The role of fibre-optic bronchoscopy in solid organ, transplant patients with pulmonary infections

S. Nusair* and M. R. Kramer†

*The Pulmonary Institute, The Hadassah University Hospital and Hebrew University-Hadassah School of Medicine, Jerusalem, Israel
†The Pulmonary Institute, Rabin Medical Center, Petah-Tikvah, Israel

Organ transplantation is currently the standard therapy for patients with end-stage organ dysfunction. The immunosuppression caused by this therapy increases the rate of infection, particularly in the lungs. Early diagnosis is extremely important and fibre-optic bronchoscopy is a helpful tool in reaching diagnosis. Knowing the timing of various pathogens following transplantation, and the radiological picture as well as the prophylactic regimen, is helpful when specific pathogens are suspected. Bronchoscopy with bronchoalveolar lavage and transbronchial biopsies are particularly helpful in diagnosis of bacterial cytomegalovirus (CMV) and Pneumocystis carinii pneumonitis, and is considered a safe procedure. Open lung biopsy is reserved for those who have negative bronchoscopy with a reasonable prognosis.

Introduction

In the last decade an increasing number of immunocompromised patients have come to medical attention because of pulmonary infiltrates of various aetiologies. Solid organ transplant recipients form an important and an increasingly growing subgroup of immunocompromised patients. Transplant patients may present at any time interval after the transplant with infections caused by bacteria, viruses, parasites or fungi. In making the clinical decisions regarding the investigation and the management of these patients, different factors should be taken into account such as the type of immunosuppression, the transplanted organ adjacent to which the infectious process is taking place and the timing of the appearance of pulmonary infiltrates following the transplant. Moreover, as the lung is exposed to the immediate surrounding environment, it is more likely to be exposed to infectious pathogens from the environment, particularly in lung transplant patients as the transplanted lung is markedly vulnerable to such infections.

As a result of immunosuppressive therapy, the clinical manifestations of pulmonary infections in the transplant patient may be variably attenuated (e.g., corticosteroids decrease fever and azathioprine may induce leukopaenia). Similarly, the spectrum of roentgenographical findings is not different from normal hosts and may include lobar or localized infiltrates which may contain cavitations as in fungal pneumonia, or interstitial infiltrates common in other opportunistic infections such as Cytomegalovirus (CMV) pneumonia and Pneumocystis carinii pneumonia (PCP). The finding of pulmonary infiltrates on chest x-ray films may be otherwise explained by pulmonary congestion, embolism or alveolar haemorrhage. It is most important to recognize pulmonary infections as they carry a great risk for morbidity and mortality in these patients.

The role of conventional methods of diagnosing pneumonia in the immunocompromised host are limited. The serological methods for the diagnosis of viral pneumonias such as caused by CMV have low sensitivity and specificity in the immunocompromised host because of decreased antibody production, due to immune suppression (1). The yield of sputum staining and culture in normal hosts is usually low, especially in atypical pneumonias. Therefore, many immunocompromised patients who are more likely to present with atypical pneumonias do not produce sufficient sputum to allow identification of a bacterial or other pathogen.

The purpose of this review is to describe the current knowledge regarding the diagnostic yield of fibre-optic bronchoscopy (FOB) when utilized for the investigation of pneumonias in solid organ transplant patients. Emphasis will be put on opportunistic pathogens such as Pneumocystis carinii and CMV, which are unique pathogens in these patients.
Timing and types of various infections in organ transplantation

In order to evaluate the role of FOB for pulmonary infiltrates in solid organ recipients, the types and timing of the various infections after transplant should be considered.

Pulmonary infections in organ transplant patients are mostly caused by bacterial pathogens. During the first 1–2 months after transplantation, there is a higher incidence of bacterial pneumonias caused by hospital-acquired pathogens (Gram-negative rods, staphylococci or Legionella pneumophila), but in later stages pneumonia may be caused by community-acquired pathogens, such as Streptococcus pneumoniae or Mycoplasma pneumoniae (2). During the time interval of 2–4 months post-transplantation, there is a significant increase in the incidence of CMV-induced pneumonitis (Fig. 1). Additionally, there is a rise in the rate of fungal infections with an epidemiology which may partly reflect the incidence of endemic fungal infections, but also an increasing incidence of invasive Candida species and Aspergillosis infections. The incidence of PCP increases significantly 2–3 months post-transplantation and remains high during the first 6 months after transplantation. The differential diagnosis of new-onset pulmonary infiltrates in organ transplant patients also includes tuberculosis, nocardiosis, and malignant processes such as lymphoma and Kaposi’s sarcoma.

