

Original Article

## Understanding Air in the Body: A Radiologic Perspective on Emphysematous and Traumatic Conditions

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### Abstract

**Background:** Abnormal collections of air within body tissues and anatomical compartments, although relatively uncommon, represent critical radiologic findings. The causative factors vary from invasive infections by gas-forming organisms to traumatic and iatrogenic breaches of tissue planes. Early and accurate radiologic identification is essential, as delayed diagnosis may result in significant morbidity and mortality. The study objective is to describe the spectrum of computed tomography (CT) imaging features, etiopathogenesis, and clinical significance of some emphysematous infections, including emphysematous pyelonephritis, cystitis, pancreatitis, and osteomyelitis, as well as traumatic and non-infectious air-related conditions such as pneumocephalus, subcutaneous emphysema, pneumothorax, pneumomediastinum, and pneumoperitoneum.

**Methodology:** A Pictorial review was conducted at a tertiary healthcare institution. The cases of emphysematous and traumatic air-related conditions diagnosed on computed tomography between July 2024 and June 2025 were retrieved from the Picture Archiving and Communication System (PACS), and characteristic diagnostic imaging findings were analysed. The clinical parameters and outcomes of patients were also analysed using hospital records, and findings were correlated with scholarly published literature.

**Results:** Most emphysematous infections, including pyelonephritis and pancreatitis, as well as trauma-related conditions such as tension pneumocephalus and pneumomediastinum, are associated with a high risk of mortality. Computed tomography consistently demonstrated the highest sensitivity for accurate diagnosis and for stratifying disease severity.

**Conclusion:** Abnormal air patterns represent a critical diagnostic feature in radiology, particularly on computed tomography. The knowledge of these characteristic imaging signs and their clinical relevance allows early intervention and better patient management.

**Keywords:** Emphysematous pyelonephritis, emphysematous pancreatitis, pneumomediastinum, pneumocephalus, pneumoperitoneum, computed tomography.

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## Introduction

Emphysematous conditions of air beyond its normal anatomical confines are uncommon but potentially fatal pathologies [1]. Depending on the etiological conditions, it may result from either gas-forming bacterial infections or from disruption of natural barriers following trauma or instrumentation. Infections such as emphysematous pyelonephritis or pancreatitis can lead to septic shock, and traumatic entities like tension pneumocephalus or oesophageal rupture have catastrophic outcomes [2,3]. The pneumo-parotid can be caused iatrogenically when a patient is asked for a puffed cheek manoeuvre for imaging pathology of buccal mucosa, and air is refluxed into the parotid gland or Stensen's duct [4]. The vascular air embolism is another radiological iatrogenic condition that is seen during or after contrast-enhanced CT scanning [5].

Radiology has a pivotal role to play in identifying these conditions, and CT is extremely sensitive in detecting even small gas volumes and delineating their anatomic distribution.

In this article, we aim to synthesise our institutional experience with these conditions across multiple body systems. Although relevant literature exists, it remains limited in scope; therefore, we seek to supplement it with contemporary evidence that highlights the CT imaging characteristics and clinical impact, thereby providing a more comprehensive overview.

## Methodology

A Pictorial review was conducted at our tertiary care institute. All computed tomography (CT) scans performed between July 2024 and June 2025 were retrieved from the picture archiving and communication system (PACS). A total of approximately 12780 scans were evaluated during this period. From these, all cases demonstrating air-related infections or gas-forming conditions were identified; these included emphysematous infections as well as traumatic or non-traumatic infective air-related abnormalities (**Table 1**). The characteristic diagnostic imaging features on CT were meticulously analysed. In addition, clinical parameters and patient outcomes were reviewed from the hospital records. Findings from our study were then correlated with previously published literature to contextualise patterns and enhance the interpretation of our results.

## Limitations

1. Only CT studies available on PACS were included, and cases evaluated using other imaging modalities or managed without CT may have been missed.
2. Despite reviewing a large number of CT scans, the number of air-related infections and gas-forming conditions was limited, restricting statistical analysis.

**Table 1. Distribution of cases identified on Computed Tomography (July 2024-June 2025)**

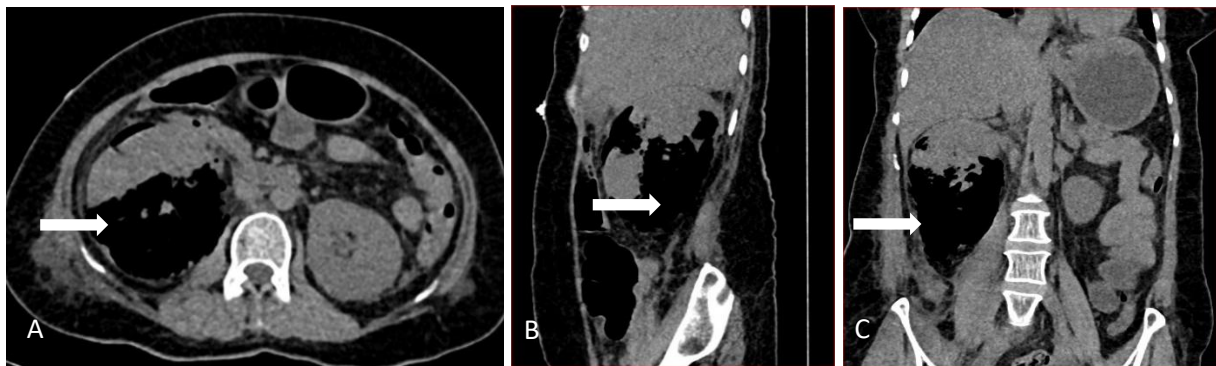
Clinical Condition (Diagnosis)	Number of Cases (n)	Percentage (%)
Emphysematous pyelonephritis	14	14.9
Emphysematous cystitis	3	3.2
Emphysematous pancreatitis	2	2.1
Emphysematous osteomyelitis	1	1.1
Pneumocephalus	20	21.3
Laryngeal trauma with subcutaneous emphysema	1	1.1
Pneumothorax	19	20.2
Pneumomediastinum	4	4.3
Pneumoperitoneum	18	19.1

