Assessment of body temperature measurement options

Märtha Sund-Levander and Ewa Grodzinsky

Abstract

Assessment of body temperature is important for decisions in nursing care, medical diagnosis, treatment and the need of laboratory tests. The definition of normal body temperature as 37°C was established in the middle of the 19th century. Since then the technical design and the accuracy of thermometers has been much improved. Knowledge of physical influence on the individual body temperature, such as thermoregulation and hormones, are still not taken into consideration in body temperature assessment. It is time for a change; the unadjusted mode should be used, without adjusting to another site and the same site of measurement should be used as far as possible. Peripheral sites, such as the axillary and the forehead site, are not recommended as an assessment of core body temperature in adults. Frail elderly individuals might have a low normal body temperature and therefore be at risk of being assessed as non-febrile. As the ear site is close to the hypothalamus and quickly responds to changes in the set point temperature, it is a preferable and recommendable site for measurement of body temperature.

Key words: Axillary ■ Ear ■ Oral ■ Rectal ■ Evidence-based ■ Measurement

Assessment and evaluation of body temperature has a huge impact on decisions in nursing care and for medical diagnosis, treatment and the laboratory test ordered by the physician. Today, there is a general acceptance that body temperature is a range and not fixed, but in clinical practice traditional definitions of normal body temperature are still considered the norm (Bentley et al, 2001; Mackowiak and Wassermann, 1995). The definition of normal body temperature as 37°C and fever as >38.0°C was established in the middle of the 19th century, when thermometers were introduced into medical practice (Wunderlich and Reeve, 1869). At that time, the understanding of the influence of thermoregulation, hormones, metabolism and physical activity on body temperature and calibration of thermometers were unknown. The measurements were performed on patients indicating that they might have been febrile at the axillary site, which only gives an estimate of peripheral temperature as opposed to the core temperature (Mackowiak, 1997b). Since 1869 the development of the technical design of thermometers, for example, the technical accuracy has been much better. However, clinical accuracy, in terms of the knowledge of physical influence on the individual body temperature, such as thermoregulation and hormones, immunological defence against microbes and the development of laboratory assays, are still not taken into consideration for body temperature assessment (Sund-Levander and Grodzinsky, 2012).

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Accepted for publication: July 2013

Traditionally, the public have learned to adjust oral and axillary readings to the rectal temperature, adding 0.3°C and 0.5°C, respectively. In addition, the manufacturer of thermometers have their own, trade secret, offsets built into the devices, although there is no scientific documentation of why these adjustments should be made or when they first emerged (Sund-Levander and Grodzinsky, 2009). This has been applied to modern devices (Betta et al, 1997). However, there is no evidence for adjusting one site to another, as no factor exists that allows accurate conversion of temperatures recorded at one site to estimate the temperature at another (Mccarthy and Heusch, 2006; Sund-Levander and Grodzinsky, 2009). Trying to define adjustments between sites or to use the term equivalence only contributes to misunderstanding (Betta et al, 1997; Giuliano et al, 1999). When measuring body temperature, the unadjusted mode should be used, without adjusting to another site. The rationale for this is based on thermoregulation and differences between and within individuals.

Thermoregulation

Thermoregulation is influenced by several factors, such as diurnal variation and cellular metabolism, due to muscle activity during the day (Stephenson, 1997; Van Someren et al, 2002), exercise (Nielsen and Kaciuba-Uscilko, 1998) and ambient temperature (Werner, 1998). The diurnal rhythm is consistent within the individual both in health and disease. Temperatures in the morning vary less compared with afternoon–early evening, underscoring the influence of exogenous factors during the daytime (Van Someren et al, 2002). The skin and the subcutaneous tissues insulate the body, and behavioural control re-establishes comfort through conscious adjustments (Cabanac, 1998; Tochihara, 2000), such as seeking shade and removing clothes in a hot environment or increasing muscle movements and wearing more clothes when it is cold.

