

Body temperature measurement methods and targets in Australian and New Zealand intensive care units

Salvatore L Cutuli, Eduardo A Osawa, Neil J Glassford, David Marshall, Christopher T Eyeington, Glenn M Eastwood, Paul J Young and Rinaldo Bellomo

Perturbations of body temperature are common in critically ill patients and predict adverse outcomes.¹⁻⁵ However, in some studies, temperature measurement methods are typically not considered, creating uncertainty about accuracy and reliability.⁶⁻¹⁶ In the past decade, three observational studies conducted in Australian and New Zealand (ANZ) intensive care units (ICUs)¹⁷⁻¹⁹ confirmed a wide use of different non-invasive methods, and a recent survey revealed variable attitudes of doctors and nurses to temperature management in the ICU.²⁰ Therefore, to inform the design of future interventional studies, we sought to investigate the current reported body temperature measurement methods and targets among doctors and nurses in ANZ ICUs.

Methods

We conducted a structured online questionnaire (www.SurveyMonkey.net) of intensive care doctors and nurses via the email list of the Australian and New Zealand Intensive Care Society Clinical Trials Group (December 2017 and February 2018). Ethical approval was obtained by the Austin Health Human Research Ethics Committee as Quality Improvement and Innovation project on 11 September 2017. Participation in the survey questionnaire was voluntary and implied that consent was granted. Participants were asked to provide anonymous information on their demographic and professional characteristics and on the methods used for measuring body temperature, timing and measured values (with options presented in 1°C bands) that they believed required intervention in five clinical scenarios of:

- suspected hypoxic ischaemic encephalopathy post-cardiac arrest (CA);
- traumatic brain injury;
- multi-organ failure;
- extracorporeal organ support; and
- post-operative monitoring.

Differences in the proportion of responses between doctors and nurses were analysed using the χ^2 or the Fisher exact test as appropriate. Statistical analyses were performed using Stata 13 (StataCorp) and graphs were drawn using Excel version 16.3 (Microsoft).

ABSTRACT

Objective: In Australian and New Zealand (ANZ) intensive care units (ICUs), the preferred measurement methods and targets for temperature remain uncertain, but are crucial for future interventional studies. We aimed to investigate the reported use of temperature measurement methods and targets in ANZ ICUs.

Design, settings and participants: Structured online questionnaire delivered via the email list of the Australian and New Zealand Intensive Care Society Clinical Trials Group.

Main outcomes measures: Measurements methods and targets for temperature in ANZ ICUs.

Results: Of 209 respondents, 130 were nurses (62.2%) and 79 were doctors (37.8%). Only 21.5% of the respondents reported having a unit protocol for measuring body temperature. However, invasive temperature measurement methods were preferred by doctors (69.8% v 55.3%) and non-invasive methods by nurses (29.9% v 44.2%). Moreover, among non-invasive methods, tympanic measurement was preferred by doctors (66.0% v 26.9%) and axillary by nurses (11.7% v 51.9%). Both professions reported a wide range of temperature thresholds that they believed required cooling interventions, but 16.7% of doctors and 42.4% of nurses reported that, in patients with cardiac arrest, they would actively cool patients only if the temperature was $\geq 38^\circ\text{C}$.

Conclusion: In ANZ ICUs, preferred temperature measurement methods and targets are typically not governed by protocol, vary greatly and differ between doctors and nurses. Targeted temperature management after cardiac arrest is not fully established. Future studies of the comparative accuracy of non-invasive temperature measurements methods and practice in patients with cardiac arrest appear important.

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Results

We collected 209 fully completed responses, 130 (62.2%) from nurses and 79 (37.8%) from doctors. Most nurses held a graduate certificate (53/130; 40.8%), a post-graduate diploma (39/130; 30.0%) or other higher degrees (41/130; 31.5%), while 67 doctors (84.8%) were ICU specialists. Respondents typically worked in mixed (192/209; 91.9%), public (193/209; 92.3%) and teaching (148/209; 70.8%) ICUs with more than 20 beds (166/209; 79.4%), and many had worked in such ICUs for ≤ 15 years (125/209; 59.8%). However, a protocol for measuring body temperature was reported by only 45 respondents (45/209, 21.5%).