Clinical Condition (Diagnosis)	Number of Cases (n)	Percentage (%)
Pneumobilia	4	4.3
Air embolism	2	2.1
Pneumoparotitis	6	6.4
<b>Total</b>	<b>94</b>	<b>100.0</b>

## Emphysematous Infections

### Emphysematous Pyelonephritis (EPN)

EPN is a radiologically diagnosed, grave, necrotising renal infection caused by gas-forming bacteria that proliferate within the parenchyma and collecting system, resulting in high rates of renal loss and mortality associated with diabetes mellitus, which is the greatest risk factor; other non-diabetic risk factors are obstructive uropathy and immunosuppression [6]. The common causative organisms are *E.coli*, *Klebsiella pneumoniae*, and *Proteus mirabilis* [7]. Though plain X-ray shows mottled gas within the renal fossa and Ultrasound showing coarse echoes/reverberation artefacts but the CT is indispensable, demonstrating mottled or streaky gas located within the renal parenchyma, perinephric tissues, or retroperitoneum (**Fig. 1**). The Huang–Tseng devised a clinical radiological classification system which separates Type I, which is having diffuse gas without fluid, having a poorer prognosis with mortality up to 20-40%, whereas Type II is having gas with fluid collections and has better prognostic significance. Patients are managed by broad-spectrum antibiotics, strict glycaemic control, and urinary decompression, commonly by radiological interventions, which are first-line and prompt treatment improves survival significantly, while in refractory cases, nephrectomy is reserved [8].



**Figure 1.** A 68-year-old woman with diabetes mellitus presented to the emergency department with a 5-day history of right renal angle pain, fever, and vomiting. Non-contrast Computed Tomography images (A, axial; B, sagittal; and C, coronal) demonstrate a large volume of gas (white arrow) involving the right renal and perinephric regions.

### Emphysematous Cystitis

Emphysematous cystitis (EC) is a relatively rare but clinically significant entity characterised by the presence of gas within the lumen and bladder wall. It is caused by gram-negative bacteria such as *Escherichia coli* and *Klebsiella pneumoniae*. It has a strong correlation with immunosuppression, diabetes mellitus, urinary tract blockage, or long-term catheterisation, and also occurs approximately twice as often in women as in men [9,10].

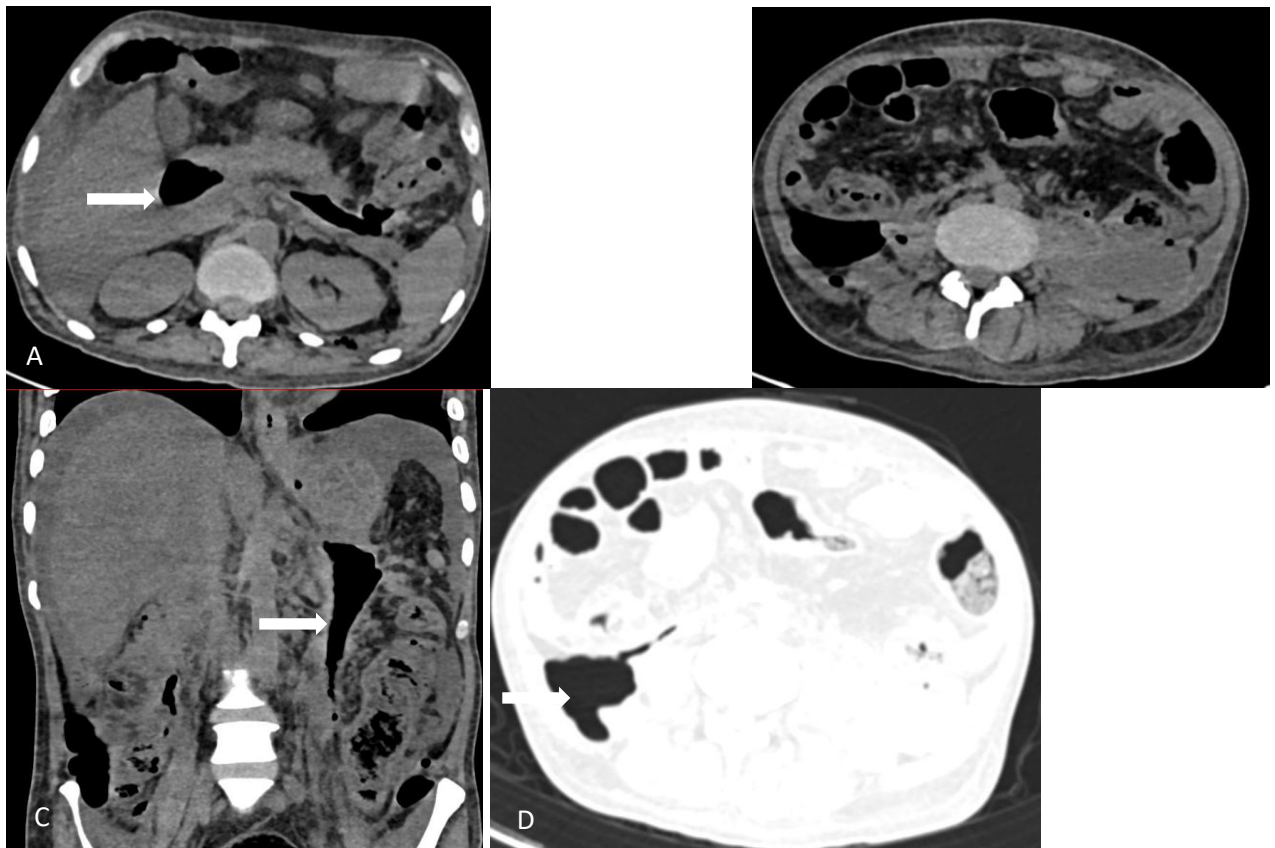
Pneumaturia, abdominal discomfort, haematuria, and dysuria are among the vague symptoms that patients present with. As this is a potentially fatal condition, and to avoid complications, such as sepsis and emphysematous pyelonephritis, early identification is essential. Plain X-ray abdomen, though, is the most common initial imaging modality, but it has low specificity. It may show a radiolucent gas outlining the bladder wall, seen as “curvilinear rim of gas”) or “Cobblestone” or “mottled” gas appearance within the bladder wall (**Fig.2**). The ultrasound is low in sensitivity and shows indirect signs in emphysematous cystitis, such as bladder wall thickening with increased echogenicity. The computed tomography is the most sensitive and specific imaging modality. It depicts air within the bladder wall, which is pathognomonic, and also Intraluminal gas resulting in air-fluid levels. The bladder wall may be thickened with peri-cystic fat stranding. The management of emphysematous cystitis is sensitive to antibiotics, along with adequate drainage of urine, and serial radiological assessment [11,12].



