Use of indocyanine green to facilitate intersegmental plane identification during robotic anatomic segmentectomy

Alessandro Pardolesi, MD,^a Giulia Veronesi, MD,^b Piergiorgio Solli, MD,^a and Lorenzo Spaggiari, MD, PhD,^a Milan, Italy

Robotic anatomic lung segmentectomy appears to be an appropriate approach for small, early-stage lung cancer^{1,2}; however, it can be challenging to identify the intersegmental planes during the operation. Transbronchial injection of indocyanine green (ICG) during video-assisted thoracoscopy has been shown to facilitate quick and easy identification of the intersegmental planes defining the target lung segment without the need for lung inflation.^{3,4} We have developed a new and simpler technique for the identification of intersegmental planes during robotic anatomic segmentectomy. After division of the target segment bronchus, vein, and artery within the hilum, peripheral intravenous injection of ICG “lights up” the nontarget segments, while the target segment shows up as uncolored.

MATERIALS AND METHODS

We report the cases of 2 patients, each with a screening-detected lung nodule less than 2 cm in maximum diameter. In patient 1, the nodule was in the superior segment of the left lower lobe (Figure 1, A); in patient 2 the nodule was in the upper left lobe (apical posterior segment; Figure 1, B). Preoperative positron emission tomography revealed standardized

uptake values of 1.5 and 1.08, respectively, suggesting malignancy (standardized uptake value cutoff of 1.0).

Both patients underwent robotic anatomic segmentectomy. Patient 1 underwent left lower lobe superior segmentectomy, and patient 2 underwent lingula-sparing lobectomy. Both procedures were performed after provision of informed consent and after verification of the absence of contraindications (hypersensitivity or allergy to ICG, sodium iodide or iodine; hyperthyroidism; thyroid neoplasm; pregnancy or breastfeeding; medications affecting liver function or for renal failure).

ICG was prepared as a sterile solution (2.5 mg/10 mL) shortly before use. A 6- to 8-mL bolus was injected into the peripheral vein catheter used to induce anesthesia, immediately followed by a 10-mL saline solution bolus.

RESULTS

The initial part of the procedure consisted of robot-assisted division of the segmental bronchus, vein, and artery or arteries within the hilum (Figure 2, A). ICG was then injected into the peripheral vein catheter and the robot visual system changed to fluorescence mode. Mediastinal and parenchymal tissue appeared green within 30 to 40 seconds. The green coloration reached maximum intensity in about a minute and subsequently faded slowly. Although perfused lung parenchyma appeared green, the isolated segment (to be removed) remained uncolored (Figure 2, B), affording excellent demarcation and facilitating its transection with endoscopic staplers. After specimen removal, radical lymph node dissection was performed. In all, 14 and 8 lymph nodes were removed from patients 1 and 2, respectively. Both patients recovered well and were discharged without major complications. Pathologic examination in both cases showed stage IA (16 mm and 19 mm) G1 adenocarcinoma

From the Division of Thoracic Surgery,^a and the Early Lung Cancer Detection Unit,^b European Institute of Oncology, Milan, Italy.

Disclosures: Authors have nothing to disclose with regard to commercial support.

A.P. and G.V. contributed equally.

Received for publication Dec 22, 2013; revisions received Feb 3, 2014; accepted for publication March 3, 2014; available ahead of print March 26, 2014.

Address for reprints: Giulia Veronesi, MD, European Institute of Oncology,

Via Giuseppe Ripamonti 435, 20141 Milan, Italy (E-mail: giulia.veronesi@ieo.it).

J Thorac Cardiovasc Surg 2014;148:737-8

0022-5223/\$36.00

Copyright © 2014 by The American Association for Thoracic Surgery

<http://dx.doi.org/10.1016/j.jtcvs.2014.03.001>

FIGURE 1. A, A nodule is visible in the superior segment of the lower left lobe in patient 1. B, A nodule is visible in the upper left lobe in patient 2.

FIGURE 2. Intraoperative photographs before (A) and after (B) indocyanine green injection.

with prominent lepidic spread; resection margins were negative.

DISCUSSION

Although still investigational, minimally invasive anatomic segmentectomy appears to be a valid approach to small, early-stage lung cancer, with equivalent oncologic outcomes to those of open procedures and the benefits of shorter hospital stay, reduced morbidity, and excellent preservation of lung function and exercise capacity. Nevertheless, video-assisted thoracoscopic surgery is a demanding technique even for experienced thoracoscopic surgeons, and robotic surgery overcomes many of its limitations and difficulties.¹ In particular, the 3-dimensional robotic visual system provides an excellent magnified view of hilar structures during the operation, although the view of the 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. ICG is a Food and Drug Administration–approved nontoxic fluorescent dye often used to identify blood vessels, lymph ducts, and tumor-parenchyma borders. Transbronchial injection of ICG, with⁴ or without³ ligation of the segmental vein to prevent ICG loss, has been successfully used to show up the target segment and demarcate its boundaries during segmental resection for lung cancer. The novelty and added simplicity of our approach is that after division of segmental blood vessels within the hilum ICG is introduced through the peripheral

venous catheter used to induce anesthesia. The ICG lights up all the structures except the isolated target segment, facilitating radical segmental resection without overextension to neighboring segments, as described previously in an experimental animal study.⁵ Furthermore, during a minimally invasive approach that does not allow lung palpation, a clear view of the parenchyma demarcation of the intersegmental plane can render the anatomic sublobar procedure safer in terms of distance between the margins and tumor, in particular in the case of small nodules.

This procedure can be a valid alternative to previously described parenchymal marking methods; however, a greater number of these procedures will be necessary to validate this new technique.

References

1. Pardolesi A, Park B, Petrella F, Borri A, Gasparri R, Veronesi G. Robotic anatomic segmentectomy of the lung: technical aspects and initial results. *Ann Thorac Surg*. 2012;94:929-34.
2. Dylewski MR, Ohaeto AC, Pereira JF. Pulmonary resection using a total endoscopic robotic video-assisted approach. *Semin Thorac Cardiovasc Surg*. 2011;23:36-42.
3. Sekine Y, Ko E, Oishi H, Miwa M. A simple and effective technique for identification of intersegmental planes by infrared thoracoscopy after transbronchial injection of indocyanine green. *J Thorac Cardiovasc Surg*. 2012;143:1330-5.
4. Oh S, Suzuki K, Miyasaka Y, Matsunaga T, Tsushima Y, Takamochi K. New technique for lung segmentectomy using indocyanine green injection. *Ann Thorac Surg*. 2013;95:2188-90.
5. Misaki N, Chang SS, Gotoh M, Yamamoto Y, Satoh K, Yokomise H. A novel method for determining adjacent lung segments with infrared thoracoscopy. *J Thorac Cardiovasc Surg*. 2009;138:613-8.