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Understanding the use of tympanic thermometry in the Post Anaesthesia Care Unit: A discussion paper

Abstract

Inadvertent perioperative hypothermia (IPH) is an uncomfortable, dangerous and costly but preventable complication of surgery. For perioperative nurses to treat this condition, they must first have an accurate means of detecting it. In making clinical decisions based on patients' temperature, an important vital sign, nurses must understand how different thermometers work and be competent in their use. It is vital that patients have accurate core body temperature recorded when admitted to the Post Anaesthesia Care Unit (PACU). Infrared tympanic thermometers are a non-invasive tool regularly used by PACU nurses and provide a quick and easily obtained measurement that is a reflection of core body temperature. Despite this, uncertainty remains about the accuracy of tympanic thermometer readings and their ability to accurately estimate core temperature, leading to questions being raised about their acceptability in clinical use. This discussion paper will evaluate the use of tympanic thermometers within the PACU and identify their benefits, limitations and alternatives, as well as the competency requirements of the nurse. Clinical trials give varying results and more research is needed into both the use of tympanic thermometers in the PACU and the competence of the user.

Keywords: tympanic thermometry, temperature measurement, post-operative

Introduction

Inadvertent perioperative hypothermia (IPH) is an uncomfortable, dangerous and costly but preventable complication of surgery.¹ For perioperative nurses to treat this condition, they must first have an accurate means of detecting it. The Post Anaesthesia Care Unit (PACU) nurse has a vital role in the management of patient thermoregulation.¹ Temperature is an important part of patient vital signs and to make accurate assessments and clinical decisions based on a patient's temperature nurses must have an understanding how different thermometers work and be competent in their use.

The ACORN standard for hypothermia states that a patient's temperature should be taken 'within the hour prior to transfer to the perioperative department, on arrival to the preoperative holding area, immediately preceding induction of anaesthesia, every 15 minutes when forced air warming is used and every 30 minutes for all patients' during the operative process.^{2, p.129} The hypothermia standard also suggests that all patients should have their temperature taken on arrival to the PACU, at least every 15 minutes during their stay, before a decision is made about discharge to either stage 2 recovery or a surgical ward area and at the time of discharge.^{2, p.129}

The ACORN standard further suggests perioperative nurses should also follow the National Institute for Health and Care Excellence (NICE) recommendations.² The NICE highly recommends prevention of IPH and states that a patient's temperature should be taken using a device or product that either directly measures core temperature or records a direct estimate of core temperature.³ The NICE also reports that an accuracy to within $\pm 0.5^{\circ}\text{C}$ is acceptable in clinical use.³ The most common thermometer used to estimate core body temperature in the PACU is an infrared tympanic thermometer.⁴ Although tympanic thermometry use is widespread, the use is subject to discussion and debate because of doubt about accuracy and reliability in the acute clinical and critical setting.⁵ Machin et al.⁵ highlight the importance of accurately measuring core body temperature and acknowledge thermometry as a focal point in research findings that many clinicians distrust the performance of some commonly used peripheral thermometers.

From our reading on this subject four themes emerged – benefits of, limitations of and alternatives to tympanic thermometry and perioperative nursing competence. This discussion paper will explore the use of tympanic thermometry, under these themes, provide greater understanding of its current use and make recommendations for perioperative nursing practice.

Discussion

Measurement of a patient's temperature in the PACU is a performance indicator as outlined by the Australian Commission on Safety and Quality in Health Care.⁶ The first important thing to understand is that there are two types of temperature readings, core and

shell.⁷ It is vital that patients have accurate core body temperature recorded when admitted to the PACU as this temperature reading provides important information to guide clinical judgment.⁷ Core temperature refers to the temperature within the contents of the skull, the thorax and the abdomen and most notably the hypothalamus.⁷ Shell temperature refers to the skin, subcutaneous tissue and the limbs and is completely expendable to ensure the core temperature is maintained.⁷ In a haemodynamically unstable patient, or one that has experienced rapid thermal changes such as hypothermia, blood supply may be shunted away from vital organs making skin temperature a poor indicator of a patient's core temperature.⁷

It is also important to understand that these alterations to the vascular system may cause changes to blood pressure readings; thus, a hypothermic patient may be vasoconstricted which can elevate the blood pressure, even in the presence of hypovolaemia.⁸ Similarly, a hyperthermic patient may be vasodilated; this can cause the blood pressure to fall.⁸ Due to the connection between temperature and blood pressure, it is vital that normothermia be achieved prior to discharge to ensure accurate blood pressure readings have been obtained.⁸

During surgery, patients are frequently exposed to the cooler perioperative environment and in combination with body exposure and central nervous depression, due to general anaesthesia, this makes them prone to IPH.¹ Equally, patients undergoing surgery may develop hyperthermia while in the PACU due to malignant hyperthermia or sepsis; therefore, it is vital that temperature readings are accurate when outside the acceptable range of 36.0°C to