Special considerations in lung and heart–lung recipients

Infections involving the grafted lung in lung and heart–lung transplant recipients deserve special consideration. The susceptibility of the grafted lungs to infections results from local factors such as changes in the lymphatic drainage of the lungs. Denervation of the lungs and the anastomosis itself suppress the cough reflex, thus masking symptoms of pulmonary infection (3). Of the local immunological factors which affect the grafted lung, immune suppression plays a central role as a risk factor for bacterial and opportunistic pneumonia, as it increases the vulnerability of the grafted lung to pathogens. Additionally, allograft rejection can cause lung injury, leading to further damage to lung tissue structure such as the tendency to develop bronchiectasis in patients with post-transplant bronchiolitis obliterans, thus adding significant risk for infection. Moreover, in patients with a single lung transplantation, the remaining lung may serve as a source of infection. Similar to the sinuses in patients with cystic fibrosis. All these factors explain the higher rate of pulmonary infection in patients after heart–lung transplantation than after heart transplantation alone (4). Accordingly, lung and heart–lung transplant recipients not only have a higher incidence of bacterial pneumonia, but also of CMV pneumonitis and PCP, compared with heart transplant recipients.
Table 1. The diagnostic yield of BAL and TBB in solid organ transplantation

<table>
<thead>
<tr>
<th>Organ transplanted</th>
<th>Reference</th>
<th>Bronchoscopies (n)</th>
<th>Yield of BAL (%)</th>
<th>Yield of TBB (%)</th>
<th>Yield of BAL for specific pathogen (%)</th>
<th>Yield of TBB for specific pathogen (%)</th>
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<tbody>
<tr>
<td>Heart</td>
<td>Schulman (21)</td>
<td>39</td>
<td>63</td>
<td>46</td>
<td>CMV (61)</td>
<td>CMV (20)</td>
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<td></td>
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<td></td>
<td>PCP (90)</td>
<td>PCP (89)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Asperg (75)</td>
<td>Asperg (22)</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>TB (50)</td>
<td>TB (NA)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bacterial (60)</td>
<td></td>
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<tr>
<td>Lung/Heart-lung</td>
<td>Sibley (73)</td>
<td>128</td>
<td>NA</td>
<td>78</td>
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<td></td>
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<td></td>
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<tr>
<td>Lung</td>
<td>Baz (22)</td>
<td>69</td>
<td>NA</td>
<td>48</td>
<td>NA</td>
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<tr>
<td>Lung/Heart-lung</td>
<td>Chan (23)</td>
<td>282</td>
<td>NA</td>
<td>67</td>
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<tr>
<td>Kidney</td>
<td>Cazzadori (4)</td>
<td>33</td>
<td>27</td>
<td>57</td>
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<td>Kidney</td>
<td>Wallace (5)</td>
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<td>NA</td>
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<td>Kidney</td>
<td>Sternberg (6)</td>
<td>58</td>
<td>69</td>
<td>NA</td>
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<td></td>
</tr>
<tr>
<td>Kidney</td>
<td>Willocx (74)</td>
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<td>NA*</td>
<td>45</td>
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<td></td>
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<tr>
<td>Liver</td>
<td>Allen (75)</td>
<td>54</td>
<td>42</td>
<td>NA</td>
<td>NA</td>
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</tr>
</tbody>
</table>

Asperg, Aspergilosis; BMT, bone marrow transplant; CMV, cytomegalovirus; HSV, herpes simplex virus; NA, not available; PCP, Pneumocystis carinii pneumonitis; TB, tuberculosis.

*Three patients underwent BAL which was positive.

The high incidence of pulmonary graft rejection and bacterial infections within the first few weeks after transplantation, combined with the increased incidence of CMV pneumonitis during 2–6 months after transplantation, has led to the use of routine surveillance bronchoscopies during the first 2 years after transplantation in many centres.

**Fibre-optic bronchoscopy (FOB)**

FOB, with bronchoalveolar lavage (BAL) and transbronchial biopsy (TBB), has played an important role in the diagnosis of pulmonary infiltrates in the immunocompromised patient in the last decade. This minimally invasive procedure allows the identification of pulmonary pathogens by sampling of bronchoalveolar lavage fluid or by direct histopathological examination of lung tissue. These methods facilitate sampling of the distal airways for cultures and cytological stains in an attempt to detect pathogens which reflect true distal airway infections, with much less risk of contamination by the oral and the upper airway flora, or by pathogens which merely colonize the upper airways (5).

