

Thomas Pavillion March 15, 2000

- 7:30–8:00 Coffee and Pastries
- 7:30–7:45 Case of the Day
Perry G. Pernicano, MD
- 7:45–8:00 Case of the Day
Satinder P. Singh, MD

Workshops

Sessions 1 - Empress Room
Sessions 2 - Thomas Pavillion
Sessions 3 - Regent Room
Sessions 4 - Viceroy Room

- 8:00–8:45 Session 1: Writing a Research Grant*
Ella A. Kazerooni, MD
- Session 2: Thoracic Radiology in Kidney and Liver Transplantation
Joel E. Fishman, MD, PhD
- Session 3: Airways Disease in Children
Sandra S. Kramer, MD
- Session 4: Protocol Selection for Thoracic Helical (Spiral) CT
Philip Costello, MD
- 8:45–9:30 Session 1: Effective Slide Presentation
Lynn S. Broderick, MD
- Session 2: Complications of Lung Transplantation: Acute and Chronic
Jannette Collins, MD, MEd
- Session 4: The Spectrum of Eosinophilic Lung Disease: Radiologic Findings
Kyung S. Lee, MD
- 9:30–9:45 Break
- 9:45–10:30 Session 1: Writing Up Your Research
N. Thorne Griscom, MD
- Session 2: Bone Marrow Transplantation Pulmonary Complication
Marc V. Gosselin, MD
- Session 3: Respiratory Emergencies in Infants and Children
Kook S. Oh, MD
- Session 4: HRCT: Know Your Buzz Words
Eric J. Stern, MD, Jannette Collins, MD, MEd

*Abstract not available at time of publication.

Wednesday



Writing a Research Grant

Ella A. Kazerooni, MD

Abstract not available at time of printing

Thoracic Radiology in Kidney and Liver Transplantation

Joel E. Fishman, MD, PhD

Objectives

- 1) To familiarize the chest radiologist with the applications of chest radiography and chest CT in patients undergoing liver and kidney transplantation, which are now commonplace procedures in end-stage organ disease.
- 2) To identify preoperative findings on chest radiographs that may affect subsequent care.
- 3) To know the expected appearances of perioperative life support lines and the most frequent perioperative complications.
- 4) To be familiar with the most common postoperative complications in transplant recipients, particularly infection and malignancy.

Introduction

In the past several decades, kidney and liver transplantation have become the procedures of choice in treating many of the causes of end-stage disease in those organs. Renal transplantation, beginning in the 1960's, has now been performed in tens of thousands of patients worldwide [1]. Mortality rates have fallen to less than 5% in the first year, due to improved immunosuppressive agents (azathioprine and prednisone in the 1960's, cyclosporine beginning in the 1980's, and the macrolide antibiotic tacrolimus (FK 506) in this decade), closer HLA matching, and reduced technical prob-

lems in the procedure itself [2]. Liver transplantation, initially a procedure reserved for the desperately ill, has now become an accepted, lifesaving procedure that can be performed much earlier in the course of liver failure [3]. In 1995, 3,700 patients received liver allografts in the United States, predominately using the orthotopic procedure (removing the recipient's liver and replacing the donor organ in the same location). However, other approaches are possible; in recent years, for example, partial transplant from a living related donor has achieved increasing success, in both the pediatric and adult population. Although the majority of radiological procedures in transplant recipients are below the diaphragm, chest radiology (including plain radiographs, chest CT, and chest biopsy procedures) is important to the overall care of these complicated individuals. In general, this abstract will consider chest radiological applications in the preoperative, perioperative, and postoperative periods.

Preoperative Evaluation

Kidney Transplantation

Of absolute contraindications to kidney transplantation, those of which the chest radiologist should be aware include *advanced cardiovascular disease* and *active infection* [1]. Heavy coronary artery and aortic calcification often mark premature vascular disease,



which can be visible on the chest radiograph. Significant ischemic heart disease is present in 5% of patients under age 55 who are considered for transplantation. Note that hypertension, occasionally with cardiomegaly, is present in 80% of prospective kidney recipients. Patients with “uremic lung” (pulmonary venous hypertension due to fluid retention) may go into right heart failure secondary to perioperative fluid administration. The preoperative radiograph should be assessed for active infection, which if present is frequently of respiratory tract or urinary origin. Indications of prior TB infection should be sought, knowing that the PPD may be false-negative in dialysis patients secondary to relative immunosuppression. Patients on transplant waiting lists may go years between chest radiographs, therefore interval development of neoplasm should be sought.

Liver Transplantation

Absolute contraindications to liver transplantation include *active infection* and *malignancy*, as with renal transplants. As above, there is particular concern for tuberculosis. If the patient is PPD+ or comes from an endemic area, there is increased chance of reactivation postoperatively. Some centers treat with TB prophylaxis if there are chest radiographic changes of healed TB even if therapy was given previously. Liver transplants are performed for primary, non-metastatic hepatocellular carcinoma in many centers, so evidence of thoracic metastasis must be actively pursued.

Advanced cardiopulmonary disease is also a contraindication to liver transplantation, but correctable causes of dysfunction must be sought before removing a patient from the waiting list. Cardiomyopathy may be secondary to alcohol, hemochromatosis, or patients with hepatoma on doxorubicin therapy. Unlike renal transplant recipients, coronary artery disease is uncommon in this group of patients (cirrhosis may provide some protective effects). There is a broad range of pulmonary abnormalities that cause hypoxemia, some of which are correctable. In particular, the *hepatopulmonary syndrome* (HPS) consists of hypoxemia without parenchymal or obstructive pulmonary disease, ascites, or pulmonary hypertension [3]. These patients usually respond favorably to transplantation. Intrapulmonary shunting causes the hypoxemia, but it is of a type that usually responds to supplemental oxygen. Furthermore, the pulmonary vessels are dilated, in distinction to patients with *severe pulmonary hypertension*. Pulmonary HTN (defined as a mean PA pressure \geq 25mm Hg) occurs in up to 2% of liver failure patients with portal hypertension. They may demonstrate exertional dyspnea or be entirely asymptomatic. Plexogenic pulmonary arteriopathy is the pathologic

lesion, and it is most common in patients who have portosystemic shunts.

Other pulmonary abnormalities that are common in these patients include ascites (high diaphragms), pleural effusions (due to hypoalbuminemia, azygous venous hypertension, or peritoneal-pleural communications), portal-pulmonary shunts, and pleural spider angiomas. ARDS can occur preoperatively and can resolve after transplantation. One cause of combined liver and pulmonary failure is *α 1-Antitrypsin deficiency*, for which combined liver \pm double lung transplants may be performed.

Perioperative Evaluation

Many of the immediate perioperative and postoperative chest radiographic features in kidney and liver transplant patients relate to standard intensive care unit protocol. Due to the nature of the two surgeries, liver transplant recipients generally undergo more intensive thoracic monitoring. Patients return to the SICU intubated, and frequently demonstrate atelectasis (especially in the left lower lobe). Early extubation should be discouraged in these cases. ARDS is a worse prognostic sign in the postoperative setting than preoperatively (see above). ARDS is defined as decreased pulmonary compliance, increased a-A gradient, and diffuse alveolar or interstitial opacities with a normal wedge pressure. The radiological differential diagnosis includes pulmonary edema and pneumonia (see below). A small amount of airway hemorrhage usually results from traumatic suctioning and rarely causes radiographic opacities. Other life support lines include a central venous catheter and a Swan-Ganz catheter. Postoperative cardiovascular problems include hypertension, cardiac failure, and pulmonary hypertension. The latter condition raises the risk of pulmonary artery trauma due to a peripheral Swan-Ganz catheter position. Pleural effusions, particularly right-sided, are commonplace both pre- and postoperatively, and can be drained using small pigtail catheters. Rarely a postoperative effusion may be hemorrhagic due to surgical trauma, for which chest CT is diagnostic. The chest radiologist should also be familiar with the variant anatomy resulting from liver transplantation, including right upper quadrant gas shadows in cases of partial (living donor) transplantation, and the appearance of a duplicated IVC on upper abdominal CT images in patients with piggybacked IVC anastomoses.

Postoperative Complications: Infection

Infections constitute the leading cause of postoperative morbidity and mortality in both liver and kidney transplant recipients [4]. The frequency of

Incidence and Types of Respiratory Infections in Transplant Recipients

Time Post-Tx (approximate)	Bacteria (50-60%)	Viruses (20-40%)	Fungi (5-15%)	Mycobacteria (few%)
1 st Month	Nosocomial (staph, enterobacter, pseudomonas)		Candida	
2 nd -4 th Months	Either ↑ or ↓	CMV	Aspergillus, PCP	TB
Up to and beyond 6 th Month	Community-acquired (pneumococcus, H.flu)	Influenza	PCP, cryptococcus	TB

infection relates to the performance of a complex operation in patients who are in an impaired state of health (particularly liver recipients), with the subsequent addition of powerful immunosuppression. Liver transplant recipients, due to the technically more complex operation, more frequent steroid boli, and prolonged intubation, demonstrate a higher frequency of infections than do kidney recipients especially in the first month. Even so, infection is still the leading cause of death (38%) in kidney transplant patients. Furthermore, the diagnosis of infection can be difficult; positive cultures do not distinguish between colonization and infection. Patients may not demonstrate classic symptoms (fever, leukocytosis, etc.) and infection may mimic rejection. There is substantial overlap in the radiographic manifestations of infection and other abnormalities including atelectasis, aspiration, contusion, hemorrhage, infarct, and edema. Nevertheless, it is worthwhile for the chest radiologist to be familiar with the range of pulmonary infections and their times of peak occurrence after transplantation, which are similar for both liver and kidney recipients.

1) Early Post-Transplantation (within 1st month)

These infections may represent a complication of surgery, reactivation of endogenous organisms, a result of aspiration, or lack of preventative infection-control measures. They are overwhelmingly bacterial in nature. Although their occurrence has decreased since the introduction of lower-dose steroids, pulmonary bacterial infection remains very common with a frequency of 33-68% in liver patients and 17-47% in kidney patients. They remain the most common life-threatening infection in liver recipients (mortality 23%). Fever during this time period is most often infectious in nature. During the first month the most common organisms are staphylococcus, enterobacter, and pseudomonas. In these immunocompromised patients, bacterial pneumonias are more often diffuse and bilateral than in healthier hosts. Atypical bacterial infections, such as anaer-

obes, Legionella, Listeria, and Nocardia, are less frequent but may occur early post-transplantation. Of non-bacterial infections, Candida (esp. *albicans*) may occur in the first month but is generally abdominal; pneumonia or infective endocarditis may be seen in the setting of dissemination. Because cultures are often difficult to interpret (i.e., colonization vs. infection), broad-spectrum antibiotics are liberally used.

2) 2nd-4th Month Post-Transplantation

During this period, the classic opportunistic pathogens predominate. Aspergillus infection is one of the most serious pneumonias occurring during this time period, and is commonly fatal [5]. *A. fumigatus* is the primary species, but others may be involved. In addition to invasive pulmonary aspergillosis, invasive tracheobronchitis and sino-orbital disease may occur. Signs and symptoms may be minimal; a slowly developing parenchymal opacity may be the primary clue. These opacities may proceed to cavitation and infarction with hemoptysis. Another fungal infection that can occur during this period (as well as in the late posttransplant period) is *Pneumocystis pneumonia* (PCP)(recently reclassified from protozoal to fungal). Prophylaxis is commonly used; if not used, pneumonia develops in 5-10% of patients. As in AIDS, bilateral interstitial opacities are the commonest radiographic finding.

Cytomegalovirus (CMV) is the most common viral pathogen affecting transplant recipients. In liver patients it usually causes hepatitis; in either patient pneumonia is usually benign but if a ventilator is required then mortality is high. Fever precedes respiratory symptoms (hypoxemia), which precede radiographic changes (usually bilateral interstitial disease but occasionally with nodules). The diagnosis is made from cytologic/histologic evidence of cellular invasion; principal therapy is ganciclovir. Occasionally CMV can prime for secondary infection with PCP. Other viruses are less common; varicella (chickenpox) pneumonitis is usually severe in transplant recipients. In the pediatric population, RSV



Type of cancer	% of total	Relative rate vs. population	Mean time of presentation
Genitourinary	34	4.3	7 yr
Gastrointestinal	20	2.5	8.5 yr
Lymphoma	12	8.8	4.5 yr
Respiratory tract	9	2.0	6.5 yr

(respiratory syncytial virus) is a major cause of morbidity.

Bacterial pneumonia can occur at any time after transplantation. Either nosocomial or community-acquired pneumonias (see below) may be seen during this intermediate period. Tuberculosis may also occur in the intermediate or late periods.

