Bronchiolitis Obliterans Organizing Pneumonia

Krista A. White, RN, MSN, CCRN
Lisa A. Ruth-Sahd, DEd, RN, CEN, CCRN

Bronchiolitis obliterans organizing pneumonia (BOOP) is a form of interstitial lung disease with unique signs and symptoms, radiological findings, and prognostic indicators. BOOP was first described as a separate disease by Epler et al in 1985 and since then has been extensively investigated and has been reported to occur throughout the world. BOOP is clinicopathological syndrome that is an important cause of acute respiratory illness in adults. Patients experience a subacute onset of mild dyspnea, a nonproductive cough, bilateral crackles, sore throat, fever, and malaise. In this article, we define BOOP and present its epidemiology, pathophysiology, clinical manifestations, differential diagnosis, diagnostic studies, and treatment and describe nursing interventions. A case study illustrates the difficulty in diagnosing and treating BOOP.

Definition

Defining BOOP requires an awareness of bronchiolitis. Bronchiolitis is a generic term used to describe a variety of inflammatory diseases that affect the bronchioles. Bronchiolitis is a common pathological change but is rarely marked enough to cause clinical signs or symptoms. Obliterans refers to the ability of the pathological change to obliterate, eradicate, or destroy the airways. The term bronchiolitis obliterans was first used in the literature in 1901 by Lange to describe a group of patients who had submucosal and peribronchiolar fibrosis leading to obliteration of the bronchiolar lumens. These patients did not have organizing pneumonia. Later, Epler and his colleagues described BOOP as an inflammatory clinicopathological lung disease characterized by polyoid intralumenal and endobronchial connective tissue plugs. These plugs are composed of proliferating myxoid fibroblasts and myofibroblasts that fill the lumens of terminal bronchioles and extend in a continuous fashion into the alveolar ducts and alveoli, characteristics of an organizing pneumonia.

The airway plugs formed by the proliferation of connective tissue and fibroblasts may lead to a cast formation that outlines the branching of the inflamed alveolar ducts and distal airways. In BOOP the airway lumens are occluded from within, so the background architecture is generally preserved. This inflammation and the occlusive infiltrates in the bronchioles lead to restricted...
lung volumes and decreased vital capacity. BOOP is sometimes referred to as cryptogenic organizing pneumonia, a term that is considered more general and representative of what happens clinically, pathologically, and structurally within the lung tissue. However, the term BOOP is specific for a lesion that occurs in the distal bronchioles and alveoli simultaneously and is a popular term used throughout the world.

Types and Causes of BOOP

In many instances, the cause of BOOP cannot be determined. Epler,3 the leading clinical expert on BOOP, identifies several known causes or associated diseases and classifies them according to types (Table 1). No links exist between the types of BOOP except that all the types lead to a final common clinical pathway that may be devastating if not detected promptly.

Idiopathic BOOP is the most common type of BOOP that critical care nurses see in practice. Stover and Mangino17 call this type cryptogenic. Patients have flulike signs and symptoms, fever, a mild cough, and dyspnea. Auscultation of lung sounds commonly reveals crackles. The prognosis of idiopathic BOOP is good, and some patients have resolution of signs and symptoms without having any treatment at all.

Rapidly progressive BOOP is a deadly form that can be fatal within 1 to 3 days of the onset of signs and symptoms. Patients may have an acute onset of acute respiratory distress syndrome; therefore, clinically, rapidly progressive BOOP can be indistinguishable from acute interstitial pneumonia.23 Acute respiratory failure quickly results and leads to

<table>
<thead>
<tr>
<th>Type</th>
<th>Causes</th>
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<tbody>
<tr>
<td>Idiopathic</td>
<td>Chlamydia, Legionella, and Mycoplasma species</td>
</tr>
<tr>
<td>Rapidly progressive</td>
<td>Adenovirus, cytomegalovirus, and influenza virus</td>
</tr>
<tr>
<td>Focal nodular</td>
<td>Malaria and Pneumocystis species</td>
</tr>
<tr>
<td>Postinfection</td>
<td>Cryptococcus species</td>
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<tr>
<td>Rheumatologic or connective</td>
<td>Lupus erythematosus</td>
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<tr>
<td>tissue</td>
<td>Rheumatoid arthritis</td>
</tr>
<tr>
<td></td>
<td>Sjögren syndrome and Sweet syndrome</td>
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<tr>
<td></td>
<td>Polymyositis-dermatomyositis</td>
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<td></td>
<td>Scleroderma–progressive systemic sclerosis</td>
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<tr>
<td></td>
<td>Ankylosing spondylitis</td>
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<td></td>
<td>Polymyalgia rheumatica</td>
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<td></td>
<td>Behçet syndrome</td>
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<tr>
<td>Immunological disorder</td>
<td>Common variable immunodeficiency syndrome</td>
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<td></td>
<td>HIV infection</td>
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<tr>
<td></td>
<td>Essential mixed cryoglobulinemia</td>
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<tr>
<td>Organ transplantation</td>
<td>Bone marrow, lung, kidney, and stem cell transplants</td>
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<td></td>
<td>Pretransplant soluble CD30</td>
</tr>
<tr>
<td>Radiotherapy</td>
<td>Radiotherapy for breast cancer</td>
</tr>
<tr>
<td>Environmental</td>
<td>Textile printing dye</td>
</tr>
<tr>
<td></td>
<td>Penicillium mold dust</td>
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<tr>
<td></td>
<td>House fire</td>
</tr>
<tr>
<td></td>
<td>Diacetyl inhalation</td>
</tr>
<tr>
<td>Drug-related/chemical</td>
<td>Antibiotics: amphotericin B, cephalosporin, minocycline, nitrofurantoin, sulfasalazine, and sulfamethoxypyridazine</td>
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<tr>
<td></td>
<td>5-Aminosalicylic acid</td>
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<td></td>
<td>Methotrexate</td>
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<td></td>
<td>Acebutolol</td>
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<td>Busulphan</td>
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<td></td>
<td>Bleomycin</td>
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<td></td>
<td>Gold salts</td>
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<td></td>
<td>Sotolol</td>
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<td>Acramin FWN</td>
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<td>Amiodarone</td>
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<td>Cyclophosphamide</td>
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<td></td>
<td>Cocaine (illicit use)</td>
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<td>L-Tryptophan</td>
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<td>Phenytoin</td>
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<td>Carbamazepine</td>
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<td>Tacrolimus</td>
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<td></td>
<td>Ticlopidine hydrochloride</td>
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<td></td>
<td>Nitrogen dioxide (inhalation)</td>
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<tr>
<td></td>
<td>Interferon alfa along with cytosine arabinoside</td>
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<tr>
<td>Miscellaneous</td>
<td>Inflammatory bowel disease</td>
</tr>
<tr>
<td></td>
<td>Lymphoma and cancer</td>
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<tr>
<td></td>
<td>T-cell chronic lymphocytic leukemia</td>
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<tr>
<td></td>
<td>Myelodysplastic syndrome</td>
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<tr>
<td></td>
<td>Hunner interstitial cystitis</td>
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<tr>
<td></td>
<td>Chronic thyroiditis and alcoholic cirrhosis</td>
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<tr>
<td></td>
<td>Seasonal syndrome with cholestasis</td>
</tr>
<tr>
<td></td>
<td>Primary biliary cirrhosis</td>
</tr>
<tr>
<td></td>
<td>Coronary artery bypass graft surgery</td>
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</table>

