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Short Report

Temperature changes of CoolSticks during simulated use

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ABSTRACT

Introduction: Cold sensation is often used to check neuraxial anaesthesia and analgesia. One opportunity to reduce the carbon footprint of anaesthesia is to replace vapo-coolant sprays such as ethyl chloride with a reusable device called the CoolStick, which is cooled in a refrigerator between uses. We designed a study to investigate how long the CoolStick remains at its working temperature, which we defined as < 15 °C.

Method: Experiments were undertaken using a thermocouple and digital temperature sensor attached to the CoolStick. We conducted two experiments to assess temperature changes following removal from the refrigerator for 10 min; the first investigated passive re-warming in the ambient theatre environment and the second investigated re-warming in simulated use. In our third experiment, we investigated the time taken to cool the device in the refrigerator, following use. Each experiment was repeated three times.

Results: In the passive re-warming experiment, the mean CoolStick temperature was 7.3 °C at the start, and 14.3 °C after 10 min. In the simulated use experiment, the mean CoolStick temperature was 7.3 °C at the start, and 18.9 °C at 10 min. In the cooling experiment, the mean CoolStick temperature was 15 °C at the start and 7.6 °C at 40 min.

Conclusion: Our study indicates that it is feasible to use the CoolStick for providing cold sensation in clinical practice. Further study would be required to directly compare the effectiveness of the device to existing methods such as coolant sprays or ice in the clinical setting.

Introduction

The CoolStick (Theophany Ltd, Christchurch, Dorset, UK) is a device designed to apply cold and touch sensation for the assessment of regional anaesthesia. It comprises a stainless-steel body with a screw-on plastic (polyoxymethylene) handle. According to the instructions for use, it should be kept in a refrigerator at between 2 and 8 degrees Celsius (the guideline temperature for pharmaceutical refrigeration).[1,2].

An increasing number of healthcare organisations appear to be implementing CoolSticks due to cost and sustainability advantages compared with vapo-coolant sprays such as ethyl chloride. For example, University Hospitals Dorset report an annual 'carbon footprint' saving equivalent to 2968 $kgCO_2$, and a financial saving of £3110 following their introduction to two operating theatre recovery rooms.[3] Because of the routine use of neuraxial anaesthesia and analgesia in obstetric anaesthesia, this is an obvious area for their deployment.

Obstetric Anaesthetists Association (OAA) guidelines suggest using light touch as the primary sensory modality for the assessment of regional anaesthesia prior to caesarean section as this is the most reproducible and is associated with the lowest risk of intra-operative pain,[4] with other modalities reserved for confirmatory testing.[5] However, cold sensation remains a mainstay of the assessment of labour epidural analgesia.[6]

High-threshold thermoreceptors are generally thought to be activated by temperatures below 15 °C,[7] although there is wide variability in this 'cold pain' threshold between individuals.[8] Cold sensation is transmitted in A-delta and C nerve fibres, making it a reasonable surrogate for the assessment of analgesic blocks.[9].

In our institution, we suggest that sensory testing with the CoolStick should involve intermittently placing the metal body of the device on the patient's skin, moving from dermatome-to-dermatome, and asking the patient to report what they can feel. This should allow the assessment of both cold and light touch sensation.[6] After use, the device should be cleaned and replaced in the refrigerator.

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Having acquired a small number of CoolSticks to trial in our maternity units, colleagues queried how long they remain at their working temperature, and how long they take to cool when returned to the refrigerator. Unable to establish this via the product literature or correspondence with the manufacturer, we designed a series of bench experiments to investigate the rate of temperature change of CoolSticks during simulated use.

Method

A washer thermocouple (type K, M6, RA Temperature Sensors, Hitchin, UK) was placed between the body and the handle of a CoolStick, with a thin layer of thermal conductive paste (BS-139, Nuomi Chemical Co., Ltd, Shenzhen, China) applied between the body and the thermocouple. The thermocouple was plugged into a digital temperature sensor with an accuracy of ± 1.5% (TL253, Proster, Hong Kong, PRC) (Fig. 1). We undertook three bench experiments, each of which was repeated three times. The operating theatre temperature displayed on the room thermometer was noted for each experiment.