3) 4th-6th Month Posttransplantation and later

At 6 months or more after transplantation, the intensity of immunosuppression is generally reduced. The most common infections during this period are community-acquired, particularly bacterial pneumonias. Pneumococcus is most common, followed by Hemophilus influenza. Focal alveolar opacities are typical. Even in a transplant patient with bronchitis but no consolidation on the radiograph, antibiotic coverage for these two organisms is given. Viral influenza is another infection to which transplant patients are susceptible. Of course, opportunistic infections can also occur late posttransplant, particularly PCP and some fungal diseases such as cryptococcus.

Postoperative Complications: Malignancy

There are many possible contributing factors to the increased incidence of malignancy in transplant recipients [6]. First, if the donor has malignancy (even unrecognized), there is a high likelihood of recipient cancer and death (making donor malignancy an absolute contraindication to use of the organ). In other cases, possible etiologies include lowered surveillance by lymphocytes of early malignant foci in immunosuppression; oncoviral infection; chronic antigenic stimulation by the transplanted organ; and a possible mutagenic action of the antirejection drug azathioprine. The most common cancers after transplantation are skin cancers. In renal transplant recipients, the frequency of other malignancies has been estimated as being between 4-7%, with distribution and other features as shown in the table on this page.

Comparable data regarding post-liver transplant malignancy has not been published but given the na-

ture of the immunosuppression required it should be at least as frequent as in kidney transplantation. One recognized posttransplant malignancy in liver patients is metastatic hepatoma in patients who are transplanted for HCC or who have HCC discovered after liver transplantation for other reasons. Most cases present within two years of transplant, commonly with pulmonary metastases.

Non-Hodgkin's lymphomas are believed to arise due to latent or primary EBV (Epstein-Barr virus) infection. Approximately 86% of these are of B-cell origin, of the large cell type. Extranodal involvement is common, as is CNS disease. Pulmonary lesions are usually ill-defined nodular opacities, either single or multiple, and not dissimilar from infection [7]. Hodgkin's disease is rare in these patients. There is a spectrum of disease under the term posttransplant lymphoproliferative disorder (PTLD), which includes both lymphomas and non-neoplastic B-cell proliferation. Treatment of the latter may first involve acyclovir and slow tapering of immunosuppression. Finally, an increasing incidence of lung cancer has been noted in transplant recipients.

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Airways Disease in Children

Sandra S. Kramer, MD

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Learning Objectives

After attending this workshop, the attendee will:
1) know the pertinent developmental anatomy of the airways; 2) understand the physiologic differences in children's airways compared to adults; 3) be familiar with the imaging modalities applicable to airway assessment; 4) understand airways information that can be directly and indirectly imaged of by CT, including lung attenuation in air-trapping; 5) be familiar with a variety of pediatric airways diseases; and 6) be able to apply this knowledge to her/his practice.

Introduction

Pathology in the intrathoracic trachea and airways distal to the carina is common in children and includes an interesting and diverse group of processes. With the imaging tools currently available, certain diseases of the lower respiratory tract, such as bronchial obstruction and bronchiectasis, can be directly visualized. However other lesions must be inferred by alterations in aeration or other secondary signs. CT measurements of lung density may also aid in diagnosis of alterations in lung aeration in problematic cases.

This workshop reviews clinical entities specific to the airways of children, with a focus on the role of imaging. Knowledge of the diseases that affect the pediatric airways at different ages is important for accurate interpretation of imaging studies.

Embryology and Anatomy

The trachea develops as a ventral diverticulum from the foregut of the embryo during the fourth week of life and subsequently divides into left and right main bronchi. Each bronchus divides into secondary bronchi supplying the lobes and tertiary bronchi supplying the segments of each lobe. The tertiary bronchi ramify into smaller airways called bronchioles. By the sixteenth week the full adult number of bronchiolar branches have developed, and the conducting airway of the embryonic lung is complete. The distal airways at this time are the smallest purely conducting airways, called the terminal bronchioles. For the remaining 24 weeks of gestation, the gas exchange portion of the lung: the respiratory bronchioles, alveolar ducts and alveoli, develops.

Bronchi out to approximately 1.5-2 mm in diameter can be seen on CT scans. However, normal lobular bronchioles are less than 1 mm in diameter with a wall thickness of approximately 0.1 mm and therefore are below the limit of CT resolution. Pathologic change, however, may make the lobular bronchioles visible. The normal lobular pulmonary arteries can often be detected on thin section high resolution CT images. They appear as small, round or branching linear densities near the center of the secondary pulmonary lobule.

Physiology in Children

There are several important functional differences in children's lungs compared to adults. Not only are the peripheral airways in children small in diameter, but they are small relative to the size of the main bronchi. The resistance to airflow in the peripheral airways in children is significantly higher than in adults. Minor amounts of edema, mucus or debris markedly narrow or occlude an infant's distal airways. Infant airways are also more collapsible in response to pressure changes than in adults. The pores of Kohn and canals of Lambert, collateral pathways that prevent the lung from collapsing in the face of an airway obstruction, are less well developed in infants. All these factors contribute to aeration disturbances, including atelectasis and air trapping in children.

The child's trachea and bronchi normally dilate in inspiration and narrow in expiration. During a sudden cough or Valsalva, they may collapse. Patients with peripheral airway obstructive lesions such as asthma and bronchiolitis, may develop expiratory collapse of the intrathoracic trachea, usually associated with hyperinflation of the lungs. The rigidity of those portions of the airway supported by cartilaginous rings increases with age.

Infections of the lower respiratory tract in young children commonly involves inflammation of the smaller airways, resulting in generalized hyperinflation and aeration disturbance (focal hyperinflation and atelectasis) which are evident on chest radiographs. Similarly, infants with congenital heart disease with significantly increased pulmonary blood flow or interstitial edema often have generalized hyperinflation or areas of atelectasis. In this case bronchial narrowing



and increased small airway resistance may be caused by peribronchial fluid, bronchial compression from the enlarged heart or pulmonary vessels, or intraluminal secretions.

Imaging Modalities

Conventional frontal and lateral chest radiographs are the standard first pulmonary imaging examination, providing an overview of lung aeration. They also provide important information about other relevant structures, such as the heart and chest wall. The tracheal and main bronchial anatomy is well often shown by high kV AP and lateral studies of the airway or chest. Air trapping can also be assessed on chest radiographs, since it is accentuated in deflated lung, as in expiration views or in the “down-side” lung on decubitus views.

CT can readily portray the trachea and the main, lobar and segmental bronchi on axial and direct coronal scans and on 2-D and 3-D reconstructions. Distal bronchi are usually too small to demonstrate unless made visible by pathology. Secondary signs of bronchial or bronchiolar disease, such as the parenchymal hypoattenuation seen with air trapping, are more apparent with CT than plain radiographs. High resolution CT (HRCT), performed with thin sections (1 -2 mm) and high resolution reconstruction algorithm, are especially helpful. Direct measurement of lung density is a burgeoning area of ongoing investigation. Areas of abnormal lung density may be important secondary indicators of airway pathology.

Nuclear medicine studies provide functional information that can be important in clinical management decisions. Ventilation studies with xenon-133 or krypton-81m can assess regional ventilation and evaluate areas of air trapping. Other radiopharmaceuticals such as technetium-99m aerosol and Technegas can give a reflection of regional ventilation. Regional pulmonary blood flow can be evaluated with 99mTc macroaggregated albumin. The degree to which the ventilation map matches the distribution of pulmonary blood flow can then be assessed.

MR imaging is rarely the initial diagnostic study because of its limitations in evaluating the lung parenchyma. However, MRI may prove more helpful in assessing tracheal and bronchial obstruction due to extrinsic compression by vascular rings and masses.

Lung Attenuation

Modern CT scanners are capable of rapidly measuring lung attenuation or density in Hounsfield units (HU). The human eye is more sensitive to relative density changes than to absolute changes of radiodensity of the entire lung; thus, CT densitometry may be helpful in cases of diffuse pulmonary pathol-

ogy such as minimal pulmonary edema, radiation pneumonitis, and bronchiolitis obliterans. A potential important application is the evaluation of areas of air trapping caused by airway obstruction.

Lung density is dependent on four factors: gas, blood, extravascular fluid and pulmonary tissue. Normal lung attenuation in children is higher than in adults, since the corresponding alveoli are smaller in children. The average lung attenuation of a child less than 3 years of age in inspiration and expiration is -550 HU and -435 HU respectively, with a standard deviation of approximately 100 HU. Lung attenuation decreases during childhood. Children over 8 years of age have an attenuation between -700 HU and -880 HU during moderate inspiration, similar to adults.

One study evaluated patients with bronchial obstruction by following lung density during the respiratory cycle using an electron beam CT scanner. The investigators were able to separate normal from abnormal patients and peripheral from central bronchial obstructions. We have also applied a dynamic CT densitometry technique employing spiral CT through the respiratory cycle to study regional air trapping. More work is needed to further define the normal values in children and assess the role of lung attenuation measurements in disease states.

Pediatric Airways Diseases

Intrinsic Tracheal Narrowing

- Congenital tracheal stenosis
- Acquired

Extrinsic Tracheal Narrowing

- Foreign body in the esophagus
- Esophageal atresia- tracheomalacia
- Vascular rings
 - Double aortic arch
 - Right aortic arch and aberrant left subclavian artery
- Innominate artery impression
- Pulmonary artery sling
- Mediastinal masses

Congenital Bronchial Anomalies

- Bronchial Atresia
- Congenital Lobar Emphysema (CLE)
- Sequestration
- Bronchogenic cyst
- Tracheal bronchus
- Pulmonary hypoplasia
- Hypogenetic lung syndrome
- Pulmonary agenesis

Bronchial Obstruction

- Aspirated Foreign Body
- Bronchial stenosis
- Bronchomalacia



Lower Airway Masses
 Bronchial wall tumors
 Laryngotracheal papillomatosis
 Post-pneumonectomy Syndrome

Bronchiolitis

Asthma

Bronchiectasis

Cystic Fibrosis

Bronchiolitis Obliterans (BO)

Bronchiolitis Obliterans-Organizing Pneumonia (BOOP)

Lung Transplantation

Conclusion

A wide variety of disease processes involve the lower airways in children. Through an understanding of the anatomy and pathophysiology involved, diseases of the lower airway can frequently be diagnosed, understood and followed by radiographic means.

SUGGESTED READING

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Protocol Selection for Thoracic Helical (Spiral) CT

Philip Costello, MD, FACR

Helical CT has transformed our ability to assess thoracic diseases through improved temporal resolution due to rapid data acquisition in a single breath-hold and by the acquisition of overlapping reconstructions. Many variables can be selected for helical CT for both routine CT examinations and with more specialized examinations. Scan variables that require selection include collimation, pitch, breath-hold pe-

riod, reconstruction interval and intravenous contrast administration and dose.

This workshop will review the basic principles of single detector helical CT, suggesting a variety of protocols that may be adopted routinely and for special clinical indications. Case illustrations will provide a practical guide to protocol selection in a variety of clinical situations.

SINGLE DETECTOR ROW CT PROTOCOLS

	THORACIC SURVEY	NECK/THORACIC INLET	PULMONARY EMBOLI
INDICATION	Detection/Staging thoracic neoplasia/complex pulmonary-pleural disease	Combined study: head/neck tumors; suspected superior vena cava syndrome, vocal cord paralysis, brachial plexus	Acute or chronic
SCANNER SETTINGS KVp: mAs:	120 250	<u>Neck</u> <u>Chest</u> 140 120 250 250	140 210
PHASE OF RESPIRATION	Suspended inspiration (\pm) hyperventilation	<u>Neck imaging:</u> Quiet breathing or suspended inspiration <u>Chest imaging:</u> Suspended inspiration	Suspended inspiration
SLICE THICKNESS	8 mm.	<u>Neck:</u> 3-5 mm. parallel to the cords, neck positioning <u>Chest:</u> 8 mm.	3 mm.
PITCH	1.0-2.0 (Variable pitch > 1 recommended in larger patients to cover the adrenals if images acquired only in a single breath-hold. <i>Important:</i> If a pitch of more than 1 is used, then collimation should be reduced so that effective slice thickness is 8 mm. maximally.)	1.0-2.0 effective slice thickness as with all thorax cases should be 8 mm. maximally and 3-5 mm. for the neck unless large masses.	2.0
HELICAL EXPOSURE TIME	Single sequential acquisitions with variable breath-hold period.	Consecutive breath-hold acquisitions with interscan delay of 12-15 sec (neck to chest) allowing for breathing.	Single breath-hold period
RECONSTRUCTION INTERVAL	8 mm.	2-4 mm. for the neck; 6-7 mm. for the thoracic inlet	2 mm.
SUPERIOR EXTENT	Superior margin of clavicles (above lung apices)	Base of the tongue	3 cm. above aortic arch Scan caudal \rightarrow cranially
INFERIOR EXTENT	Posterior costophrenic sulci (caudal lung bases). Include adrenals.	Carina	Diaphragm
IV CONTRAST	100 ml. 60% contrast material at 3 ml/sec. 20 sec. delay.	100 ml. 60% contrast material at 3 ml/sec. 20 sec. delay.	100 ml. 60% contrast material at 3 ml/sec. 15 sec. delay.



