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Review Article

TRAUMATIC PNEUMORRHACHIS/PNEUMOMEDIASTINUM PATHOGENESIS, DIAGNOSIS AND MANAGEMENT

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A B S T R A C T

Traumatic pneumorrhachis is a rare but known complication of basilar skull fracture with air localized in the cervical subarachnoid space. Pneumorrhachis the presence of intraspinal air, is an exceptional but eminent radiographic finding, accompanied by different aetiologies and possible pathways of air entry into the spinal canal. Extradural, intraspinal and epidural air may also be associated with other traumatic aetiologies.
The incidental finding of intraspinal air in the trauma setting mandates a search for the etiology.
Pneumomediastinum is uncommonly associated with pneumorachis. The condition can be caused by injury or disease. Most often, it occurs when air leaks from any part of the lung or airways into the mediastinum.
Method: By reviewing the literature and analysing a personal case of traumatic cervical and thoracic pneumorachis, pneumomediastinum aftermultitrauma, we present current data regarding the pathoanatomy, clinical and radiological presentation, diagnosis and differential diagnosis and treatment modalities of patients with pneumorachis, pneumomediastinum and associated pathologies to highlight this uncommon phenomenon and outline aetiology-based guidelines for the practical management of these conditions.

INTRODUCTION

Pneumorrhachis (PR), or intraspinal air, is an unusual radiographic finding, predominantly due to a traumatic or iatrogenic aetiology. It is associated with possible pathways of air entry into the spinal canal.Although PR has been previously described, mainly in theradiological literature, spine specialists are less acquainted with this unusual pathological entity. The causes can be classified as iatrogenic, non-traumatic and traumatic, the last of which is the rarest. Its precise mechanisms remain unknown. PR is typically asymptomatic and clinically non-specific. It does not tend to migrate butis spontaneously reabsorbed into the bloodstream over a period of several days. Patients with PR are thus typically treated conservatively1.

MATERIALS AND METHODS

Data Assessment

We performed a search of the terms intraspinal air, pneumorrhachis, epidural pneumatosis, and pneumomediastinum on *PubMed*and found 53case reports in English,which were published between 1989 and 2017 as full-length articles or letters.

Table 1 Classification of 53 Patients with Spontaneous Pneumomediastinum and Pneumorrhachis

No. of Patients	
Primary disease	12
Secondary disease	
Predisposing disease	
Bronchial asthma	12
Bronchiolitis obliterans and organizing	3
Pneumonia in graft-vs-host disease 1	
Pulmonary bullae 5	
Anorexia nervosa with or without vomiting	5
Precipitating factor	
Hyperpnoea7	
Illicit drug inhalation	5
Forceful vomiting 3	
Violent coughing 7	
Long distance Air travel 2	

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Total includes 14 females and 39 male subjects, aged between 4 and 76 y, median age 18 y.

Cause of Pneumorrhachis / Pneumomediastinum

- Trauma
- Respiratory complications and conditions that produce high intrathoracic pressure and barotraumas
- Recent iatrogenic manipulations during surgical, anaesthesiological and diagnostic interventions
- Malignancy and its associated therapy
- Spontaneous
- > iatrogenic, traumatic, nontraumatic
- Violent coughing
- After cardiopulmonary resuscitation
- Airway obstruction due to foreign body aspiration
- After physical exertion
- Inhalational drug abuse
- Prolonged and forceful emesis with diabetic ketoacidosis
- Head, cervical, thoracic, abdominal, pelvic, combined injuries
- Invasive tumour progression and postradiation changes
- Surgical interventions
- Nasotracheal intubation and peri- or epidural anaesthesia involving a lumbar puncture

