Simulation of the Fissureless Technique for Thoracoscopic Segmentectomy Using Rapid Prototyping

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Introduction

The fissureless lobectomy or anterior fissureless technique is a novel surgical technique, which avoids dissection of the lung parenchyma over the pulmonary artery during lobectomy by open thoracotomy approach or direct vision thoracoscopic surgery. This technique is indicated for fused lobes. We present two cases where thoracoscopic pulmonary segmentectomy was performed using the fissureless technique simulated by three-dimensional (3D) pulmonary models. The 3D model and rapid prototyping provided an accurate anatomical understanding of the operative field in both cases. We believe that the construction of these models is useful for thoracoscopic and other complicated surgeries of the chest.

Keywords: rapid prototyping technique, fissureless technique, thoracoscopic surgery, pulmonary segmentectomy

Materials and Methods

We present two cases where thoracoscopic pulmonary segmentectomy was performed in 2013 using the fissureless technique simulated by 3D pulmonary models.

A four-port thoracoscopic segmentectomy was performed in the lateral decubitus position. The four skin incisions (1–2 cm long) were made on the mid- and anterior axillary lines. Based on volume analysis of Synapse Vincent (Fujifilm Medical Co., Ltd., Tokyo, Japan) data derived from contrast-enhanced computed tomography (CT) scans, we were able to fabricate a 3D mixed-color replica of the anatomy with a 3D model printer (Connex, Stratasys, Ltd., Tokyo, Japan). We used white resin for bronchi and transparent resin for vessels in the cases in this manuscript. We obtained the approval of institutional ethics committee before starting this research.

Results

Case 1

A 65-year-old female patient underwent a hysterectomy and bilateral salpingo-oophorectomy for uterine leiomyosarcoma in March 2010, and abdominal lymphadenectomy...
in April 2011. She was referred to our department for further examination of an abnormal lung shadow. Retrospective review of her chest CT revealed the tumor had grown from 0.4 cm to 2.7 cm in size during two years. The patient underwent thoracoscopic basal segmentectomy of the left lower lobe. At first, the left superior and inferior pulmonary veins were exposed. Because the upper and lower lobes were fused, the pulmonary artery was subsequently exposed at the anterior and posterior hilum (Fig. 1A and 1C). The periadventitial plane of the pulmonary artery was followed to undermine the major fissure. The stapler anvil was introduced in this plane, and the fused major fissure was divided using the stapler and ultrasonically activated scalpel protecting the superior segmental artery of the left lower lobe and the lingular artery (Fig. 1B and 1D). The basal pulmonary arteries, vein, and bronchus were consecutively divided. The intersegmental plane was visualized by creating an inflation and deflation line, and an intersegmental fissure was made using staplers. The pathological diagnosis was metastatic leiomyosarcoma. The patient’s postoperative course was uneventful, and she was discharged on postoperative day 6.

Case 2
A 66-year-old female patient with an abnormal shadow of ground glass opacification was monitored for 3 years and 6 months. During this period, her tumor had grown from 6 mm to 10 mm in size. She underwent a thoracoscopic left anterior basal segmentectomy after a preoperative diagnosis of lung cancer. The upper and lower lobes were fused except for the posterior part. The left superior and inferior pulmonary veins were exposed, and the pulmonary artery was exposed in the anterior hilum (Fig. 2). The periadventitial plane of the pulmonary artery was followed from the anterior hilum to undermine the major fissure, and the fused major fissure was divided using staplers. The anterior basal pulmonary artery, bronchus, and vein were consecutively divided. The intersegmental plane was visualized by creating an inflation and deflation line, and an intersegmental plane was made using staplers. The pathological diagnosis was bronchioloalveolar carcinoma of the lung. The patient’s postoperative course was uneventful, and she was discharged on postoperative day 6.

Discussion
For a lobectomy, the parenchyma over the pulmonary artery is typically divided by electrocautery or ultrasonically activated scalpel. However, this procedure may cause air leaks, which can prolong the durations of chest tube drainage and hospitalization. Temes, et al., in 1998, described a fissureless lobectomy with open thoracotomy, a technique in which the pulmonary artery is exposed using a stapler for the entire dissection of lung parenchyma over the pulmonary artery in order to minimize air leaks. They commented that this technique could be modified and adapted to segmentectomies or thoracoscopic lobectomies with incomplete fissures. Gómez-Caro, et al. reported that the fissureless technique for a right upper lobectomy with a posterolateral incision decreased the incidence of prolonged air leakage after lobectomy.1) They divided the pulmonary artery after dividing the corresponding bronchus. Ng, et al. reported that the anterior fissureless technique for a right upper lobectomy with a lateral thoracotomy or muscle sparing lateral thoracotomy reduced air leakage and the duration
understanding of the anatomy of the lesion even in an unusual operative field.

Using 3D models, we can image and sense the depth of the structures of pulmonary vessels and bronchi. On the other hand, from 3D images using multidetector CT, we can also understand the relations of structures, for instance, which is anterior side or posterior side. But it is usually difficult to sense the depth of these structures. Experienced general thoracic surgeon may be able to image the depth of these structures, but for unexperienced general thoracic surgeons, 3D models will assist to understand the depth of the structures than 3D images.

We believe that construction of these models is worthwhile for thoracoscopic and other complicated surgeries of the chest.

Disclosure Statement

None to declare.

References


of hospital stay. In addition, Refai, et al. reported that this procedure reduced air leakage and hospital costs without increasing operative time. Nomori, et al. described operative procedures for various pulmonary lobectomies with fused fissures using video-assisted thoracoscopic surgery. They usually divided the lobar bronchus first, followed by the pulmonary arterial branches within the fissure, and eventually the fissure itself.

Thus, the fissureless technique appears to be useful for both open thoracotomies and thoracoscopic surgeries, but there are no reports of pulmonary segmentectomies or complete thoracoscopic surgeries in conjunction with this method to the best of our knowledge. In order to adopt a new operative technique in an unusual operative field, simulation is desirable. Rapid prototyping techniques have been proven to be beneficial in various fields of surgery. These 3D models can be useful for pre- and intraoperative surgical procedure planning; nevertheless, only a few pulmonary models have been detailed in the literature in the field of general thoracic surgery. The 3D model and rapid prototyping technique used in the two cases described above provided us with an accurate understanding of the anatomy of the lesion even in an unusual operative field.

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