There was great variability of temperature measurement methods. Non-invasive methods were preferred by nurses and invasive methods by doctors ($P < 0.001$) (online Appendix, eFigure 1; available at cicm.org.au/Resources/Publications/Journal).

Among non-invasive methods, axillary measurements were preferred by nurses and tympanic measurements by doctors ($P < 0.001$) (Figure 1). Doctors and nurses reported a wide range of temperature values they believed should receive cooling interventions, with significantly lower values for nurses ($P < 0.001$) (Figure 2).

Invasive methods and hourly measurements (online Appendix, eFigure 2) were preferred in patients with suspected hypoxic ischaemic encephalopathy post-CA and in patients with traumatic brain injury (Figure 3). However, in patients with suspected hypoxic ischaemic encephalopathy post-CA, 16.7% (11/66) of doctors and 42.4% (50/118) of nurses reported that they would actively cool patients only if the temperature was ≥ 38°C. Similarly, 80.8% of respondents reported they would require this trigger to cool patients with traumatic brain injury (online Appendix, eFigure 3).

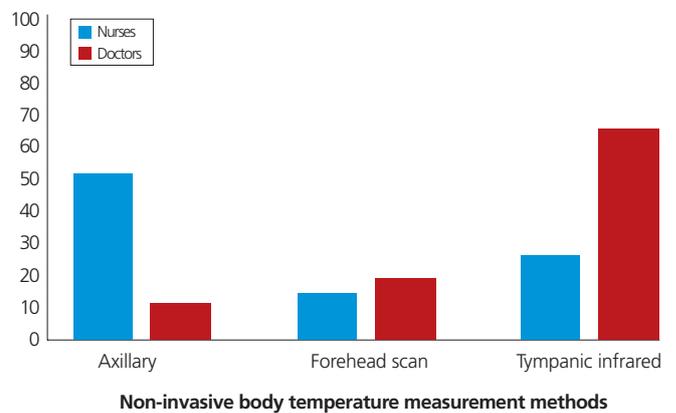
Discussion

Among more than 200 ANZ ICU doctors and nurses, only a minority reported having an ICU protocol for the measurement of body temperature. Moreover, preferred methods and targets varied significantly when comparing nurses with doctors. Finally, a significant proportion of respondents would allow a temperature ≥ 38°C before reacting in patients post-CA and the majority would allow such fever before cooling patients with traumatic brain injury.

Relationship to previous studies

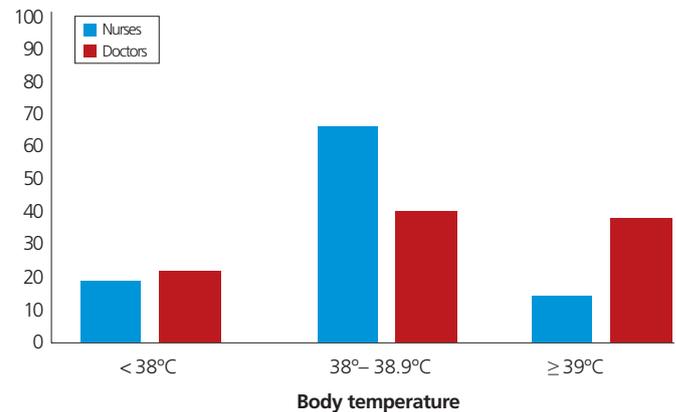
Previous observational studies described the approach to temperature management among ANZ ICUs¹⁷⁻¹⁹ with findings similar to ours. In 2008, Saxena and colleagues¹⁷ conducted a multicentre observational study of 217 ICU

Figure 1. Preferred non-invasive body temperature measurement methods used by nurses and doctors in different intensive care unit situations*



* Fifteen nurses (15/264; 6%) and two doctors (2/103; 2%) preferred the oral site; one doctor (1/103; 1%) and three nurses (3/264; 1%) were unsure.

