Evaluation Of Zero-Heat-Flux Thermometry As An Alternative To Rectal Thermometry In Critically Ill Neurosurgical Patients

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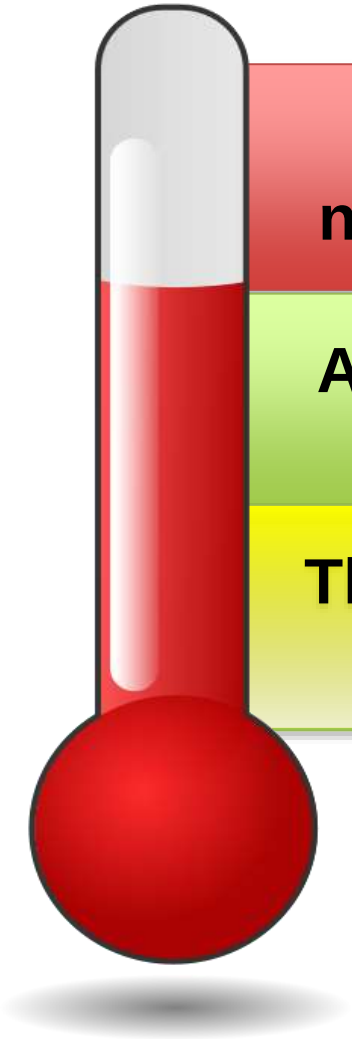
Introduction