**Figure 2.** A 72-year-old woman with diabetes mellitus presented to the emergency department with fever and dysuria. Non-contrast Computed Tomography images (A, axial; B, sagittal; and C, coronal) demonstrate a circumferential intraluminal gas (white arrow) along the bladder wall.

### Emphysematous Pancreatitis

Emphysematous pancreatitis is a rare, fatal complication of acute severe pancreatitis characterised by the presence of air within or around the pancreas. It is caused by infection with gas-forming organisms represent rapid clinical deterioration if untreated [13,14]. The gram-negative anaerobes are the most common organisms associated with Emphysematous infection, and *Escherichia coli* is the most common one [13,15]. This condition has having grave prognosis, and early radiological assessment is important in influencing patient outcome by CT is the primary modality of choice for diagnosing emphysematous pancreatitis due to its high specificity and sensitivity in delineation of abnormal gas, either intraparenchymal or peripancreatic gas within areas of necrosis, which is considered virtually pathognomonic for infection (**Fig.3**). The patient is managed with supportive treatment, which includes early initiation of broad-spectrum intravenous antibiotics and care in an intensive setting is sometimes essential. Some patients with persistent infected collections may require definitive therapy, which may involve percutaneous image-guided drainage or surgical necrosectomy [17].

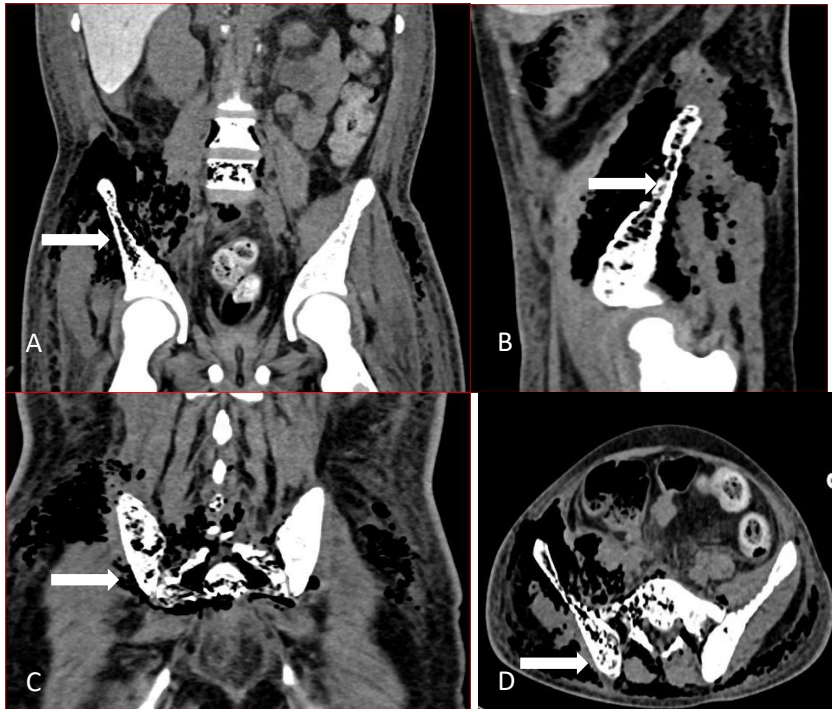


**Figure 3.** A 42-year-old known case of recurrent alcohol induced pancreatitis presented to the emergency department with severe epigastric pain and vomiting. Non-contrast CT images (A, B, D, axial; C, coronal) demonstrate a large amount of gas in the peripancreatic locations (white arrow).

### Emphysematous Osteomyelitis

Emphysematous osteomyelitis is a rare but potentially life-threatening condition that needs aggressive management [18]. The first case of emphysematous osteomyelitis on a CT scan was described by Ram et al. in 1981. The cause of infection is monomicrobial or polymicrobial by anaerobes or Enterobacteriaceae, but in our case, due to post-splenectomy status, *Streptococcus pneumoniae* was the causative agent, which is not seen in the published scholarly work [19]. Imaging plays a crucial role in diagnosing a case of emphysematous osteomyelitis; moreover, it is difficult to distinguish between the emphysematous and non-emphysematous osteomyelitis only based on symptomatology and clinical examination [20]. Though Plain X-rays can detect air pockets in soft tissue and bone, in most cases, and in our case, they are inconclusive. Ultrasound has limitations due to air, which casts reverberation artefacts. CT scan sufficiently confirmed the diagnosis of emphysematous osteomyelitis, and it also efficiently described the entire extent of the spread of the disease [17,18] (**Fig.4**). The bones commonly involved are thoracic and lumbar vertebrae, sacrum, femur, pelvis, tibia or fibula and in our case, there is extensive involvement of multiple bones, i.e. sacrum, pelvic bones and bones of the right foot.

The radiological differential diagnosis to be considered is osteonecrosis, post-intervention, like bone biopsy, open fracture or wound, and invasive malignant pathology, but extension into adjacent soft tissue favours the diagnosis of emphysematous osteomyelitis [19,21]. The radiological examination plays an important role in diagnosing the nature and extent of the disease and guides the implementation of an aggressive treatment plan [17,18]. The surgical debridement and intravenous antibiotic therapy are the cornerstones of management of this condition, as well as controlling the spread of the infection [20,21].



