

METHODS

This was a prospective comparative study of body temperature measurements using the TAT and a conventional digital rectal thermometer (REC).

The study was conducted from March to April 2013 at the ED, at Bispebjerg and Frederiksberg Hospital. All patients presenting in daytime on weekdays were screened for eligibility. The inclusion criteria were age ≥ 18 years and informed consent. The exclusion criteria were cognitive impairment (due to inability to give informed consent and receive instructions about the REC measurement procedure), constipation, rectum removed surgically and anal disorders such as haemorrhoids or wounds, which would cause discomfort for the patient during the rectal measurement.

A total of 385 (59%) patients were included in the study. Four patients were excluded due to constipation found during the measurement of the rectal temperature. Hence, the analysis was completed on 381 patients with data on both temporal and rectal temperature measurements.

Measurements of temporal artery temperature were collected with an infrared thermometer, and the rectal measurements were collected using a digital REC. Both instruments were unused prior to the initiation of the study and were used according to the manufacturer's instructions. Hygienic precautions from the hospital and the manufacturers were followed.

The TAT calculates body temperature based on a peak of a forehead scan, measuring skin temperature just above the temporal artery and its surroundings [2]. The rectal temperature was measured approximately 1.5 cm proximally to the anal sphincter. The measurements were read on the displays and immediately written on a prefabricated chart.

The two measurements were performed immediately after each other with no more than seven minutes separating them. In all cases, the TAT was performed before the digital REC. This approach was used because digital REC is considered the "gold standard", and the initial measurement of TAT eliminated any expectations of the result before measurement. The data were recorded in °C. To minimise measurement bias and potential inter-user variation, the same clinical nurse specialist conducted all measurements.

Bland-Altman analysis was used to analyse the difference between the two measuring methods [10-12]. The

limits of agreement (LOA) frames the interval where 95% of the differences between the temperatures measured by TAT and digital REC transpires. Prior to the data collection, the maximum allowed difference between the two measurements was set to ± 0.3 °C [11]. In addition, the sensitivity and specificity of the TAT measurements were evaluated. Fever was defined as a temperature ≥ 38.0 °C. The model assumption of normal distribution between the differences was tested.

Trial registration: Study procedures were approved by the local ethical committee and submitted to www.clinicaltrials.org (NCT01817881).

RESULTS

In total, TAT and rectal measurements were obtained from 381 patients. The differences between the two measurements are shown in the Bland-Altman plot (**Figure 1**). Mean of difference is 0.17 (95% confidence interval (CI): 0.13-0.2) and the LOA was 0.77-1.11. The maximum differences measured were +1.17 °C and –1.17 °C.

The positive bias and the wide range seem to be due to mean measures < 38 °C, whereas for higher means, data were closer together. For the nine hypothermic patients (rectal temperature < 36 °C), differences were all with a positive value and none were identified as hypothermic by the TAT (Figure 1).

The standard deviation (SD) of the differences was ± 0.47, indicating a wider variation of measures than the initially established clinically acceptable range of ± 0.3 °C. In 202 patients (53%), the measurements deviated by less than the defined limit of ± 0.3 °C and in 283 (74%) by less than ± 0.5 °C (**Figure 2**). In 16 patients (4%), measurements deviated by > 1 °C.

Table 1 shows the number of patients identified with a temperature below/above 38 °C measured with a digital REC and by TAT, respectively. Thirty-six patients were identified as having a fever (rectal temperature ≥ 38 °C), and 345 had a rectal temperature < 38 °C measured. The TAT identified 24 and 331 of those, respectively. Hence, the sensitivity of the TAT was 66.7% (95% CI: 49.0-81.4%) and the specificity was 95.9% (95% CI: 93.3-97.8%). Thus, the positive predictive value (PPV) of the TAT was 63.2% (95% CI: 46.0-78.2%) and the negative predictive value (NPV) was 96.5% (95% CI: 94.0-98.2%).

FIGURE 1 / Bland-Altman plot of the difference between temperature measured by temporal artery thermometers and rectal thermometers.

