A lung segmentectomy performed with 3D reconstruction images available on the operating table with an iPad

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1. Introduction

Initially described for benign conditions, anatomic segmentectomy was first performed very rarely for cancer patients because of initial reports showing a three times increased risk of local recurrence after sublobar resection [1]. There is currently a regain of interest in segmentectomy, first because more recent studies did not confirm the increased recurrence rate after segmentectomy if performed for peripheral T1N0 lesions <2 cm and second because it is useful in patients with poor pulmonary reserve [2-4].

Because of the relative rarity of this procedure, thoracic surgeons in training hardly get to do a significant number of each of the possible segmentectomies and therefore do not always get used to the intrapulmonary arterial, venous and bronchial anatomy with their wide variations.

We report the case of a segmentectomy of the upper segment of the left lower lobe. The three-dimensional (3D) anatomy of the patient was studied preoperatively using the Open Source OsiriX software (www.osirix-viewer.com), and 3D rendered images as well as reformatted planes were generated and transferred to the iPad tablet to be displayed during the surgical intervention.

2. Case report

A 53-year-old male had undergone a partial pharyngectomy with neck dissection in 2008 for a squamous cell carcinoma pT2N0G2. During follow-up computed tomography (CT), he presented with a new lung nodule of 6 mm that was followed for three months. At the positron emission tomography-computed tomography (PET-CT) evaluation three months after the CT, the nodule showed significant growth (9 mm) and fluorodeoxyglucose (FDG) uptake (SUV 2.8). There was no sign of local recurrence on imaging studies or on ear nose and throat (ENT) examination.

The nodule was in the center of the upper segment of the lower lobe (Fig. 1). A segmentectomy was considered to be the procedure of choice in his case because we could not assert whether the nodule was malignant preoperatively and, if malignant, it would not be possible to differentiate intraoperatively whether it is a primary lung tumor or a lung metastasis of the squamous cell cancer of the pharynx.

We performed an anatomical segmentectomy through a small postero-lateral thoracotomy. The pulmonary artery was dissected in the fissure and the branch to the upper segment was identified and sectioned. The vein coming from the upper segment was identified and sectioned as well. The reconstructed 3D images were used to help perform these vascular steps safely. Then the upper segmental bronchus was identified and stapled. The lung was reinflated and the lung parenchyma was stapled following the line of inflation. A routine mediastinal lymph node dissection was performed.

The preoperative planning included reconstruction of 3D images from a standard high resolution CT using the Open Source OsiriX software.
Source OsiriX software, which took the surgeon about 15 min (Fig. 2). Images were then transferred to an iPad and carried to the operating room. Based on the images we were able to confirm that the anatomy of the patient was standard (one artery, one vein and one bronchus) (Video 1). In the operating room the iPad was inserted in a sterile plastic bag to be used and manipulated in the operating field. Surgeons were able to review and manipulate the 3D images interactively to assist in the identification of the different anatomical landmarks, in particular the arterial and venous branch to and from that segment (Video 2).

A thoracic drain was left in the thorax and the thoracotomy was closed. Follow-up was uneventful and the patient went home on the sixth postoperative day. Final pathology showed a squamous cell carcinoma of 1.2 cm at distance from the resection margins and from the bronchus. Because of the similarities between this tumor and his ENT tumor it was considered to be a metastasis from the ENT tumor. All lymph nodes were benign.

3. Discussion

The more frequent use of screening methods for smokers and advances in imaging techniques led to an increase in the rate of small and suspicious lung lesions requiring surgical excision for diagnosis and therapeutic purposes. Anatomical segmentectomy is a recommended procedure in those patients because it is considered oncologically sufficient for small cancers having some criteria of non-aggressive behavior \(2\) and because it represents a very small amputation of the pulmonary function. To avoid peri- and postoperative complication, precise anatomic landmarks need to be carefully identified and followed. The vascular and bronchial anatomic variations need to be recognized. Surgeons therefore require adequate technical help from preoperative imaging data to adequately plan the surgical procedure.

The Open Source OsiriX software provides the tools for interactive reconstruction of 3D images and multiplanar reformatting of data from any imaging modality. Its intuitive user interface and high performance processing power allows surgeons to easily generate a variety of images in real time and select the most adequate view of the specific anatomical structures that are of interest. Image segmentation and sculpting tools allow to extract the relevant anatomical structures and remove unnecessary anatomical layers. Color and transparency adjustments are also used to provide the best 3D vision from any angle. However, having prepared the procedure, surgeons also need to regularly access these images during the operation to compare the intraoperative anatomy with the reconstruct-
ed images. Static as well as dynamic images can be transferred to the iPad tablet together with the original two-dimensional images of the scanner to be further manipulated on the iPad using the mobile OsiriX viewer specifically designed for iPhone and iPad platforms. The operating surgeon and his residents/fellows can follow the surgical procedure step by step. This not only helps perform the procedure safely but also helps teach and learn the intrapulmonary anatomy.

We elected to perform the segmentectomy by a small thoracotomy because we are at the beginning of our experience of thoracoscopic anatomic resections but these procedures can certainly also be performed safely thoracoscopically in the future [5]. For endoscopic interventions, the ability to have 3D images of the anatomy of the patient available to the surgeons in the operating room could be even more valuable. In this case, a segmentectomy of the upper segment of the lower lobe was necessary, which is the easiest of the possible anatomical segmentectomies. The help of having images sterily accessible intraoperatively would be still more valuable for more complex procedures like segmentectomy of the anterior segment of the upper lobes or of the latero-basal segment of the lower lobes for instance.

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References