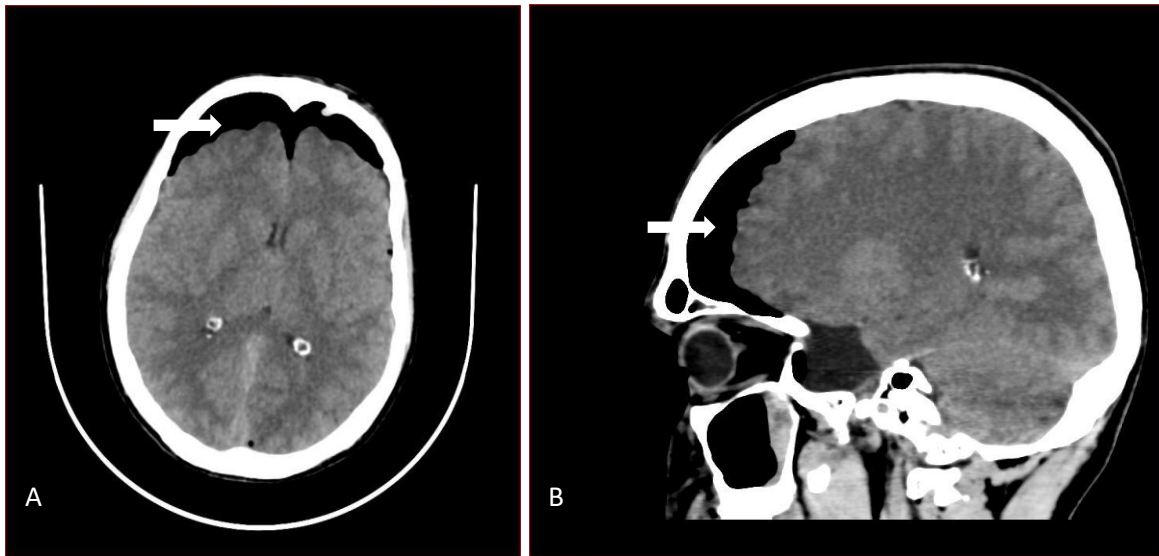
**Figure 4.** A 23-year-old man with known Thalassemia major and a history of splenectomy presented in a debilitated state to the emergency department, having sepsis for 3 days with gradually increasing fever, oedema, pain, and inability to move for the past month. He was investigated in the radiology department with CECT of the chest, abdomen, and lower limbs. Findings noted on CECT were the presence of multifocal extensive emphysematous osteomyelitis seen involving the pelvic bones (arrow). This case was managed, though unsuccessfully, in the intensive care unit empirically with antibiotics as per microbiological sensitivity and surgical drainage and debridement, but unfortunately patient succumbed in 10 days.

## Traumatic and Non-Infectious Air Conditions

### Pneumocephalus and the Mount Fuji Sign

Pneumocephalus, also known as pneumo-cranium, is defined as the presence of abnormal air within the cranial cavity, most frequently associated with traumatic injury to the head, surgical procedures of the brain, and rarely infections and spontaneous causes [22]. Air may be seen in epidural, subdural, subarachnoid, intraparenchymal, or interventricular compartments. Tension pneumocephalus is seen radiologically on computed tomography as air causing compression of the frontal lobes and widening of the interhemispheric space between them, termed the Mount Fuji sign, resembling iconic mountain peaks in Japan [23](**Fig.5**). Treatment depends on the cause, and most cases are stable; air gradually gets reabsorbed and some resolve with bed rest, oxygen therapy, and avoidance of Valsalva manoeuvres. A few severe cases may require urgent neurosurgical intervention [22,24].

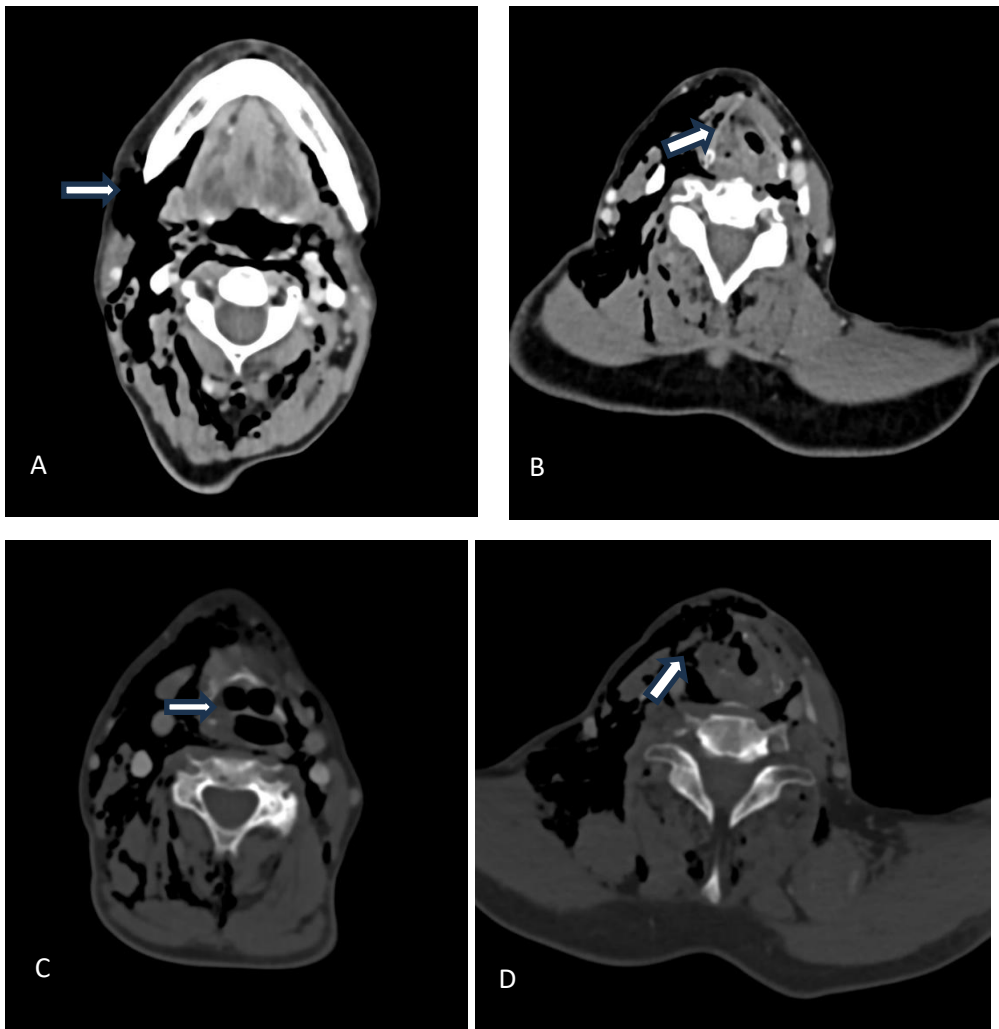
. (5)



