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TRAUMATIC PNEUMOCEPHALUS : AIR REPLACEMENT PROCEDURE VS CONTROLLED DECOMPRESSION WITH EXTERNAL DRAINAGE

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ABSTRACT **Introduction:** Air within cranium may be classified according to the site of occurrence. The pathophysiology of the same is varied and the effects are manifold. **Methods:** Patients with tension pneumocephalus are taken up for surgery.**Results:** In controlled decompression group, the pain requirement and duration of hospital stay was more. The air replacement procedure group had more recollection and one patient required a second procedure.**Conclusion:** Most of the cases subside with normobaric 100% oxygen therapy. In patients with persistent pneumocephalus for more than two weeks, more definitive procedures for sealing of the dural rent may be required.

KEYWORDS : pneumocephalus, controlled decompression, air replacement procedure, pneumocerebri, normobaric oxygen therapy

Introduction:

Air within cranial cavity may be

1. Pneumocephalus, also known as intracranial aerocele/ pneumatocele (air in extra dural, subdural, sub arachnoid spaces) was first described by Wolff in 1914[10],
2. pneumo cerebri or intra parenchymal pneumocephalus
3. pneumo ventricle

Air enters cranial cavity via[9]

1. dural tear – idiopathic, neoplastic erosion or trauma
2. infection by gas producing organism

The pneumocephalus may be common after trauma (any cranial fracture, sinus fractures,mastoid air cells breech, spinal cord dural tear at any level) , cranial surgeries, otolaryngologic sinus surgery, neoplasm eroding dura, barotrauma following scuba diving, nitrous oxide anaesthesia in non intracranial procedures, patients travelling to high altitude within a week of cranial procedures.

Dandy was of the idea that air is an irritant to brain and causes oedema and thereby seizures. The term "tension pneumocephalus", coined by Ectors in 1962. It is used when there was neurological deterioration caused by pneumocephalus(e.g., focal neurological defecit, deteriorating GCS of patient or seizures, pupillary abnormality). The volume of air in comparison to the volume of the cranial vault and brain parenchyma of patient should be considered to state a patient has tension pneumocephalus.

There are two postulated mechanisms[1] by which pneumocephalus occurs is

1. ball valve mechanism, proposed by Dandy, in which an osteo meningeal fistula (e.g. A skull base fracture through the posterior wall of frontal sinus) is tamponaded by dural flap and brain parenchyma as a ball valve.
2. Inverted soda bottle effect postulated by Horowitz[5]. Subarchnoid pneumocephalus due to violation of posterior ethmoidal and sphenoid sinus can be successfully explained by this model. Continuous CSF leak from an enclosed space creates a void space and relative negative pressure, allowing air to bubble in and fill the void.

The investigation of choice is CT as it can detect as low as 0.5cc of air as compared to a skull radiograph which requires 2cc of air to be detected. The various signs described are,

1. air bubble sign - small air pockets in cisterns and the arachnoid space
2. peaking sign[8] - bilateral compression but no separation of the frontal lobes
3. Mount Fuji sign[6] described by Ishiwata et al in 1988

The medical management consists of flat head end, avoiding valsalva maneuver of any form(coughing, nose blowing, straining at stools), breathing 100% normobaric oxygen through a non rebreather mask.

Surgical management is considered when medical management fails or patient develops neurological deficit or deterioration of GCS. Surgery can be air replacement procedure or controlled decompression with external drinage.

We here discuss a case series of 8 cases of pneumocephalus with mount Fuji sign, that has been managed surgically with either air replacement procedure or controlled decompression with external drinage and compare pain medication requirement, duration of hospital stay, resolution rate of pneumocephalus and requirement for a second procedure.

Materials and methods :

The patients with head trauma with CT brain with bone window showing mount Fuji sign of pneumocephalus from age group of 18 years to 80 years in Madurai medical college were included in the study. The study period was from September 2019 to July 2021. Patients who were with altered sensorium, or focal neurologic deficit or seizures on presentation were included in the study. Patients were divided into two groups as, one group who were treated with air replacement procedure and another group treated with controlled decompression with external drinage.

Results:

Among the 8 patients, 4 underwent air replacement procedure and other 4 underwent controlled decompression with external drinage.

1. Pain medication requirement was higher in controlled decompression group (average of 3 days in the air replacement group and 6 days in the controlled decompression group)
2. Resolution in post op 6 hour CT scan was satsifactory in both groups, but there was recollection in 24 hour CT scan in air replacement group in 2 patients
3. Duration of hospital stay was shorter in the air replacement group - 3 discharged on post op day 5, one at post op day 11, in controlled decompression group, patients were discharged at post op day 11 or 12.
4. One patient in air replacement group required a second procedure.

Discussion:

Dexter and Reasoner[2] in 1996, developed a theoritical model to explain the absorption rate accelerated by 100% oxygen in patients who have not undergone surgery for tension pneumocephalus. At

fraction of inspired air of 0.4 or 1.0, a total of 30% and 72% of intra cranial air would be absorbed within 2 days as predicted by the model.

The various surgical procedures performed for a tension pneumocephalus include,

1. air replacement procedure (twist drill evacuation)[7] – a 5mm drill through a stab incision near frontal hairline is made and two cannulas are inserted and air is replaced with Ringer's solution.
2. Controlled decompression with external drinage [3]– a no.18 intravenous cannula is inserted through a burr hole and is connected to a closed water seal drinage at a draining pressure of 2cm H2O by a extension tube. The first vial traps fluid and second vial sets the pressure for drinage. The depth of insertion determines the system opening pressure.

The 100% oxygen supplementation is continued after surgery(that helps to replace the 80% nitrogen content of atmospheric air trapped intra cranially with oxygen which can diffuse better than nitrogen – gases diffuse into blood following Fick's law and Graham's law). The use of 100% oxygen is limited to 48 hours for fear of pulmonary toxicity.

In cases of pneumocephalus persisting after two weeks without any symptoms, exploration and proper sealing of the dural rent is considered after identifying it with dye or radionuclide tests.

To prevent pneumocephalus, in elective surgeries, avoiding sitting position, re expansion of the brain at the end of the surgery, reduction of hyperventilation and reinjection of let out CSF at the beginning of the procedure, avoiding use of nitrous oxide for anaesthesia, avoiding dehydrating agents(mannitol, furosemide) during surgery, water tight closure of dura, autologus fat graft, fibrin glue, avoid air travel for 7 days after brain or spine surgery as gas expands at high altitude[4].

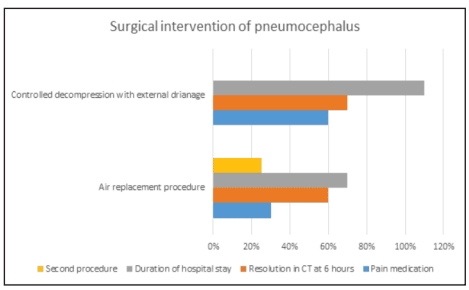
Compliance with Ethical standards:

Funding : No funding was received for this research

Conflict of interest : Dr. Sivakumar Krishnasamy declares that he has no conflict of interest, Dr. Balasubramanian Hitler declares that he has no conflict of interest, Dr. Srisaravanan Jeevarajan declares that he has no conflict of interest, Dr. Geo Jerosh J.R. declares that he has no conflict of interest.

Ethical approval: Approval was obtained form the ethics committee of Madurai medical college. The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Informed consent: Informed consent was obtained from all individual participants included in the study.



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