37.5°C .¹ Both the ACORN standard² and the NICE guidelines³ recommend that temperature measurement be obtained at least every 15 minutes while the patient is in the PACU. The frequency of recording the patient's other vital signs should also be increased when a patient's temperature is outside of the clinically acceptable range.⁶

Rauch et al.⁹ recommend that highly perfused anatomic structures such as the tympanic membrane, nasal pharynx and the distal oesophagus, which is adjacent to the left atrium, should be used for core temperature measurement. The gold standard of core body temperature measurement is the temperature obtained at the pulmonary artery⁹; however, a pulmonary artery catheter is very invasive and not present in PACU patients. Similarly, a temperature sensor positioned within the bladder and distal oesophagus provide accurate core body temperature but are also invasive and not always practical for patients emerging from anaesthesia in the PACU.⁴ This has led to alternative methods for obtaining accurate estimates of core body temperature to be sought.

Benefits of tympanic thermometry

Tympanic thermometry has been embedded in clinical practice because of its ease of use and the speed with which measurements are displayed, allowing nurses to make clinical decisions and alterations to patient care based on accurate information.⁷ Robertson and Hill¹⁰ identify the benefits of tympanic thermometry including the ability to measure core temperature rapidly and close to the hypothalamus, convenience for patients and preservation of their dignity, and good hygiene when used with probe covers.

Jevon and Joshi¹¹ explain that the tympanic membrane blood supply is provided by the carotid artery, which also supplies blood to the hypothalamus. This allows the tympanic membrane to reflect core body temperature when other more invasive measures are not practical.¹² Modern tympanic thermometers measure the temperature at the tympanic membrane by sensing the infrared radiation emitted by the tympanic membrane and through algorithms that convert the measurement into a temperature reading.¹³ Infrared tympanic thermometers used in a clinical environment must comply with the International Organization for Standardisation standard ISO 80601-2-56:2017¹⁴ and comply with the Australian *Therapeutic Goods (Medical Devices) Regulations 2002*.¹⁵

Niven et al.¹² conducted a meta-analysis and systematic review of the accuracy of thermometers for estimating temperature. In their study they explored 75 studies (n = 8682) in which 52 studies were relevant to tympanic thermometers and concluded that peripheral thermometers, including tympanic thermometers, temporal artery thermometers and oral thermometers, did not have a clinically acceptable limit of agreement (LOA) when compared to pulmonary artery catheter temperature measurement.¹² However, Niven et al. did acknowledge an improvement in LOA between pulmonary artery temperature and tympanic measurement when the tympanic thermometers had been calibrated before use – the pooled mean difference in the calibrated group was -0.01 (-0.49°C to 0.47°C at 95% LOA) compared to -0.24 (-1.61°C to 1.13°C at 95% LOA) in the non-

calibrated group.¹² As a result of this information, Niven et al. recommend that when a central invasive thermometer is impractical then a tympanic thermometer that has been calibrated was the best alternative for accurate temperature readings in both adult and paediatric patients.¹² Niven et al. also reported a +/-0.5°C correlation at 95 per cent for calibrated tympanic thermometers,¹² placing them within the NICE guidelines of accuracy and acceptability for clinical use.³

In their scoping review of 35 studies which included healthy adults and patients who had cardiovascular and neurological emergencies, Mase et al.¹⁶ noted an accurate correlation between tympanic thermometry and central target temperature management during both local and whole-body cooling. The ability for tympanic thermometers to track temperature changes associated with active cooling and active warming is crucial in the PACU where treatment of IPH is required.²⁻³

Limitations of tympanic thermometry

While tympanic thermometers are commonly used due to their ease of use, they do have limitations to do with clinical accuracy. In their two prospective observational studies (n = 100), Aykanat et al.⁴ explored the reliability of tympanic thermometers and temporal artery thermometers compared to urinary bladder temperature and nasopharyngeal temperature in the PACU. Aykanat et al.⁴ concluded that neither tympanic thermometer or temporal artery thermometers were reliable compared to an indwelling catheter temperature sensor in the bladder, although they highlighted that the tympanic thermometers gave a

marginal improvement with a mean bias of 0.13°C (95% LOA +/-0.54°C) versus a mean bias of 0.15°C (95% LOA +/-1.4°C) in the temporal artery thermometer group.

In 2018, Ryan-Wenger et al.¹⁷ in their meta-analysis of 197 articles recommended removal of all peripheral thermometers including tympanic thermometers from their hospital and a change of hospital policy to reflect this because of the inaccuracies compared to central temperature measurement. It should be noted that this outright exclusion of peripheral thermometers is not practical, and the use of invasive devices as recommended by Ryan-Wenger et al. is unacceptable in the PACU environment, as previously mentioned by Aykanat et al.⁴ There were also limitations within the study conducted by Ryan-Wenger et al.¹⁷ in that 39 of the samples on tympanic thermometry were dated between 1994 and 2014, with only five being conducted after 2010. There have been several newer models of tympanic thermometers produced since this date range that were not included in the study conducted by Ryan-Wenger et al. The results may be different if the meta-analysis was repeated with these studies included.

