Reviewing the effectiveness of tympanic thermometers

AUTHOR David Gallimore, MSc, BSc, RGN, is tutor in adult nursing, University of Wales, Swansea.

ABSTRACT Gallimore, D. (2004) Reviewing the effectiveness of tympanic thermometers. Nursing Times; 100: 32, 32–34. Tympanic thermometers have become a popular alternative to glass mercury thermometers for recording patients’ temperatures. This article reviews studies that have been performed to audit their use in clinical practice. It examines the accuracy of tympanic thermometers and discusses ways to improve the use of this instrument and the implications for nursing practice.

The significance of changes in body temperature to identify illness was discovered about 140 years ago by Carl Wunderlich, who developed the clinical mercury thermometer. He was the first person to realise that there was a normal range for body temperature and that anything outside that normal range could indicate the presence of disease.

Types of thermometer

Mercury-in-glass thermometers continued to be used until recently. The first replacement was the electronic thermometer, a device similar to the mercury thermometer, but the reading was taken by an electronic probe rather than a column of mercury.

More recently tympanic thermometers have been introduced to clinical practice. The first documented use was in 1986, although they did not become widely used until the early 1990s (Betta et al, 1997). Tympanic thermometers work by reading the temperature of the tympanic membrane in the ear and displaying this on a small digital screen.

The design of tympanic thermometers

Tympanic thermometers are usually small handheld devices with a probe that is inserted into the patient’s ear canal, at the end of which is the tympanic membrane, a thin structure which is well perfused with blood (Fig 1). The sensor at the end of the probe records the infrared radiation (IRR) that is emitted by the membrane – as a result of its warmth – and converts this into a temperature reading presented on a digital screen.

The probe is protected by a disposable cover, which is changed between patients to prevent cross-infection.

It has been suggested that tympanic thermometers give a more accurate representation of actual body temperature because the tympanic membrane lies close to the temperature regulation centre in the hypothalamus and shares the same artery (Van Staaij et al, 2003).

Reasons for tympanic thermometer use

Numerous reasons have been suggested for the widespread introduction of the tympanic thermometer, but probably the most significant is the speed and convenience with which temperature readings can be achieved. To obtain an accurate recording a mercury thermometer bulb has to be in contact with the patient for 6–11 minutes, while tympanic thermometers take only a few seconds to obtain a reading (Carroll, 2000).

This aids a more rapid diagnosis, which is particularly important in areas such as A&E and critical care. It also means patients’ temperatures can be assessed more frequently in all clinical areas, enabling staff to identify problems at an earlier point.

Another important reason for the introduction of tympanic thermometers has been concern about the amount of mercury in the environment. It has been reported that a small number of cases of iatrogenic trauma have been caused by glass thermometers breaking in patients’
mouths. However, with correct training staff should be able to deal with the minor spillage of mercury from a broken thermometer (Blumenthal, 1992).

Concerns have also been raised about the possibility of cross-infection through inadequately sterilised thermometers. Cutter (1994) found that disinfection policies were frequently not followed both between patient use and during use by one patient.

In addition there is evidence that patients prefer the tympanic thermometer (Van Staaij et al, 2003). However, tympanic thermometers have often been introduced by health care providers without auditing their performance, which means their perceived advantages may not be realised in practice. This article discusses research literature evaluating these devices.

**Accuracy of tympanic thermometers**

Probably the most important question to resolve about tympanic thermometers is their accuracy.

There has been considerable research interest in this subject during the past 10 years, and more than 30 studies have assessed their accuracy. The studies have compared the body temperatures recorded by a tympanic thermometer with:

- Mercury thermometers placed orally and axillary;
- Invasive thermometry, including oesophageal, and in the pulmonary artery;
- Digital probe thermometers placed orally, axillary and rectally;
- Tympanic thermometers produced by different manufacturers.

The results of these studies have been inconclusive. Overall tympanic thermometers have been found to display temperatures of between 1.02°C below and 0.91°C above those detected by other recording devices. This has led some authors to suggest that tympanic thermometers should not be used to record body temperature.

While this difference in temperature may affect the clinical management of patients, a difference of 1.7°C has also been found between recording the temperature at different sites in the oral cavity (Erickson, 1980). A number aimed to detect high body temperature, including one where the person’s body temperature was deliberately modified.

By restricting most of the research studies to mainly healthy volunteers with normal body temperature, the relevance of the results in actual clinical practice to hospital patients must be questioned.

**Comparison of temperature sites**

All the studies compared the temperature of the tympanic membrane with the temperature found at a different part of the body. This has been identified as a basic design flaw in the studies (Trombley, 1999), as a difference in the temperature found in these areas does not indicate an inaccuracy in the tympanic thermometer.

