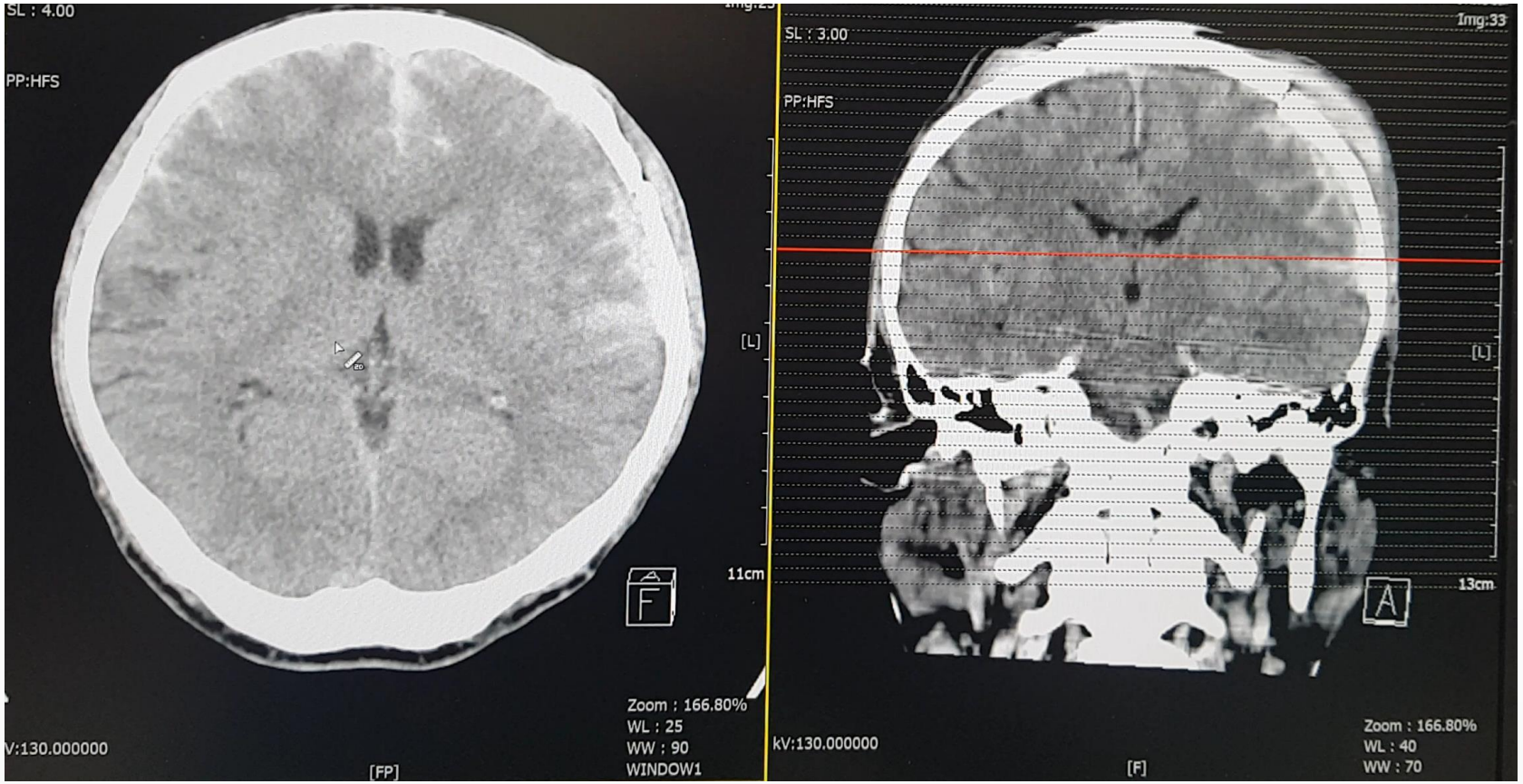
Targeted Temperature Management in Severe Traumatic Brain Injury

