

## Lung Lobectomy Using a Thoracoabdominal Stapler for Primary Lung Tumor in Two Dogs

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**Abstract :** Two dogs presented to our facility were each diagnosed with a thoracic mass. Radiography and computed tomography revealed isolated primary lung tumors. Partial lung lobectomy was applied in Case 1 and total lung lobectomy in Case 2, using a thoracoabdominal stapler. No complications were observed after surgery in either dog. The outcome of these cases indicates that use of a thoracoabdominal stapler in partial and total lung lobectomy may be recommended for small-breed dogs.

**Key words :** adenocarcinoma, dog, lung lobectomy, primary lung tumor, thoracoabdominal stapler.

### Introduction

Primary lung tumors occur less frequently than metastatic lung tumors and arise as a solitary mass. They are found mostly in dogs over 10 years of age (1,2,4), and the diagnosis is usually an incidental finding because there are no clinical signs at the initial stage (1,4). Various clinical signs develop as the tumors grow and invade the parenchyma. During the late stage, dry cough, dyspnea, lethargy, or anorexia may occur in affected dogs (1,6). Diagnosis is confirmed using radiography, contrast-enhanced computed tomography (CT), and histopathological examination (4). Wide surgical resection is indicated for solitary masses in the lung lobe (3,4), with a favorable prognosis for non-metastasized and well-differentiated primary lung tumors in dogs (4).

Lung lobectomy can involve total or partial lobe resection depending on tumor location or distribution. Traditional lobectomy involves individual dissection and ligation of the bronchus and vessels, which can be tedious and time consuming (3,4). A thoracoabdominal (TA) stapler is a surgical stapling instrument that can be used in lung lobectomy, partial splenectomy, gastrectomy, and skin anastomosis (9). Wykes *et al.* report five cases in which dogs with cardiac tumor were treated using a TA stapler (12). In addition, Jeoung *et al.* describe a Pekingese dog with pulmonary torsion treated by lobectomy using an endoscopic stapler (7).

Here, we report two cases of focal lung tumor in small-breed dogs treated with partial and total lung lobectomy using a TA stapler.

### Case

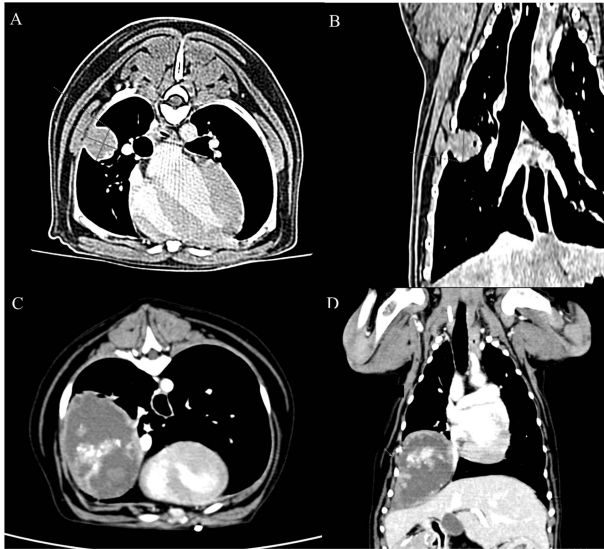
#### Case 1

A 13-year-old castrated-male Shih Tzu dog was referred to Konkuk Veterinary Medical Teaching Hospital for diagnosis and treatment of a lung mass discovered as an incidental finding at a local hospital. The patient showed no clinical signs related to the lung mass. Physical examination, blood



**Fig 1.** Thoracic radiography images at initial presentation. In Case 1, a round mass (arrows) is present in the right middle lung lobe in the VD view (A), and summation with the upper cardiac region is seen in the left lateral view (B). In Case 2, a mass (arrows) with soft-tissue density and well-defined margins is present in the right caudal lung lobe in the VD view (C) and the right lateral view (D).