*Adapted from Epler,3 with permission. Copyright ©2001, American Medical Association. All rights reserved.
death. Early diagnosis based on histological examination of the primary BOOP lesion and initiation of corticosteroid therapy might improve survival in these patients.6 This form of BOOP occurs in less than 10% of patients with BOOP and occurs equally in men and women and at all ages.

Focal nodular BOOP is clinically important because distinguishing it from lung cancer is difficult.18-21 It occurs in approximately one fourth of patients who have idiopathic BOOP.22 Although some focal nodular lesions might progress to the typical bilateral process of idiopathic BOOP, most do not, and resection results in a cure. Multiple bilateral nodular lesions may regress on their own without treatment.20 Approximately 50% of patients with multiple nodular lesions (mean number of masses was 5) have pleuritic chest pain.

BOOP can occur after a variety of different types of infective pneumonias,1 including those caused by bacterial pathogens such as Chlamydia,21 Legionella, and Mycoplasma pneumoniae.24 Viral causes include cytomegalovirus, parainfluenza virus,25 and adenovirus.26 BOOP after parasitic infections such as malaria27 and fungal infections, including those caused by Cryptococcus neoformans28 and Pneumocystis carinii,29 has also been reported. The relationship between many types of infection and the onset of BOOP is still unknown.1

Drug-related BOOP can occur after the use of several different types of medications, including anti-inflammatory and immunosuppressive agents such as bleomycin sulfate,30 gold, cyclophosphamide, penicillamine, and methotrexate; antibiotics such as sulfasalazine, sulfamethoxypyridazine, cephalosporins, and amphotericin B; anti-seizure medications such as carbamazepine31 and phenytoin32,33; illicit use of cocaine; and a massive dose of l-tryptophan. Minocycline-associated BOOP34 has been reported in a woman who was taking this medication for acne. Other medications thought to lead to BOOP and commonly administered by critical care nurses are amiodarone,35 tiaclopidine hydrochloride, and nitrofurantoin.31

Rheumatologic or connective tissue BOOP can occur in patients with connective tissue diseases such as lupus erythematosus,34 rheumatoid arthritis,35 Sjögren syndrome,36 and dermatomyositis.37 BOOP can also occur in patients with ankylosing spondylitis18 and polymyalgia rheumatica,39,40 and it can affect patients with immunological diseases such as immunodeficiency syndrome40 and cryoglobulinemia.41

BOOP can occur in recipients of lung,41 kidney,44 bone marrow,44,46 and stem cell transplants.47 In lung transplantation, BOOP generally occurs up to 10 months after transplantation and is usually associated with an acute rejection reaction.48-50 This type of BOOP has been reported in 10% to 28% of lung transplant recipients and is often reversible, especially if the underlying acute rejection is successfully treated. If a transplant recipient is admitted to a critical care unit within this time frame because of an acute onset of shortness of breath, BOOP should be considered as a causative factor. In these patients, the BOOP reactions should be treated aggressively.

BOOP has been described in a patient who underwent an allogeneic marrow transplantation and in another patient who received a syngeneic bone marrow transplant from his twin brother.49 Too few reports have been published to determine whether BOOP in these patients was an incidental finding or an actual complication of bone marrow transplantation. BOOP can also occur as a late complication after transplantation of hematopoietic stem cells.47

BOOP is an important clinical complication in patients being treated with radiotherapy for breast cancer and may occur in up to 3% of women receiving radiation therapy for breast carcinoma.50-52 The usual signs and symptoms are fever, non-productive cough, and various degrees of shortness of breath that occur up to 12 months after completion of radiotherapy. Chest radiographs show peripheral patchy or alveolar infiltrates, often outside the radiation field.53 In one study,54 patients had infiltrates outside the irradiated lung to the contralateral nonirradiated lung. The underlying mechanism of radiotherapy BOOP remains unknown. A patient’s condition may improve with the initiation of corticosteroid therapy, but relapses may occur.54

Environment-related BOOP has been reported in relation to textile printing dye; the authors of the report suggested that the cause was related to the spraying of a respirable aerosol; however, the reactive chemical agent is a mystery. Another environmental cause is Penicillium janthinellum mold dust, inhaled from a powdery dust of a growth on the top of a discarded orange juice container.55 BOOP due to smoke inhalation has been reported in a patient with erythema nodosum who was in a house fire.55
Miscellaneous BOOP continues to be reported in association with myelodysplastic syndrome, interstitial cystitis, chronic thyroiditis, and disorders of the liver such as alcoholic cirrhosis and primary biliary cirrhosis. It has been reported in patients infected with HIV and has occurred during pregnancy. Guzman et al described a case of BOOP in a patient who had coronary artery bypass graft surgery. In patients with inflammatory bowel disease, BOOP is an important treatable abnormality. BOOP also can occur in patients with T-cell leukemia or lymphoma.