Oral temperatures are affected by factors such as breathing rate, oxygen therapy, eating, drinking and smoking (Closs, 1987). Rectal temperatures are frequently higher than core temperature due to bacterial activity and its poor cooling system (Trombley, 1999). The temperature in the rectum also changes more slowly than that in the body due to the heat-retaining properties of faeces.

These methodological problems can be overcome by research design and statistical analysis of the data. Most tympanic thermometers can be set to express the equivalent oral or rectal temperature. Absolute temperature should not be compared, but a correlation between a range of temperatures should be established. However, not all studies which report a difference in temperature have taken these steps.

Most studies define a ‘gold standard’ against which they compare the readings of the tympanic thermometer. Unfortunately this is not consistent across all studies, which makes it difficult to compare their findings.

A number of factors have been identified that prevent the tympanic thermometer obtaining an accurate recording of core body temperature (Box 1).

**Experimental studies**

To overcome the problems associated with testing tympanic thermometers in a clinical environment an experiment was conducted using a mechanical, artificial ear

---

**REFERENCES**


---

**KEYWORDS** • Patient assessment • Tympanic thermometers • Observations


The first recorded use of tympanic thermometers was in a paediatric setting (Betta et al, 1997). There are advantages to using them to record children’s temperatures: with a simulated tympanic membrane (Betta et al, 1997). Tympanic thermometers from three manufacturers were compared for accuracy and consistency. The aim was to measure the ability of tympanic thermometers to accurately record temperature, but without the complications associated with real patients in a clinical setting. The results showed that one of the thermometers examined was able to produce accurate and consistent results, supporting the continued use of this device. However, the tympanic thermometers from the other two manufacturers gave rather poor results that would suggest only a limited use in practice. This difference in accuracy identifies a need for independent testing of these devices prior to their general use in the health care setting.

Cost implications

Although a large number of studies have investigated the accuracy of tympanic thermometers in determining body temperature, the financial implications have yet to be thoroughly examined. A study to investigate the cost-effectiveness of electronic probe thermometers (Davies et al, 1986) found them to be more cost-effective than mercury-in-glass thermometers. This was mainly due to the nursing time saved, a finding which could also be applied to tympanic membrane thermometers. Equipment costs for tympanic thermometers are far greater than for mercury thermometers. Not only is there the initial outlay on each device, but there are also costs for calibrating and servicing them, and for purchasing disposable covers for the probe. Other considerations

However, Edwards (1997) believes considering these costs alone is short-sighted. While mercury thermometers are relatively inexpensive per unit in terms of purchase price and maintenance, other factors need to be considered. All patients should have their own mercury thermometer, which must be comprehensively sterilised when they are discharged (Cutter, 1994). Fulbrook (1993) suggests that after eight months of usage, one-quarter of all mercury thermometers begin to lose their accuracy, so the cost of routine replacement must be considered. It can also take nurses up to 10 times longer to record patients’ temperatures using mercury rather than tympanic thermometers. Breakages of mercury thermometers incur not only the cost of a replacement thermometer but also a mercury spillage kit, and of the mercury disposal. Although introducing the tympanic thermometer will involve a time cost for staff training, Carroll (2000) suggests that regular training should be provided in the use of all temperature recording devices. Training costs will also be incurred in teaching staff to manage any mercury spillage in the event of a breakage.

The paediatric setting

Distressed children can be easily and quickly assessed without adding to their anxiety levels (Fawcett, 2001); Frequent recordings can be made of temperature allowing earlier detection of problems; Parents can take these recordings at home quickly and effectively (Van Staaij et al, 2003). Despite this, the evidence for measuring temperature in this way is less strong than for adult patients. The main problem is the smaller size of the child’s auditory canal, which means the temperature is not taken from the tympanic membrane using a standard size probe as it cannot be inserted deeply enough. Different probe sizes are available for children of varying ages and it is recommended that these are used appropriately (Bailey and Rose, 2001).

Conclusion

As a result of the studies on the use of tympanic thermometers a number of recommendations have been made to increase the effectiveness of their use (Box 2). The use of the tympanic thermometer has become widespread in the past 10 years due to their convenience of use and acceptability to patients. Numerous studies have been performed to assess their accuracy, and a number of these have raised serious doubts about this. Due to the inconsistency of the results of the studies it would seem that further work needs to be undertaken in order to determine the reasons for these negative results. In the meantime it would seem that there is sufficient evidence to continue to use tympanic thermometers, providing nurses adhere to the recommendations that are listed above.