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Subxiphoid video-assisted thoracoscopic surgery *versus* standard video-assisted thoracoscopic surgery for anatomic pulmonary lobectomy

Yu-Yun Nan, MD,[a] *Yen Chu, PhD,*[a] *Yi-Cheng Wu, MD,*[a] *Ming-Ju Hsieh, MD,*[a] *Chien-Ying Liu, MD,*[b] *Yin-Kai Chao, MD,*[a] *Ching-Yang Wu, MD,*[a] *Yun-Hen Liu, MD,*[c,*] *and Hui-Ping Liu, MD*[a]

[a] *Department of Thoracic Surgery, Chang Gung Memorial Hospital, Chang Gung University, Taoyuan, Taiwan, ROC*
[b] *Department of Thoracic Medicine, Chang Gung Memorial Hospital, Chang Gung University, Taoyuan, Taiwan, ROC*
[c] *Laboratory Animal Center, Chang Gung Memorial Hospital, Chang Gung University, Taoyuan, Taiwan, ROC*

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ABSTRACT

Background: A subxiphoid surgical approach to thoracic cavity operations has potential advantages such as preventing injuries to intercostal nerves and vessels due to the bypass of the intercostal space during thoracic surgery. The aim of this study was to compare the feasibility and efficacy of the subxiphoid and standard transthoracic approaches for anatomic pulmonary lobectomy in a canine model.

Methods: Nineteen dogs were assigned for pulmonary lobectomy using either the subxiphoid ($n = 10$) or standard transthoracic approaches ($n = 9$). Each group underwent thoracic exploration and anatomic pulmonary lobectomy. Subxiphoid thoracoscopy was performed with a flexible bronchoscope via a 3-cm incision over the xiphoid process. In the conventional thoracoscopy group, approach to the thoracic cavity was obtained through a 3-cm incision over the seventh intercostal space. Physiological parameters (respiratory rate and body temperature) and blood samples (white blood cell counts and arterial blood gases) were collected during the preoperative and postoperative periods. Surgical outcomes data (operating time, operative complications, and body weight gain) were also collected and compared between the groups. The animals were sacrificed 14 d after surgery for necropsy evaluations.

Results: Anatomic pulmonary lobectomy was successfully performed without intraoperative and postoperative complications in all animals. There were no significant differences in the mean operating times or weight gain after surgery between the subxiphoid and the standard transthoracic approach groups. In terms of physiological and pulmonary parameters, there were no observed differences between the two surgical groups for respiratory rate, body temperature, white blood cell counts, and arterial blood gases at any time during the study. Necropsy confirmed the success of lobectomy without complication in all studied animals.

Conclusions: This study demonstrated that the subxiphoid approach was comparable with the standard transthoracic approach for anatomic pulmonary lobectomy, in terms of feasibility and effectiveness.

* *Corresponding author*. Department of Thoracic Surgery, Chang Gung Memorial Hospital, Chang Gung University, 5 Fushing Street, Gueishan Shiang, Taoyuan, Taiwan 333, ROC. Tel.: +886 3 3281200x2118; fax: +886 3 3285818.
E-mail address: zebraairmail@gmail.com (Y.-H. Liu).
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1. Introduction

Video-assisted thoracoscopic surgery (VATS) was first reported in the early 1990s. Since then, the safety and efficacy of thoracoscopy for diagnosing and treating pleural, pulmonary, and mediastinal disease has been demonstrated with similar oncological results, which were confirmed by multiple clinical studies. Although VATS for thoracic surgery is practical, has been shown to reduce postoperative discomfort, and has improved cosmetic results when compared with open thoracotomy, unfortunately, chronic thoracic wound discomfort and postoperative neuralgia were found in a significant portion of patients [1–4].

Recently, a minimally invasive approach that is different from the conventional multiport thoracoscopic technique is gradually becoming of great interest in the diagnosis and treatment of thoracic surgical disease. Single-port VATS is one of the most promising emerging surgical techniques which allows the surgeon to perform most thoracic surgeries and with similar perioperative outcomes that are comparable with the conventional multiport technique. However, a very limited number of clinical studies have demonstrated the advantages of single-port VATS in postoperative pain reduction, when comparing with the traditional multiport thoracoscopic approach [5,6].

