Case Report

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Tension pneumocephalus as a complication of intracranial pressure monitoring: A case report

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Abstract: Intracranial pressure monitoring has become routine in the management of severe head injuries. We describe an unusual complication secondary to intracranial pressure monitoring with subdural cup catheter. A 35 year-old man was admitted to the Neurosurgery Department following blunt head trauma. He underwent insertion of subdural cup catheter for monitoring of intracranial pressure. A progress computed tomography scan of the brain revealed tension pneumocephalus. As far as the authors are aware, this is the first reported case of tension pneumocephalus resulting from insertion of a subdural intracranial pressure monitor.

Keywords: intracranial pressure monitoring, complications, tension pneumocephalus, cup catheter, head trauma

INTRODUCTION

Pneumocephalus, the presence of air within the cranial cavity, is most commonly caused by trauma, tumor, infection and fistulation into the intracranial cavity [1]. The occurrence of fistulas has been reported as secondary to many congenital, acquired and iatrogenic causes[1-21]. We present a case of tension pneumocephalus as a complication secondary to insertion of an intracranial pressure (ICP) monitor. To our knowledge this is the first report of such a complication.

Case report

A 35-year-old male was found lying at the roadside with features of a head injury. He was taken to an Emergency Department where he was found to have facial swelling and scalp lacerations in keeping with a blunt head injury. He opened his eyes to pain, localized pain and vocalized. There were no clinical signs of skull fracture, and no other systemic injuries. No other history was available. Computed tomography (CT) scan of his brain revealed diffuse traumatic subarachnoid hemorrhage with a sliver subdural hematoma covering most of the right hemispheric convexity and extending into the inter-hemispheric space. There was an overall impression of raised intracranial pressure with the midline remaining central. No skull fractures, including skull base, were seen. In view of the CT scan findings and the fact that the patient had deteriorated his level of consciousness further, it was decided to insert an intracranial pressure monitor. An Integra NeuroSciences “cup catheter” ICP monitor was inserted, via a right frontal craniectomy. Intra-operatively, a small amount of liquid subdural blood was evacuated. Following surgery the patient was transferred to the Neurosurgical Intensive Care Unit where his Glasgow Coma Score (GCS) was found to be 7/15 (localizing pain bilaterally). His intracranial pressure trends remained within normal limits.

On day one following surgery the patient’s motor response deteriorated and an urgent CT scan brain was obtained (with the ICP remaining within normal limits). The CT scan revealed the ICP monitor to be in the right frontal subdural space. An extensive bilateral frontal pneumocephalus with mass effect on the frontal lobes and anterior ventricular spaces was evident (Fig.1a and b). There was a small amount of residual subdural and interhemispheric blood, but there were no signs of raised ICP. At this stage it was decided to remove the ICP monitor and relieve the pneumocephalus.

Over the next few days, the patient’s condition did not change. Follow-up CT scan of the brain revealed

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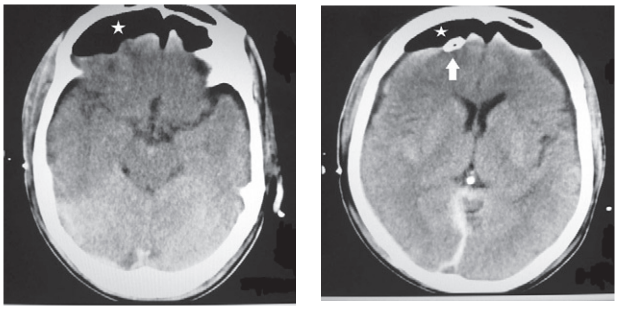

Fig 1: CT images showing the presence of bilateral frontal air collections (stars) displacing and compressing frontal lobes (Fig 1a, and 1b), and the presence of ICP monitor over right frontal lobe (arrow, Fig 1b). Note bilateral subdural collections and the interhemispheric blood.

complete resolution of the pneumocephalus and no new lesions.

The patient developed a lower respiratory tract infection, which proved fatal about one week after initial injury.

A medico-legal autopsy was carried out. The relevant findings included healing abrasions and lacerations to face, deep scalp bruising in the frontal, right parietal and occipital areas, cerebral cortical contusions of anterior poles of right frontal and temporal lobes. There were no fractures of the anterior or middle cranial fossae. A small linear right occipital fracture was seen, but this did not extend into the mastoid air cells, and the dura overlying the fracture was intact. There were extensive broncho-pneumonic consolidations involving both lungs. The cause of death was concluded as pneumonia following blunt head trauma.