The purpose of thermoregulation is to maintain the core body temperature within an individual temperature range, (set point). Thermo-sensitive neurons in the pre-optic anterior

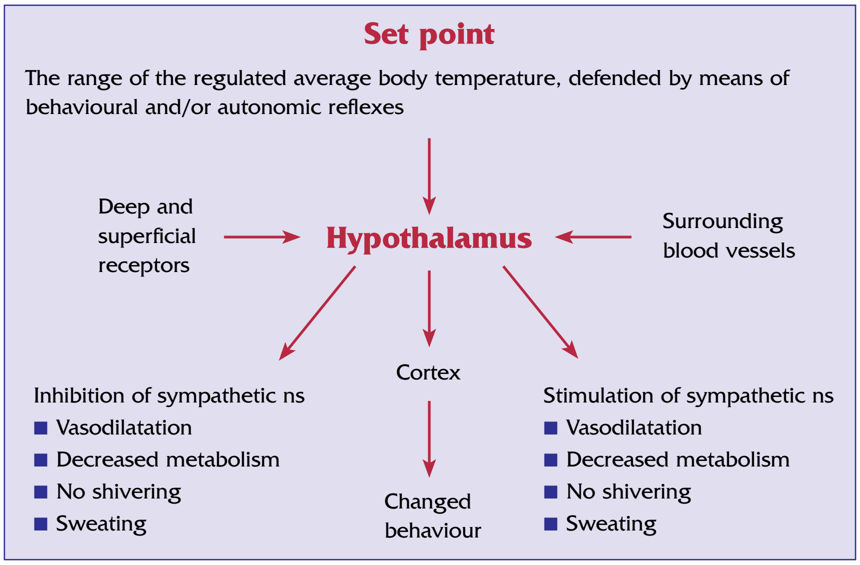

Figure 1. The purpose of thermoregulation is to maintain the core body temperature within the individual temperature range, set point. Thermo-sensitive neurons in hypothalamus compare set point with information from the surrounding blood and peripheral receptors. In a warm environment, the set point shifts to a lower level to increase heat loss responses and inhibit heat production, and in a cold environment the set point shifts to a higher level to evoke heat production, with shivering as the emergency response, and inhibit heat loss mechanisms

area of the hypothalamus integrate information from the surrounding blood and peripheral receptors and compare this with the individual set point. In a warm environment, the set point shifts to a lower level to increase heat-loss responses and inhibit heat production, and in a cold environment the set point shifts to a higher level to evoke heat production, with shivering as the emergency response, as well as mechanisms that inhibit heat loss. Neurons in the midbrain reticular formation and in the spinal cord respond to thermal stimulation of the skin, and the vagus nerve act as a signal-transfer pathway from the periphery to the brain (Boulant, 1997; Boulant, 1998; Van Someren et al, 2002; Charkouidan, 2003) (*Figure 1*).

A consequence of thermoregulatory mechanisms is temperature variations over the body, due to the distance to the hypothalamus; all sites outside the hypothalamus need time to adjust to changes in the set-point temperature, especially peripheral sites such as the axillary and forehead (Sund-Levander and Grodzinsky, 2009). A recently published systematic review showed large variations in body temperature related to different sites in older people (Lu et al, 2010).

Site of measurement

In clinical practice the rectal, oral, axillary, forehead and ear are used to measure body temperature. *Table 1* summarise the pros and cons of each site.

The rectal site

The rectal site provides an indication of the deep visceral temperature, modified by the temperature of the skin of the buttocks, the iliac artery and the iliac vein (Dubois, 1951). The rectal temperature is higher than at other sites (Brennan et al, 1995; Smitz et al, 2000), due to the low blood flow and high isolation of the area, giving a low heat loss (Petersen and Hauge, 1997). The rectal area has no thermal significance of its own (Benzinger, 1969) and it is located far from the central nervous system as well as from the pulmonary artery. Therefore, it significantly lags behind changes at other core sites, especially during rapid temperature changes such as warming and cooling during surgery, exercise and fever (Gerbrandy et al, 1954; Giuliano et al, 1999, Robinson et al, 1998b; Rotello et al, 1996; Togawa, 1985), and may be both higher or lower than the core temperature (Blatties, 1998).

When the rectal, oral and tympanic membrane temperatures were measured at the same time, rectal temperature did not change during a 20-minute exposure to either cold or warm, while oral and tympanic membrane temperatures did (Zehner and Terndrup, 1991). A 20-minute lag time for adjustment to other core sites during general anaesthesia (Benzinger, 1969), and up to 1.5 hours during re-warming from cardiac surgery has been reported (Rotello et al, 1996). In head-injured patients, the rectal temperature has been reported to underestimate brain temperature by as much as 2.1°C (Rumana et al, 1998) and in cold conditions the difference can be as high as 2.3°C (Togawa, 1985).

Hard stool might obstruct adequate placement of the thermometer, and inflammation around the rectum (Varney et al, 2001) and heat-producing activity of micro-organisms in faeces can influence the reading (Blatties, 1998; Robinson et al, 1998a).

