The Journal of Laryngology and Otology
May 1999, Vol. **113**, pp. 480–482

Radiology in Focus

Extensive and symptomatic cranial pneumatization: caused by frequent performance of Valsalva's manoeuvre?

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Abstract
Pneumocranium and spontaneous pneumocephalus are very rare disorders. We report a case in which the patient had suffered for some time from neck pain and neurological symptoms which originated from an extensively pneumatized cranium. The symptoms and the abnormal bone pneumatization disappeared after normalization of a high middle-ear pressure. The history and the findings suggest that the pathological pneumatization was caused by the patient's habit of frequently performing Valsalva's manoeuvre, in combination with the Eustachian tube functioning as a valve.

Key words: Pneumocephalus; Ear, middle; Eustachian tube; Valsalva's manoeuvre

Introduction

Extensive pneumatization of the cranium and spontaneous pneumocephalus are rare conditions, with only a very few cases being reported in the literature (Lo and Zapanta, 1983; Stavas *et al.*, 1987; Canavan and Osborn, 1991; Sener, 1992; Ciuchi *et al.*, 1995; Maier *et al.*, 1996; Sadler *et al.*, 1996; Park *et al.*, 1998). We report an additional symptomatic case, with complete disappearance of the abnormal pneumatization during follow-up. The case indicates a possible pathogenesis.

Case report

A 34-year-old male was admitted to the neurological department after recurring attacks of neurological symptoms related to low barometric pressure. The first episode had occurred shortly after a flight take-off. At that time he experienced acute and severe pain in the occipital region, a radiating pain to both shoulders and a weakness of the left arm. The symptoms disappeared during the flight descent. The second episode took place about one month later and one month before admission to hospital and was identical to the first, but occurred while skiing at a high altitude (>1500 m). On admission he reported that pressure against the occipital region provoked a sensation of pressure in the right middle ear similar to that taking place during a Valsalva manoeuvre. Left arm weakness and a left-sided tendon reflex preponderance were noted on clinical examination. The cranial nerves were normal. An X-ray of the skull and computed tomography (CT) scanning showed extensive pneumatization of the right mastoid process and of the occipital bone (bilateral), but mainly on the right side. The internal osseous lamina, in particular, was displaced and eroded and was invisible in some areas (Figure 1a). The pneumatization was also present in both occipital condyles and the atlas, where assimilation between the atlas and the base of the skull could be observed (Figure 1b). Air could be seen in the epidural part of the spinal canal. ENT examination one week after admission revealed a right middle-ear pressure of 200 mmH_2O and an increased compliance. A ventilation tube was inserted in the tympanic membrane two days later because repeated tympanograms had showed unaltered high pressure. The levelling of the pressure required several minutes. The neck pain disappeared after the procedure. Two weeks later the tube was removed due to infection, and the neck pain recurred and persisted for one month, during which time the tympanic pressure fluctuated within the range 40–100 mmH_2O.

The middle-ear pressure was found to be between 25 and 100 mmH_2O during a recurrent episode some six months later, where the pain was also related to high altitude. It was later demonstrated that a Valsalva manoeuvre increased middle ear pressure from 25 to 175 mmH_2O. The pressure even remained high after 10 minutes of rest and was unaffected by swallowing. Detailed questioning revealed that the patient had had the habit, since childhood, of performing Valsalva's manoeuvre frequently. He agreed to attempt to give up this habit and has since shown no symptoms (September 1997). A follow-up CT-scan seven months later showed complete resolution of the pneumatization and partial reossification of the right temporal and occipital bones (Figure 2).

Discussion

A pre-requisite for the progression of the excessive skull pneumatization to the atlas in our patient was atlanto-occipital assimilation. It is conceivable that this progression

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Accepted for publication: 18 February 1999.