Figure 2. Highest measured limit of body temperature that respondents believed required lowering in different intensive care unit situations*

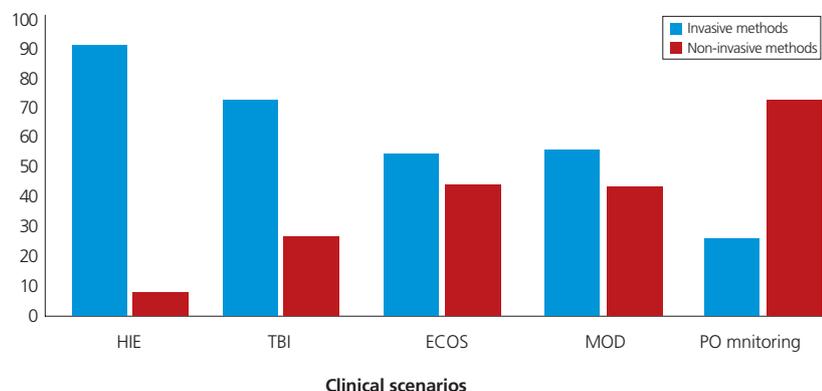


* Six nurses (6/591; 1%) were unsure.

patients and found that non-invasive body temperature methods were used in 83% of patient-days, with 21% of measurements between 38°C and 39°C. In 2009, Saxena et al¹⁸ studied temperature management in 106 patients with neurological injury admitted to 33 ANZ ICUs and observed variable use of non-invasive measurement methods (68%), with the axillary route used in 40% of cases and a body temperature ≥ 38°C in 22%. In a study conducted in 2010 and published in 2013, Hammond and colleagues¹⁹ described body temperature management in 311 adult patients admitted to 38 ANZ ICUs with sepsis or other inflammatory conditions and found that non-invasive methods were used in 82.6% of

SURVEY

Figure 3. Body temperature measurements in five clinical scenarios and percentage of respondents who would use invasive or non-invasive methods*



ECOS = extracorporeal organ support. HIE = hypoxic ischaemic encephalopathy. MOD = multi-organ dysfunction. PO = post-operative. TBI = traumatic brain injury. * Four respondents were unsure about the body temperature measurement methods they would use in patients with TBI (1/193; 0.5%), ECOS (2/188; 1%) and MOD (1/177; 0.6%).

Study implications

A key implication of our study is that dedicated temperature management protocols even among selected Australian and New Zealand Intensive Care Society Clinical Trials Group ICUs are uncommon, which, in turn, implies a degree of neglect of this vital sign. Moreover, our study shows that, 7 years after the previous survey, nurses and doctors continue to prefer different methods and targets, implying a disconnect between what may be expected and what might be actually done at the bedside. Due to the unclear accuracy and precision of different non-invasive methods,⁶⁻¹⁶ these observations imply a high risk of misleading temperature measurements. Finally, our findings suggest a disconnect between reported responses to fever in patients post-CA and in patients with traumatic brain injury and evidence-based recommendations.

observations, with axillary (38.2%) and tympanic (36.2%) routes frequently reported and 20.3% of patients with a peak temperature $\geq 38^{\circ}\text{C}$. In 2011, Saxena et al²⁰ described a highly variable attitude to fever management among doctors and nurses similar to that reported in our survey. In 2013, a multinational questionnaire surveyed 139 ICU site leads participating in the EUROBACT study.²¹ The use of thermometers followed a protocol in 65% of centres, and axillary (58/139; 41.7%) and tympanic (30/139; 21.6%) methods were frequently indicated as primary routes of temperature measurement.

For the first time, however, we found that, in patients post-CA and in contradiction to trial findings²² and guidelines,²³ almost a third of respondents would not respond to fever unless it was $\geq 38^{\circ}\text{C}$. In 2013, the Target Temperature Management (TTM) trial²² showed no differences in mortality and neurological outcomes of mild therapeutic hypothermia at 33°C compared with strict therapeutic normothermia (STN) at 36°C in unconscious patients admitted to the ICU post-CA. Accordingly, STN has been implemented in the care of post CA, and preliminary reports from ANZ ICUs^{24,25} observed greater rates of fever above 38°C in STN compared with therapeutic hypothermia period. Difficulties in maintaining STN outside a clinical trial^{24,25} and low adherence to or abandonment of TTM²⁵ protocol to prevent fever in favour of treating fever are possible explanations of such results.

