

Extensive craniocervical bone pneumatization

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ABSTRACT

We report a case of extensive abnormal craniocervical bone pneumatization accidentally found in a patient without any history of trauma or surgery. The patient had only mild unspecific thoracic pain and bilateral paresthesia that did not correlate with computed tomography findings.

Key words: • bone • skull • cervical vertebrae pneumatization

Pneumatization of the temporal bone is normally confined to the mastoid process, but may vary remarkably among individuals. The expansion of pneumatization to the occipital bone is exceptionally rare; the first reports date back to 1940 (1). Cases of craniocervical pneumatization first appeared in the 1990s (2). We report a case of extensive pneumatization of the skull base, atlas, and axis without any history of trauma or surgery.

Case report

A 47-year-old man presented with mild bilateral paresthesia of the fingers, corresponding to dermatomes C6/C7, and mild nonspecific thoracic pain. There was no history of trauma or surgery. In his medical history, there was chronic thromboembolic pulmonary hypertension with no sign of chronic obstructive pulmonary disease in the spirometry. The patient had started to complain of similar symptoms approximately 10 years ago.

Multislice computed tomography (CT) of the skull base and upper cervical spine was performed with a 64-detector row CT scanner (Siemens Sensation 64, Siemens AG Sector Healthcare, Erlangen, Germany). Axial, coronary, and sagittal reconstructions were performed on 0.75-mm slices. Multislice CT clearly depicted extensive pneumatization of the right occipital bone in the sagittal reconstructed images (Fig. 1a), complete pneumatization of the atlas in the axial plane (Fig. 1b), and the right hemicorpus of the axis in the coronary reconstructions (Fig. 1c). In terms of pneumatocoles, submillimeter axial images showed small amounts of subperiosteally trapped gas (Fig. 1d). There was no intraspinal emphysema that would have explained the symptoms of the patient. Even a thorough analysis of the submillimeter multiplanar reconstructed CT images did not confirm free communication between the occiput, atlas, and axis or an atlantooccipital assimilation.

Discussion

We present a very rare case of extensive pneumatization of the occiput and the first two cervical vertebrae with small subperiosteal pneumatocoles but without epidural soft-tissue emphysema. To the best of our knowledge, varying combinations of abnormal craniocervical bone pneumatization, with or without trauma, have only been reported in a handful of cases (predominantly in males) (1–7). A case of an air-filled palpable occipital mass occurring after minor trauma in the presence of extensive pneumatization of the occipital bone was reported as far back as 1940 (1). Reviewing the recent literature shows that in several of these cases, there was documented history of conditions with serious pressure changes such as repetitive Valsalva's maneuver or free diving. The clinical presentation was mild and included a palpable mass,

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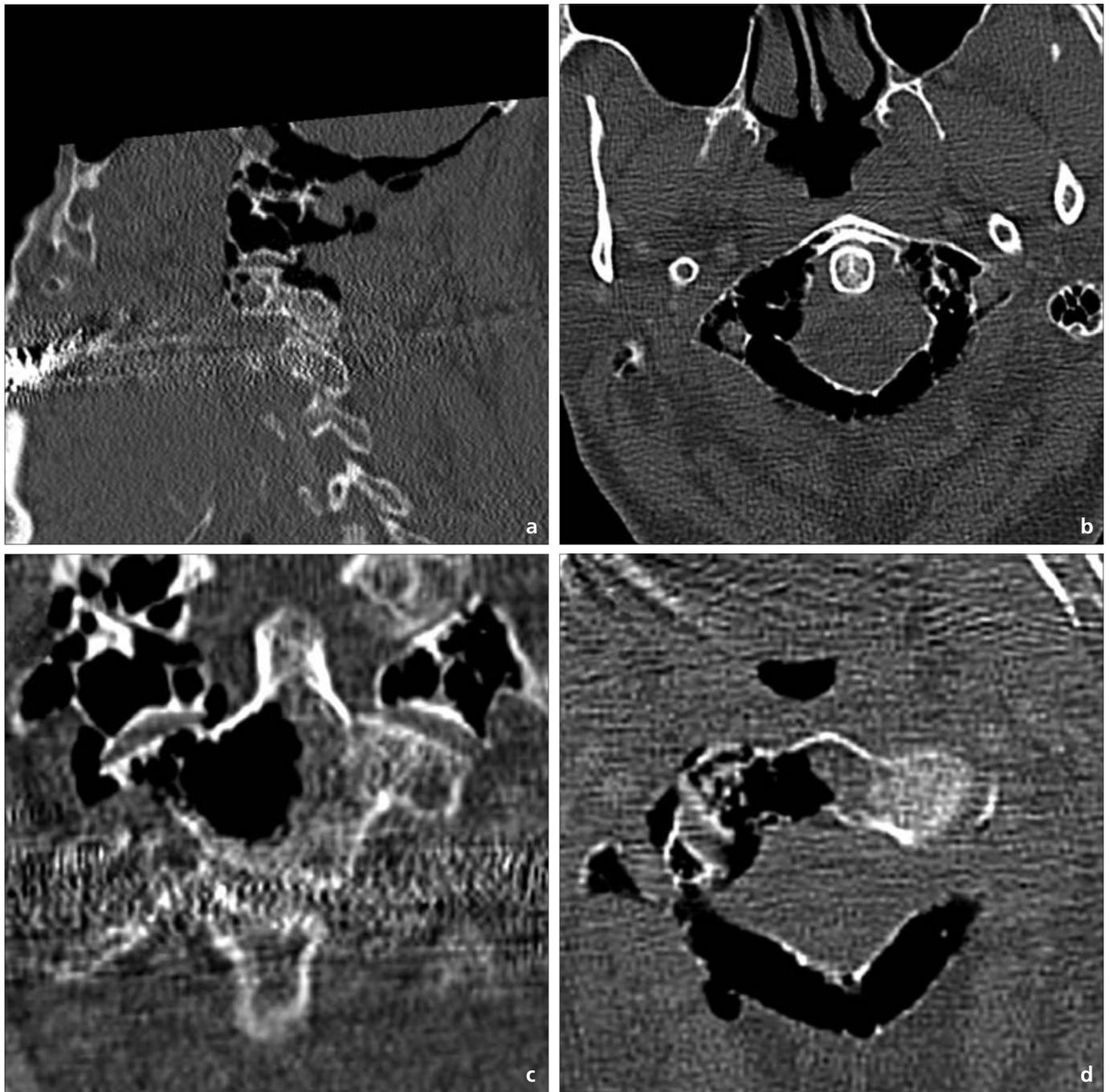