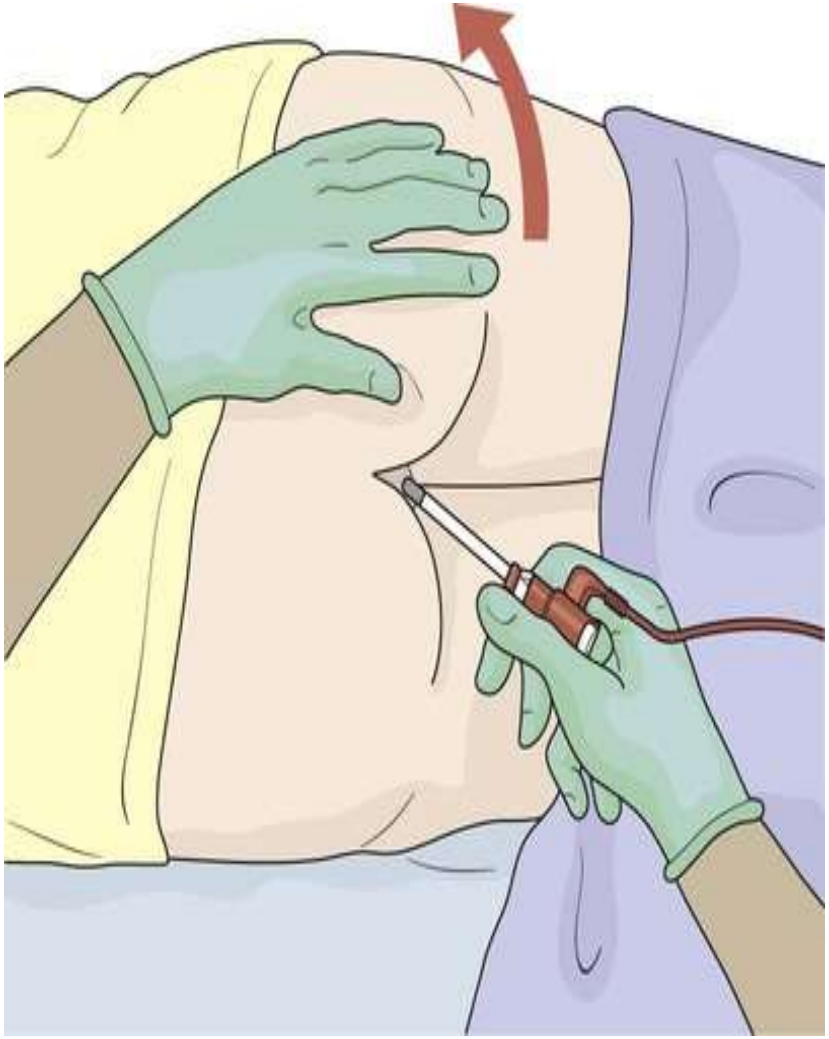


Fever worsens outcome in neurosurgical (NES) patients

All NES patients require core temperature monitoring

The standard in SICU is rectal thermometer

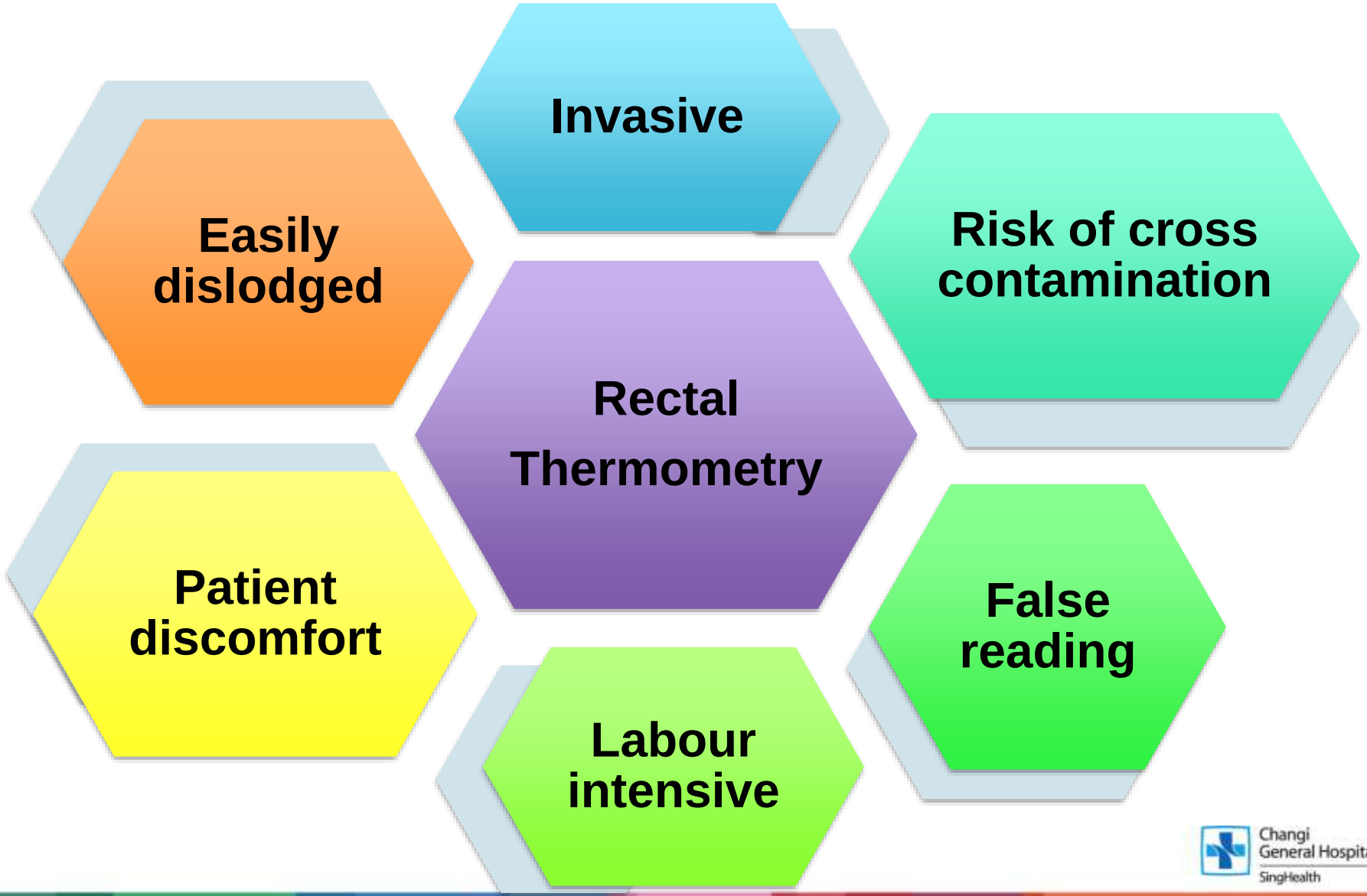
Advantages of rectal thermometer



Core temperature = higher accuracy

Allow continuous monitoring

Disadvantages of rectal thermometry



Literature Review

Makinen 2016, Iden 2015, Eshraghi 2014, Wollerich 2012

Skin — **2014 to 2016**

2005 to 2010 — **PA**

Stelfox 2010, Kimberger 2007, Lawson 2007, Farnell 2005, Myny 2005

Wollerich 2012, Stelfox 2010, Kim 2007, Moran 2007, Lefrant 2003, Erickson 1993, Nierman 1991

Bladder — **1991 to 2012**

1991 to 2011 — **Esophageal**

Lefrant 2003, Stavern 1997

Giuliano 1999, Yaw 1999, Fulbrook 1997, Stravern 1997, Erickson 1993, Milewski 1991, Nierman 1991

