# Is the Use of Hypertonic Saline Effective in Reducing Intracranial Pressure After Traumatic Brain Injury in Dogs?

A Knowledge Summary by

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## KNOWLEDGE SUMMARY

**Clinical bottom line**

Hypertonic saline appears to be effective in reducing intracranial pressure after traumatic brain injury in dogs in experimental studies.

### Question

In dogs with traumatic brain injury, does hypertonic saline, compared to lactated Ringer's solution, reduce intracranial pressure?

### Clinical Scenario

A three year old 15kg male entire Terrier cross is brought in after running into the road and colliding with a car. It is in hypovolaemic shock and after fluid resuscitation (25ml/kg LRS in 15 minutes) the only visible injuries found are epistaxis and a fractured jaw. However, the dog is stuporous and consciousness does not seem to improve with stabilising cardiovascular parameters.

Would treatment with hypertonic saline be beneficial for this dog?

### The Evidence

Nearly all available evidence for this PICO question comes from experimental studies. How much experimental and clinical traumatic brain injury differ is unclear.

### Summary of the evidence

Abbreviations Used

| | |
|---|---|
| CPP | cerebral perfusion pressure |
| CVP | central venous pressure |
| ICP | intracranial pressure |
| LRS | lactated Ringer's solution |
| MAP | mean arterial pressure |

| **Prough (1986)** | |
|---|---|
| **Population:** | Dogs |
| **Sample size:** | 17 |
| **Intervention details:** | After 30 minutes of experimentally induced haemorrhagic shock (MAP <50mmHg) dogs were resuscitated with hypertonic saline solution or LRS. |

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| **Study design:** | Randomised, experimental study. |
| **Outcome studied:** | Systolic and diastolic blood pressure, cardiac output, MAP and ICP. |
| **Main findings: (relevant to PICO question):** | ICP after resuscitation with hypertonic saline was lower than after LRS while restoring systolic blood pressure and cardiac output to the same level. |
| **Limitations:** | • experimental study<br>• no brain injury or increased ICP to begin with<br>• small number of cases |

| **Gunnar (1988)** | |
|---|---|
| **Population:** | Laboratory Beagles |
| **Sample size:** | 22 |
| **Intervention details:** | Hypovolaemic shock and closed head injury were simulated via bleeding of 40% of blood volume and epidurally inflated balloon in 17 dogs. This was maintained for 1h, after that resuscitation with the shed blood and either 3% hypertonic saline (6 dogs), 0.9% saline (5 dogs) or dextran-40 (6 dogs) was attempted. A solution of Evans Blue was also injected. After 2h of resuscitation the dogs were euthanised and their brains weighed and checked for Evans Blue staining under microscope. A control group of five dogs wasn't bled or ballooned but normal saline and Evans Blue solution only. |
| **Study design:** | Experimental controlled study. |
| **Outcome studied:** | Continuous ICP monitoring, blood brain barrier function assessed by degree of Evans Blue staining and cerebral oedema formation assessed by wet brain weights. |
| **Main findings: (relevant to PICO question):** | 3% hypertonic saline caused lower intracranial pressure and less cerebral oedema than either 0.9% saline or dextran-40, but blood brain barrier integrity is not restored. |
| **Limitations:** | • experimental study<br>• no survivors to assess clinical outcome<br>• short term study of only 3h duration<br>• small number of cases |

| **Gunnar (1989)** | |
|---|---|
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| **Intervention details:** | Hypovolaemic shock and closed head injury were simulated via bleeding of 40% of blood volume and epidurally inflated balloon. This was maintained for 1h, after that resuscitation with the shed blood and either 3% hypertonic saline, 0.9% saline or dextran-40 |

| | |
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| | was attempted, after this, normal saline was given at a rate to maintain CVP at 10mmHg. |
| **Study design:** | Experimental uncontrolled study. |
| **Outcome studied:** | Cerebral blood flow and ICP were measured at baseline, at the end of the shock period, during resuscitation and after resuscitation. |
| **Main findings: (relevant to PICO question):** | Though the intracranial pressure was lower in the hypertonic saline group, cerebral blood flow did not vary. |
| **Limitations:** | • experimental study<br>• no assessment of clinical outcome<br>• short term study of only 3h duration<br>• small number of cases |

