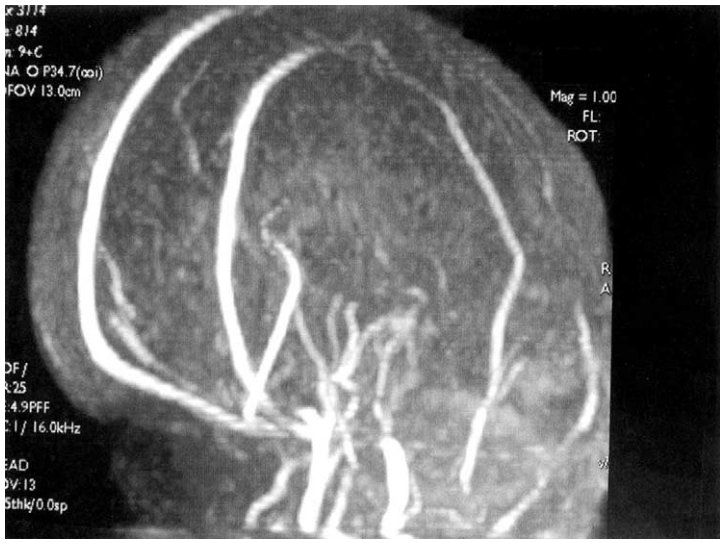

Fig. 5 – Post-natal 2D TOF (time of flight) MR venogram shows the abnormal dural venous sinuses. The superior sagittal sinus appears divided. This piece of information is important to the neurosurgeon, before the insertion of VP shunt.

delayed fine motor function. Social and language development were also retarded.

CONCLUSION

This case illustrates the usefulness of MR imaging in the antenatal diagnosis of Chiari III malformation. Furthermore, we have demonstrated the usefulness of the SSFSE sequence in antenatal MR examination of the fetus.

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Intravertebral Vacuum Phenomenon that Developed During Transpedicular Biopsy

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The vacuum phenomenon (VP) is frequently seen in degenerate intervertebral discs, but rarely within vertebral bodies. About 120 cases of intravertebral vacuum phenomenon (IVP) have been reported in the literature, mostly as case reports [1–5]. Historically, it has been suggested that IVP is virtually pathognomonic of vertebral avascular necrosis. However, recent studies have refuted this theory and shown that it may be associated with osteoporotic

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compression fractures, systemic corticosteroid consumption, and intraosseous disc herniations. Demonstration of IVP in vertebral fractures is considered good evidence that the underlying process is not malignant [2,3,5,6].

During a literature survey, we found no reported cases of IVP associated with vertebral biopsy. We describe below a case of intravertebral vacuum phenomenon which occurred during a computed tomography (CT) guided transpedicular biopsy that was performed to clarify the aetiology of a vertebral fracture.

CASE REPORT

A 68-year-old woman on chronic steroid medication and lacking a history of trauma presented with back pain and difficulty in walking. CT examination (Prospeed; General Electric, MI, Wisconsin, U.S.A.) was performed using 3 mm contiguous data acquisition in sequential mode and sagittal reformatted images. CT revealed a T12 vertebral body fracture with a retropulsed osseous fragment causing thecal sac compression and 40% encroachment on the spinal canal (Fig. 1). The vertebral sclerosis was due to trabecular compression. Magnetic resonance (MR) examination was performed with a 1.5 T unit (Signa Horizon; General Electric, Milwaukee, WI, U.S.A.) using sagittal SE T1-, FSE T2-, fat saturated FSE T2-, axial SE T1-, FSE T2-weighted sequences. Decrease in vertebral height with pathological signal changes, hypointense on T1- and hyperintense on T2-weighted images were detected in the T12 vertebral body (Fig. 2). CT and MR examination revealed no evidence of a mass or osseous destruction. Other thoracal vertebrae showed no pathological changes except for generalized osteoporosis.

Although the patient had no history of malignancy and both CT and MR findings were thought to represent a benign fracture caused by osteoporosis, lack of a history of trauma and the age of the patient led the orthopedic surgeons to request CT-guided vertebral biopsy to rule out malignant pathological fracture. During the biopsy procedure, air rushed through the needle into the vertebral body and post-biopsy images revealed gas within the vertebral body (Fig. 3). This phenomenon had not been seen previously in the author's experience of 54 vertebral biopsies and a total of 142 bone biopsies. It was regarded as an additional sign of benignancy, and histopathological findings confirmed this.