Rectal — **1991 to 1999**

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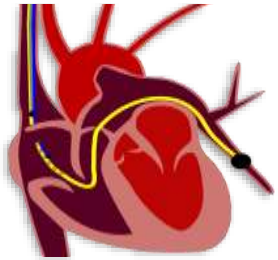
Unsuitability of thermometers for NES patient

Pulmonary Artery Catheter

(*Gold standard)

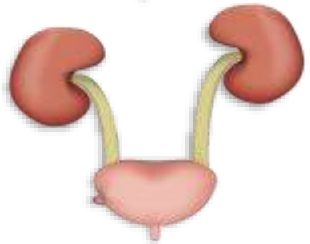


Impractical, Fatal complications

Esophageal

Frequent CXR to confirm placement

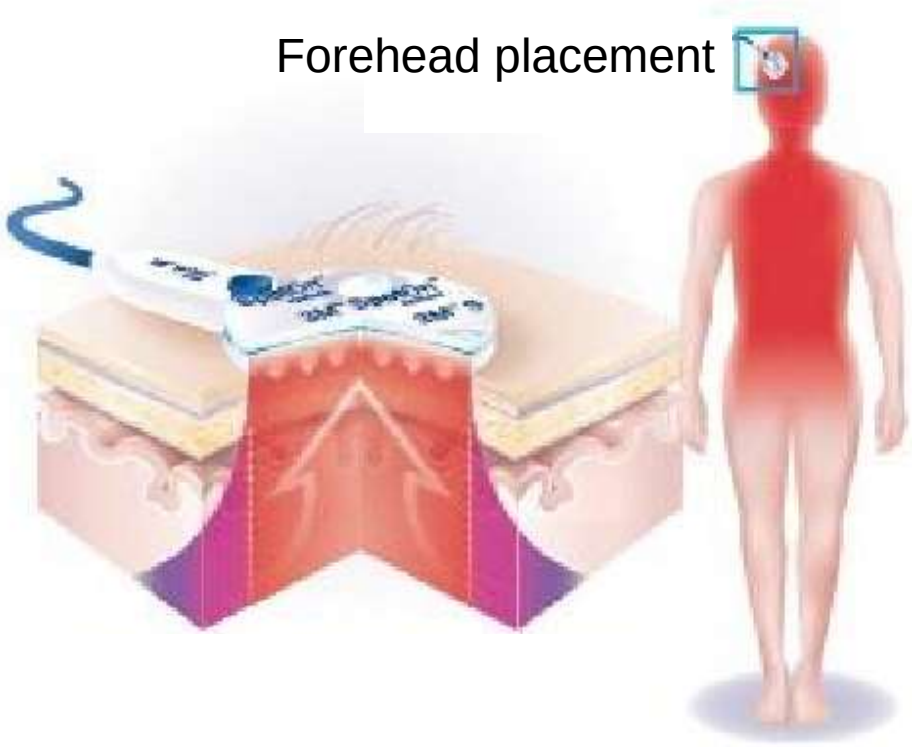
Bladder



Diuresis may affect measurement

New method of core thermometry

Forehead placement

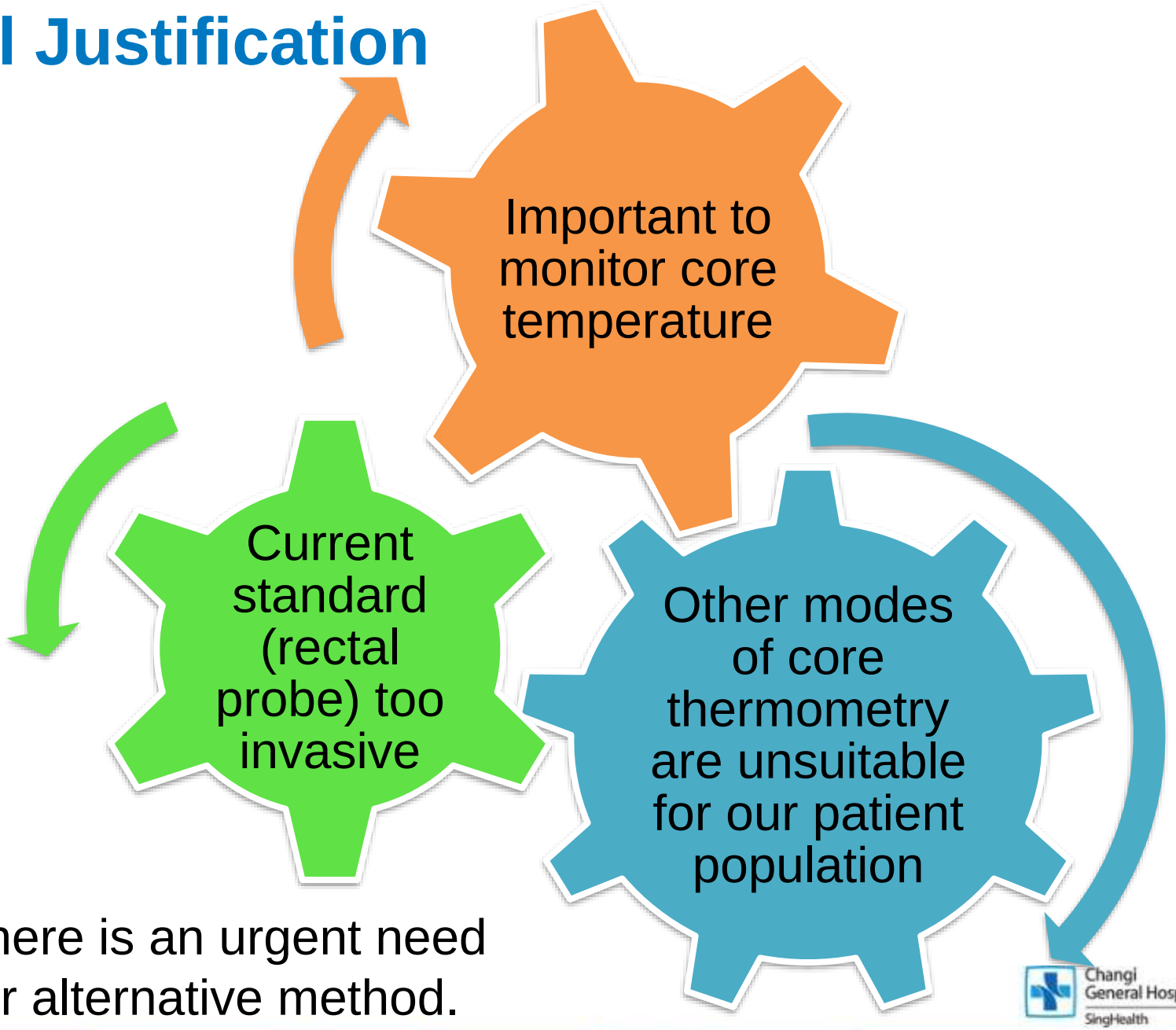


Zero Heat Flux Thermometry

➢Sensor creates a zone of perfect insulation, eliminating heat loss to environment

➢After equilibration, core temperature rises to surface through isothermal pathway