Acceptance of fever up to 38°C was also seen for patients with traumatic brain injury, despite concerns about the adverse effects of fever in such patients.²⁶⁻²⁷

Strengths and limitations

We tested the questionnaire in a pilot sample of experienced clinicians before distribution. We delivered the questionnaire via a widely used online tool and surveyed a large sample of doctors and nurses. Moreover, our findings have revealed several areas of concern with temperature management in ANZ ICUs, such as lack of protocols, a doctor–nurse disconnect in preferences and priorities and acceptance of fever in patients for whom it should be prevented. However, we acknowledge we received only a few responses from private and rural hospitals, making extension of our findings to such settings uncertain. Furthermore, we acknowledge that reported behaviour may significantly differ from actual practice.

Conclusion

Most ANZ ICU doctors and nurses who responded to our questionnaire report having no unit temperature measurement protocol; using a wide range of non-accuracy tested, non-invasive measurement methods; showing a disconnect between doctors and nurses regarding their selection, routes and thresholds of intervention; and accepting fever in patients for whom its avoidance is strongly recommended. These findings imply a degree of neglect in relation to the measurement of a key vital sign and suggest the need for education, training and systematic assessment of measurement methods before interventional studies.

Competing interests

None declared.

Author details

Salvatore L Cutuli¹

Eduardo A Osawa¹

Neil J Glassford^{1,2,3}

David Marshall¹

Christopher T Eyeington¹

Glenn M Eastwood¹

Paul J Young^{4,5}

Rinaldo Bellomo¹

1 Department of Intensive Care, Austin Health, Melbourne, Vic, Australia.

2 Intensive Care Unit, Royal Melbourne Hospital, Melbourne, Vic, Australia.

3 Department of Epidemiology and Preventative Medicine, School of Public Health and Preventative Medicine, Monash University, Melbourne, Vic, Australia.

4 Department of Intensive Care, Wellington Hospital, Wellington, New Zealand.

5 Medical Research Institute of New Zealand, Wellington, New Zealand.

Correspondence: sl.cutuli@gmail.com

References

- 1 Peres Bota D, Lopes Ferreira F, Mélot C, Vincent JL. Body temperature alterations in the critically ill. *Intensive Care Med* 2004; 30: 811-6.
- 2 Laupland KB, Zahar JR, Adrie C, et al. Determinants of temperature abnormalities and influence on outcome of critical illness. *Crit Care Med* 2012; 40: 145-51.
- 3 Karalapillai D, Story DA, Calzavacca P, et al. Inadvertent hypothermia and mortality in postoperative intensive care patients: retrospective audit of 5050 patients. *Anaesthesia* 2009; 64: 968-72.
- 4 Young PJ, Saxena M, Beasley R, et al. Early peak temperature and mortality in critically ill patients with or without infection. *Intensive Care Med* 2012; 38: 437-44.
- 5 Saxena M, Young P, Pilcher D, et al. Early temperature and mortality in critically ill patients with acute neurological diseases: trauma and stroke differ from infection. *Intensive Care Med* 2015; 41: 823-32.
- 6 Jefferies S, Weatherall M, Young P, Beasley R. A systematic review of the accuracy of peripheral thermometry in estimating core temperatures among febrile critically ill patients. *Crit Care Resusc* 2011; 13: 194-9.
- 7 Lefrant JY, Muller L, de La Coussaye JE, et al. Temperature measurement in intensive care patients: comparison of urinary bladder, oesophageal, rectal, axillary, and inguinal methods versus pulmonary artery core method. *Intensive Care Med* 2003; 29: 414-8.
- 8 Moran JL, Peter JV, Solomon PJ, et al. Tympanic temperature measurements: are they reliable in the critically ill? A clinical study of measures of agreement. *Crit Care Med* 2007; 35: 155-64.
- 9 Farnell S, Maxwell L, Tan S, et al. Temperature measurement: comparison of non-invasive methods used in adult critical care. *J Clin Nurs* 2005; 14: 632-9.