	THORACIC AORTA	AIRWAY DISEASE	AIRWAY DISEASE
INDICATION	Aortic dissection, aneurysm assessment, penetrating aortic ulcer	Bronchiectasis, inflammatory disease, endobronchial lesions	Occult airway disease (hemoptysis)
SCANNER SETTINGS kVp: mAs:	120 250	120 250	120 250
PHASE OF RESPIRATION	Suspended inspiration	Suspended inspiration (\pm) hyperventilation	Suspended inspiration (\pm) hyperventilation
SLICE THICKNESS	3 mm.	3 mm.	3 mm.
PITCH	2.0	1.0-2.0	2.0
HELICAL EXPOSURE TIME	Single breath-hold	Single acquisition	Single acquisition
RECONSTRUCTION INTERVAL	2-3 mm.	Every 2-3 mm.	Every 2-3 mm.
SUPERIOR EXTENT	2 cm. above aortic arch	Thoracic inlet	True vocal cords
INFERIOR EXTENT	Aortic bifurcation	Lung bases	Lung bases
IV CONTRAST	100 ml. 60% contrast material at 3 ml/sec. 15 sec. delay		

	FOCAL LUNG DISEASE
INDICATION	Solitary nodule/arteriovenous malformations
SCANNER SETTINGS kVp: mAs:	120 250
PHASE OF RESPIRATION	Suspended inspiration
SLICE THICKNESS	1-3 mm.
PITCH	1.0-2.0
HELICAL EXPOSURE TIME	Single breath-hold through region of interest (ROI)
RECONSTRUCTION INTERVAL	1-3 mm.
SUPERIOR EXTENT	Above nodule
INFERIOR EXTENT	Below nodule
SECTION SEQUENCING	Following an initial thoracic survey, 1-3 mm. sections are obtained through a select ROI (nodule) without contrast to assess for possible calcification and/or fat. Then repeat with contrast.
IV CONTRAST	100 ml. 60% contrast material at 3 mm./sec.





Multidetector Row CT

Multidetector row CT (MDCT) scanners have been recently introduced and are capable of producing four simultaneous slices in one x-ray tube rotation. The speed of these systems is particularly advantageous to thoracic imaging where respiratory and cardiac motion may produce artifacts. With a 4 slice system and a 0.5 sec. cycle time the volume data can be acquired 8 times faster than with a single slice 1-second scanner. MDCT can allow us to image the entire thorax with 1 mm. collimation in a single breath-hold, providing an infinite number of reconstruction options. From a single acquisition the raw data may be sampled to provide 1.25 mm. thick (HRCT) images at 10 mm. intervals and 5 mm. sections at 5 mm. intervals without any additional radiation. Retrospective thin section analysis with MDCT routinely improves lesion characterization as there is isotropic resolution at the voxel level. When MDCT is applied to vascular imaging there are fewer motion artifacts, decreased volume averaging due to thinner sections and improved lesion resolution particularly for smaller vessels. Combining the fast rotation times of MDCT with ECG cardiac gating opens up

the possibility of the cardiac CT for cardiac calcification scoring and intravenous coronary angiography.

Protocols

Indications

- Pulmonary emboli—acute and chronic
- Thoracic aneurysm / dissection / trauma
- Airway diseases—post op complications / stenoses / tumors
- Post lung transplantation complications
- Coronary artery visualization (IVCTA)
- Brachial plexus
- Mesothelioma staging

Techniques

- kVp: 120-140
- mAs: 140-180
- Scan length: 300
- Collimation: 1 or 2.5 mm.
- Pitch: 6
- Reconstruction interval: 1.5
- Slice thickness: 1.25, 3 or 5
- Contrast: 100 ml at 3 ml/sec
15 sec. delay



Effective Slide Presentation

Lynn S. Broderick, MD
University of Wisconsin-Madison

Objectives

After attending the workshop “Effective Slide Presentation”, the attendee should be able to:

1. Describe the initial considerations of an effective slide presentation – topic, audience and time
2. Utilize the concept of storyboarding when creating a slide presentation
3. Describe recommendations for effective word slides
4. Describe recommendations for effective radiographic slides
5. Describe recommendations for delivery of presentation

Initial Considerations

Whether in academic radiology or private practice, nearly every radiologist is asked to give a presentation at some time in his/her career. Every one of us has sat through countless lectures and presentations. We can easily tell if a presentation we are witnessing is effective or not. However, when the tables are turned, and we are required to give the presentation, it becomes more difficult to start from ground zero and create an effective presentation.

All presentations begin with the determination of three components:

1. the selection of the topic,
2. the intended audience, and
3. the allotted time.

Regardless of what topic is chosen, the topic must be well defined. Topics that are too broad can not be adequately addressed in a single lecture. The topic must also suit the intended audience. The content of a lecture on pulmonary infections given to a group of thoracic radiologists will be very different from that of a lecture given to a group of third year medical students. When assessing the intended audience, one has to determine both their level of interest as well as their level of expertise. Finally, the topic chosen must conform to the time allotted for the presentation. If the topic is too large, it must be broken down into a manageable size. It is better to present a small amount of information well, than to present a large amount of information poorly. After the topic, audience and allotted time are known, one must then determine the goals and objectives of the presentation.

A goal is a general statement of what the attendee is expected to learn from the presentation. The objectives are specific statements of how the attendee can demonstrate that he/she has attained the educational goal. When giving a presentation for CME, the objectives of your presentation are generally requested anyway. By stating the specific objectives of your presentation, you can hone in on the information you want to convey to your audience.

Storyboarding

Storyboarding is a technique borrowed from the film and advertising industries. It is essential when creating a presentation because it allows you to see if your material is accurate and complete. It also allows you to see if your ideas flow smoothly and in logical sequence. The whole of the presentation is more than the sum of its parts. Once the topic is known, and the information has been gathered, the presenter makes an outline of what they wish to present. It is helpful to establish the learning objectives early on, since this will help shape your outline. The outline will provide the basis for the individual slides. The initial storyboard will be a skeleton of the final presentation. As the storyboard is fleshed out, the information can be transferred to PowerPoint in slide format.

Slides

After storyboarding your topic, you are now ready to create your word slides. In creating the word slides, you need to consider not only the content but also the size, type and color of the font, the color of the background and the use of graphics. According to Whitman, if the audience is unable to understand the information on a slide within 4 seconds, it is an ineffective slide (Neal Whitman, Creative Medical teaching, 1990). Word slides must be legible and easy to understand. Because most projection screens are horizontal, horizontal slides are preferred. This ensures that the top and bottom of the slide will not project off of the screen. Each slide should represent one idea. By using the “rule of 6 (or seven)”, you can prevent cluttered slides. In general, titles should contain no more than 6-7 words. The slide should have no more than 6-7 lines with a maximum of 6-7 words per line. Always spell check and proofread your slides.





Font types come in serif and non-serif styles. A serif is the small decorative tail attached to the ends of a letter (an example of a serif font is the one used in this abstract – Times New Roman). Serif fonts make printed documents easy to read, since the tails guide the eye along the line. A sans serif font has lines of uniform thickness that makes it easier to read when projected on a screen. Examples of sans serif fonts include Arial and Helvetica. If different fonts are used in the same presentation, only two fonts should be used on a single slide, for example, one for the heading and the other for the text. Complete sentences should be avoided. The information on the slide should convey the main points that the speaker is making. Title case should be used for the title or headings only. Lower case type should be used for the text of the slide. All capital letters should not be used, as it is difficult to read. Non-standard abbreviations should also not be used.

In general, you should be able to read a slide while holding it. Font size is measured in points. One point is equal to 1/72 of an inch. The body of the text should never be smaller than 14 pt. Holzl determines font size by the size of the room in which the presentation is given:

Room Size	Heading	Main Text
<50 people	32 point	24 point
<200 people	36 point	28 point
>200 people	42 point	36 point

Left justification should be used for the text, although the heading can be centered. Line spacing can be altered so that the slide appears proportionately filled even if there are only a few lines of text.

The use of color for slides is standard now. The color for the text and background should be complementary and distinguishable. The background color should be a darker shade than the color used for the text. If using a shaded background, the intensity of the color should increase from top to bottom. Keep in mind that the colors usually appear darker when projected in large rooms. Color choices should be consistent from slide to slide and no more than four colors should be used per individual slide. The use of color can aid the speaker by highlighting key messages, emphasizing relationships or discriminating between topics. Color makes the slides more interesting to the eye and adds a professional touch.

Graphics also add interest to a slide presentation. Logos, borders or shading keeps the viewer's interest. The easiest way to incorporate graphics is by using a template. This results in recurring graphics on every slide, in the same location. Clip art can also be used effectively, but should not be overused. The use of bullets draws the eye to the message and emphasizes the text.

Radiographic slides should be properly cropped and centered. Whatever the finding, it should be easily recognized by the audience. If the findings are subtle, magnified views should be used. When choosing cases, the final quality of the projected image should be assessed. Poor quality images or slides should not be used. Images that are incorporated into PowerPoint slides can be annotated, which can aid the audience in comprehending the findings. Identifiable information (name, medical record number) should not appear on the image.

Presentation

The presentation relies on three key elements:

1. Good content
2. Skillful presentation
3. Effective use of support tools (slides, pointer, etc)

Although we are trained to be physicians, when presenting a lecture we are required to become performers. This is a form of entertainment. By the time of presentation, you have thoroughly researched your topic. You have honed the topic down so that you have a discrete message that can be given in the allotted time. You have created visually effective slides that enhance your message. Now it's show time!

Good presenters practice their talks. All of the information on the slides should be memorized. By the time you give your presentation, you should be able to deliver it at the drop of a hat. There are two ways of memorizing the talk. One is to use the notes page feature on PowerPoint. The text for what you will say while projecting each slide can be typed into the notes space below the slide. The presentation can be printed in this format. This can be helpful in memorizing the presentation. The second way of memorizing the talk is to load the slides onto carousels and repeatedly run through the presentation until you are able to give the same talk every time. Never read the slides to the audience. The audience will be reading the main points that you have projected on the screen while you discuss the very same points. When the talk has been memorized, give the presentation to a live audience and ask for their feedback.

When presenting, remember to speak clearly and slowly. If using a microphone, be sure to speak into the microphone, even if this requires you to remain in one position during the presentation. Otherwise, your voice will fade in and out and you will lose the audience. Vary the inflection in your voice; do use monotone speech. Show your enthusiasm for the subject by giving an animated delivery. Make eye contact with the members of the audience if possible – if not at least look at the audience. Don't apologize for the quality of the slides, yourself or anything else.

Humor can be used effectively in a presentation but should be appropriate. Be careful with the pointer – use two hands, and steady your arm on the podium. Use the pointer to identify what you are talking about on a radiographic slide. Do not point at the words as you read them.

Do not exceed your allotted time. If you say the words “in conclusion”, you must end your talk within 30 seconds since that is the expectation of the audience. If there is a question and answer period after your presentation, always repeat the question that has been asked. Give a clear and succinct answer. However, do not be afraid to say, “I don’t know”, if you really don’t know the answer.

Technical Aspects

Once your slides are printed, place them in order. Load the slides in carousels and practice the presentation. If possible, carry the slides to the presentation already loaded in carousels. If this is not possible, number the outer edge of the slide and indicate whether it goes in the left or right carousel. Slides should always be advanced in tandem so that they stay in order. Blank slides can be used for the right carousel (audience right) if only one slide is needed. Scenic views, although frequently used, are distracting to the audience and should be avoided. Load the slides in slide protectors and carry them with you at all times until you reach your destination.

Ideally, the presentation should be practiced in the room in which it is to be given. Often this is not possible. However, it can be helpful to investigate the room during off-hours. Stand at the podium and see its relation to the projection screen. Oftentimes, the podium is very close to the screen so that the presenter must view the screen from an oblique angle. This can make it difficult to see what is on the slides. Therefore, it is essential that the presenter is completely familiar with the information on the slides.