Several recent studies have attempted to evaluate the utility of BAL and TBB in the immunocompromised host. In one retrospective study, the results of 157 bronchoscopic procedures, including both BAL and TBB, in 142 immunosuppressed patients were reviewed (see Table 1) (6). All patients were treated with empirical wide-spectrum antibiotic therapy prior to performing FOB with no satisfactory response. In the specific group of kidney transplant patients, BAL had a diagnostic yield of 27%. However, the diagnostic yield of TBB was 57.5%. The total additional diagnostic yield of TBB to BAL was 33%. These results suggest an important role for TBB in addition to BAL whenever there is no additional significant risk and no contraindications to performing TBB.
In another study (7), 19 bronchoscopies with BAL were performed to evaluate acute pulmonary infiltrates in a group of 18 immunocompromised patients, including AIDS patients, organ transplant patients and patients with solid tumours who were receiving cytotoxic chemotherapy. The bronchoscopy yielded a definite diagnosis in 72% of these patients. As a result of the overall findings at bronchoscopy, management was changed in 61% of the patients. In the group of patients who had BAL alone without an additional TBB, BAL was diagnostic in 75% of the patients and treatment management was consequently changed in 42%. Retrospectively, these results showed that the initial clinical diagnosis was correct in only 56% of the patients and that empirical therapy would have lead to incorrect management in 28%. These results demonstrate the importance of performing BAL at an early stage after presentation with pulmonary infiltrates. In this series however, performing TBB did not increase the diagnostic yield. In a subgroup of seven renal transplant recipients, the diagnostic yield of bronchoscopy was 85% and the sensitivity was 71%, but with no additional diagnostic value for TBB compared to BAL.

In another retrospective analysis, Sternberg et al. (8) evaluated kidney transplant recipients who had a combination of fever, pulmonary infiltrates and/or hypoxia. In 40% of these patients, the results of BAL lead to a change in the initial empirical antibiotic therapy. During the first 4 months, CMV infection was common, as would be expected (2). In instances where co-infections were found, CMV was the most common pathogen. Of five patients with PCP, three patients had also findings of CMV pneumonitis on histological examination. Two additional patients had proven CMV viremia, with no evidence of CMV pneumonitis on lung biopsy. Thus this study demonstrates that TBB serves an important role in recognizing co-infection with bacterial infection and viral or parasitic pathogens. In cases where CMV is isolated in BAL fluid or CMV viremia is detected, a definite diagnosis of CMV pneumonitis could be determined by identifying CMV inclusion bodies within the pulmonary parenchyma.

The diagnostic utility of FOB for specific pathogens

**BACTERIAL PNEUMONIA**

Pneumonias caused by bacteria are most likely to occur within the first few weeks after transplantation (2), with lung and heart–lung transplantation patients being the most vulnerable (1,3). Transplant patients are more likely to be exposed to prolonged antibiotic treatment, be mechanically ventilated, have an in-dwelling nasogastric tube, or be given antacid therapy which elevates the stomach content pH, all well-known risk factors for nosocomial pneumonia.

The most likely pathogens during the first weeks after transplant, include nosocomial pneumonias such as those caused by Gram negative rods and *Staphylococcus aureus*. However, community pathogens such as *Streptococcus pneumoniae*, *Haemophilus influenza* and *Mycoplasma pneumoniae* may also cause pneumonia in these patients and are still predominant in the later stages after the transplant procedure (1–3). Nosocomially acquired, *Legionella* infections tend to occur in the first few weeks after transplant. Characteristically, they are accompanied by changes in mental status and gastrointestinal disturbances, with widespread chest radiographical changes (9). *Nocardia*, particularly *asteroides*, is increasingly recognized as a pathogen of the late stages after solid organ transplantation, particularly in renal transplant patients, with an incidence of about 2% (10,11). Besides the lungs, *Nocardia* has predilection for the skin and the brain. Interestingly, the incidence of *nocardiosis* in transplant patients has decreased since the use of cyclosporine compared with patients who received azathioprine in their immunosuppressive regimens (11). The routine administration of trimethoprim–sulphamethoxazole for prophylaxis in PCP has caused a reduction in bacterial and *Nocardia* infection, as noted after renal transplantation (14). *Pseudomonas aeruginosa* may be an important pathogen in early post-operatively stages and when lung transplantation is performed in patients with cystic fibrosis (12). *Pseudomonas* pneumonia is also seen at later stages after lung transplantation because of bronchectatic changes in the lung parenchyma secondary to chronic inflammatory processes such as bronchiolitis obliterans (13). Some authorities have advocated the regular use of quinolones after bone marrow transplant (BMT) as prophylaxis for bacterial infections, but this is not routinely used in solid organ transplant recipients (15).