**Figure 5.** A 28-year-old man was admitted to the emergency ward following a road traffic accident with a head injury. Non-contrast Computed tomography (NCCT) images (A, axial; and B, Sagittal) demonstrate bilateral low-attenuating subdural air collections compressing and separating the frontal lobes, with widening of the interhemispheric space in between the tips of the frontal lobes, giving a characteristic “mount fuji sign”.

### **Emphysema in the subcutaneous and intermuscular planes secondary to Laryngeal trauma**

Laryngeal fracture, though rare with an incidence of 1:37000, is a potentially fatal condition with mortality ranging from 2.04% to 15% [25]. These injuries are commonly caused by blunt trauma to the neck, roadside accidents, assaults, and sports-related injuries [26]. The spectrum of injuries depends upon the mechanism of the injury, which can range from mild mucosal injury to fractures of the laryngeal and cartilaginous framework. To prevent mortality and morbidity, correct early diagnosis and acute airway management are of utmost importance in the emergency department. In the published literature, investigators have shown favourable outcomes and recovery, which depend upon precise imaging diagnosis of laryngeal injuries and subsequent prompt restoration of the laryngeal framework. The high rate of mortality up to 80% is in the pre-hospital setting, whereas once the airway is secured and injury to the laryngeal framework is correctly diagnosed, the mortality rate is drastically reduced to 5% [27]. It is important to have suspicion of laryngeal framework injury in blunt trauma neck, getting prompt imaging diagnosis and subsequent management, thus preventing mortality and morbidity [28]. MDCT provides a rapid, detailed assessment of both soft tissue and cartilaginous injuries, often outperforming conventional radiography and even endoscopy in the acute setting (**Fig.6**).

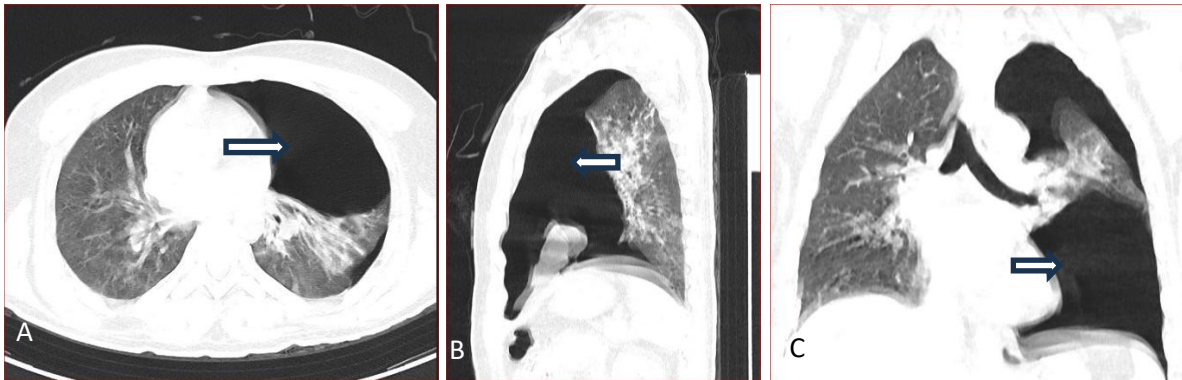


**Figure 6:** A 76-year-old woman involved in a road traffic accident sustained blunt trauma to the anterior neck, presenting with neck swelling, respiratory distress, and hoarseness of voice. On suspicion of laryngeal trauma, a Multi-detector Computed Tomography (MDCT) scan was obtained. Axial CECT scan (**Image A**) of neck demonstrates Extensive emphysema is seen involving the subcutaneous, intermuscular and interfascial planes of neck bilaterally(Right>Left), Axial CECT (**Image B**) scan of neck shows heterogenous area is seen in the region of supraglottic and glottis on right side leading to mass effect on true and false vocal cords and displacement towards contralateral side- Hematoma with laryngeal edema, Axial CECT (**Image C**) scan of neck demonstrates fracture of inferior cornu of thyroid cartilage with disruption of cricothyroid membrane. Axial CECT scan (**Image D**) of the neck shows near complete disruption of the thyro-cricoid membrane on the right side, with communication of the laryngeal lumen with the extralaryngeal space.

### Pneumothorax

Pneumothorax is the presence of air in the pleural space separating the two visceral and parietal pleura and collapsing the lung parenchyma. Pneumothorax can be traumatic or non-traumatic; when it is non-communicating, it is called simple, whereas it is called tension pneumothorax when there is a persistent pleural defect causing its progressive enlargement, resulting in disruption of pleural cavity dynamics, exerting pressure on the diaphragm and mediastinal structures, resulting in potentially fatal hypoxemia, venous obstruction, and cardiovascular collapse [29,30]. Pneumothorax is evaluated initially with chest