As the temperature increases by 0.8°C with each 2.54 cm the device is inserted (Togawa, 1985; Rotello et al, 1996) a standardised depth of 4 cm in adults (Blatties, 1998) and 2–3 cm in children (Mackowiak, 1997a) is recommended.

Rectal temperature measurement is unhygienic and can pose a risk of injury to the intestinal mucosa, especially in infants and in rectal surgery. It increases physical and psychological stress and can cause embarrassment, anxiety and physical discomfort (Blatties, 1998; Fallis, 2000). Hence, rectal measurement should be avoided, especially in children.

The oral site

As a branch of the external carotid artery perfuse, the area of the posterior sublingual pockets in the posterior part of the mouth, the oral temperature follows changes in core temperature (Blatties, 1998). The sublingual temperature differs between the posterior and the anterior area by 0.8°C in apyrexial and 1.6°C in febrile subjects (Erickson, 1980) as well as between the left and right side of the posterior sublingual pockets (Modell et al, 1998). Other influencing factors are salivation (Blatties, 1998), previous intake of hot or cold food and fluids (Blatties, 1998; Rabinowitz et al, 1996; Terndrup et al, 1989), gum chewing, smoking (Rabinowitz et al, 1996) and rapid breathing (Cranston et al, 1954). Vasomotor activity in the sublingual area also affects the temperature (Cooper et al, 1964), for example, a fall in oral temperature during the onset of fever may occur due to reduced blood flow (Cranston et al, 1954; Gerbrandy et al, 1954).

The axillary site

Accuracy is affected by ambient temperature, local blood flow, underarm sweat or closure of the axillary cavity, and duration of the reading (Blatties, 1998). Furthermore, there is a temperature difference of 1.4°C between the right and

Table I. Pros and cons with non-invasive measurement of body temperature (Sund-Levander and Grodzinsky, 2009)

Site of measurement	Technical design	Pros	Cons
Ear	■ Infrared radiation device ■ Measures the infrared heat waves from the tympanic membrane	■ Assess core temperature ■ Close to hypothalamus ■ Hygienic ■ Rapid measurement ■ Convenient for the patient ■ Painless for the patient ■ Do not threaten the patient's integrity	■ Gives low readings if incorrectly placed ■ Training in operator technique is needed before performance ■ The reading may be influenced by otitis ■ Incorrect placement of the probe due to a narrow cavity may affect accuracy
Rectal	■ Digital electronic device ■ A sensor produces electronic signals, reflecting the tissue temperature ■ Temperature displayed in unadjusted, adjusted value in a steady-state mode or a predictive mode	■ Assess core temperature ■ Easy to perform	■ The reading is higher than at other places during steady state ■ Affected by hard stool and heat-producing activity of micro-organisms in faeces ■ Affected by inflammation around the rectum ■ The thermometer has to be inserted 4 cm in adults and 2-3 cm in a child, to give a correct reading ■ Serious lag time for adjustment to set point temperature, especially during rapid changes, such as cooling of the skin, exercise, fever and hypothermia ■ Risk of nosocomial infection ■ Risk of rupture of intestinal mucosa ■ Embarrassing for the patient ■ Intrusive for the patient
Oral	■ Digital electronic device ■ A sensor produces electronic signals, reflecting the tissue temperature ■ Temperature displayed in unadjusted, adjusted value or a predictive mode	■ Assess core temperature ■ Easy to perform	■ Placement affects the reading, e.g. there is a difference between the posterior pocket and the front area and also between the posterior pockets ■ Affected by salivation, previous intake of hot or cold food and fluids, smoking, gum chewing, and breathing with open mouth ■ Contraindicated in unconsciousness, confused patients ■ Contraindicated when there is a risk of seizures ■ Inappropriate in individuals with uncooperative or disturbed behaviour ■ Inappropriate in young children
Axillary	■ Digital electronic device ■ A sensor produces electronic signals, reflecting the tissue temperature. ■ Temperature displayed in unadjusted, adjusted or a predictive mode	■ Convenient for the patient ■ Might be reliable when measuring body temperature in babies under the age of 3 months	■ Do not assess core temperature ■ Strongly affected by ambient temperature, local blood flow, underarm sweat, appropriate placing of the probe or closure of the axillary cavity, and duration of the reading ■ The reading is lower compared to other sites in steady site ■ Serious lag time for adjustment to set point temperature, especially during rapid changes, such as cooling of the skin, exercise, fever and hypothermia ■ Unreliable for assessing body temperature
Temporal artery (forehead)	■ Infrared radiation device ■ Measures the infrared heat waves from the skin above the tympanic artery	■ Convenient for the patient ■ Might be reliable when measuring body temperature in babies under the age of 3 months	■ Do not assess core temperature ■ Unreliable for assessing body temperature ■ Strongly affected by local blood flow, placement of the device, moisture in the skin, the amount of subcutaneous fat, physical activity and ambient temperature ■ The reading is lower compared to other sites in steady site ■ Serious lag time for adjustment to set point temperature, especially during rapid changes, such as cooling of the skin, exercise, fever and hypothermia