It may be difficult to determine the incidence of bacterial pneumonias in transplant patients due to the low yield of standard methods in identifying bacterial pathogens and the high frequency of bacterial colonization of the airways. In a large group of BMT patients, the specific bacterial pathogens were identified in 52% of the infectious episodes of bacterial pneumonias which could not be explained by opportunistic pathogens or non-infectious processes (16).

FOB with quantitative protected specimen brushing (PSB) and BAL cultures may significantly aid in investigating possible lower respiratory tract infections and distinguish them from bacterial colonization. (17). It is acceptable to diagnose pneumonia if the cultures of specimens acquired by protected specimen brushing (PSB) and BAL have bacterial organism counts above a certain threshold concentration. (i.e. PSB > 10⁵; and BAL > 10⁴ colony forming units per ml (cfu/ml)) (17). PSB is a method with higher diagnostic specificity than simple sputum or sample is acquired by endotracheal aspiration for the diagnosis of nosocomial pneumonia and may better differentiate true infections from contamination.

Several studies reviewing the results of bronchoscopic procedures in immunocompromised hosts including transplant patients have shown additional yield with BAL for diagnosing bacterial pneumonia (18–20). The identification of *Nocardia* on a sputum smear requires a Ziehl–Nelsen stain, but the culture may take 3–4 weeks to become positive (10). *Legionella* may be difficult to grow; however, examining respiratory secretions using the direct fluorescent antibody technique may allow a faster diagnosis (9). In
patients after heart transplantation, the sensitivity of BAL or PSB for identifying bacterial pathogens was 60% (21).

Although FOB is useful for surveillance purposes after lung transplantation, the yield of the procedure is significantly increased when it is performed to evaluate a new infiltrate (8.7 vs. 0.6%) (22). A higher diagnostic advantage of PSB compared with BAL may result from a cautious policy followed by certain bronchoscopists, in which small amounts of fluid are used (24). These data support the use of BAL and PSB in evaluating transplant patients with new pulmonary infiltrates; as these methods improve the diagnostic yield of bacterial pneumonia and aid in differentiating bacteria from other non-bacterial pathogens.

**Pneumocystis carinii**

This is a common protozoan pathogen in immunocompromised patients in whom T-lymphocyte dysfunction is a dominant mechanism of immune dysfunction. PCP is the most common opportunistic pulmonary infection in AIDS (20), strongly suggesting that *Pneumocystis carinii* exists in a latent form in normal hosts and is reactivated as the host’s immunity level is reduced. In organ transplant patients, PCP is most likely to occur within the first 2–6 months after transplant (2). Of organ transplant patients, lung and heart–lung transplant patients are particularly vulnerable to PCP (3,4). Very effective prophylaxis for the prevention of PCP after organ transplantation has been achieved by providing patients with oral trimethoprim-sulfamethoxazole (24,25) and, to a lesser degree of success, with inhalations of pentamidine (26).

The diagnostic utilities of BAL and TBB for the diagnosis of PCP are comparable (6,21). This may be explained by the fact that *Pneumocystis carinii* is present in the alveoli (27–29), unlike CMV which is an intracellular pathogen, thus the yield of BAL in detecting CMV is relatively lower than the yield of detecting *Pneumocystis carinii*.

**VIRAL INFECTIONS**

The incidence of herpetic infections in organ transplant patients increases significantly 4 weeks after organ transplantation. Primary infections, or reactivation of herpes simplex virus and herpes varicella virus are commonly characterized by their diagnostic cutaneous rashes (1,2).

CMV is an important pathogen of pneumonia in transplant patients. In bone marrow recipients, CMV may play an important role in immune reactions, such as the induction and propagation of graft versus host disease in the lung (30–32) and the pathogenesis of bronchiolitis obliterans (30,33). Such an association between bronchiolitis obliterans and CMV infection has been suggested in lung transplant patients has not been clarified (3,34).