In experiment 1 (passive re-warming), we placed the CoolStick on the middle shelf of the operating theatre refrigerator (PE207, LEC Refrigeration, Prescot, UK) and waited for the temperature to stabilise (defined as two identical readings 10 min apart). The CoolStick was removed from the refrigerator and held in air by the handle. Temperature measurements were recorded every min for 10 min.

In experiment 2 (simulated use) we cooled the CoolStick as in experiment 1. To simulate use in sensory assessment, we removed the CoolStick from the refrigerator and repeated cycles of 8 s holding the CoolStick in air as in experiment 1, then 2 s lightly touching the skin of the experimenter's antecubital fossa with the tip of the CoolStick body. This 10 second cycle was agreed amongst the experimenters to be representative of the method used in our institutional practice. Temperature measurements were recorded every min for 10 mins.

In experiment 3 (cooling), we allowed a refrigerated CoolStick to re-warm to 15 °C, then placed it on the middle shelf of the drug refrigerator in our preparation room (PPSR158UK, LEC Refrigeration, Prescot, UK), selected as it was less frequently used than the operating theatre refrigerator. Temperature measurements were recorded every 10 min for 40 min. The temperature displayed on the refrigerator display was noted.

Results

The mean starting temperature in experiment 1 was 7.3 °C (range 7.2–7.5), and the mean temperature at 10 min was 14.3 °C (13.7–15.1). Temperature measurement data are displayed in Fig. 2. The operating theatre temperature was 23 °C in run 1, 22.1 °C in run 2, and 22.7 °C in run 3.

The mean starting temperature in experiment 2 was 7.3 °C (7.2–7.4), and the mean temperature at 10 min was 18.9 °C (18.1–19.5). The temperature measurement data are displayed in Fig. 3. The operating theatre temperature was 23.2 °C in run 1, 22.9 °C in run 2, and 22.6 °C in run 3.

In experiment 3, the starting temperature was 15 °C for all runs. The mean temperature at 40 min was 7.6 °C (7.1–8.3). The temperature measurement data are displayed in Fig. 4. The refrigerator temperature was 6.3 °C in run 1 and 2, and 6.9 °C in run 3.

Discussion

Our findings demonstrate that after removal from the refrigerator the CoolStick remains under 15 °C in an ambient theatre environment for over 10 min. In simulated use, the 15 °C threshold was reached in

