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The intravertebral vacuum phenomenon

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Abstract. An intravertebral vacuum phenomenon was observed within 19 vertebrae of 17 patients. It represents a non-healing vertebral fracture. Three possible pathologic mechanisms are discussed: ischemic bone necrosis, trauma with ensuing ischemic necrosis, and intraosseous disc prolapse. The intravertebral vacuum phenomenon was found in two patients with multiple myeloma and thus does not exclude the presence of malignancy in the affected bone. Radiographs obtained during traction or extension may be of diagnostic value.

Key words: Vacuum phenomenon – Spine, fracture – Pseudarthrosis – Osteonecrosis, ischemic

The term vacuum phenomenon relates to the accumulation of gas within a joint space, an intervertebral disc, or bone. A gaseous lucency within a disc is a common finding which can be observed in 1% to 20% of spinal radiographs [12] and in almost 50% of computed tomograms of the spine in patients over 40 years of age [8]. It is most commonly associated with pre-existing changes of the spine, such as osteochondrosis, spondylosis deformans, other degenerative appearances and Schmorl nodes; it has also been reported in patients with metastatic disease of the spine [11, 12, 14].

An intravertebral vacuum phenomenon – characterized by a gaseous lucency within a vertebral body – is less common [2, 4, 5, 8–11, 14]. We describe the radiographic spectrum of intravertebral gaseous collections detected on plain radiographs. Possible etiologies and pathologic mechanisms of this finding are discussed.

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Materials and methods

Plain radiographs of the thoracic and lumbar spine, obtained in 2,000 patients with oncologic, rheumatologic, degenerative, and endocrinologic disorders, were reviewed. An intravertebral vacuum phenomenon was detected in 17 patients (11 female, 6 male). The age range was 51 to 81 years with a mean of 67 years. Antero-posterior and lateral plain films were supplemented by conventional tomography in ten patients. Additional plain films during traction were obtained in nine patients. Bone scintigraphy was performed in six patients.

Radiographic – pathologic correlation was possible in two patients with multiple myeloma, who had autopsies. In the remaining patients, the final diagnosis was based on clinical and radiographic follow-up over two years.

Results

Clinically, all 17 patients presented with back pain, without neurologic deficit. All had severe osteoporosis and extensive degenerative disc disease. In 14 of the 17 patients intervertebral ankylosis of the adjacent vertebrae was demonstrated. Of the 17 patients, 15 revealed an intravertebral vacuum phenomenon within one vertebra, and two patients showed intravertebral gaseous lucencies in two vertebrae, accounting for a total of 19 vertebrae exhibiting this phenomenon. Lesions were commonly located at the thoracolumbar junction: ten at the T11 to L1 level and the remaining lesions were found from T5 to L3. The intravertebral vacuum phenomenon was seen exclusively in conjunction with vertebral fracture and collapse.

The collapsed vertebrae were reduced in height by 25% to 75% compared to the adjacent vertebrae. In 15 patients the intravertebral lucencies were oriented horizontally and involved more than half of the vertebral body width, measuring between 1 and 3 mm in height (Fig. 1). In two patients a central round gas collection was noted, measuring 10 and 11 mm in diameter, respectively (Fig. 2).

With traction, the lucencies broadened between 1 to 4 mm in five of nine patients (Fig. 3). One