| **Pinto (2006)** | |
|---|---|
| **Population:** | Crossbreed dogs |
| **Sample size:** | 15 |
| **Intervention details:** | 20 minutes after experimentally induced haemorrhagic shock via bleeding to MAP of 40mmHg and simulated traumatic brain injury via fluid percussion and epidural balloon, volume was replaced with 3% hypertonic saline (8ml/kg over 10 min) or LRS (16ml/kg over 10 ml) in five dogs each. 20 minutes later shed blood and more of the previous fluids were given to a haematocrit of 30% and a MAP of >70mm Hg. A control group of five received no fluids at either point. After 60 minutes the epidural balloon was deflated in the treatment groups. |
| **Study design:** | Experimental, randomised, controlled study. |
| **Outcome studied:** | MAP, cardiac index, ICP, CPP, biochemistry and blood gases. |
| **Main findings: (relevant to PICO question):** | 3% hypertonic saline results in lower ICP than LRS even though CPP remains similar. Hypertonic saline also causes higher serum sodium concentration and osmolarity than LRS. |
| **Limitations:** | • experimental study<br>• no clinical outcome described<br>• small number of cases |

| **Sharma (2015)** | |
|---|---|
| **Population:** | Client-owned dogs with head trauma <5 days before hospital admission. |
| **Sample size:** | 72 |
| **Intervention details:** | No specific interventions, clinical records were analysed. |
| **Study design:** | Retrospective descriptive study, based on medical records. |

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| **Outcome studied:** | The prognostic value of clinical and laboratory variables, scoring systems and treatments (such as hypertonic saline) in dogs with head trauma was calculated. |
| **Main findings: (relevant to PICO question):** | Hypertonic saline administration was associated with lower likelihood of survival to discharge (8 survivors, 4 nonsurvivors). |
| **Limitations:** | • retrospective case study<br>• no control group<br>• multiple parameters observed, prognostic value of individual variables on their own hard to quantify<br>• small number of cases |

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| **Study design:** | Experimental controlled study. |
| **Outcome studied:** | MAP and ICP were measured, changes in pupil state were assessed every 10 minutes, macroscopic and microscopic brain pathology and prostaglandoid production were assessed. |
| **Main findings: (relevant to PICO question):** | ICP was the lowest in the hypertonic saline cases during the initial 60 minutes. In brains that had received hypertonic saline, no cerebral oedema was identified macroscopically and ischaemic lesions were less evident. In cases with pupil changes, the pupils reversed to normal sooner in the hypertonic saline group. |
| **Limitations:** | • experimental study<br>• no survivors to assess clinical outcome<br>• short term study of only 3h duration<br>• macroscopic assessment for cerebral oedema only<br>• small number of cases |

## Appraisal, application and reflection

The purpose of this Knowledge Summary was to look at the evidence for the use of hypertonic saline in

reducing intracranial pressure in head trauma patients.

The experimental studies available in dogs seem to indicate that hypertonic saline might have a good effect on increased intracranial pressure after traumatic brain injury while achieving desirable haemodynamic parameters.

There are no controlled clinical studies that evaluate the use of hypertonic saline as an independent variable. In the descriptive study from Sharma & Holowaychuck (2015) the decision to use hypertonic saline was the clinician's, and sometimes made after other treatment options had been unsuccessful. The choice to use hypertonic saline appears mostly to have been made in very severe cases, which may explain the negative predictive value of hypertonic saline use on survival until discharge.

In conclusion, hypertonic saline appears to be effective in reducing intracranial pressure after traumatic brain injury in experimental studies. How effective its use might be in clinical settings cannot be answered.

## Methodology Section

| **Search Strategy** | |
|---|---|
| Databases searched and dates covered: | PubMed database, accessed via the NCBI website (1910-2015) and the CAB abstracts database (1973-2015) |
| Search terms: | (dog OR dogs OR canine OR puppy OR puppies OR canis) AND (((brain AND (trauma OR injur*)) OR (head AND (trauma OR injur*))) AND (hypertonic AND (saline OR sodium)) |
| Dates searches performed: | 18th July 2016 |

| **Exclusion / Inclusion Criteria** | |
|---|---|
| Exclusion: | Articles not available in English or German, single case reports, book chapters and conference proceedings, articles which were not relevant to the question. |
| Inclusion: | Articles available in English or German, which were relevant to the question. |

**Search Outcome**

| Database | Number of results | Excluded – language | Excluded – not relevant to question | Total relevant papers |
|---|---|---|---|---|
| CAB Abstracts | 2 | 0 | 1 | 1 |
| PubMed | 15 | 0 | 9 | 6 |
| Total relevant papers when duplicates removed | | | | **6** |

## CONFLICT OF INTEREST

The author declares no conflict of interest.

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