Comparison of the Use of Liquid Crystal Thermometers with Glass Mercury Thermometers in Febrile Children in a Children’s Ward at Port Moresby General Hospital, Papua New Guinea

by L. Mauta,a J. Vince,b and P. Ripac

aPaediatric Department, Port Moresby General Hospital, Papua New Guinea
bDiscipline of Child Health, School of Medicine and Health Sciences, University of Papua New Guinea, Papua New Guinea
cMedical Education Unit, School of Medicine and Health Sciences, University of Papua New Guinea, Papua New Guinea

Summary

We compared the temperatures recorded, in febrile children admitted to a children’s ward at Port Moresby General Hospital, by a doctor and by a group of nurses using glass mercury thermometers (GMT) and liquid crystal thermometers (LCT, NextempR and TraxitR). The mean difference (with 95% confidence intervals) in temperatures between GMT and NextempR were −0.12°C (−0.16°C to −0.08°C) for the doctor and 0.12°C (0.04–0.20°C) for nurses. The mean difference in temperatures between GMT and TraxitR were −0.05°C (−0.09°C to −0.01°C) for the doctor and 0.19°C (0.10–0.28°C) for the nurses. A similar result was obtained when one of the NextempR thermometers used in the initial study was compared with GMT on a small sample of patients by the doctor 8 months later. Limited evaluation showed nursing staff were in favour of using the LCTs. NextempR and TraxitR thermometers can be used interchangeably with GMT in this setting.

Introduction

Body temperature measurement is an integral part of patient monitoring and management. The GMT has been considered to be more accurate than other thermometers [1] and, since its development in 1866 by Sir Thomas Allbutt, it has been the gold standard for body temperature measurement against which other devices are judged. GMTs are, however, not without their problems. They are fragile, and there is a potential danger of mercury-vapour toxicity following breakage [2], and injury to skin and mucous membranes. In resource-rich countries, they have to a large extent been replaced, at least in hospital settings, by other instruments such as the tympanic membrane thermometer. These instruments are, however, expensive and some studies have reported variable accuracy [3–8]. In resource-poor environments they are both impractical and unaffordable. The big advantage of the GMT is that it is cheap, and it is still the most widely used form of thermometer in many parts of the world.

LCTs, which depend on the change in colour of liquid crystals with temperature change, have been available in various forms since the early 1970s. They were initially trialed in anaesthesia [9, 10], but the development of easy-to-use devices led to their more widespread use in the 1980s and 1990s. Whilst their introduction was reported by some authors as being cost-effective and useful [11, 12], others found them unreliable [13], and considerable variation in performance of different products has been reported [14]. Some authors recommended caution in their use by parents in the home [15]. Whilst primarily used for the detection of fever, the LCTs have also been reported to be useful in the detection of hypothermia in infants, particularly at the community level in resource-poor settings [16–18].

The NextempR and TraxitR thermometers (Medical Indicators, Pennington, NJ, USA) are examples of the newer generation of LCTs and

Acknowledgements

The authors would like to thank the nursing staff for helping in collecting the data and evaluating the use of the new thermometers, Professor Trevor Duke for helpful comments and suggestions, and Dr John Stace for the original idea and for donating the thermometers.

Correspondence: J. Vince, Division of Clinical Sciences, PO Box 5623, Boroko, Papua New Guinea.
E-mail <johndvince@gmail.com>.

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doi:10.1093/tropej/fmp027 Advance Access Published on 24 April 2009
have been on the market for several years. Nextemp$^R$ is marketed as a disposable or reusable thermometer primarily to be used for taking oral temperatures on a single patient. The manufacturer claims that it is easy to use, non-toxic, hygienic and low cost, requires no special storage conditions and does not need calibration. Traxit$^R$ is designed to adhere to the patient’s skin, allowing continuous monitoring of temperature [19]. The Nextemp$^R$ thermometer is a flexible polystyrene plastic strip, 9.1 cm long with a temperature sensor at one end of the device. The sensor consists of a matrix of dot-like indentations, each less than 1 mm in diameter, arranged in rows of five. Each dot contains three liquid cholesteric crystal compounds and a soluble additive. The dots are covered with a multilayer transparent plastic film to seal in the chemicals. The mixture in each dot is formulated to melt and change colour from green to black at a specific temperature. The 50 dots represent temperature increments of 0.1°C over the range 35.5–40.4°C. In effect each indicator dot is a miniature independent thermometer. During temperature measurement, all dots up to and including the one indicating the patient’s temperature melt and change colour from green to black [4]. The Traxit$^R$ thermometer is heart-shaped, and the dots are arranged in rows of nine. It has on a sticker that has an adhesive back to stick to the patient’s axilla. The last dot to turn black is recorded as the patient’s temperature.

