Temperature measurement in paediatrics

Community Paediatrics Committee, Canadian Paediatric Society (CPS)

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Also available: How to take a child's temperature

Index of position statements from the Community Paediatrics Committee

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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, reliable 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 many recent studies have revealed some of its limitations (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.

Most parents are uncomfortable with this method of temperature assessment, and the majority of children resent it.

Axillary thermometry
While axillary temperature is extremely easy to measure (compared with oral or rectal measurements), it has been found to be the worst estimate of core temperature in children (13,15,18,21). This type of measurement relies on the traditional mercury 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 recommmended 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).

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)

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 children. This method of temperature measurement cannot be used in young children, or in unconscious or uncooperative patients. Pacifier thermometers are available but have yet to be evaluated (23). 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.

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.

An IRED can measure the infrared radiation of the TM in two ways. A thermopile sensor detects the level of heat in the area directly proximal to the TM by taking multiple readings very quickly. A pyeloelectric sensor, which is a heat flow detector that measures the speed at which the thermal energy flows through a sensor, takes a 'snapshot' of the heat that it records from the TM, just like photographic film. Both methods have demonstrated comparable accuracy.

Digital vs. mercury thermometers
Over the last several years, the traditional mercury thermometer has gradually 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 CPS no longer recommends the use of mercury thermometers.

Reliability of tympanic versus conventional thermometry

Because much has been written both in support of (15,16,26,27) and against (28-31) the use of infrared tympanic thermometers in clinical practice, many physicians remain confused about measurement reliability. Results of a recent 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.

To date, there have been the following two main problems with the evaluation of tympanic thermometry.

Terms of reference used to evaluate tympanic thermometry

Most studies that compare the accuracy of tympanic thermometers with other classical measures of body temperature evaluate the reliability 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. Most researchers advise eliminating these adjusted modes and simply using unadjusted ear temperature (Table 1) (16,18,21).

Reliability of the instrument

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.

TABLE 2: Summary of recommended temperature measurement techniques

Age	**Recommended technique**
Birth to 2 years	1. Rectal (definitive)
	2. Axillary (screening)
Over 2 years to 5 years	1. Rectal
	2. Tympanic
	3. Axillary
Older than 5 years	1. Oral
	2. Tympanic
	3. Axillary

Conclusion

While it is evident that all devices available currently to measure temperature in children have their strengths and weaknesses, it is clear that the choice made by parents is influenced by the convenience of use, cost and advertising. For professionals, the older, time-honoured methods will be chosen often 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 in use.

Based on the evidence currently available, there is no doubt that 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 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 (Table 2).

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Principal co-authors: Drs Denis Leduc, Montreal, Quebec; Sandra Woods, Val-d'Or, Quebec

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