Editorial

Thoracoscopic anatomical segmentectomy for early-stage non-small cell lung cancer: minimally invasive surgery involving various approaches

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Although lobectomy has been a standard procedure for lung cancer since the randomized trial by Ginsberg *et al.* in 1995, segmentectomy has become an acceptable procedure for small-sized lung nodules, particularly for early-stage lung cancers sized less than 2.0 cm or with ground glass opacity (GGO) (1-3). In recent years, a prospective clinical trial—JCOG0802/WJOG4067—demonstrated the feasibility of segmentectomy (4). The results of this study provide surgical strategies for early-stage lung cancer, which could be a valuable topic for further studies.

Thoracoscopic surgery has also been widely performed as a minimally invasive surgery and has shown some advantages, such as less pain, preservation of pulmonary function, and earlier recovery after surgery (5,6). Gonzalez *et al.* (7) first reported uniportal thoracoscopic anatomic lung resection in 2011; although this approach was impressive, multiple attempts were required for the procedure to become widely accepted due to the difficulty of surgical maneuvers involved. However, recent advancements in specialized instruments for this approach may have led to an improved ability to perform thoracoscopic anatomic lung resection worldwide. Therefore, many reports of successful uniportal segmentectomy have been published in recent years (8-11).

In the case report by Wang *et al.* (12), the uniportal video-assisted thoracoscopic segmentectomy was shown as a right apical (S1) segmentectomy and was relatively complex. This procedure is currently the most popular among minimally invasive surgeries, and the case report contained useful information that included the details of procedural steps, the understanding of the precise anatomies of pulmonary vasculatures and bronchi using a three-dimensional (3D) reconstruction, and the characteristics of uniportal video-assisted thoracoscopic surgery (VATS). Thoracoscopic segmentectomy comprises various procedural types that are broadly classified as simple and complex segmentectomy. Complex S1 segmentectomy is expected to be more difficult than other segmentectomies under the uniportal approach because the right S1 segment is located in the most apical space of the thoracic cavity, and the maneuver is difficult under uniportal VATS. Igai *et al.* (13) also reported a case of uniportal right S1 segmentectomy and described the difficulties encountered with this technique. Although the incision site in the report by Wang *et al.* may be slightly lower than that in the report by Igai *et al.*, the report clearly described the technical aspects of these difficulties.

In addition, the patient described in the report by Wang *et al.* (12) had other lung nodules at the same time and therefore needed a surgical strategy of resection planning for multiple nodules. We occasionally encounter cases with multiple small-sized GGO-dominant tumors, such as that of this patient. In such cases, it is important to plan strategies to effectively manage multiple nodules. Usually, based on oncological aspects, the largest tumor

in the consolidation size is planned to be resected first. However, when considering the intraoperative oxidation based on respiratory function, it may be acceptable that smaller tumors be resected first as an alternative if performing a second surgery is impossible after the first surgery due to poor pulmonary function. Furthermore, the combination of various procedures for multiple nodules, such as segmentectomy and lobectomy, segmentectomy and segmentectomy, segmentectomy and wedge resection, and wedge resection and wedge resection, should also be planned given that strategies for multiple tumors differ according to each patient's physical status and tumor characteristics.

Thoracoscopic anatomical segmentectomy is a more challenging procedure than a lobectomy because a more precise understanding of the lung anatomy, including the thinner pulmonary vasculatures and bronchi, during surgery is required for segmentectomy than for lobectomy. Therefore, several thoracoscopic anatomical segmentectomies using 3D computed tomography (CT) or 3D printing have been attempted and reported thus far. Consequently, these technologies have enabled us to perform not only simple but also complex segmentectomy thoracoscopically (14-16).

Various technical aspects should be discussed in segmentectomies, such as the recognition of the intersegmental plane and the resection margins and lymph node (LN) biopsy as described in the discussion section of the report by Wang *et al.* (12). The number of reports aiming to address these issues has also increased in recent years.

While the inflation–deflation method and identifying the intersegmental veins are traditional methods for identifying the intersegmental plane, a modified inflation-deflation method and a method using indocyanine green (ICG) have been recently reported and found to be very useful (17-21). The modified inflation-deflation method by Yao *et al.* (17) was found to be reasonable for identifying intersegmental planes. The ICG method appears to be widely used owing to its utility in visually identifying intersegmental planes and securing the working space (18-21).

Securing an adequate surgical margin is essential, especially in sub-lobar resections such as segmentectomy or wedge resection. Although segmentectomy is thought to more easily secure an adequate surgical margin compared to wedge resection, if the intersegmental veins are used as the landmark of the intersegmental line and the distance from the tumor is of an adequate length, as we previously reported (15), a supplemental method using dye marks as virtual-assisted lung mapping has also been reported for adequate surgical margins. This method is expected to be beneficial, although some additional bronchoscopy techniques are required (22).

LN dissection may be selectively performed according to the tumor characteristics and location in early-stage lung cancer. Zhang *et al.* (23) first proposed selective LN dissection for lung cancer by assessing the LN metastasis based on tumor location, the proportion of GGO, and other traits. In thoracoscopic segmentectomy at my institute, a regional LN biopsy around the targeted segmental bronchus has been routinely performed as LN biopsy itself is not a difficult procedure.

The indication criteria of segmentectomy are important for lung cancer, as described in the details of the report by Wang *et al.* (12). Segmentectomy has become increasingly popular and is a topic of discussion owing to the recent randomized trials (4). The size and consolidation ratio of the tumor are key factors for the decision-making regarding procedure options for lung cancer. The consolidation ratio is the ratio of the solid nodule to all nodules with GGO. Such GGO-dominant nodules have a good prognosis, and sub-lobar resection, not only in segmentectomy but also in wedge resection, may be acceptable in cases of GGO nodules. However, in solid nodules, recurrence after the sub-lobar resection is a possibility. If appropriate indication criteria for lung cancer can be adopted, segmentectomy can be expected to replace lobectomy as the standard procedure. To follow an appropriate procedure for lung cancer, it would be essential to further elucidate the preoperative tumor characteristics with tools such as CT and/or positron emission tomography, along with comparisons with postoperative pathological evaluations.

Recently, an increasing number of studies on robotic segmentectomy have also been reported (24,25). The robotic approach has multiple angles and provides comfortable scope-control for the surgeons. Therefore, this approach may offer some advantages in performing precise segmentectomy and dividing the inter-segmental plane with multi-angular approaches.

Thus, thoracoscopic anatomical segmentectomy, as a minimally invasive surgery, includes some approaches and various useful techniques. Although these technical aspects will be continued to be discussed in the future, it must be noted that securing a sufficient surgical margin remains the most important aspect of segmentectomy. The various approaches and techniques may be acceptable if they provide a sufficient surgical margin, depending

on the preferences of each institution. In addition, other approaches or techniques may also be applied in the future.

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