Although the Nextemp$^R$ is sold either as a covered disposable or an uncovered reusable instrument for measuring oral temperatures, it is robust, with a claimed 5-year shelf life and can be used for measuring axillary temperature. It seemed highly likely that it could be used for repeated measurements of axillary temperatures on many patients. The aim of this study, therefore, was to assess the practicality of using Nextemp$^R$ and Traxit$^R$ LCTs in the context of a busy paediatric ward in a resource-poor environment. The objectives were: (1) to determine the accuracy of the LCTs against GMTs and (2) to assess the nursing staff’s view of the practicality of the LCTs.

**Materials and Methods**

This prospective study was conducted between April and August 2007 in the paediatric wards of the Port Moresby General Hospital, the only tertiary referral hospital in Papua New Guinea. It involved a convenience sample of 200 children who were admitted with fever. The first author (L.M.) measured and recorded the temperature of each of 100 children using GMT, Nextemp$^R$ and Traxit$^R$ simultaneously. Following instruction in the use of the new LCTs, a group of twelve nurses also took the three temperature readings from each of a further 100 patients. A questionnaire was then given to the nurses at the end of data collection to gauge their views of the new LCTs. Patients with temperature readings by GMT outside the range of the Nextemp$^R$ and Traxit$^R$ thermometers (<35.5°C and >40.4°C) were to be excluded. The GMT and Nextemp$^R$ were placed in the axilla and left in place for 2–3 min before a reading was taken. The Traxit$^R$ thermometer was stuck in place in the patient’s axilla following exposure of its adhesive backing.

In order to assess reliability over time, one of the Nextemp$^R$ thermometers used for the study was tested against GMT on 10 children, 8 months after the start of the study.

All data collected were analysed by using the SPSS 10.0 and STATCALC statistical packages and the Bland and Altman plots for assessing agreement between two methods of clinical measurement [20].

**Results**

A total of 200 patients participated in the study. Of the studied population 58% (116) were male and 42% (84) were female. The age of the participants ranged between <1 and 13 years of age with a median age of 2 years and an inter-quartile range of 1–3 years. The weights of the children studied were between 2.22 and 36 kg with a median of 8.8 kg and an inter-quartile range of 6.5–11.9 kg. None of the children had a temperature recorded by GMT that was outside the range of LCTs (35.5–40.4°C). The mean difference (with 95% confidence intervals) in temperature between GMT and Nextemp$^R$ in the case of the doctor’s readings was $-0.12°C (-0.16°C to -0.08°C)$ and in the case of the nurses it was $0.12°C (0.04–0.20°C)$. For GMT and Traxit the mean temperature difference was $-0.05°C (-0.09°C to -0.01°C)$ for the doctor and $0.19°C (0.10–0.28°C)$ for the nurses. Box plots of the temperature differences between GMT and Nextemp$^R$ and GMT and Traxit$^R$ are shown in Figs 1 and 2. The full and inter-quartile ranges of the doctor’s measurements are smaller than those of the nurses, and there are several outliers in the nurses’ recordings.

Bland Altman plots of the mean temperature differences between the Nextemp$^R$ and GMT and Traxit$^R$ and GMT are shown in Figs 3 and 4. The mean differences were $0.004°C (-0.043°C to 0.050°C)$ and $-0.069°C (-0.121°C to -0.017°C)$. Based on these differences the Nextemp$^R$ thermometer performed slightly better than the Traxit$^R$ thermometer in comparison to the GMT.

