

ICP managment

Intraoperative teaching · CA-2

THE QUESTION

Where the evidence disagrees

This topic was selected because an evidence synthesis beats a textbook on it: the trials disagree, or the guidance has moved recently.

THE EVIDENCE

What each source contributes, and how strong it is

Study design first — a cohort and a randomised trial do not carry the same weight.

Design	Year	Journal	What it found
Guideline	2020	Neurocritical care	This guideline found corticosteroids appear helpful in reducing cerebral edema in
Meta-analysis	2025	World neurosurgery	This meta-analysis found no significant mortality difference between early—defined
Randomised trial	2021	Journal of neurotrauma	This randomized trial found that TBI patients requiring ICP therapy spent 46.5% of
Review	2025	England)	This review reports that brain ultrasound, automated pupillometry
Guideline	2018	critical care & pain medicine	This guideline recommends updated first-24-hour strategies for intracerebral
Meta-analysis	2024	Neurocritical care	This meta-analysis found that in acute traumatic brain injury, hypertonic saline was

6 resolved citations behind this deck; every point above traces to one of them.

WHERE THE GUIDANCE SITS

What the guidelines and pooled evidence say

4 findings, each on the slide that follows.

NEUROCRITICAL CARE 2020

This guideline found corticosteroids appear helpful in reducing cerebral edema in

This guideline found corticosteroids appear helpful in reducing cerebral edema in bacterial meningitis but not intracerebral hemorrhage.

WORLD NEUROSURGERY 2025

This meta-analysis found no significant mortality difference between early—defined

This meta-analysis found no significant mortality difference between early—defined by 4-hour or 6-hour cutoffs—and late intracranial pressure...

CRITICAL CARE & PAIN MEDICINE 2018

This guideline recommends updated first-24-hour strategies for intracerebral

This guideline recommends updated first-24-hour strategies for intracerebral monitoring, cerebral perfusion pressure management

NEUROCRITICAL CARE 2024

This meta-analysis found that in acute traumatic brain injury, hypertonic saline was

This meta-analysis found that in acute traumatic brain injury, hypertonic saline was associated with adverse hyponatremia versus other...

WHERE THE GUIDANCE SITS

This guideline found corticosteroids appear helpful in reducing cerebral edema in

Guideline · Neurocritical care

This guideline found corticosteroids appear helpful in reducing cerebral edema in bacterial meningitis but not intracerebral hemorrhage.

Guidelines for the Acute Treatment of Cerebral Edema in Neurocritical Care Patients, Neurocritical care 2020 · PMID 32227294

WHERE THE GUIDANCE SITS

This meta-analysis found no significant mortality difference between early—defined

Meta-analysis · World neurosurgery

This meta-analysis found no significant mortality difference between early—defined by 4-hour or 6-hour cutoffs—and late intracranial pressure monitoring in traumatic brain injury patients.

Timing of Intracranial Pressure Monitoring in Traumatic Brain Injury: A Systematic Review and Meta-Analysis, World neurosurgery 2025 · PMID 40449835

WHERE THE GUIDANCE SITS

This guideline recommends updated first-24-hour strategies for intracerebral

Guideline · critical care & pain medicine

This guideline recommends updated first-24-hour strategies for intracerebral monitoring, cerebral perfusion pressure management, and medical management of raised intracranial pressure in severe traumatic brain injury.

Management of severe traumatic brain injury (first 24hours), Anaesthesia, critical care & pain medicine 2018 · PMID 29288841

WHERE THE GUIDANCE SITS

This meta-analysis found that in acute traumatic brain injury, hypertonic saline was

Meta-analysis · Neurocritical care

This meta-analysis found that in acute traumatic brain injury, hypertonic saline was associated with adverse hyponatremia versus other intracranial-pressure-lowering agents with relative risk 2.13 but no evidence of effect on six-month Glasgow Outcome Scale scores or mortality.

Hypertonic Saline Versus Other Intracranial-Pressure-Lowering Agents for Patients with Acute Traumatic Brain Injury: A Systematic Review and Meta-analysis, Neurocritical care 2024 · PMID 37380894

WHAT THE TRIALS FOUND

This randomized trial found that TBI patients requiring ICP therapy spent 46.5% of

Randomised trial · Journal of neurotrauma

This randomized trial found that TBI patients requiring ICP therapy spent 46.5% of monitored time within 5 mm Hg of an individualized autoregulation-guided CPP target with no significant between-group difference in therapeutic intensity level.