神經醫學中心 神經重症科 葉美吟

Traumatic Brain Injury
創傷性腦損傷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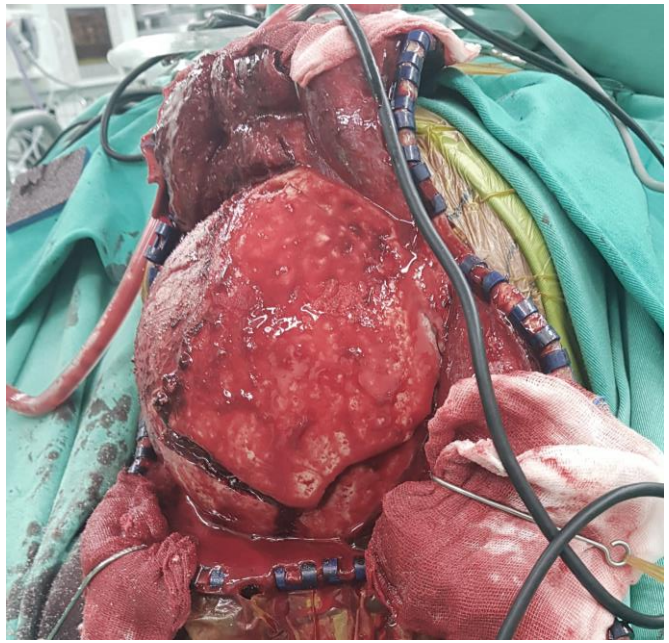
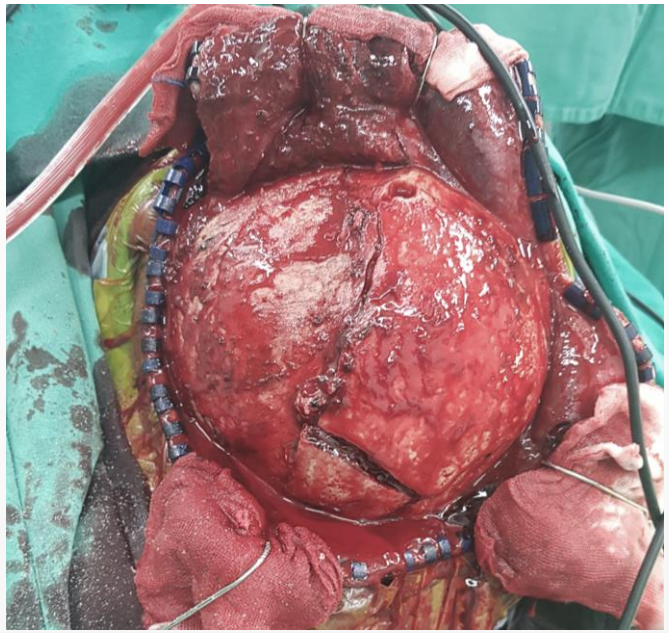
WW : 70





Intensive Care Med (2020) 46:919–929
https://doi.org/10.1007/s00134-019-05900-x

CONFERENCE REPORTS AND EXPERT PANEL

A management algorithm for adult patients with both brain oxygen and intracranial pressure monitoring: the Seattle International Severe Traumatic Brain Injury Consensus Conference (SIBICC)

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BASIC CARE Applies to all Severe TBI Patients

TIER 0

Expected Interventions:

- Admission to ICU
- Endotracheal intubation and mechanical ventilation
- Serial evaluations of neurological status and pupillary reactivity
- Elevate HOB 30–45°
- Analgesia to manage signs of pain (not ICP directed)
- Sedation to prevent agitation, ventilator asynchrony, etc. (not ICP directed)
- Temperature management to prevent fever
  - Measure core temperature
  - Treat core temperature above 38°C
- Consider anti-seizure medications for 1 week only (in the absence of an indication to continue)
- Maintain CPP initially ≥ 60mmHg
- Maintain Hb > 7g/dL
- Avoid hyponatremia
- Optimize venous return from head (e.g. head midline, ensure cervical collars are not too tight)
- Arterial line for continuous blood pressure monitoring
- Maintain SpO_2 ≥ 94%

Recommended Interventions:

- Insertion of a central line
- End-tidal CO_2 monitoring

Cause of cerebral hypoxia	Treatment
↓ CBF, ↓CPP	↑ABP, ↑$PaCO_2$
↓PaO_2	↑FiO_2
↓Hb	Consider transfusion
↑ Metabolism	↑Sedation, ↓Brain temperature

Intensive Care Med
https://doi.org/10.1007/s00134-022-06788-w

	ICP < 22 mmHg	ICP > 22 mmHg
$P_{bt}O_2$ > 20 mmHg	Type A	Type B
$P_{bt}O_2$ < 20 mmHg	Type C	Type D