This is particularly true of the radiographic slides. Abnormalities must be readily pointed out to the audience. This is easier with annotated images. If there is lighting near the projection screen, it may wash out the images making the slides difficult to see. The projectionist should be able to dim any of the light sources in the room. Some things cannot be foreseen, such as noise or activity in an adjacent room. Regardless of what occurs, keep your presence of mind and remember that the show must go on!

Internet Resources

<http://www.utmb.edu/meo/r0000009/sld001.htm>
Rassin GM. Slide show on presentations, including “Kroenke’s Rules”

http://www.uab.edu/uasomume/CDM/CDM_TipsLecture.htm Brooks CM, McKittrick JL. Effective lectures.

<http://uga.berkeley.edu/sled/compendium/>
Gross BG, Wood L, Wilson RC. A Berkeley Compendium of Suggestions for Teaching with Excellence.

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Complications of Lung Transplantation: Acute and Chronic

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Objectives

1. State the most common complications occurring acutely after lung transplantation. 2. State the most common chronic complications occurring after lung transplantation. 3. Describe the time course and imaging features that help to distinguish among the different acute and chronic complications of lung transplantation.

Lung transplantation, widely accepted as therapy for certain forms of end-stage lung and pulmonary vascular disease, is associated with a 71% 1-year and 45% 5-year survival if all recipient subgroups are combined [1,2]. Since the first successful lung transplantation, performed in 1983, 2,428 heart-lung, 4,777 single lung, and 3,278 double lung transplantations have been recorded by the Registry of the International Society for Heart and Lung Transplantation, as of March, 1998 [2]. The frequency of different complications related to lung transplantation has changed since the 1980's. Improved surgical technique, immunosuppressive protocols, and prophylactic antibiotic regimens have decreased the number of episodes of infection, acute rejection, and bronchial anastomotic dehiscence. Obliterative bronchiolitis has emerged as the primary cause of morbidity and mortality, and although decreased, the frequency of infection remains high.

Acute Complications

Patient mortality is highest in the immediate postoperative period owing to pleural bleeding, respiratory infection with or without septicemia, severe acute rejection, adult respiratory distress syndrome, diffuse alveolar damage and respiratory failure, severe reperfusion edema, and multiorgan failure [3]. Hyperacute rejection is a very serious but uncommon complication that manifests as immediate graft failure. Specific acute life-threatening diagnoses that can be made with imaging include hemothorax, lung torsion, pneumomediastinum, pulmonary embolism, pneumothorax, bronchial anastomotic dehiscence, lung collapse, paralysis of the diaphragm, and sternal dehiscence [3].

Beyond the immediate postoperative period, but within 3 months of transplantation, the most common complications include reperfusion edema, acute rejection, and infection. These and other acute complications are listed in the Table.

TABLE

Acute Complications of Lung Transplantation

Pulmonary complications

Most common

Reperfusion edema
Acute rejection
Infection

Less common

Bronchial anastomotic stricture or dehiscence
Primary graft failure (diffuse alveolar damage)
Bronchiolitis obliterans organizing pneumonia
Pneumothorax
Graft compromise from hyperexpanded native lung
Pleural effusion/empyema
Pulmonary embolism
Pulmonary venoocclusive disease
Diaphragmatic dysfunction

Non-pulmonary complications

Central nervous system complications
Osteoporosis
Cardiac arrhythmia
Cyclosporine nephrotoxicity
Hyperlipidemia
Hyperglycemia
Anemia
Menstrual irregularities
Cholecystitis
Hepatitis
Pancreatitis
Ascites
Gastroparesis
Pneumatosis intestinalis

Reperfusion Edema

Reperfusion edema is a form of noncardiogenic pulmonary edema associated with lung transplantation, and has been defined as "the morphologic, roentgenographic and functional changes that occur in a lung transplant in the early postoperative period as a result of surgical trauma, ischemia, denervation, lymphatic interruption and other injurious processes (exclusive of rejection) that are unavoidable aspects of transplant operation" [4]. Reperfusion edema manifests on chest radiography on day 1 of transplantation as perihilar and/or basilar interstitial and/or air-space disease that peaks in severity by day 4. The



process clears by day 10 in the majority of patients, but can persist for up to 3 weeks [5]. There is no significant correlation between the extent of chest radiograph abnormalities and oxygenation efficiency of the transplanted lungs [5,6]. A number of conditions, including fluid overload, left ventricular failure, rejection, infection, and atelectasis, can mimic reperfusion edema, and therefore, reperfusion edema is a diagnosis of exclusion. However, any pulmonary process beginning or worsening after the fifth day after transplantation should be assumed to be due to a cause other than reperfusion edema and investigated accordingly.

Acute Rejection

The pathologic findings defining acute rejection are perivascular and peribronchial lymphocytic infiltration. Accurate diagnosis is critical, as treatment consists of increasing the doses of immunosuppressive therapy, which could lead to clinical deterioration in patients with opportunistic infection, and prompt and appropriate treatment may be associated with a lower incidence of chronic rejection. Symptoms are nonspecific and include fever, dyspnea, tachypnea, and cough.

Findings on chest radiography include new or increasing pleural effusions and septal lines, without increase in cardiac size, change in vascular pedicle, or vascular redistribution [7]. HRCT is more sensitive than chest radiography in detecting subtle abnormalities. During the first postoperative month, HRCT findings are not sufficiently discriminant to permit a distinction to be made among rejection, reperfusion edema, and fluid overload. After the first month, patchy ground glass opacity is the only significant finding observed during episodes of acute rejection [8]. The degree of HRCT abnormalities correlates with the severity of changes on histologic samples. When there is no evidence of ground glass opacity on HRCT, a moderate and severe acute rejection episode can be eliminated with a high degree of confidence. Minimal changes on HRCT can aid in guiding transbronchial biopsy.

Infection

Infection is the most common cause of perioperative mortality and the second most common cause of late mortality (beyond 90 days post-transplant) after lung transplantation. Opportunistic infection occurs in 34%-59% of all patients after lung transplantation [9]. The reasons for the high frequency of respiratory infection in the lung transplant population include impaired mucociliary transport in the denervated lung, altered phagocytosis in alveolar macrophages, direct communication of the lungs with the atmosphere, loss

of cough reflex, and interrupted lymphatic drainage. The widespread institution of antibiotic prophylaxis and careful manipulation of immunosuppressive drugs have greatly decreased perioperative infection-related morbidity. Antibacterial, antiviral, antipneumocystis, and more recently, antifungal prophylaxis are all utilized [10]. The universal use of trimethoprim-sulphamethoxazole has virtually eliminated *Pneumocystis* infection and probably a number of other infections (e.g., *Nocardia*).

Pneumonia is the most common thoracic infection, with pseudomonas, cytomegalovirus, and *Aspergillus* being the most common single responsible organisms [11]. Nodules, areas of consolidation, ground glass opacities, septal thickening, and pleural effusion are common CT findings of bacterial, viral, and fungal infections [11]. However, when these findings are seen on CT in a patient with a lung transplant, they are not helpful in making a specific infectious diagnosis. Lymphadenopathy is uncommonly seen with all types of infections. CT scan abnormalities involve only the transplant lung in 47% of patients with viral, bacterial, fungal, or mixed pneumonia and a single lung transplant [11]. This does not help to distinguish infection from rejection or lymphoproliferative disease, which also tend to involve predominantly the transplant lung. Neither the type nor distribution of CT findings is sufficiently specific to diagnose infection versus lymphoproliferative disease or rejection.

Chronic Complications

The most common complications occurring more than 3 months after transplantation are infection, obliterative bronchiolitis, lymphoproliferative disease, and recurrence of underlying disease. Infection occurs both in the acute and chronic stages after lung transplantation, but the CT scan findings are similar regardless of the time of onset. While the incidence of bacterial pneumonia is highest in the first month after transplantation, bacterial pneumonia continues to be a major infectious complication throughout the transplant recipient's life [9]. Pulmonary infection with *Aspergillus* most commonly occurs 2-6 months after transplantation, and Cytomegalovirus pneumonia between 1 and 4 months after transplantation [12,13]. The incidence of pulmonary tuberculosis after lung transplantation is estimated to be between 2% to 3.8%, typically occurring 1.5 to 9 months after surgery [14].

Obliterative Bronchiolitis

Obliterative bronchiolitis (OB), widely accepted as a manifestation of chronic rejection, is the most common cause of death one year or more after lung



transplantation [2]. The incidence of OB after lung transplantation is variously reported at between 10% and 70% [15-17]. There is no curative treatment for OB, but early diagnosis and enhancement of immunosuppressive treatment can result in stabilization of the process. OB is confirmed histologically by the presence of a chronic inflammatory and fibroproliferative process centered on the terminal and respiratory bronchioles leading to airway distortion and scarring [18]. Transbronchial biopsy is only 15%-18% sensitive in making the diagnosis of OB, due to the patchy nature of OB and difficulty in adequate sampling of bronchioles. Chronic rejection is therefore usually a clinical diagnosis, based on changes in forced expiratory volume in 1 second (FEV1), established by the International Society For Heart and Lung Transplantation [19]. The diagnosis of chronic rejection, when made clinically, is referred to as "bronchiolitis obliterans syndrome".

On HRCT, bronchiectasis has been reported as a frequent though often late finding in lung transplant recipients with OB. A mosaic pattern of lung attenuation is 64% sensitive for identifying OB, and air trapping on expiratory CT has a sensitivity of 91% [20]. The role of expiratory HRCT in the detection of early, preclinically evident OB is currently under investigation as a prospective study at the University of Wisconsin.

Lymphoproliferative Disease

The incidence of posttransplantation lymphoproliferative disease (LPD) after lung transplantation ranges from 6.2% to 9.4% and is twofold higher than that seen after transplantation of other organs [21]. Among heart and lung transplant recipients, the risk of developing posttransplantation LPD remains 5%-6% per year, and it is the third leading cause of mortality outside the perioperative period, accounting for 7% of the deaths in both groups [22]. There is a strong association between Epstein-Barr-virus infection and the development of LPD. Symptoms of posttransplantation LPD occur at a mean 2-5 months after lung or heart-lung transplantation, but can occur up to several years after transplantation [23]. The most common histologic diagnoses are polyclonal LPD and malignant lymphoma, and the most common CT findings for both include multiple nodules, large and small, with a peribronchovascular and subpleural distribution, involving the middle and lower lung zones [23]. An early diagnosis is critical to provide early treatment, usually consisting of modulation of immunosuppressive therapy, for a favorable clinical response. The differential diagnosis in the lung transplant population includes infection (especially with fungus or Cytomegalovirus) or rejection.

Recurrence of Disease

In addition to the complications related to surgery, patients with lung transplantation are vulnerable to developing complications related to their primary disease, including recurrence of the primary disease. Diseases which have recurred after lung transplantation include diffuse panbronchiolitis [24], alveolar proteinosis [25], sarcoidosis [26,27], giant cell pneumonia [28], desquamative interstitial pneumonitis [29], and lymphangioleiomyomatosis [30].

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The Spectrum of Eosinophilic Lung Disease: Radiologic Findings

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Introduction

The diagnosis of eosinophilic lung disease is obtained by satisfying one of the following three conditions: (1) peripheral eosinophilia and chest radiographic abnormalities (pulmonary infiltrates with eosinophilia, PIE); (2) tissue eosinophilia confirmed by either open lung biopsy or transbronchial lung biopsy; (3) increased eosinophils in bronchoalveolar lavage (BAL) fluid [1]. In this review, the author classifies the various forms of eosinophilic lung disease into several categories, presents the radiologic findings, and introduces integrated diagnostic approach for the disease.

Eosinophilic Lung Diseases of Unknown Causes

Simple Pulmonary Eosinophilia

Simple pulmonary eosinophilia, known as Loeffler's syndrome, is characterized by migratory pulmonary abnormalities on the chest radiograph, increased peripheral blood eosinophils and minimal or no pulmonary symptoms. The disease resolves spontaneously within one month. Pathologically, eosinophils and histiocytes accumulate in alveolar spaces and walls [1].

Chest radiographs most commonly demonstrate nonsegmental areas of consolidation that can be unilateral or bilateral. The abnormalities are usually transient and migratory. Neither cavitation in consolidation nor findings of pleural effusion, lymph node enlargement and cardiomegaly has been reported [1, 2]. Cases appearing as single or multiple pulmonary nodules simulating the findings of primary or metastatic malignancy may be seen. CT especially high-resolution (HR) CT scan may add areas of ground-glass opacity (halo sign) around consolidation or nodule [2].