left axilla (Howell, 1972) and a large variation in repeated measurements (Sund-Levander et al, 2004). As axillary measurements, even with careful positioning, slowly register changes in core temperature, the readings widely deviate from other sites (Robinson et al, 1998b), especially during fever due to vasomotor activity.

The temporal artery (forehead) site

Forehead thermometers estimate the temporal artery temperature, indirectly measuring the temperature of the overlying skin of the forehead (Crawford et al, 2006). This site fluctuates considerably due to perspiration, use of make-up, lotions, oils, hair, local blood flow, placement of the device, moisture on the skin, the amount of subcutaneous fat, physical activity and ambient temperature (Liu et al, 2004; Bridges and Thomas, 2009; Edling et al, 2010).

Vasopressive medication, skin thickness, bone and tissue between the temporal artery and the skin, temporal artery atherosclerotic disease, postoperative vasoconstriction and circulation of catecholamine concentrations may affect the accuracy in adults (Suleman et al, 2002).

Accuracy is especially questioned during rapid changes in body temperature (Kistemaker et al, 2006), particularly in febrile subjects and patients in theatre.

As the absolute temperature at the outer surface of the head over the temporal artery and the target arterial temperature is not the same, adjustments depending on reference temperature are programmed into the device (Pompei, 1999). These offsets are trade secrets; they are not available to anyone other than the manufacturers.

The ear site

The tympanic membrane and hypothalamus share their blood supply from the internal and external carotid arteries (Benzinger, 1969; Giuliano et al, 2000) and the area is relatively devoid of metabolic activity. As the probe is placed about 1.5 cm away from the tympanic membrane (Togawa, 1985), the reading is a combination of heat from both the tympanic membrane and the ear canal (Fraden, 1991). To compensate for the deviation, there is an offset system included in the instrument (Lefrant et al, 2003). The ear temperature should be measured in the unadjusted mode, without adjustments to other sites (Brennan et al, 1995; Smitz et al, 2000; Sund-Levander et al, 2004; Sund-Levander and Grodzinsky, 2009).

The accuracy of infrared devices for reflecting the tympanic membrane temperature and for changes in the core temperature during physical exercise and warming are reliable (Jakobsson et al, 1992; Sund-Levander and Grodzinsky, 2009). Ambient temperature may alter the reading (Zehner and Terndrup, 1991; Betta et al, 1997; Sato et al, 1996), although no affect was found during facial cooling or fanning (Sato et al, 1996; Shibasaki et al, 1998).

The influence of earwax is inconsistent, with some reporting no influence (Chamberlain et al, 1991; Castle et al, 1992; Modell et al, 1998), while others observed a greater variability in the measurements (Rabinowitz et al, 1996) and an underestimation by an average of 0.3°C (Doezema et al, 1993).

The occurrence of otitis media has been associated with 0.1°C higher values (Chamberlain et al, 1991), while others reported no effect (Robb and Shahab, 2001).

A narrow ear cavity may affect repeatability, because of difficulty to place the probe correctly (Duberg et al, 2007).

A difference in temperature between the left and right ear might indicate the impact of operator being left or right handed (Lee et al, 1999). Others have suggested duplicate or triplicate ear temperature measurements (Chamberlain et al., 1995; Stavem et al, 1997; Childs et al, 1999) , but the authors have shown that repeated measurements do not improve reproducibility, it is more dependent on education and training (Sund-Levander et al, 2004).

The tympanic/ear is a good site for non-invasive core measurement of body temperature, however, care should be exercised with the different modes of operation offered (Mangat et al, 2010).