Tier Zero (not ICP dependent): Treat core temperature >38.0°C

- Sedation, endotracheal intubation and mechanical ventilation
- CPP >60 mmHg
- SpO_2 >94% and Hb >7g/dL
- Consider EEG monitoring and seizure prophylaxis, avoid hyponatraemia

Tier 1: Controlled normothermia (target core temperature 36.0–37.5°C)

- Titrate sedation and analgesia to control ICP
- CPP 60–70 mmHg
- $PaCO_2$ 35–38 mmHg / 4.7–5.1 kPa
- Consider osmotherapy and external ventricular drainage

Tier 2: Controlled normothermia (target core temperature 36.0–37.5°C)

- CPP individualised goals
- $PaCO_2$ 32–35 mmHg / 4.3–4.6 kPa
- Consider neuromuscular blocker

Tier 3: Mild hypothermia (target core temperature 35.0–36.0°C)

- Consider decompressive craniectomy
- Consider barbiturate coma

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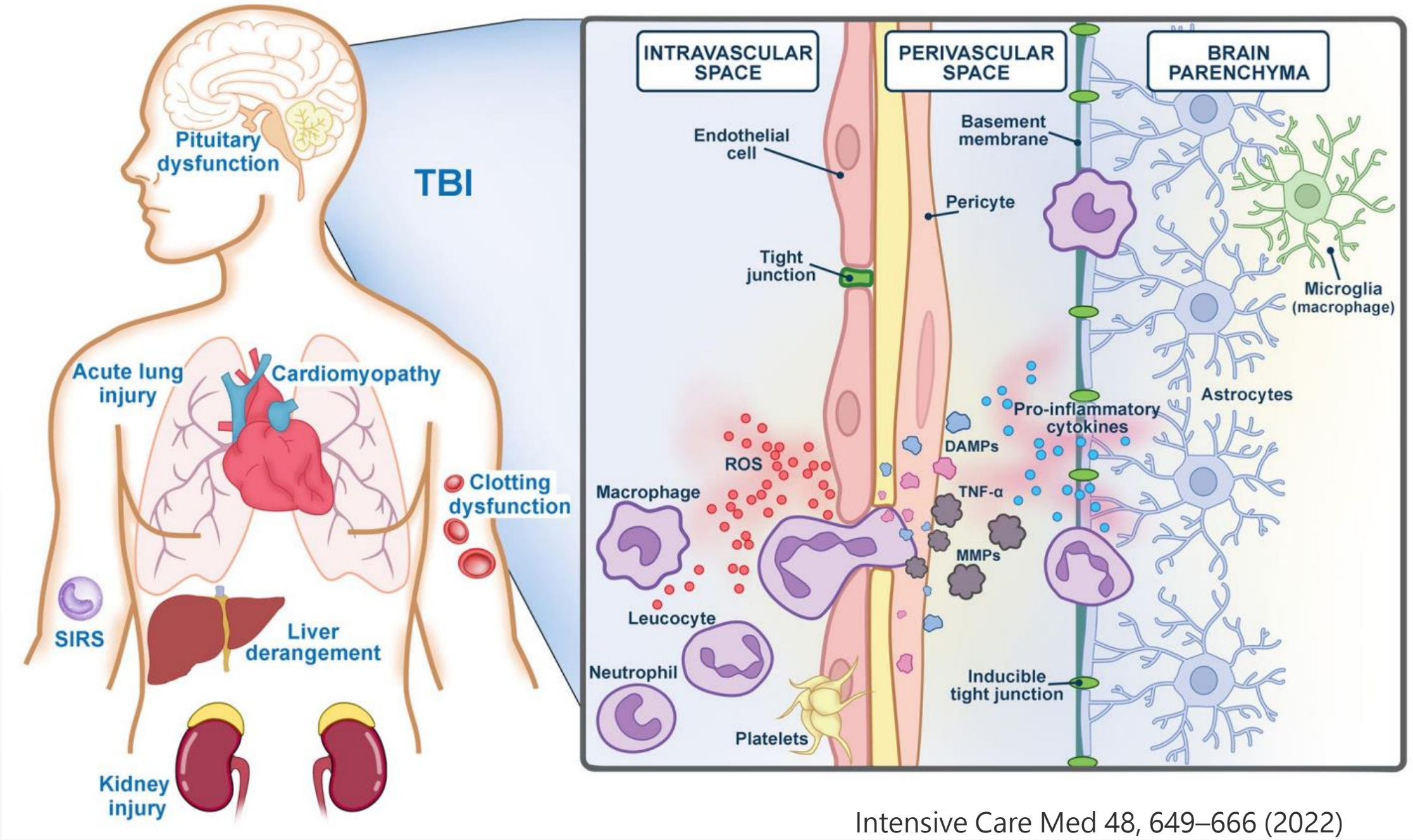