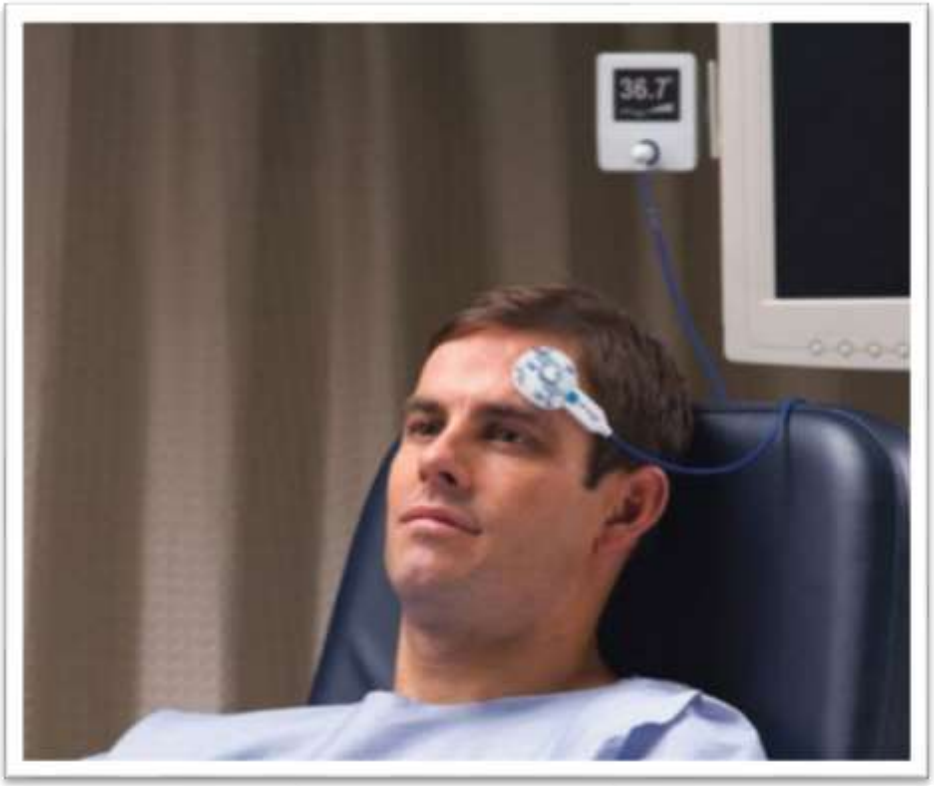
Clinical Justification



Therefore there is an urgent need to source for alternative method.

Hypothesis

ZHF thermometry is appropriate as an alternative to rectal thermometry for measurement of core temperature in critically ill neurosurgical patients.



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Methodology

- ✓ CIRB approved 1 year study period (from August 2016 to 2017)
- ✓ Waiver of consent from CIRB
- ✓ **Study design**:
  - Quasi-experimental design
  - Prospective observational study

- ✓ **Sampling:**
  - Non-randomised
  - Consecutive sampling of subjects
  - Period from October 2016 to August 2017

- ✓ **Population**:
  - Neurosurgical critically ill patients

Inclusion criteria

- Age ≥ 21 years old
- NES critically ill
- Requires mechanical ventilation

Exclusion criteria

- Impaired skin integrity
- Previous rectal surgery
- Documented rectal perforation
- Risk for PR bleeding