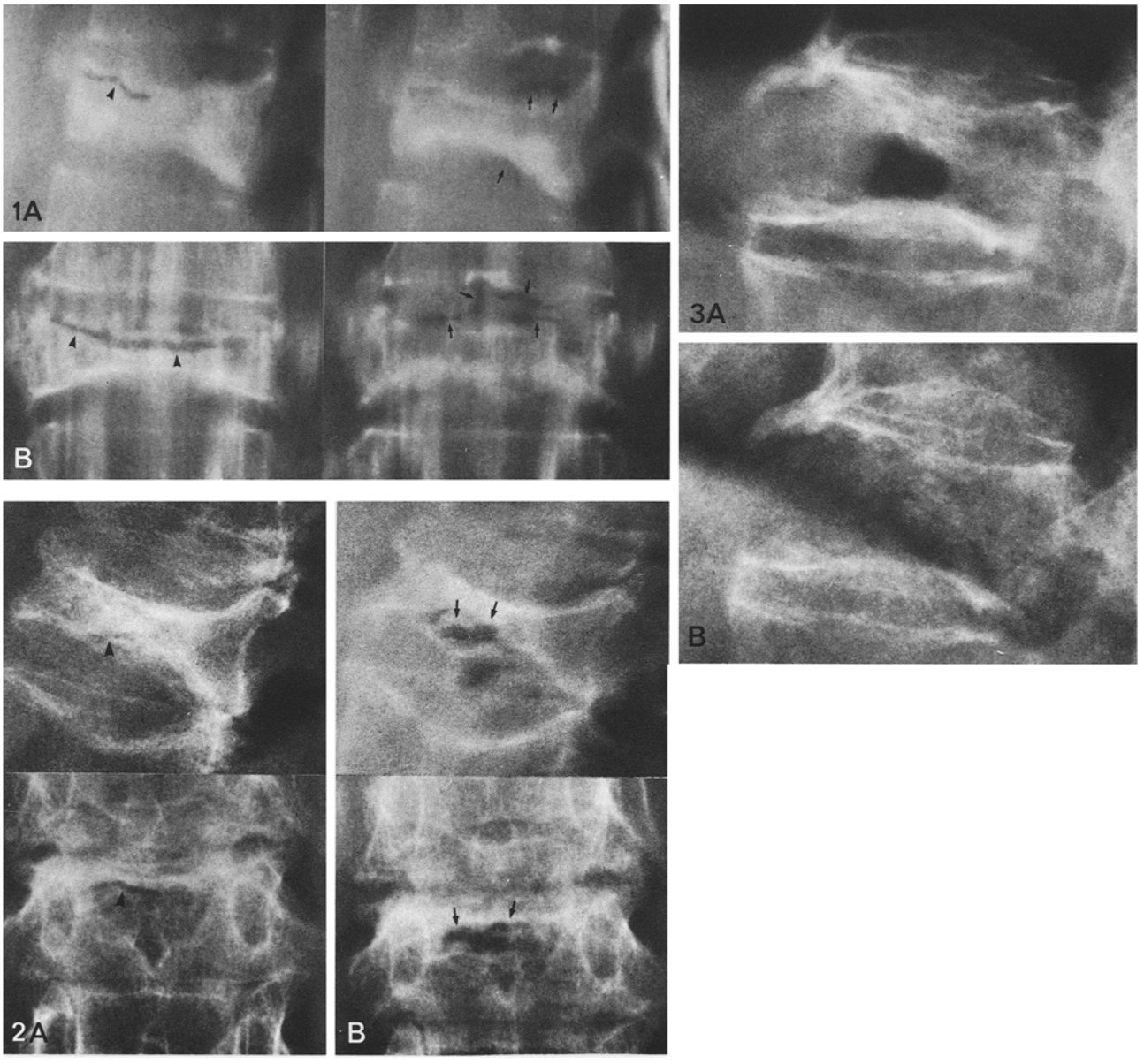

Fig. 1 A, B. Post-traumatic pseudarthrosis with intravertebral vacuum phenomenon: 63-year-old male patient with severe osteoporosis and a history of trauma 8 weeks ago. Lateral (**A**) and anteroposterior (**B**) tomograms of the T 11 vertebra show a subchondral, linear, intraosseous vacuum phenomenon (*arrowheads*). It involves almost the entire width of the vertebral body and is confined to its anterior portion. There is sclerosis of the adjacent bone. In addition, the vertebral collapse is accompanied by an intervertebral vacuum phenomenon within the T 10/11 and the T 11/12 discs (*arrows*)

Fig. 2 A, B. Value of traction for demonstration of the vacuum phenomenon: 63-year-old male patient with steroid-induced osteoporosis. Lateral and anteroposterior plain films of the L 1 vertebra (**A**) demonstrate a small subchondral vacuum phenomenon measuring 1 mm in its cranio-caudal extension (*arrowheads*). Radiographs obtained during traction (**B**) demonstrate broadening of the vacuum cleft which now measures 4 mm in its cranio-caudal diameter (*arrows*). Note intervertebral vacuum phenomenon and sclerotic bone adjacent to the cleft

Fig. 3 A, B. Multiple myeloma and vacuum phenomenon: 74-year-old female with multiple myeloma and collapse of the T11 vertebra. Large, round collection of gas, probably related to intravertebral disc prolapse (**A**). The vacuum phenomenon is barely visible on a follow-up film obtained 10 days later (**B**). This sequence demonstrates the dynamic changes of intravertebral gas collections

of the patients with multiple myeloma exhibited the intravertebral vacuum phenomenon only after traction. After release of traction, the gas disappeared within minutes. When traction was used the collapsed vertebrae gained height, the gain being equal to the broadening of the lucency. With release of traction the vertebral bodies assumed their original height within 24 h. In seven patients, a concomitant intervertebral vacuum phenomenon also was observed (Fig. 1). In two patients, intervertebral gas collections appeared during traction maneuvers. Bone scintigraphy showed increased radionuclide uptake in the fractured vertebrae in all six patients in whom it was performed. In 16 of 19 lesions, sclerotic bone bordered the vacuum cleft. This was interpreted as an ununited vertebral fracture with formation of a pseudarthrosis.