Acute Eosinophilic Pneumonia (AEP)

Clinically, idiopathic AEP is characterized by an acute febrile illness of one to five-day duration accompanied by myalgias, pleuritic chest pain, and hypoxemic respiratory failure. It is characterized pathologically by infiltration of eosinophils and mononuclear cells and edema within alveoli, bronchial

walls and to a lesser degree in the interstitial space and pleura [2 - 4]. Allen et al. [3] suggested the following features as diagnostic criteria of AEP:

- (1) acute febrile illness;
- (2) severe hypoxemia;
- (3) diffuse pulmonary infiltrates;
- (4) increased eosinophil counts in bronchoalveolar lavage (BAL) fluid;
- (5) no history of other infectious or atopic illness;
- (6) rapid improvement with steroid therapy; and
- (7) no relapses.

Patients have no evidence of infection or drug reaction. Peripheral eosinophil count is usually normal initially, but is elevated during the subsequent clinical course [1, 4].

The predominant initial radiographic finding is diffuse bilateral reticular densities. Bilateral patchy areas of ground-glass opacity are observed on CT scans. Smooth septal thickening and pleural effusions can also be seen [4]. The radiologic findings, when associated with acute fever and dyspnea, may suggest the diagnosis of AEP.

Chronic Eosinophilic Pneumonia (CEP)

CEP is characterized pathologically by eosinophilic and lymphocytic accumulation in the alveoli and interstitium. Interstitial fibrosis and eosinophilic abscess may be seen. Histologic features of bronchiolitis obliterans organizing pneumonia or low grade vasculitis may also be present [1, 2]. The symptoms are insidious and continue for at least one month before diagnosis in all patients [1, 2]. Peak incidence of the disease is in the fifth decade. Forty percent of patients have associated asthma. Women are more frequently involved than men (2:1 ratio) [1, 2]. Chest radiograph classically shows bilateral areas of nonsegmental consolidation in a subpleural distribution. This pattern is seen in 60% of cases. Nodules with or without cavitation are present in 20% of cases [2]. Pleural effusions are rare and observed in less than 10% of cases [2]. CT scan also shows subpleural areas of consolidation [2]. In the early stage of the disease consolidation is the predominant abnormality on CT, while nodules or reticular densities predominate in later stages [12]. Mediastinal adenopathy can be seen (it was observed in 3 of 6 patients in one study [5]).



Idiopathic Hypereosinophilic Syndrome

Idiopathic hypereosinophilic syndrome is a rare and fatal multiorgan disorder characterized by blood eosinophilia of greater than 1,500/ for more than 6 months [1, 2]. Onset of the disease is usually in the third or fourth decade with a male predominance (7:1 ratio) [1]. Thromboembolic disease, peripheral neuropathy, and involvement of gastrointestinal tract, kidneys, joints and the skin have been reported. Endocardial infiltration leads to endocardial fibrosis and restrictive cardiomyopathy. Forty percent of patients with hypereosinophilic syndrome have clinical pulmonary involvement. Most of the pulmonary abnormalities are related to cardiac disease [1, 2], however, pathologic findings similar to chronic eosinophilic pneumonia are also seen [6].

Chest radiographic findings are varied, including patchy areas of reticular densities, poorly-defined nodules or consolidation bilaterally. Pleural effusion may be associated in one half of the patients [1, 2]. CT scan shows patchy areas of consolidation or nodules with or without surrounding ground-glass opacity (halo) [2] or diffuse areas of ground-glass opacity suggesting pulmonary edema.

Eosinophilic Lung Diseases of Known Causes

Allergic Bronchopulmonary Aspergillosis (ABPA)

ABPA is characterized by a history of asthma, pulmonary abnormalities, peripheral eosinophilia, central bronchiectasis and evidence of an allergic reaction to *Aspergillus fumigatus* (immediate skin test hypersensitivity, elevated serum IgE [nonspecific] and specific anti-*Aspergillus* Ig G and Ig E antibodies). The disease affects about 10% of steroid-dependent asthmatics [1, 2].

Histologically the disease is characterized by bronchocentric inflammatory lesions consisting of eosinophils, lymphocytes, plasma cells and monocytes. *Aspergillus* hyphae can be identified in the lung parenchyma.

The classic chest radiograph shows central bronchiectasis predominantly involving the upper lobes with the finger-in-glove sign (medium-sized bronchi filled with mucus) and areas of consolidation. When mucus is expectorated, a tram-track appearance or ring shadow indicating bronchiectasis may be seen [2]. Central bronchiectasis is present in 85% of patients at initial presentation [2], however, it may be absent in early disease period [1]. HRCT demonstrates areas of parenchymal consolidation and central bronchiectasis with mucoid impaction. Centrilobular nodules and branching linear structure suggesting bronchiolar inflammation may also be seen [2].

Bronchocentric Granulomatosis (BG)

The diagnosis of BG depends on histologic criteria: granulomatous and necrotizing replacement of bronchial or bronchiolar epithelium. The surrounding lung parenchyma demonstrates chronic inflammatory changes, tissue eosinophilia and Charcot-Leyden crystals, or aggregated eosinophil granules [1]. Approximately one third of cases are seen in asthmatics [7].

In asthmatics, BG is caused by *Aspergillus* and is an histologic component of ABPA. In nonasthmatics, the underlying cause is often unclear. Mycobacterial or fungal infections may be associated in some cases of BG in nonasthmatics. In asthmatics (mean age, 22 years), BG develops earlier than in nonasthmatics (mean age, 50 years). The incidence in both sexes is equal [7]. Peripheral eosinophilia, present almost always in asthmatics, is seen in 50% of patients [1, 2].

Chest radiograph shows two major patterns of abnormalities: mass(es) and consolidation. The pattern of disease does not have any correlation with asthmatic status of the patients. Mass lesions, observed in 60% of cases, are usually solitary and represent a mass of necrotic tissue with surrounding granulomatous or organizing pneumonia [1, 2]. Areas of consolidation, seen in 30% of cases, are due to either eosinophilic or obstructive pneumonia and usually in the upper lung zones and unilateral. In 10% of cases, the disease appears with diffuse reticulonodular lesions.

Parasitic Infection

In the United States, *Strongyloides*, *Ascaris*, *Toxocara*, and *Ancylostoma* are the most common parasites [1]. Tropical pulmonary eosinophilia is caused by the filarial worms, *Wuchereria bancrofti* and *Brugia malayi*. Most cases have been reported from India, Africa, South America, and southeast Asia. In far Eastern Asia, India, and Africa, the lung fluke *Paragonimus westermani* (PW) causes eosinophilia accompanied by pulmonary symptoms and radiographic abnormalities [2].

Tropical pulmonary eosinophilia is more common in man (about four times as frequent as in woman) [1]. Chest radiograph shows fine diffuse reticulonodular lesions preferentially in the lower lung zones. The reticulonodular lesions on chest radiograph correspond histologically to the areas of histiocytes in the alveolar spaces and eosinophils in the alveolar spaces and walls [1, 2].

In PW infection, chest radiograph demonstrates pulmonary (about 80%) or pleural lesions (20%). Parenchymal lesions consist of patchy airspace consolidation with or without cystic change, peripheral linear densities, or ring shadows. Pneumothorax or pleural effusion is seen as pleural lesion. CT scan adds the finding of round low-attenuation cystic lesion of 5-15



mm in size, filled either with or gas within the area of consolidation, which is quite characteristic of PW infection [2].

Drug Reaction

More than 30 drugs have been reported to be associated with eosinophilia and pulmonary abnormalities. Methotrexate, nitrofurantoin, salicylates, sulfonamides, antiepileptic drugs, penicillins, and other antibiotics are the most commonly encountered. Histologically, the pulmonary interstitium contains eosinophils and other inflammatory cells with desquamation into the alveolar spaces [1, 2].

Chest radiograph demonstrates variable patterns of abnormalities including consolidation (methotrexate, nitrofurantoin, salicylates, sulfonamides, penicillins and other antibiotics), hilar adenopathy (antiepileptic drugs), pleural effusion (nitrofurantoin) and reticulonodular densities (methotrexate and nitrofurantoin) [1, 2]. CT, especially HRCT reveals more clearly pattern and extent of variable findings including areas of ground-glass attenuation, consolidation, nodules and irregular lines.

Eosinophilic Vasculitis

Allergic Angiitis and Granulomatosis (Churg-Strauss Syndrome)

Churg-Strauss syndrome is characterized by hypereosinophilia and systemic vasculitis occurring in patients with asthma and allergic rhinitis. There are three major histologic criteria in the diagnosis of the disease: necrotizing vasculitis, tissue infiltration by eosinophils and extravascular granulomas [1, 2]. Multiple organs are involved including upper airways, lung, skin, nerve, gastrointestinal tract, heart, kidneys, and the joints. Upper airway disease and pulmonary abnormalities are most common and occur in about 70% of patients [1, 2].

Chest radiograph demonstrates transient, patchy, nonsegmental consolidation, however, small non-cavitary nodules or diffuse reticular opacities have also been reported [1, 2]. Pleural effusion occurs in 30% of the patients and hilar lymph node enlargement has occasionally been reported [2]. In one study of nine patients with Churg-Strauss syndrome [8], most frequent HRCT findings were areas of ground-glass opacity (100%), centrilobular micronodules in areas of ground-glass opacity (89%), or consolidation (56%), distributed at subpleural lower lung zone. Associated findings were bronchial wall thickening

(78%), macronodules (44%), mediastinal adenopathy (44%), pleural effusion (22%) and pericardial effusion (22%).

Other Diseases Associated with Eosinophilia

Asthma is frequently associated with peripheral eosinophilia or increased eosinophils in bronchoalveolar lavage fluid. Idiopathic pulmonary fibrosis is frequently associated with increased BAL eosinophils and with peripheral blood eosinophilia. Tissue eosinophils are common in patients with Hodgkin's lymphoma, as a component of mixed inflammatory infiltrate. An increase in both BAL and blood eosinophils has been reported. Both nonHodgkin's lymphoma and lymphocytic leukemia can be associated with pulmonary abnormalities and peripheral blood eosinophilia [1, 2].

Non-small cell carcinoma of the lung can be accompanied by peripheral blood eosinophilia, although an increase of eosinophils in BAL fluid is uncommon [1, 2].

Pneumocystis carinii infection in patients with AIDS is associated with an increase of BAL eosinophils in 15% of patients [1, 2]. BAL eosinophilia is usually not associated with peripheral blood eosinophilia.

An increase in tissue eosinophils is noted on open lung biopsy in 81% of patients with Langerhans cell histiocytosis (eosinophilic granuloma), but an increase in BAL fluid is seen in only 15% of patients [9].

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Writing Up Your Research

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Here are a few principles, all well known [1,2,4] and thoroughly tested over many years, that increase the chance that your manuscript will be accepted for publication in a good journal, read by its subscribers, and remembered. The article assumes that the research has already been done and the data have already been collected. The focus here is not on the performance of the research but on its presentation.

Writing well is difficult. You will not get things right on the first try and probably not on the second or third. You may have intelligence, integrity, perceptiveness, and experience, and your research results may be spectacular; writing them up still takes hard work.

Preliminaries

One early test is, do you really have something to say? Are you bursting to get your message out? Is your work important or, on consideration, trivial? Is it original, or is it stale? Are your conclusions well supported or only weakly documented? Are your findings helpful to your readers or useless? If your work fails these tests, you are not ready to start writing.

Early on, you should force yourself to make a one- or two-sentence summary of your message. This is not easy. If you succeed, you probably have just told yourself the focus [2] of your paper. Ignore the side issues. Tell yourself your hypothesis, if you have one. Hypotheses make for good science. Your hypothesis might be, to construct an unlikely example, "In children, computed tomography of the chest causes abdominal pain." Putting something on paper makes its imperfections more obvious, so you should write down the specific question you are asking: "Is abdominal pain more common in children in the 24 hours after a chest CT?" Compose your summary message, something like "In children, chest CT is followed by an increase in the prevalence of abdominal pain from 1% to 12%." Each of these simple but demanding steps helps you think more concretely about the paper you are about to write and helps to establish its focus.

Can you explain your work aloud to a colleague? To your spouse? To your teen-age offspring, presumably bright, accustomed to well organized presentations, and impatient of muddled thinking? To your chief? Listen to their questions. What do they have trouble understanding? What do they have misgivings about? What impresses you but not them? At

what point did they stop listening? This is free feedback, a first informal passage through the review process. Use it to sharpen and improve your message.

If, after all this, you still find your work exciting, congratulations; you may have a viable paper. If your work excites others as well, proceed immediately; someone else may publish first.

Which Journal?

At an early stage, you should decide which journal is best for your paper. *The New England Journal of Medicine* and the *Journal of the American Medical Association* are so eminent that they arouse envious criticism in the popular press [3]. However, their standards are very high, too high for most of us. They are interested only in articles of wide application to the practice of medicine, a criterion that eliminates most radiologic manuscripts. Besides, their reproduction of radiologic images is only fair.

