Intravertebral cleft sign: From vacuum phenomenon to fluid sign

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Learning objectives

Fig.

References: Radiology, Nagasaki University, Nagasaki University Hospital - Nagasaki/JP

- To present a general description of intravertebral cleft (IVC) sign, and the clinical presentation and risk factors associated with it.
- To describe the pathologic mechanism and the radiological findings of IVC sign.
- To define the significance of this sign in diagnosis, management and prognosis of compression vertebral deformity.
Background

Introduction:

Intravertebral cleft sign is a radiological finding first described by Maldague et al in 1978, which was thought to represent an ischemic vertebral collapse. This sign is characterized by gaseous lucency within vertebral body seen on radiographs or CT scan. As its counterpart within the joint space which is known as “vacuum phenomenon”, this sign is also called “intravertebral vacuum phenomenon” or “intravertebral vacuum cleft sign”.

Although this sign was believed to represent a gaseous collection within vertebra, MR imaging often shows fluid-like signal intensity within the cleft, which is called "fluid sign". Many studies showed that signal void due to gas within the cleft is gradually replaced by fluid in prolonged supine position. Collectively, we can say that an IVC sign represents a collection of gas, fluid or both within the cleft of the collapsed vertebral body.

IVC is usually found in elderly patients with back pain weeks to months after history of trauma. However, it may be found incidentally in asymptomatic patients. The lesion is mainly located in thoraco-lumbar junction (Th11-L1) and usually associated with osteoporosis or osteopenia and sometimes with corticosteroid therapy, alcoholism, or radiation therapy.

Pathologic mechanism:

The mechanism of IVC has not been will determined and it is difficult to say which is the initiative event of cleft formation, fracture or necrosis. The main two hypotheses are:

- **Ischemic bone necrosis theory**: Vertebral collapse and cleft formation occur as a consequence of a vascular insult, leading to secondary bone necrosis. This theory is supported by:
  1. Histopathological examination showing bone necrosis.
  2. The predisposing factors in avascular necrosis of bone (e.g. history of corticosteroid, alcohol abuse) are frequently associated\(^4\).

- **Non-union fracture theory**: Instability of the fractured vertebra, impaired fracture healing process in elderly patients, or vascular compromise due to granulation tissue and necrotic bone can lead to nonunion and pseudoarthrosis. This theory is supported by:
  1. About eighty percent of lesions located in thoraco-lumbar junction, which is the most dynamic level of spine.
2. Gross examination of IVC shows notable movement with fluid accumulation, while histological examination shows fibrocartilaginous membrane lining the cleft, suggesting pseudoarthrosis\(^{(2)}\).
Imaging findings OR Procedure details

1- Primary findings:

There is no one gold standard for recognition of IVC sign, but the choice of the modality depends on the case

- **Radiography:** IVC sign is characterized by a linear or semilunar horizontally oriented radiolucency within the collapsed vertebrae, which may be centrally located or adjacent to the end plate (Figs. 1 on page 8, 5 on page 11). Conventional AP and lateral views may not reveal the lucent cleft and extension stress or cross-table supine views are needed for best visualization of the cleft. Additionally, extension lateral view reveals the anterior height of the vertebral body increase compared to that in flexion, suggesting instability (pseudarthrosis) of compressed vertebral fractures with IVC (Fig. 3 on page 9).

- **CT:** The cleft appears more heterogenous and irregular than it does on radiograph. Using MDCT scanners, sagittal and coronal reformat images in addition to axial images are the preferred modality to show gas collection in the cleft (Fig. 7 on page 13).

- **MRI:** The gas within the cleft shows low signal intensity in all sequences; it is often difficult to recognize on MRI (Fig. 6 on page 12). The fluid in the cleft shows hypointense signal on T1-WI and hyperintense signal on T2-WI and STIR, which known as fluid sign (Fig. 4 on page 10). In many cases, however, we can see both gas and fluid at the same time showing air-fluid level in the cleft (Figs. 2 on page 8, 8 on page 14). The amount of fluid increases in prolonged supine position, representing the dynamic changes in content of cleft depending on time and position of the patient (5). Contrast enhancement MR study shows the cleft as a nonenhanced area and this finding may be more sensitive in demonstrating the cleft than the findings on nonenhanced MR images (6,7).

2- Secondary findings:

There are additional findings that may be associated with IVC sign. We can divide them according to their site as following:

- **Vertebral body:** The collapsed vertebral body often shows diffuse abnormal signal of the bone marrow probably representing necrosis, fibrosis, osteosclerosis or edema on MRI (Figs. 2 on page 8, 4 on page 10, 6 on page 12); the lesion can be mistaken as tumors or infection without noting the IVC sign.
• **Intervertebral disc**: Intervertebral gas can be associated with intravertebral cleft as much as 83% of cases\(^4\) (Fig. 8 on page 14). Fluid also can be seen in the disc\(^10\) (Fig. 9 on page 15).

• **Paravertebral region**: Gas or fluid in the cleft may escape into the paravertebral region, such as the psoas muscle (Fig. 10 on page 16).

• **Posterior element**: The pedicles or spinous process may show an edematous change or fracture on MRI, suggesting instability of vertebra with cleft (Figs. 11 on page 17, 12 on page 18).

3- Lesions with similar findings:

• **Gas in the vertebral body**: Intravertebral gas can be seen in Schmorl's node (Fig. 13 on page 19), limbus vertebra, and pneumocyst. All of them can be differentiated from IVC sign by their characteristic morphology\(^1\). In rare occasions gas may appear in pathological fracture (tumor) of vertebral body (Figs. 14 on page 20, 15 on page 21). Clinical history of the patient correlated with radiological finding is important for differentiation.