Box-1 Cause of Pneumorrhachis/Pneumomediastinum

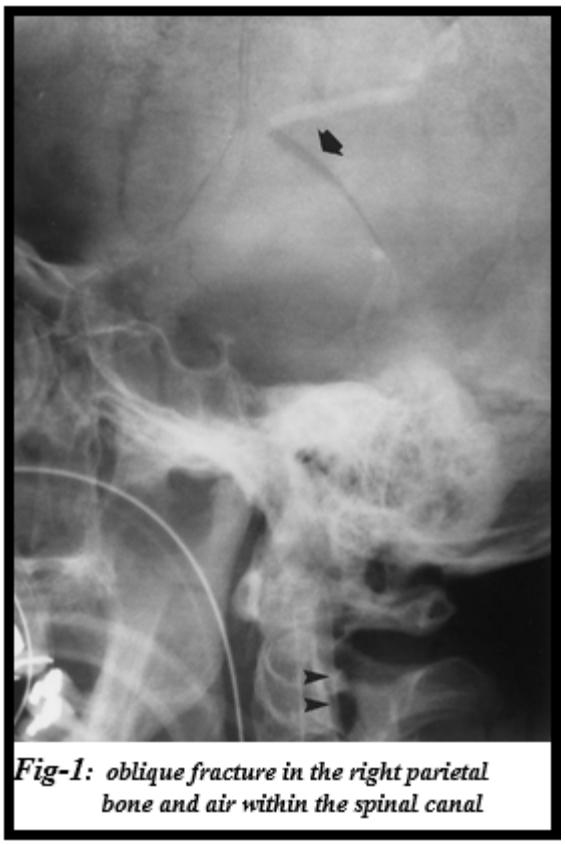

Fig-1: *oblique fracture in the right parietal bone and air within the spinal canal*

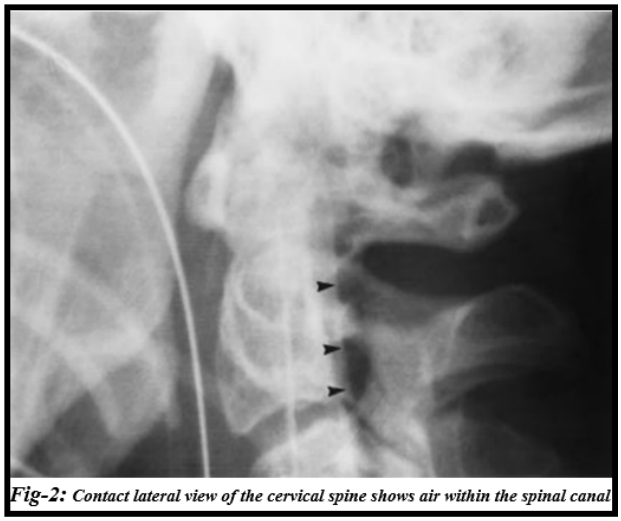

Fig-2: *Contact lateral view of the cervical spine shows air within the spinal canal*