Osteoporosis was caused by steroids in four patients. One of these patients had Cushing disease, two had been on long-term steroid medication for rheumatoid arthritis, and one patient had received steroids for idiopathic thrombocytopenia. Ischemic bone necrosis may have been the etiologic factor in these patients [9]. In three other patients a history of severe trauma was obtained, and repeated microtrauma may have been the cause of vertebral fracture in several other patients [10]. Besides ischemic necrosis and trauma, a third mechanism may have caused an intravertebral vacuum phenomenon in two patients: vertebral collapse accompanied by intraosseous disc prolapse [8, 11]. Two of our 17 patients had multiple myeloma. In both, neoplastic involvement of the vertebrae, which exhibited a vacuum phenomenon, was confirmed by autopsy.

Discussion

The vacuum phenomenon observed in degenerative disc disease is caused by accumulation of gas, predominantly nitrogen [6]. Likewise, it is presumed that intraosseous vacuum clefts result from the release of gas within cracks in the subchondral bone after vertebral fracture [9]. The phenomenon probably represents an ununited vertebral fracture with possible formation of a pseudarthrosis. The etiology and pathologic mechanism of these findings are uncertain. Possible causes include ischemic necrosis of bone, trauma, or trauma followed by intravertebral disc prolapse.

Maldague et al. described an intravertebral vacuum phenomenon in ten patients with vertebral collapse at the thoracolumbar junction [9]. Seven of their patients were on long-term corticosteroid therapy. Vertebral collapse was never associated with neoplastic or inflammatory changes or related to trauma. Hence, they felt that the intraosseous vacuum phenomenon represents a specific sign of bone ischemia associated with nonhealing vertebral collapse. Accordingly, they and other authors assumed that a collapsed vertebra exhibiting a vacuum phenomenon excluded neoplastic involvement of this vertebra [4, 9]. Brower and Downey reported a case with delayed post-traumatic collapse of a vertebral body (Kümmell disease) and a vacuum phenomenon [2]. Although their patient had not received steroids, they believed that the vertebral fracture was associated with bone ischemia. However, it is not clear whether bone ischemia predisposes to vertebral fracture or whether vertebral fracture results in vascular damage and ensuing bone ischemia.

This controversy has been stressed by Stojanovic and Kovac, who performed selective spinal angiography in three patients with vertebral collapse [13]. Their patients showed reduced or absent vertebral vascularisation. Although their angiographic observations suggest ischemic vertebral collapse, they did not observe an intravertebral vacuum phenomenon in their three patients. Resnick et al. considered the radiolucent "crescent sign" at the site of a linear fracture through subchondral bone pathognomonic of bone necrosis, as exemplified by that which accompanies osteonecrosis of the femoral head [11]. In these sites there is no evidence of possible pseudarthrosis, in contrast to vertebral lesions. A propos a case of myeloma, they observed that intravertebral vacuum phenomena occasionally occur in patients with vertebral collapse secondary to neoplastic bone changes. Wendling described two cases of intravertebral gaseous lucencies with underlying neoplastic disease [14].

The two patients in our series with multiple myeloma provide further evidence that the vacuum phenomenon does not exclude a neoplasm in the affected bone. Therefore, we do not consider it a specific sign of ischemic bone necrosis. All our 17 patients presented with osteoporosis, but this was steroid-induced in only four. In this latter group, the vacuum phenomenon probably was caused by ischemic bone necrosis.

Conversely, we believe that the phenomenon may have resulted from macro- or microtrauma in the remaining patients [10]. This assumption is strongly supported by the case history in three patients, as well as by the predilection for vacuum phenomena at the thoracolumbar junction – an area of concentrated stress [7]. Since severe osteoporosis was universely present, repeated micro-

trauma may have resulted in vertebral fracture and collapse in some of our patients. Spondylosis deformans with fixation of adjacent segments of the spinal column is likely to predispose to pseudarthrosis formation. This is comparable to the pathologic mechanism of vertebral fracture in patients with ankylosing spondylitis [1, 3, 7]. We, however, did not observe fusion or fracture of posterior vertebral elements indicating alteration in joint mobility. An osseous or fibrous spondylotic fixation could lead to the development of a pseudarthrosis; the presence of such a pseudarthrosis is suggested by the observation that sclerotic bone usually borders the gaseous lucency.

In 15 of 17 patients, the vacuum phenomenon was manifest as a linear transverse lucency. A round intravertebral collection of gas was observed in only two patients (one had severe trauma, the other multiple myeloma) and may have been caused by vertebral collapse accompanying intraosseous disc prolapse (Figs. 2, 3).

In conclusion, we consider the intravertebral vacuum phenomenon a nonspecific finding that does not exclude the presence of malignancy within the affected vertebra, as demonstrated by our two patients with multiple myeloma. In our opinion, this phenomenon represents a non-healing vertebral fracture. It may result from ischemia, from trauma with ensuing ischemia, or it may be due to fracture with intraosseous disc prolapse. Traction or extension views are helpful for optimal delineation of the vertebral cleft.

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