Eight months after the start of the study, the mean difference between GMT and one of the Nextemp$^R$ thermometers used at the start of the study was $-0.15°C (-0.002°C to -0.30°C)$ for 10 recordings by the same doctor.

In spite of prompting, only 6 of the 12 nurses completed questionnaires. Those that did so listed ease of use, reusability, accuracy, safety and indestructibility as attributes.
Fig. 1. Boxplot of temperature difference between GMT and Nextemp.

Fig. 2. Boxplot of temperature difference between GMT and Traxit.
During the course of our small study over a period of 5 months, eight GMTs were known to have been broken. Robust, reliable and inexpensive thermometers are required in all countries, but particularly so in resource-poor countries. LCTs have the potential to fill the void. Relatively few studies have assessed their use to detect febrile children in such situations. In Kenya, Esamai [12] showed that in 14 of a sample of 56 children there was no temperature

**Fig. 3.** Agreement between Nextemp and mercury thermometer.

**Fig. 4.** Agreement between Traxit and mercury thermometer.

**Discussion**

During the course of our small study over a period of 5 months, eight GMTs were known to have been broken. Robust, reliable and inexpensive thermometers are required in all countries, but particularly in resource-poor countries. LCTs have the potential to fill the void. Relatively few studies have assessed their use to detect febrile children in such situations. In Kenya, Esamai [12] showed that in 14 of a sample of 56 children there was no temperature
reading difference between the GMT and LCT, in 12 the chemical dot thermometers recorded higher readings than the GMT by an average of 0.34°C and in 30 children the GMT recorded higher readings than the LCT by an average of 0.67°C. In a study from Zambia, Morley and colleagues compared two different LCT devices with GMT [14]. The sensitivities and positive predictive values of the FeverScanR and TempDOTR devices to correctly identify febrile children were 89% and 57% for the former and 92% and 86% for the latter.

In a study comparing the use of NextempR with GMT and Tympanic thermometers in adults, Rajee and Sultana [21] showed that the NextempR thermometer agreed with the GMT within −0.6°C to 0.5°C and concluded that it can be used interchangeably with current mercury and tympanic thermometers. In a study of 29 neonates, McKenzie [22] showed that the mean (SD) temperature difference between the GMT and the TraxitR thermometer was 0.04°C (0.22°C) on a first reading and −0.11°C (0.17°C) on a second reading. Our own study supports the conclusion that when used correctly, both NextempR and TraxitR compare very closely with GMT.

In order for a new technology to be introduced into everyday practice it is essential that it is well accepted by those using it most frequently—in this case the nursing staff. The results of our study showed that the differences recorded by the single doctor were more closely aligned to the GMT readings that were those of the nurses. This is not surprising given that there were 12 nurses involved. Unfortunately only six nurses completed the simple evaluation questionnaire. It is at least possible that those who found the LCT difficult to use may have felt embarrassed and therefore reluctant to complete it, and the results obtained are therefore not reliable. Those that did answer, however, were favourably impressed.

LCTs have some disadvantages compared with GMTs. They are unable to read temperatures <35.5°C and >40.4°C. The reading has to be done immediately on removal from the patient since the temperature reading reverts back to ambient temperature once removed. The individual dots on the NextempR are small, and good light and good eyesight is required to read the device, although this is also required for GMT.

The TraxitR thermometer is sold as a stick-on thermometer to be applied to the thoracic wall of the axilla and, according to the manufacturer, is supposed to stick on for at least 48 h. However, in this study it often fell off before 24 h.

The present study is the first of its kind in Papua New Guinea. It shows clearly that NextempR and TransitR can be used interchangeably with GMT in a Papua New Guinean hospital setting. The LCTs have significant advantages over GMTs in terms of longevity and lack of potential dangers. When used on an individual and disposable basis they are expensive, but when used repeatedly, as in our study, they are eminently affordable.

We conclude that the LCT such as NextempR and TraxitR devices can have a significant place in hospital and clinic practice in resource-poor environments.

References


