

# Natural orifice surgery in thoracic surgery

Yun-Hen Liu<sup>1</sup>, Yen Chu<sup>1</sup>, Yi-Cheng Wu<sup>1</sup>, Chi-Ju Yeh<sup>1</sup>, Chien-Ying Liu<sup>1</sup>, Ming-Ju Hsieh<sup>1</sup>, Hsu-Chia Yuan<sup>1</sup>, Po-Jen Ko<sup>1</sup>, Hui-Ping Liu<sup>2</sup>

<sup>1</sup>Laboratory Animal Center, Department of Surgery, Chang Gung Memorial Hospital at Linko, Chang Gung University, Taoyuan, Taiwan; <sup>2</sup>Division of Thoracic and Cardiovascular Surgery, Beijing New Journey Cancer Hospital, Peking University Affiliated International Cancer Center, Beijing 100161, China

*Corresponding to:* Yun-Hen Liu. Department of Surgery, Chang Gung Memorial Hospital, Chang Gung University, 5, Fushing Street, Gueishan Shiang, Taoyuan, Taiwan 333. Email: zebraairmail@gmail.com; Hui-Ping Liu. Division of Thoracic and Cardiovascular Surgery, Beijing New Journey Cancer Hospital, Peking University Affiliated International Cancer Center, Beijing 100161, China. Email: foreverairmail@gmail.com.



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Since Kallo *et al.* reported the first transgastric peritoneoscopy in 2004, several studies have shown the safety and benefits of natural orifice surgery (NOS) in abdominal surgery in human studies. The feasibility of NOS thoracoscopy has been reported using different natural orifice access (transvesical, transesophageal, transtracheal, transoral, and transumbilical) in porcine and canine models. However, only a minority of thoracic procedures (myotomy for achalasia, sympathectomy for palmar hyperhidrosis) are performed using the NOS technique (1-9). This paper presents the development and current status of our work, and provides an overview of the questions that still need further investigation, regarding NOS in thoracic disease and future plans.

## Animal studies for natural orifice surgery

### *Transvesical approach (2)*

In 2007, Lima *et al.* demonstrated the feasibility and safety of transvesicle thoracoscopy and lung biopsy via transvesical and transdiaphragmatic incision in six female pigs. There were no postoperative complications or respiratory distress. The lack of relatively long rigid endoscopic instruments to reach the overall thoracic cavity is a major barrier to the transvesicle approach.

### *Transgastric approach (3)*

In 2010, De Palma *et al.* evaluated the feasibility and safety of the transgastric approach in accessing the thoracic cavity in four female pigs. Lung biopsies were successfully

performed via the gastric wall combined with diaphragmatic wall incision without complications in the first 15 days after surgery. The incisions were closed with endoscopic clips. However, owing to the absence of direct comparative data with current video assisted thoracic surgery, further studies are necessary to clarify the utility of the transgastric approach in thoracic surgery.

### *Transesophageal approach (4,10)*

The transesophageal approach is the most frequently utilized platform in the exploration of the thoracic cavity. This is in likelihood due to the familiarity with the transesophageal endoscopy procedure and the proximity of the esophagus and thoracic cavity. Thoracic procedures performed via the transesophageal approach include lymphnode dissection, pleural biopsy, pericardial window creation, and lobectomy. Postoperative complications (tension pneumothorax and descending aortic injury) following the transesophageal thoracic procedure were encountered in 10 out of 56 animals (17.8%). The exact role of this approach in thoracic surgery remains to be elucidated.

### *Transtracheal approach (5)*

The first successful approach to the thoracic cavity via tracheal incision was reported by our research group. We performed pleural biopsy, lung biopsy, and pericardial window creation using a needle knife via one or two small tracheal incisions. The tracheal wound was closed



**Video 1** Transumbilical right upper, middle, and lower lobectomy.

with a silicone airway stent. Although the transtracheal approach is, feasible, lung injury and bleeding led to the intraoperative death of three of the 14 animals. We believe that life-threatening complications and limited work-space via the small tracheal incision prohibits further investigation into transtracheal thoracoscopy.

#### ***Transoral approach (6)***

Another novel approach described by our research team is the transoral approach. Surgical lung biopsy and pericardial window creation were completed via a 12 mm incision over the vestibulum oris region. We demonstrated that the transoral approach was comparable to thoracoscopic surgery in terms of procedure success rate, hemodynamic impact, and inflammatory changes. Further, the transoral approach achieves better cosmetic outcome compared to the thoracoscopic approach.

However, the shortcoming of the transoral approach is the size of lung specimen removed from a 1.2-cm wound over the vestibulum oris region.

#### ***Transumbilical approach (7) (Video 1)***

Many researchers have reported on the safety and efficacy of approaching the thoracic cavity via an abdominal wound and a good outcome can be achieved via the transumbilical approach. We investigated the feasibility of transumbilical thoracoscopy in a canine model. We demonstrated that pericardial window creation and large lung wedge resection

could be performed via a 3 cm vertical transumbilical incision. More recently, we also found that anatomic lobectomy could be performed with the current approach but was associated with intraoperative complications. However, we strongly believe that increased familiarity with the surgical approach and refinement of endoscopic instruments might clarify the role of transumbilical surgery in thoracic disease.

### **Human clinical applications for natural orifice surgery**

#### ***Transesophageal approach (9)***

In 2009, Inoue and colleagues developed an innovative procedure to perform therapy for achalasia in 17 consecutive patients with achalasia. The procedure consisted of creating an esophageal submucosal tunnel via the lower esophagus, and extending to the oesophagogastric junction and beyond, onto the gastric cardia. Endoscopic myotomy of circular muscle bundles and the lower esophageal sphincter was then completed under direct vision. The short-term outcome of transesophageal myotomy for achalasia was excellent and it can be used in routine clinical practice. The long-term efficacy and comparative study with other interventional therapies will clarify the role of transesophageal myotomy in achalasia. However, results of transesophageal NOS performance of mediastinal and thoracic therapeutic procedures in humans has not yet been published.

#### ***Transumbilical approach (8)***

In 2013, Zhu and colleagues reported the first series of performance of sympathectomy by natural orifices transumbilical technique for women with palmar hyperhidrosis without thoracotomy. The procedure was successfully completed with an ultrathin flexible endoscope via a 5-mm umbilical incision combined with a 5-mm diaphragmatic incision in all patients. There were no intraoperative or postoperative complications. All patients were satisfied with the cosmetic outcome of the incision. A retrospective comparison of transumbilical with conventional video assisted thoracoscopic surgery (VATS) sympathectomy in 66 patients with severe palmar hyperhidrosis, further demonstrated that the transumbilical approach offers apparent advantages over conventional VATS with regard to postoperative pain, chest wall paresthesia, and better cosmetic results.

### Future perspective

With no well-established NOS platform available for surgery within the thoracic cavity, our research teams have demonstrated that transumbilical thoracoscopy is a practical approach for evaluating intrathoracic structure. Further experimental investigations with clear evidence-based information will clarify the possible role of the transumbilical approach in the surgical treatment of thoracic disease. Current projects pursued by our research group include (I) comparative study of safety and efficacy between transumbilical and transthoracic anatomic lobectomy in a canine survival model; (II) comparative study of safety and efficacy between hybrid transumbilical (transumbilical combined with a minithoracoscopic wound) versus pure transumbilical anatomic lobectomy in a canine survival model; (III) feasibility study of transumbilical anatomic lobectomy in a cadaveric model. We believe that all these investigations are important before this technique can be used in clinical practice in humans.

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