Segmentectomy guided by three-dimensional computed tomography angiography and bronchography

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Abstract

We describe the benefits of a three-dimensional multidetector computed tomography angiography and the bronchography-guided segmentectomy technique. Preoperative determination of the anatomical intersegmental plane is possible by visualizing the segmental branches of the pulmonary veins and segmental bronchi. This new technique may be useful in segmentectomy of the lung.

Keywords: Segemetectomy • 3-Dimensional computed tomography (3DCT) • Hybrid VATS

INTRODUCTION

Advances in computed tomography (CT) technology have led to an improved detection rate of small lung abnormalities and a higher frequency of the diagnosis of early-stage lung cancers and pulmonary metastases, which may increase the number of minimally invasive sublobar pulmonary resections. A few authors have recently reported the benefit of simulation methods for lobectomy and segmentectomy, using three-dimensional CT (3DCT) volume rendering to visualize the individual pulmonary arteries and veins [1–3]. However, there is no report about the benefit of a simulation method using 3DCT to simultaneously visualize individual pulmonary vessel branches and segmental bronchi. The aim of this study was to describe the method of identifying pulmonary vessel branches and segmental bronchi using 3DCT angiography and bronchography (3DCTAB) and its benefit for segmentectomy.

TECHNIQUE

Simulation of a segmentectomy using 3DCTAB images was performed with a 64-channel multidetector CT. A total of 35 ml of contrast agent was injected by a mechanical injector at the rate of 5 ml/s, followed immediately by the injection of 20 ml of saline. Using 3D volume rendering, a solid image was constructed from 1.0-mm data slices of the contrast-enhanced CT images. The volume data from the arterial and venous phases were transferred to a workstation with volume-rendering reconstruction software (Ziostation, Tokyo, Japan), which converted the data to a 3DCT angiography format. The procedure for the 3D reconstruction of the bronchial tree involved mathematical morphology-based 2D segmentation performed on axial images, followed by further restoration by the manual addition of segments from the 2D axial images to the 3D image. Radiology technicians processed the 3D images, and respiratory surgeons made the final confirmations.

PREOPERATIVE SIMULATION

The most important factor in preoperative simulation is the determination of the intrasegmental veins in the affected segment that are to be divided and the intersegmental veins that are to be preserved. To accurately identify the venous branches in the affected segment and the intersegmental veins, we typically used 3DCTAB (Fig. 1A) and 3DCT images showing only the pulmonary veins and bronchi of the lung (Fig. 1B). The 3DCTAB image gives information on the bronchial resection line as the vertical surgical margin of segmentectomy. In cases of malignancy, we measured the distance between the intersegmental veins and the tumour edge using the 3DCT and 2DCT images, and we designed the resection lines with surgical margins of at least 2.5 cm in the preoperative simulation (Fig. 1B). When the preservation of the margin in a single segment resection was difficult, we designed an extended segmentectomy by dissecting the parenchyma across the intersegmental vein or a combined segmentectomy with the adjacent subsegment.

OPERATIVE PROCEDURE

Initially, we attempted this new method for hybrid video-assisted thoracoscopic surgery (VATS) [4] segmentectomy beginning January 2010. Basically, two skin incisions are made to create access without cutting the extracostal muscles or ribs: one utility incision (skin incision, 4–8 cm long) for manipulation and another as an access port for the insertion of the thoracoscope. The surgeon directly observes the hilum of the diseased lobe and individually detached and dissected all bronchi and vessels.

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When dissecting an area out of direct view, television monitor guidance is variably used. However, beginning in April 2011, we have used this technique for totally thoracoscopic segmentectomy. Five ports (1 with a diameter of 20 or 25 mm [flexible], two with a diameter of 10 mm and two with a diameter of 5 mm) are prepared for the port access technique. The surgeon individually detached and dissected all bronchi and vessels under television monitor guidance.

The 3DCT-guided segmentectomy is initiated by detaching the arteries and veins from the pulmonary parenchyma along the shortest route to the intended segmental bronchi, according to the preoperative simulation and intraoperative 3DCTAB guidance (Fig. 2A). When we perform an upper lobe segmentectomy, we first ligate and dissect the intrasegmental veins and segmental arteries, and then divide the segmental bronchi. However, when we perform a lower lobe segmentectomy, with the exception of the superior segment (S6), the intrasegmental and intersegmental veins are ligated after dividing the segmental bronchi (Fig. 2B). After the segmental bronchi are isolated, a surgeon inserts a bronchoscopybscope through the double-lumen tube into the orifice of the targeted segmental bronchi, in which selective segmental jet ventilation is started [4]. The diseased segment is inflated while the preserved segments appear collapsed, and a line is formed between the inflated and deflated lung parenchyma, evidencing the anatomic intersegmental plane. In general, we ligate and dissect the segmental bronchi using 2-0 silk or a stapling device after in-ligated and dissected, and the intersegmental plane between S6 and S10 was already divided. The intersegmental plane is approached along the intersegmental vein (V9).

In no patient did the procedure need to change from hybrid VATS and totally thoracoscopic segmentectomy to open thoracotomy segmentectomy. Furthermore, there were no intraoperative complications that forced patients to undergo lobectomy rather than segmentectomy.

COMMENTS

The efficacy of 3DCT angiography for preoperative assessment for thoracic surgery has been previously described [1, 2]. Fukuhara et al. [2] reported that 3DCT angiography using MDCT clearly revealed individual anatomies of pulmonary arteries and could play an important role in safely facilitating a complete VATS lobectomy procedure. Oizumi et al. [3] have recently demonstrated that simulation by 3DCT angiography is a powerful tool to enable the surgeon to identify the intersegmental pulmonary veins and secure surgical margins in a thoracoscopic lung segmentectomy. However, to our knowledge, 3DCTAB has never been recommended as a preoperative procedure for segmentectomy.

Before a segmentectomy is performed, it is critical to identify the intersegmental veins as the boundary lines of the pulmonary segments, to determine the lateral surgical margins and to identify the target segmental bronchi as the vertical surgical margin. However, given the many anatomical variations of the pulmonary veins and bronchi in the lung, it is sometimes difficult to preoperatively identify the intrasegmental and intersegmental veins and target segmental bronchi using only 3DCT angiography. Thus, to accurately identify the intrasegmental and intersegmental veins and target segmental bronchi, we need information about not only anatomical variations of the pulmonary veins and bronchi but also the positional relationship between the segmental veins and bronchi. We believe that we are able to obtain accurate preoperative information regarding the relationships among the tumour, the intrasegmental and intersegmental veins, and the target segmental bronchi using only 3DCTAB. Furthermore, in the surgical field view during segmentectomy, not only the pulmonary veins and artery but also the bronchi are visible. During the preoperative simulation and under

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intraoperative guidance using only 3DCT angiography, it was not easy to identify the intrasegmental and intersegmental veins for a segmentectomy because the running roots of the pulmonary veins were complexly associated with the bronchi. However, 3DCTAB demonstrates not only the pulmonary vessels but also segmental bronchi in the natural surgical field view. Therefore, preoperative simulation and intraoperative guidance using 3DCTAB are powerful tools that facilitate an effective segmentectomy, and hybrid VATS segmentectomy and totally thoracoscopic segmentectomy are especially useful.

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Conflict of interest: none declared.

REFERENCES