Figure 1. a–d. CT images (64-detector row CT) of the cervical spine show extensive pneumatization of the occipital bone and the upper cervical spine. Sagittal reconstructions of the skull base show pneumatization of the occiput (a). Axial slices demonstrate extensive pneumatization of the atlas (b). Coronal reconstructions show pneumatization of the right hemicorpus of the axis (c). The axial plane shows small amounts of subperiosteal trapped gas next to the atlas (d).

vertigo, tinnitus, headache, and transient arm weakness. In one case, there was 12th cranial nerve palsy and transient left trigeminal nerve palsy (2). In some cases, the intensity of the symptoms was related to pressure changes, e.g., barometric pressure (3) changes or applying pressure directly to the palpable mass (4). In the light of this context, a sort of “pneumomechanic

theory” (air hammer theory) or “expansion theory” has been stressed to explain the extension of pneumatization per continuitatem to the upper cervical vertebrae (5). In the case of occipital hyperpneumatization and an atlantooccipital assimilation (4), this explanation seems obvious. However, in order to reach the atlas or even the axis without assimilation (as in the

case above), the pneumatization has to cross several bony and cartilage-covered surfaces via occipitoatlantic and atlantoaxial joints. Therefore, focal defects or some type of channel has to be created to allow air to travel continually or intermittently into the bone marrow spaces. As far as we know, it is not proven that there is indeed atmospheric air contained in

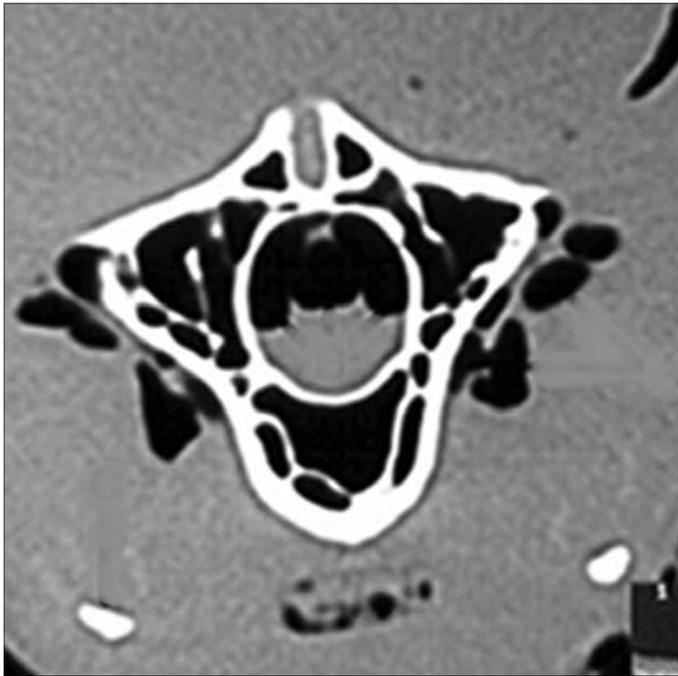


Figure 2. The CT image (axial plane) shows physiologically pneumatized vertebrae in *Struthio camelus* (ostrich). Figure taken from “The evolution of vertebral pneumaticity in sauropod dinosaurs” (10), with permission from Dr. Mathew J. Wedel from the Western University of Health Sciences, College of Osteopathic Medicine of the Pacific and College of Podiatric Medicine, Pomona, California, USA.