• **Lesions containing fluid or fluid-like tissue on MRI**: Bone marrow edema or hemorrhage in acute vertebral compression fracture may mimic IVC sign, but it is not well demarcated as fluid in intervertebral cleft (Fig. 16 on page 22). Granulation tissue and fluid associated with some infection such as tuberculous spondylitis may show MR findings similar to that of IVC sign (Fig. 17 on page 23). Other clinical and imaging features are important for differentiation.

• **Severe vertebral compression fracture**: Vertebral compression with severe collapse often demonstrates low signal intensity in all sequences of MRI that looks like intravertebral gas (Fig. 18 on page 24). CT and radiography shows sclerotic change associated with impaction of lamellar bone.

• **Fracture in diffuse Idiopathic skeletal hyperostosis (DISH)**: Fractures in DISH may involve the vertebral body in the ankylosed segment or may occur close to the endplate. Continuous motion at the site of fracture can result in pseudoarthrosis\(^8\) (Fig. 19 on page 25)

**Clinical Implication**:

1. Presence of IVC sign suggests benign nature of the vertebral compression fracture and is useful to differentiate it from infections and malignancies in most of the cases and to avoid unnecessary imaging or biopsy.

2. Appearance of IVC about 3 weeks after injury represents instability and a risk factor for delayed collapse and possible neurological deficit, requiring immobilization and careful observation\(^3\).
3. Painful compression fracture with IVC may need a vertebroplasty augmentation or surgical treatment if it does not respond to conservative treatment.

4. Recognition of IVC before vertebroplasty is useful to predict solid filling pattern for optimal pain control and maximum restoration of vertebral height\(^{(6)}\).
Case 1A: A 82 year-old female

Fig. 1: Radiographs show semilunar horizontally oriented radiolucency within collapsed vertebra

Fig. 0

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Fig. 2: MR images show air-fluid level within cleft of collapsed vertebra (arrows). Fluid appears as hyperintense signal in T2WI and STIR, while air appears as signal void in all sequences. The vertebral body shows posterior bulging with diffuse abnormal signal.
Fig. 3: Extension lateral radiograph reveals the anterior height of the vertebral body increase compared to that in neutral position (arrows).

Fig. 0

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Case 2B: A 74 year-old female

Fig. 4: MR images show IVC filled with fluid (fluid sign) (arrow). The body shows diffuse abnormal signal.

Fig. 0

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Case 3A: A 52 year-old female with history of gastric cancer.

Fig. 5: AP and lateral radiographs show gas within collapsed vertebra (arrows).

Fig. 0

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Case 3B: A 52 year-old female with history of gastric cancer.

Fig. 6: The gas in the vertebral body is difficult to recognize in these MR images.

Fig. 0

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Case 3C: A 52 year-old female with history of gastric cancer.

Fig 7: CT clearly shows the gaseous collection in the cleft.

Fig. 0

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Case 4: A 76 year-old male.

Fig. 8: MR images show intervertebral gas (arrows) associated with IVC filled with gas and fluid (arrowhead)

Fig. 0

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Case 5: A 73 year-old female.

Fig. 9: MR images show fluid in intervertebral disc (red arrows) communicating with fluid in the cleft of collapsed vertebra (yellow arrows).

Fig. 0

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Case 6: A 67 year-old female.

Fig. 10: MR images show extension of fluid from IVC to right paravertebral region on coronal view (arrowhead), and anterior extension on sagittal view (star).

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Case 7: A 71-year-old female.

Fig. 11: MR images show edema and fracture in spinous process associated with IVC (arrows).

**Fig. 0**

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Fig. 12: Suggested mechanism of spinous process fracture due to instability of vertebra with cleft.
Case 8: A 85 year-old female.

Coronal

Sagittal

T1WI

T2WI

Fig. 13: On CT Schmorl's node appears as a round lesion filled with gas which is surrounded by rim of sclerotic bone. However, on MRI the gas is difficult to recognize.
Case 9A: A 67 year-old female with history of endometrial cancer.

Fig. 14: CT images show gas within collapsed vertebral body (pathological fracture).

Fig. 0

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Case 9B: A 67 year-old female with history of endometrial cancer.

Fig. 15: MR images show soft tissue masses bulging posteriorly (arrows), suggesting metastases.

Fig. 0

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Case 10: A 74 year-old female

Lateral  T1WI  T2WI

Fig. 16: MR images show ill-demarcated bone marrow edema (arrow) in acute vertebral compression fracture that mimic IVC sign. Radiograph shows no evidence of fracture.

Fig. 0

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Case 11: A 83 year-old female with tuberculous spondylitis

Fig 17: MR images show fluid-like signal similar to that seen in IVC (arrows). Axial T2WI shows paravertebral mass lesion associated with tuberculosis (stars).

Fig. 0

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Case 12: A 49 year-old female with severe compression fracture

Fig 18: MR images show low signal intensity of sclerotic bone that looks like intravertebral gas (arrows).

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Case 13: A 72 year-old female with DISH complicated with fracture.

Fig. 0

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Conclusion

- Knowing the clinical presentation and the risk factors is the key to looking for IVC.
- Pathologic mechanism is still controversial and it needs more researches.
- Primary and secondary radiological findings are helpful to define the IVC.
- Lesions with similar findings should be differentiated by considering clinical, pathological and radiological findings.
- Recognition of IVC sign has clinical implication in diagnosis, management and prognosis of compression vertebral fracture.
References