POSITION STATEMENT

Temperature measurement in paediatrics

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Despite the fact that temperature measurement in children seems so simple – a wide variety of devices are available to record a fever from skin, oral or rectal mucosa or the tympanic membrane – the choice for health professionals and parents has never been so complicated.

According to traditional teaching, the normal body temperature is 37°C (98.6°F), but it is generally accepted that a temperature of 38°C (100°F) or greater, as measured by a rectal thermometer, represents a fever [1][2].

In febrile children younger than 36 months of age, most serious illnesses are caused by infectious agents [3]-[6]. The presence of a fever in children younger than three months of age triggers a thorough investigation into the source of the infection [7][8]. However, the presence of a normal or subnormal temperature in children younger than three months of age can also be associated with severe infections in the presence of other appropriate signs and symptoms. The definition of a fever of unknown origin also relies on stringent diagnostic criteria (ie, a fever lasting more than 14 days with no etiology found after routine tests), and depends on precise temperature recordings [9]-[11]. Finally, an appropriate recording of the absence of a fever reassures both parents and health care providers who seek to diminish fever phobia, and inappropriate medical consultations and investigations [12]. It is, therefore, essential that the measurement of a fever be accurate and reproducible from infancy through adolescence.

Current measurements and methods

Rectal thermometry

Rectal thermometry has traditionally been considered the gold standard for temperature measurement [13][14], but some studies have revealed limitations of this method [15]-[18]. Rectal temperatures are slow to change in relation to changing core temperature, and they have been shown to stay elevated well after the patient's core temperature has begun to fall, and vice versa. Rectal readings are affected by the depth of a measurement, conditions affecting local blood flow and the presence of stool. Rectal perforation has been described [19][20], and without proper sterilization techniques, rectal thermometry has the capacity to spread contaminants that are commonly found in stool.

Many parents may be uncomfortable with this method of temperature assessment, and older children may resent it.

Axillary thermometry

While axillary temperature is easy to measure (compared with oral or rectal measurements), it has been found to be an inaccurate estimate of core temperature in children [13][15][18][21]. This type of measurement relies on the thermometer remaining directly in place over the axillary artery, and it is largely influenced by environmental conditions.

Despite its low sensitivity and specificity in detecting fever, axillary temperature is recommended by the American Academy of Pediatrics as a screening test for fever in neonates because of the risk of rectal perforation with a rectal thermometer [22], although this complication is estimated to occur in less than 1 in 2 million measurements [23].

Oral thermometry

The sublingual site is easily accessible and reflects the temperature of the lingual arteries. However, oral temperature is easily influenced by the recent ingestion of food or drink and mouth breathing [21]. Oral thermometry relies on the mouth remaining sealed, with the tongue depressed for 3 to 4 min, which is a difficult task for young children. This method of temperature measurement cannot be used in young children, or in unconscious or uncooperative patients. Generally, it has been suggested that the accuracy of oral thermometry lies somewhere between that of axillary and rectal thermometry. It appears that accuracy may increase with the age of a child, primarily due to compliance and the ability to use proper technique.

Digital vs. mercury thermometers

The traditional mercury thermometer has been replaced by the more "user friendly" digital thermometer. Since the accuracy is comparable with both instruments [24] and mercury remains an environmental hazard, the Canadian Paediatric Society no longer recommends the use of mercury thermometers.

Tympanic thermometry

The first devices used to measure tympanic membrane (TM) temperature did so by being in direct contact with the tympanic membrane. In 1969, it was shown that such a device measured core temperature better than a rectal thermometer [25]. However, thermistors in direct contact with the TM are not practical for everyday use.

Instead of being in direct contact with the TM, today's tympanic thermometers measure the thermal radiation emitted from the TM and the ear canal, and have therefore been called infrared radiation emission detectors (IRED). Because the amount of thermal radiation emitted is in proportion to the membrane's temperature, IRED accurately estimates TM temperature [16]. In contrast with other sites of temperature measurement, the TM's blood supply is very similar in temperature and location to the blood bathing the hypothalamus, the site of the body's thermoregulatory centre. It is, therefore, an ideal location for core temperature estimation [26][27]. Crying, otitis media or earwax have not been shown to change tympanic readings significantly.

Much has been published both in support of [15][16][26][27] and against [29]-[32] the use of infrared tympanic thermometers in clinical practice, and it is no wonder that many physicians remain skeptical about measurement reliability. Results of a questionnaire completed by randomly selected members of the American Academy of Pediatrics and the American Academy of Family Physicians demonstrated that 78% of respondents had used infrared thermometers at least once; 65% of paediatricians and 64% of family practitioners were current users [32]. The most commonly reported causes for the discontinued use of tympanic thermometers were inaccuracy or lack of staff trust with the device.

