pISSN 1598-298X
J Vet Clin 32(1) : 9-15 (2015)
http://dx.doi.org/10.17555/ksvc.2015.02.32.1.9

Journal of Veterinary Clinics
www.ksvc.or.kr

Portal Placement for Thoracoscopic Right Middle Lung Lobectomy with One-Lung Ventilation in Beagle Dogs

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(Accepted: February 14, 2015)

Abstract : Purpose of this study is to determine the reasonable portal approach for thoracoscopic right middle lung lobectomy in small sized dogs under 10 kg. Ten healthy beagle dogs weighing 8.67 ± 0.49 kg were included. Under general anesthesia, one-lung ventilation (1LV) was achieved using endobronchial blocker with guidance of fiber-optic bronchoscope. Two portal approaches were used; 8-6-10 intercostal space (ICS) and 8-6-5 ICS approach. Thoracoscopic right middle lung lobectomy was performed using endoscopic linear self-cutting stapler and specimen retrieval bag. Each approach was evaluated by scoring 0; bad, 1; endurable, 2; good, 3; excellent in following five category, 1) visualization, 2) triangulation; instrumental sword fighting in the thoracic cavity, 3) approach to hilar pedicle; application of stapler, 4) any obstacles in applicating Lap Bag, and 5) the operator's convenience. Favorable working space was secured by 1LV and thoracoscopic right middle lung lobectomy was successfully completed in all dogs. There was no need to change the portal location and iatrogenic complication. Most of scores were good to excellent in both approaches. Consequently, both approaches are feasible methods for thoracoscopic right middle lung lobectomy with one lung ventilation using endoscopic linear self-cutting stapler in dogs weighing less than 10 kg.

***Key words* :** thoracoscopic lung lobectomy, right middle lung lobe, portal location, one lung ventilation, dog.

Introduction

Lung lobectomy can be performed partially, totally, and unilaterally (pneumonectomy) in conditions of pulmonary abscess, bullous emphysema, consolidation, neoplasia, or lung lobe torsion (21). Conventional invasive approach usually requires intercostal or median thoracotomy. The former allows wide regional exposure but access to the entire hemithorax is limited, while the latter allows the exploration of entire thoracic cavity but severe pain due to sternotomy with problems related to sternal fixation dehiscence (5,21). Thoracoscopy is routinely used as diagnostic and therapeutic tool in human medicine, and lobectomy with video-assisted thoracoscopic surgery (VATS) is well established and performed all around the world, as well (9). Thoracoscopy provides excellent illumination and magnified visualization leading to complete exploration of the pleural cavity removing the physical difficulty of working even in deep-chested dogs (5,12,26). Moreover, benefits of minimal trauma and deformity of chest wall, reduced postoperative pain due to absence of excessive rib retraction, decreased patient morbidity, and shorter hospitalization stay has shown great promise in veterinary medicine (11,26). However, it requires time for proficiency, expense of specialized equipment, and anesthetic expertise. Direct palpation of the lesion and tissues around is also limited (5,16). Thoracoscopy in veterinary medicine is still in infancy since described first in 1990 (7). It has been attempted in dogs for biopsy sampling (pleura, mediastinum, lymph node, or pulmonary lesion), correction of persistent right aortic arch or patent ductus arteriosus, thoracic duct ligation, thymoma resection, pericardiectomy, and treatment of bullous emphysema or lung lobectomy (2,3,7,10, 11,17,18,23,25).

With regard to the traditional lung lobectomy, the artery, vein, and bronchus has been isolated and ligated one by one at the level of hilus before transection. Each ligation can be achieved manually using suture materials, but, with a trend toward *en bloc* hilar stapling in dogs and cats, there need not to isolate nor to ligate artery, vein, and bronchus separately, anymore. Using thoracoscopic anastomosis (TA) stapler needs following transection after clamping and firing, but provides rapid, secure ligation (21). So, there are little worries of interference on hilar visualization in manipulation of vessels (13). In case of thoracoscopic lung lobectomy, ligation also can be performed by pre-tied suture and endoscopic linear stapling device (21). Self cutting stapling devices meet the requirements of ease, speed, safety and efficacy of the procedure (8,10,13,25). Serial clamping, ligation, cutting of tissues and release of transected sides are achieved at the same time with one application. Staplers has 4 or 6 rows of B shaped staples and cut leaving 2 or 3 rows on each side separated. This can prevent spillage of contents from lesions to be resected and maintain clear surgical field. This point may be useful in case of neoplasia and severe inflammation particulary. So use of staplers in thoracoscopic lung lobectomy is standard in recent days (11).