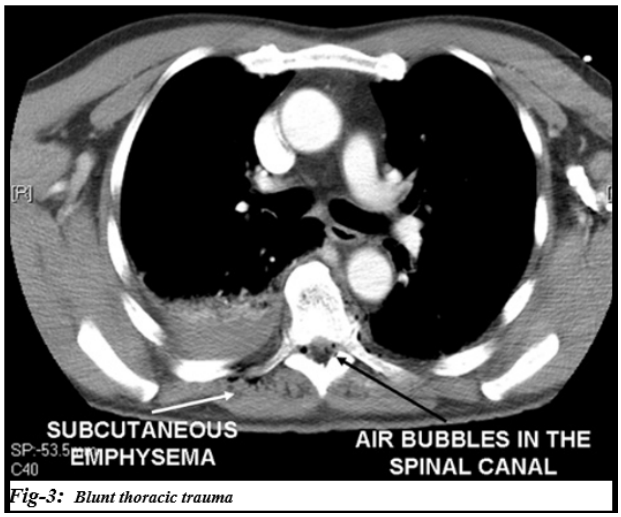

Fig-3: *Blunt thoracic trauma*

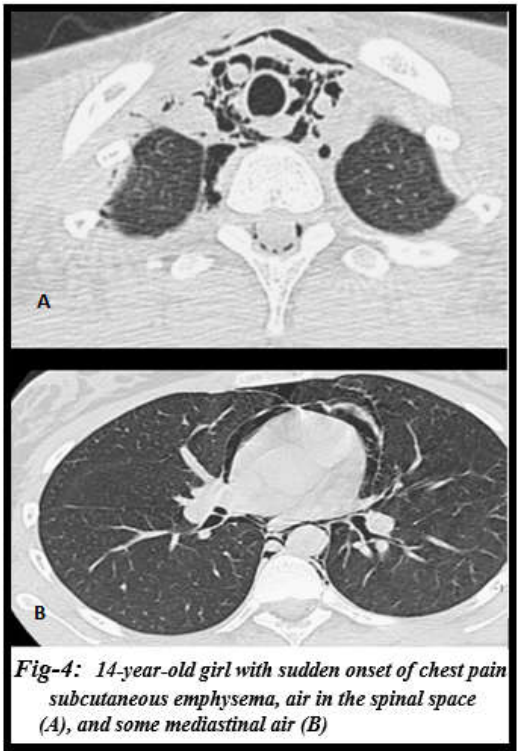

Fig-4: *14-year-old girl with sudden onset of chest pain subcutaneous emphysema, air in the spinal space (A), and some mediastinal air (B)*

Localisation & distribution

- Most cases: isolated air in cervical, thoracic or lumbosacral region
- Air in the entire spinal canal (n = 21)
- air bubbles distributed in the cervical, thoracic and lumbar region (n=3)
- Air in the thoracic and lumbar region (n = 10)
- Air in the cervical and thoracic region (n = 11)

Box-1 Localisation & distribution

Almost exceptionally, PR is found in combination with associated air distribution in other compartments and cavities of the body, including the following:

- Pneumocephalus
- Pneumothorax
- Pneumomediastinum
- Peumopericardium
- Surgicalemphysema

Fig-5: Pneumocephalus with significant compression of the right frontal lobe

Although intraspinal air is described in the literature under various terms, it is most commonly referred to aspneumorrhachis. Other terms include intraspinal pneumocele, spinal pneumatosis, spinal emphysema, aerorachia and pneumosaccus. 2, 3

In case of spontaneous pneumomediastinum, pneumorrhachis develops when air dissects along fascial planes from the posterior mediastinum or the retropharyngeal space through the neural foramens into the epidural space, which is not protected by a true fascial envelope.

Fig-6: A asthmatic patient who had a history of fever and violent cough, air in the mediastinum and subcutaneous tissue

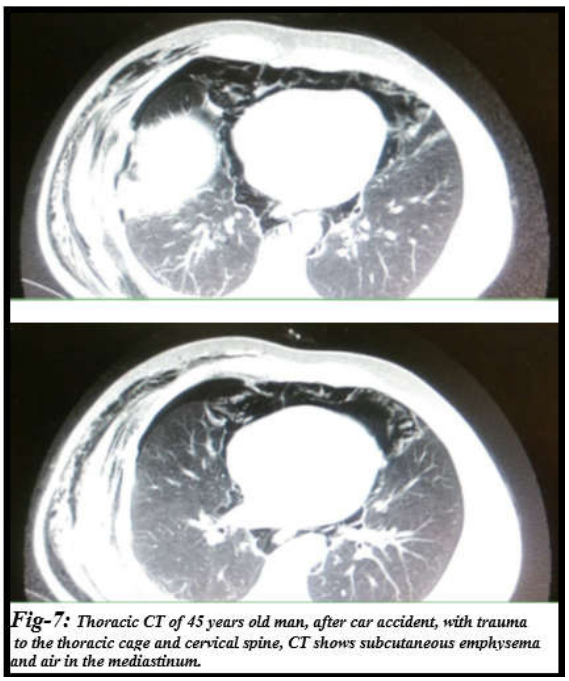

Fig-7: Thoracic CT of 45 years old man, after car accident, with trauma to the thoracic cage and cervical spine, CT shows subcutaneous emphysema and air in the mediastinum.