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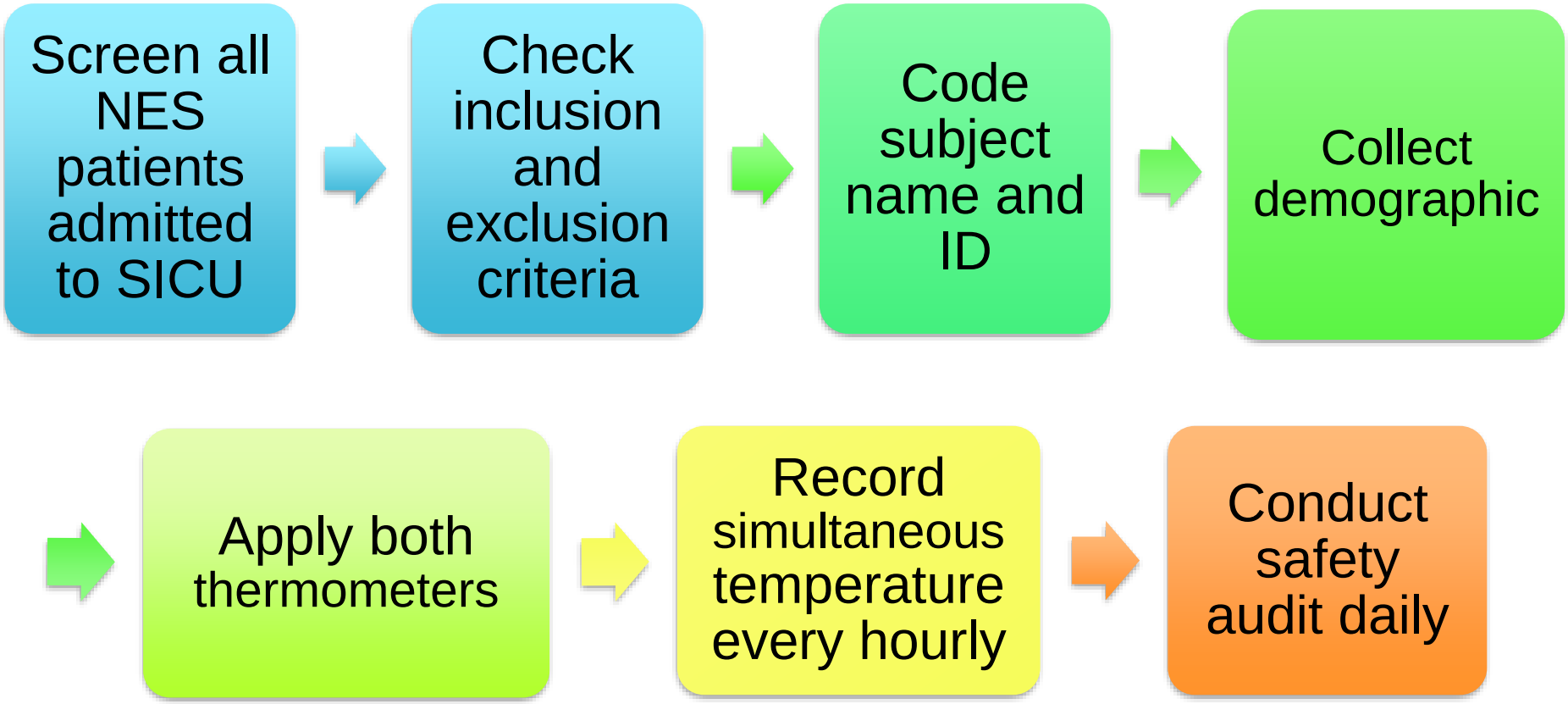
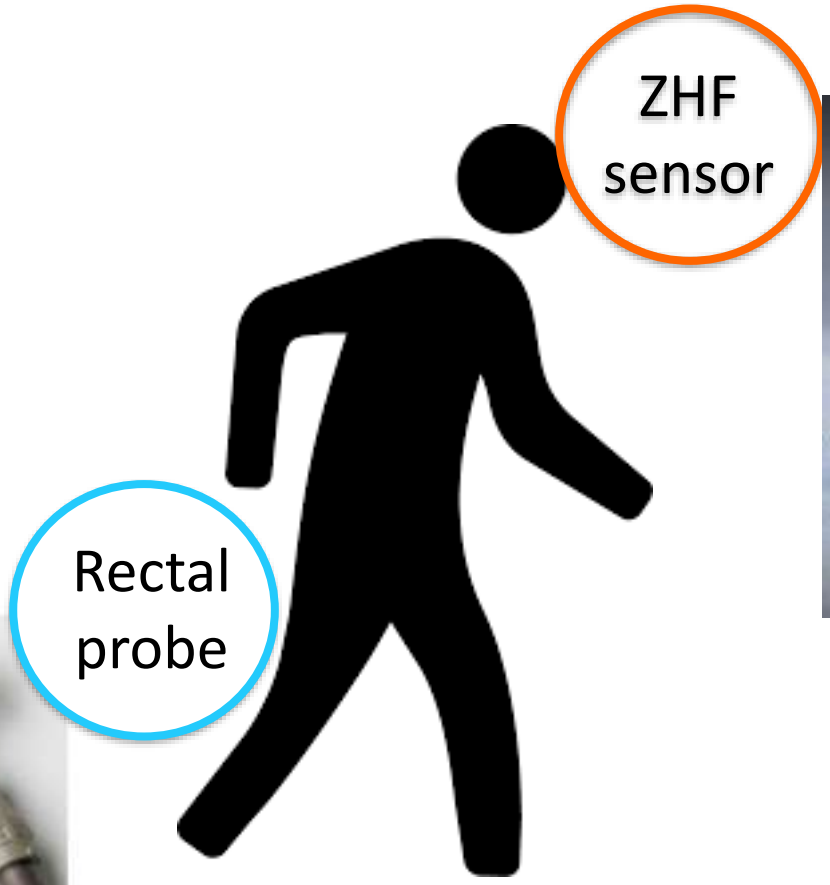
Methodology

Data Collection Workflow



Method of application of thermometers



Paired recording is documented every hour, 24 pairs per subject

Methodology - Analysis method

Data analysis performed after consultation with biostatistician

Statistical tool: Bland Altman method

Statistical software: Medcalc

A priori, limits of agreement set at 95%. Acceptable tolerance ± 0.5 ^{o}C

"Bland Altman (BA) plot is a graphical method used to describe agreement between 2 quantitative measurement techniques."

Results

Table 1: Demographic Characteristics	
Subjects	Recruited (N=51) Included in analysis (n=45)
Age **M ± SD (range)**	55.7 ± 15.4 (23-80)
Gender **Male** **Female**	 29 (64%) 16 (36%)
Diagnosis Category	Traumatic Brain Injuries = 14 (31.1%) Hemorrhagic Stroke = 27 (60%) Ischemic Stroke = 0 (0%) Aneurysmal Bleed = 1 (2.2%) Others = 3 (6.7%)

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Results

Table 2: Data	
Total Data pairs	1024
Data agree on clinical tolerance	93.4% (956 pairs)
Median no. of paired data per subject	24 pairs (5 to 24)
Data collection ceased due to suspected rectal mucosal tear	Nil
Data excluded due to faulty equipment	6 subjects (Subject No. 17, 21, 35, 40, 42, 49)