Furthermore, an endoscopic tissue retrieval bag facilitates removal of the lung lobe through a cannula site and de-

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creases the potential of seeding neoplastic cells (especially widespread mesothelioma) or infection to the chest wall (19). The risk of recurrence of neoplasia at the cannula site in human is considered low (3 of 934 operations), however, it is fatal once seeding occurs, so use of retrieval bag is also standard in human surgery (15,20). Portal site metastasis despite use of retrieval bag had been reported in human (1 of 308) (24).

Therefore, in performing thoracoscopic lung lobectomy, enough working space for manipulation of instruments like stapler and specimen retrieval bag and safe application of staples are keys through the procedure. Moreover, poor operative vision (by poor approach or bleeding) and adhesion (to the diaphragm, mediastinum or inter-lobar) are the most common reasons of conversion to thoracotomy (11,23). Consequently, appropriate portal placement securing of appropriate space and visualization for target lobe is extremely important and it would be particularly in infants or small breed dogs with narrower thoracic cavity. Choosing portal sites that will triangulate the camera and instruments toward the organ of most interest is paramount (12). Intercostal approach is preferred rather than trans-diaphragmatic approach for thoracoscopic lung lobectomy of predetermined lesion.

Specific portal sites have been described for some procedures, but sites were usually chosen on a case-by-case basis. Three ports of 4-4-3rd intercostal space (ICS) were used for congenital diaphragmatic hernia in nine infants ranged from 7 days to 8 years old with CO_2 insufflation (14). Thoracoscopic lung lobectomy was fulfilled in infants with one lung ventilation (1LV) and CO_2 insufflation. One study selected 8th ICS for primary port and 4~5th ICS and 6~7th ICS for other instrumental ports in fifty patients (27), while another study fixed just one primary port on 5th or 6th ICS and other instrumental ports were adjusted according to the target lobe in six patients of 6~19 months old (4). To correct patent ductus arteriosus, primary port in each 3rd and 4th ICS, and two additional ports in 5th ICS were chosen in two dogs (2).

As for thoracoscopic lung surgery in dogs, two thoracoscopic-assisted left cranial lung lobectomies were performed with one port in dorsal one-third of 8th ICS and 5 cm minithoracotomy in 6th ICS, or with ports in 8-8-6th ICS and 5 cm minithoracotomy in 4th ICS (10). These accompanied 1LV in Rhodesian ridgeback dogs. While, for the totally thoracoscopic lung lobectomy, four ports were placed in 5-5-4-8th ICS with 1LV for left caudal lobe in mongrel dogs (7). In another study, ports in 7-8-5th ICS and 8-6-10-7th ICS were used with 1LV for cranial and caudal lung lobes, respectively (11). Other trials for the lesion in right middle and cranial lung lobes were converted to thoracotomy as poor portal access and visibility or adhesion (11,23). Approach to right middle lung lobe is particularly fastidious, to the author's knowledge, there is just one report of thoracoscopic right middle lung lobectomy so far, with 8-6-10th ICS ports and 1LV (25). One recommended 10th, 11th, or 12th ICS approach for right middle lung lobe (11) and the other did 3rd and 4th ICS approach for right middle or caudal lung lobe (22).

Compared with laparoscopy, thoracoscopy does not require CO_2 insufflation because the rib cage maintains the thoracic cavity in an expanded state. However, intrathoracic organs, especially lung parenchyma with repeated movement, may interfere the visualization and encroach working space. Methods of increasing working space during thoracoscopy including 1LV or one bronchus intubation, and additional thoracic insufflation with low tension CO_2 (4~6 mmHg) are extensively used in human medicine (14). But, the latter is not recommended in veterinary medicine as risk of tension pneumothorax (12) and decrease in cardiac ouput (6). Therefore, it may be crucial to use 1LV for thoracoscopic surgery in small breed dogs when narrow thoracic cavity is the most concerned roadblock.

With all these aspects, purpose of this study was to determine the reasonable portal approach for thoracoscopic right middle lung lobectomy in small sized dogs. We investigated the portal sites for thoracoscopic right middle lung lobectomy with 1LV in Beagle dogs weighing less than 10 kg and these feasibility separated in two portal approaches.

