Case Report
Diagnosis and treatment of craniocervical bone pneumatization and literature review

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Abstract: Objective: Craniocervical bone pneumatization occurs rarely and has been reported less in China and abroad. This paper introduces the case of a patient with craniocervical bone pneumatization diagnosed and treated in our hospital. Method: To combine analysis of imaging manifestations, clinical manifestations and therapeutic results of a patient with craniocervical bone pneumatization, and literature review. Result: The pathogenesis of craniocervical bone pneumatization may be related to craniopharyngeal dysfunction, ball valve mechanism and Valsalva manipulation. Craniocervical bone pneumatization is mainly manifested as cavitation of the skull, local expansion, local bone damage and so on, and these manifestations can involve the cranial cap bone, the skull base bone, and the upper cervical vertebra. Awareness of craniocervical bone pneumatization has been increasing this year. Local hypergasification and bone defects can be treated surgically. Conclusion: Craniocervical bone pneumatization is rare, and further study on its clinical manifestations, imaging manifestations, diagnosis, and treatment can provide a reliable basis for physicians to correctly identify the disease.

Keywords: Craniocervical bone pneumatization, diagnosis and treatment, literature review

Introduction
Craniocervical bone pneumatization mainly manifests as cavitation of the skull, partial bombe, and bone destruction. Occurrence is rare and was first reported by Mcarthur in 1905 [1]. At present, there is no specific definition for craniocervical bone pneumatization in academic circles, including giant gasified mastoid [2], astoid overgasification, and cranial overgasification. After reviewing the literature, it was found that this disease was more common in men, especially on the right side, and the position of its occurrence was more visible in the temporal bone, occipital bone, parietal bone and upper cervical vertebra. Reports at home and abroad have been increasing yearly, and the understanding of craniocervical bone pneumatization is growing.

Clinical data
Male, age 62. Clinical symptoms: Left posterior auricular skull was lacking and irregular. The subcutaneous emphysema was clearly visible, and the rest was normal. The patient had no history of ear disease and head trauma.

Imaging examination: CT showed partial deficiency on the left side of the occipital bone, and a large amount of gas density shadow was seen on the inside and outside of adjacent cranial plate. The adjacent cranial plate was separated, showing airbag changes and extending out of the mastoid process (Figure 1). MRI showed that the left mastoid chamber was overvaporized and extended to the adjacent slope and left occipital bone, which was absorbed under the compression of sclerotin in the corresponding area. The outer plate of the left occipital bone was punctured to form a subcutaneous emphysema (Figure 2).

Process of diagnosis and treatment
The patient was admitted to the hospital for routine examination. There was no obvious abnormality in the ear examination, and bilateral
Craniocevical bone pneumatization

Figure 1. CT images of the skull show extensive pneumatization of the left occipital bone and the adjacent cranial plate was separated with plenty of subperiosteally trapped gas. The cavitation of the skull extends to the mastoid.

Figure 2. MRI images demonstrated mastoid hyperpneumatization and extending to occipital bone and clivus. The left occipital plate absorption and subcutaneous emphysema were presented in this case.

hearing was normal. After the surgery, the left occipital lateral mastoid process was found to have a bone defect with irregular shape, indicating subdural transverse sinus and ethmoid sinus. Trabecular hyperplasia between the surface of the dura mater and the external cranial plate expanded the resection of some residual and broken cranial plates and increased the exposure of deep mastoid structures. The bone resection was sent for pathological examination. Microscopically, the mastoid process was found to be open in the deep part of the mastoid process. During the surgery, the patient was anesthetized and injected with saline. No obvious bubble overflow was seen. Bone wax closing and autologous tissue filling were performed to consolidate the effect of EC glue before flushing the area with hydrogen peroxide. Hemostasis occurred outside the dura after an artificial titanium mesh modification (arrow) was fixed with a titanium nail. Postoperative pulsating tinnitus disappeared in the patient. Skull CT reexamination (Figure 3) showed that the skull gasification range was significantly reduced and that the titanium mesh had good plasticity. At the follow-up pathological examination, a small amount of lamellar bone and hyperplasia of fibrous tissue was observed (Figure 4). Postoperative follow-up after 2 years showed no significant discomfort, changes in intraoperative gasification or bone defects (Figure 5).