In lung and heart–lung transplant patients, surveillance bronchoscopies are routinely performed within the first 4–6 months in many centres (22,35) to allow early detection of graft rejection or CMV pneumonitis. The definite diagnosis of CMV pneumonitis may be determined on the basis of CMV inclusion bodies within the lung parenchyma, obtained through TBB (3), or the presence of cells with cytopathic changes typical of CMV within the BAL fluid. Growing CMV in BAL cultures is not considered definitely diagnostic of CMV pneumonitis because it may only reflect viral shedding or colonization of the respiratory tract with CMV (36). However, in BMT patients there are indications that obtaining CMV from BAL cultures may be predictive of an episode of CMV pneumonitis (37,38). In organ transplant patients, growing CMV from BAL culture has a low positive predictive value for CMV pneumonitis. On the other hand, the detection of CMV inclusion bodies or antigenemia may be predictive (39,40).

In general, BAL has a higher sensitivity than TBB for detecting CMV (23,41). The reported yield of BAL for the diagnosis of CMV pneumonitis is 14–63% (7,21), while TBB yields diagnosis in 20% of cases (21). A recent study has suggested that negative BAL culture in a lung graft can exclude CMV pneumonitis in most cases (42). Confirmation of the CMV diagnosis may possible using centrifugation culture (43), the shell vial culture technique (44), monoclonal antibodies (45), or the polymerase chain reaction (PCR) (46). Although these methods may be more sensitive and allow earlier diagnosis of CMV infection than BAL cytology, they have low specificity and thus their results must be interpreted cautiously.

**FUNGAL INFECTIONS**

Fungal infections play an important role in morbidity and mortality in organ transplant patients. Essentially, the diagnosis of fungal pneumonia requires the demonstration of the fungal pathogen within the lung parenchyma. The incidence of fungal pneumonia increases significantly in the first 2 months after transplant (1,2). The most important fungal pathogens are *Candida* and *Aspergillus*. While *Candida* mostly involves the upper tracheobronchial tree, *Aspergillus* is capable of dissemination and invading the whole lung (27).

Immunocompromised patients who are particularly susceptible to *Aspergillus* infections are granulocytopenic patients or those with cellular immunodeficiency. BMT patients are at a very high risk for *Aspergillus* infection within the first month after transplant (30) and the infection carries a high mortality rate. *Aspergillus* is the most common cause of fungal pneumonia in liver and kidney transplant patients (1). Twenty-five per cent of patients may develop a pulmonary infection with *Aspergillus* after lung transplantation, with the majority of these infections occurring within the first month (3). Tracheo-bronchial involvement with invasive *Aspergillus* may further extend to involve the cartilage of the main bronchi (47).

Other fungal pathogens in immunocompromised patients include *Candida neoformans*, which may cause concurrent pulmonary and central nervous system infections (48), *Mucomycosis*, which is more likely to occur in
diabetic and acidotic kidney transplant patients (49), and endemic fungi such as Histoplasmosis and Blastomyces which cause pulmonary infection with a later dissemination (2).

It has been shown that, in diagnosing fungal pneumonia, TBB has an additional diagnostic yield of 29% relative to BAL stain and culture (50). In a mixed group of immunocompromised patients, BAL had a very high sensitivity but a relatively low specificity for the detection of Candida infection (51); however, the specificity of finding other fungi within BAL secretions is much higher, with a relatively lower sensitivity (52,53). These findings strongly suggest that the presence of Candida in the BAL fluid may represent colonization by Candida rather than infection or contamination of the endoscopic instrument as it passes through the upper respiratory tract. Using PSB can overcome this problem of contamination, thus significantly increasing the yield of FOB for detection of fungal infection (51). The diagnostic sensitivity and specificity of BAL may be enhanced by culturing the secretions for fungi (53). Unfortunately, in invasive fungal infection such as Aspergillus, BAL is not capable of demonstrating blood-vessel invasion (53), therefore there TBB still has an important role in the diagnosis of pulmonary fungal infections. In many cases where FOB cannot make the diagnosis of fungal pneumonia, an open lung biopsy is required.