Difference, °C

Mean temperature of both methods, °C

— Mean
— Mean – 2 SD
— Mean + 2 SD
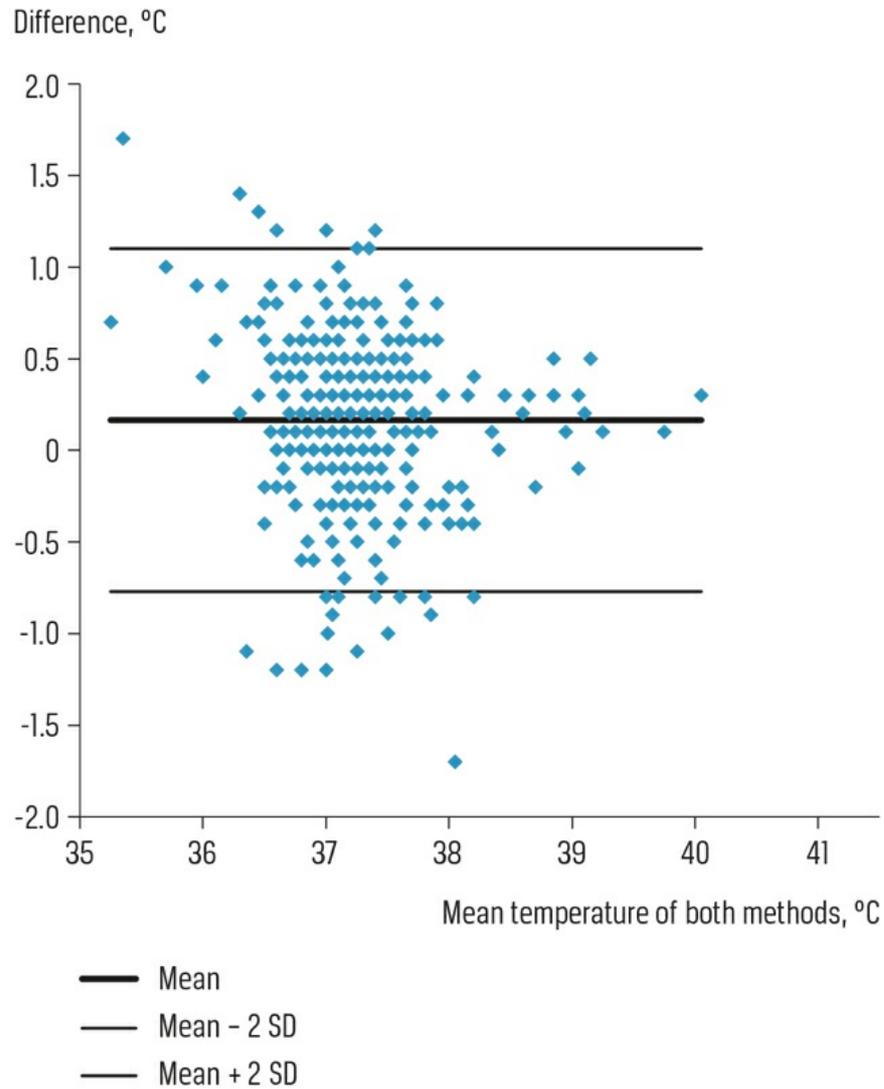
SD = standard deviation; TAT = temporal artery thermometer.