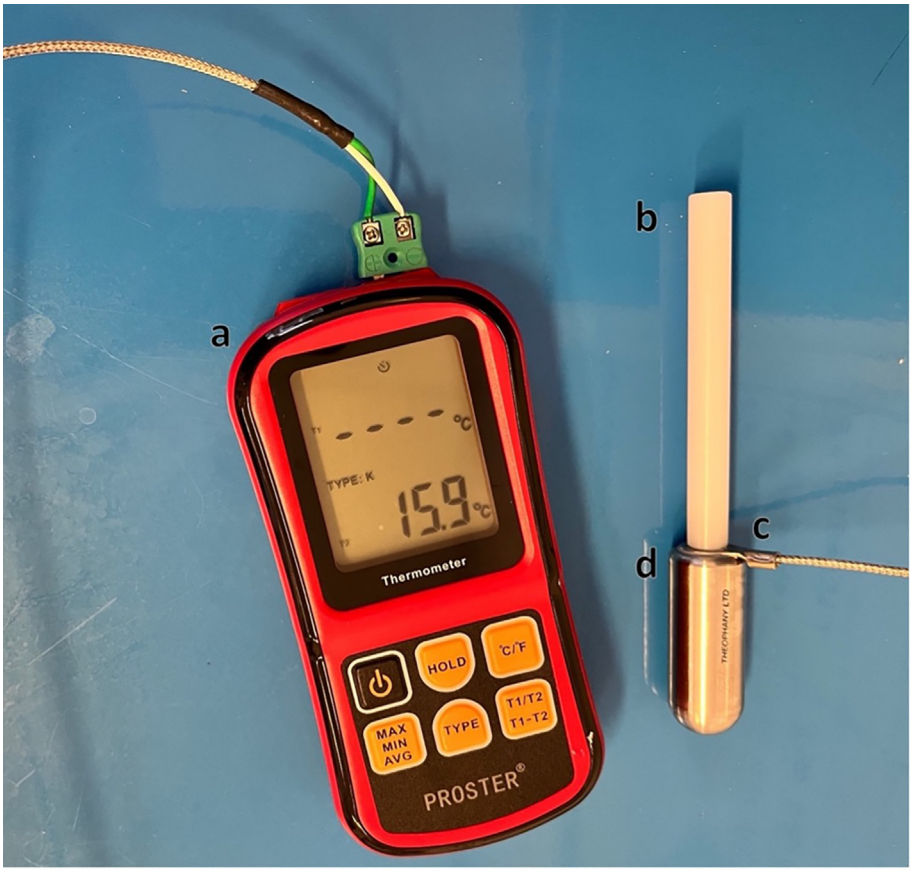

Fig. 1. Experimental equipment: a - digital temperature sensor; b - CoolStick handle; c - washer thermocouple; d - CoolStick body.

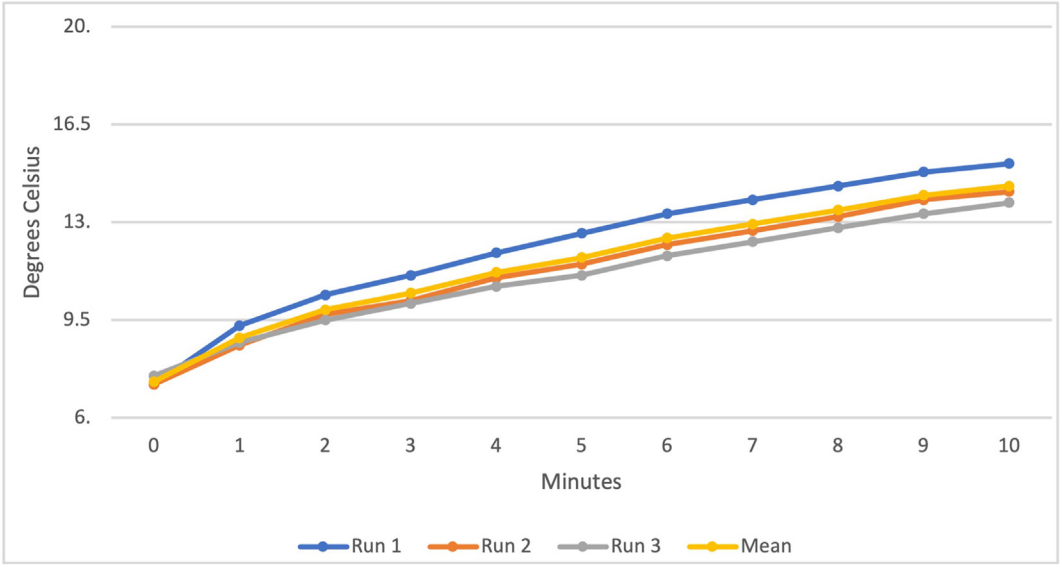

Fig. 2. Temperature changes during experiment 1 (passive re-warming).

