Detecting intersegmental plane in thoracoscopic segmentectomy using infrared thermography

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To the Editor: Segmentectomy is an effective surgical method to cure early lung cancer. Segmentectomy which is designed precisely can preserve the pulmonary function to the maximal level with comparable post-operative survival rate. However, there are still some factors such as surgical experience, anatomy familiarity, and intersegmental plane identification, influencing the application of segmentectomy.

Identifying the intersegmental plane is an important intra-operative procedure for successful lung segmentectomy. Currently, there are several methods used by surgeons, including (1) inflation–deflation: displaying the border between inflated and deflated lung segments; (2) injection of indocyanine green by an intravenous or intrabronchial route. These methods have obvious shortcomings: the "inflation–deflation" method needs about 10 to 15 minutes of intra-operative time, which reduces operation efficiency and increases patient risk; injection of indocyanine helps to identify the intersegmental plane but there are risks of toxicity and allergies associated with indocyanine.

As a result, safer, faster, and more reliable methods are still needed to develop for identifying the intersegmental plane in the lung surgery. Based on the characteristics of pulmonary circulation, we hypothesized that the surface temperatures of resecting segments would decrease after the ligation of target pulmonary arteries and this temperature difference would be identified by the thermographic images that can display a boundary between the ligated segments and the normal lung portion. Recently, thermographic studies of animal lungs demonstrated that the temperature of the non-perfused lung is lower than that of the perfused lung;[1,2] the difference in temperature could reach about 1.5 to 2°C. In this study, we report our initial outcomes of identifying intersegmental planes during human lung segmentectomy using an infrared thermography.

This study was approved by the Medical Ethics Committee of the General Hospital of the Chinese People's Liberation Army (No. S2019-222-01). The patients have given their informed consent before enrollment. There were two cases included in this report: the first one was a case of microinvasive adenocarcinoma with the lesion located in the apical segment of the right upper lobe (S1), and the second one was a case of adenocarcinoma *in situ* with the lesion located in the apical-posterior segment of the left upper lobe (S1+2). The main steps of detecting intersegmental planes were listed in Figure 1.

One to two minutes after ligating the segmental artery, we inserted a customized detector through endoscopic trocar and obtained infrared thermography images for detecting the intersegmental plane directly. In the past, the infrared equipment was hand-held and large-sized, and cannot be put into the human body through small surgical incisions. Now, the new device is developed and can be used for endoscopic thoracic surgery. Readings from infrared thermography indicated that the temperature of ligated region dropped from 36.8°C to 34.7°C in patient one and from 37.5°C to 35.3°C in patient two about three minutes after the ligation of target arteries. If the surgeons inflate the lung before detecting the plane and wait for about 5 minutes, the difference will be even more obvious.

Totally, the boundary of lung segments was successfully detected in both cases in this pilot study. The advantages of this surgical method include: (1) There is no need to inject any extra-medicine to enhance the image, thus eliminating the risk of drug allergy or side reaction. (2) There is no need to wait for the lung to collapse, shortening the operating time. (3) Intersegmental planes displayed by infrared thermography are three-dimensional, providing perfect information to surgeons for guiding segmentation operation. (4) Infrared thermometer can be easily used in the operating room, without need for special training of surgeons. (5) The key steps for segment detection, such as artery ligations, are included in the routine surgical procedure; therefore, the technology is safe and convenient.

