Comparison of Equiosmolar doses of Mannitol 20% Versus Hypertonic Saline 3% infusion in the Reduction of intracranial pressure during Supratentorial brain tumor resection

Thesis protocol
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ABSTRACT

Supratentorial brain tumors compose a group of neoplasms that cause progressive increase in ICP.

One of the goals of neuroanesthesia is to control intra cranial pressure before opening the dura and provide optimal operating conditions by producing a slack brain that facilitate surgical dissection

The hyperosmolar solutions; mannitol and hypertonic saline (HS) have been used for treatment of elevated ICP. The effects of equiosmolar doses of mannitol 20% and HS 3% on ICP, hemodynamic profile (heart rate & MAP) and serum electrolyes (Na & K) are evaluated.

Because of its dynamic nature, ICP requires an invasive monitoring. In this study ICP is measured via an intraparenchymatous probe inserted at the ipsilateral side of the lesion during elective resection of supratentorial brain tumors.

HS 3% had shown to lower ICP slightly more effectively than mannitol 20% with no considerable systemic side effects

Key words: (Supratentorial brain tumors, Mannitol 20%, Hypertonicsaline 3%, ICP probe Codman MicroSensor)

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ADH	**:**	Anti Diuretic Hormone
BBB	**:**	Blood Brain Barrier.
CBF	**:**	Cerebral Blood Flow.
CBV	**:**	Cerebral Blood Volume
cGMP	**:**	cyclic guanosine monophosphate
CNS	**:**	central Nervous System
CVR	**:**	Cerebral Vuscular Resistance
CMR	**:**	Cerebral Metabolic Rate.
$CMRO_2$	**:**	Cerebral Metabolic Rate for Oxygen.
CO_2	**:**	Carbon dioxide
CPP	**:**	Cerebral Perfusion Pressure.
CSF	**:**	Cerebro Spinal Fluid.
CSW	**:**	Cerebral Salt Wasting
CT	**:**	Computed Tomography.
ECF	**:**	Extra Cellular Fluid.
EEG	**:**	Electroencephalogram
$ETCO_2$	**:**	End tidal carbon dioxide
HS 3%	**:**	Hypertonic Saline 3%
HTN	**:**	Hypertension
ICP	**:**	Intra Cranial Pressure
ICHTN	**:**	Intra Cranial Hypertension
ICU	**:**	Intensive Care Unit.
MAP	**:**	Mean arterial pressure.
MAC	**:**	Minimum Alveolar Concentration
mmHg	**:**	millimeter Mercury.

MRI	**:**	Magnetic resonance imaging
NaCl	**:**	Sodium
NO	**:**	Nitric oxide.
O_2	**:**	Oxygen
$PaCO_2$	**:**	Partial Pressure of carbon dioxide
PaO_2	**:**	Partial Pressure of oxygen
SIADH	**:**	Syndrome of Inappropriate ADH secretion
SPO_2	**:**	Oxygen saturation.
VIPergic	**:**	Vaso active intestinal peptide-ergic

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INTRODUCTION

Primary brain tumors compose a heterogeneous group of neoplasms that vary widely by site of origin, morphologic features, growth potential, extent of potential invasiveness and tendency for progression, and recurrence and treatment response.

The tentorium is a double fold of dura mater that forms a partition between the cerebral hemispheres and the brain stem and cerebellum. Surgery may be classified by anatomical location. The supratentorial approach is used to gain access to lesions of the frontal, parietal, temporal, and occipital lobes. The infratentorial approach is used to gain access to lesions of the brain stem or cerebellum.

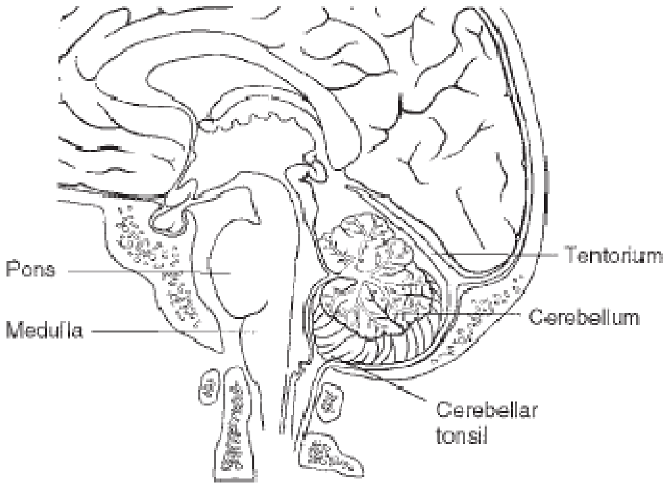

Figure (1) Reprinted with permission. Hickey, J. V. (2003). *The clinical practice of neurological and neurosurgical nursing* (p 322, 5thed.). Philadelphia: J.B. Lippincott.