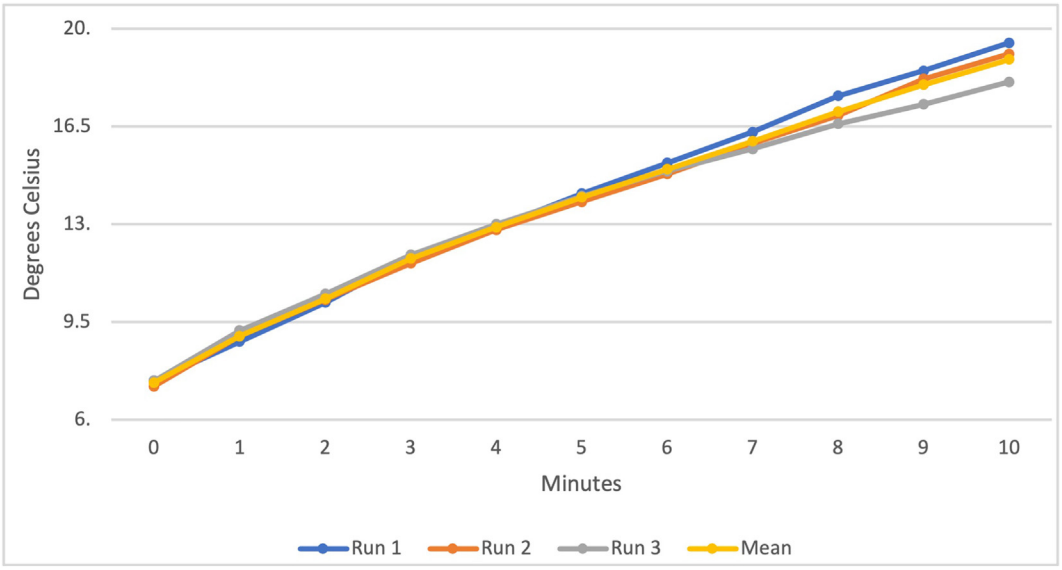

Fig. 3. Temperature changes during experiment 2 (simulated use).

6 min. Taken together, these findings suggest that the CoolStick is a suitable device for the assessment of a straightforward neuraxial block if removed from the refrigerator just prior to testing. However, if removed from the refrigerator prior to commencing the block, or if testing is prolonged (e.g. due to a block with slow onset) the CoolStick may warm to an extent where the cold sensation applied to the patient's skin may become inconsistent and unreliable.

On replacing the CoolStick in the refrigerator, our findings show that it takes approximately 40 min to cool to below 8 °C. Again, this indicates that a single CoolStick could be used for a typical, straightforward obstetric operating theatre list, where intervals of < 40 min between anaesthetics would be unusual. However, promptly returning the CoolStick to the refrigerator may not always be achievable (in case of an emergency, for example), so it may be more practical to stock additional devices in high-turnover theatres.

Vapo-coolant sprays such as ethyl chloride are the mainstay of cold sensation assessment in many UK centres, however there are significant drawbacks to the use of these medications. In terms of the accuracy of clinical assessment, it can be difficult to definitively determine a precise dermatomal level as sprays can often disperse across more than two levels simultaneously.[6] Vapo-coolant sprays are also costly (approximately £25 per can) and have substantial environmental impacts associated with their manufacture, transport, disposal, and use.[2,10] Vapo-coolant sprays are volatile compounds which create a cooling effect via the latent heat of vaporisation; like volatile anaesthetic agents they are greenhouse gases. Although ethyl chloride has a global warming potential (GWP) less than that of carbon dioxide (CO_2),[11] Dermogesic (Vitame, Elara Phramaservices Europe Ltd, Dublin, Ireland) is stated by the manufacturer to have a GWP 1411 times greater than CO_2.[12] Ice is another alternative to apply cold sensation, however ice machines have been removed from many hospitals recently, due to infection control concerns.[13]

There are several limitations to our study. Our experiments were designed to assess the performance of the CoolStick in a controlled