Materials and Methods

Experimental animals

This study was performed under the guidance of Chungnam National University Institutional Animal Care and Use Committees. Ten 3 year old, purpose-bred intact male Beagle dogs weighing 8.67 ± 0.49 kg (range: 7.7~9.6 kg, BCS: 4/9~6/9) were included. All dogs were clinically healthy based on physical examination, the results of complete blood count, serum biochemistry and electrolytes panel, thoracic radiography. Dogs were randomly allocated into 2 groups according to the intercostal portal placement (8-6-10 approach, 8-6-5 approach).

Anesthetic regimen

Dogs were pre-oxygenated for 5 minutes with pure oxygen and 10 mL/kg/hr fluid of normal saline was administered through cephalic vein. Each dog was premedicated with glycopyrrolate (Mobinul®, Myungmoon Pharm Co, Korea, 0.011 mg/kg IV) and diazepam (Diazepam®, Samjin Pharm Co, Korea, 0.05 mg/kg IV). Anesthesia was induced with propofol (Provive®, Myungmoon Pharm Co, Korea, 4 mg/kg IV) and maintained with isoflurane (up to 1.5 MAC) after endotracheal intubation. Inhalation rates were controlled in response to patient monitoring parameters sufficient to retain appropriate surgical anesthetic depth and recorded. Intravenous meloxicam (Metacam®, Boehringer Ingelheim Vetmedica, Germany, 0.2 mg/kg IV) was injected once before anesthesia and oxygen with 1 of FiO_2 was used through the procedure. Prophylactic antibiotics were administered after induction.

All dogs were placed in left lateral recumbency after induction of anesthesia and dorsal pedal artery was catheterized for systemic blood pressure monitoring. Dogs were mechanically ventilated with administration of atracurium besylate (Atra®, Hana Pharm Co, Korea, 0.2 mg/kg, IV).

Lung separation

1LV was initiated using a endobronchial blocker (Arndt Endobronchial Blocker Set, 5fr., Cook Critical Care, USA) with guidance of fiber-optic bronchoscope (EPK-700, Pentax Medical, Japan) (Fig 1). Tidal volume with 1LV was

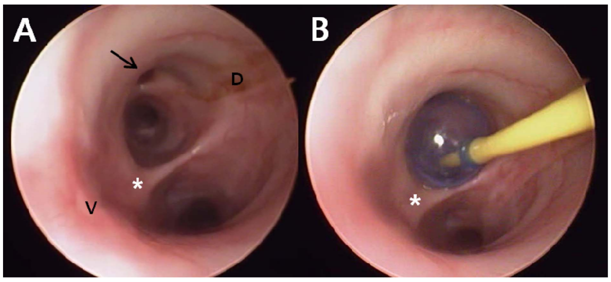

Fig 1. Bronchoscopic view at the level of tracheal bifurcation in a dog (A) and endobronchial blocker occluding the right main bronchus (B). Bronchial opening of right cranial lung lobe is shown just lateral to tracheal bifurcation.
Black arrow; bronchial opening to right cranial lung lobe, *; tracheal bifurcation, D; dorsal, V; ventral.

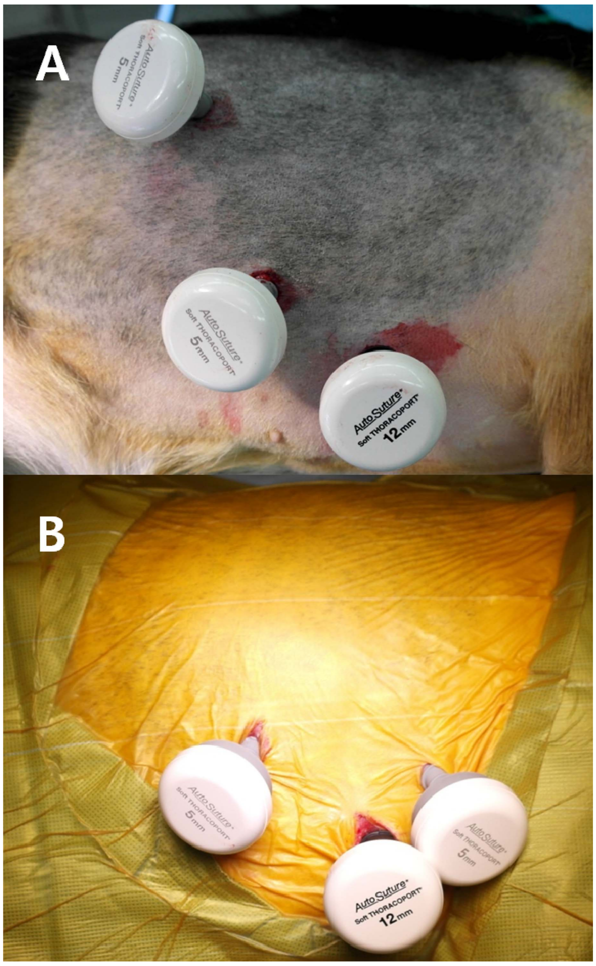

Fig 2. Portal placements in 8-6-10 approach (A) and 8-6-5 approach (B) for thoracoscopic right middle lung lobectomy in dogs.

