A novel wireless wearable fluorescence surgical navigation system used in pulmonary segmentectomy

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Introduction: Recently, segmentectomy has become a secure and effective treatment for certain small, early-stage lung cancer, especially in patients with emphysema. To achieve complete segmentectomy, it is critical to precisely identify adjacent lung segments, which is difficult for surgeons without suitable interventions. Thus, a novel technique by transbronchial or intravenous injection of indocyanine green (ICG) has been developed, which can efficiently avert needless resection, lower the costs and reduce complications. However, lack of intraoperative fluorescence imaging systems has seriously impeded the further development of this method. So, we developed a novel wireless wearable fluorescence surgical navigation system (WFNS), which combined the mobility of the goggle system and the sensitivity of other imaging systems. To test the mobility and sensitivity of WFNS, twelve *in vivo* studies of pulmonary segmentectomy in swine by intravenous injection of ICG were executed.

Methods: WFNS is composed of a laptop, Google glass, light source (center wavelength 785nm, maximum power 2W) and handle, which consists of a filter (wavelength 810-870 nm), C mount lens (f/1.4 12.5 mm) and CCD camera (MVC1300F-M00, Microview, China). Firstly, NIR light excited by the light source transmitted through the filter, illuminated the target and then was collected by the NIR camera installed in the handle. An application was written to capture real-time images. Finally, the result was displayed simultaneously on the Google glass in real-time mode at video-rate capacity of 20 frames per second, which was achieved by synchronizing the Google glass with the laptop.

Results: Twelve swine were equally divided into two groups. Group A was injected with 0.2mg/kg ICG into the marginal ear vein and Group B was injected with 0.6mg/kg ICG. Five seconds later after injection, the black-and-white transition borders among the targeted segment and the non-targeted segments were easily recognized visually in all swine. Real-time videos were displayed on the prism screen of the Google glass during the surgery. Using ImageJ (Image Processing and Analysis Application in Java), the corresponding SBR of the two groups (Group A and Group B) were 9.00±0.70 and 8.96±1.23 respectively. The NIR fluorescent images of Group A lasted ten minutes and those of Group B lasted up to fourteen minutes until the SBR was 1. Besides, the surgical field was 200 mm×200mm.

Conclusions: This study demonstrates our system has major advantages in identifying intersegmental planes and potentials in determining the margin of tumors.

Index Terms—Near-infrared fluorescence, Image guided surgery, Lung cancer, Segmentectomy, Indocyanine green

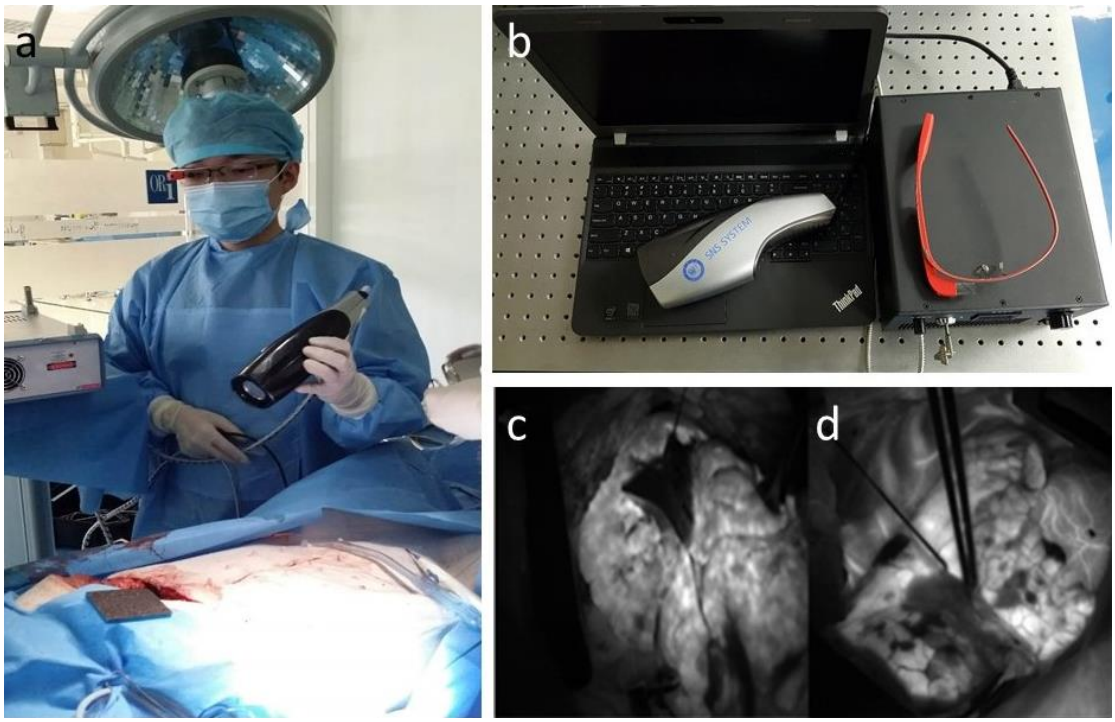

FIG.1 NIR fluorescence imaging using WFNS in pre-clinical ICG experiments. **a.**WFNS was used in swine trials;
b. The picture of WFNS. There are four parts as follows: a handle, NIR light source, Google glass and laptop; **c.** ICG (0.2mg/kg) fluorescent image of intraoperative pulmonary segmentectomy in vivo; **d.** ICG (0.6mg/kg) fluorescent image of intraoperative pulmonary segmentectomy in vivo.