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Thermometry in children

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Abstract

Accurate measurement of temperature is important for detection of fever and hypothermia in pediatric patients. Ideal temperature-measurement technique should be safe, easy, noninvasive, cost effective, time efficient, and should precisely reflect core body temperature. Pulmonary artery is the closest to hypothalamus and best reflects the core temperature. Other sites used are distal esophagus, urinary bladder and nasopharynx. All these methods are invasive and difficult to use in clinical practice. Amongst the noninvasive methods, rectal thermometry is considered to be the closest to core temperature, but it has its own drawbacks. With the current evidence available, tympanic artery thermometry for children more than 2 years of age and temporal artery thermometry in all age groups are taking precedence over other methods.

Keywords: Children, temperature measurement, fever

INTRODUCTION

Temperature measurement is an important aspect of patient care, with a considerable clinical impact. Temperature is measured to detect presence of fever, which is the single most common complaint, reported in about 30% of children presenting in the emergency department.[1] It becomes important to detect not only fever but also hypothermia, at least in the neonatal period, as it is an important contributor to neonatal mortality in developing countries.[2] Wrong temperature detection by the caregivers can lead to delay in seeking medical care, delayed diagnostic workup and eventually delayed treatment. For a clinician to decide the treatment to be administered, temperature measurement carries great importance in both acute febrile illnesses presenting in emergency room, as well as chronic illnesses.

While measuring temperature, one should aim to be as close to core temperature as possible. Core temperature is the temperature of the blood that bathes the temperature-regulating center of the body, i.e., hypothalamus. There is a variable gradient between the hypothalamus and different body sites where temperature can be measured. Ideally, the temperature measurement should be safe, easy, noninvasive, cost effective, time efficient and technique independent and should precisely reflect core body temperature and should not be influenced by the environmental temperature. Pulmonary artery

is the closest to hypothalamus and its temperature best reflects the core temperature, but it is practically not possible to measure pulmonary artery temperature. Despite much advancement till now, none of the thermometry methods meet all these criteria.

Different techniques used for measuring temperature in children can be broadly classified into invasive and noninvasive methods.

INVASIVE METHODS

Pulmonary artery thermometry

Pulmonary artery (PA) temperature is the best to be used as reference standard for core temperature. Pulmonary artery temperature is 0.2°C lower than the temperature of blood measured in internal jugular vein.[3] PA temperature is measured by placing a probe in pulmonary artery and is restricted to children undergoing cardiac surgery.[4] PA temperature measurement is practically not possible in the clinical scenario and is only useful for research purposes.

Distal esophagus thermometry

Distal esophagus gives temperature closest to that measured in the pulmonary artery, but the use of distal esophagus thermometry is limited to intensive care units or per operative settings.[5,6] The temperature can be measured by inserting an esophageal probe in the distal esophagus, which is done by a trained anesthetist, in a sedated patient. Esophageal temperature has been shown to be more accurate than the temperatures measured by other modes over a wide range of temperature.[6] Disadvantage is that the temperature readings are affected by tracheal cooling by inspired gases and position of the probe. One needs to exclude abnormal esophageal anatomy before performing such a measurement.

Bladder thermometry

Urinary catheters with thermistors are used to measure bladder temperatures in ICU settings.[6] The results for bladder temperature measurements are not very encouraging as this is an invasive method, and the temperature measured using this method does not carry good correlation with core temperature and is significantly affected by the presence of urine in the bladder.

Nasopharyngeal thermometry

There is only one study in the pediatric age group that has measured nasopharyngeal temperature.[7] Mean difference between nasopharyngeal temperature and PA temperature was found to be 0.43°C, and nasopharyngeal temperature correlated better with PA temperature than did rectal, axillary and tympanic temperatures. The procedure carries a significant risk of nasopharyngeal trauma.