Clinical implications

Assessing body temperature

The purpose when measuring body temperature is to estimate changes in core temperature. A site that quantitatively and rapidly reflect changes in arterial temperature and is independent of local blood flow or environmental changes, would appropriate estimate core temperature (McCarthy and Heusch, 2006). From both a technical as well as a clinical view, accuracy and precision of the reading and repeatability is significant to ensure a correct assessment (Iso, 2009; Pursell et al, 2009; Sund-Levander and Grodzinsky, 2012). Accuracy also includes measurement of the 'actual' body temperature, without adjustments to other sites, and a correct placement, i.e. following the manufacturer guidelines, as incorrect placement can cause serious variations (Crawford et al, 2006).

Assessment and evaluation must be evidence-based and not reliant on tradition and personal beliefs (Emmoth and Edwinsson-Månsson, 1997; Sund-Levander et al, 1998). As an example, if we still consider a fixed temperature as fever and do not use evidence-based knowledge in practice, frail elderly individuals are at risk of being assessed as non-febrile due to a lower baseline body temperature, contributing to a delayed diagnosis and treatment (Sund-Levander et al, 2003).

Figure 2 illustrates the deviation (mean ± 2 standard deviations (SD)) (Bland and Altman, 1999) between simultaneously measured rectal and ear morning body temperature in 245 individuals, aged 19 to 99 years (Sund-Levander and Wahren, 2002; Sund-Levander et al, 2004). For the whole group the range was -1.3°C to +3.4°C (n= 245). However, when dividing into gender this was true only for women (n=178) while the corresponding figures in men (n=67) was

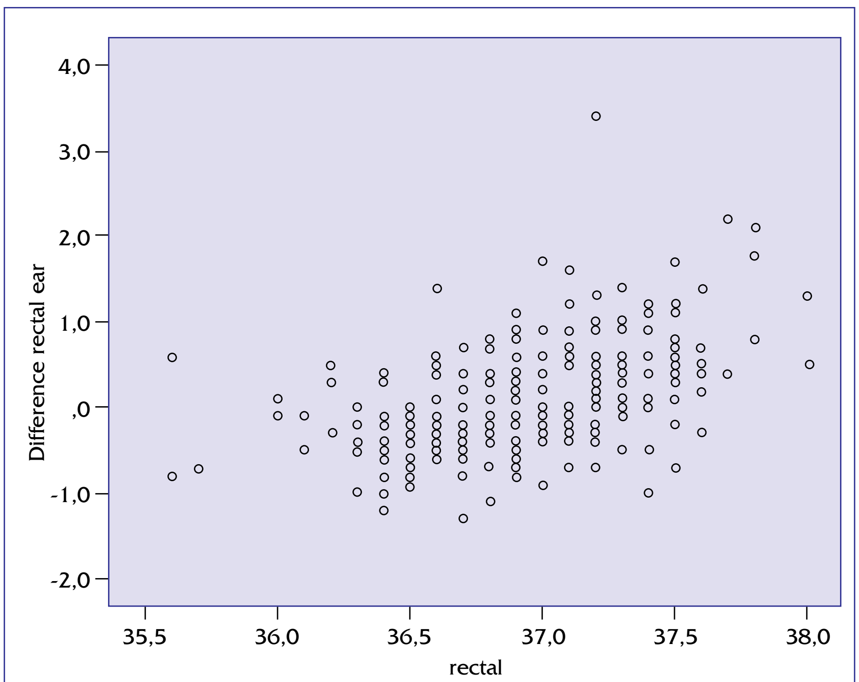

Figure 2. Limits of agreement (mean ± 2 standard deviations (SD)) (Bland and Altman, 1999), 0.1°C + 1.6°C of the difference between rectal and ear morning body temperature (∞C), measured at the same time in 67 men and 178 women aged 19 to 99 years

−1.2°C to +1.7°C. In addition, when separating into younger individuals (19 to 65 years, n=84) and elderly (66 to 99 years, n=161) the differences was -1.3°C to +3.4 °C. Furthermore, individuals with dementia (n=71) showed a variation ranging from −1°C to +3.4°C, while in those without dementia (n=174), the range was −1.3°C to +2.1°C.

The Genius™ 2 Tympanic Thermometer (Covidien UK)

The Genius 2 thermometer has an infrared sensor housed in the probe tip that detects infrared energy from the tympanic membrane. During the temperature measurement phase the Genius 2 gathers up to 100 readings and displays the highest value on the LCD screen. This is known as the 'peak select system'. As the highest temperature is displayed this overcomes any issues of draw-down in the ear canal, technique adjustments, or any mix of heat from the tympanic membrane and the ear canal (Fraden, 1991).