Pathophysiology

A trigger of some kind, for example, an infectious agent, a drug, or a connective tissue disorder, stimulates the inflammatory process known as BOOP. Because BOOP is an inflammatory lung disease, the key pathophysiological findings are related to the inflammatory pathway rather than to the fibrosing pathway as in idiopathic pulmonary fibrosis. Inflammation in the walls of the alveoli and bronchioles and an increase in foamy, lipid-laden macrophages in the alveoli are significant and lead to accumulations of fibromyxoid connective tissue.

Histological features include clusters of mononuclear inflammatory cells that form granulation tissue and plug the distal airways and alveolar spaces. These plugs of granulation tissue may form polyps that migrate within the alveolar ducts or may be focally attached to the wall. The polyps may extend in a continuous fashion from the alveoli and alveolar ducts into the terminal and distal bronchioles. The Figure provides a summary of the pathophysiology of BOOP.

Epidemiology and Mortality

BOOP is most common in the fourth to sixth decade of life and accounts for 20% to 30% of chronic infiltrative lung diseases. BOOP occurs equally in men and women and in all races. It has no corollary relationship with smoking. The incidence in the United States does not differ significantly from that of other countries worldwide. MacLaughlin and King and Epler set mortality due to BOOP at 5%, whereas McKee and Epler note 3% to 13% mortality, depending on the underlying cause of the BOOP.

Prognosis and Incidence of Relapse

Most patients with idiopathic BOOP fully recover after a sufficient course of corticosteroids. However, the success of this treatment depends on the presence of other comorbid conditions and associated problems such as connective tissue disorders or underlying pulmonary diseases. Compared with treatment of BOOP alone, treatment of BOOP in patients with other disease processes is more challenging because of the multidisciplinary approach required. Furthermore, once successful treatment has been started, relapses occur in approximately one third to one half of
patients. The likelihood of relapse may be linked to several factors, including completion of the recommended corticosteroid treatment regimen and the severity of hypoxemia manifested initially.3,22,69

Clinical Manifestations

Signs and Symptoms

The onset of clinical manifestations of BOOP is usually acute (1 week) to subacute (months) no matter what the causative factor; the mean time is 4 to 10 weeks. Patients commonly have weeks to months of nonspecific respiratory signs and symptoms. The clinical manifestations vary according to the type of BOOP. Typical idiopathic BOOP is characterized by a flulike illness, bilateral crackles, and patchy infiltrates on chest radiographs. The initial signs and symptoms may include fever and night sweats, malaise, nonproductive cough and dyspnea, and sore throat. Anorexia and weight loss are common. Physical assessment reveals tachypnea, hypoxia, and respiratory crackles over the involved lung fields in more than 80% of patients.68 Wheezing and hemoptysis are rare.7 The severity of the illness depends on the signs and symptoms.

Laboratory Studies

Hematologic abnormalities are most prevalent in BOOP, although other serum abnormalities may also be evident (Table 2). White blood cell counts are most consistently elevated.3,4,70 In a differential count, neutrophils may be increased to as high as 0.72 (proportion of 1.00), lymphocytes to 0.16, and monocytes to 0.12.71 Increases in eosinophils are rare.70 In 2 case studies,72 2 patients with fairly typical sequelae of pulmonary tuberculosis had BOOP, and 1 of the 2 had thrombocytosis, which occurs in approximately 20% of cases of BOOP.

In addition to the hematologic findings, other laboratory values may be abnormal in BOOP. Patients may have hypoalbuminemia.68 Erythrocyte sedimentation rates can be increased to greater than 60 mm/h as a result of the overwhelming pulmonary inflammatory response that occurs.3,4,71 Serum levels of C-reactive protein are also elevated.4,70

Differential Diagnosis

Both clinically and radiographically, BOOP mimics a variety of other pulmonary abnormalities. Clinically, fever, malaise, nonproductive cough, mild dyspnea, and weight loss of insidious onset can be due to a myriad of causes. Radiographic findings characteristic of BOOP may help in narrowing the list of possible causes to a more manageable number, but the definitive means for confirming BOOP is histological examination.5,74 BOOP should be considered in patients with a suspected infective pulmonary disorder who do not respond to antibiotic therapy.5,74

Table 3 provides a differential diagnosis for patients with indications suggestive of BOOP.

Diagnostic Studies

Radiological Studies

In diagnosing BOOP, findings on chest radiographs are merely a means to an end. Because the findings are also consistent with those of other pulmonary disorders, these studies alone are not sufficient to confirm a diagnosis of BOOP. Three main imaging patterns suggest BOOP.

The first pattern is patchy alveolar and diffuse interstitial infiltrates, usually bilaterally. These findings are consistently visualized on chest radiographs.1,6,68,69,71,72 In as many as 25% of patients with BOOP, the infiltrates are described as migratory, a
### Table 3  Differential diagnosis in patients with indications suggestive of bronchiolitis obliterans organizing pneumonia