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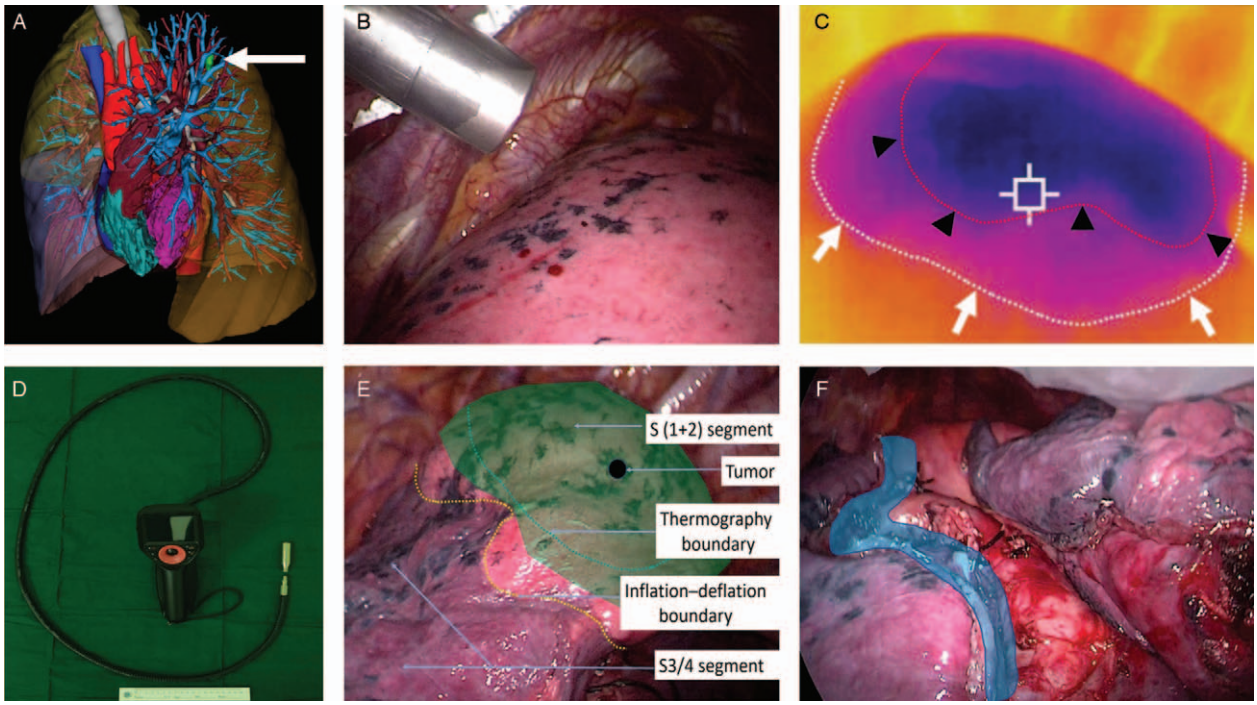

Figure 1: (A) Pre-operative 3D lung reconstruction model, and the green color indicates tumor (white arrow). (B) Infrared thermography camera is placed at the surgical site. (C) The infrared images are obtained after ligating apical and posterior segmental artery. The dotted line indicated by the white arrow is the boundary between low temperature edge zone and normal temperature zone, the black arrow is the boundary between low temperature core zone and edge zone, and the square indicates the center of vision. (D) Endoscopic mode infrared thermography detector (wavelength range: 1–20 μm). (E) Inflation–deflation boundary and infrared boundary in apical and posterior segment of left upper lobe. (F) Resection of apical and posterior segment (blue zone) along infrared boundary.

There were some reports about infrared thermography several years ago,[3,4] but most of these reports were animal experiments, and infrared thermography technique has not been used in human body. Some studies used indocyanine green to detect lung boundary or lesion location,[5,6] but the direct application of minimally invasive infrared thermography detection technology is rarely reported. On our thermography detector screen, different temperatures are displayed by different colors to enhance visualization. We noticed that the infrared thermography and inflation–deflation boundaries were not overlapping completely [Figure 1C]. The boundary of the latter is slightly larger than that of the former, and the reason may be due to that the pores of Kohn lead to ventilation effects between pulmonary alveoli; and the inflation–deflation boundary looked not as smooth as infrared thermography boundary.

The limitation of this report is the small sample size. We only report two cases in this paper. There are not enough samples to investigate the advantages of infrared thermography technology in identifying intersegmental planes and check the accuracy and consistency. The firmer clinical conclusions will wait to be drawn from our further studies with a larger sample size.

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Conflicts of interest

None.

References

1. Motoyama H, Chen F, Hijiya K, Kondo T, Ohata K, Takahashi M, *et al*. Novel thermographic detection of regional malperfusion caused by a thrombosis during ex vivo lung perfusion. Interact Cardiovasc Thorac Surg 2015;20:242–247. doi: 10.1093/icvts/ivu386.
2. Sakamoto K, Kanzaki M, Mitsuboshi S, Maeda H, Kikkawa T, Isaka T, *et al*. A novel and simple method for identifying the lung intersegmental plane using thermography. Interact Cardiovasc Thorac Surg 2016;23:171–173. doi: 10.1093/icvts/ivw076.
3. 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;138:613–618. doi: 10.1016/j.jtcvs.2009.01.003.
4. 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;143:1330–1335. doi: 10.1016/j.jtcvs.2012.01.079.
5. Gotoh M, Yamamoto Y, Igai H, Chang S, Huang C, Yokomise H. Clinical application of infrared thoracoscopy to detect bullous or emphysematous lesions of the lung. J Thorac Cardiovasc Surg 2007;134:1498–1501. doi:10.1016/j.jtcvs.2007.07.051.
6. Tarumi S, Misaki N, Kasai Y, Chang SS, Go T, Yokomise H. Clinical trial of video-assisted thoracoscopic segmentectomy using infrared thoracoscopy with indocyanine green. Eur J Cardiothorac Surg 2014;46:112–115. doi: 10.1093/ejcts/ezt565.

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