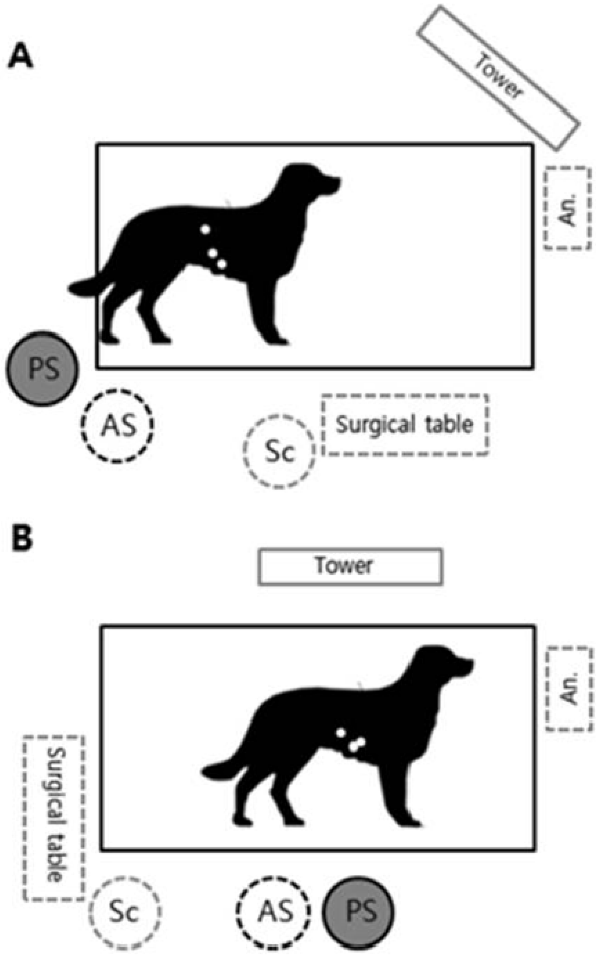

Fig 3. Aerial view of approach for thoracoscopic right middle lung lobectomy in dogs. (A) 8-6-10 approach, (B) 8-6-5 approach. PS; primary surgeon, AS; assistant surgeon, Sc; scrub, An.; anesthesiologist, white spots; portal locations.

reduced to half of that of baseline and vigilant monitoring was indicated. Atelectasis of entire right lung field was confirmed by thoracoscope and dislodgement or displacement of the endobronchial blocker was monitored during thoracoscopic lung lobectomy.

Portal placement

Right hemithorax was surgically prepped with a cushion placed under the dorsal part of the left hemithorax to raise the spine. Two methods of intercostal portal approach were used as (1) 8-6-10, and (2) 8-6-5 approach (Fig 2). Open chest condition was achieved with three ports using two 5 mm and one 12 mm soft threaded trocars (Thoracoport^{TM}, Covidien, USA) through minithoracotomy. Primary trocar for 5 mm telescope (0°, 1188 HD, X8000, Stryker, USA) was placed in the ventral third of 8th ICS in both approaches and additional two secondary trocars were placed. One 12 mm trocar for endoscopic linear self cutting stapler (ENDOPATH® ETS Linear Cutters, Ethicon endosurgery, USA; Endo GIA^{TM} Ultra, Covidien, USA) and specimen retrieval pouch (Lap Bag^{TM} (S), Sejong Medical, Korea) was located in the ventral fifth of 6th ICS in both approaches. However, the other secondary trocar for 5 mm grasper was located in the dorsal third of 10th ICS in 8-6-10 approach and ventral fourth of 5th ICS in 8-6-5 approach.

Minithoracotomy at each portal site was performed close to the cranial border of rib not to damage intercostal vessels lying at the caudal aspects of the rib, or life-threatening hemorrhage may occur. Locations of tower, patient, and surgeons were adjusted according to the method of approach (Fig 3).