Clinical scenarios

Case one

A 45-years-old man (Mr Miller) was admitted to the neurosurgical intensive care unit (NICU) as he had a subarachnoid haemorrhage (SAH). He was unconscious, but his face showed signs of discomfort and anxiety on pain stimulation. He had only a towel covering the lower part of his body.

The nurses regularly gave him prescribed anaesthetic sedatives and muscle-relaxing drugs. He was nasally intubated and treated on a ventilator. His body temperature was measured every third hour in the axilla and when the nurse observed symptoms indicating changes in temperature. When Mr Miller was observed shivering the nurses measured the axillary temperature and when it was above 38°C surface cooling was started. The axillary temperature varied between 38.1°C and 38.9°C, which prompted the nurse to start surface cooling by placing alcohol-based wraps in the armpits and groins and using a fan. Mr Miller had three episodes of severe shivering (visual contractions in the chest and/or trunk musculature and/or general contractions including extremities).

The procedures followed by the nurse are routine in order to avoid elevated body temperature, as this is critical in cerebral-injured patients (Sund-Levander and Wahren, 2000). Mild hypothermia, defined as a body temperature of less than 36°C and more than 34°C, protects the brain from hypoxia by reducing intracranial pressure and increasing cerebral perfusion pressure (Grände, 1992; Shinozaki et al, 1993). However, a rapid reduction of body temperature by surface cooling can initiate shivering, which increases body metabolism by 300–500% (Guyton and Hall, 2000) and a release of catecholamines and stress hormones (Augustine, 1990). The oxygen debt in the musculature remains after shivering has ended (Holtzclaw, 1993). Shivering is also unpleasant and painful for the patient and so all measures should be taken to prevent it. In induced surface cooling, shivering is stimulated by the increased gradient between the set point and the peripheral temperature (Holtzclaw, 1993; Spaniol et al, 1994).

As Mr Miller was taking part in the study examining shivering, the ear and tip-toe temperature were measured as well as the axillary temperature (the ear temperature was measured using Genius 2). It was therefore possible to follow the gradient between the core (ear) and peripheral (tip-toe) temperatures.

In the morning, when Mr Miller was not shivering, the gradient was 6°C between tip-toe and ear temperatures. Before the three shivering episodes, the gradient increased to 13.7°C, 15.9°C and 16.4 °C, respectively (Sund-Levander and Wahren, 2000). The ear temperature varied between 36.1°C to 36.9°C and the tip-toe temperature 21.6°C to 23.8°C during the day, in comparison with the axillary temperature variation of 38.1°C to 38.9°C. So, the axillary thermometer constantly gave a high temperature value, leading to surface cooling, that actually triggered shivering, which is extremely stressful for a critical ill patient. In addition, the high axillary temperature could give the impression that the patient had a fever. In fact, it can be explained by muscle contractions and the built-in adjustment in the device. If the ear and tip-toe sites had been used, surface cooling could have been avoided and consequently, the shivering. To shiver is far more dangerous for a cerebral-injured patient than to have a core temperature of 36.1°C–36.9°C.

This case underlines the significance of thermoregulation and sites selected for assessment of body temperature. The axillary site does not measure core temperature, is slow to react on changes in set-point temperature and is adjusted to other sites, with unknown offset, by the manufacturer. It is therefore unreliable for assessment of body temperature.

If the nurse instead had considered how shivering is triggered and measured the ear-skin temperature in the unadjusted mode, she would have detected the increased gradient earlier, and been able to prevent shivering.

Case two

A 66-year-old woman (Mrs Smith), was admitted to the hospital after she slipped and broke her leg. The fracture was complicated so she was operated on immediately. Post-operatively she was cared for in the recovery room in the intensive care unit. After the surgery her body temperature was reduced due to anaesthetics. She could not be transferred to the orthopaedic ward until her body temperature was normal (37°C). Her vital parameters were measured every 15 minutes for the first 3 hours following surgery. Her body temperature was measured every 30 minutes with an infrared forehead thermometer (TA).

When Mrs Smith arrived at the recovery room she was so cold so she was shaking. Her skin was pale and cool and her superficial blood vessels were vasoconstricted. The nurses covered her with blankets designed to conserve heat, placed a heat-radiating lamp above her bed and gave her warmed intravenous fluids to support her body to gain heat and avoid shivering. During the first 2 hours the TA temperature increased from 35°C to 36°C. After 3 hours her TA temperature was 37.7 °C and so the nurse took away the lamp and blanket and prepared for her transportation to the orthopaedic ward.