DISCUSSION

The subdural cup catheter evolved from the Richmond screw principle[22]. The ICP is being transmitted from the subdural space to an external transducer via a column of fluid. The device is tape-shaped (3 mm thick, 8 mm wide) with a central lumen and a distal cup on the surface that faces the brain. The catheter is made from barium impregnated silicone and is manufactured by Integra NeuroSciences (Integra NeuroSciences, Plainsboro, NJ). The monitor can be used following craniotomy, but alternatively, may be inserted through a burr hole. The subcutaneous tunneling provides a relative barrier to the infection and possible CSF leak. The device can be withdrawn by gentle traction, similarly to an EVD. While in use, a small amount (0.25 ml) of sterile Ringer's lactate solution is injected every two hours to replace any fluid leakage from the distal cup[22, 23]. The reported complications with use of subdural cup catheters include malpositioning and infection[24, 25]. The subdural cup catheter is an inexpensive, easy to use, and reliable ICP monitor which has been used in our unit for over 20 years.

Pneumocephalus is the presence of air within the cranial cavity. Free intracranial air implies communication with the atmosphere or paranasal sinuses, although pneumocephalus can be secondary to infection from gas forming organisms[26]. Tension pneumocephalus occurs when air enters the extradural or intradural spaces in sufficient volume to exert a mass or pressure effect on the brain, leading to brain herniation [27].

Pneumocephalus is most commonly caused by trauma (75%), tumor, infection, and fistulas between intracranial cavity and external air spaces[1]. The occurrence of fistulas has been attributed to congenital cranial bony defects, tumors, hydrocephalus, encephalocoele, open myelomeningocoele, cranial hyperpneumatization, chronic otitis media[1-3,7,9,15,16], and iatrogenic causes. Iatrogenic pneumocephalus have been reported, following intracranial or sinus surgery, thoracic surgery, ventriculo-pleural and ventriculo-peritoneal shunting, anaesthesia with nitrous oxide, epidural anesthesia, insertion of lumbar drain, lumbar puncture, intravenous catheterization, nasotracheal intubation, nasogastric tube insertion, insufflation of the middle ear, continuous positive airway pressure after trauma, bag-mask ventilation, skull base radiation, hydrogen peroxide irrigation, halo vest application, and even frequent Valsalva manoeuvre[2,4-6,10-14,17-21]. There are previous reports of pneumocephalus resulting from barotraumas in a pilot and scuba divers[28-30], and in an airline passenger[31]. One study documented that intracranial air is present in all cases following supratentorial craniotomy[18].

In our patient, there are several possible mechanisms for pneumocephalus occurrence. Firstly, air might have been introduced during time of insertion of the ICP monitor. Against this scenario is the fact that the initial ICP remained within normal limits, and the patient's condition deteriorated some time after the operation. Another possibility is that of accidental introduction of air during ICP monitor flushing. However, the ICP trace and wave forms were present throughout the monitoring period. The suction of air via a base of skull fracture was excluded during negative autopsy findings.

The only fracture found was in the right occipital area, which did not extend into the mastoid air cells, and the overlying dura was intact. This leaves the most likely scenario of air entry at the ICP monitor insertion site, which might behave like "ball valve". The wound area would act as a one-way valve where air could enter but be unable to exit the intracranial cavity. The air could be forced into the intracranial cavity during changes of intracranial pressure during patient's coughing or straining. The other possibility is that the CSF leakage created low intracranial pressure which permitted the air ingress.

Headache and altered level of consciousness are the most frequent symptoms of pneumocephalus[32]. It has been postulated that a characteristic symptom of pneumocephalus is the patient complaining of a splashing sound inside his head, referred to as a "succussion splash"[5,33], reportedly present in only 7% of patients[1].

Tension pneumocephalus is diagnosed on CT scan where bilateral subdural hypodense collections of air cause compression and separation of the frontal lobes. The collapsed brain and widened interhemispheric space between the tips of the frontal lobes have the appearance of the tip of a volcano. This radiological finding has been termed the "Mount Fuji" sign[34]. The treatment for tension pneumocephalus includes urgent decompression via burr hole or needle aspiration, repair of the skull defect and closure of the dural fistula[27]. Bed rest in an upright position, avoidance of the Valsalva manoeuvre, analgesia and high concentration oxygen are used for the less urgent cases[4,6,31,34]. However, meticulous watertight dural and skin closure can prevent this complication in most cases.

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