Intensive Care Med 48, 649–666 (2022)

Review > J Neurosci Nurs. 2004 Feb;36(1):23-31. doi: 10.1097/01376517-200402000-00004.

Comparison of brain temperature to core temperature: a review of the literature

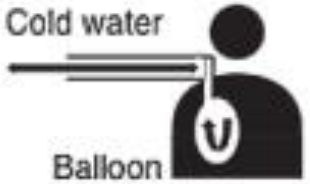
Laura Mcilvoy [1]

- A systematic review of all published studies between 1990 and 2002 found brain temperatures to be significantly higher when compared to core temperatures in brain-injured patients

- Average brain temperature during the first 5 days post-TBI was 38.9 ℃ +-1.0 ℃ while the average rectal temperature was 37.8 ℃ +-0.4℃

Rumana, C. S., et al. Critical Care Medicine 1998;26:562-567

→In the absence of brain temperature monitoring, the population appears to be afebrile.

Techniques		Advantages	Disadvantages
External cooling system		Tight thermoregulatory capacity Reducing the risk of over-cooling in induction	Skin reactions
Endovascular cooling system		Rapid and accurate establishment of the target temperature Stable maintenance	Need special catheter Central venous cannulation with the risk of venous thrombosis and infection
Cold infusion		Easy and rapid induction Applicable regardless of location	Difficult temperature maintenance
Extracorporeal circulation system (e.g. ECMO, dialysis)		Rapid induction	Highly invasive Need anticoagulant
Others	• Iced saline gastric lavage • Cooling helmets	• Water immersion system • Trans-nasal cooling devise	

Nosaka N., er al. Aactaa Med. Okayama 2017;71:1-9

GUIDELINE Lavinio et al. Critical Care (2024) 28:170 Open Access

Targeted temperature control following traumatic brain injury: ESICM/NACCS best practice consensus recommendations

Andrea Lavinio[1,2*], Jonathan P. Coles[1,2], Chiara Robba[3], Marcel Aries[4,5], Pierre Bouzat[6], Dara Chean[7], Shirin Frisvold[8,9], Laura Galarza[10], Raimund Helbok[11,12], Jeroen Hermanides[13], Mathieu van der Jagt[14], David K. Menon[1,2], Geert Meyfroidt[15], Jean-Francois Payen[6], Daniele Poole[16], Frank Rasulo[17], Jonathan Rhodes[18], Emily Sidlow[19], Luzius A. Steiner[20], Fabio Silvio Taccone[21,22] and Riikka Takala[23,24]

Pathophysiology

(i) Temperature measurement and control is an essential aspect of high-quality care in patients with severe TBI

(ii) In patients with impending cerebral herniation, temperature control is essential

Monitoring

(1) Continuous temperature monitoring is preferable over intermittent temperature measurements in patients with severe TBI.

(2) Monitoring core temperature (e.g., bladder, oesophageal, brain) is strongly recommended over measuring or monitoring superficial temperature (e.g., skin, tympanic) in severe TBI.

(3) When brain temperature monitoring is in place, it is advisable to assess an additional source of core temperature monitoring (i.e. oesophageal, bladder).