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Onset, signs and symptoms, findings on physical examination/laboratory studies</th>
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</thead>
<tbody>
<tr>
<td><strong>Interstitial lung disorders</strong></td>
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</table>
| Bronchiolitis obliterans organizing pneumonia                             | Onset: Indolent over weeks to months  
Fever, nonproductive cough, malaise, weight loss, mild dyspnea  
Usually occurs in nonsmokers  
Findings: Crackles |
| Usual interstitial pneumonia/idiopathic pulmonary fibrosis<sup>6,75</sup>  | Onset: No flu-like signs or symptoms, severe dyspnea, chronic cough  
Findings: Crackles, clubbing |
| Acute interstitial pneumonia or Hammond-Rich syndrome<sup>1,56</sup>      | Onset: Rapid, several days, sometimes after a viral illness  
Cough, shortness of breath, fever, and cyanosis  
Findings: Crackles |
| Desquamative interstitial pneumonia<sup>4,76</sup>                        | Onset: Gradual  
Cough, dyspnea; generally occurs in smokers  
Findings: Crackles, hypoxemia, clubbing |
| Chronic eosinophilic pneumonia<sup>1,80,71</sup>                         | Onset: Fever, night sweats, weight loss, severe dyspnea  
Findings: Crackles |
| **Infective lung disorders**                                              |                                                                                |
| Infective pneumonias (community-acquired, nosocomial, aspiration)<sup>5,74,77</sup> | Onset: Rapid, <6 days  
Fever, malaise, purulent sputum, cough, dyspnea, tachypnea, hypoxia, bronchospasm  
Findings: Crackles, hypoxemia |
| Pulmonary tuberculosis<sup>77,78</sup>                                   | Onset: Fever, weight loss, night sweats, anorexia, malaise, productive cough, hemoptysis  
Suspected exposure to mycobacteria  
Findings: Crackles, positive skin test with purified protein derivative, sputum positive for acid-fast bacilli |
| **Other lung disorders**                                                  |                                                                                |
| Acute respiratory distress syndrome and diffuse alveolar damage<sup>11,79</sup> | Onset: Rapid, 24-48 hours after injury  
Dyspnea, tachypnea, shallow inspiratory effort  
Findings: Crackles, oxygen-resistant hypoxemia, wheezing  
Sometimes, mottling and cyanosis |
| Radiation pneumonitis and hypersensitivity pneumonitis<sup>1,17,71</sup>  | Onset: Low-grade fever, malaise, cough, severe dyspnea, pleuritic pain  
For hypersensitivity pneumonitis, exposure to bird droppings, spores, or protein material  
Findings: Crackles |
| Wegener’s granulomatosis<sup>1,71,80</sup>                               | Onset: Fever, shortness of breath, malaise, arthralgia, sinus pain, epistaxis, otitis media, cough, hemoptysis  
Findings: Positive for antineutrophil cytoplasmic antibodies |
<table>
<thead>
<tr>
<th>Findings on radiographs and high-resolution computed tomography (HRCT) scans</th>
<th>Histological findings on lung biopsy</th>
<th>Treatment and prognosis</th>
</tr>
</thead>
</table>
| Bilateral, patchy alveolar infiltrates and ground-glass opacities, may be peripheral and migratory | Newly formed fibromyxoid plugs of granulation tissue within the distal airways and alveoli | Treatment: Corticosteroid regimen for 6 months to 1 year
Prognosis: excellent, approximately 5% mortality |
| Pleura-based “triangles” common on HRCT scans | Interstitial and alveolar infiltrates with foamy macrophages | |
| Sometimes, linear or crescent-shaped opacities at the bases or nodular lesions | Preserved background lung architecture although sometimes parenchymal involvement | |
| Massive fibrosis appearing as a honeycomb pattern on HRCT scans and traction bronchiectasis (lung architecture distortion) | Interstitial fibrosis, inflammation, fibrogenic foci | Treatment: Corticosteroids for exacerbations and antibiotics medications
Prognosis: Poor, fatal course of 4-6 years |
| Irregular linear infiltrates generally in lower lung zones | | |
| Accelerated interstitial pneumonitis with fibrosis and ground-glass attenuation Interlobular septal thickening | Neutrophils most common cells in bronchoalveolar lavage fluid Type II pneumocyte hyperplasia with hyaline membranes prevalent Diffuse alveolar damage Distorted lung architecture with fibrosis | Treatment: Corticosteroids, supportive pulmonary care with mechanical ventilation
Prognosis: Very poor |
| Both central and peripheral bronchial wall thickness Bilateral interstitial infiltrates Ground-glass attenuation common | Alveoli filled with homogeneous inflammatory cells Extensive interstitial thickening | Treatment: Smoking cessation Corticosteroids sometimes beneficial
Prognosis: Good with smoking cessation |
| Diffuse migratory, patchy alveolar infiltrates often along the pleural edges Ground-glass opacities | Massive alveolar infiltrates made up of eosinophils and lymphocytes Alveolar wall thickening | Treatment: Corticosteroids
Prognosis: Good |
| Generally, either unilateral or bilateral infiltrates Aspiration pneumonia infiltrates common in gravity-dependent regions | Presence of microorganisms | Treatment: Anti-infectives Corticosteroids contraindicated
Prognosis: Excellent with treatment |
| Upper lobe infiltrates with cavities Bilateral small rounded opacities in miliary tuberculosis Enlarged mediastinal lymph nodes and ground-glass infiltrative opacities in primary tuberculosis | Encapsulated granulomas with acid-fast bacilli | Treatment: Rifampin, isoniazide, pyrazinamide, ethambutol
Prognosis: Good with treatment |
| Focal infiltrates initially, with rapid progression to diffuse bilateral interstitial infiltrates Alveolar consolidation, often in dependent lung zones | Alveolar-capillary membrane damage resulting in edema-filled air spaces Hyaline membrane Adherence of neutrophils to damaged membranes | Treatment: Supportive pulmonary care with mechanical ventilation Antibiotics if sepsis the cause
Prognosis: Poor, with mortality 40%-60% |
| Diffuse linear opacities for chronic radiation pneumonia and focal ground-glass opacities for radiation pneumonitis Reticular nodular opacities and ground-glass opacities for hypersensitivity pneumonia | In chronic radiation pneumonia, findings like those in usual interstitial pneumonia In acute radiation pneumonia, findings like those in bronchiolitis obliterans organizing pneumonia In hypersensitivity pneumonia, diffuse granulomas | Treatment: Corticosteroids
For hypersensitivity pneumonia, eliminate exposure
Prognosis: Fair to good |
| Solitary or multiple nodular opacities Cavitation sometimes Localized airspace consolidation Interlobular and septal thickening | Typical granulomas of the Wegener type with vasculitis | Treatment: Corticosteroids and cyclophosphamide
Prognosis: Fair to good with treatment |
term that implies the movement of the newly formed granulation tissue within small distal airways and alveolar ducts. These migratory lesions may also spontaneously regress or vanish. These opacities are often present peripherally, indicating their location just under the pleural lining and thus are termed subpleural. On computed tomography, such opacities are seen as a ground-glass pattern with peripheral orientation. Pleural effusions and airway hyperinflation are uncharacteristic in idiopathic BOOP.

The second radiographic finding suggestive of BOOP is multiple foci of consolidation or solitary nodular appearing lesions. In some patients with cancer, notably renal carcinoma, these lesions have been confused with pulmonary metastases, but the lesions may spontaneously regress, an unlikely occurrence in metastatic disease.

The third and final characteristic radiographic finding is the appearance of small linear or crescent-shaped densities surrounding the ground-glass area of attenuation. This finding is less frequent than other radiograph patterns; it occurs in approximately 20% of patients with BOOP.

