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Comparison of cerebral relaxation using intraoperative 10% mannitol or 3% hypertonic saline

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Abstract

Objective of the study was to compare cerebral relaxation during the intraoperative administration of hypertonic saline or mannitol during an elective craniotomy. Our investigation included 58 adult patients, of both sexes, aged 44-49.5 years, classed I-II by the American society of anesthesiologists and scheduled for elective craniotomy under balanced general endotracheal anesthesia at King Hussein hospital, King Hussein medical city, Amman, Jordan, during the period Jan 2014-Mar 2015. Cerebral relaxation was assessed before the start of infusion, 15 and 60 minutes after the infusion of loads of 10% mannitol (250 ml)(group I, n=34) or 3% hypertonic saline (125 ml)(group II, n=24). Cerebral relaxation was scored at the opening of the Dura-mater, using a four-point scale: 1) Perfect relaxation, 2) Satisfactory relaxation, 3) Firm brain and 4) Swollen brain. The volume of intravenous fluids administered and diuresis were recorded. ANOVA and Students t tests were used to test intra- and intergroup statistical differences. A p value < 0.05 was considered statistically significant. There were no significant differences between the two groups regarding cerebral relaxation. The mannitol (10%) group had a significantly greater diuresis at both time intervals in comparison with hypertonic saline 3% group. Cerebral relaxation in the Mannitol group was scored I in 24 of 34 patients, while it was scored 1 in the hypertonic saline in 18 of 24 patients (p >0.05). Administration of hypertonic saline solution 3% or mannitol (10%) with equivalent loads was potent and safe in attaining cerebral relaxation during elective craniotomy under general balanced anesthesia.

Keywords: Cerebral relaxation; Craniotomy; hyperosmolar: Hypertonic saline, Mannitol.

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Introduction

Cerebral relaxation is crucial in during anesthetic technique for neurosurgery and inpatients with raised intracranial pressure. It is a neuroprotective procedure, decreasing surgical pressure, local hypoperfusion and cerebral ischemia. When the dura-mater is opened, the intracranial pressure becomes zero but a non-relaxed brain may decrease the quality of neurosurgery. Osmolality is the initial factor of water shifts via the intact blood-brain barrier. Increasing serum osmolality will dehydrate normal brain tissue, decreasing the cerebral volume and the intracranial pressure. Neurosurgical patients commonly have water and sodium imbalances due to cerebral salt wasting syndrome, inadequate antidiuretic hormone secretion and diabetes insipidus.

Hyperosmolar treatment at the before opening the dura-mater is used to induce cerebral relaxation in elective intracranial surgery. Mannitol is the conventional of hyperosmolar treatment during neurosurgery. It may be correlated with intense side effects such as intravascular volume depletion, rebound intracranial pressure increase and renal failure [1]. Although it has potential adverse effects, hypertonic saline solutions are an alternative treatment [2]. Hypertonic saline is as efficient as mannitol for managing raised intracranial pressure

[3]. Our study aims to compare cerebral relaxation during the intraoperative administration of hypertonic saline or mannitol through an elective craniotomy.

Methods

Our investigation included 58 adult patients, of both sexes, aged 44-49.5 years, classed I-II by the American society of anesthesiologists and scheduled for elective intracranial surgery under balanced general endotracheal anesthesia at King Hussein hospital, King Hussein medical city, Amman, Jordan, during the period Jan 2014-Mar 2015 after obtaining written informed consent from all patients and approval from the royal Jordanian medical military services ethical and research board review committee. Cerebral relaxation was assessed before the start of infusion, 15 and 60 minutes after the infusion of loads of 10% mannitol (250 ml) (group I, n=34) or 3% hypertonic saline (125 ml) (group II, n=24). Cerebral relaxation was scored at the opening of the duramater and after hyperosmolar therapy use, using a four-point scale according to the opinion of a senior neurosurgeon: 1) Perfect relaxation, 2) Satisfactory relaxation, 3) Firm brain and 4) Swollen brain. The volume of intravenous fluids administered and diuresis were recorded. Any patient with therapy using hyperosmotic solution during the preoperative 24 hours was ruled out from the study.

