Fluid therapy in central neural system infections in children

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Box 2 Normal ranges of intracranial pressure in children

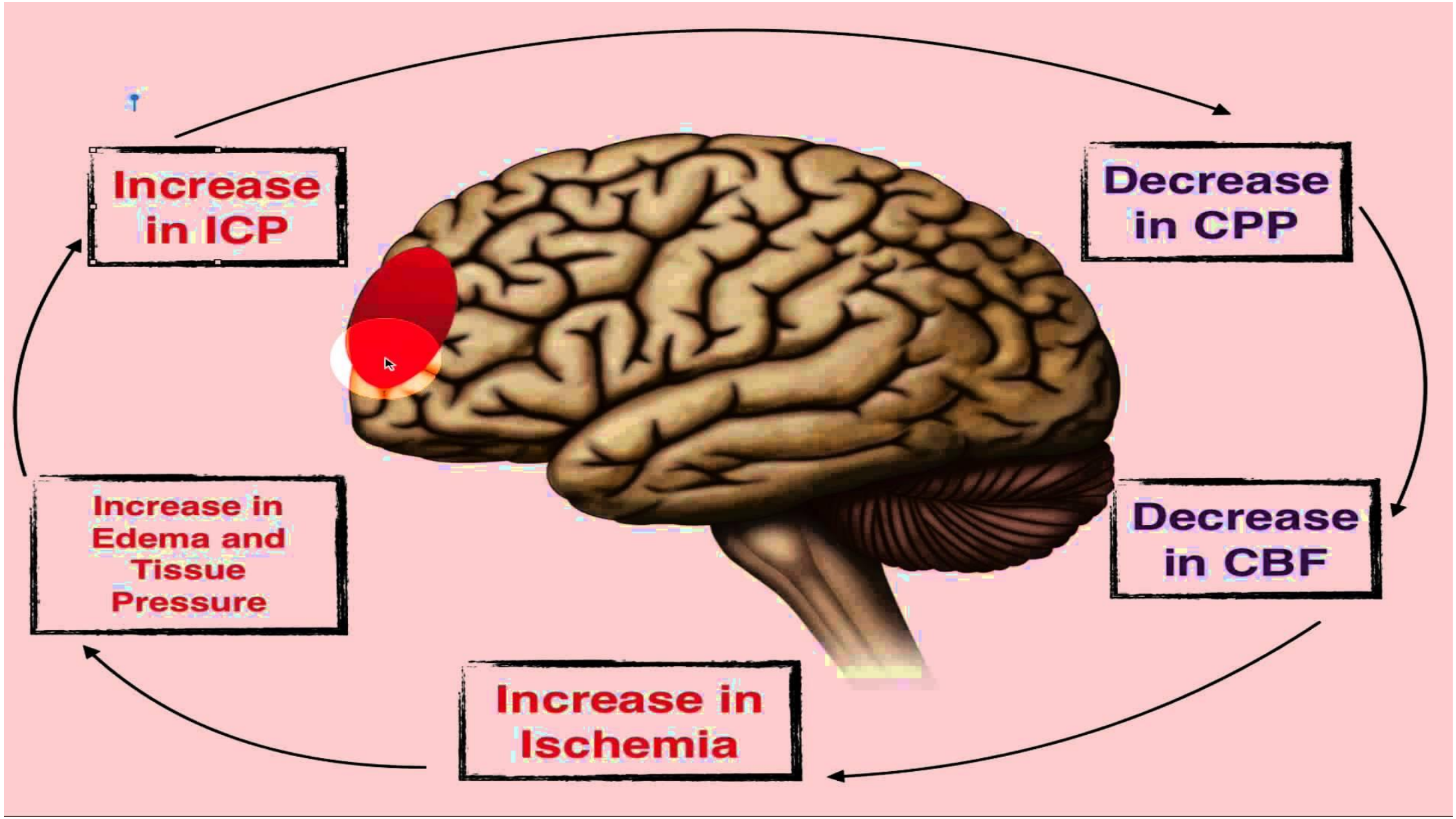
- Term infants: 1.5mmHg-6mmHg.
- Toddlers: 3mmHg-7mmHg.
- Pre-pubertal children: <12mmHg.
- Post-pubertal children/adults: <18mmHg.

An intracranial pressure of >25mmHg warrants urgent treatment.

(Dunn 2002)

increased intracranial pressure:

ICP > 20mmHg


Increase in ICP
Decrease in CPP
Decrease in CBF
Increase in Ischemia
Increase in Edema and Tissue Pressure

Stage of limitation of both fluid and salt intake

Time earlier than 1975, the fluid intake of the BE and ICH in children were limited <1,000-1,200 mL/m²·d or <30-60 mL/kg·d (1-3). Both intake of fluid and sodium salt (NaCl) were limited in order to reduce the edema of brain. Mannitol and diuretics were already used in that time, some patient after treatment passing a lot of urine and became dehydrated but the intake of fluid and salt were still limited. The fault of the treatment caused dehydration, and even shock etc., the mortality of BE and ICH in children was very high even >60% (4) in that period.