Targeting Autoregulation-Guided Cerebral Perfusion Pressure after Traumatic Brain Injury (COGITATE): A Feasibility Randomized Controlled Clinical Trial, Journal of neurotrauma 2021 · PMID 34407385

IN PRACTICE

This review reports that brain ultrasound, automated pupillometry

Review · England)

This review reports that brain ultrasound, automated pupillometry, and noninvasive pressure waveform monitoring are shifting ICP management toward more accessible and continuous evaluation strategies in severely brain-injured patients.

Monro-Kellie 4.0: moving from intracranial pressure to intracranial dynamics, Critical care (London, England) 2025 · PMID 40474297

IN THE ROOM

What this changes about the next case

Colour is the strength of the evidence behind each step, not the urgency.

- 1**
This guideline found corticosteroids appear helpful in reducing cerebral edema in bacterial meningitis but not intracerebral hemorrhage.
- 2**
This guideline recommends updated first-24-hour strategies for intracerebral monitoring, cerebral perfusion pressure management, and medical management of raised intracranial pressure in severe traumatic brain injury.
- 3**
This meta-analysis found no significant mortality difference between early—defined by 4-hour or 6-hour cutoffs—and late intracranial pressure monitoring in traumatic brain injury patients.
- 4**
This meta-analysis found that in acute traumatic brain injury, hypertonic saline was associated with adverse hyponatremia versus other intracranial-pressure-lowering agents with relative risk 2.13 but no evidence of effect on six-month Glasgow Outcome Scale scores or mortality.
- 5**
This randomized trial found that TBI patients requiring ICP therapy spent 46.5% of monitored time within 5 mm Hg of an individualized autoregulation-guided CPP target with no significant between-group difference in therapeutic intensity level.

KEY TAKEAWAYS

What to carry into the next case

This guideline found corticosteroids appear helpful in reducing cerebral edema in

Neurocritical care 2020

This meta-analysis found no significant mortality difference between early—defined

World neurosurgery 2025

This randomized trial found that TBI patients requiring ICP therapy spent 46.5% of

Journal of neurotrauma 2021

This review reports that brain ultrasound, automated pupillometry

England) 2025

This guideline found corticosteroids appear helpful in reducing cerebral edema in

QUESTIONS I'LL ASK YOU IN THE ROOM

1. How does your plan change if the patient is not optimised?
2. What is the physiology behind what we just did?
3. Talk me through the trade-off you made there.
4. What would make you abandon this plan and do something else?

BOARD QUESTIONS

1. A systematic review restricted to randomised trials published from 2000 onwards pooled 10 trials in 760 patients comparing hypertonic saline with other intracranial-pressure-lowering agents in traumatic brain injury, with the six-month Glasgow Outcome Scale as its primary outcome. What did it find, and what harm did it identify?
2. A meta-analysis pooled five randomised trials — 112 patients with 184 episodes of raised intracranial pressure — that compared equiosmolar doses of hypertonic sodium solutions with mannitol. What was the relative risk of successfully controlling an episode of intracranial hypertension?
 - A. 1.16 (95% CI 1.00 to 1.33) favouring hypertonic saline, with a mean intracranial pressure difference of 2.0 mmHg (95% CI -1.6 to 5.7)
 - B. 2.10 (95% CI 1.55 to 2.85) favouring hypertonic saline, with a mean intracranial pressure difference of 9 mmHg
 - C. 0.86 (95% CI 0.75 to 0.99) favouring mannitol, with a mean intracranial pressure difference of 2.0 mmHg
 - D. 1.16 (95% CI 0.72 to 1.87), with the pooled point estimate favouring mannitol
3. A meta-analysis with trial sequential analysis pooled 12 randomised trials in 464 patients comparing hypertonic saline with mannitol for raised intracranial pressure after traumatic brain injury. Contrast what it found for the physiological endpoints with what it found for patient-centred outcomes, and say what the trial sequential analysis added.