Supratentorial tumors change hemodynamics predictably. Initially, when the lesion is small and slowly expanding volume-spatial compensation occurs by compression of the CSF compartment and nearby cerebral veins, which present with increase in ICP. As the lesion grows, compensatory mechanisms are exhausted and further increases in tumor mass cause progressively greater increase in ICP

The hyperosmolar solutions mannitol and hypertonic saline (HS) have both been used for treatment of elevated intracranial pressure. The hyperosmolarity of mannitol and HS, combined with the impermeability of the blood–brain barrier (BBB) to mannitol and sodium, provides favorable conditions to move water from the brain to the intravascular compartment. However, the differential effects of these agents on clinical conditions in patients undergoing neurosurgery have not been compared in a rigorous fashion.

Mannitol has been used extensively, and various clinical and experimental studies have demonstrated that single doses of mannitol at least transiently reduce increased ICP. Because of its osmotic effect, mannitol is assumed to decrease cerebral edema. Mannitol might improve cerebral perfusion by decreasing viscosity (by increasing the intravascular volume), and results in increased brain oxygenation and as a free-radical scavenger, it might act as a neuroprotectant; the long-term beneficial effects of mannitol are still controversial, (some of the common complications of mannitol therapy are fluid and electrolyte imbalances, cardiopulmonary edema, and rebound cerebral edema), furthermore, mannitol is not effective in some patients (i.e. ischemic, renal patients). Therefore, alternative therapies for increased ICP are warranted. [1, 2, 3]

Hypertonic saline solutions have been primarily used for "small volume resuscitation" (SVR) in patients with hemorrhagic shock. Compared with standard shock therapy, SVR produces a more rapid volume expansion; increases cardiac output, systemic blood pressure, and microvascular perfusion; and may improve survival. In particular, the subgroup of neurosurgical patients seems to have higher survival rates after SVR. Hypertonic saline reduces intracranial hypertension through a variety of mechanisms, including optimization of systemic and cerebral hemodynamics, reduction of cerebral edema, modulation of cerebral vasospasm, and alterations in cerebral immunology and neurochemistry. However, the single greatest advantage of hypertonic saline appears to be its ability to restore mean arterial pressure without increasing cerebral edema or intracranial pressure, hypertonic saline with or without dextrans/Haes-Steril® has been successfully used in a various reports and in clinical series of euvolemic head-trauma patients even after the failure of conventional therapy. [4, 5, 6]

Intracranial pressure (ICP) is derived from cerebral blood and cerebrospinal fluid (CSF) circulatory dynamics and can be affected in the course of many diseases of the central nervous system. ICP monitoring is useful, if not essential, in head injury, poor grade subarachnoid hemorrhage, stroke, intracerebral hematoma, meningitis, hydrocephalus, benign intracranial hypertension and brain tumors. [10] Monitoring of ICP requires an invasive transducer. Because of its dynamic nature, instant CSF pressure measurement using the height of a fluid column via lumbar puncture may be misleading.[7,8]

The aim of work

The purpose of this study is to prospectively evaluate the effects of equiosmolar doses of Mannitol 20% and Hypertonic Saline 3% on intracranial pressure, surgeon satisfaction, hemodynamic stability and the changes on serum electrolytes and osmolarity during elective craniotomy for supratentorial brain tumor resection.

In this study ICP is measured via an intra-parenchymatous ICP probe (Codman MicroSensor) inserted at the ipsilateral side of the lesion.

THE CEREBROSPINAL FLUID

The CSF is found in the ventricles of the brain and in the subarachinoid space around the brain and the spinal cord. It is a clear, colorless fluid. It possesses, in solution, inorganic salts similar to those in the blood plasma. The glucose content is about half that of blood, and there is only a trace of protein. Only a few cells are present, and these are lymphocytes. The normal lymphocyte count is 0 to 5 cells per cubic millimeter. The pressure of the CSF is kept constant, 60 to 150 mmH_2O (in adults). This pressure may be raised by straining, coughing, or compressing the internal jagular veins. The total volume of CSF in the subarachinoid space and within the ventricles is about 150 ml [9].