Stage of no limitation of both fluid and salt

There were quite a number of reports discovered that the fault of treatment of BE and ICH in children with the strict limitation of both fluid and salt and the change of this principle of treatment in 1979~2002 (4). For example Gellis SS *et al.* (ed) Current Pediatric Therapy 1971 (5th ed) limited the fluid intake of BE in children to 1,000-1,200 mL/m^2·d and limited the salt intake too (1). The 13th ed (1990) of that book no limitation of fluid and salt intake and maintained the normal fluid and electrolytes balance was its principle of treatment (5). Youman JR Neurological Surgery 4th ed

(1996) made clear the principle of treatment for the ICH of traumatic brain injury (TB1) should maintain the balance of body fluid and electrolytes (6). Since then the majority textbooks with no more limitation of fluid and salt intake treatment for both BE and ICH in children. However, only a few textbooks still persisted the limitation of fluid principle of treatment (7).

Cochrane Library

Fluid therapy for acute bacterial meningitis (Review)

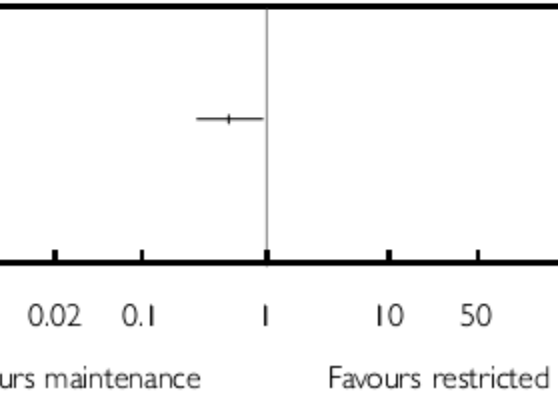
three trials with a total of 420 children

no significant difference between maintenance versus restrictive fluid regimens for the outcome of death and acute severe neurological complications

Cochrane Database of Systematic Reviews 2016, Issue 11. Art. No.: CD004786.
DOI: 10.1002/14651858.CD004786.pub5.

Outcome: 5 Spasticity

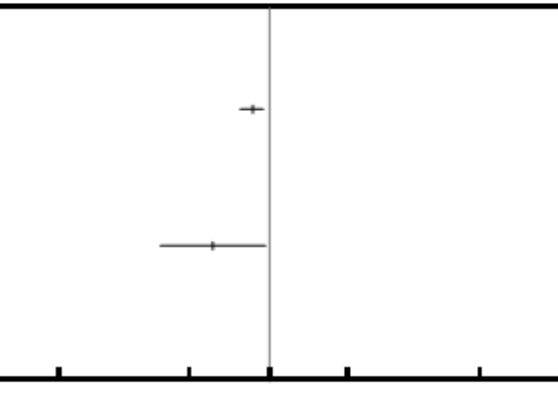
Study or subgroup	Maintenance fluids n/N	Restricted fluids n/N	Risk Ratio M-H,Fixed,95% CI	Risk Ratio M-H,Fixed,95% CI
1 At 14 days				
Duke 2002				0.50 [0.27, 0.93]



some evidences favouring maintenance fluid therapy over restricted fluids for chronic severe neurological events

Outcome: 6 Seizures

Study or subgroup	Maintenance fluids n/N	Restricted fluids n/N	Risk Ratio M-H,Fixed,95% CI	Risk Ratio M-H,Fixed,95% CI
1 Within the first 72 hours				
Duke 2002	38/181	63/176		0.59 [0.42, 0.83]
2 At 14 days				
Duke 2002	2/181	10/176		0.19 [0.04, 0.88]



Stage to maintain proper cerebral perfusion pressure (CPP)

There are quite a number of research discovered that to maintain the proper CPP is very important in the treatment of TB1. It is very important of maintaining CPP to 70-100 mmHg in order to avoid the secondary injury of anoxemia of brain after TB1, which is said to be the most important factor to influence the prognosis.

Randomized Controlled Trial Comparing Cerebral Perfusion Pressure–Targeted Therapy Versus Intracranial Pressure–Targeted Therapy for Raised Intracranial Pressure due to Acute CNS Infections in Children*

Hundred ten children (1–12 yr) with acute CNS infections having raised intracranial pressure and a modified Glasgow Coma Scale score less than or equal to 8 were enrolled

Crit Care Med 2014; 42:1775–1787

Patients were randomized:

Group 1: cerebral perfusion pressure–targeted therapy (n = 55) (maintaining cere-bral perfusion pressure ≥ 60 mm Hg, using normal saline bolus and vasoactive therapy—dopamine, and if needed noradrenaline)

Group 2: intracranial pressure–targeted therapy (n = 55) (maintaining intra-cranial pressure < 20 mm Hg using osmotherapy while ensuring normal blood pressure)