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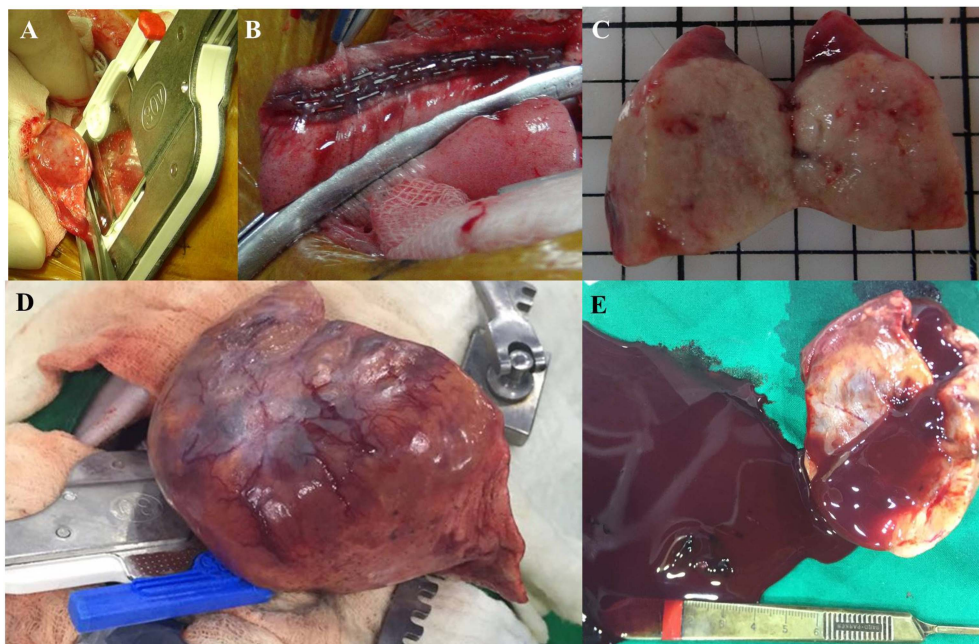


**Fig 2.** CT images at initial presentation. In Case 1, a mass of approximately 15 mm in diameter is present in contact with the thoracic wall in the transverse view (A) and the sagittal view (B). In Case 2, a mass involving the bronchus is seen in the right caudal lung lobe in the transverse view (C) and the sagittal view (D). The margin is enhanced while the center is not, indicating that this is a cyst containing liquid.

tests, radiography, ultrasonography, fine needle aspiration biopsy (FNAB), and CT were performed. Blood test results revealed no remarkable findings except for a slightly elevated alkaline phosphatase (ALP) level of 132 U/L. On thoracic radiography, a nodule was identified in the right middle chest (Fig 1A and B). On ultrasonography, a nodule was observed in the spleen, while spleen echogenicity was nor-

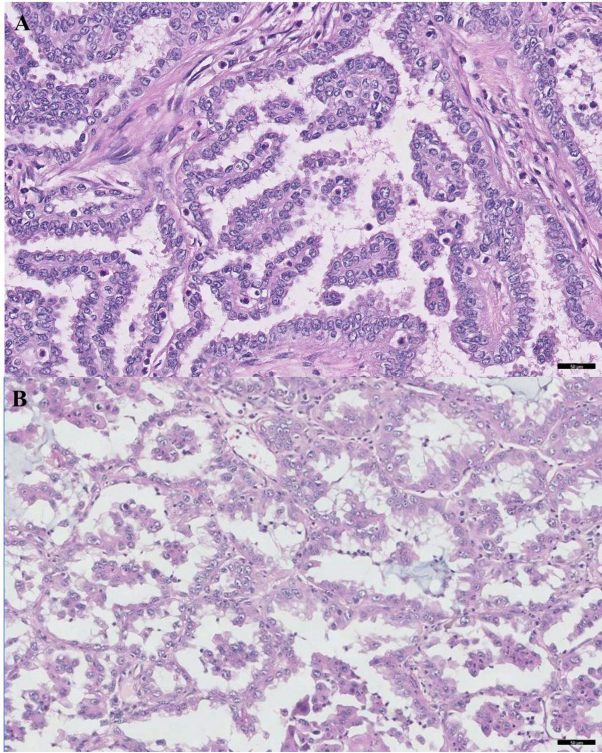
mal. On CT, a nodule involving the bronchus in the right lung lobe was confirmed, and the mass in the spleen was not enhanced in post-contrast images (Fig 2A and B). The lung mass was round with a diameter of approximately 15 mm, and the lymph node near the mass was not enlarged. Examination of FNAB samples revealed round to ovoid nuclei of approximately equal size with well-differentiated to intermediate-grade malignancy characteristics. Therefore, primary lung tumor was diagnosed and surgical intervention was performed to prevent metastasis.