Although Mrs Smith as still very sleepy, she had recovered from the anaesthesia and was able to express herself. She complained that she was feeling cold and asked for a blanket. The nurse was surprised by this as Mrs Smith's body temperature was 37.7°C.

KEY POINTS

- The ear site is a reliable and preferable site for measuring body temperature
- When measuring body temperature, the unadjusted mode should be used, without adjusting to another site
- The same site of measurement should be used as far as possible
- Peripheral sites, such as the axillary and the forehead site, is not recommendable as an assessment of core body temperature in adults
- Frail elderly individuals might have a low normal body temperature and therefore be at risk of being assessed as non-febrile

During surgery the anaesthesia had caused a drop in body temperature due to muscle relaxation and vasodilatation and so Mrs Smith was hypothermic when she was transferred to the recovery room. Thermal control is dynamic when working to achieve a balance between heat production and dissipation. In normal conditions, when the core temperature is low, heat production in terms of muscle movements exceeds heat output and raises the body temperature. The anaesthetised patient is treated with medication that causes total muscle relaxation, and therefore the ability to produce body heat by muscle movements is inhibited. The actions taken by the nurses to rewarm Mrs Smith, i.e. cover her with a heat-conserving blanket, use the heat-radiation lamp and giving her warmed intravenous fluids, helped the body preserve heat without consuming muscle activity, i.e. shivering. However, for Mrs Smith it would have been better to use the ear site to measure her temperature (with the Genius 2 thermometer).

All sites outside the hypothalamus need time to adjust to changes in the set-point temperature (Sund-Levander and Grodzinsky, 2009). For the ear site this time for adjustments is small due to the short distance to the hypothalamic thermosensory area. However, for the forehead the time for adjustment takes longer due to the distance to the hypothalamus. Also, the forehead thermometer has several degrees of adjustments programmed into it to compensate for the real difference between the forehead skin temperature and that of the temporal artery (Pompei, 1999). Therefore the TA thermometer shows false high values even though, in this case, the patient was still hypothermic

In addition, the accuracy of forehead thermometers is especially questioned during rapid changes in body temperature (Kistemaker et al, 2006), such as rewarming after surgery.

Case three

Mr Jones, an 87-year-old man, had been living in sheltered housing for older people for 5 years. Late-stage dementia had resulted in severe cognitive decline, and he had chronic obstructive pulmonary disease (COPD). He needed a great deal of care for managing activities of daily living. He was often anxious and restless and would react aggressively when the nursing assistant (NA) helped him with personal hygiene, eating, or toileting. He was also sometimes apathetic. Because of the cognitive decline he had difficulties with memory, understanding others and expressing himself. He was on daily medication of sedatives and antidepressants. The nurses believed that he had pain in his knees and therefore he was given analgesics (paracetamol) three times a day. However, due to his condition, the nurses found it very difficult to understand and interpret his reactions when he was not feeling well.

One morning the NA noted that Mr Jones was behaving differently. He seemed infirm and did not want any breakfast or to take his morning medication. He looked at the NA with a blank stare. During the day he was getting worse and the NA noted general signs of disease and respiratory symptoms. After breakfast he stayed in bed for the rest of the day. In the evening he is was bit more alert and ate some dinner.

A urine sample taken in the morning showed no signs of active infection. The NA continued to document that Mr Jones was not feeling well for the next few days and reported his changed condition to the nurse, who noted that he might have a cold but took no further action as Mr Jones did not have a fever. His ear temperature (measured using Genius 2) was 37.6°C in the morning and 36.8°C in the afternoon the first day, and 37.2°C in the morning and 37.3°C in the evening of the second day. After 5 days the nurse documented that Mr Jones has a temperature of 38.1°C and the following day she informed the physician, who recommended observation and suggested the NA 'wait and see'.

The following week the NAs continued to report their observations. However, as Mr Jones temperature was below 38°C, no action was taken until 16 days after the first observation, when his body temperature was 38.9°C. The next morning the nurse contacted the physician who prescribed antibiotics due to suspected pneumonia. However, Mr Jones deteriorated and 24 days after the NA's first observation he died of pneumonia.

This case illustrates the process from the first signs of infection to diagnosis and action with an elderly person with cognitive decline and physical impairment. In elderly individuals, the presence of non-specific signs and symptoms and lack of specific ones are common in relation to infection (Norman, 2000; Sund-Levander et al, 2003; Cristofaro, 2004; Loeb, 2004), especially in frail elderly people (Norman, 2000).