ANSWER KEY

1. It found no evidence of an effect on any clinically important outcome. Glasgow Outcome Scale at six months showed no difference (risk ratio 0.82, 95% CI 0.48 to 1.40), nor did all-cause mortality (risk ratio 0.96, 95% CI 0.60 to 1.55) or total length of stay. The point estimate for uncontrolled intracranial pressure favoured hypertonic saline but did not reach significance (risk ratio 0.52, 95% CI 0.26 to 1.04). The harm identified was hypernatraemia, roughly twice as common with hypertonic saline (risk ratio 2.13, 95% CI 1.09 to 4.17). Most of the included trials were at unclear or high risk of bias and the evidence was rated low to very low certainty.

Set this beside the earlier meta-analyses and the shape of the evidence becomes clear: hypertonic saline moves intracranial pressure and cerebral perfusion pressure in some trials and at some time points, has never been shown to change six-month outcome, and carries a measurable sodium cost. This review is the most conservative of the three — here even the reduction in uncontrolled intracranial pressure did not reach statistical significance, on low to very low certainty evidence. That is enough to justify keeping it in the algorithm and not enough to justify claiming it is better.

Bernhardt K et al., Hypertonic Saline Versus Other Intracranial-Pressure-Lowering Agents for Patients with Acute Traumatic Brain Injury: A Systematic Review and Meta-analysis, Neurocrit Care 2024 · PMID 37380894

2. A. 1.16 (95% CI 1.00 to 1.33) favouring hypertonic saline, with a mean intracranial pressure difference of 2.0 mmHg (95% CI -1.6 to 5.7)

Note how narrow the margin is. The lower bound of the relative risk sits on 1.00 and the mean intracranial pressure difference crosses zero. The authors' own reading is that hypertonic saline may be superior and that a large multicentre trial is needed to settle first-line therapy — a 16% relative advantage in five small trials is a reason to keep hypertonic saline in the algorithm, not a reason to say mannitol has been beaten.

Kamel H et al., Hypertonic saline versus mannitol for the treatment of elevated intracranial pressure: a meta-analysis of randomized clinical trials, Crit Care Med 2011 · PMID 21242790

3. The physiological endpoints favoured hypertonic saline, but only after a delay: intracranial pressure was no different at 30 to 60 minutes (mean difference -0.19 mmHg) and significantly lower after hypertonic saline at 90 to 120 minutes (mean difference -2.33 mmHg, 95% CI -3.17 to -1.50). Cerebral perfusion pressure was higher after hypertonic saline at both windows, by 5.48 and 9.08 mmHg. The patient-centred outcomes showed nothing: mortality did not differ (relative

risk 0.69, 95% CI 0.45 to 1.04) and neither did favourable neurological outcome (relative risk 1.28, 95% CI 0.86 to 1.90). The trial sequential analysis added the crucial qualifier — the accumulated number of patients is insufficient to make reliable statements about long-term outcome, so the absence of an outcome difference here is an underpowered result rather than a demonstrated equivalence.

A drug that lowers the number on the monitor has not yet been shown to change what happens to the patient. Trial sequential analysis is the tool that tells you whether "no difference" has actually been tested or merely not yet observed.

Schwimmbeck F et al., Hypertonic Saline Versus Mannitol for Traumatic Brain Injury: A Systematic Review and Meta-analysis With Trial Sequential Analysis, J Neurosurg Anesthesiol 2021 · PMID 31567726

This guideline found corticosteroids appear helpful in reducing cerebral edema in

SOURCES

- [1] Guidelines for the Acute Treatment of Cerebral Edema in Neurocritical Care Patients, Neurocritical care 2020 · PMID 32227294
- [2] Timing of Intracranial Pressure Monitoring in Traumatic Brain Injury: A Systematic Review and Meta-Analysis, World neurosurgery 2025 · PMID 40449835
- [3] Targeting Autoregulation-Guided Cerebral Perfusion Pressure after Traumatic Brain Injury (COGiTATE): A Feasibility Randomized Controlled Clinical Trial, Journal of neurotrauma 2021 · PMID 34407385
- [4] Monro-Kellie 4.0: moving from intracranial pressure to intracranial dynamics, Critical care (London, England) 2025 · PMID 40474297
- [5] Management of severe traumatic brain injury (first 24hours), Anaesthesia, critical care & pain medicine 2018 · PMID 29288841
- [6] Hypertonic Saline Versus Other Intracranial-Pressure-Lowering Agents for Patients with Acute Traumatic Brain Injury: A Systematic Review and Meta-analysis, Neurocritical care 2024 · PMID 37380894