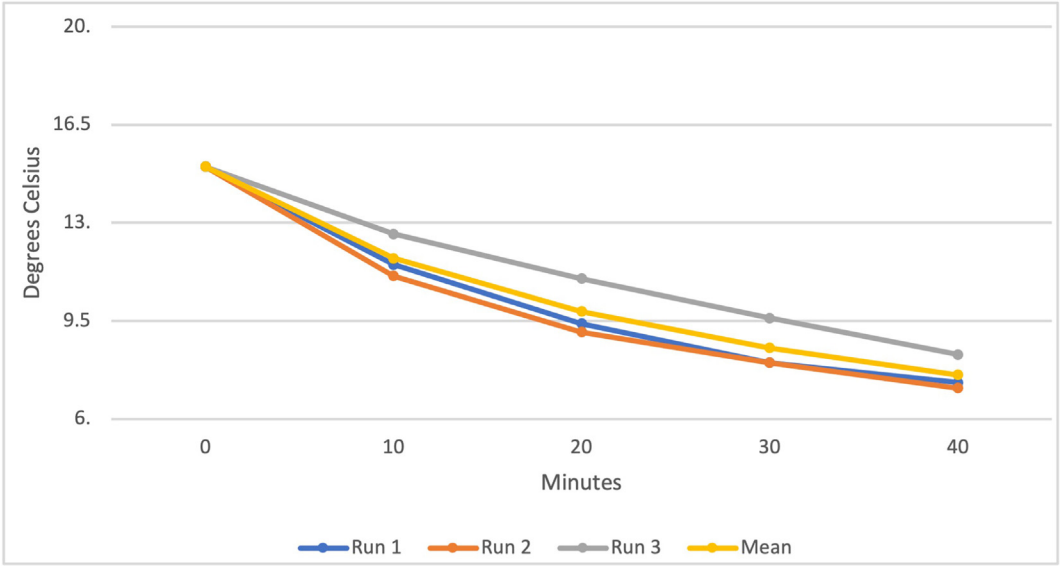

Fig. 4. Temperature changes during experiment 3 (cooling).

environment. We ensured that our refrigerators and operating theatre were within the relevant guideline temperature limits,[2,14] but our experimental conditions are not representative of every setting. The use of a washer thermocouple allowed us to securely attach the temperature sensor to the CoolStick, and we optimised heat conduction using thermal paste. However, the addition of the washer will have effectively increased both the mass and the surface area of the CoolStick, affecting both the heat capacity and the radiative heat loss of the system. However, given that the mass of the CoolStick body (113 g) is much greater than that of the washer (1 g), the effect on the results is likely to be minimal. The experiments were undertaken in a simulated fashion, and we acknowledge that using the CoolStick on the experimenters' skin (of which the temperature was not measured) may not be fully representative of that of patients who have undergone regional anaesthesia, especially considering that the time required for communication can vary. In addition, there are conflicting studies when assessing the true temperature required for the perception of cold to be determined, and the optimal working temperature of the device would need to be established by further work.[15] Of note, the suggested working temperature of the CoolStick is greater than that of melting ice (0 °C); the cooling effect of vapo-coolant sprays depends on the duration of application and, as far as we are aware, has not been quantified in obstetric practice.

Overall, our findings indicate that CoolSticks remain at their working temperature for long enough to allow the assessment of a neuraxial block in the obstetric setting. Their implementation may allow anaesthesia departments to reduce their costs and environmental footprint without affecting patient care,[3,16,17] however additional modes of assessment may be required in complex cases, or where a refrigerator is not available nearby. Furthermore, light touch (advised for caesarean section) may be reliably assessed using cotton wool, which is likely to have a very low environmental footprint and is low cost.[4,5] In our experiment, the CoolStick remained at its working temperature for 10 min in the theatre environment, and provided 6 min of simulated block assessment. The onset time of spinal anaesthesia is variable, and has frequently been observed to be over 6 min.[18–20] Accordingly, we recommend that CoolSticks are kept in the refrigerator until sensory assessment is indicated, for example once a motor block has been observed, as stated in the 2022 OAA guidelines.[5]

Future studies would be useful to directly compare CoolSticks or similar devices to alternatives such as ice and vapo-coolant sprays, and investigate their use in clinical practice.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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