Pneumocephalus

Definition
Pneumocephalus is the presence of air in the intracranial cavity. Other terminologies used to describe air in the cranium include intracranial aerocele and pneumatocele capitis (Brousseau, Zeitouni, Zakhary, & Leblanc, 2004).

Epidemiology
More than 70% of pneumocephalus is related to trauma. It is commonly resulted from skull base or paranasal sinus fracture. Other causes include tumors, infection, surgery, spinal or epidural anesthesia and positive pressure ventilation (Lin, Cheah, Ng, & Yeo, 2000).

Pathophysiology
Pneumocephalus is resulted from atmospheric air entering into the intracranial cavity (Aferzon, Aferzon, & Spektor, 2001; Brousseau, Zeitouni, Zakhary, & Leblanc, 2004). Air may enter into the cranium directly from atmosphere or from defeated structures in the skull such as paransal sinuses, middle ear, or mastoid (Freess, & Suzozi, 2009). Pnemocephalus can be resulted from trauma, infection, surgery, barotraumas, tumor erosion, gas forming organism, spinal anesthesia, or spontaneous (Mateo, López-Alarcón, Moliner, Calabuig, Vivó, De Andrés, & Grau, 1999; Schrijver, & Berendse, 2003).

Several models have been used to explain the formation of pneumocephalus. The inverted pop bottle model indicated that once air entered into the intracranial cavity, it will rise to the top of the cranium as air entered an inverted pop bottle. Example: air entered into the spinal subarachnoid space during introduction of epidural anesthesia raise to the intracranial cavity when patient sit up. The ball-valve model suggested that air entered the intracranial cavity was trapped because the brain tissue acted as the ball valve and block the exit of the air. Example: during positive pressure ventilation, air was “push” into the cranium through a fracture or defective structure during inspiration. During expiration, air was trapped inside the cranium because the brain tissue blocked the air passage. The negative pressure model described that cerebrospinal fluid was forced out from the cranium when intracranial pressure (ICP) increases. After the intracranial pressure decreases, air was “sucked” into the cranium to equalize the ICP. Example: during Valsalva maneuver, coughing, or sneezing, the transient increased ICP pushes CSF out from the cranium through a fracture or defective structure. After coughing, ICP drops below the normal level due to lost of CSF during coughing, air is “sucked” into the cranium (Walker, & Vern, 1986).

Manifestation
Depending on the amount and location of intracranial air, patients with pneumocephalus may be asymptomatic or presented with generalized or local neurological signs such as headache, seizure, weakness, visual field defects, behavioral changes, CSF rhinorrhea, and changes in level of consciousness (Bernstein, Cassidy, Duchynski, & Eisenberg, 2005; Gautschi, & Zellweger, 2006). A characteristic presentation of pneumocephalus is bruit hydro-aerique. It is the splashing sound heard when patient moves his/her head (Brown III, & Symbas, 1995).

Air trapped in the cranium may cause increased intracranial pressure, patient may presented with vomiting, nausea, and deteriorate in level of consciousness (LOC) (Gautschi, & Zellweger, 2006).

Diagnostic Tests
Different radiodiagnostic techniques have been used to diagnose pneumocephalus. Skull X-ray is able to identify pneumocephalus as small as 2mL, however, CT scan is the gold standard for diagnosis of pneumocephalus. It is more sensitive and is able to detect air as small as 0.5mL (Goldman, 1986; Webber-Jones, 2005). MRI has also been used to detect the site of cerebrospinal fluid leak (Chan, Yau, Lweis, & Kinirons, 2000).

Air (black area)

CT scan shows the pneumocephalus

Tension pneumocephalus
Tension Pneumocephalus is a rare but severe form of pneumocephalus (Kuo, Lien, Wang, & Chen,
2005). The communication between the cranium and atmosphere has a ball valve effect. Air continuously entering and trapped inside the cranium through the cranial atmosphere communication. Increased volume of trapped air in the cranium creates the mass effect and results in increased ICP. Severe tension pneumocephalus may lead to cognitive impairment, cerebral ischemia, brain herniation, coma, and death (Aferzon, Aferzon, & Spektor, 2001; Freess, & Suozzi, 2009). A characteristic image of tension pneumocephalus can be seen on CT scan called Mount Fuji sign (Freess, & Suozzi, 2009).

Presentations of tension pneumocephalus include deteriorate in LOC, severe restlessness, generalized seizure, and focal neurological signs (Prabhakar, & Sharma, 2006; Satapathy, & Dash, 2000).

CT scan shows a tension pneumocephalus with the Mt Fuji sign (white arrow)

Air (black area)

Treatment options
Pneumocephalus is usually benign. Small pneumocephalus usually resolves spontaneously. Patients usually have complete reabsorption in the first week, but some may take up to 3 weeks (Randall, & Hall, 1993; Webber-Jones, 2005). Asymptomatic patients are managed conservatively. Administer 100% oxygen is able to wash out nitrogen and decrease intracranial gas (Gautschi, & Zellweger, 2006).

If patient presented with signs and symptoms of increased intracranial pressure, surgical interventions such as burr hole, needle aspiration, and endoscopic repair can release the trapped air and decrease ICP (Aferzon, Aferzon, & Spektor, 2001; Freess, & Suozzi, 2009).

Strategies such as minimizing CSF loss, maintain hydration for proper cerebral perfusion, and maintaining end-tidal CO₂ at normal level may bring the brain regain its normal contour and prevent accumulation of air in the cranium (Prabhakar, Bithal, & Garg, 2003).

Nursing implications
If patient develops pneumocephalus, place patient in supine position. Administer 100% oxygen. Avoid coughing, sneezing, or straining to prevent negative pressure effect.

The patient neurological status usually improves after air in the cranium is removed. However, re-accumulation of air can occur within 10 minutes. Monitor patient’s neurological sign closely post procedure.

Reference

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