A more realistic list of possibilities for your article might include *Radiology*, the *American Journal of Roentgenology*, *Academic Radiology*, and the *Journal of Thoracic Imaging*. Each of these four journals is excellent. Each has its favorable and unfavorable characteristics. Are there articles like yours in the journal you are considering? Do you like the articles that you read there? Is this the audience you hope to reach? If you answer "yes," turn to their instructions for authors and read them carefully. Can you adapt your material to fit those instructions (which you *must* follow) without too much strain?

Please remember that journal editors are not minor gods sent down from Olympus to harass the rest of us. They are ordinary hard-working human beings, interested in attracting good presentations of good science. They know that it is to their advantage to be friendly and courteous. They will cultivate authors who write well on interesting subjects and have important, original things to say. If you send them worthwhile material, it is likely to be welcomed warmly. A well-written article showing that computed tomography of the chest is often followed in children by abdominal pain would probably be accepted by any one of the four journals listed above.

All four of these journals have high editorial standards. All use the peer review system. Submitted manuscripts are sent out to anonymous reviewers



with pertinent expertise. They give an opinion on the value and the publishability of the manuscript and suggest improvements. The editors rely heavily on those opinions when deciding which manuscripts to publish and how thoroughly they must be revised before publication. All four reproduce images well, though some rely on minification to an undesirable degree. You should thumb through a recent issue of the journal you are considering, looking only at the reproductions. Are they good enough for your material? Will it survive the degradation, seldom major but always present, inherent in that journal's publication process? If the answer is "no," you should look elsewhere. Do not assume that the editor will show your images at the size you submit them.

The Major Elements of the Paper

The format of the classical scientific paper [1,2] is remarkably stylized. If your material is being submitted as a substantial contribution to medical knowledge, editors will expect you to follow their version of this format rigidly. Other types of manuscripts can be much more informal, especially if their science is less rigorous or their message is less weighty. Those manuscripts (review articles, technical notes, case reports, and so forth) need not adhere to the following plan in detail; please see the instructions of the journal you have picked. However, what follows is the standard for the more ambitious papers.

The major elements of the text are the *Introduction* (why abdominal pain after chest CT is important); the *Subjects and Methods* (what you did to investigate that question, and how you did it); the *Results* (what you found out); and the *Discussion* (what it all means to radiologists and their patients).

Introduction: This should be brief, from two to ten sentences long. You might well write it first, to remind yourself why you are doing all this work and to convince yourself that it is worth while. State the objective or purpose of the paper. Give a bit of background and maybe a reference or two: "Chest CT is usually assumed to be painless." Put the subject in context: "The discomfort caused by bronchography is one reason it was abandoned with such alacrity." State the hypothesis of the paper. Use this section as a lead-in, to persuade the reader to keep on reading. But make it short; readers sense that verbosity here predicts verbosity elsewhere.

Subjects (Materials) and Methods: Who or what was examined? What (in some detail) was done? Spell out the research design. Were there controls? How did you avoid bias and maintain objectivity? What statistical methods were used (give a reference or two)? This section must be fairly dense and dry; flights of literary fancy are grossly out of place. Ant-

icipate questions and objections from reviewers and readers and deal with them. The reviewers have been down this road before. They will check to see if you fell into the traps they know so well from bitter experience. Disappoint them if you can.

Results: This section, the heart of the paper, should present the facts, unadorned. Clarity and brevity are its watch-words. What were your findings? Be quantitative if at all possible. If the results were numerous, be selective in presenting them. Do not feel compelled to tell all you know. If the subject is abdominal pain after chest CT, don't include the fact that one child got a headache. Give the statistical significance of your numbers here.

Discussion: The subjects and methods section and the results section are inevitably packed with facts and allow the author almost no freedom. The discussion, at last, allows a little literary creativity, but not much. A sentence or very short paragraph might deal with the background of the problem, but do not repeat the introduction. If your results are complex, a very brief restatement of them might be in order. Relate your results to others' work; several references will probably be useful here. What is new and important about your work? What are its implications? Be sober and straightforward; don't be either boastful or shy. Input from colleagues is valuable in assessing significance; you will be in love with your work, but they will have an arm's-length objectivity. Give the limitations of your data. Don't wait for reviewers to point out the weaknesses you know are there; disarm them.

The Other Elements of the Paper

Title: Make it short and sweet if you can. Be clear and specific, not vague or indirect. The title must indicate the contents. If it includes two or three key words and phrases, that will help indexers and get the attention of the readers you hope to attract.

Authors: Authorship, the usual road to academic promotion, is a sensitive subject. The listing of the authors of your paper, therefore, needs to be settled early.

The first author is presumably you. This implies that you have done most of the research, are doing most of the writing, take most of the responsibility, and expect to receive most of the credit. You are the captain of this particular ship. However, you are probably getting help from your colleagues, mentors, fellows, or chief. If their help is substantial, they should be listed as co-authors. If their help is smaller, list them (expressing your gratitude courteously) in the acknowledgments. Keep the list of authors short; a long list suggests that nobody did much of the work and that nobody is really willing to take responsibility for it.

Abstract: Some experienced authors write the abstract first, to focus their thinking and to get an idea



of what their material looks like in print. They count on rewriting it in toto at the end of the process. Others, knowing that their understanding of the data will be greatly enriched by the writing process, work on the abstract last.

The abstract is at least as important as any of the elements so far described. It is the reader's introduction to you and your work. When well written, it will induce many of them to read further. When mediocre, it will induce only a yawn and some quick turning of pages. It is often reproduced alone and therefore must represent the entire paper fairly.

References: Your references should be relevant, recent, and highly selected. Don't include a reference just because it is on the same subject. Computer searches yield many references, but most of them should be rejected. Study your references, don't just add them to the list. Be fair and accurate. Many reviewers are picked by editors from the paper's references. If you are disparaging or inaccurate about their work, they may take a disapproving view of yours. Above all, get the citation right, and then check it.

Illustrations: Editors of radiology journals have a problem. Their purpose is to advance the science of medical imaging, but images, at least in printed journals, are more costly to publish than text. Furthermore, omission of one image saves as much space as the deletion of many sentences. Therefore, they will try to reduce the number of images in your paper, and you should forestall them by submitting only images critical to your message. A paper on abdominal pain after chest CT might have no illustrations at all. Does a figure show what another figure shows better? It is probably superfluous. Anticipate degradation of your images, an increase in their contrast (the dark tones may turn darker, the light tones lighter), and minification. If an illustration cannot survive these assaults, it should not be submitted. Have someone tell you whether your prints really show what you claim they show; you know what information was contained in the original, but he or she does not.

Tables: Editors don't like tables much. The reasons are that important messages get buried in them, readers have trouble deciphering them, they tend to contain material better expressed or already expressed in the text, they are often bloated with non-essential data, and unchecked inaccuracies creep into them. To be worthwhile, a table should be central to your message and should give its part of your message better than ordinary text could. Which children got abdominal pain after chest CT - after a long examination or a short, after contrast enhancement or not, whether sedated or not, which age and sex - might be shown well by a table. For repetitive data from a large number of cases, a table is often best.

If you use a table, keep it simple. Show it to someone unfamiliar with your subject and see if it is easy to understand; if not, modify it or reject it. You will be surprised how much time it takes an unprepared reader to grasp the message of a table.




The Writing Style Itself

Medical articles are not written to amuse, to excite, to convert, or to provide an esthetic experience. They are expository, written to communicate. Four of the cardinal attributes of expository writing are unity (it carries one overarching message), coherence (its parts support each other in that message), clarity (the message is easily understood), and brevity (neither words nor sentences are wasted). If your manuscript is unified, coherent, clear, and short, it has already gone a long way toward acceptance. Crisp, clear writing is the result of crisp, clear thinking, and readers know this. Sloppy, muddy writing suggests sloppy, muddy thinking. If the reader doesn't understand a sentence or paragraph, perhaps the author didn't either. Furthermore, weakness and errors in the presentation of your research suggest weakness and errors in the research itself.

Use the correct word. Don't say "prominent" if you mean "large." Use short words [1] and phrases. Long ones are just clutter. Express yourself directly, not by circumlocution. Reject "There is no doubt but that abdominal pain after chest CT is a subject on which there is much disagreement" in favor of "On abdominal pain after chest CT, radiologists disagree." Use the simple word, not the pompous one. You are writing to communicate, not to impress, and readers recognize the difference. Use the active voice. If you find yourself writing, "Abdominal pain is suffered by a substantial number of children," substitute "Many children have abdominal pain." Put statements in a positive form. Reject "Chest CT is not an unstressful experience for children" in favor of "Children find chest CT stressful." Be definite, concrete, and specific. If one of your sentences reads, "CT is not always entirely free of unpleasant, unwanted side effects for patients," change it to "CT sometimes causes worry and pain." Ask yourself repeatedly whether you would enjoy reading what you have just written; if not, try again.

Revise, revise, and then revise again [2]. Expect to go through perhaps six thorough revisions. Each one will be an improvement. Put the manuscript aside for a few days; rereading it then will make its flaws more obvious. What can be deleted? If in doubt, you should probably cut it out.

Presumably you have had continuous input from your co-authors during this whole process. Ask that their suggestions be both blunt and thorough, not



hesitant or perfunctory. Ask them to be critical not only of the sections they are primarily responsible for but of the whole manuscript. Remind them that their names are going on the entire paper, not just part of it.

Final Steps

Carefully check the instructions to authors for the journal you have selected. You will probably have done something wrong or left something out. You may think that the reviewers and editor will not notice, but they will; fix it.

When you think perfection has been attained, show the paper to your spouse and your teen-age daughter or son, asking for comments. Get input from your chief. Ask for comments from your secretary, who knows the paper as well as you do and has been biting his or her tongue waiting for this chance. Pay strong attention to their suggestions; their solu-

tions may not be the best ones, but their identification of problems is likely to be unerring.

Lastly, put the paper aside once again for a few days, and then reread it carefully and slowly when you know you will not be disturbed. Unexpected small ways of improving it will occur to you. Make those changes, then send it off. If some misbegotten editor rejects it, he has just brought medical progress to a screeching halt, but you don't care; you did your best.

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Bone Marrow Transplantation Pulmonary Complication



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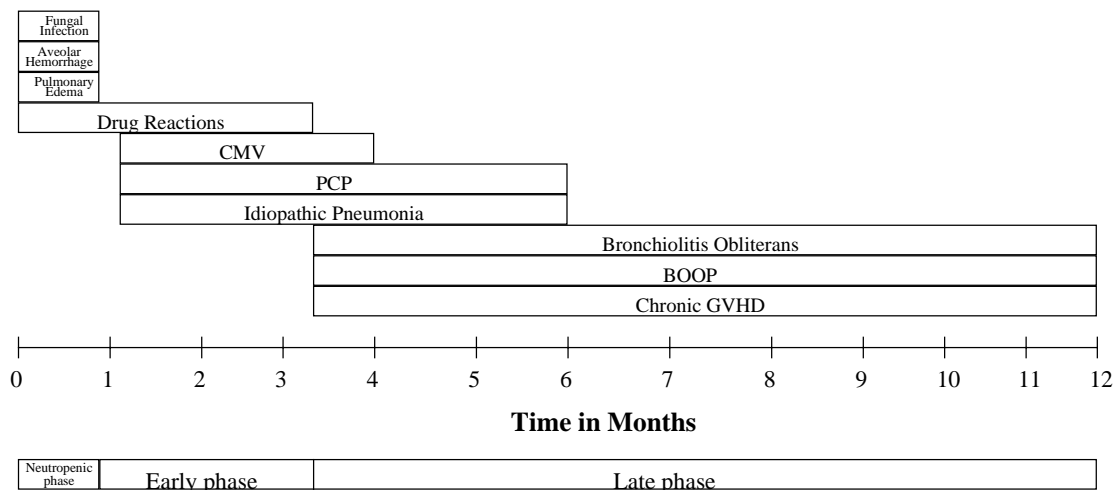
The main objective of this workshop is to 1) review the current pulmonary complications that occur following bone marrow transplants, (BMT). There will be an initial review of the common complications and the BMT time line. Following this will be a staging of a problem-oriented approach with multiple cases and different diagnostic strategies. The other objective of this workshop is to help the radiologist become more familiar with the diagnostic approach and management of BMT patients with pulmonary complications.

