Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.JournalofSurgicalResearch.com

Feasibility and safety of endoscopic transumbilical thoracic surgical lung biopsy: a survival study in a canine model

Chih-Tsung Wen, MD,[a] Yen Chu, PhD,[a] Chi-Ju Yeh, MD,[b] Chien-Ying Liu, MD,[c] Hsu-Chia Yuan, BS,[a] Po-Jen Ko, MD,[a] Yun-Hen Liu, MD,[a,*] and Hui-Ping Liu, MD[d,**]

[a] Laboratory Animal Center, Department of Surgery, Chang Gung Memorial Hospital at Linko, Chang Gung University, Taoyuan, Taiwan
[b] Department of Pathology, Chang Gung University, Taoyuan, Taiwan
[c] Department of Thoracic Medicine, Chang Gung University, Taoyuan, Taiwan
[d] department of Surgery, Benq Medical Center, Nanjing, China

ARTICLE INFO

Article history:
Received 29 September 2012
Received in revised form
22 November 2012
Accepted 30 November 2012
Available online 20 December 2012

Keywords:
Transumbilical endoscopy
Thoracoscopy
Lung biopsy

ABSTRACT

Background: Transumbilical laparoscopy allows the patient to undergo various surgical procedures associated with abdominal disease. The aim of this study was to evaluate the feasibility and safety of transumbilical thoracic exploration and surgical lung biopsy in a canine survival model.

Methods: We performed the procedure in 12 dogs weighting 7.1–9.1 kg. The thoracic cavity was accessed using a metal tube inserted via umbilical and diaphragmatic incisions. After transumbilical thoracoscopy, we resected the predetermined lung lobe with an electrocautery loop. We carried out daily clinical examinations, including determination of respiratory rate and rectal temperature. Laboratory parameters (white blood cell count) and inflammatory parameters, including serum interleukin-6 and C-reactive protein, were measured before surgery and at postoperative days 1, 3, 7, and 14. We performed necropsies 2 wk after surgery.

Results: We successfully performed corrected surgical lung biopsies for the predetermined lung lobe in all animals, with a median time of 43.5 min (range, 32–65 min). We observed two perioperative complications: One dog had minor postoperative air leakage and one had hemodynamic collapse because of inadequate ventilation. These animals recovered well without signs of perioperative infection. Necropsies at 2 wk after surgery showed no evidence of mediastinitis or peritonitis.

Conclusions: Exposure of the thoracic cavity and surgical lung biopsy via a transumbilical incision is feasible in this canine model of survival. This procedure may have potential advantages over currently used transthoracic thoracoscopy techniques.

1. Introduction

Three-port laparoscopic surgery is the reference standard diagnostic and therapeutic modality in various surgical subspecialties, including gastrointestinal surgery, gynecologic surgery, and urology. However, there is still a demand for an alternative procedure that is associated with less postoperative discomfort and results in better cosmetic outcomes after surgery. Transumbilical single-port laparoscopy has the potential to minimize scarring and incisional pain compared

* *Corresponding author*. Department of Surgery, Chang Gung Memorial Hospital, Chang Gung University, 5, Fushing Street, Gueishan Shiang, Taoyuan, Taiwan 333, ROC. Tel.: +886 3 3281200, ext. 2118; fax: +886 3 3285818.
** *Corresponding author*. Department of Surgery, Benq Medical Center, Nanjing, China.
E-mail addresses: zebraairmail@gmail.com (Y.-H. Liu), hp.liu@benqhospital.com (H.-P. Liu).
0022-4804/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.jss.2012.11.058

with traditional three-port laparoscopic surgery, and is considered an attractive alternative to conventional three-port laparoscopic surgery.

In thoracic surgery, the most cumbersome chronic complication in both three-port and single-port thoracoscopic surgery is post-thoracotomy discomfort. This problem is caused by damage to the intercostal nerve during thoracoscopic surgery and results in a variety of symptoms, including pain, numbness, and paresthesia. The total frequency of such complications with thoracoscopic surgery has been reported to be as low as 4% (six of 140) by Stammberger *et al* [1], about 12.5% (18 of 144) by Hutter *et al* [2], and as high as 32% (19 of 59) by Passlick *et al* [3].

To date, no studies have compared the severity of postoperative pain for transthoracic thoracoscopy and transumbilical laparoscopy. However, the transumbilical approach obviates the potential complication of intercostal nerve injury, neuralgia, and chronic thoracic pain. These potential benefits prompted our team to investigate an alternative transumbilical access into the thoracic cavity. This study evaluated the feasibility and safety of the transumbilical approach for thoracic cavity exploration and surgical lung biopsy in a live canine model.