Most studies that compare the accuracy of tympanic thermometers with other classical measures of body temperature evaluate the accuracy of tympanic readings by comparing them with rectal, oral or axillary measurements. Given the variations of temperature ranges with each of these methods and the limitations of their accuracy discussed above, using any one method as a 'benchmark' or 'gold standard' is misleading. Because estimates of core temperature measured at different body sites will vary, an effort has been made by manufacturers of IREDs to correlate tympanic readings to rectal or oral equivalents [16].

These conversion scales (known as 'offsets') convert the measured ear temperature to one that would be found at a different site, allowing a user to define more easily a fever from a measurement in the ear. The offsets are based on an algorithm that transforms a subject's tympanic temperature to that found at either the oral or rectal site. However, the data used to develop these offsets may not be readily applicable to the paediatric population. Some researchers advise eliminating these adjusted modes and simply using unadjusted ear temperature (Table 1) [16][18][21].

TABLE 1
Normal temperature ranges

Measurement method	Normal temperature range
Rectal	36.6°C to 38°C (97.9°F to 100.4°F)
Ear	35.8°C to 38°C (96.4°F to 100.4°F)
Oral	35.5°C to 37.5°C (95.9°F to 99.5°F)
Axillary	34.7°C to 37.3°C (94.5°F to 99.1°F)

Factors related to the patient, instrument, technique and environment contribute to the variability of ear-based temperature measurements. For example, the ear canal's structure, probe design and probe positioning affect how well the canal is sealed from ambient influences and what parts of the tympanic membrane, ear canal wall, and perhaps skin surface, are in the thermometers field of view [33]. To get an accurate reading of tympanic temperature, the infrared probe (up to 8 mm in diameter) must be small enough to be deeply inserted into the meatus to allow orientation of the sensor against the TM [28]. While this is of less concern in children older than two years of age whose meatus is wider than 8 mm, the average diameter of the meatus in young children (4 mm at birth, 5 mm at two years of age) can cause complications for tympanic thermometry. When the probe is too large, it will detect infrared emissions from both the TM and the proximal meatus wall. Because the thermometer averages the two surface temperatures, it can produce an erroneously low reading. It is generally recommended that a slight tug of the pinna to straighten the ear canal can improve accuracy and consistency.

Also, each different brand of ear thermometers has its own design, technology, offsets and operating instructions that affect its reliability, accuracy and use. Consumer and professional units are available; the latter are designed to be more durable to withstand day-to-day use in a professional setting. While many current brands exist, the reliability of different instruments seems to be comparable, if the manufacturers instructions are followed properly.

The authors of a recent systematic review and meta-analysis comparing infrared tympanic and rectal thermometry concluded that infrared tympanic thermometery lacks sufficient agreement with their defined gold standard - rectal thermometry - to be used with confidence in situations where body temperature needs to be measured with precision [35].

Other devices

Infrared arterial temperature can be measured with a device that is passed overt the front of the forehead to the temporal area. This relatively new method of body temperature measurement has been shown to be more accurate than tympanic thermometry and better tolerated than rectal thermometry [36].

In a recent trial in a busy paediatric emergency department, the temporal artery device was shown to have a sensitivity of about 80% to identify fever (as determined by rectal measurements). When a cut-off temperature over 37.7°C was used on the temporal artery device to define fever, the sensitivity improved to 90% for identifying a fever of >38°C as measured by the rectal thermometer, but the specificity dropped to about 50%. Moreover, the parents use of a similar device resulted in inadequate agreement with rectal temperatures [37].

Temporal artery thermometry may be a promising tool for screening children at low risk in the ER but cannot yet be recommended for home use or hospital use when definitive measurements are required.

Pacifier thermometers may not be feasible for sick infants (particularly if in respiratory distress) and have been shown to be less accurate than rectal thermometers. [38].

Conclusion

While it is evident that all devices available currently to measure temperature in children have their strengths and weaknesses, the choice made by parents may be influenced by the convenience of use, cost and advertising. For professionals, the older, time-honoured methods may be chosen because they are deeply entrenched in the medical literature and there is no groundswell for change. However, in keeping with environmental concerns, mercury thermometers should no longer be used.

Based on the evidence currently available, the relative ease, speed, accuracy and safety of the infrared tympanic thermometer warrant its inclusion in the group of currently available instruments for temperature measurement in older children. Nonetheless, children who are younger than two years of age should continue to have their temperature taken rectally until an adequate probe for tympanic thermometry is designed or until other methods of measurement are shown to be accurate and reliable in larger studies (Table 2).

TABLE 2
Summary of recommended temperature measurement techniques

Age	Recommended technique
Birth to 2 years	1. Rectal (definitive) 2. Axillary (screening low risk children)
Over 2 years to 5 years	1. Rectal (definitive) 2. Axillary, Tympanic (or Temporal Artery if in hospital) (screening)
Older than 5 years	1. Oral (definitive) 2. Axillary, Tympanic (or Temporal Artery if in hospital) (screening)

Canadian Task Force on Preventive Health - Strength of Recommendation B, II [39]

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