General anesthesia was induced using propofol 2 mg/kg, fentanyl 5 mcg/kg and atracurium 0.5mg/kg after which a suitable size of an endotracheal tube was inserted through which a mixture of oxygen (4L/min) and sevoflurane (2MAC) was delivered .Volume and rate were controlled to adjust end tidal CO2 at 35-40 mmHg. Normovolemia was maintained by the intravenous administration of 0.9% normal saline.

Hypertonic saline (3%) or mannitol (10%) was administered via a peripheral vein at a rate of 250 ml/h or 500 ml/h, respectively, for 30 minutes. The total volume of 125 ml of hypertonic saline (3%) has an osmolar load equal to 250 ml of mannitol (10%). Diuresis was assessed at the start of the hyperosmolar administration, and 15 and 60 minutes after its end along with the total intravenous fluid volume infused.

Statistics: ANOVA and Bonferroni tests were used to compare the intra group means, while the Student *t* test was used to compare intergroup means. A p value < 0.05 was considered ad significant.

Results

There were no significant differences between the two groups regarding the demographic data. The mannitol (10%) group had a significantly more diuresis at both time intervals (15 and 60 min) compared to hypertonic saline 3% group. There were no significant discrepancies between the two groups in terms of cerebral relaxation. Cerebral relaxation in the Mannitol group was scored I in 24 of 34 patients, and it was scored 1 in the hypertonic saline in 18 of 24 patients. P>0.05.The cerebral relaxation was adequate in both groups. The intravenous volume administered was not different significantly between both groups. The diuresis was different significantly between the groups.

Parameter	**Group I (n=34)**	**Group II (n=24)**
Age(yr) range	44-48	46.5-49.9
Sex(no) M F	 21 13	 16 8
ASA (no) I II	 15 19	 17 7
Hyperosmolar therapy	Mannitol 10% (250 ml)	Hypertonic saline 3% (125 ml)
Intraoperative intravenous fluid (normal saline 0.9%) volume adm. (ml) At 15 min. after adm. Between 15 and 60 min.after adm.	 503.8 1031	 499.1 1214

Table I: Characteristic data of study group patients.

Serum osmolality was 281.2 ± 2.04 mOsm/kg before hypertonic saline infusion, became 299.1 ± 2.1 mOsm/kg($p < 0.05$) at 15 min. interval and 301.2 ± 2.43 mOsm/kg ($p < 0.05$) at 60 min. interval after infusion of hypertonic saline. Serum osmolality had a mean rise of 17.9 ± 1.53 mOsm/kg and 20.0 ± 1.73 mOsm/kg at 15 and 60 minutes after infusion, respectively. Diuresis

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immediately before hypertonic saline administration and at 15 minutes after administration was 119.4 ± 24.83 ml, while the intraoperative intravenous volume administered (125 ml of HS + 0.9% saline) in the same period was 499.1 ± 102.7 ml. Between 15 and 60 minutes after the administration of hypertonic saline, the diuresis was 298.6 ± 79.01 ml, while the intravenous volume administered (0.9% saline) was 1214 ± 181.3 ml. Cerebral relaxation according to the four-point scale: 18 (75%) patients had a score of 1, while six patients (25%) received a score of 2.

Parameter	Interval	Group I	Group II
Serum osmolality (mean) mOsm/kg	Before administration	280.1	281.2
	At 15 min. interval after adm.	285.6	299.1
	At 60 min. interval after adm.	290.3	301.2
Diuresis (ml)	Before administration and at 15 min after adm.	325.3	119.4
	Between 15 and 60 min after adm.	573.4	298.6
Cerebral relaxation score			
1		24	18
2		10	6

Table II: Study results.

The mannitol (10%) group had a significantly more diuresis at 15 and 60 min. intervals than the hypertonic saline group. Diuresis immediately before the administration of mannitol (10%) until 15 minutes after administration was 325.3 ± 41.32 ml, and the intraoperative intravenous fluid administrated (250 ml of 10% mannitol + 0.9% saline) in the same period was 503.8 ± 0.32 ml. Between 15 and 60 minutes after administration of mannitol (10%), diuresis was 573.4 ± 102.1 ml, while the intravenous volume (0.9% saline) administered was 1031 ± 103 ml. The volume infused between 15 and 60 minutes after infusion of mannitol (10%) demonstrated a correlation with the volume of diuresis ($p < 0.05$). Cerebral relaxation according to the four-point scale: 24 (70.6%) patients had a score of 1 and 10 patients had (29.4%) a score of 2.