NONINVASIVE METHODS

Rectal thermometry

Rectal temperature measurement is supposed to be the closest to core temperature among the measurements done at various peripheral sites and has been the gold standard in routine clinical practice.[6] Advantage with rectal temperature is that it is not affected by environmental temperature and is specifically useful for patients of hypothermia. The problems with rectal thermometry are that it is uncomfortable for, and unacceptable to, older children and adults and carries a risk of cross-contamination. The measurements are affected by the presence of stool in the rectum, and by rectal blood flow. Risk of HIV transmission remains a concern when using this method. There is also a potential risk of rectal perforation in neonates. Rectal temperature measurements have shown

variable results when compared with pulmonary artery temperature measurements.[8,9] Hebbar *et al*.[10] compared temporal artery temperatures with pulmonary artery, rectal and axillary temperatures and concluded that the bias was significantly less in the pulmonary artery temperature–rectal temperature pair in both febrile and afebrile patients. Also, rectal temperature was found to have good agreement with esophageal temperatures, with a mean esophageal temperature–rectal temperature difference of 0.00±0.18°C.[5]

Sublingual (oral) thermometry

Sublingual thermometry, using both mercury and digital thermometers, can be used for temperature measurement in older children and adults. The site is easily accessible, and the measurements are less likely to be affected by the environmental temperature. Sublingual temperature is more accurate as compared to axillary temperature. When pulmonary artery temperature was compared with other noninvasive methods of temperature measurement in adult ICU patients, oral temperatures were found to correlate best. Only 19% of patients had a difference of ±0.5°C; followed by temporal artery measurement, using which such a difference was seen in 20% of the patients.[11]

Axillary thermometry

Axillary thermometry is one of the earliest methods used for temperature recording. The temperature is measured by placing a thermometer directly over axillary artery, located deep in the apex of axilla. Axillary temperatures are significantly altered by peripheral cooling and often provide inaccurate readings. A systematic review of 20 studies by Craig *et al*. concluded that temperature readings using both mercury and electronic axillary thermometers showed wide variation across all the studies and that axillary thermometry is not a good method when accurate temperature measurements are required.[12] In another study by Kara *et al*., axillary temperature was compared using chemical and mercury thermometers, and the results led to the conclusion that axillary temperature measurement using a chemical thermometer is not a good method for screening of fever.[13]

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.[14]

Tympanic membrane thermometry

The tympanic membrane (TM)'s blood supply is derived from the carotid artery, and thus the temperature measured here closely reflects the core temperature.[15,16] Initial TM temperature measurements were done using a probe, applied directly to the membrane. Now, infrared radiation emitting thermometers, called infrared radiation emission detectors (IREDs), are available, which measure the thermal radiation emitted from the tympanic membrane and ear canal. The amount of thermal radiation emitted is in proportion to the membrane's temperature, so it accurately estimates tympanic membrane temperature.[17] These readings are not altered by the presence of wax or otitis media. Other advantages are easy accessibility of the site, speed and ease of measurement. The issues related to infection control are not much with tympanic membrane thermometers. These thermometers are difficult to use in children less than 2 years of age because of the narrow ear canal.

Some of the tympanic membrane thermometers have built-in offsets that attempt to estimate the core, oral or rectal temperature from actual tympanic membrane temperature. If the thermometer is used in incorrect mode, it may wrongly estimate the presence or absence of fever.

Many studies have been conducted regarding reliability of tympanic membrane thermometry, and their results are equivocal. In a meta-analysis of 44 studies comparing rectal (as reference site) and infrared thermometry, the agreement between TM temperatures and rectal temperatures was low, and

the differences were in either direction. Even when the device was used in rectal mode, it was not found to be an approximation of rectal temperature.[18] Other authors have also found the tympanic membrane temperatures to be inconsistent — in comparison with rectal temperatures, and also age and temperature dependent.[19–21] When tympanic membrane measurements using home and clinical TM thermometers were compared with axillary temperatures for accuracy of fever, home-use TM thermometers were likely to miss fever in a significant number of patients. Thus a home-use TM thermometer can only be used as a screening tool for fever but not for follow-up of febrile patients.[22]

Purssell utilized tympanic membrane thermometry to assess normal tympanic membrane temperature and its repeatability. Their study concluded TM thermometry to be a reliable method of temperature measurement with a mean TM temperature of 36.65°C and an overall repeatability index of 0.78°C.[23] The only Indian study on the use of TM thermometry was conducted by Sehgal *et al*. in meningitis and non-meningitis patients. They concluded that TM temperatures had a good correlation with rectal temperature over a wide range of temperatures.[24] Another advantage of tympanic membrane thermometry is its acceptability in the pediatric age group.[25]