When there is a lack of specific signs, temperature becomes an important indicator of possible infection. However, what was not noted is that Mr Jones' normal ear body temperature in the morning, before he had taken the analgesics, was 35.7°C. A rise to 37.6°C in morning temperature is actually an increase from baseline of 2.1°C. A frail elderly person's body temperature may rise significantly without being noticed because of a low basal body temperature (Castle et al, 1991).

The NAs in this case study are aware of the low normal body temperature in people they care for. They also claim that the nurse and physician required increased temperature above 38°C to take action. NAs are in an ideal position to observe early signs that might help to confirm suspected infection in elderly nursing-home residents (Tingström et al, 2010).

A final point to remember is that Mr Jones was taking paracetamol at 8am, 2pm and 8pm, thereby lowering his body temperature while he was in fever. This makes the temperature reading of 36.8°C in the afternoon of the first day of observation unreliable.

A non-contact comparison of two tympanic thermometers

This study was undertaken by Iain Threlkeld, Head of Clinical Engineering, Bradford Teaching Hospitals NHS Foundation Trust, who also wrote this abstract

Introduction

Tympanic thermometry is a well-established, reliable and effective method of recording body temperature. However, developments in technology have seen the emergence of non-contact infrared thermometers, which appear to offer cost-saving benefits as there is no ongoing cost of probe covers, as well as improvements in infection control. The aim of this laboratory study was to measure different thermometers against a constant blackbody radiator to identify whether there were any adjustments made and to determine how these devices compare in terms of accuracy with tympanic thermometers. Two types of tympanic thermometer were used in the study; the Genius 2 from Covidien and the Pro4000 from Braun; accuracy was compared with the Syner-Med VeraTemp+ non-contact infrared thermometer. All testing has been carried out under controlled conditions using methods approved by each manufacturer.

Method

Before the start of the test both the tympanic thermometers had their calibration verified using the manufacturers' approved procedures; the non-contact thermometer is shipped calibrated and does not require any further calibration according to manufacturers instructions. Both the tympanic thermometers were tested in the laboratory using a heat source specified by each manufacturer as being acceptable to test their device by and 50 readings were taken at 36.0°C, 38.5°C and 41.0°C; 150 readings in total. The non-contact thermometer specified a type of heat source that could be adjusted over a wide range of temperatures, so a further 100 readings were taken in order to measure its performance across the whole operating range of the device.

Results

At all temperatures above 36.5°C all three thermometers performed within the accuracy specified by each manufacturer. However, below 36.5°C the non-contact infrared thermometer started to differ from the expected readings and actually recorded higher readings than expected in 100% of readings taken below this value. The difference between the recorded and actual temperatures increased as the temperature dropped, at 36°C it read on average 0.7°C higher, at 34.5°C it read on average 2.4°C higher and at 33°C, which is the lower end of the stated range of the thermometer, it read on average 3.1°C higher.

Conclusions

Both the Braun Pro4000 and Covidien Genius 2 thermometer, when tested in ideal laboratory conditions, are both very accurate thermometers and perform well within the manufacturers' stated accuracy. There is no evidence from these tests to suggest either product would not be suited to a clinical environment. The Syner-Med VeraTemp+, however, only performs within specification over approximately 36.5°C. Below this, the temperature it reads differs from the expected temperature by quite a margin. The user manual for the VeraTemp+ states that the thermometers internal software automatically adjusts the temperature to provide a reading which approximates body temperature. This test however has been unable to determine how this adjustment is calculated as the thermometers error varies across the temperature range. There is a concern that if the results from the laboratory test reflect the actual performance in a clinical environment, the thermometer may not be suitable for use when measuring body temperatures below 36.5°C.

Conclusion

There is considerable knowledge about thermoregulation, and factors influencing inter- and intra-individual variations. If the baseline value is not known it is important to notice that for example frail elderly individuals are at risk of a low body temperature and therefore might have a temperature below established traditional cut off values for fever. As body temperature varies with age, gender and site of measurement, it should be evaluated in relation to individual variability, i.e. a baseline value, and that the same site should be used, without adjustments to other sites.

Body temperature measurement needs to be a holistic approach for clinicians, biomedical engineers and purchasers to ensure the medical device is fit for purpose and reads native temperature without an offset requirement. BJN

Conflict of interest: The authors have no financial interest in the products, technology or methodology discussed in this article.

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Editor's note. An incorrect version of this article was published in BJN ***22(15): 880-8****. The editor extends sincere apologies to the authors and readers for any confusion or embarrassment caused by this error.*