2. Methods

The Institutional Animal Care and Use Committee of Chang Gung Memorial Hospital in Taiwan (No. 2009121003) approved this study, which we conducted in accordance with the *Guide for the Care and Use of Laboratory Animals*, as promulgated by the Institution of Laboratory Animal Resources, National Research Council [4]. We carried out 12 survival experiments on 7.1- to 9.1-kg dogs under 2% isoflurane general anesthesia with endotracheal tube intubation (we placed the endotracheal cuff in the main bronchus opposite the surgical lung to achieve one-lung ventilation) (Figs. 1 and 2). Pre-anesthesia medication consisted of an intramuscular injection of ketamine (5 mg/kg; Pfizer Inc, Taipei, Taiwan) and xylazine hydrochloric acid (10 mg/kg; Bayer HealthCare). We gave single-dose intravenous cefazolin 200 mg before surgery to prevent infection.

With the dog in the supine position, we made a 12- to 15-mm-deep incision in the umbilicus and used it as the entrance port into the abdominal and thoracic cavities, and to perform transumbilical thoracoscopy. We then inserted a blunt-tipped, homemade metallic tube (9 mm internal diameter, 10 mm outer diameter, 45 cm in length) via the umbilicus incision, and introduced a bronchoscope (4.9 mm external diameter; Olympus, Tokyo, Japan) via the metallic tube for abdominal cavity exploration. Using upper abdominal palpation as a guide, we found a subxyphoid transdiaphragmatic access region approximately 1 cm just below the xyphoid process. We then inserted a needle knife (Olympus, Tokyo, Japan) through the working channel of the bronchoscope and used it to create a 1-cm incision above the diaphragm in all 12 animals. To avoid complications of vital organ injury and iatrogenic bleeding, we turned off the ventilator, and then advanced the metallic tube through the diaphragmatic incision (just behind the posterior border of the lower sternum and following the anterior border of the pericardium) into the thoracic cavity, under bronchoscopic guidance. During introduction of the metallic tube, the lower sternum was lifted upward with the metallic tube to increase the substernal space for access to the thoracic cavity. We meticulously inspected the thoracic cavity for intrathoracic structures and any evidence of vital organ injury resulting from insertion of the metallic tube. Once we confirmed the appropriate location for surgical lung biopsy (right upper [cranial] lobe [$n = 3$], right middle lobe [$n = 3$], right lower [caudal] lobe [$n = 2$], left upper [cranial] lobe [$n = 2$], and left lower [caudal] lobe [$n = 2$]), we used an electrocautery loop (Olympus Optical Co., Ltd.), inserted through the metallic tube, to perform the lung biopsy (Fig. 1). We also used an endoscopic grasper, introduced through the working channel of the bronchoscope, to assist the lung biopsy by means of gentle traction and alignment of the biopsy region into the proper position. We then removed the resected specimen using the endoscopic grasper. The resected bed of the lung was routinely reinforced with homemade Endoloop ligature (Ethicon, Somerville, NJ), to decrease the occurrence of air leakage. We performed a saline immersion test under positive pressure (20 cm H_2O) to check for integrity (or leakage) over the resected lung margin. We then evacuated residual air over the pleural cavity via the bronchoscope to facilitate complete lung expansion. After completion of transumbilical surgical lung biopsy, we carefully removed the metallic tube and bronchoscope from the pleural and abdominal cavities. We closed the umbilical wound with 3-0 nylon sutures (Ethilon; Ethicon). To simplify the surgical procedure and reduce operation time, we did not repair the diaphragmatic wound and left it to heal through normal healing processes. To decrease postoperative discomfort, and because of previous successful experiences using Endoloop ligature in bullae ablation in humans, and in the management of air leaks after surgical lung biopsies in animal studies, we did not use chest tube drainage for the prophylaxis of postoperative pneumothorax.

We allowed the animals to recover from anesthesia after the procedure. A regular diet was resumed within 4 h after surgery. We closely monitored the animals for signs of distress or infection, and observed them for 2 wk. We determined serum C-reactive protein (CRP), interleukin-6 (IL-6), and white blood cell counts (WBCs) for each animal at the following times: pre-operation, post-operation, and 1, 3, 7, and 14 d after the procedure. We also collected arterial blood for analysis of pH, pCO_2, and pO_2 at pre-operation and post-operation, and 14 d after surgery. During autopsy, we examined the transdiaphragmatic access site for complete healing and the pleural cavity for signs of bleeding, infection, adhesion, and successful surgical lung biopsy. Pathologists reviewed all transdiaphragmatic access sites and surgical lung biopsy regions for microscopic findings under hematoxylin and eosin staining.

2.1. *Enzyme-linked immunosorbent assay for IL-6 and CRP*

We stored serum for IL-6 and CRP analysis at −80°C, and determined the levels of IL-6 and CRP using a commercially available enzyme-linked immunosorbent assay kit with