ICP management

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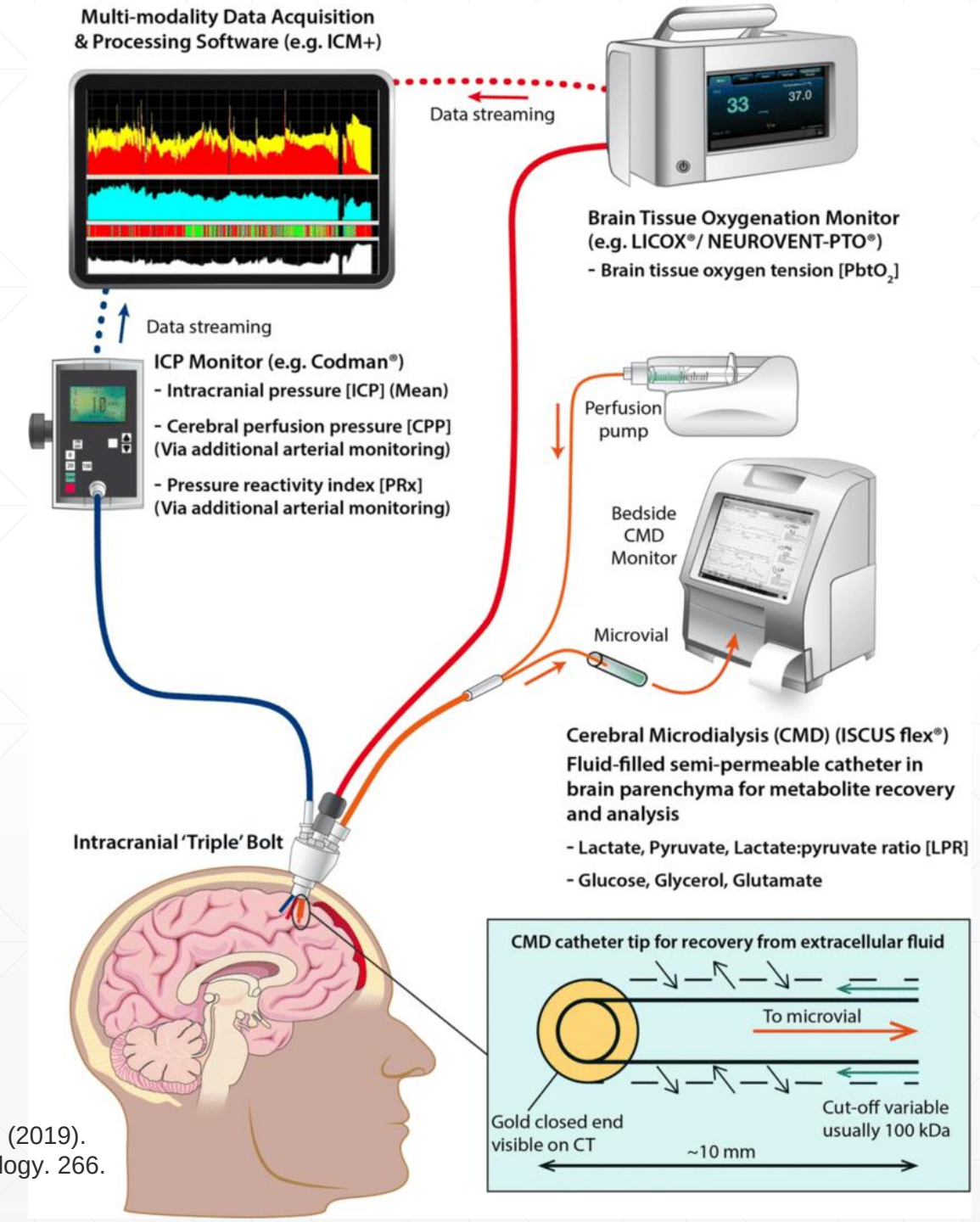
(1) Temperature control is a key component of ICP management in severe TBI.

(2) Controlled normothermia (i.e., target core temperature 36.0–37.5 °C) should be included as an addition to the Tier 1 and Tier 2 treatments defined within the Seattle International Severe Traumatic Brain Injury Consensus Conference (SIBICC) 2019 guidelines.

(3) Therapeutic hypothermia (i.e., target core temperature ≤ 36.0 °C) should be considered in cases where tier 1 and 2 treatments (as per SIBICC guidance) have failed to control ICP.

(4) If hypothermia is considered to control ICP, target temperature should be managed as close to normothermia as possible.



Khellaf, Abdelhakim & Khan, Danyal Zaman & Helmy, Adel. (2019). Recent advances in traumatic brain injury. Journal of Neurology. 266. 10.1007/s00415-019-09541-4.

Fever

(1) Neurogenic fever (core temperature > 37.5 °C) driven by neurological dysregulation in the absence of sepsis or a clinically significant systemic inflammatory process is relatively common in TBI, and it should be promptly detected and treated (i.e., with controlled normothermia targeting 36.0 °C to 37.5 °C), irrespective of ICP level.