Thoracoscopic right middle lung lobectomy

Right middle lung lobe was gently upward retracted with atraumatic alligator or bob-cock grasping forceps toward thoracic inlet. Then, endoscopic linear self cutting stapler was applied on the exposed hilar pedicle perpendicular to its long axis. Resected lung lobe was retrieved using specimen retrieval pouch through the 12 mm portal site without retraction of the rib. Surgical field was re-explored for the inspection of hemorrhage, air leakage, or tearing of pedicle.

Evaluation of the portal placement

During the thoracoscopic right middle lung lobectomy with 1LV, 8-6-10 approach and 8-6-5 approach were evaluated focused on following five parameters; 1) visualization, 2) triangulation; instrumental sword fighting in the thoracic cavity, 3) approach to hilar pedicle; application of stapler, 4) any obstacles in applicating Lap Bag, and 5) the operator's convenience (Table 1). Score 0, bad means 'need to change the portal location'.

Results

Thoracoscopic right middle lung lobectomy with one lung ventilation was successfully completed in all dogs without unwilling events. Collapse of right lung field was completed in 3.83 ± 1.25 minutes after lung separation and additional working space was obtained by 1LV. Mean surgical time of ten dogs was 6.40 ± 1.09 minutes, divided into cannulation and lobectomy time, 2.82 ± 0.49 and 3.57 ± 0.88 minutes, respectively (Table 2), and there was no significant difference according to method of approach.

Portal placement

Same thoracoscopic views were obtained by two approaches with same location of primary trocar (Fig 4) and satisfactory vision was obtained by both of 8-6-10 and 8-6-5 approaches during right middle lung lobectomy. Intrathoracic exploration after atelectasis of right lung field showed azygous vein, intercostals vessels, and sympathetic trunk dorsally, diaphragm, part of caudal esophagus, and accessory lobe caudally, internal thoracic vessels, trachea, and heart cranially. Favourable triangulation was provided for thoracoscopic right middle lung lobectomy with pre-planned portal locations in both approaches. There were no instrumental fighting and problems impairing visualization, hilar approach of staplers, and application of Lap Bag in both groups (Table 3). So, there were no needs of portal modification or conversion to thoracotomy and procedures in all dogs were achieved successfully (Figs 5, 6). Both of 8-6-10 and 8-6-5 approaches were suitable for thoracoscopic right middle lung lobectomy with one lung ventilation in Beagle dogs weighing less than 10 kg.

Table 1. Parameters to evaluate portal approach

	Score			
	Bad	Endurable	Good	Excellent
Visualization	0	1	2	3
Triangulation	0	1	2	3
Approach to hilar pedicle	0	1	2	3
Application of Lap Bag	0	1	2	3
Operator's convenience	0	1	2	3

Table 2. Surgical lead time of thoracoscopic right middle lung lobectomy with one lung ventilation in dogs

Procedure	Cannulation[a)]	Lobectomy[b)]	Total[c)]
Time (minute)	2.82 ± 0.49	3.57 ± 0.88	6.40 ± 1.09

Data are expressed as mean ± SD (n = 10).
[a)]From skin incision for 1st portal placement to termination of 3rd trocar cannulation,
[b)]From the intrathoracic introduction of endoscopic grasper to retrieval of resected right middle lung lobe using Lap Bag,
[c)]Sum of a and b.

Table 3. Evaluation of the portal approaches of thoracoscopic right middle lung lobectomy in dogs

	Approach									
	8-6-10					8-6-5				
Visualization	3	3	3	3	3	3	3	3	3	3
Triangulation	3	3	3	3	3	3	3	3	3	3
Approach to hilar pedicle	3	3	3	3	3	3	3	3	3	3
Application of Lap Bag	3	3	3	3	3	3	3	3	3	3
Operator's convenience	3	2	2	3	3	3	2	3	3	3

0; bad, 1; endurable, 2; good, 3; excellent.