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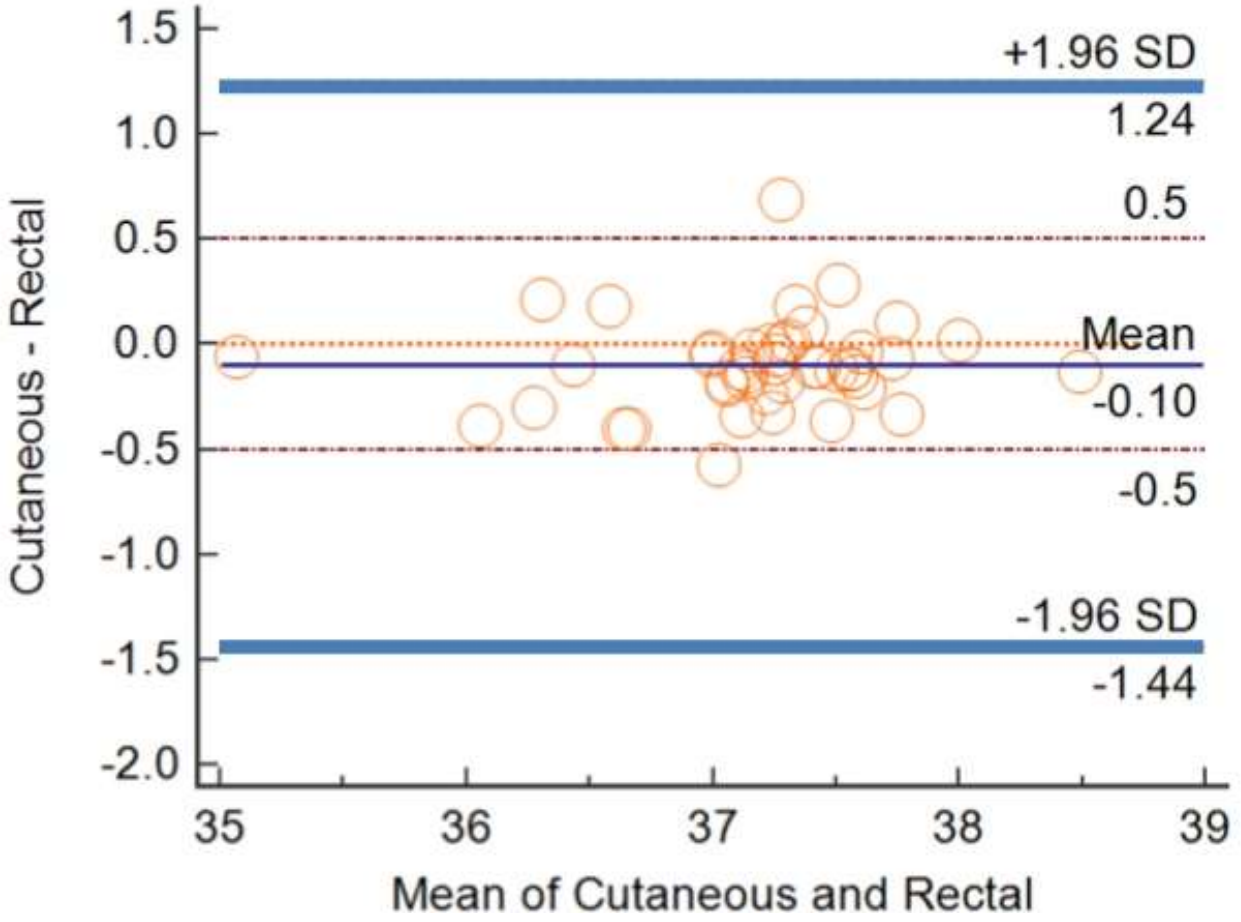
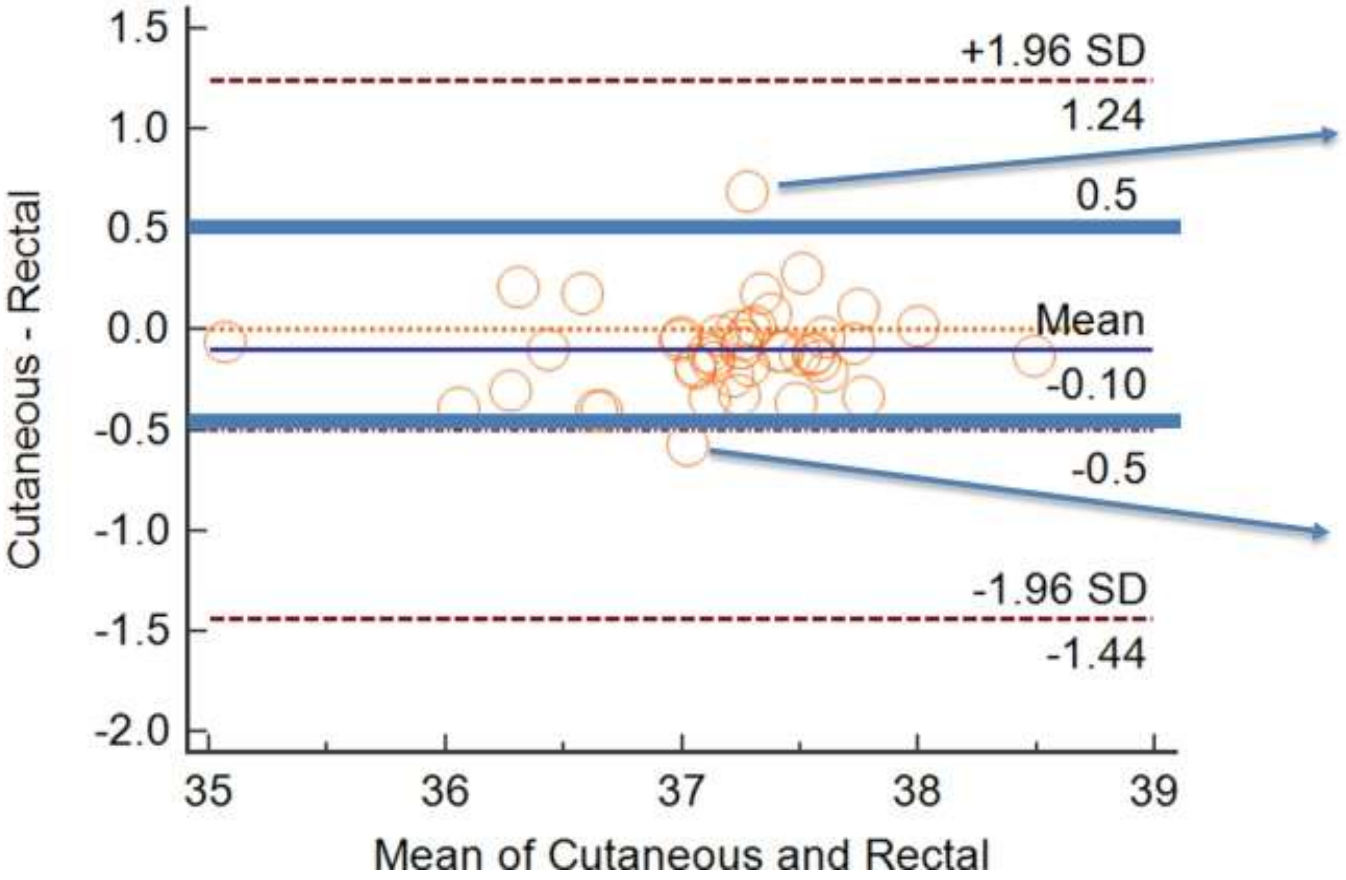
Results – BA Plot (Statistics perspective)