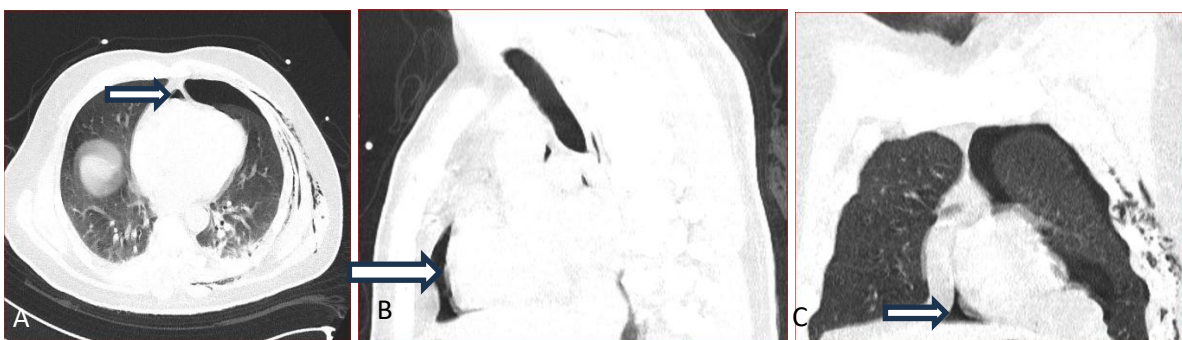
radiograph, and various radiographic signs like visceral pleural line, absence of lung markings distal to the visceral pleural line, collapse of lung, tension pneumothorax resulting in shifting of mediastinal structures, etc, are seen. The ultrasonography may be specific in demonstrating absent lung sliding signs in cases of pneumothorax. The computed tomography is a definitive imaging modality in pneumothorax [29] (**Fig.7**). The treatment of pneumothorax is based on the quantity of air and the severity. Watchful waiting for spontaneous results is done in case of small asymptomatic cases, whereas in cases of tension pneumothorax, prompt needle decompression followed by chest tube thoracotomy is done [29,31].



**Figure 7:** A 27-year-old man with a history of a road traffic accident, sustained blunt chest trauma, and presented to the emergency department with left-sided chest pain and low oxygen saturation. The CT chest demonstrates a left-sided pneumothorax associated with partially collapsed upper and lower lobes of the lung.

### Pneumomediastinum

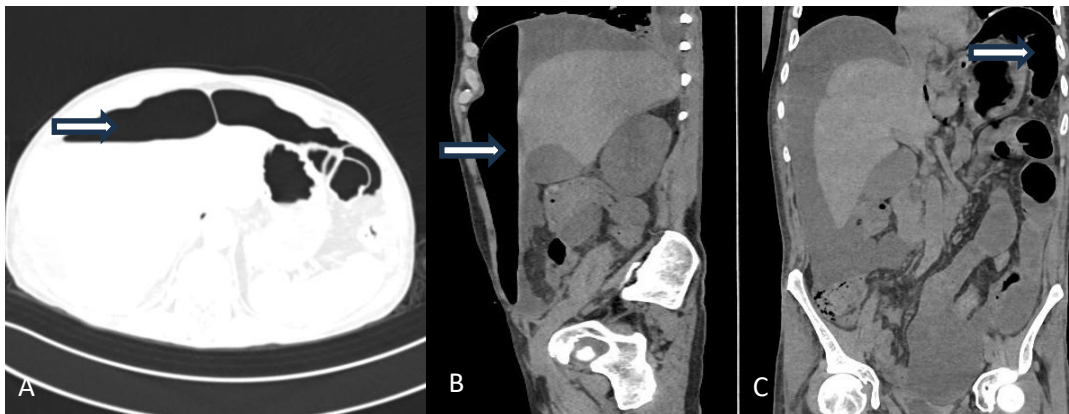
Pneumomediastinum refers to free air or gas in the mediastinum, and its aetiological pathologies, which can be traumatic or non-traumatic or spontaneous, may originate from lungs, like alveolar rupture, a narrowed or plugged bronchial tree, perforated oesophagus, perforated hollow viscus in the abdomen, or from the neck, like laryngeal trauma. Spontaneous cases are often self-limiting, whereas secondary forms may become life-threatening [32,33,34]. Though chest radiograph is the first line of investigation for diagnosing many signs, like the continuous diaphragm sign, CT is a definitive modality demonstrating mediastinal gas tracking along fascial planes and air outlining various mediastinal structures [32] (**fig.8**). Treatment of pneumomediastinum also depends on the amount of air and the severity it is causing. While mild cases are managed by supportive care of bed rest, pain control, oxygen administration, etc, severe cases may require a surgical procedure and chest tube drainage if associated with pneumothorax [33].



**Figure 8.** A 65-year-old man with sudden onset dyspnoea presented to the outpatient department. The chest radiograph was unremarkable; however, non-contrast computed tomography (NCCT) of the chest demonstrated a mild left-sided pneumothorax with a small loculated pneumomediastinum. The patient improved with supportive care, and both the air in the thorax and mediastinum resolved gradually.

### Pneumoperitoneum

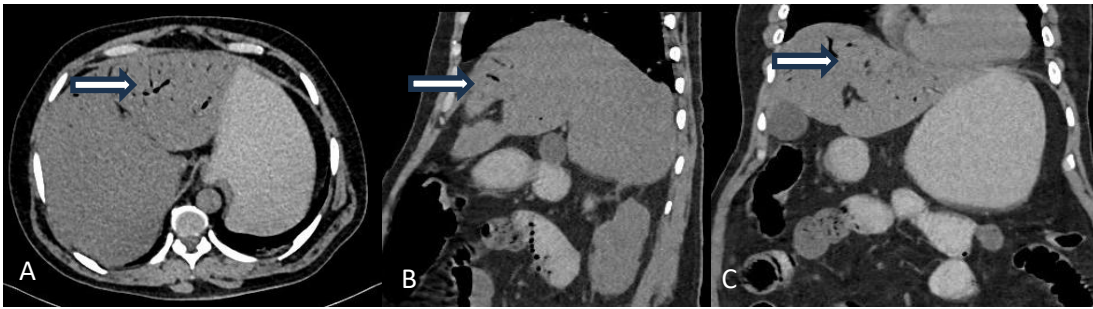
Pneumoperitoneum refers to the abnormal presence of air in the peritoneum and is often due to a hollow viscus perforation, which is a surgical emergency, besides numerous other causes like abdominal trauma, postoperative states and spontaneous benign pneumoperitoneum, and the clinical relevance varies with these modes of entry of gas within the peritoneal cavity [35]. Plain X-ray film of the abdomen shows gas under the diaphragm in the standing position, the Rigler sign, which is a double wall sign of air on both sides of the bowel wall, and the football sign, given by air along the peritoneal ligament. The Contrast-enhanced CT is the most sensitive imaging modality, which detects even a small amount of air in the peritoneal cavity, and it may accurately identify the perforation site and is capable of guiding surgical or interventional management (**Fig. 9**). Therefore, it enables early recognition for surgical intervention to reduce mortality and morbidity [35,36].