The first successful bone marrow transplant occurred in the late 1960's. It is currently the treatment of choice for hematologic malignancies and aplastic anemia. Its role is increasing in the treatment of solid tumors (especially breast and testicular cancer), multiple myeloma, and myelodysplastic syndrome. The procedure entails the intravenous infusion of hematopoietic progenitor cells to replace the defective or malignant bone marrow cells. The earliest transplants were allogeneic, which utilized the marrow from an HLA matched donor. Syngeneic transplants use the marrow of a donor who is an identical twin. Autologous transplants use the patients own marrow in order

to reestablish the hematopoietic function and have had fewer associated complications. The newest form of BMT is stem cell transfusion and should be considered similar to the autologous transplants (1).

Pulmonary complications occur in 40 – 60% of BMT patients and account for morbidity and mortality associated with this procedure (1). The complications are generally classified into infectious and non-infectious categories. The risks of developing a BMT related pulmonary disorder depends on a number of variables. The type of underlying malignancy, the patient's conditioning regimen employed prior to BMT, the type of BMT (allogeneic versus autologous), and the presence of graft vs. host disease (GVHD) (1). There is a predictable course of immunosuppression and recovery which allows for the development of BMT time lines. This is of great assistance when confronted with an abnormal chest radiograph of a BMT patient. The time course will narrow the differential diagnosis to particular complications, which characteristically occur at certain points along the immunosuppression - recovery evolution (1,2,3). Please see the accompanying summary table 1.

Complications over the course of time following BMT





The three major time intervals can be divided into 1) Neutropenic phase – First 30 days, 2) Early phase – About 30 days to 100 days post BMT, and 3) Late phase – After 100 days post BMT.

Neutropenic Phase

The neutropenic phase occurs immediately after transplantation and extends for approximately 30 days. The combination of severe neutropenia and damaged mucosal membranes results in serious immunosuppression and defective host defenses. Bacterial and invasive aspergillosis characterizes the infectious complications that occur most often during this period (2). The non-infectious complications include pulmonary edema, drug toxicity, and diffuse alveolar hemorrhage (3).

Pulmonary edema is quite common during this phase. It likely represents a combination of non-cardiogenic (capillary leak) and cardiogenic factors. The patients often receive high volumes of fluid for medications, TPN and the multiple transfusions. The heart may also be comprised by a number of drugs (i.e. Adriamycin) used for induction. In addition, the total body radiation, induction drugs, and septic episodes may damage the capillary membranes, leading to non-cardiogenic edema (1). These radiographic findings of vascular and hilar indistinctness, enlarged heart, reduced lung volumes and small pleural effusions are typically seen. The patient's weight will also increase and they will have increasing dyspnea and bibasilar crackles.

Drug toxicity is most often associated with use of cytotoxic medications such as bleomycin, methotrexate, and busulfan. The combination of lung injury from total body radiation likely contributes to the cytotoxic effects (3). These drugs can induce a hypersensitivity pneumonitis pattern of injury with ground glass opacities seen on the radiograph and CT scan. Other patterns of injury include non-cardiogenic edema or, at a later stage, pulmonary fibrosis.

Diffuse Alveolar hemorrhage (DAH) is seen in both allogenic and autologous transplants. It often presents with sudden onset of dyspnea, non-productive cough, hypoxia, and fever. Hemoptysis is actually quite uncommon. The associated mortality rate ranges between 50 – 80%. There is no significant association with thrombocytopenia or prolonged PT and PTT. The chest radiograph will usually show diffuse consolidation. BAL often demonstrates a progressively bloodier return of the lavage fluid (1). The etiologies are likely multiple, but most believe that it relates to the influx of neutrophils into the lung, especially since the onset often corresponds with the marrow engraftment period (7-21 days post transplantation). Studies have shown that early detection and

institution of high doses of steroid therapy improve the survival of patients in whom DAH occurs (4).

Bacterial infections are also often diagnosed during this period. Bacteremia is quite common, especially gram negative bacteria, presumably from the GI tract and oral mucosa (2). Radiographic evidence of pneumonia is rarely present, most likely because of the routine use of broad-spectrum antibiotics.

Aspergillous infections are common during this neutropenic phase to occur most frequently in allogenic transplants (2). The combination of ill-defined nodules/masses (with or without cavitation) and focal consolidations are the most common radiographic findings. On CT, aspergillous may show a nodule or mass surrounded by a halo of ground glass. This is thought to represent a hemorrhagic infarction around the consolidated fungal infection (3). Concomitant sinusitis may also be present. Symptoms include fever, dyspnea, dry cough and, occasionally, hemoptysis. Mortality associated with concomitant sinusitis is high (85%) and may be secondary to delays in the diagnosis. Amphotericin B is the most effective current antifungal therapy, but its use with BMT patients has generally not been successful (5). The use of particulate air filter masks and adequate laminar airflow rooms has helped decrease the incidence of infection (6).

Early Phase

The early phase complications occur between approximately 30 days and 100 days after BMT (postengraftment period). The underlying deficit is cellular and humoral mediated immunity suppression. There is a gradual improvement in the neutrophils with decreasing incidences of fungal infectious and increasing risks of viral infections, most notably CMV. PCP is less often seen due to the routine use of prophylaxis (2). Herpes virus is also common but tends to be more limited to mucocutaneous involvement. The non-infectious problem that predominates during this period is Idiopathic Pneumonia Syndrome, which pathologically represents a form of diffuse alveolar damage.

CMV pneumonia occurs in approximately 10 – 40% of BMT patients, often between 6 – 12 weeks post transplant. This occurs more commonly in allogenic transplants. The fatality rate is high, approximately 85% (7). Death usually results from reactivation of the latent endogenous virus. Patients present with fever, dyspnea, hypoxia and a non-productive cough. Radiographs often show diffuse ground glass opacities and/or nodules, most often predominating in the mid and lower lung zones. Early diagnosis is very important since ganciclovir therapy can increase chances for survival. By the time respiratory failure occurs, therapy does not appear effective for reversing the poor prognosis (1).



Idiopathic pneumonia syndrome (IPS) is a diffuse lung injury, for which no infectious etiology can be found, that can occur after BMT. The result is a progressive diffuse alveolar damage and associated high mortality rate (>70%) (1). It occurs most often between 30 – 60 days post transplant with an early peak at about 14 days. It is a diagnosis of exclusion. There is no effective therapy for IPS once it develops (1,3). The radiographs show a progressively worsening diffuse consolidation that occurs over a period of days.

Late Phase

The late phase complications occur after 100 days post BMT. The patient's immune system gradually returns to near normal by the end of one year. Most problems are associated with chronic graft vs. host disease (GVHD). They include bronchiolitis obliterans or BOOP-like reactions. Most GVHD involves the liver, GI tract, sinuses, and skin (1,3). Some, or all, of these organ systems are often involved when the lungs are affected. Infectious complications are relatively uncommon *except* in the setting of GVHD, in which the host defenses are impaired and the patients often receive immune suppressive therapy. Bacterial infections and typical respiratory viruses occur commonly in patients with chronic GVHD (1,2).

Bronchiolitis obliterans (OB) can be seen in approximately 10% of patients with chronic GVHD. It tends *not* to occur in patients with allogenic transplants. Patients who suffer from (OB) develop a non-reversible airflow obstruction with increasing nonproductive cough and dyspnea (1). Thin-section CT shows bronchial dilation and mosaic lung attenuation with small airway obstruction on expiratory scans (3). This condition can develop anytime after three months post-transplant. There is currently no effective treat-

ment. Most cases are felt to be the residual effects of the bronchial mucosal damage from GVHD. Some cases of OB may also originate from viral infections.

BOOP is also felt to be predominantly a reaction to chronic GVHD. A non-productive cough, low-grade fever, and dyspnea are common presenting symptoms. Radiographs show patchy consolidations involving multiple lobes. CT scans may demonstrate the characteristic peribronchial distribution of the disease (3). It may also have a more nodular appearance, which studies suggest may be related to a BOOP-like reaction to an underlying infection. (8) BOOP often can be corrected with steroid therapy.

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Respiratory Emergencies in Infants and Children

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Respiratory emergencies result from a spectrum of entities in different age groups that require speedy diagnostic evaluation and quick transfer of information to responsible physicians for an immediate and appropriate treatment. In this presentation I will just present and discuss the frequently encountered conditions. Entities that cause respiratory distress in the immediate neonatal period are arbitrarily excluded. The diagnostic approach and the characteristic radiographic findings are presented and the effective selection of diagnostic modalities is emphasized.

I. Malposition of Endotracheal Tube

The endotracheal tube enters the right main stem bronchus in most of the patients when it traverses beyond the carina. The side wall of the endotracheal tube obstructs the right upper lobe bronchus and left main stem bronchus resulting in atelectasis of the right upper lobe and left lung. It is quite possible to cause damage to the right upper lobe bronchus, that is why we see postextubation atelectasis of the right upper lobe (1). When the “beveled” orifice abuts the tracheal wall, it increases the resistance up to 487% above the baseline and impedes ventilation. It can easily be corrected by repositioning of the patient’s neck (2).

The endotracheal tube can cause acute iatrogenic perforation usually in the posterior wall of the trachea near the carina. Tracheal perforation is suspected because of an unusual inferior location of the tip of the endotracheal tube below the carina and the concomitant development of pneumomediastinum and /or pleural effusion (3).

When one suspects placement of the endotracheal tube in the esophagus and cannot be sure, the right posterior oblique radiograph is recommended to separate the trachea from the esophagus.

II. Malposition of Nasogastric Tube

The nasogastric tube often enters the airway which can easily be detected. When it reaches the bronchus, it can easily cause atelectasis because of the small caliber of the airway in infants and children. The younger the child, the easier it is for the nasogastric tube to perforate the pharynx or the esophagus. It is suspected

when pneumomediastinum occurs after placement of the nasogastric tube. Subcutaneous emphysema and pneumothorax may occur. Perforation of the pharynx or esophagus can be confirmed by an injection of non-ionic, low osmolar, water-soluble contrast medium through the nasogastric tube under fluoroscopic observation (4). It may form traumatic pseudodiverticulum of the pharynx or esophagus. Diagnostic procedures should be performed immediately because unrecognized pharyngeal or esophageal perforation can cause appreciable morbidity. At the time of insertion of a nasogastric tube, one must listen for a change in the child’s voice because their voice will become hoarse due to the inadvertent insertion of the nasogastric tube into the airway. In addition, the child will frequently experience choking spells.

III. Retropharyngeal Abscess

Retropharyngeal abscess is caused by direct penetrating injury or spread of adjacent infection often from tonsillitis and/or adenitis. When the abscess compresses the larynx and the trachea, acute respiratory distress may occur (5). CT or MRI can be performed for a definitive diagnosis. A skillful radiologist can aspirate the retropharyngeal abscess under ultrasonographic guidance. Before a CT or MRI examination is performed, one must exclude a pseudoretropharyngeal mass effect. In infants and preschool children, the posterior pharyngeal wall moves freely during the respiratory cycle or during flexion and extension of the neck. When the pharynx is not fully distended, it often produces the findings that mimic the presence of a retropharyngeal abscess or mass lesion. The lateral view of the neck should be obtained with full distension of the pharynx during deep inspiration with slight extension of the neck. If necessary, fluoroscopy can easily confirm the pseudoretropharyngeal mass effect (6). The abscess is posterolateral to and off the midline and may not be evident on a lateral radiograph of the neck. Therefore, a lateral radiograph is not sensitive to visualize an early retropharyngeal abscess (7).

IV. Epiglottitis

It usually affects children between the ages of three and six years. Sudden death is not uncommon.



It is usually caused by *Haemophilus influenzae* infection. Epiglottic swelling, "sore thumb" appearance may also result from trauma, bleeding, radiation, ingestion of corrosive substances, angioneurotic edema, lymphoma, and hemangioma. Swelling of the aryepiglottic fold is characteristic of epiglottitis (8).

V. Vascular Ring and Sling

A vascular ring is a developmental anomaly associated with encirclement and compression of the trachea and esophagus by the anomalous aortic arch and its associated abnormal branches. Complete double aortic arch is a true undivided vascular ring and is the most common vascular ring. The right aortic arch is usually higher in position and larger in size than that the left (9, 10). Therefore, the trachea is deviated to the left and bowed anteriorly. Esophagus shows a large posterior indentation and asymmetric circumferential narrowing. The indentation on the right side of the barium-filled esophagus is usually larger in size and higher in position than the one on the left side. MRI is the procedure of choice for the diagnosis (11). Angiography is rarely necessary. The spiral CT angiographic techniques are being developed, but need to be perfected, and need the use of radiation (12). The right aortic arch with the right descending aorta, aberrant left subclavian artery, and left ligamentum arteriosum is the second most common vascular ring. MRI (or CT) can differentiate this from complete double aortic arch.