BA plot with multiple measurements per subject

All subjects fall within the 95% limits of agreement (-1.44,1.24)

Results – BA Plot (Clinical perspective)



12 out of 45 (26.7%) subjects have at least 1 temperature difference of 0.5 ^{o}C more
68 out of 1024 pairs of readings (6.6%) have exceeded acceptable range

Discussion

- A prospective evaluation of the agreement in temperature assessment between a new methodology (ZHF) and current standard (rectal thermometry).
- This study has translated similar findings from other studies (Eshraghi 2014, Iden 2015, Makinen 2016) that ZHF is accurate as a non-invasive measure of core temperature in hospitalised patients.
- This study has one of the largest sample size as compared to similar studies conducted.

Limitations of study

- 6 subjects were excluded when the equipment have been proven faulty.
- On-site BME support is not available to recalibrate the equipment immediately when it is faulty.
- It is unrealistic for bedside nurses to check the position of rectal probe every minute to ensure accuracy.
- One subject (A26) had 5 pairs of data excluded from analysis due to patient factors (e.g. diarrhoea).

Conclusion

- ZHF thermometry is suitable as alternative to rectal thermometry in NES critically ill patients, as all subjects fell between the 95% LOA.

- Clinical application of ZHF technology = Non-invasively, continuously measures patients' deep tissue core temperature

Acknowledgement and Declaration

- This study was awarded a research grant from Changi General Hospital (FY2016).

- None of the study team members had affiliations with 3M™ or Philips Healthcare.

- Biostatisician Carmen Kam for analyzing our results.

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