Pathomechanism and aetiology

Apart from artificial, usually traumatic spinal leaks and penetrating spine injuries as a possible explanation for a direct route of intraspinal entry, air may entrap due to a one-way air valve mechanism and dissect indirectly between the paraspinal soft tissues into the epidural space of the spinal canal via the neural foramina and along the vascular and nerve root sheaths, and vice versa, thereby resulting in pneumorrhachis.

CASE REPORT

A 25-year-old man was admittedwith history of assault with a sickle.

On examination he had multiple lacerated wounds over his suboccipital, frontal and parietooccipital regions. He had a GCS of 13. Computed tomography (CT) of the head was normal. Spinal CT demonstrated intra-dural air lucency in the cervical vertebral column (Fig. 7). This was mainly situated posterior to spinal cord with a track of air extending into the muscular and subcutaneous plane. The patient was managed conservatively and discharged after 2 days.

A 23-year-old male patient, involved in a Motor Vehicle Accident, was admitted to Sahlgrenska university Hospital with the Glasgow Coma Score of 15; he was conscious, oriented, with no history of loss of consciousness or vomiting and no bleeding from the external orifices.

His pupils were equal and reactive to light and no wounds on the head or neck were detected. The respiratory effort and circulation was normal. On admission, the physical examination revealed abrasions and subcutaneous haematomas with tissue emphysema, tenderness on the left thoracic side and in the left upper abdomen with rigidity and guarding. Emergency echocardiography was unremarkable; chest X-ray confirmed emphysema on the left side with no haemopnemothorax. AFAST scan was conducted and was unremarkable. No skeletal damage was detected on CT, however, the presence of air in the spinal canal was detected (Fig. 8, 9).

Fig-8: Case 1, Spinal CT demonstrated intra-dural air lucency in the cervical vertebral column.

Fig-9: Case 2, presence of air in the spinal canal.

Being haemodynamically stable, the patient was kept under close observation and treated conservatively. The patient did not develop any complications and was discharged home after 48 hours.

Fig-10: Thoracic CT of 50 years old, after MC accident, with trauma to the thorax and abdomen, CT shows subcutaneous emphysema and air in the mediastinum, right lung and contraction of the pneumothorax. After ATLS evaluation, he got a chest tube and directly to OR for laparotomy and suture of liver damage. He went home 5 days later.

DISCUSSION

Free air surrounding the dura mater spinalis is an uncommon phenomenon that was primarily reported by Gordon *et al*. in 1977 and variously described as intraspinal pneumocele or pneumocoele spinal epidural and subarachnoid pneumatosis, spinal and epidural emphysema, aerorachia, pneumosaccus, air myelogram pneumomyelogram or pneumomyelography.**4** In 1987, the term pneumorrhachiswas universally applied **6.**

Pathogenesis and definition and classification

Pneumorachis is classified descriptively into an *internal, intradural* or *external, extradural*pattern. Moreover, it is extremely important to differentiate intraspinal air from free intraspinal gas, collected during degenerative, malignant, inflammatory and infectious diseases produced by gas-forming microorganisms **7**. Differentiating between these is likely to be infeasible on CT. Internal traumatic pneumorachis is frequently associated with major trauma and believed to be a marker of severe injury **8**. Penetrating spinal injuries are usually a direct source of air entry, but other causes of pneumorachis can be explained by entrapment of air into the paraspinal soft tissues and into the epidural space via the neural foramina along the vascular and nerve root bundles. This could occur in conditions producing exceptionally high intrathoracic pressures (e.g. coughing, sneezing and vomiting) as well as either a complication of surgical or anaesthetic procedures or a complication of malignancy and its therapy 9-12,13.

Traumatic cervical pneumorachis, a rare finding, was originally described by Newbold in a patient with basilar skull fracture. Air was identified in the cervical subarachnoid space and Newbold *et al*. suggested that pneumorachis, similar to pneumocephalus, is a secondary sign of basilar skull fracture.

Pneumorachis is defined as air within the spinal canal. Pneumocephalus, which may cause pneumorachis, is classified as either intra- or extracranial 14.