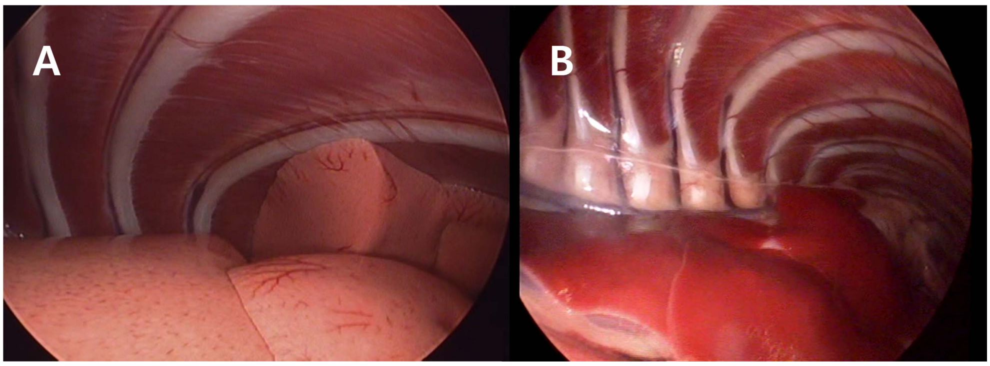

Fig 4. Thoracoscopic view through 8th instercostal port in dogs before lung separation (A) and after complete collapse of right lung field with one lung ventilation (B).

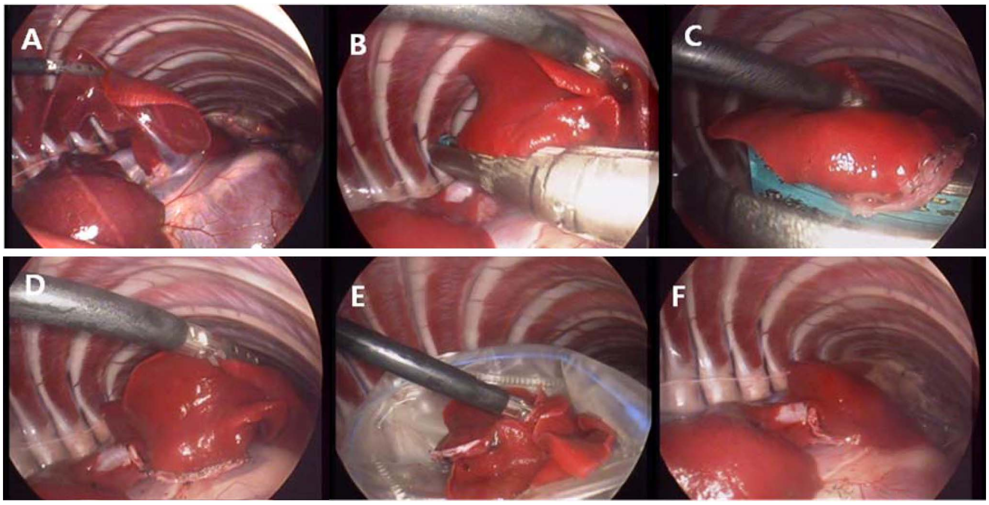

Fig 5. Intrathoracic views of thoracoscopic right middle lung lobectomy with one lung ventilation in dogs through 8-6-10 approach. (A) Hilar exposure of right middle lung lobe (RML), (B) Hilar application of endoscopic linear self-cutting stapler, (C) Cut surface with fired staples, (D) Resected RML, (E) RML within the retrieval bag, (F) Resected site of hilar area.

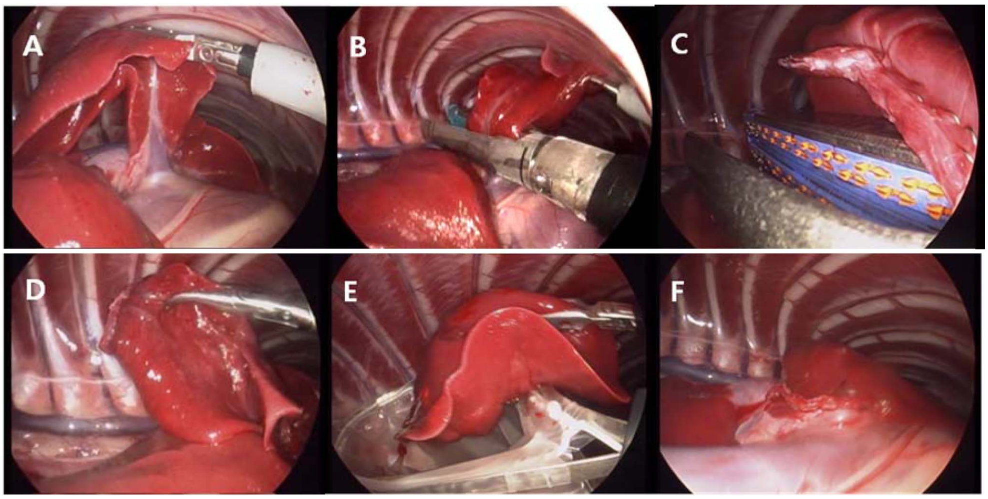

Fig 6. Intrathoracic views of thoracoscopic right middle lung lobectomy with one lung ventilation in dogs through 8-6-5 approach. (A) Hilar exposure of right middle lung lobe (RML), (B) Hilar application of endoscopic linear self-cutting stapler, (C) Cut surface with fired staples, (D) Resected RML, (E) RML within the retrieval bag, (F) Resected site of hilar area.