Previous studies in the literature have suggested that the subxiphoid approach may be associated with less postoperative pain and can prevent subsequent intercostal neuralgia due to the bypass of intercostal space, when compared with conventional transthoracic approaches [7–9]. Furthermore, several studies have reported the feasibility of a single subxiphoid incision for the surgical resection of metastatic tumor in the bilateral lungs [10]. However, a large clinical study of thoracoscopic surgery via a subxiphoid approach is yet to be performed. Therefore, obtaining reliable evidence of thoracoscopic surgery via a subxiphoid approach is the key factor that will determine the future use of the subxiphoid approach.

The aim of our study was to compare the feasibility and effectiveness of standard transthoracic approaches with the subxiphoid approach for anatomic pulmonary lobectomy in a canine model.

2. Materials and methods (Figs. 1 and 2)

The study was approved by the Institutional Animal Care and Use Committee of Chang Gung Memorial Hospital in Taiwan. Nineteen beagle dogs, each weighing between 6.35 and 10.25 kg, were used to evaluate the efficacy and safety of subxiphoid ($n = 10$) and transthoracic ($n = 9$) anatomic lobectomy. The procedures were performed under general anesthesia and intubations with an endotracheal tube for single-lung ventilation (by placing the cuff in the main bronchus opposite to the surgical lung). The anesthesia was maintained with isoflurane (3%) inhalation, and surgery was performed under supine position. The regions of anatomic lobectomy were predetermined before the surgery as follows: right upper lobe ($n = 4$; two subxiphoid, two transthoracic); left upper lobe ($n = 4$; two subxiphoid, two transthoracic); right middle lobe ($n = 4$; two subxiphoid, two transthoracic); right lower lobe ($n = 4$; two subxiphoid, two transthoracic); and left lower lobe ($n = 3$; two subxiphoid, one transthoracic). Single-dose intravenous cefazolin (20 mg/kg, Standard Chem & Pharm, Tainan, Taiwan) was given before surgery and on postoperative days (PODs) 1 and 2 to prevent postoperative infection. To reduce postoperative pain, 0.6 mL of 2% Xylocaine (Taiyu chemical & pharmaceutical, Hsinchu, Taiwan) was administered after operation. Oral acetaminophen (30 mg/kg/d) was also given during the first 3 d after surgery.

The subxiphoid anatomic lobectomy was performed with the following procedures:

1. A 3-cm longitudinal incision was made over the xiphoid process.
2. A subcostal tunnel was dissected blindly with fingers.
3. A wound protector system (Alexis Wound Retractor; Applied Medical, Rancho Santa Margarita, CA) was placed into the pleural cavity via the xiphoid process to expose the chest cavity.
4. The endoscope (a 4.5-mm flexible bronchoscope; Olympus, Tokyo, Japan) was used for endoscopic visualization during operation.
5. The dissection of the pulmonary hilar structures was performed using endoscopic scissors (Scanlan International, Inc, St Paul, MN) and 18-cm curved Adson baby forceps (Medline industries, Inc., Mundelein, IL).
6. The lobar branches of the pulmonary vein were transected using LigaSure (Valleylab, Boulder, CO) after ligation of the proximal end with a 4/0 Prolene suture ligature.
7. The lobar branches of the pulmonary artery were transected using LigaSure after ligation of the proximal end with a 4/0 Prolene suture ligature.
8. The lobar bronchus was then transected with a 45-mm vascular Endo-GIA (Echelon 45 Endopath stapler; Ethicon, San Lorenzo, Puerto Rico).
9. The margin of the resected pulmonary vessel and bronchus was carefully examined to ensure good hemostasis and an airtight seal.
10. The lung lobe was removed through the xiphoid incision.
11. The xiphoid wound was closed using continuous 3-0 Vicryl suture (Ethicon, San Lorenzo, Puerto Rico) and interrupted 3-0 Nylon Suture (Ethicon, San Lorenzo, Puerto Rico) without chest tube drainage.

For the transthoracic thoracoscopic approach, the anatomic lobectomy was performed via a 3-cm incision over the seventh intercostal space in the midclavicular line. The predetermined lung lobe was resected using the aforementioned techniques, described in the subxiphoid thoracoscopic lobectomy.

The animals were closely monitored daily for rectal temperature, respiratory rate, daily behavior, postoperative pain, and the presence of surgical complications such as bleeding, infection, and mortality. Venous blood samples for inflammation analysis (white blood cell count) were taken from each animal at the following times: (1) before the surgery, (2)