DISCUSSION

The terms vacuum phenomenon (VP) is used to describe non-infective gas collections in an area of the body that does not normally contain gas [5]. Ninety percent of this gas is nitrogen [2,7]. VP is commonly seen in degenerate intervertebral discs, usually in the lumbar region [2,4]. Plain spinal radiographs can show VP in the majority of cases [6]. However, CT is regarded as the most sensitive method for the detection of gas within the body, and is capable of demonstrating small gas collections that cannot be seen on plain radiographs. CT examinations of patients over the age of 40 show intradiscal VP in 46% of cases [8]. Occasionally, gas may be seen in the spinal canal, apophyseal joints, soft tissues and vertebral bodies [6]. Intravertebral or intervertebral gas may leak into the epidural space and cause irritation on spinal nerve roots. Gas may also extend into the psoas muscle [3,5].

The most common localizations of IVP are vertebral bodies from T12 to L4. It occurs mainly in the elderly, and is slightly more common in women than in men [1,3,5,6]. This feature is evidence that factors other than simple fracture contribute to the cause of IVP, although its aetiology is still not clear [2–4]. Several authors suggest that IVP is a pathognomonic sign of avascular necrosis of the vertebra [2,6,9,10] and explain the gas deposit as a consequence of lack of fluid and blood at the fracture site due to ischaemia. Thus, an analogy has been pointed out between the crescent sign of femoral head avascular necrosis and IVP [6,9,10]. However, recent studies relate this theory and show that IVP may be associated with osteoporotic compression fractures, systemic corticosteroid medication, and intraosseous disc herniations [2]. Bone necrosis by itself is no cause of gas production and there is no definite evidence that osteonecrosis represents a major causative mechanism of IVP. Moreover, osteonecrosis is rarely seen in the vertebral body [11] whereas IVP occurs more commonly than was previously thought [1]. In the literature, histopathologic signs of osteonecrosis have been identified in biopsy specimens of seven cases out of 18 which have undergone a biopsy procedure in the literature [4].

Stabler and co-workers stated that fracture and mechanical motion are required for IVP to occur [5]. Inter- or intravertebral VP is a response to negative pressure. Soluble gas dissolved within the interstitial fluid of surrounding tissues diffuse into the fissures secondary to a fall in

(*a*)

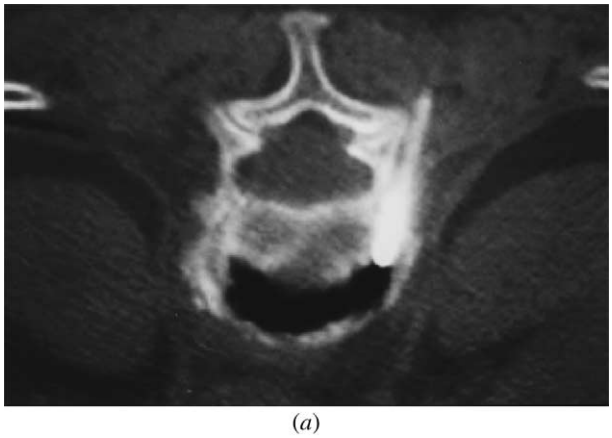
(*b*)

Fig. 1 – CT examination. (*a*) Axial image shows the compressed vertebral body with retropulsed posterior fragment. (*b*) Sagittal reconstructed image.

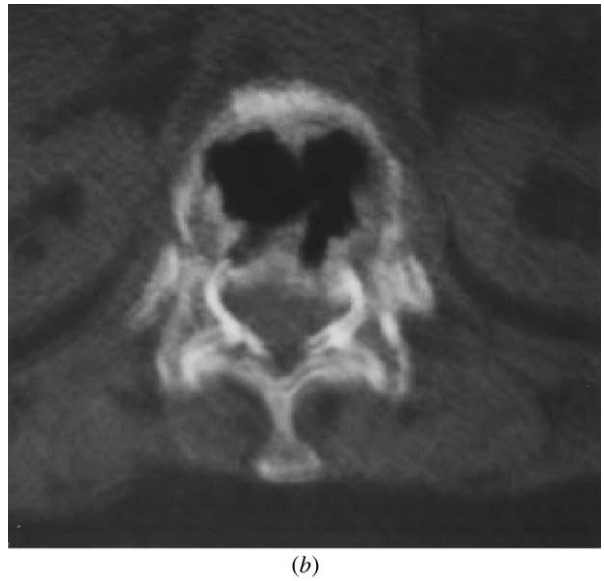
(*a*)

(*b*)

Fig. 2 – MR examination. (*a*) T1-weighted mid-sagittal image demonstrates diffuse hypointensity of the affected vertebra. (*b*) T2-weighted image reveals the high signal intensity of medullary bone and signal void fracture line in the posterior half of the vertebral body.