The barium esophagram does not have circumferential narrowing, but right-sided indentation by a right aortic arch. The trachea is bowed anteriorly. A pulmonary sling is the anomalous left main pulmonary artery that arises from the posterior aspect of the right main pulmonary artery and passes between the trachea and esophagus (13). There is an indentation on the anterior wall of the barium-filled esophagus. Air trapping can be bilateral or unilateral depending upon the location of the airway compression or associated intrinsic anomalies of the tracheobronchial tree. These airway anomalies include complete cartilaginous rings and tracheobronchial stenosis causing obstructive emphysema and respiratory distress. In newborns, fetal lung fluid can be trapped in the involved portion of the lung causing respiratory distress.

VI. Foreign Body Aspiration

An episode of sudden coughing and choking should alert us to suspect foreign body aspiration. The mean age for girls is 22.5 months and 34.8 months for boys. The most common foreign bodies removed from airways are peanuts, almonds, and walnuts. It is important to quickly diagnose and remove the foreign body

before it breaks down. Others foreign bodies include vegetables and other organic materials, and wooden, plastic, and metallic materials. In a recent series, foreign bodies were found in the right main stem bronchus in 31.4% of patients and in the left main stem bronchus in 30% of patients (14). Complications are almost always related to the diagnostic delay. Chest radiographs are not sensitive and were normal in 31% of the patients with unilateral nonopaque foreign bodies (15). Chest fluoroscopy or lung radionuclide perfusion scintigraphy should be performed without delay if clinically indicated.

VII. Phrenic Nerve Palsy and Injury to the Diaphragm

(Refer to Radiologic Evaluation of the Diaphragm in this program.)

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HRCT: Know Your Buzz Words

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At the completion of this presentation, the attendee will be able to:

- 1) properly use the HRCT scanning descriptive term “Crazy Paving” and state the different disease processes that cause this pattern.
- 2) properly use the HRCT scanning descriptive term “Mosaic pattern of lung attenuation” and state the different disease processes that cause this pattern.
- 3) properly use the HRCT scanning descriptive term “Tree-in-bud” and state the different disease processes that cause this pattern.
- 4) properly use the HRCT scanning descriptive term “Ground glass opacification” and state the different disease processes that cause this pattern.

High resolution CT scanning (HRCT) of the chest often shows findings that produce a very short differential diagnosis, sometimes pathognomonic for certain disease processes, such as centrilobular pulmonary emphysema, bronchiectasis, or classic honeycomb lung fibrosis. Several colorful descriptive terms have been popularized in the radiology literature, becoming HRCT “buzz words”. These terms, describing a particular disease process, are sometimes used inappropriately to infer a pathognomonic finding, when in fact, the terms are often non-specific. These HRCT buzz words include “crazy paving”, “mosaic perfusion or mosaic pattern”, “ground glass opacity”, and “tree-in-bud”. The term crazy paving has been used to describe the CT scan findings of pulmonary alveolar proteinosis. The terms mosaic perfusion or “mosaic oligemia” describe the chest CT scan finding of pulmonary thromboembolism. The term ground glass opacity, or ground glass attenuation, has been used for many years to describe any radiographic or CT scan finding of a hazy increase of opacity involving the lungs, as well as bones in fibrous dysplasia, and was popularized as a chest HRCT scan finding of alveolitis in patients with usual interstitial pneumonia. The term tree-in-bud has also been used for many years, dating back to the bronchogram descriptions of respiratory bronchioles by Twining and Kerley, but more recently popularized as a chest CT scan finding of active endobronchial tuberculosis. These terms and the findings they represent are much less specific than once thought and are now recognized to be associated with a number of disorders. In this perspective, we

will discuss these HRCT chest buzz words and review the proper use of the terms and their significance.

Buzz Word: Crazy Paving

Crazy paving is a colorful descriptive term for the HRCT scan findings of apparent thickened interlobular septa and intralobular structures, in areas of ground glass opacity, forming typical polygonal shapes, with no architectural distortion. The diseased lung is usually quite well demarcated from surrounding normal lung tissue, creating a “geographic” pattern.

Crazy paving is thought by many to be a pathognomonic finding of pulmonary alveolar proteinosis. The finding is still strongly suggestive of pulmonary alveolar proteinosis in the appropriate clinical setting. However, in isolation, this HRCT scan pattern has also been described with such diverse disease processes as *Pneumocystis carinii* pneumonia, sarcoidosis, bronchioloalveolar carcinoma, ARDS, and exogenous lipid pneumonia.

Buzz Word: Mosaic Pattern

The term “mosaic perfusion” was popularized by Martin et al as a CT scan finding of pulmonary thromboembolic disease resulting from regions of hyperemic (higher attenuation) lung adjacent to oligemic (lower attenuation) regions of lung. While acute pulmonary thromboembolism usually does not produce a mosaic pattern of lung attenuation, similar CT findings of mosaic perfusion are described for pulmonary arterial hypertension.

In addition to vascular disease, a mosaic pattern of lung attenuation has been described in two other disease categories: (1) small airways disease, (2) infiltrative lung diseases. Areas of variable lung attenuation in a lobular or multilobular distribution are almost never a normal finding, except as an easily distinguished normal gravitational gradients of lung density.

The mosaic pattern of lung attenuation presents a challenge to the radiologist when deciding which are the abnormal regions of lung, those of low attenuation or high attenuation, or both. It is often possible to distinguish among these categories by using the following additional CT scan findings.

CT performed at suspended full expiration shows the physiologic consequence of small airways (bronchiolar) diseases: air trapping. Lung regions that re-



tain air during exhalation remain more lucent and show less decrease in volume than lung supplied by normal airways. The distribution of air trapping is often patchy and dependent on the level and severity of the airway obstruction. When the level of airway obstruction is at the subsegmental or lobular level, a mosaic pattern of normal lung and hyperlucent lung can result. Lung regions that retain air show a decrease in the caliber and number of pulmonary vessels relative to normal lung. The inciting pathologic processes can be permanent, such as seen in patients with obliterative bronchiolitis or reversible, such as seen in patients with asthma. In some instances, air trapping can be completely unsuspected on routine suspended full inspiration CT scanning and only become evident on CT scans obtained at suspended full expiration. In small airways diseases, the lucent regions of lung seen at inspiration remain lucent at expiration because of air trapping, showing no or minimal increase in lung attenuation and no or minimal decrease in volume. In chronic vascular disease, because there is no air trapping or airway disease, the attenuation of both the hyperemic and oligemic lung at inspiration will increase in a similar fashion and the volume of both will decrease uniformly at expiration.

A patchy infiltrative process within the interstitium of the lung or partial filling of the air spaces by fluid, cells, or fibrosis can occur such that the CT attenuation of the affected lung increases relative to that of normal parenchyma. This patchy distribution can appear as a typical mosaic pattern. The vessel caliber and number are not appreciably different between the normal and abnormal regions of lung. Diseases that can produce such a CT pattern of mosaic lung attenuation include *Pneumocystis carinii* pneumonia, chronic eosinophilic pneumonia, hypersensitivity pneumonia, bronchiolitis obliterans organizing pneumonia, or bacterial pneumonia.

Buzz Word: Tree-in-Bud

The term tree-in-bud has also been used for many years, dating back to the bronchogram descriptions of respiratory bronchioles by Twining and Kerley, but more recently popularized as a chest CT scan finding of active endobronchial tuberculosis.

The “tree-in-bud” (TIB) pattern is a direct CT scan finding of bronchiolar disease. Gruden and colleagues have described this same appearance as resembling the childhood toy “jacks”. This pattern is analogous to the larger airway “finger-in-glove” appearance of bronchial impaction, but on a much smaller scale. The TIB pattern has become a popular descriptive term for many bronchiolar disease processes, all with similar appearances, though is still often used inappropriately to imply a pathognomonic finding for tuberculosis.

The list of diseases associated with the bronchioles potentially producing a TIB pattern at CT scanning is extensive. The more common disease processes can be grouped as follows: 1) infection, 2) immunologic disorders, such as allergic bronchopulmonary aspergillosis, 3) congenital disorders, such as Kartagener’s syndrome, 4) aspiration, and 5) idiopathic conditions such as diffuse pan-bronchiolitis. Aspiration of infected oral secretions or other material is the most common cause of the tree-in-bud appearance in our experience.

Endobronchial spread of *Mycobacterium tuberculosis* represents a chronic granulomatous infection in which active organisms spread via the airways after necrosis of a bronchial wall and softening or liquefaction necrosis of caseous material. When the spread is pathologically extensive enough to be detected with CT scanning, the earliest CT scan finding is the TIB pattern of 2 - 4 mm centrilobular nodules and branching linear structures of similar caliber originating from a single stalk. This TIB appearance is characteristic, but not pathognomonic, of active, likely contagious, tuberculosis. *In the proper clinical setting*, the TIB pattern is thought to be a reliable criterion for disease activity, distinct from old fibrotic lesions. A typical example is an upper lobe cavitory lesion containing active infectious organisms that subsequently “spills” out into lower lung airways, resulting in bronchogenic spread of disease.

Indirect CT scan signs of bronchiolar disease include air-trapping, especially with expiratory CT scanning, and subsegmental atelectasis.

Buzz Word: Ground Glass Opacity

Ground glass opacification describes a finding on high resolution CT of the lungs in which there is a “hazy increased attenuation of lung, with preservation of bronchial and vascular margins; caused by partial filling of air spaces, interstitial thickening, partial collapse of alveoli, normal expiration, or increased capillary blood volume; not to be confused with consolidation, in which bronchovascular margins are obscured; may be associated with an air bronchogram”. This finding is often occult on chest radiographs. GGO can represent either normal or abnormal interstitial or alveolar processes, findings beyond the resolution of the HRCT technique.

The term ground glass opacity, or ground glass attenuation, has been used for many years to describe any radiographic or CT scan finding of a hazy increase of opacity involving the lungs, as well as bones in fibrous dysplasia, and was popularized as a chest HRCT scan finding of alveolitis in patients with usual interstitial pneumonia. Ground glass opacification has





TABLE 1

Simplified list of the more common etiologies of Ground Glass Opacification on CT scanning of the lungs

- A- Alveolar Proteinosis
- B- Blood (Contusion, Hemorrhage)
- C- Cancer, Collagen vascular disease
- D- Drug toxicity
- E- Edema (BAL, ARDS, Lavage)
- F- Fibrosis
- G- Granulomatous disease (e.g. Sarcoidosis)
- H- Hypersensitivity pneumonitis
- I- Infections (e.g. pneumocystis carinii)

become a non-specific finding, but which in certain clinical circumstances can suggest a specific diagnosis, indicate a potentially treatable disease, or guide a bronchoscopist or surgeon to an appropriate area for biopsy. GGO is a frequent finding on HRCT, with a lengthy differential diagnosis. It is very important to correlate the HRCT scan finding of GGO with the clinical presentation to narrow the lengthy differential diagnosis.

The following disease processes can all result in a ground glass pattern as the sole, dominant, or accompanying HRCT scan manifestation: lung parenchymal fibrosis with or without active inflammation, pulmonary contusion, acute pulmonary hemorrhage from any etiology, bronchioloalveolar carcinoma, intrathoracic lymphoproliferative disorders, cardiac and non-cardiac pulmonary edema, adult respiratory distress syndrome, sarcoidosis, and infectious pneumonia of any etiology.

Hypersensitivity pneumonitis is an interesting disease process that can manifest several of the HRCT “buzzwords” including a mosaic pattern of lung attenuation, GGO, and of air trapping. Hypersensitivity pneumonitis is a complex immunologic reaction by the lung, primarily to inhaled organic antigens, although non-inhaled drugs can also be an inciting agent. The most important and common disorders and their inciting agents are farmer’s lung from thermophilic actinomycetes in moldy hay, and bird fancier’s lung from avian protein in droppings and feathers. The clinical presentation may be categorized as acute, subacute, or chronic, depending on the periodicity of exposure and quantity of inhaled antigen. GGO is a dominant feature in subacute hypersensitivity pneumonitis.

There are even some non-disease states—normal conditions, and technical factors—producing GGO. For example, narrow window widths and levels can erroneously create the appearance of GGO. Thick (5-10 mm) collimation may cause a false appearance of GGO that is shown to be volume averaging of linear structures with thin sections.

Subpleural opacities are frequently identified in the dependent portions of the lungs, as a result of gravity and microatelectasis. These dependent opacities consist of reticular, linear, and ground glass opacities, that can be confused with or mask true infiltrative lung disease. Repeat scanning with the patient in the prone position can make the distinction between infiltrative lung disease and nonpathologic dependent opacities.

Lung attenuation normally increases with exhalation. This increased attenuation can mask underlying GGO, or create an appearance of diffuse lung disease if the expiratory nature of the examination is not appreciated.

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Notes