**Figure 9.** A 28-year-old man presented to the emergency department with a history of a road traffic accident, sustaining blunt trauma to the abdomen. Non-contrast CT of the abdomen demonstrates free air within the peritoneal cavity and under the left dome of the diaphragm, seen as a dark, low-density lucent area (arrow)

### Pneumobilia

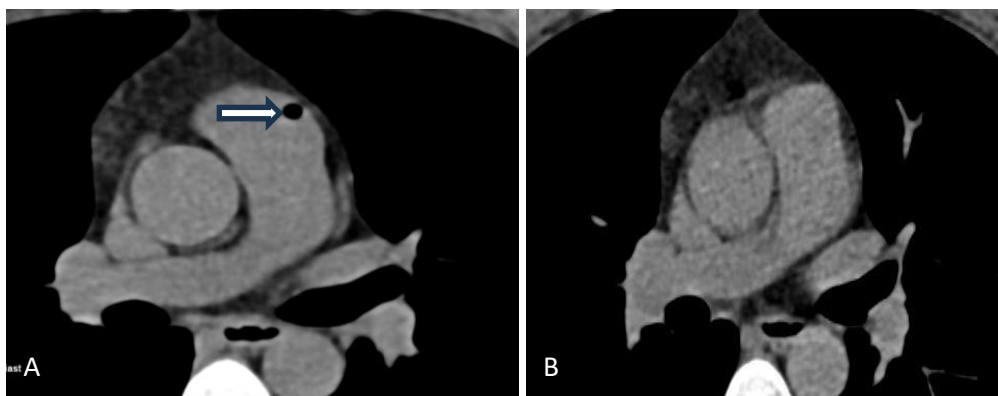
Pneumobilia refers to the presence of air in the gall bladder or biliary tree and is a common finding after intervention procedures carried out on the bile duct, like endoscopic biliary manipulations, etc. It may be associated with emphysematous cholecystitis, cholangitis, cholecystoduodenal fistula, blunt trauma to the abdomen, and small bowel obstruction. Prompt diagnosis of pneumobilia is important as it may sometimes lead to cholangitis[37,38]. The plain X-ray abdomen may sometimes reveal a sword-shaped lucency in the common hepatic duct as the sabre sign. Ultrasound is a sensitive modality that detects gas in the biliary tree as reverberation artefacts. However, CT remains the gold standard for establishing the diagnosis of pneumobilia; it also differentiates gas within the biliary tree from the portal venous system, as air tends to be central in the biliary tree and peripheral in the venous system [39] (**Fig.10**).



**Figure 10.** A 75-year-old man presented to the outpatient department with abdominal discomfort, fever, and jaundice. Non-contrast CT abdomen demonstrates focal intra-biliary air within the left hepatic lobe bile ducts (Arrows)

### Air embolism after contrast administration in computed tomography

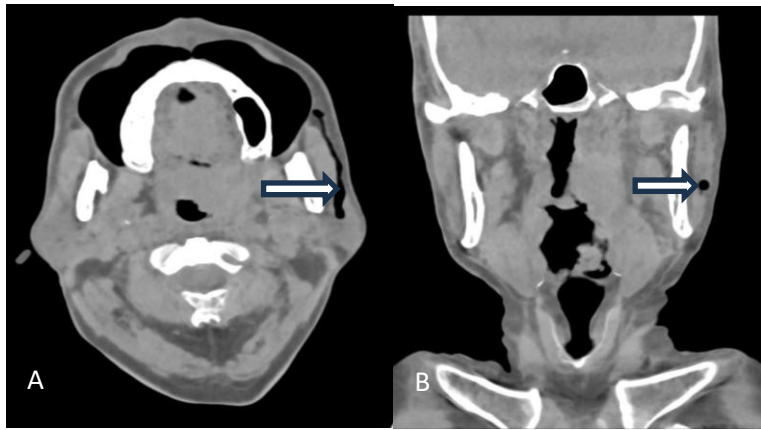
Air embolism in the venous or arterial system is a common iatrogenic condition often reported as a consequence of the injection of contrast [40]. Though it is a non-symptomatic, non-fatal condition, patients with risk factors like arteriovenous malformations, cardiac shunts, particularly right-to-left, may lead to neurological deficits even with a small amount of air embolism; moreover, 100cc or greater amount of air has been reported fatal [40,41]. Therefore, asymptomatic air embolism does occur frequently and does not require intervention, but vigilance is recommended to prevent air embolism during contrast administration [41,42] (**Fig. 11**).



**Figure 11.** A 42-year-old man underwent CT coronary angiography for atypical chest pain. An incidental air embolism was identified within the aortic arch (**arrow in image A**), likely secondary to the inadvertent air introduction during contrast injection. The patient remained asymptomatic, and follow up non-contrast CT performed the following day demonstrated complete resolution of the air embolism (**Image B**).

### Pneumoparotid

Pneumoparotid also referred as pneumoparotitis, pneumosialadenitis etc. is a condition with air within the parotid gland and Stensen's duct, a rare condition with variable causative factors, but commonly seen in patients with lesions in the buccal and oral cavity region undergoing computed tomography examination with the "puffed cheek" technique, in which the patient is asked to blow air in a closed mouth [43] (**fig.12**). Though some patients may experience transient fullness but this condition is self-limiting without any complications [43,44].



**Figure 12.** A 76-year-old man underwent a computed tomography scan for a buccal mucosal ulcer. During the puffed-cheek manoeuvre, incidental insufflation of air into the left Stensen’s duct was observed (arrows).

