Commentary on Thoracic Surgery

Virtual navigation to guide personalized treatment of small-size lung cancer using minimally invasive techniques

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Ouizimi and colleagues authors have developed a technique of anatomical segmentectomy and subsegmentectomy, performed by video-assisted thoracic surgery (VATS) and guided by contrast-enhanced three dimensional (3D) computed tomographic (CT) simulations (1). They describe a right anterior segmentectomy using the technique. The authors routinely use CT with angiography to produce detailed 3D images of segmental anatomy particularly blood vessels and bronchi. The images guide the resection using electrical devices and staplers, and in particular assist the isolation and division of blood vessels and bronchi. Even small subsegments can be resected with sufficient surgical margins. The authors place a slip-knot round the bronchus of the segment to be removed, inflate the target lung, tighten the knot and deflate the lung again, so that the target segment remains inflated, helping to identify the intersegmental plane.

VATS and robot-assisted surgery are established minimally invasive techniques for resecting lung cancers that avoid rib-spreading and division of the major thoracic muscles. However they are not widely used. A survey conducted by the European Society of Thoracic Surgeons in 2007 found that only around 5% of responding European surgeons were using VATS for pulmonary resections (1). Nevertheless, the number of surgeons embracing VATS has increased in recent years, as evidence of the benefits to patients has accumulated. Systematic reviews and randomized trials (2-4) consistently indicate that compared to open approaches, VATS is associated with shorter length of hospital stay, reduced postoperative pain, reduced blood transfusions, and lower complication rates; as well as improved aesthetic and functional outcomes leading to better quality of life. The most frequent reason given by surgeons for not using VATS for lobectomy was that it is a difficult technique with a steep learning curve (1). If lobectomy is considered challenging, segmentectomy—and even more subsegmentectomy—are clearly very demanding procedures, yet the group of Ouizumi has obtained excellent results with their approach (5).

Segmentectomy and wedge resection have mainly been considered suitable for elderly patients or those with impaired lung function who cannot tolerate lobectomy—the standard surgical approach to early lung cancer in fit patients (6). However, over the last 15 years, several publications (7,8) have reported that segmentectomy can be associated with comparable oncological outcomes to those of lobectomy for lung cancers less than 2 cm in diameter. With the dissemination of lung cancer screening (9,10), small early-stage cancers are an increasing proportion of the lung cancers diagnosed. Depending on cancer characteristics (volume doubling time, size, density and standardized uptake value) many of these early cancers appear to be adequately treated by segmentectomy or wedge resection, which would ideally be performed by a minimally invasive approach (VATS or robot-assisted surgery). Two large ongoing randomized trials are re-examining the role of sub-lobar resection for small early-stage lung cancer. It will be also important to determine whether anatomic segmentectomy is equivalent to non-anatomical (wedge) resection for subcentimetric peripheral nodules in carefully selected patients.

We have found that the risk of lymph node involvement is very low in screening-detected cancers <1 cm in diameter with standardized uptake value (FDG) <2.5, indicating that radical lymph node dissection can be avoided in such cases.

We perform sublobar lung resections using a robotic system (11). The robot's 3D visual system provides an excellent magnified view of hilar structures during the operation, although the view of lung parenchyma may be limited. Furthermore, the lung inflation method normally used to pick out the segment to be removed does not afford perfect demarcation of planes. We have used the non-toxic fluorescent dye indocyanine green (ICG) to successfully reveal the target segment and demarcate its boundaries during segmental resection. After division of segmental blood vessels within the hilum, we introduce ICG through the peripheral venous catheter used to induce anesthesia. The ICG lights up all structures except the isolated target segment, facilitating radical resection without extension to neighboring segments. The clear parenchymal demarcation of the intersegmental plane that this technique affords makes it easier to obtain adequate margins. Although the technique requires further validation, it is an excellent example of how computerized imaging systems can facilitate minimally invasive surgical resections (12).

Of course the key feature of the study by Oizumi and colleagues is their use of imaging technology to guide their minimally invasive approach. Combination of the best features of these two techniques into a hybrid therapeutic modality seems likely to be the way forward in surgery (13), particularly for complex procedures like sublobar resection.

Virtual reality (VR) is a realistic computer-generated 3D environment, in which the user is immersed; the user interacts with that environment by means of sensors and effectors. Medical VR software can use DICOM format images (obtained from CT scan) to elaborate a VR model of the patient. Virtual navigation through, and exploration of, the body is then possible, enabling identification of target structures, surgical planes, resection margins and other anatomical details that may be difficult to discern on standard images. The VR model can be used to facilitate or optimize diagnosis and assist with surgical planning.

The important step however would be to integrate this preoperative information with intraoperative information obtained in real time from the VATS or robotic visual system. This could be done using the techniques of augmented reality (AR). AR displays the 3D model of the patient and a 3D model of instruments with overlay of the real surgical video feed, thus augmenting the real view with virtual information. This would enable, for example, the surgeon to locate blood vessels and diseased structures that are not directly visible, and which previously could only be appreciated by palpation. As yet no such system is commercially available, but the techniques of VR and AR are already with us (12). Needless to say this envisaged future of surgery will require the integration and perfection of computer technologies, image guidance technologies, and robotics technologies. The primary aim should always be to increase patient safety and improve quality of life. It will also require a radical change in operating room practice and mindset.

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Footnote

Conflicts of Interest: G Veronesi is proctor in robotic thoracic surgery for Ab Medica. No conflicts of interest or financial ties to disclose have been declared by M Alloisio and P Novellis.

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