Adverse Events

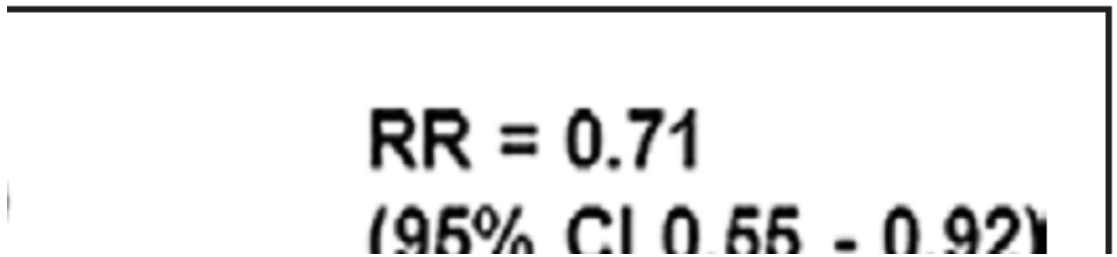
No technical complication was encountered during insertion of ICP monitoring catheter. Two patients underwent intraventricular pressure monitoring because of evolving hydrocephalus after 3 days of initial intraparenchymal monitoring. Both patients died, one of them after developing ventriculitis.

Variables	Intracranial Pressure Group ($n = 55$)	Cerebral Perfusion Pressure Group ($n = 55$)	Relative Risk (95% CI)	p
Mortality				
During PICU stay	20 (36.4)	10 (18.2)	2.0 (1.03–3.87)	0.032
Total mortality at 90 d post discharge	21 (38.2)	10 (18.2)	2.1 (1.09–4.04)	0.020
Neurodisability at the time of discharge from PICU				
None	6/35 (17.1)	21/45 (46.7)	0.37 (0.17–0.81)	0.011[a]
Mild	4/35 (11.4)	3/45 (6.7)	1.71 (0.41–7.2)	0.693[b]
Moderate	6/35 (17.1)	7/45 (15.6)	1.1 (0.4–3.0)	0.90[a]
Severe	19/35 (54.3)	14/45 (31.1)	1.74 (1.00–2.99)	0.037[a]
Neurodisability at 90-day follow-up				
None	10/34 (29.4)	28/45 (62.2)	0.47 (0.27–0.83)	0.004
Mild	6/34 (17.6)	4/45 (8.9)	1.99 (0.61–6.49)	0.313[b]
Moderate	6/34 (17.6)	8/45 (17.8)	0.99 (0.38–2.59)	0.778[a]
Severe	12/34 (35.3)	5/45 (11.1)	3.18 (1.24–8.16)	0.021[a]
Composite poor outcome[c]				
At the time of discharge from PICU	39/55 (70.9)	24/55 (43.6)	1.63 (1.15–2.29)	0.004
At 90-day follow-up	33/55 (60)	15/55 (27.3)	2.20 (1.36–3.56)	<0.001

TABLE 4. Median Modified Glasgow Coma Scale Scores at 24, 48, and 72 Hours After Enrollment, at the Time of Removal of Intracranial Pressure Catheter, and Discharge From PICU in the Two Study Groups

Variables	ICP Group ($n = 55$)	Cerebral Perfusion Pressure Group ($n = 55$)	p[a]
24 hr after enrollment	5 (4–6)	7 (6–7)	< 0.001
48 hr after enrollment	6 (4–8)	8 (7–9)	< 0.001
72 hr after enrollment	7 (4–9)	10 (9–11)	< 0.001
At time of removal of ICP catheter	8 (4–9)	11 (9–12)	< 0.001
At the time of PICU discharge	10 (3–12)	13 (11–15)	< 0.001

Our findings are in line with to those of Rosner et al (26) in adults and those of Prabhakaran et al (27) in children with TBI. Rosner et al (26) showed that ICP decreased as CPP increased, and CPP-targeted therapy lowered the mortality rate and improved functional outcome across all GCS score categories in patients with TBI.



CPP = MAP - ICP *(As ICP is suspected to be elevated, but the level can not be measured at this stage, assume it to be 20 mmHg)*

CPP = Cerebral Perfusion Pressure, MAP = Mean Arterial Pressure, ICP = Intracranial Pressure

Minimum CPP Targets

Age	Minimal CPP Target	Minimal MAP target if ICP unknown but suspected to be elevated
< 1 years	40 mmHg	60 mmHg
1 - 2 years	45 mmHg	65 mmHg
3 - 4 years	50 mmHg	70 mmHg
5 - 6 years	55 mmHg	75 mmHg
7 - 10 years	60 mmHg	80 mmHg
11 - 15 years	65 mmHg	85 mmHg
> 15 years	70 mmHg	90 mmHg

Reference - Traumatic Brain Injury Guideline, Birmingham Children's Hospital, 2014.

CONCLUSION

- No significant difference between maintenance versus restrictive fluid regimens for the outcome of death and acute severe neurological complications but favouring maintenance fluid therapy over restricted fluids for chronic severe neurological events in acute bacterial meningitis

- This study shows that CPP-targeted therapy, which relied on more frequent use of vasopressors and lesser use of osmotherapy and hyperventilation, was superior to ICP - targeted therapy for management of raised ICP in children with acute CNS infection


Thank you for
listening