Extracranial pneumocephalus was originally described within the sub aponeurotic space of the scalp, the subgaleal aerocele, by Jones15. Intracranial pneumocephalus occurs most commonly in the subdural or subarachnoid space. Traumatic pneumorachis, defined by Newbold *et al*. and North, occurs when a fracture of the cranium is associated with a dural tear, allowing communication between the subarachnoid space and an air-containing cavity 14-16.

The presence of pneumorachis is associated with increased morbidity including a 25% risk of meningitis as well as an overall mortality rate of 16% 17. Traumatic pneumorachis has been reported following deceleration motor vehicle collision in three cases of polytraumatized patients.

Place and Pezutti and *Scialdone and Wagle* each described adult patients who sustained bluntchesttrauma18**, 19**. In each case pneumothorax and ipsilateral rib fractures were identified on chest radiographs, and the cervical spine radiographs were normal to the C6 level.

Computed tomography of the cervical spine to evaluate the cervicothoracic junction revealed airout lining acervical nerverootinan extradural location in one case, and a small epidural gas collection associated with pneumomediastinum and right main bronchus laceration in the other.

Cervical pneumorachis has been described in association with basilar skull fracture and unsuspected pneumothorax as well as pneumomediastinum after blunt chest trauma 20. It is relatively simple to understand why, with a basilar skull fracture involving an air cavity, air may be seen in the cervical subarachnoid space 21.

The etiology of pneumorachis associated with pneumothorax or pneumomediastinum is less evident.

Scialdone and Wagle postulate that rupture of the right main bronchus resulted in pneumomediastinum with secondary air tracking into the thoracic epidural space 22.

Cervical pneumorachis, in association with pneumomediastinum, may result either from rostral migration of air in the epidural space or through fascial planes of the mediastinum and neck epidural space. This theory may explain air transfer following pneumothorax as well 22. The most common cause of extradural air is iatrogenic from surgery, lumbar puncture, or epidural anesthesia 21, 22. *Laman and McCleskey* propose that air introduced into the epidural space during epidural anesthesia may escape from the epidural space via the neural foramina to enter the mediastinum**22**. Further air

transfer occurs by dissection through the deep fascia of the mediastinum and neck, to ultimately reach the subcutaneous tissue. The theory of air transfer that explains the occurrence of intraspinal air with pneumothorax and pneumomediastinum correlates well with this hypothesis of air transfer between the epidural space and subcutaneous tissues. Additional causes of extradural air include degenerative disc disease 23,24 and epidural abscess 25.

There are no epidemiological databut a review of the literature describes 71 case reports or series, each encompassing no more than three cases reporting a total of 86 cases of pneumorachis26. A recent review by Bellot*iet al*. found 42 reports for 47 cases of spontaneous Pneumomediastinum complicated by PR that were published between 1989 and 200927. The median age of occurrence was 18 years and there was a male predominance in the epidemiology. The diagnosis was always made by CT. In five of the cases, Pneumomediastinum and pneumorachis were associated with a pneumothorax.

Diagnosis

Since intraspinal air is usually asymptomatic and clinically unspecific, pneumorachis is primarily a radiographic and not a clinical diagnosis. The diagnostic work-up of patients with pneumorachis should include plain roentgenograms and CT scanning of the spine. X-ray may be helpful as an initial examination for the early detection of possible associated injuries and to detect larger amounts of intraspinal air.

A linear lucency along the spinal canal on a lateral chest radiograph was described as a useful sign in the detection of PR28. Moreover, PR itself to some extent acts as a negative contrast agent to delineate canal morphology 28. Pneumorrhachis is usually asymptomatic, reabsorbs spontaneously and is mostly managed conservatively. When symptomatic, the treatment should involve addressing the associated injuries 29. Occasionally, pneumorrhachis may results from spinal anaesthetics 30.

In traumatic patients, the presence of gas within the spinal canal is an indication for determining the aetiology and possible pathway of air entry into the space. Posttraumatic pneumorrhachis is thought to relate to increased morbidity and mortality rates. When associated with decreased intraspinal pressure, secondary to possible cerebrospinal fluid leakage, it is usually of a more benign character31.