Appearance	Clear and colorless
Volume	150 ml
Rate of production	0.33 ml/min
Pressure	60-150 mmH_2O
Composition	
Protein	15-45 mg/100 ml
Glucose	50-85 mg/100 ml
Chloride	720-750 mg/100 ml
No. of cells	0-5 lymphocytes/cu mm

Table (1): Physical characteristics and composition of CSF [9].

<u>Production:</u> 80% of the CSF is produced by the choroids plexus of both lateral ventricles, 4th ventricle. The rest of intracranial production occurs in the interstitial space [10]. A small amount may be produced by the ependymal lining of the ventricles. In the spine, CSF is produced in the dura of the nerve root sleeves. [11]

<u>Production rate :</u> in the adult, CSF is produced at a rate of about 0.33 ml/min. in more relevant clinical terms 450ml/24hrs, which means that in an adult, CSF is turned over three times every day. The rate of production is independent of the ICP [11.]

Property	**Pediatrics**	**Adult**
Total volume (ml)	5	150
Formation rate	25 ml/day	0.33ml/min or 450ml/day
Pressure (mmH_2O)	9-12	7-15

Table (2): Normal CSF pressure, production, and volumes [11]

<u>Circulation:</u> the fluid passes from the lateral ventricles into the third ventricle through the intraventricular foramina of Monro. It then passes into the forth ventricle through the cerebral aqueduct. The circulation is aided by the cilia on the ependymal cells lining the ventricles.

From the forth ventricle, the fluid passes through the median aperture of Magende and the lateral foramina of Luchka and enters the subarachnoid space. It then moves through the basal cisterns and the tentorial notch to reach the inferior surface of the cerebrum. It then moves superiorly over the lateral aspect of each cerebral hemisphere. Some of the CSF moves inferiorly in the subarachnoid space around the spinal cord and cauda equina. [11]

<u>Absorption;</u> The main sites for the absorption of the CSF are the arachnoid villi that project into the dural venous sinuses grouping together to form the arachnoid granulations. Some of the CSF is absorbed directly into the veins in the subarachnoid space. The absorption of CSF into the venous sinuses occurs when the CSF pressure exceeds the venous pressure or the ICP must exceed 6.8 mmH_2O [12.]