(*a*)



(*b*)

Fig. 3 – (*a*) CT during the biopsy procedure shows the rush of air through the needle into the vertebral body. (*b*) Control CT after the procedure reveals the persistence of the intravertebral air.

pressure [2,4]. After the trabecular compression of an acute vertebral fracture, the volume of the vertebral body is decreased. Volume reduction of the vertebral body results in negative pressure in the trabecular bone when the patient is in the supine position, which distracts the opposing surfaces of the cleft. So, the cleft appears or is enlarged in the supine position and can disappear in the flexed or standing position [9,12]. Disappearance of gas within the cleft is suggestive of slow replacement of gas by fluid [13]. No report has been seen in the literature regarding IVP in the prone position. In our case, the biopsy was performed in the prone position and the rush of room air through the biopsy needle into the vertebral body indicated the existence of negative pressure within the bone compared with the

atmosphere. This negative pressure seems to be secondary to extension stress applied on the thoracic curve while the patient was in the prone position, with a similar mechanism as in the supine position.

If the blood supply of the bone is adequate, the cleft is filled with blood, plasma and tissue fluid instead of gas. This is typical for hematopoietically active bone marrow with low fat content, and for pathologic fractures due to neoplasm [5]. In case of malignancy, the tumoral tissue occupies the space in the clefts. In an acute fracture of the spine the space between the bone fragments is occupied by hematoma [2].

Trabecular bone in osteoporotic patients of advanced age has decreased hematopoietic tissue and higher fat content. Osteoporotic compression fractures may lead to more serious vascular damage along with structural changes due to decrease of trabecular interconnections in osteoporotic bone. VP in osteoporotic compression fractures is caused by lack of filling of the clefts with fluid after distraction of fractured trabeculae, whether or not histopathological evidence of osteonecrosis is present [5]. In osteoporotic elderly patients, decreased and damaged intraspongious vessels and severe fragmentation are the predisposing factors that increase the incidence of osteonecrosis and VP. It is suggested that osteonecrosis may be a non-specific process occurring as a consequence of the fracture but not the primary cause of the fracture or the VP [4–6]. There is significant correlation between the amount of reduction of bone mineral density and the occurrence of IVP [4,5]. This correlation may account for the strong association of IVP with vertebral fractures in elderly patients. However, atherosclerosis and possible subsequent vertebral ischaemia may also be another predisposing factor for vertebral collapse in elderly patients. Moreover, recent articles have described osteoporosis in all patients with vertebral osteonecrosis [6,9,11,13]. It is likely that bone ischaemia may follow rather than precede vertebral collapse [13].

Lafforgue *et al*. reported that there is an association of IVP with intradiscal gas in the adjacent disc. They found that 83% of the 23 cases of IVP were associated with intradiscal gas. They suggested that IVP is the result of the migration of intradiscal gas collection through the fractured end plates of osteoporotic collapsed vertebra [4]. However, Stabler and associates found no relation between inter- and intravertebral VP. In their series none of the intradiscal gas was in a segment in which IVP was present [5].

Laredo *et al*. detected IVP in 15% of osteoporotic vertebral fractures, while none of the 32 fractures caused by tumours showed VP. Likewise, Golimbu and associates did not observe VP in a retrospective review of 67 fractures due to primary and secondary vertebral neoplasms [2]. Stabler *et al*. also reported that in their study of 96 vertebral body fractures, no IVP has been detected in a nine tumor-related pathological fractures [5]. However, Kumpan and associates have described two cases of intraosseous vacuum in myelomatous involvement of vertebrae in their series of 17 patients [15]. Thus IVP does not absolutely exclude the coexistence of malignancy in the affected bone. Another two examples of IVP were described in patients with myeloma by Resnick *et al*. and Gagnieri *et al*. [16,17]. In the case of Gagnieri *et al*., histopathologic examination showed evidence of bone necrosis without any abnormal plasmacytosis [17]. At present, it is widely accepted that IVP seen in vertebral fractures is a reliable sign that the underlying pathology is not a tumour [2,3,5]. However, plasmacytoma is an exception and must be kept in mind.

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