Discussion

Regarding thoracoscopic procedures reported in dogs, most of patients were large breed dogs weighing 20~30 kg or more. This tendency is considered as spatial limitation of rib cage for triangulation and instrumental manipulation, especially in case of small breeds (1,3,7,11,17). Experimental and clinical thoracoscopic or thoracoscopy assisted lung lobectomies have been attempted in similar condition, reported in Labrador retriever, Rhodesian ridgeback, Rottweiler, and mongrel dogs (7,10,16). Thoracoscopic lung lobectomy has been reported in every lobe, however, the left caudal lung lobe is the most common site with or without neoplasms like adenocarcinoma, metastatic osteosarcoma (7,10,11,16). In the veterinary medicine, 17 ± 3.2 kg mongrel dogs were the smallest patient with experimental lung lobectomy of left caudal lung lobe, to the author's knowledge (7).

Thoracoscopic lung lobectomy of right middle lobe presents the greatest challenge. There is just one case of thoracoscopic right middle lung lobectomy in a 30 kg German wirehaired pointer first reported in 2012 using 8-6-10 approach and selective lung ventilation excluding right middle and caudal lung lobes with double lumen endobronchial tube (25). Portal locations of ventral third of 8^{th} ICS as primary trocar and dorsal third of 10^{th} ICS for grasper were same to 8-6-10 approach in present study. But one port of 6^{th} ICS for stapler and specimen retrieval bag was different from that of present study in height; ventral third, while ventral fifth in present study.

Two portal approaches of 8-6-10^{th} and 8-6-5^{th} ICS in this study induced neither visual handicap nor instrumental fighting, therefore, thoracoscopic right middle lung lobectomies were performed successfully in 10 Beagle dogs weighing less than 10 kg. Moreover, 1LV provided satisfactory visualization and spatial spare and was well-maintained during the procedure irrespective of lung lobe manipulation. As for lung separation occluding all right lung field with endobronchial blocker in dogs, craniolaterally located entrance to the right cranial lobar bronchus right after the level of bifurcation was a concerned point. During the courses of this study, continuous thoracoscopic and intermittent bronchoscopic monitoring of bronchial occlusion was performed, there was no dislodgement of blocker through the procedure. Additionally, 1LV can provide not only spatial benefit but also ease in identification of centric pulmonary mass which is unnoticeable in inflated parenchyma.

As same portal approach of instruments except grasper, visualization and hilar application of stapler were same in all dogs. Two different sites for grasping forceps also did not induce any problem in lobar retraction or Lap Bag application. 8-6-10 approach seemed to provide theoretical perfect triangulation and it was, indeed. But in author's case, there was a tendency that arms of the operator should be opened broadly with obtuse angle from the hilus. This point might be considered as load to surgeons in prolonged procedure, but not in this study. In 8-6-5 approach, on the other hand, two instruments introduced 5, 6^{th} ICS ports might be thought to parallel each other. But, it was quite reasonable as points of fulcrum from the surgical table of two ports and heading angles of each instrumental tip were different. Stapler introduced through more ventral fulcrum spares more space and range of vertical motion.

Staplers were introduced through the secondary port placed in ventral fifth of the 6^{th} ICS. When the device was clamping the bronchus of the right middle lung lobe, its long axis was almost parallel to the sagittal plane right over the heart. Similarly, its tip was also parallel, or headed little bit lateral to the sagittal plane. So there was less concern about the damage of major vascular structures like aorta and azygos vein running along the vertebrae, but the right middle lung lobe was able to be resected close to the hilus without forced upward retraction. If there is not enough space between portal introduction site and the hilus to open the jaw of stapler, shorter cartilage may be considered. In this study, 45 mm cartilage was used at first, but 30 mm cartilage was also compatible and the length was sufficient to the hilar pedicle in Beagle dog.