(2) Controlled normothermia should be considered when pyrexia is secondary to sepsis or inflammatory processes, and when the patient is perceived to be at risk of secondary brain injury, especially in the acute phase of TBI.

(3) Uncontrolled fever (neurogenic or secondary to inflammation or infection) can precipitate secondary brain injury in patients with severe TBI.

(1) Fever control is recommended in patients with severe TBI who have seizures or are perceived to be at high risk of seizures.

(2) In patients with severe TBI who are sedated and ventilated, controlled normothermia, irrespective of ICP, should be initiated reactively when fever is detected.

(3) When neurogenic fever is detected in TBI cases, controlled normothermia should be continued for as long as the brain remains at risk of secondary brain damage.

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Hypothermic TTC induction

1. It is recommended that the rapid induction of hypothermia in traumatic brain injury cases should be achieved with automated feedback-controlled temperature management devices.

TTC maintenance

(1) An automated feedback-controlled TTC device that enables precise temperature control is desirable for the initiation of TTC and maintenance at target temperature in patients with severe TBI.
(2) The maximum temperature variation that a patient should experience during normothermia is less than or equal to +/− 0.5 °C per hour and ≤ 1 °C per 24-hperiod
(3) When hypothermia is indicated, treatment should be continued for as long as the brain is considered to be at risk of secondary brain injury.

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Rewarming following hypothermic TTC

(1) Obtaining an interval scan and/or an alternative assessment of intracranial compliance, in addition to the absolute number of ICP, is recommended before rewarming.

(2) Rebound hyperthermia should be prevented whenever possible or promptly treated in cases when the brain is perceived to be at risk of secondary brain injury.

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Journal of *Clinical Medicine*