- 10 Fullbrook P. Core body temperature measurement: a comparison of axilla, tympanic membrane and pulmonary artery blood temperature. *Intensive Crit Care Nurs* 1997; 13: 266-72.
- 11 Nonose Y, Sato Y, Kabayama H, et al. Accuracy of recorded body temperature of critically ill patients related to measurement site: a prospective observational study. *Anaesth Intensive Care* 2012; 40: 820-4.
- 12 Smith LS. Temperature measurement in critical care adults: a comparison of thermometry and measurement routes. *Biol Res Nurs* 2004; 6: 117-25.
- 13 Stavem K, Saxholm H, Smith-Erichsen N. Accuracy of infrared ear thermometry in adult patients. *Intensive Care Med* 1997; 23: 100-5.
- 14 Giuliano KK, Giuliano AJ, Scott SS, et al. Temperature measurement in critically ill adults: a comparison of tympanic and oral methods. *Am J Crit Care* 2000; 9: 254-61.
- 15 Knapik P, Rychlik W, Duda D, et al. Relationship between blood, nasopharyngeal and urinary bladder temperature during intravascular cooling for therapeutic hypothermia after cardiac arrest. *Resuscitation* 2012; 83: 208-12.
- 16 Shin J, Kim J, Song K, et al. Core temperature measurement in therapeutic hypothermia according to different phases: comparison of bladder, rectal, and tympanic versus pulmonary artery methods. *Resuscitation* 2013; 84: 810-7.
- 17 Saxena MK, Colman T, Hammon N, et al. A multicentre audit of temperature patterns after traumatic brain injury. *Crit Care Resusc* 2015; 11: 129-34.
- 18 Saxena MK, Taylor CB, Hammond NE, et al. Temperature management in patients with neurological lesions: an Australian and New Zealand point prevalence study. *Crit Care Resusc* 2013; 15: 110-8.
- 19 Hammond NE, Saxena MK, Taylor C, et al. Temperature management of non-elective intensive care patients without neurological abnormalities: a point prevalence study of practice in Australia and New Zealand. *Crit Care Resusc* 2013; 15: 228-33.
- 20 Saxena MK, Hammond NE, Taylor C, et al. A survey of fever management in febrile intensive care patients without neurological injury. *Crit Care Resusc* 2011; 13: 238-43.
- 21 Niven DJ, Laupland KB, Tabah A, et al. Diagnosis and management of temperature abnormality in ICUs: a EURO-BACT investigators' survey. *Crit Care* 2013; 10; 17: R289.
- 22 Nielsen N, Wetterslev J, Cronberg T, et al; TTMM Trial Investigators. Targeted temperature management at 33°C versus 36°C after cardiac arrest. *N Engl J Med* 2013; 369: 2197-206.
- 23 Nolan JP, Soar J, Cariou A, et al. European Resuscitation Council and European Society of Intensive Care Medicine guidelines for post-resuscitation care 2015: section 5 of the European Resuscitation Council guidelines for resuscitation 2015. *Resuscitation* 2015; 95: 202-22.
- 24 Casamento A, Minson A, Radford S, et al. A comparison of therapeutic hypothermia and strict therapeutic normothermia after cardiac arrest. *Resuscitation* 2016; 106: 83-8.
- 25 Bray JE, Stub D, Bloom JE, et al. Changing target temperature from 33°C to 36°C in the ICU management of out-of-hospital cardiac arrest: a before and after study. *Resuscitation* 2017; 113: 39-43.
- 26 Carney N, Totten AM, O'Reilly C, et al. Guidelines for the management of severe traumatic brain injury, fourth edition. *Neurosurgery* 2017; 80: 6-15.
- 27 Cariou A, Payen JF, Asehnoune K, et al. Targeted temperature management in the ICU: guidelines from a French expert panel. *Ann Intensive Care* 2017; 7: 70.