### Discussion

The abnormal presence or entry of air or gas in various body tissues and compartments is either due to emphysematous infection or due to air leak. The conditions related to emphysematous infections -like pyelonephritis, osteomyelitis, and pancreatitis are due to gas produced in situ by gas-forming organisms in tissues of the body, which are poorly perfused or necrotic and are commonly seen in diabetic and immunosuppressed patients [45]. Emphysematous infections represent life-threatening conditions requiring an aggressive approach to management, whether medical or surgical. Though initial evaluation is done with conventional X-ray and ultrasonography, these are inconclusive most of the time; therefore, CT becomes the modality of choice due to its high sensitivity and specificity in detecting as well as localising the abnormal air. Moreover, CT can also differentiate benign from pathological gas sources, which is of utmost importance as treatment decisions hinge on the underlying cause [45] (Table 2).

**Table 2. Radiologic Manifestations of Pathologic Air in Infectious and Traumatic Conditions**

Condition	Key CT features	Clinical implication
Emphysematous Pyelonephritis	Mottled intraparenchymal/perinephric air	Sepsis, retroperitoneal spread
Emphysematous Cystitis	Curvilinear bladder wall air	Sepsis
Emphysematous Pancreatitis	Air in the necrotic pancreatic tissue and peripancreatic region	Sepsis Multiple organ dysfunction syndrome (MODS)
Emphysematous Osteomyelitis	Linear or mottled air in the bone	Systemic sepsis
Pneumocephalus	Bilateral frontal lobe compression with a peaked contour giving the “Mount Fuji sign.”	Raised Intracranial pressure (ICP), brain herniation

Laryngeal trauma with subcutaneous emphysema	Air in various soft tissue compartments	Sepsis
Pneumo-thorax	X-ray showing viscera pleural line beyond which pleural markings are absent.	Tension pneumothorax leading to obstructive shock.
Pneumo-mediastinum	Continuous diaphragm sign on X-ray, mediastinal air	Tension in the mediastinum leading to shock, sepsis.
Pneumo-peritoneum	Gas under the diaphragm on x-ray abdomen standing.	Peritonitis Sepsis
Vascular air embolism	Air foci within vessels	Mostly asymptomatic does not require intervention
Pneumo-parotid	Air in the parotid ductal system	Mostly asymptomatic does not require intervention

On the other hand, there are conditions in which there are mechanical air leaks in entities like pneumocephalus, pneumothorax, pneumomediastinum, laryngeal trauma, air embolism, etc. In these conditions, air enters through breaches in alveoli, airways, hollow viscus, or vascular channels. The clinical implications are variable and depend upon the site, amount, and rapidity of air accumulation, with symptoms varying from mild to life-threatening in cases of tension pneumothorax and tension pneumocephalus. Diagnostic radiology, CT in particular, plays an important role in diagnosis and quantifying the air, and treatment revolves around decompression, repair of the defect, and supportive care, and in cases of vascular air embolism, hyperbaric oxygen, along with positioning strategies, plays an important role.

The challenge is twofold for radiologists: on one hand, to detect even small amounts of abnormal air, and on the other hand, to distinguish life-threatening causes from incidental findings. CT remains a robust imaging modality for both detection and prognostic stratification, enabling timely surgical or interventional decisions.

### How CT Altered Management

In our study, CT played a decisive role in altering patient management by enabling early and confident identification of pathological air, precise localization, and assessment of disease extent. In cases of emphysematous infections, CT not only confirmed the presence of gas but also delineated its distribution within organs, adjacent soft tissues, and fascial planes, thereby helping to distinguish focal disease amenable to conservative management from extensive involvement requiring urgent surgical intervention. CT findings such as intraparenchymal gas, perinephric or retroperitoneal extension, and associated

collections directly influenced decisions regarding antibiotic escalation, percutaneous drainage, or emergency surgery. In air-leak syndromes, CT helped quantify the volume of air, detect subtle breaches, identify associated injuries, and recognise tension physiology, prompting timely decompression or surgical repair. Thus, CT served as a critical problem-solving tool that bridged clinical suspicion and definitive management.

### **Diagnostic Challenges and Mimics**

Despite its high sensitivity, the interpretation of abnormal air on CT can be challenging due to several mimics. Benign or iatrogenic air related to recent procedures, postoperative states, instrumentation, or trauma can closely resemble pathological gas, particularly in critically ill patients. Infections may be overdiagnosed when intraluminal bowel gas, vacuum phenomena, degenerative disc gas, or physiological air in sinuses and joints are misinterpreted as disease. Conversely, early emphysematous infections with minimal gas may be overlooked, especially if clinical suspicion is low. Differentiation requires careful evaluation of gas morphology, location, associated soft tissue changes, enhancement patterns, and clinical context. Awareness of these pitfalls is essential to avoid unnecessary interventions or delays in treatment.

### **Relevance to Emergency and Low-Resource Settings**

The role of CT is particularly significant in emergency and low-resource settings, where rapid and accurate diagnosis can be life-saving. In acute care scenarios, CT offers a single comprehensive examination capable of identifying the source of abnormal air, associated complications, and alternative diagnoses, thereby reducing diagnostic uncertainty. Although access to advanced imaging may be limited in resource-constrained environments, CT—when available—provides high diagnostic yield and can prevent inappropriate surgeries or missed life-threatening conditions. Even in settings where immediate surgical or interventional facilities are not available, CT findings assist in triage, referral decisions, and prioritisation of care. Familiarity with key CT imaging patterns of pathological air, therefore, remains crucial for radiologists working across diverse healthcare settings.

### **Limitations**

This study has certain limitations. Its retrospective design may have introduced selection and information bias, as imaging and clinical data were dependent on existing records. Being a single-centre experience, the imaging patterns and management implications observed may not be fully generalisable to other institutions with different patient populations and imaging practices. Additionally, although a large number of CT scans were reviewed, individual air-related pathologies—particularly rare conditions—were represented by small sample sizes, limiting subgroup analysis and broader extrapolation of findings.

### **Conclusion**

Pathologic air requires prompt detection, whether arising from infection or trauma, and its identification on imaging should immediately alert the radiologist to potentially life-threatening underlying conditions. Familiarity with the characteristic imaging patterns—particularly on CT—allows accurate localisation, etiologic differentiation, and assessment of disease extent, thereby guiding appropriate and timely clinical decision-making.

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