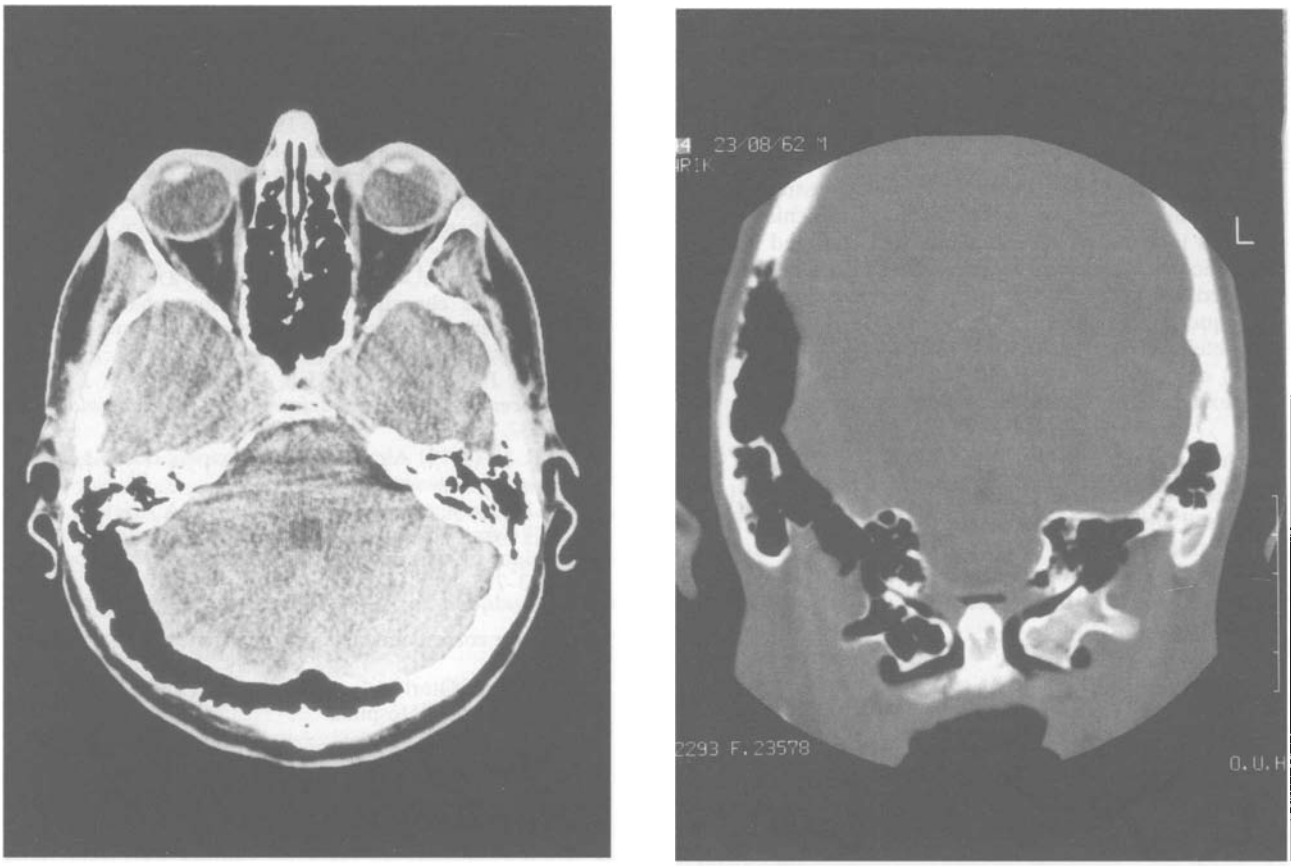

FIG. 1a and 1b

CT scans. 1a: Axial scan showing extensive pneumatization of the right temporal and occipital bones, as well as thinning of the internal osseous lamina. 1b: Coronal scan showing pneumatization of both the temporal and occipital bones on the right side. The pneumatization extends to the right occipital condyle and the right half of the atlas. Epidural air can be seen around the dens axis and in the atlanto-axial joint.

with subsequent delicate thinning of the compact atlas lamina immediately adjacent to a functioning joint (atlanto-axial) was responsible for the leaking of air into the soft tissue, resulting in the acute clinical symptoms. A similar atlantic air progression was found in the case reported by Sadler *et al.* (1996), as well as that reported by Lo and Zapanta (1983). Both of these patients had acute onset of symptoms after minor head injury and after a fit of coughing, respectively. Coughing also appeared to be the eliciting factor in another patient (Stavas *et al.*, 1987). A CT scan demonstrated extensive bone pneumatization in one patient suffering from headache (Sener, 1992).

A low barometric pressure was the eliciting factor in our patient. This may have created a pressure gradient across the membrane lining the pneumatized system if the Eustachian tube did not function correctly. It was later found during an ENT examination that such a malfunction was, in actual fact, present. Maier *et al.* (1996), Stavas *et al.* (1987) and Park *et al.* (1998) have each reported cases of pneumocephalus, and suggested that the cause was a ball-valve mechanism, activated by increased middle-ear pressure. Ciuchi *et al.* (1995) reported a case with abnormal pneumatization of the petrosal part of the temporal bone, with associated neurological symptoms. The symptoms and the pneumatization disappeared after

FIG. 2

Axial CT scan seven months later. The pneumatization has completely disappeared and both the right temporal and occipital bone have become partially re-ossified.

https://doi.org/10.1017/S0022215100144287 Published online by Cambridge University Press

closure of a fistula between the Eustachian tube and the pneumatized area. Our finding of a valve-like function of the Eustachian tube and the normalization of the middle-ear pressure, as well as of the bone structure after cessation of the frequent performance of Valsalva's manoeuvre strongly suggests a possible pathogenesis of the extensive pneumatization. The increased tympanic pressure was, in all probability, due to a malfunctioning Eustachian tube.

It was indeed fortunate that the tube inserted into the tympanic membrane had to be removed because infection occurred. The very simple measure of dropping the habit of frequently performing the Valsalva's manoeuvre was completely successful. The patients reported by Maier *et al.* (1996) and Park *et al.* (1998) were cured of their illness after extensive neurosurgery.

Conclusion

Extensive pneumatization of the base of the skull may be caused by a combination of a malfunctioning Eustachian tube and the habit of frequently performing Valsalva's manoeuvre. Air reaching the atlas produces a risk of leakage into the adjacent soft tissue with resulting acute clinical symptoms.

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