However, when intraspinal air enters the craniospinal compartment with a one-way air valve mechanism, the gas is entrapped and might cause tension pneumorrhachis and pneumocephalus, which results in nervous tissue compression and requires intervention. 31

Generally, prophylactic management with antibiotics is not recommended in cases of extradural pneumorrhachis and in patients with intradural pneumorrhachis without signs and symptoms of meningitis.31

Since intraspinal air is usually asymptomatic and clinically unspecific, PR is primarily a radiographic and not a clinical diagnosis.The diagnostic work-up of patients with PR should include plain roentgenograms and CT scanning of the spine.

Differential diagnosis

Intraspinal gas collections due to degenerative, malignant, inflammatory and infectious diseases by gas-forming organisms. Intraspinal gas, which usually has the same low density as air collections on CT, cannot be clearly differentiated by CT examination and can simulate pneumorachis.

Management

Pneumorachis is usually asymptomatic, does not tend to migrate and reabsorbs spontaneously and completely with the air being passed directly into the blood in several days without recurrence. May cause syndromes of both intracranial and intraspinal hypertension as well as hypotension secondary to either an increase or decrease of intracranial and intraspinal pressure.Pneumorachis per se is rarely symptomatic, but if so, is associated with discomfort and pain or even neurological deficits. No empiric guidelines for the treatment of PR and standards of care exist. Thought to be associated with an increased morbidity and mortality. Pneumorachis associated with decreased intraspinal pressure secondary to cerebrospinal fluid leakage usually has a more benign character. Entrapped intraspinal air under pressure entering the cranio-spinal compartment usually in combination with a one-way air valve mechanism might cause tension pneumorachis and pneumocephalus with nervous tissue compression requiring intervention.

CONCLUSION

Pneumorrhachis can be caused by a multitude of sources and the evaluation of aetiologies of PR could be a diagnostic challenge. Although PR per se usually is self-limiting and without further therapeutic consequences, prompt recognition of the underlying cause is essential.

The attending spine specialist must carefully evaluate the associated pathologies leading to PR to enable adequate therapy.The incidental finding of intraspinal air in the trauma setting mandates a search for an etiology. Thus, when extradural air is present in the diagnostic work-up of a patient who has suffered blunt trauma or polytrauma, it is imperative to identify an unsuspected basilar skull fracture, pneumothorax, or pneumomediastinum, with open injury. Less likely possibilities in the differential diagnosis of intraspinal air, such as bronchial injury, spinal fracture, degenerative disc disease, or hollow viscous injury, may be considered in the appropriate setting. Pneumomediastinum associated with pneumorachis has a benign course in most patients and patients can be expected to recover fully.

Disclosure*:* The authors declare no conflicts of interest.

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References

1. Goh BK, Yeo AW. Traumatic Pneumorrhachis. *J Trauma* 2005;58(4):875-9
2. Oertel MF, Korinth MC, Reinges MH, KringsT, Terbeck S, Gilsbach JM. Pathogenesis, diagnosis and management of pneumorrhachis. *Eur Spine J* .2006; 15 (suppl 5): 636-643.