the pneumatized spaces as opposed to merely gas, e.g., nitrogen or a mixture of gases. Some authors accepted the lack of visible bony borders on multiplanar reconstructed CT images as an indication of free communication between pneumatized condyles and vertebrae (2, 6). This does not exclude the possibility that there is still a very thin, noncalcified competent border that is impermeable to air. We were not able to confirm the existence of definite free communication, even on submillimeter, reconstructed images. At follow-up, the appearance of fluid within those pneumatized spaces, but not within the middle ear and mastoid (7) might be indicative of a separate, perhaps autonomic, “compartment” with the ability to produce fluid after the discharge of pressure due to fracture or rupture of the covering structures. Therefore, apart from acquired pneumatization during the course of the theory mentioned above, these cases may represent idiopathic or embryologic etiologies. After formation of the notochord, it divides into

sclerotomes, which form the vertebrae and intervertebral discs, etc. The so-called “proatlas” is derived from the embryonic fourth occipital sclerotome, with its principal derivatives forming the occipital condyles, dorsal articular facets of the atlas, and tip of the odontoid (8). In all cases with reported pneumatization of the atlas, at least one *massa lateralis* beneath the articular facet was hollow (3, 5, 7, 9). Apart from the presented case, there is only one report of pneumatization of the axis; that case displayed pneumatization of the odontoid tip (6). One might speculate that all three derivatives of the proatlas (i.e., the entire fourth occipital sclerotome, as a developmental unit) were pneumatized.

In birds, the vertebrae, among other bones, are physiologically pneumatized (Fig. 2). The ontogenetic sequence in birds parallels the evolution of vertebral pneumaticity in sauropods (9–11). Because ontogeny recapitulates phylogeny, the pneumatization of human vertebrae could perhaps be seen as an embryological remnant, although

we have no information reinforcing this theory.

In conclusion, craniocervical bone pneumatization in humans is very rare. Only a handful of cases have been reported. Various theories (e.g., the extension of pneumatization per continuitatem, the “pneumomechanic theory” or “expansion theory”) about the genesis of this condition have been discussed in the literature. Cases unexplained by such theories could represent idiopathic or embryologic etiologies with extensive, far-reaching pneumatization of the upper cervical bones.

Conflict of interest disclosure

The authors declared no conflicts of interest.

References

1. Berendes J. Über einseitige pathologische Pneumatisation des Hinterhaupt- und Scheitelbeins mit Bildung eines subperiostalen Luftbrüchtes. *European Archives of Oto-Rhino-Laryngology* 1940; 148:51–57.
2. Sadler DJ, Doyle GJ, Hall K, Crawford PJ. Craniocervical bone pneumatization. *Neuroradiology* 1996; 38:330–332.
3. Nyrop M, Bjerre PK, Christensen J, Jorgensen KE. Extensive and symptomatic cranial pneumatization: caused by frequent performance of Valsalva’s manoeuvre? *J Laryngol Otol* 1999; 113:480–482.
4. Pans S, Van Breuseghem I, Geusens E, Brys P. Extensive occipital bone pneumatization presenting as an occipital mass. *AJR Am J Roentgenol* 2003; 181:891.
5. Martin ML, Bhargava R, Ashforth RA, Russell DB. Mastoid pneumocele causing atlantooccipital pneumatization. *AJNR Am J Neuroradiol* 1998; 19:1231–1233.
6. Turowski B, Rettig J, Raab P, Zanella FE. Cutaneous emphysema and craniocervical bone pneumatization. *AJNR Am J Neuroradiol* 2001; 22:1398–1400.
7. Moreira B, Som PM. Unexplained extensive skull base and atlas pneumatization: computed tomographic findings. *Arch Otolaryngol Head Neck Surg* 2010; 136:731–733.
8. Cone RO, Flournoy J, MacPherson RI. The craniocervical junction. *Radiographics* 1981; 1:1–37.
9. Wedel MJ. Vertebral pneumaticity, air sacs, and the physiology of sauropod dinosaurs. *Paleobiology* 2003; 29:243–255.
10. Wedel MJ. The evolution of vertebral pneumaticity in sauropod dinosaurs. *Journal of Vertebrate Paleontology* 2003; 23:344–357.
11. Salomon FV, Krautwald-Junghans ME. Anatomie der Vögel. In: Salomon FV, Geyer H, Gille U, eds. *Anatomie für die Tiermedizin*. 2nd ed. Stuttgart: Enke, 2008; 754–814.