Discussion and literature review

Imaging manifestations

The manifestations of craniocevical bone pneumatization vary, and diagnosis is mainly based on imaging examinations, including cranial plain film, CT and MRI examination. With the diversification of examination methods and the development of science and technology, CT and MRI are more widely used. Gas cavity and changes of skull shape mainly show plain radiographs. CT abnormalities include mainly hardening of the edge and skull air cavity with a clear boundary, visible line calcification and scattered fat and soft tissue density. MRI signal changes are complex, and contrast enhancement in low and high signal also changes.

Possibility of pathogenesis

Excessive vaporization of the skull, skull base and upper cervical vertebrae is a very rare condition with uncertain etiology and pathophysiology, and most scholars believe excessive vaporization is caused by abnormal development. Due to the excessive vaporization of the mastoid process chamber of the temporal bone and the spread, the skull outer plate is damaged, and the gas formed in the mastoid pro-
cess chamber breaks through the periosteum and spills under the skin, causing the formation of subscalp emphysema. If the gas fails to break through the periosteum, a subperiosteal emphysema is formed. Pathogenesis may be related to Eustachian tube dysfunction, ball valve mechanism and techniques of Valsalva, high-altitude and repeated contact. Skull gasification with Vm for long habits, high altitude and high pressure can occur as time progresses [2-4].

Hypopharyngeal dysfunction: Eustachian tube dysfunction can be divided into Eustachian tube obstruction and tube dysfunction that is open abnormally. Eustachian tube obstruction is the main reason of middle ear diseases, such as secretory otitis media and suppurative otitis media, for which inappropriate treatment can lead to irreversible damage to hearing. Fussey et al. [4] reported that the increase of intra-auricular pressure was closely related to extensive vaporization of the skull and the upper cervical spine. Reasons for Eustachian tube dysfunction are nasopharyngeal space-occupying lesions, changes in the shape of the Eustachian tube and the influence on Eustachian tube function caused by surface chemistry (middle ear negative pressure, middle ear effusion, and surface active substance), immune abnormalities, and infection.

Valsalva method: Vm is a powerful inflation of a closed airway to increase internal pressure. Some authors hypothesize that the repeated increase in internal pressure caused by repeated Vm may be a key problem in sinus cavity expansion including increased intraosseous pressure and subsequent increased intraosseous pressure, which remains to be confirmed by further experimental studies [5-7].

Mechanism of ball valve: The air inhaled into the Eustachian tube is trapped and gradually leads to the expansion of the sinus, extending to the occipital bone. Triggers include repeated Valsalva actions, excessive coughing, repeated high-altitude exposure, and high-altitude travel [8].

**Clinical manifestation and significance**

Craniocervical bone pneumatization has clinical features such as pulsating tinnitus, pharyngeal drum tube dysfunction, subcutaneous emphysema, skull defects caused by cranial plate damage, chronic epidural gas accumulation, neck and shoulder pain and upper cervical spine fractures [6].

The disease is observed occasionally; however, the number of reports has increased in recent years. Some patients have a clear history of head injury, for whom diagnosis and treatment should be closely combined with head CT diagnosis to avoid misdiagnosis and missed diagnosis. They should also receive 3-D reconstruction to give a definitive diagnosis. In summary, according to many reports, excessive vaporization...
Craniocervical bone pneumatization can take the following forms: 1. Craniocervical bone pneumatization to the top of skull; 2. Mastoid process and occipital hypergasification; 3. Extensive gasification of skull base and craniocervical junction [2, 6-8].

There is no recommended treatment for skull hypergasification. Through the cases we have observed, we think patients with middle ear disease should be actively treated with this pathology. Patients with development of hypergasification in the cranial bone and with mastoid parietal and occipital gasification should consider fistula treatment with bone wax and autologous tissue filling. Patients who have bone destruction with one skull defect caused by phase line skull repairing should consider the same. For patients with extensive vaporization of the skull base and the craniocervical junction, conservative treatment was mainly used, Vm action was stopped, and regular review was conducted.

Conclusion

Craniocervical bone pneumatization is a relatively rare occurrence. According to its clinical manifestations and imaging features, we can make an accurate diagnosis. Through this case, further knowledge of treatment for craniocervical bone pneumatization is gained, which also has significance for the improvement of rare diseases and for relevant clinical departments to provide treatment for difficult miscellaneous diseases.

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References