High-Resolution Computed Tomography

In patients with BOOP, high-resolution computed tomography reveals ground-glass attenuation with a subpleural and peribronchial distribution. The ground-glass appearance may be the result of alveolar septal inflammation and the organizing pneumonia in alveolar ducts. In addition, as many as 65% of patients have peripheral lower lobe consolidation. The pattern of this peripheral consolidation is similar to that of a triangle with the base along the pleural surface and the tip of the triangle toward the mediastinum.

In comparison, patients with fibrotic lung disease have a classic honeycombing pattern.

Video-Assisted Thoracoscopy With Open Lung Biopsy

Although both clinical manifestations and radiological findings may suggest BOOP as a probable diagnosis, histological findings are required to confirm the diagnosis. Video-assisted thoracoscopy with open lung biopsy is the preferred method for gathering samples and making the diagnosis. This open technique allows for enhanced visualization, more complete tissue sampling, and less risk of errors due to small-sized samples. Because the distal airway and alveolar lesions are migratory, the location of the areas of opacity should be confirmed via chest radiography just before the biopsy is done. This sequence will ensure the most accurate tissue sampling, which will in turn help in making the most probable diagnosis. Using the open technique to obtain samples for histological examination is imperative because use of corticosteroids, the primary treatment for BOOP, is not beneficial for many of the differential diagnoses.

Though limited, bronchoalveolar lavage as a diagnostic means has been used effectively. Bronchoalveolar lavage indicates that large percentages of lymphocytes, often 20% to 40% of the white blood cells in the lavage fluid, are most characteristic of BOOP. Epler notes that findings of more than 0.25 lymphocytes are suggestive of BOOP. Other cell types, such as neutrophils, eosinophils, mast cells, and plasma cells, may also be present, but in smaller amounts.

Histological Studies

In confirmed cases of BOOP, the main findings on histological examination are organized granulation tissue in the distal bronchioles and organized alveolar exudates composed of interstitial infiltrates with mononuclear cells (organizing pneumonia). A finding of organizing pneumonia is not diagnostic for BOOP because this type of pneumonia can occur in association with other pulmonary diseases or abnormalities. Pathological examination of a tissue obtained via open lung biopsy is the best method for an accurate diagnosis. Examination of bronchoalveolar lavage fluid alone cannot be used to diagnose BOOP.

Definitive histological findings in BOOP are as follows:

- Diffuse distal airway inflammation and fibromyxoid, polyloid plugs made up of fibroblastic connective tissue are present. Located in the distal airways, alveolar ducts, and alveoli, these plugs are both newly formed and have a large amount of vascularization, a characteristic that becomes vital for the effectiveness of treatment.

- Large interstitial and alveolar infiltrates that contain mononuclear cells and “foamy” macrophages are present. Foamy macrophages are lipid-laden because often the phagocytosed materials are of lipid origin and the debris inside the macrophages gives the cells the appearance of bubbling foam.

- Patchy involvement of pulmonary parenchyma with preservation of background lung architecture.
is present. This architecture is preserved because BOOP occurs intraluminally within the pulmonary tree. In idiopathic BOOP, histological examinations generally reveal no microorganisms.

Table 4 gives common values for pulmonary functions tests in patients with BOOP.

### Table 4: Results of pulmonary function tests

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Forced vital capacity, L</td>
<td>4.8</td>
<td>Decreased</td>
</tr>
<tr>
<td>Ratio of forced expiratory volume in 1 second to forced vital capacity, %</td>
<td>&gt;75</td>
<td>Normal except in smokers</td>
</tr>
<tr>
<td>Total lung capacity, L</td>
<td>6</td>
<td>Decreased</td>
</tr>
<tr>
<td>Single breath diffusing capacity, mL/min per mm Hg</td>
<td>25</td>
<td>Decreased</td>
</tr>
<tr>
<td>Alveolar and arterial oxygen pressure gradient, mm Hg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At rest</td>
<td>5-20</td>
<td>Increased</td>
</tr>
<tr>
<td>During exercise</td>
<td>5-20</td>
<td>Increased</td>
</tr>
</tbody>
</table>

[^4]: For a healthy young man with a body surface area of 1.7 m^2.
[^9]: Single most abnormal finding in patients with bronchiolitis obliterans organizing pneumonia.

Treatment and Nursing Considerations

Patients with BOOP are a challenge because of the acute nature of the disease process. Treatment and nursing considerations include starting corticosteroid therapy, considering other medications such as macrolides for treatment, closely collaborating with staff in the pulmonary department and pulmonologists, and educating the patients and their family members about procedures and treatment.

Because BOOP is generally a noninfective infiltrative lung disease, anti-infective agents are not routinely part of the treatment regimen. Overwhelmingly, the mainstay treatment for BOOP is an extensive course of oral prednisone; most patients improve markedly after the initial 48 hours to 1 week of therapy. If a patient does improve within this time frame, a physician must be alerted because other diagnostic tests may be necessary. The recommended dosing of prednisone is 0.75 to 1 mg/kg per day for 3 months, then 40 mg/d for 3 months, and finally tapering to 20 mg/d or 20 mg every other day for 6 months, for a total treatment time of approximately 1 year. Monitoring for untoward effects of steroid therapy such as gastrointestinal bleeding, hyperglycemia, fluid retention, depression, personality changes, psychosis, and restlessness is a priority of care. In addition, the risk for concomitant infections is increased because long-term corticosteroid therapy is immunosuppressive.

Several schools of thought exist about the mechanism by which corticosteroids work in BOOP. The fibrous buds of newly formed connective tissue in distal airways and alveolar spaces are highly vascular, a characteristic that may allow the anti-inflammatory steroid to better attack these lesions. The specifics of how corticosteroids work in the disappearance of fibrous intra-alveolar buds, diffuse peripheral subpleural peribronchial opacities, and extensive inflammatory changes continue to perplex clinicians. Most likely fibroblasts are a key component in the formation of the buds and also play a vital role in the buds’ degradation. Degradation of the fibrous polyoid matrix requires certain enzymes. These enzymes, produced by fibroblasts and leukocytes in the intra-alveolar areas, facilitate the breakdown and resolution of the polyps or buds previously created by the fibroblasts and leukocytes. This enzymatic action may account for those patients who appear to recover spontaneously without exogenous treatment. Successful resolution of clinical and radiographic findings associated with BOOP by treatment with corticosteroids has been well documented despite the unknown pharmacodynamics of the medications.