*Mycobacterium tuberculosis (TB) and other mycobacteria*

TB in transplant patients mostly reflects the reactivation of an old TB focus. Another possible source of infection is the grafted organ (2). In the Western world, the incidence of immunocompromised patients, BAL had a very high sensitivity but a relatively low specificity for the detection of mycobacterial infections after organ transplantation approaching 1%, compared to an incidence of 0.1% in the general population. Unfortunately, thrombocytopaenia, which is common in BMT patients, and uraemia in renal transplant patients, prevent the performance of TBB in many cases because of the risk of bleeding. In patients with pulmonary hypertension, intrapulmonary haemorrhage may be an important concern. In a recently described series of heart transplant patients who underwent TBB, only 15% had minimal intrapulmonary haemorrhages with volumes of less than 25 ml (21).

**Complications**

TBB is associated with a relatively low incidence of complications. The risk of complications after TBB in immunocompromised hosts does not exceed that of the general population. Unfortunately, thrombocytopaenia, which is common in BMT patients, and uraemia in renal transplant patients, prevent the performance of TBB in many cases because of the risk of bleeding.

In one study, only four out of 106 (3.7%) patients had complications, of whom three had pneumothorax and one an intrapulmonary haemorrhage, with no known coagulopathy (5). In patients with pulmonary hypertension, intrapulmonary haemorrhage may be an important concern. In a recently described series of heart transplant patients who underwent TBB, only 15% had minimal intrapulmonary haemorrhages with volumes of less than 25 ml (21).

**OPEN LUNG BIOPSY (OLB)**

In cases where FOB is not diagnostic, OLB should be considered. This method is considered the gold-standard for evaluation of lung infiltrates in the immunocompromised host. OLB is performed in up to one-third of these patients due to failure of previous less invasive diagnostic procedures, or due to rapid deterioration in the general state of the patient despite an adequate trial of empirical therapy. In a mixed group of 61 patients, OLB led to a
definite diagnosis in 34 (56%) (64). Of these patients, 36% were immunosuppressed and OLB, while diagnostic in 59% of cases, led to a change of treatment in 77% of the patients.

In a recent retrospective review of the utility of OLB in a mixed group of patients, the subgroup which seemed to benefit most OLB were immunosuppressed patients (with only one patient after organ transplantation), as they had a high yield with the highest rate of unexpected diagnoses leading to a change in therapy (65). Unfortunately, this benefit was offset by a high mortality rate, which reflects the worse prognosis of this group of patients, resulting from their underlying conditions.

OLB may lead to a change in the therapeutic strategy in one-third of lung transplant patients (66). The results from OLB in lung transplant patients suggest that it may be more important, and more likely to lead to a change in therapeutic strategy, when it is used for pulmonary infections, which appear at a later stage after transplant, compared with infections occurring within the first month (66). In heart transplant recipients, OLB was diagnostic in 78% of the patients in one series (67). Earlier studies have cast doubts on whether OLB is able to improve survival of patients with pulmonary infiltrates, probably reflecting the severity of the condition of these patients (68,69). The presence of several pathogens simultaneously may be partly responsible for this bad outcome (69). The general rate of complications of OLB is 11–18% (64,70,71), which result mainly from surgical technique. Such complications include bronchopleural fistulas and persistent air leak, which may require prolonged mechanical ventilation (64). There was no increase in the rate of infections related to the procedure in immunocompromised patients compared with normal hosts despite their vulnerability to such infections (64).

Despite evidence that OLB in immunocompromised patients is very helpful in investigating opportunistic infections, especially those occurring at a later stage after transplant, it is still considered an invasive method which carries a certain risk for morbidity and mortality. Nevertheless, OLB remains the final diagnostic resort whenever FOB fails to provide a proper diagnosis in transplant patients with pulmonary infiltrates.

Conclusion

The data presented were reflect the importance of early FOB in patients after organ transplantation, as this may lead to the early identification of pathogenes in patients presenting with pulmonary infiltrates and fever.

Due to the wide variety of possible infectious and non-infectious causes of pulmonary infiltrates in solid organ transplant patients, we recommend early performance of FOB, including TBB, whenever there is no contraindication. Such an approach will enable the prompt treatment of life-threatening complications and will protect the patient from unnecessary measures, which carry a high risk of morbidity.

FOB and TBB are relatively safe with a low rate of complications in solid organ transplant patients, and carry no excess rate of morbidity relative to non-transplant or non-immunocompromised patients. Even in critically ill transplant patients, there is a favourable risk-benefit ratio for performing FOB, due to the diagnostic information provided by BAL and TBB.

References