FIGURE 2 / Cumulated spread of the differences in 0.1 °C intervals. The red dotted line marks the defined maximum allowed difference between the temporal artery thermometer temperature and the rectal temperature at 0.3 °C.
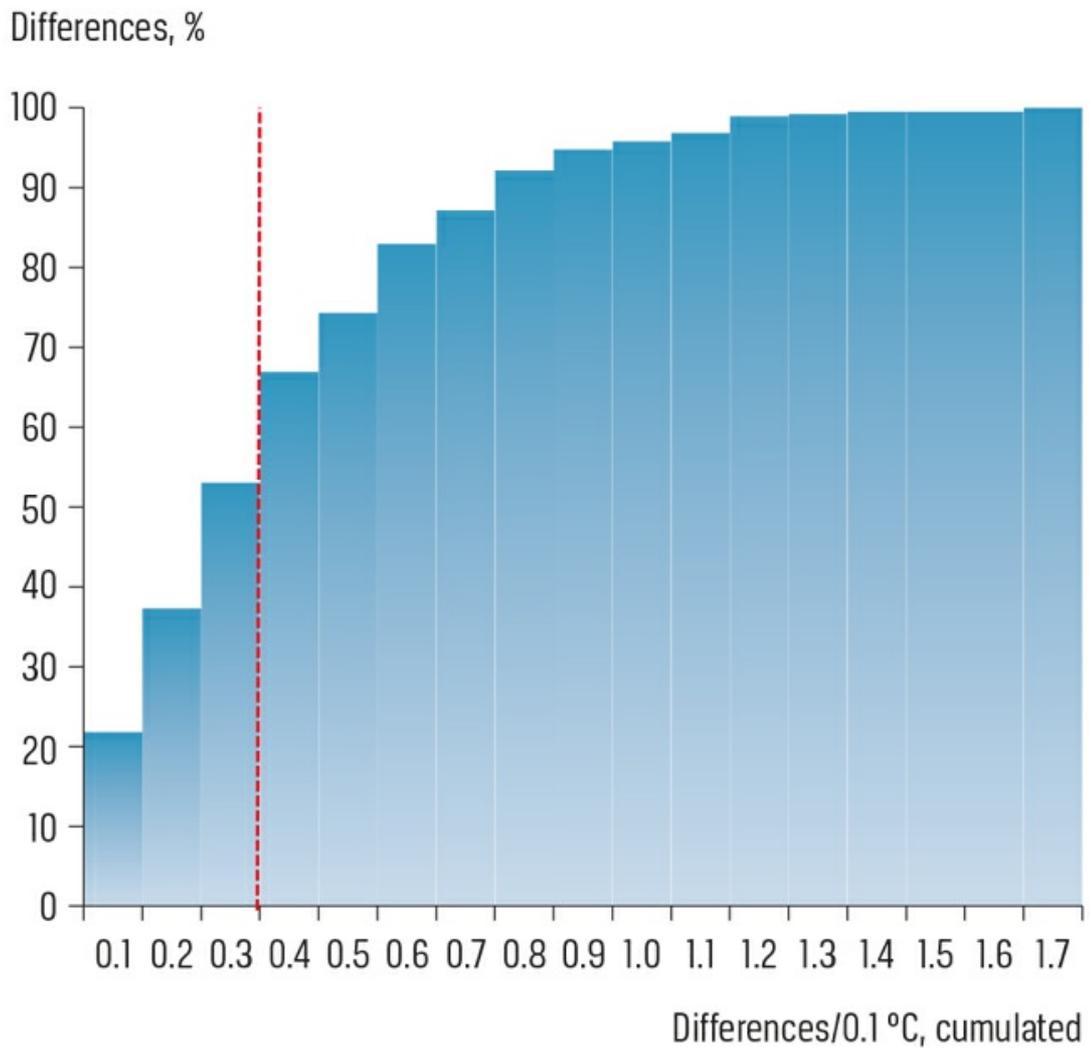
TABEL 1 / Number of patients with temperature above/below 38.0 °C by temporal artery thermometer (TAT) and rectal 38.

	TAT temperature, °C		Total
	‹ 38.0	≥ 38.0	
Rectal temperature ‹ 38.0 °C	331	14	345
Rectal temperature › 38.0 °C	12	24	36
Total	343	38	381

DISCUSSION

In this study, we found a significant difference between TAT and digital REC with TAT overestimating the temperature by an average of 0.17 °C. The variations were considerable with SD = ± 0.47 and LOA: –0.77-1.11, meaning that 95% of the differences fell within a range considerably larger than the initially established clinically accepted deviation of ± 0.3 °C. Only 53% of the patients had a TAT temperature measurement within ± 0.3 °C of the digital REC temperature measurement and 20% deviated by ± 0.5-1 °C. Hence, our result adds to growing evidence of the TAT's inability correctly to identify fever in adult acute medical patients.

The first temperature measurement in the ED is performed as a screening to establish if the acute patient is hypo-, hyper-, or normothermic and guides further examination and treatment [9]. Our study shows that TAT has a sensitivity of 67%, a specificity of 95.9%, a PPV of 63% and an NPV of 97%. The minimum sensitivity of a clinical test accepted by clinicians has been stated to be 90% [4]. Thus, the TAT in our study has a poor ability correctly to detect fever in patients who actually have a temperature > 38 °C.

This result is supported by Bijur et al [7] comparing TAT and digital REC in a population comparable to ours. They found a mean of differences at 0.0 with an SD of differences at 0.6 with LOA: –1.1-1.1. When using 38 °C as cut-off value for fever, they found the sensitivity to be 71.1% and the specificity to be 92.3%. When lowering the cut-off for fever, Bijur et al [7] found an increase in sensitivity but a decrease in specificity leading to an unacceptable increase in false-positive measurements. Thus, the TAT does not approach the degree of accuracy required to determine the use of the non-invasive thermometer. non-invasive thermometer.