Although corticosteroids are the preferred treatment for BOOP, other medications have also been effective. Macrolides such as clarithromycin 250 mg twice daily for 2 months and then 250 mg/d for an additional 1 month can result in resolution of BOOP. Members of the macrolide class of anti-infective agents decrease the influx of polymorphonuclear cells in the lungs and slow the production of cytokines, which promote the inflammatory cascade. Erythromycin is also effective in patients with BOOP. Cyotoxic drugs such as cyclophosphamide and azathioprine have been used in BOOP patients who had only minimal improvement in signs and symptoms and radiographic findings with usual corticosteroid treatments. Inhaled
triamcinolone has been used as an adjunct treatment.\(^3\) The success of drug therapy is indicated by the decrease in pulmonary signs and symptoms and the return of the results of pulmonary function tests to normal.

Vigilant pulmonary assessment and hygiene coupled with close collaboration with the pulmonary department are necessary to ensure adequate oxygenation and perfusion, which are key to improving outcomes in patients with BOOP. The critical care nurse must assess daily chest radiographs to detect the resolution of the intra-alveolar findings after corticosteroid therapy is implemented. In addition, the nurse must assess findings on pulse oximetry and analysis of arterial blood gases and observe for subtle indications of hypoxemia. Both the maintenance of proper oxygen delivery and the proper positioning of patients facilitate oxygenation, thus enhancing patients’ recovery.

Additionally, the critical care nurse must educate both patients and their families about diagnostic tests and the use and potential complications of long-term steroid therapy. Because patients have procedures such as bronchoscopy with bronchoalveolar lavage, open lung biopsy, and high-resolution computed tomography, the nurse must provide clear instructions in order to alleviate anxiety. A large array of side effects associated with use of corticosteroids may occur because patients with BOOP are often treated for long periods. Therefore, teaching about the medication must be extensive. For patients with BOOP, excellence in both the art and skill of critical care nursing is imperative to ensure the best possible outcomes. Table 5 is a plan of care for patients with BOOP.

**Case Study**

Kerry Frank, a 57-year-old Vietnam veteran, was being treated on an outpatient basis for kidney failure. He began having trouble breathing, worsening shortness of breath when performing activities of daily living, and a cough. A chest radiograph showed patchy pulmonary infiltrates and irregular nodular opacities in both lungs. Consequently, he was admitted to the hospital. His medical history consisted of obesity and insulin-dependent diabetes mellitus.

On admission to the hospital, he continued to be short of breath, with respirations of 40/min and a resting oxygen saturation of 88%. Supplemental inhaled oxygen was administered via a facial mask. Other vital signs were blood pressure 150/90 mm Hg, heart rate 110/min, and body temperature 38.5ºC. Crackles were heard bilaterally in both lungs. Laboratory findings included erythrocyte sedimentation rate 76 mm/h, white blood cell count 13.2 \(\times\) \(10^9\)/L, level

<table>
<thead>
<tr>
<th>Table 5 Nursing plan of care for patients with bronchiolitis obliterans organizing pneumonia (BOOP)(^8)(^9)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem</strong></td>
</tr>
<tr>
<td>Impaired gas exchange related to alveolar and bronchiolar inflammation due to BOOP</td>
</tr>
<tr>
<td>Ineffective airway clearance related to inflammation, edema, and presence of mucous plugs in bronchioles</td>
</tr>
<tr>
<td>Imbalanced nutrition: less than body requirements related to increased energy needs because of increased work of breathing</td>
</tr>
<tr>
<td>Activity intolerance related to imbalance between oxygen supply and demand due to BOOP</td>
</tr>
<tr>
<td>Anxiety related to change in health status due to BOOP</td>
</tr>
</tbody>
</table>
### Interventions