Temporal artery thermometry

Temporal artery (TA) thermometry is a relatively new method of body temperature measurement. The temporal arterial temperature is measured by passing the probe of an infrared thermometer over the front of the forehead to the temporal area. Its advantage over TM thermometry is its relative safety as blind introduction of the instrument into the ear canal is not required. In a study, TA thermometry was found to be an inaccurate predictor of fever, in comparison to rectal thermometry, with only 66% sensitivity;[26] but another study found it to be an effective screening tool and a more acceptable method in infants as compared to TM and rectal thermometry.[27] Similar results were observed by Titus *et al*., who advocated TA thermometry as an effective screening tool in children between 1 and 4 years of age.[28] Suleman *et al*. compared TA temperature measurements with PA temperature measurements and found only a modest agreement between the two in children.[29] This agreement was even poorer in adults. These results were contrary to the results of a pilot study by Al-Mukhaizeem *et al*.[5] They found good agreement between TA and esophageal temperatures.

A large study was conducted by Roy *et al*.; they tried to give age-specific normal values of temperature measurement using temporal artery thermometer by measuring TA temperature of 2,346 patients aged 0-18 years. Fever was defined as the temperature that was greater than two standard deviations above the normal. Although there were different cutoffs for different age groups, a TA temperature of ≥38.0°C or ≥100.4°F could define fever in children 0-47 months of age.[30]

Cutaneous infrared thermometry

Cutaneous temperature-measuring devices, utilizing the basis of infrared thermometry, are being developed. The purpose of these devices is rapid detection of fever in a noninvasive manner. Pierre Hausfater assessed the accuracy of infrared thermometer in 2,026 patients, both children and adults, and compared it with that of TM thermometry. The negative predictive value of the device was seen to be 0.99 and a positive predictive value of 0.10 at temperature of ≥38.0°C. Thus the technique was not found to be suitable for mass detection of fever.[31] Contradicting results were observed by Ng *et al*.[32] They also found environmental temperature as an important confounder in cutaneous thermometry.

Tactile assessment

Palpation of skin to assess temperature is an age-old method, which is still widely used by parents

and caregivers to check for the presence of fever. The method is less accurate and is easily affected by lowering of skin temperature because of vasoconstriction. A large study by Whybrew *et al*. found touch to overestimate skin temperature and thus falsely label children as having fever.[33] Banco *et al*. found mothers to have a better prediction (80%) than medical students (42%).[34] Similar results were observed in an Indian study by Chaturvedi *et al*., who found slightly better sensitivity and specificity of tactile assessment by medical staff (78% and 63.6%, respectively) as compared to caregivers (70.5% and 40.9%, respectively), thus both of them over- and under-diagnosing fever.[35]

Tactile assessment of temperature cannot certainly be used for follow-up of febrile patients. The method can bring a child to a health facility, but correct assessment using a precise temperature-measuring device is required. Tactile assessment to detect hypothermia in neonates (by touching abdomen and feet) can be used at the peripheral level to categorize cold stress and hypothermia, and can be utilized for further management and referral.[36]

Amongst invasive methods of thermometry, pulmonary artery thermometry is the ideal way for measuring the core temperature. However, its use is restricted to very sick patients in intensive care unit or per operative setting. Various noninvasive options for temperature measurement are available to choose from. Evidence-based results are variable in support of each method. Children's comfort and their preference become important in the choice of an instrument. In a study conducted by Pickersgill *et al*. on 83 children (39, between 6 and 10 years of age; and 44, between 11 and 15 years of age), preference was seen for tympanic membrane thermometry in both the age groups.[37] Community Pediatrics Committee formed by the Canadian Pediatric Society (CPS) still recommends use of rectal thermometer in children less than 5 years of age; and oral thermometer, in children more than 5 years of age. Tympanic membrane thermometer or temporal artery thermometer can be used as a screening mode in a hospital setting. Use of mercury thermometers should be discontinued due to environmental hazards.[38]

CONCLUSIONS

With the available evidence, tympanic membrane thermometer in children more than 2 years of age and temporal artery thermometer in all the age groups seem to have the potential to become the methods of choice both among clinicians and parents. The problem that needs to be addressed is related to the availability of normal body-temperature values with each of these methods. Tympanic membrane thermometers that can be safely used for smaller children need to be designed.

Footnotes

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