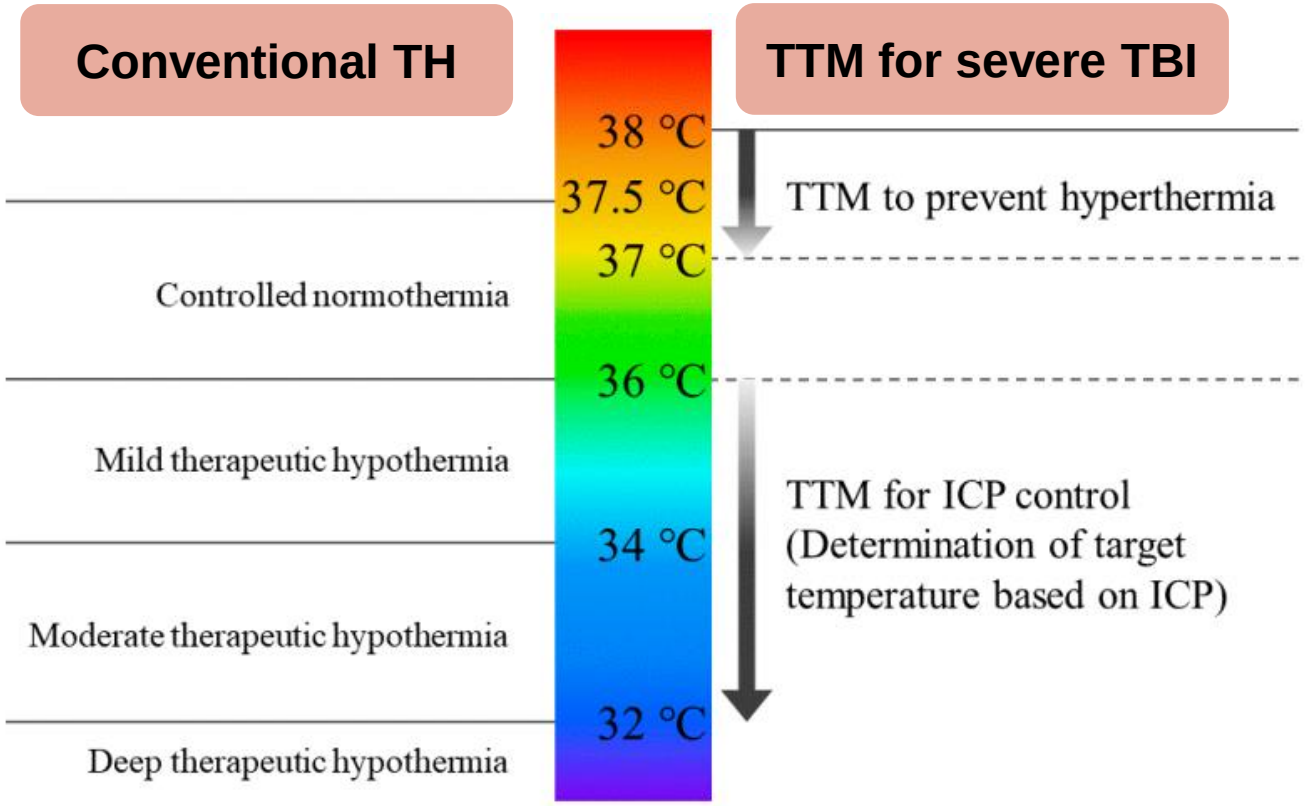
MDPI

Review

Review of Temperature Management in Traumatic Brain Injuries

Kenya Kawakita [1,*], Hajime Shishido [1] and Yasuhiro Kuroda [2]

J. Clin. Med. **2024**, *13*, 2144. https://doi.org/10.3390/jcm13072144



- TTM serves two primary purposes
  - Regulation of ICP
  - Prevention of hyperthermia

Purpose	ICP Control	Prevention of Fever
Subject	Severe TBI and stroke	Severe TBI and stroke
Target temperature	33–36 °C	37–38 °C
Device	Intravascular catheters Surface cooling	Intravascular catheters *
Medication	Analgosedative drugs, muscle relaxants, and antipyretic drugs	Antipyretic drugs and analgosedative drugs
Respirator	with	with or without
Duration	1–2 weeks	1–2 weeks

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Prevention of Shivering during TTM

- Shivering
  - Metabolic rate *2
  - Oxygen consumption↑(by 40%-100%)
  - Work of breathing↑, heart rate↑
- Stress-like response
  - Tachycardia, Hypertension
  - IICP
  - Morbid cardiac events

STEP 1 (Go to next step if BSAS > 0)	Acetaminophen 650–1000 mg IV/PO q 4–6 h Skin counter-warming Magnesium sulfate 20 mEq/20 mg IV (if with hypomagnesemia)
STEP 2 (Go to next step if BSAS > 0)	Meperidine 35–50 mg IV q 3–4 h and/or Dexmedetomidine IV infusion 0.2 mcg/kg/h and/or Fentanyl IV infusion 25 mcg/h
STEP 3 (Go to next step if BSAS > 0)	Intubation if not already undertaken Propofol 20–40 mg IV bolus followed by 0.5–3 mg/kg/h or Midazolam 3–5 mg IV bolus followed by 0.06–0.18 mg/kg/h
STEP 4	Rocuronium 50 mg IV bolus followed by 10–20 mg/h

Who is difficult to lowering temperature??

- Age – effectiveness of heat conservation and heat generation decreases
  - Less vasoconstriction
  - Ability detect small temperature change
  - Lower basal metabolic rate
  - Drug clearance – dose of opiates/sedatives use higher in young
- Body mass – insulating of adipose tissue→obese difficult to cool
- Severe brain injury
  - Diminish/obviate thermoregulatory response
  - Absent shiver response
  - 越嚴重的患者越易降溫, poor prognostic sign

Polderman K. Circulation 2015;132:152-157

	難治型顱內高壓之低溫療法					
47081B	一首日		v	v	v	6057
47082B	一第二至七日(每日)		v	v	v	2505
	註：					
	1.適應症：因下列原因造成之顱內高壓，以傳統治療方式如：頭部抬高 30 度、降腦壓藥物、開顱手術、深度鎮靜且 ICP 仍處於 20mmHg>10 min 者，皆無法使顱內壓降低：					
	(1)出血性中風。					
	(2)次重度或重度腦創傷 GCS 小於等於 12。					
	2.禁忌症：					
	(1)任意原因引起之休克。					
	(2)在意外前即有失智或長期意識障礙。					
	(3)腦死。					
	(4)自發性低體溫者＜32℃。					
	(5)顱內有占據顱內空間病灶如血塊、腦水腫、水腦症等，符合手術適應症，但未進行手術者。					
	(6)嚴重感染者。					
	(7)呼吸窘迫症候群。					

How to create our own protocol?

- Check lab data
- Electrolyte replacement – K^+
- Shivering
- Chest caring
- Cooling period