<table>
<thead>
<tr>
<th>Interventions</th>
<th>Rationale for interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor respiratory rate, depth, and effort</td>
<td>Increased respiratory rate and use of accessory muscles indicate hypoxia</td>
</tr>
<tr>
<td>Use oxygen to maintain PaO(_2) &gt;90 mm Hg</td>
<td>Airway cannot compensate without oxygen</td>
</tr>
<tr>
<td>Monitor oxygen saturation continuously; notify pulmonologist if &lt;90%</td>
<td>Presence of crackles or wheezes may indicate changes in respiratory status</td>
</tr>
<tr>
<td>Auscultate lung sounds every 1-3 hours</td>
<td>Increased respiratory rate and use of accessory muscles indicate hypoxia</td>
</tr>
<tr>
<td>Monitor for changes in mental status, restlessness, dysrhythmias, tachycardia, and cyanosis</td>
<td>Changes in mental status, restlessness, dysrhythmias, tachycardia, and cyanosis may indicate hypoxia</td>
</tr>
<tr>
<td>Position patient in semi-Fowler's position, with an upright posture of 45 degrees and turn patient every 2 hours</td>
<td>Upright position and changes to prone position enhance oxygenation, and turning is important to prevent complications of immobility and decrease development of atelectasis</td>
</tr>
<tr>
<td>Consider using prone positioning</td>
<td>Mechanical ventilation may be necessary to maintain oxygenation and acid-base balance</td>
</tr>
<tr>
<td>Prepare patient for treatment with mechanical ventilation as warranted</td>
<td>Corticosteroid therapy is used to treat BOOP</td>
</tr>
<tr>
<td>Administer corticosteroid therapy</td>
<td>Hypoxia and hypoxemia may necessitate supportive oxygenation. Knowledge of this possibility will decrease apprehension</td>
</tr>
<tr>
<td>Instruct patient and patient’s family about the possible use of mechanical ventilation</td>
<td></td>
</tr>
<tr>
<td>Auscultate lung fields every 1-3 hours</td>
<td>Presence of crackles or wheezes may indicate changes in respiratory status</td>
</tr>
<tr>
<td>Monitor respiratory rate, depth, and effort</td>
<td>Increased respiratory rate and use of accessory muscles indicate hypoxia</td>
</tr>
<tr>
<td>Monitor blood gas values and oxygen saturation as indicated by pulse oximetry</td>
<td>Oxygen saturation &lt;90% or PaO(_2) &lt;80 mm Hg indicates significant oxygenation concerns</td>
</tr>
<tr>
<td>Encourage patient to use a forced expiratory cough or “huff cough”</td>
<td>Use of a forced expiratory cough prevents the glottis from closing and helps clear secretions from central airways</td>
</tr>
<tr>
<td>Observe color and amount of sputum</td>
<td>Normal sputum is clear or gray</td>
</tr>
<tr>
<td>Assess for bronchophony</td>
<td>Bronchophony occurs with increased lung consolidation</td>
</tr>
<tr>
<td>Assist with bronchoscopy if indicated</td>
<td>Bronchoscopy may be required to diagnose BOOP and to remove mucus plugs</td>
</tr>
<tr>
<td>Monitor for signs of malnutrition</td>
<td>Brittle hair, dry and pale skin, and muscle wasting are signs of malnutrition</td>
</tr>
<tr>
<td>Monitor results of laboratory tests such as serum levels of albumin, total protein, prealbumin, transferrin, electrolytes, and glucose</td>
<td>Serum albumin levels &lt;35 g/L indicate risk of poor nutritional status</td>
</tr>
<tr>
<td>Weigh patient daily</td>
<td>Values for serum levels of total protein, prealbumin, transferrin, electrolytes, and glucose are low in patients with BOOP</td>
</tr>
<tr>
<td>Observe for muscle wasting</td>
<td>With daily weighing, changes in weight be readily detected and healthy body weight can be maintained</td>
</tr>
<tr>
<td>Collaborate with dietary personnel</td>
<td>Muscle wasting can indicate depletion of muscle stores, which may also affect the respiratory muscles</td>
</tr>
<tr>
<td>Note food intake and assess patient’s ability to eat</td>
<td>Collaborating with dietary personnel allows a multidisciplinary approach to the patient’s care</td>
</tr>
<tr>
<td>Test stools and gastric contents for guaiac</td>
<td>Patients with BOOP may be too short of breath to eat</td>
</tr>
<tr>
<td>Insert a small, weighted nasogastric feeding tube as warranted</td>
<td>Stressors such as being in the intensive care unit and taking the steroids commonly used to treat BOOP can cause gastrointestinal bleeding</td>
</tr>
<tr>
<td>Obtain chest or plain abdominal radiograph after the tube is inserted</td>
<td>Tubes with small lumens are less irritating to the nasal mucosa than tubes with large lumens</td>
</tr>
<tr>
<td>Radiographic verification of placement of the tube is necessary before feedings can be started</td>
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</tr>
<tr>
<td>Measure oxygen saturation during activity</td>
<td>Supplemental oxygen may be required during activities of daily living</td>
</tr>
<tr>
<td>Monitor response to activity by checking for use of accessory muscles or changes in skin color</td>
<td>Use of accessory muscles or changes in skin color may indicate hypoxia</td>
</tr>
<tr>
<td>Instruct patient to use pursed-lip breathing</td>
<td>Pursed-lip breathing helps slow the rate of breathing</td>
</tr>
<tr>
<td>Collaborate with pulmonary rehabilitation</td>
<td>Pulmonary rehabilitation can relieve dyspnea and fatigue</td>
</tr>
</tbody>
</table>

### Rationale for interventions

- "Increased respiratory rate and use of accessory muscles indicate hypoxia."
- "Airway cannot compensate without oxygen."
- "Presence of crackles or wheezes may indicate changes in respiratory status."
- "Changes in mental status, restlessness, dysrhythmias, tachycardia, and cyanosis may indicate hypoxia."
- "Upright position and changes to prone position enhance oxygenation, and turning is important to prevent complications of immobility and decrease development of atelectasis."
- "Mechanical ventilation may be necessary to maintain oxygenation and acid-base balance."
- "Corticosteroid therapy is used to treat BOOP."
- "Hypoxia and hypoxemia may necessitate supportive oxygenation. Knowledge of this possibility will decrease apprehension."
- "Presence of crackles or wheezes may indicate changes in respiratory status."
- "Increased respiratory rate and use of accessory muscles indicate hypoxia."
- "Oxygen saturation <90% or PaO\(_2\) <80 mm Hg indicates significant oxygenation concerns."
- "Use of a forced expiratory cough prevents the glottis from closing and helps clear secretions from central airways."
- "Normal sputum is clear or gray."
- "Bronchophony occurs with increased lung consolidation."
- "Bronchoscopy may be required to diagnose BOOP and to remove mucus plugs."
- "Brittle hair, dry and pale skin, and muscle wasting are signs of malnutrition."
- "Serum albumin levels <35 g/L indicate risk of poor nutritional status."
- "Values for serum levels of total protein, prealbumin, transferrin, electrolytes, and glucose are low in patients with BOOP."
- "With daily weighing, changes in weight be readily detected and healthy body weight can be maintained."
- "Muscle wasting can indicate depletion of muscle stores, which may also affect the respiratory muscles."
- "Collaborating with dietary personnel allows a multidisciplinary approach to the patient’s care."
- "Patients with BOOP may be too short of breath to eat."
- "Stressors such as being in the intensive care unit and taking the steroids commonly used to treat BOOP can cause gastrointestinal bleeding."
- "Tubes with small lumens are less irritating to the nasal mucosa than tubes with large lumens."
- "Radiographic verification of placement of the tube is necessary before feedings can be started."
- "Supplemental oxygen may be required during activities of daily living."
- "Use of accessory muscles or changes in skin color may indicate hypoxia."
- "Pursed-lip breathing helps slow the rate of breathing."
- "Pulmonary rehabilitation can relieve dyspnea and fatigue."
- "Anxiety can have deleterious effects on patient’s recovery."
- "Coping skills that were successful in the past may help again."
- "Explaining and teaching regarding the patient’s health status may reduce the patient’s anxiety."
- "Therapeutic touch, back rubs, and massage decrease anxiety."
of C-reactive protein 119 mg/L, and serum albumin level 32 g/L. Other than indications of hyperglycemia and abnormal results in renal function tests, all other laboratory findings were normal. Cultures of the blood, sputum, and urine were negative for microorganisms.

