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Abstract We report on a patient with chronic myelogenous leukemia who developed bronchiolitis obliterans organizing pneumonia (BOOP) after allogeneic bone marrow transplantation (BMT). A 19-year-old Japanese male complained of dry cough and dyspnea 7 months after BMT. The chest X-ray and computed tomography revealed patchy infiltrates bilaterally. Lung function test, lung biopsy and bronchoalveolar lavage were consistent with the diagnosis of BOOP. The patient also suffered from suspected graft-versus-host disease (GVHD) of the liver, after discontinuation of cyclosporine. Furthermore, prednisolone proved effective against the BOOP and the liver dysfunction. These findings indicate that BOOP is a possible pulmonary manifestation of chronic GVHD, and that immunological mechanisms may have effected the onset of BOOP after BMT in this case.

Keywords Allogeneic bone marrow transplantation · Bronchiolitis obliterans organizing pneumonia · Graft-versus-host disease · Immunological reaction

Abbreviations ALP Alkaline phosphatase · BMT Bone marrow transplantation · BO Bronchiolitis obliterans · BOOP Bronchiolitis obliterans organizing pneumonia · CML Chronic myelogenous leukemia · GVHD Graft-versus-host disease

Introduction

Infectious and non-infectious pulmonary complications are relatively common after allogeneic bone marrow transplantation (BMT) [8]. It is suggested that chronic graft-versus-host disease (GVHD) and late-onset non-infectious pulmonary complications, such as diffuse alveolar damage, interstitial pneumonia and bronchiolitis obliterans (BO) are connected [7]. Moreover, bronchiolitis obliterans organizing pneumonia (BOOP) has previously been reported following BMT [1, 5, 6, 9]. Although histologic findings of BO and BOOP share several similarities, their clinical features are quite different. BO is characterized by obstructive airway disease. The chest X-ray shows no findings or hyperinflation. The disease responds moderately to steroids and usually shows a progressive course. In contrast, BOOP is characterized by restrictive impairments; BOOP chest X-rays show patchy areas of consolidation; steroids treatment generally improve the clinical and radiological findings. We report on a patient who developed BOOP in coincidence with suspected GVHD of the liver after allogeneic BMT, however, the etiology of BOOP and its relationship with GVHD remain unclear.

Materials and methods

A 19-year-old male with chronic myelogenous leukemia (CML) in its second chronic phase was transferred to our hospital for BMT in August 1997. After one course of chemotherapy, he received an allogeneic bone-marrow transplant from his HLA-identical sister in November. The conditioning regimen consisted of fractionated total body irradiation (from days -8 to -5; 3 Gy/day), etoposide (on day -4; 1600 mg/m² per day), and cyclophosphamide (on days...
-3 and -2; 2250 mg/m² per day). The patient received methotrexate (on day 1; 15 mg/m² per day, and on days 3 and 6; 10 mg/m² per day) and Cyclosporin A (CSA) (3 mg/kg administered daily as a continuous infusion) in order to prevent GVHD. The engraftment of bone marrow was favorable. He was discharged on day 98 without acute GVHD in February 1998.

CSA was tapered and stopped on day 150, although aminotransferase levels gradually rose. The patient complained of a non-productive cough and low-grade fever on day 150. Although he was treated with antibiotics, he had to be rehospitalized on day 239 for progressive dyspnea. On admission, the serum aspartate aminotransferase (AST) level had increased to 83 U/L, that of alanine aminotransferase (ALT) to 141 U/L, and that of alkaline phosphatase (ALP) to 575 U/L (Fig. 1). The chest X-ray with air bronchogram revealed multiple patchy infiltrates. High resolution computed tomography (CT) of the lung also demonstrated bilateral nodular patchy inclusions (Fig. 2a). Lung function tests showed a moderate, restrictive impairment (VC 2.13 l/min, 47.9% of expected value and FEV₁ 2.91 l/min, 96.3%). Carbon monoxide diffusion capacity was 21.06 ml/mm Hg per s (58.1% of expected value). Analysis of arterial blood gas showed a slight hypoxemia. Transbronchial lung biopsy and bronchoalveolar lavage (BAL) were performed on day 245. Pathological findings showed interstitial fibrosis with lymphocyte infiltration and intraluminal fibrosis with plugs of inflammatory cells, fibroblasts, and connective tissue (Fig. 3). The most conspicuous cells were foamy macrophages occupying free alveolar air spaces. Cytology of BAL fluid revealed a high lymphocyte count (36.0%), and the CD4/CD8 ratio was 0.04, using flow cytometry analysis. Examination of BAL fluid including cultures for bacteria, fungi and PCR for cytomegalovirus were negative. From these findings, the lung lesion was diagnosed as BOOP.

The patient received prednisolone at a dose of 1 mg/kg daily from day 248. Clinical symptoms disappeared, and the chest X-ray improved within few days. The lung CT also showed improvement of the patchy lesions on day 13 after prednisolone treatment (Fig. 2b). The patient was discharged on day 276 without symptoms. Around day 280, the serum AST- and ALT levels improved to 25 U/L and 40 U/L, respectively. He is now doing well without immunosuppressive therapy after a follow-up period of 28 months after BMT.

**Fig. 1** Clinical course

**Fig. 2** a The chest CT scan indicates bilateral patchy infiltrates with peribronchial thickening on day 240 (pre-treatment with prednisolone). b Abnormal shadow apparently improved on day 260 (post-treatment)