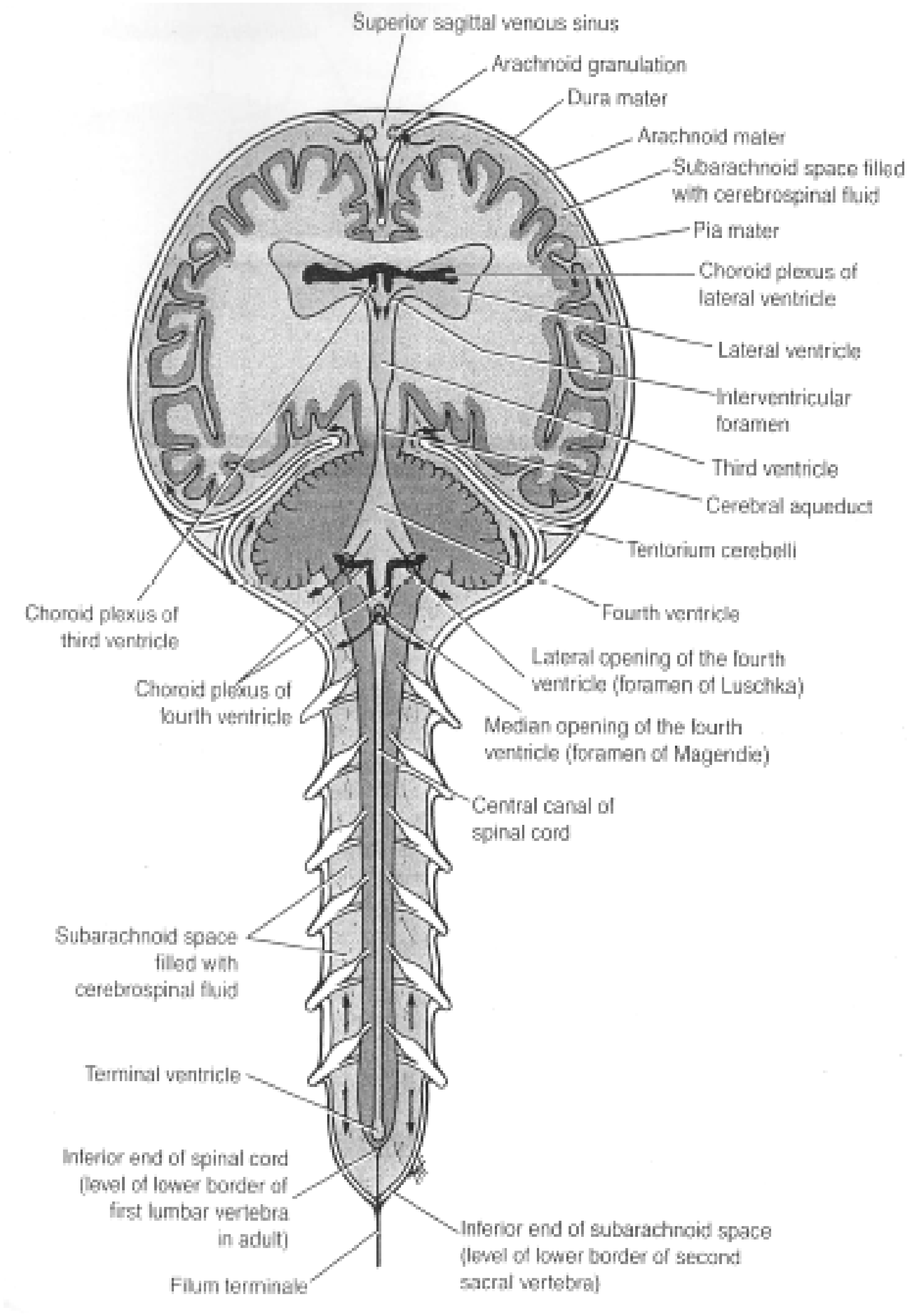

Figure (2): Origin and circulation of the CSF. [9]

Blood brain and blood CSF barriers

The central nervous system requires a very stable environment in order to function normally. This stability is provided by the existence of the so-called blood-brain and blood-CSF barrier. [9]

Blood brain barrier:

Examination of an electron micrograph of the CNS shows that the lumen of a blood capillary is separated from the extra cellular space around the neurons and the neuroglia by the following structures: (1) the endothelial cells in the wall of the capillary, (2) a continuous basement membrane surrounding the capillary outside the endothelial cells, and (3) the foot process of the astrocytes that adhere to the outer surface of the capillary wall. [13]

On the basis of this evidence, it is known that the tight junctions between the endothelial cells of the blood capillaries are responsible for the blood brain barrier. [13]

The blood brain barrier is absent in the following areas: choroid plexus, area postrema, hypophysis, tuber cinereum, pineal and preoptic recess. [13]

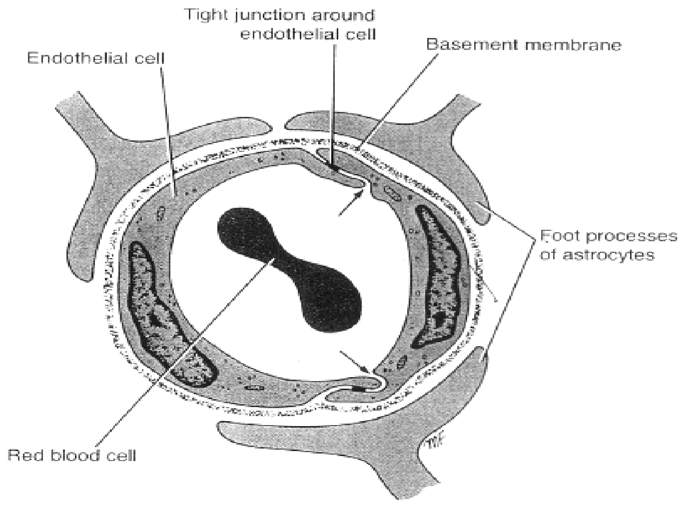

Figure (3): Structure of the blood brain barrier. [9]