Because of the findings on the chest radiograph, high-resolution computed tomography of the chest was performed. The scan showed bilateral patchy, ground-glass opacities with a triangular area of consolidation with the base along the pleural surface of the lung posteriorly. Later the next day, bronchoscopy with a bronchoalveolar lavage was performed; on the basis of the results, pneumonia was ruled out. At that time, Mr Frank was being treated with oral prednisone 60 mg/d.

Despite treatment, the lung problems continued, and therefore on the seventh day of his admission, he agreed to undergo an open lung biopsy via video-assisted thoracoscopy. Tissue samples taken from 2 anterior lung sites and 1 posterior lung site showed evidence of BOOP. Pathological examination of the biopsy specimens revealed myxoid fibroblastic tissue, foamy macrophages, and lymphocytes and eosinophils in the alveolar spaces. Of note, plugging of the distal bronchioles and alveolar spaces with organized inflammatory exudates was also evident. Cultures and stains of the biopsy specimens were negative for organisms.

Mr Frank sought a second opinion from a large teaching hospital; the diagnosis of BOOP was confirmed. He was given intravenous methylprednisolone at a dose of 80 mg every 8 hours for 5 days and then prednisone 150 mg once a day. The dosage was gradually decreased, and at the time of discharge, 3 weeks after admission, he was taking 60 mg/d. After he was discharged from the hospital, he continued treatment with supplemental oxygen at home. During the next 12 months, the dosage of prednisone was gradually decreased, and treatment with the drug was stopped when the BOOP was completely resolved.

Conclusion

BOOP is an inflammation of the distal small airways (bronchioles) and surrounding alveolar lung tissue. This inflammation can affect a small region of the lung or the entire lung. Critical care nurses should consider the possibility of BOOP when caring for a patient with suspected pneumonia and respiratory failure who does not respond to conventional antibiotic therapy. As vital members of the healthcare team, critical care nurses acting as patients’ advocates will improve patients’ outcomes by providing high-quality comprehensive care appropriate for patients with BOOP. Early diagnosis and treatment with steroids is essential in reducing complications and mortality. Actions by critical care nurses are imperative to minimize pulmonary residual effects and maintain a high quality of life in BOOP patients.

Additional Information

For additional information on BOOP, visit the following Web sites:
- http://www.epler.com/boop1.html,
- http://www.emedicine.com/radio/topic117.htm, and

Acknowledgments

Thank-you to “Kerry Frank” for allowing us to share his story so that others may learn and benefit from his experiences. The insignificant characteristics of the case study have been altered to comply with the regulations of the federal Health Information Portability and Accountability Act and maintain patient confidentiality. The patient’s name has been changed. An enormous thank-you to Gary R. Epler, MD, the internationally known expert and father of BOOP, for his review and mentoring during the preparation of the manuscript. Without his assistance, this article would not have been completed.

Financial Disclosures

None reported.

References


1. Which of the following commonly results from the inflammation and infiltrates associated with bronchiolitis obliterans organizing pneumonia (BOOP)?
   a. Decreased alveolar oxygen pressure
   b. Increased single breath diffusing capacity
   c. Decreased vital capacity
   d. Increased lung volumes

2. Auscultation of lung sounds in a patient with BOOP frequently reveals what finding?
   a. Crackles
   b. Rhonchi
   c. Expiratory wheezes
   d. Inspiratory wheezes

3. Which type of BOOP is most commonly seen by critical care nurses in practice?
   a. Rapidly progressive BOOP
   b. Idiopathic BOOP
   c. Cryptogenic organizing pneumonia
   d. Inspiratory wheezes

4. Focal nodular BOOP is clinically important because of the difficulty distinguishing it from what other lung disease?
   a. Connective tissue disease of the lungs
   b. Infectious bronchiolitis
   c. Pneumonia obliterans
   d. Septic cascade pathway

5. BOOP is sometimes referred to as which more general term?
   a. Connective tissue disease of the lungs
   b. Infectious bronchiolitis
   c. Pneumonia obliterans
   d. Cryptogenic organizing pneumonia

6. Pathophysiological findings in BOOP are related to which of the body’s response pathways?
   a. Septic cascade pathway
   b. Immune system pathway
   c. Inflammatory pathway
   d. Fibrosing pathway

7. BOOP should be considered as a causative factor in which of the following patients who is admitted to a critical care unit?
   a. A diabetic patient with chronic renal failure
   b. An elderly male who has hypertension and coronary artery disease
   c. A multiple-trauma victim with systemic inflammatory response syndrome
   d. A transplant recipient with acute-onset shortness of breath

8. Once successful treatment for BOOP has been started, relapse occurs in approximately what percentage of patients?
   a. 10%
   b. 35% to 50%
   c. 15% to 25%
   d. 60%

9. Which of the following is a common sign and symptom of idiopathic BOOP?
   a. Hemoptysis
   b. Nonproductive cough
   c. Wheezing
   d. Shortness of breath

10. Which is the hematologic abnormality most consistently present in BOOP?
    a. Elevated white blood cell count
    b. Hyperalbuminemia
    c. Thrombocytopenia
    d. Decreased erythrocyte sedimentation rate

11. What radiographic finding is most common and suggestive of BOOP?
    a. Pleural effusion
    b. Airway hyperinflation
    c. Crescent-shaped densities along pleural edges
    d. Patchy alveolar and diffuse interstitial infiltrates

12. Which is the following is the mainstay treatment for BOOP?
    a. Macrolide medications
    b. Oral prednisone
    c. Anti-infective agents
    d. Inhaled cytotoxic drugs

13. Which of the following is a priority of care for patients undergoing treatment for BOOP?
    a. Frequent monitoring of white blood cell counts
    b. Placing patients in a negative pressure room
    c. Monitoring for hyperglycemia
    d. Maintaining a high-protein, sodium-free diet

14. Which of the following are appropriate nursing interventions for a patient with BOOP?
    a. Trendelenburg positioning and continuous oxygen saturation monitoring
    b. Semi-Fowler positioning and restricted fluid intake
    c. Frequent monitoring of white blood cell counts
    d. Assessment for malnutrition and frequent sputum cultures

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Bronchiolitis Obliterans Organizing Pneumonia
Krista A. White and Lisa A. Ruth-Sahd

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