3. Caceres M, Ali SZ, Braud R, Weiman D, Garrett HE Jr. Spontaneous pneumomediastinum: a comparative study and review of the literature. *Ann Thorac Surg.* 2008; 86 (3): 962 - 966 .
4. Markus F. Oertel Æ Marcus C. Korinth Æ Marcus H. T. Reinges Æ Timo Krings Æ Sandra Terbeck Æ Joachim M. GilsbachPathogenesis, diagnosis and management of pneumorrhachis *Eur Spine J* (2006) 15 (Suppl. 5):S636-S643
5. Gordon IJ, Hardman DR. The traumatic pneumomyelogram. A previously undescribed entity. *Neuroradiology* 1977; 13: 107-108.
6. Newbold RG, Wiener MD, Vogler JB 3rd, *et al*. Traumatic pneumorrhachis. *Am J Roentgenol* 1987; 148: 615-616
7. Burke V, Mall JC: Epidural gas: an unusual complication of Crohn disease. *AJNR Am J Neuroradiol* 1984; 5: 105106.
8. Goh BKP, Yeo AWY. Traumatic pneumorrhachis. *J Trauma* 2005; 58: 875-879
9. BalachandranS, GuintoFC, GoodmanP, et al. Epidural pneumatosis associated with spontaneous pneumomediastinum. *Am J Neuroradiol* 1993; 14: 271-272.
10. Coniglio M, De Santis M, Pizzi G, *et al*. Pneumorachis associated with spontaneous pneumomediastinum. A case report. *Radiol Med* (Torino) 1997; 94: 531-532.
11. Defouilloy C, Galy C, Lobojoie E, *et al*. Epidurual pneumatosis: a benign complication of benign pneumomediastinum. Eur Respir J 1995; 8: 1806-1807.
12. Koelliker PD, Brannam LA. Epidural pneumatosis associated with spontaneous pneumomediastinum: case report and review of the literature. *J Emerg Med* 1999; 17: 247-250.
13. Newbold RG, Wiener MD, Vogler JB 3rd, *et al*. Traumatic pneumorrhachis. *Am J Roentgenol* 1987; 148: 615-616.
14. Newbold RG, Wiener MD, Volger JB, III, Martinez S (1987) Traumatic pneumorachis. *AJR Am J Roentgenol* 148: 615±616
15. North JW (1971) On the importance of intracranial air. *Br J Surg* 58: 826±829
16. Rogers LF (1982) Radiology of skeletal trauma. Churchill Livingstone, NewYork, pp221±223
17. North JW (1971) On the importance of intracranial air. *Br J Surg* 58: 826±829
18. Place JN, Pezutti RT (1989) Clinical significance of traumatic pneumorachis. *AJR Am J Roentgenol* 153: 655
19. Scialdone CJ, Wagle W (1990) Intraspinal air: an unusual manifestation of blunt chest trauma. *Clin Imaging* 14: 59±60
20. Khodadadyan C, Hoffman R, Neumann K, Sudkamp NP (1995) Unrecognized pneumothorax as a cause of intraspinal air. *Spine* 20: 838±840
21. Rogers LF (1982) Radiology of skeletal trauma. Churchill Livingstone, NewYork, pp221±223
22. Scialdone CJ, Wagle W (1990) Intraspinal air: an unusual manifestation of blunt chest trauma. *Clin Imaging* 14: 59±60
23. Austin RM, Bankoff MS, Carter BL (1981) Gas collections in thes pinal canal on computed tomography.*J Comput Assist Tomogr* 5: 522±524
24. Gulati AN, Weinstein ZR (1980) Gas in the spinal canal in association with the lumbosacral vacuum phenomenon: CT findings. *Neuroradiology* 20: 191±192
25. KirznerH, Oh YK, Lee SH(1988) Intraspinalair: aCT finding of epidural abscess. *AJR Am J Roentgenol* 151: 1217±1218
26. Oertel MF, Korinth MC, Reinges MH, *et al*. Pathogenesis, diagnosis and management of pneumorrhachis. *Eur Spine J* 2006; 159: 636-643.
27. Belotti EA, Mattia R, Rodoni-Cassis P, *et al*. Air within the spinal canal in spontaneous pneumomediastinum. *Chest* 2010; 137: 1197-1200.
28. Oertel MF, Korinth MC, Reinges MH, *et al*. Pathogenesis, diagnosis and management of pneumorrhachis. *Eur Spine J* 2006; 159: 636-643.
29. WośkoJ, DąbrowskiW, Zadora P FijałkowskaA, GrzyckaKowalczyk L: Odmaśródczaszkowaikanałukręgowego u chorego z urazemklatkipiersiowej. *AnestezjolIntens Ter* 2011; 43; 40-44
30. Nay PG, Milaszkiewicz R, Jothilingam S: Extradural airas a cause of paraplegia following lumbar analgesia. *Anaesthesia* 1993; 48:402-404
31. Dawoud El-Halabi, TaekAlkandari, Mohamed MammdohYaktien traumatic air in spinal canal (pneumorrhachis Anaesthesiology Intensive Therapy 2012; 44: 25-27

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