Discussion

Our investigation demonstrated that hyperosmolar solutions of hypertonic saline 3% or mannitol (10%) are efficient in attaining cerebral relaxation during elective intracranial surgery using general intravenous endotracheal anesthesia. Although there are significant differences in diuresis during the first hour after the administration of both types of hyperosmolar solutions.

Gemma et al. [4] found adequate cerebral relaxation in all patients when various osmolar loads with comparable volume of hypertonic saline (7.5%) or mannitol (20%) were administered. Rozet et al. [5] reported a comparable influence on cerebral relaxation when equiosmolar solutions of mannitol and hypertonic saline were administered. The principal mechanism of action of hyperosmolar solutions is the production of an osmolar gradient across the blood brain barrier, related to its impermeability to solutes (sodium and mannitol) [5], resulting in contraction of cerebral tissue and decreasing the intracranial pressure. The efficiency of hyperosmolar solutes depends on their reflection coefficient, which causes the relative impermeability of blood brain barrier to the solute. The reflection coefficient of the membrane for sodium is 1 and the reflection coefficient for mannitol is 0.9 [6]**.** In the periphery, the intracellular and not interstitial, fluid represents the most of fluid moved after hypertonic saline administration. In cerebral capillaries, the endothelial membrane is impermeable to sodium, and water movements across blood brain barrier is governed by the total osmotic gradient produced by both large molecules and small ions [7], while fluid mobilization after the hypertonic saline administration is from intracellular and interstitial spaces to intravascular space. When serum osmolality increases the osmotic gradient drags water out of brain tissue. Serum osmolality was always under the safe threshold determined (320 $mOsm.kg^{-1}$) during the use of hypertonic saline by the Brain Trauma Foundation. Small differences (< 5%) in osmolality with hypertonic saline may change cerebral water content and ICP [8].

Using 7.2% NaCl/HES 200/0.5 (1.4 ml/kg) in the management of intracranial hypertension, there was an increase in serum osmolality from 284 (272-300 mOsm/kg) to 300 (284-319 mOsm/kg), corresponding to decreases in intracranial pressure from 22 (19-31) to 15 (8-18) mmHg, and increases in cerebral perfusion pressure from 60 mmHg to 72 mmHg in neurosurgical patients [9]. Hypertonic saline concentrations more than 10% may open tight junctions in blood brain barrier. The influence of hypertonic saline only is short-acting. Generating an osmolar gradient across blood brain barrier, the decrease in CSF production, enhancement in blood rheology and anti-inflammatory characteristics of hypertonic saline and mannitol play a role in brain therapy [5,10]. In elective neurosurgeries, blood brain barrier is intact in main part of the brain. The administration of a number of solutions composed of 7.2% to 7.5% NaCl with dextran or 6% to 10% HES was associated with a low potential for complications [11].The main important problem in the therapy with hypertonic saline is the development of neurological complications related to osmotic demyelination syndrome or central pontine myelinolysis. Hypertonic saline use did not increases serum sodium [10]. Patients have tolerated an acute increase in serum sodium levels up to 155-160 mEq/l [4, 7]. Acute brain dehydration may result in mechanical stretching of ligating blood vessels with the resultant of subarachnoid hemorrhage.

The diuretic action of mannitol can normalize sodium serum levels, primarily decreased, which is shown by a positive correlation ($P < 0.05$) between serum sodium levels 15 minutes after mannitol administration and diuresis. Rozet et al. [5] demonstrated lower sodium serum levels 15 and 30 minutes after mannitol administration. Hypertonic saline and mannitol have comparable neurological actions. Hypertonic saline does not induce an immediate diuretic action [7], although for others, hypertonic saline is a diuretic.

Conclusion

Hypertonic saline (3%) or mannitol (10%) administration with equivalent osmolar loads are considered effective and safe in attaining cerebral relaxation during elective intracranial surgery under general anesthesia, but with intraoperative diuresis more after mannitol than hypertonic saline.

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