Our findings of mean of differences close to zero followed by wide LOA ranging within positive and negative values is in accordance with findings by Geijer et al presented in a systematic review and meta-analysis [4]. The overall pooled mean in their study was –0.19 with LOA: –1.16-0.77. Based on this variation and the wide LOA observed in our study, including negative as well as positive differences, it is indicated that no systematic correction of temporal measurements exists.

Our findings are also in accordance with those of other studies which reported a mean sensitivity of 73% (95% CI: 61-81%) [4, 8]. Our study deviates from these studies by investigating acutely medically admitted adult patients and by using rectal temperature as a reference measure. By finding the same results and drawing the same

conclusion as previous studies conducted in various populations and using other reference measures, our study adds to the growing body of evidence that the sensitivity of the TAT is not influenced by reference measure, age of patient, manufacturer [4] or emergency severity [9].on as previous studies conducted in various populations and using other reference measures, our study adds to the growing body of evidence that the sensitivity of the TAT is not influenced by reference measure, age of patient, manufacturer [4] or emergency severity [9].

The low PPV leads to clinically unnecessary further examinations, higher health expenses, unjust concerns and discomfort for patients. However, it is more worrying that the 97% NPV misleads clinicians towards not initiating relevant examinations. With the low prevalence of fever, it may be argued that only few patients are not offered relevant examination, but late initiation or no examination might have fatal consequences for the individual.

Our study showed that the TAT was unable to correctly identify any of the hypothermic patients (temperature < 36.0 °C). This deviation generates a serious clinical concern that has not previously been reported. Further research is needed to validate our findings in larger hypothermic populations.

An unreliable measurement like TAT is not usable in a clinical setting, but due to the minimal privacy, it is obviously problematic to implement digital REC in the ED during triage. In a clinical guideline from Clearing House [1], oral temperature measurement is considered second best to digital REC in cases in which a rectal measurement is not possible for physiological reasons. The result of the oral measurement depends on the correct placement of the thermometer and intake of foods and liquids, and therefore we argue that it is not suited as a systematic replacement of the digital REC in the ED. Thus, it is relevant to examine future non-invasive methods of temperature measurement.

Only patients admitted during daytime on weekends were screened for eligibility. We do not believe that this affected the generalisability of the study. 40% of approached eligible patients were not included in the study. This was mainly due to younger patients' rejection of participation in order to avoid rectal measurement and older patients with cognitive impairment. We do not believe that the exclusion systematically affected the results.

One possible limitation in previous studies may be the risk of measurement bias and interpersonal variations because data were collected by several nurses [4]. Despite training, this adds a risk of variation in the ability to use the instrument and hence false conclusions as to the instruments' accuracy in measuring body temperature. In our study, the same clinical nurse specialist was responsible for all measurements, which were made using the same two thermometers. This increases the level of reliability and reproducibility and limits variation due to instrument handling. However, we found the same variation in measurements as previous studies have. This indicates that the variation is, in fact, due to the TAT's inability to correctly measure body temperature.

On the other hand, the design with one clinical nurse specialist collecting all measurements may be a limitation introducing a systematic bias, causing all differences to deviate in the same direction (larger or smaller) due to the same incorrect handling of the TAT in all measurements. We do not believe that this is a problem in our study, as differences were observed in both directions and as our results were in accordance with previous findings.

It is a possible limitation in our study that data were collected in 2013. Despite previous reporting of problematic use, the TAT is still being used in Danish EDs. Thus, data are relevant and results transferrable to the present.

Another limitation may be that no data on the administration of antipyretics was documented. We cannot exclude the possibility that antipyretic medication accounts for small positive differences as the digital REC temperature was measured last. However, the two temperatures were measured at a maximum seven-minute

interval. Therefore, we believe that antipyretic medication does not account for the pronounced positive deviation. Furthermore, our results are in accordance with those of previous studies. Thus, we do not believe that the missing antipyretic data are a major problem in our study.

CONCLUSIONS

We found that the accuracy of TAT was too low as half of the patients' measurements deviated by more than ± 0.3 °C and the sensitivity failed to reach the clinical recommendation of 90%. We suggest that TAT should not be used as a standard non-invasive method for measuring body temperature in acutely admitted adult patients.

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LITERATURE

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