More recent research comparing seven different commercially available thermometers (four digital infrared thermometers, one digital sublingual thermometer, one zero heat flux thermometer and one infrared thermal imaging camera) found that not all temperature monitoring techniques are equal, and recommended that tympanic thermometers are the most accurate commercially available system for the regular measurement of body temperature.¹⁸

Alternatives to tympanic thermometry

The variance in results obtained by studies researching the effectiveness of tympanic thermometers in accurately reflecting core body temperature leads to the question of whether alternative peripheral thermometers provide more accurate measurements. There are several different peripheral thermometers that exist that have been used in the PACU with varying levels of accuracy.¹⁹ One such device that has made its way into the PACU is the temporal artery thermometer.³

In findings from research conducted by Fong et al.²⁰ (n = 106) temporal and forehead temperature readings were generally lower than tympanic readings and were unreliable in detecting fever. This was also supported by Minzola and Keele²¹ who suggested that temporal artery thermometers had greater mean bias (-0.55 bias at 95% LOA -0.97 to 2.07) than tympanic thermometers (-0.37 bias at 95% LOA -0.79 to 1.54) when compared to rectal temperatures. Skin temperature, which depends on vasomotor tone and varies across the surface area, is affected by surgical procedures, central nervous system depression, environmental temperature and skin products such as alcohol-based skin preparation agents.²² Alcohol-based skin preparation can often cool skin down and, if a temporal artery thermometer or contact-free infrared thermometer is used, may provide a lower temperature reading than tympanic.²²

This limits the choice further to oral and axillary temperature measurements. While both are easy to use, results can vary significantly.¹⁰ Oral temperature measurement is also contraindicated in the unconscious patient and is affected by salivation and

therefore impractical in the PACU.¹⁰ Axillary temperature measurement, on the other hand, does not assess core temperature and is affected by ambient and environmental temperatures and has been found to provide a lower reading than other methods in febrile patients.¹⁰ In hypothermic patients vasoconstriction occurs and thus axilla readings do not provide an accurate temperature measurement.^{7, 23}

Competence of perioperative nurses

A common theme noted in the literature is the need for nurses to be competent in the use of different tympanic thermometers,^{24, 25} and the need for regular calibration of these devices.¹² Despite passing approval for clinical use and having acceptable ranges in test settings,^{5, 13, 25} accuracy when measuring tympanic temperature is dependent on the skill of the clinician and the technique they use. While there are several factors that may affect the reliability of tympanic thermometers, problems may be a result of user error.^{24, 25} It is vital that nurses are assessed as competent in the use of tympanic thermometers and familiar with the individual manufacture guidelines when undertaking temperature assessment.^{24, 25} Jevon²⁵ explains that the temperature difference between the tympanic membrane and the opening of the ear canal can be as much as 2.8°C which contributes to inaccuracy when incorrect technique is used. Yeoh et al.²⁶ explain the importance in understanding how tympanic thermometry works and emphasise that knowledge is required about the correct positioning and the anatomy of the tympanic membrane. Yeoh et al.²⁶ highlight that consistently obtaining the temperature at a specific focal spot on the tympanic

membrane increased accuracy and gave a reliable measurement. Nurses should ensure that the ear canal is free from any visible debris and insert the tympanic probe at the correct angle in the ear canal to achieve accurate results.²⁷ Consideration should also be given to patients who arrive in the PACU in the lateral position and the tympanic temperature should be taken from the ear that is facing up as this will reflect core temperature.²⁸

Conclusion

The literature presented in this discussion does not make a definitive recommendation about peripheral thermometers in measuring core temperature and fails to suggest alternative body temperature measurement strategies that are non-invasive for the PACU patient.

It does appear that when calibrated and used correctly by competent users tympanic thermometers are more reliable than temporal artery thermometers, axillary thermometers and oral thermometers for providing a best estimate of core temperature. It is therefore vital that all tympanic membrane thermometers are regularly calibrated and that PACU nurses are trained and assessed as competent in the use of the type of tympanic membrane thermometer used in their PACU. Several studies suggest that the newer generation of tympanic thermometers have a place in clinical practice, due to their ease of use and ability to provide an adequate estimate of core temperature, and these are recommended when invasive measurement is contraindicated.

Tympanic temperature measurement will continue to aid the PACU nurse to obtain a non-invasive core temperature measurement that is practical, cost effective and

minimally disruptive to patients' dignity. The accuracy of tympanic thermometers is still a focal point of research and there are minimal studies that measure the effectiveness of tympanic and other peripheral thermometers specific to the PACU environment; this highlights a need for more research into this aspect of perioperative practice.

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