Subjects of this study were Beagle dogs weighing less than 10 kg and thoracoscopic right middle lung lobectomy using self-cutting stapler and Lap Bag was accomplished favourably with 1LV. Right caudal thoracic cavity with deflated caudal lung field was spacious enough to control the Lap bag with its tip heading to the diaphragm when introduced through the port. Problems like active hemorrhage, failure of 1LV, air leakage, entrapment of endobronchial blocker tip by staples, and anesthetic crisis were not identified during procedure. There was one incomplete transection of stapling line in 8-6-5 approach, but, this was a trouble in firing stapler, not resulted from portal approach. Hilar pedicle was completely stapled but only separation was incomplete just at the tip of device, so, unseparated tissue was released by endoscopic metzenbaum scissor between stapled lines.

Surgeons may have benefits in surgical time by means of self cutting staplers. Only several seconds are sufficient for application and firing it. In the present study, mean surgical time of thoracoscopic right middle lung lobectomy in was 6.40 ± 1.09 minutes. Small incisions and use of advanced instruments are the main factors of speed and safety in thoracoscopic procedures as thoracic opening and closure were tedious time consuming in traditional thoracotomy. Furthermore, articulation of the stapler may alleviate deep and narrow cavitary limitation in case, as well. In addition, the occurrence of hemorrhage requiring additional ligature after stapling and postoperative pneumothorax were described as 5% and 2.7% only (28, 29).

Although two methods were feasible for thoracoscopic right middle lung lobectomy in small dogs, additional options might be considered to improve procedure; more ventrally moved 10^{th} ICS trocar in 8-6-10 approach, or modification of 8-6-10 approach to 8-6-11 approach or 8-6-5 approach to 8-6-4 approach could be attempted. Besides, application of 30^o telescope or smaller arthroscopic instruments could be helpful in narrower cavity.

This study was conducted in healthy dogs, however, in case of too large pulmonary mass or mass that are too close to hilus would impair the visualization and make manipulation for dissection and stapler placement difficult even though reasonable portal placement. In these conditions, there would be no choice without conversion to standard open thoracotomy. These decisions are able to be made by the surgeon using thoracoscopy as a diagnostic tool prior to open thorax. In addition, patients might have more unstable cardiovascular or hemodynamic functions with impaired immunity and delicate to other stress factors, whereby, ability of compensation would be suspected somewhat low as well. With 1LV, meticulous anesthetic monitoring should be indicated during thoracoscopic procedures regardless of anesthetic regimen.

Conclusion

Both approaches through 8-6-10 ICS and 8-6-5 ICS for thoracoscopic right middle lung lobectomy with one lung ventilation using endoscopic linear self-cutting stapler were feasible and can be selected with satisfaction in clinically healthy Beagle dogs weighing less than 10 kg.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (2013R1A1A2010029).

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비글견에서 편측성 분리폐 환기를 이용한 흉강경 우중폐엽 절제술을 위한 포트 위치

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요 약 : 본 연구는 10 kg 미만의 소형견에서 흉강경을 이용한 우측 중폐엽 절제술을 적용할 때, 적합한 포트 접근법의 설정을 위하여 실시되었다. 평균 체중 8.67 ± 0.49 kg의 비글견 10마리에서 전신 마취를 실시한 후 기관 내시경 유도하에 우측 주기관지를 폐쇄하여 편측성 분리폐 환기를 실시하였다. 포트는8-6-10 늑간과 8-6-5 늑간을 통한 두 가지 접근법으로 위치시켰고, 흉강경 우중폐엽 절제술에는 복강경용 자가 절단 스테플러와 검체 회수 주머니가 사용되었다. 각 접근법은 1) 시각화, 2) triangulation; 흉강내 기구간 충돌, 3) 스테플러의 폐문부 접근 및 적용의 용이성, 4) 검체 회수 주머니 사용의 장해 여부, 5) 술자의 편의도의 5가지 항목을 점수화하여 평가하였다. 모든 개체에서 편측성 분리폐 환기에 의해 양호한 작업 공간이 확보되었고, 성공적인 흉강경 우중폐엽 절제술이 완료되었다. 어느 경우에서도 포트 위치를 수정할 필요는 없었으며, 의인성 합병증 역시 발생하지 않았다. 두가지 접근법 모두 높은 점수를 얻어, 이들은 10 kg미만의 개에서 편측성 분리폐 환기하에 자가 절단 스테플러를 이용한 흉강경 우중폐엽 절제술을 실시함에 적합한 것으로 확인되었다.

주요어 : 흉강경 폐엽 절제술, 우측 중폐엽, 포트 위치, 편측성 분리폐 환기, 개