The dog received intravenous injection of 0.2 mg/kg butorphanol (Butophan Inj.; Myungmoon Pharm, Seoul, Korea) and 0.3 mg/kg midazolam (Vascam Inj.; Hana Pharm, Gyeonggi-do, Korea) for premedication, as well as 30 mg/kg cefazidime (LG Ceftazidime Sodium Inj.; LG Life Sciences, Seoul, Korea) for antimicrobial prophylaxis. Anesthesia was induced by intravenous injection of 6 mg/kg propofol (Provide Inj. 1%; Claris Lifesciences, Ahmedabad, India) and maintained by inhalation of isoflurane (Ifran Solution; Hana Pharm). In addition, an intercostal nerve block was performed at the fifth intercostal space using 2 mg/kg bupivacaine (Bupivacaine HCl Inj.; Myungmoon Pharm). The thoracotomy incision was made in the fifth intercostal space and the opening in the intercostal space was maintained using a Finochietto retractor. Adhesions between the mass and the thoracic wall were not identified. The mass was gently exteriorized, and a TA stapler (TA30V3S, TA30V3L; Covidien, Mansfield, USA) was used to place three rows of staples in normal lung tissue cranial to the mass, after which the tumor was resected with a No. 15 blade between the staples and the mass (Fig 3A). Bleeding was not observed on the edge of the normal lung when gently holding with intestinal forceps (Fig 3B). The thoracic cavity was lavaged with



**Fig 3.** Surgical procedures and resected masses. (A) The TA stapler has been applied to the lung lobe in Case 1. (B) The three rows of staples are seen in the normal lung tissue after the lesion has been resected in Case 1. (C) Macroscopic appearance of the resected mass in Case 1. (D) The right caudal lung lobe has been exteriorized and a TA stapler inserted over the bronchus and pulmonary artery and vein of the right caudal lung lobe in Case 2. (E) Macroscopic appearance of the resected mass in Case 2.





**Fig 4.** Histopathologic sections of the masses. (A) In Case 1, fairly uniform, polyhedral to occasionally cuboidal epithelial cells are observed. The cells contain minimal to moderate amounts of pale eosinophilic cytoplasm and moderately hyperchromatic round to ovoid nuclei with finely stippled chromatin and a single nucleolus. (H&E staining,  $\times 400$ , scale bar = 50  $\mu\text{m}$ ) (B) In Case 2, a densely cellular, unencapsulated, poorly demarcated, infiltrative epithelial lung mass is seen, consisting of variably sized and irregularly shaped tubular structures lined by cuboidal to polygonal cells and surrounding a moderately fibrovascular stroma. Abundant lightly basophilic mucus, presumably produced by the tumor cells, fills some of the tubular spaces. Extensive foci of tumor necrosis, along with moderate suppurative inflammation, are present. (H&E staining,  $\times 400$ , scale bar = 50  $\mu\text{m}$ ).

normal saline and the lung submerged to confirm that there was no air leakage. The chest was closed using preplaced sutures and then drained of free air several times using negative pressure applied with a syringe fitted with a three-way cock. Macroscopic examination revealed that the mass was soft and solitary (Fig 3C). The patient was monitored postoperatively for one day in an oxygen chamber and then kept in the hospital for two days. Surgical wound dressings were changed and thoracic radiography was conducted once a day. The patient was also administered antibiotics and analgesics. There was no recurrence after 7 months of follow-up.

On histologic examination, the mass was found to contain fairly uniform polyhedral to occasionally cuboidal epithelial cells. The cells contained minimal to moderate amounts of pale eosinophilic cytoplasm and moderately hyperchromatic round to ovoid nuclei with finely stippled chromatin and a single nucleolus. Therefore, bronchoalveolar papillary carcinoma derived from bronchoalveolar epithelium was diagnosed (Fig 4A).

## Case 2

A 14-year-old castrated-male Maltese dog was brought to the Korea Animal Cancer Center with occasional panting and dry cough. Physical examination, blood tests, radiography, ultrasonography, and CT were performed. On physical examination, muffled sounds were auscultated over the right caudal thorax. On thoracic radiography, a mass was observed in the right caudal lung lobe with soft-tissue density and well-defined margins (Fig 1C and D). The mass was in contact with the thoracic wall and diaphragm, but was confined to the thorax as evidenced by an intact diaphragm. On ultrasonography, focal calcification was observed in the mass and Doppler flowmeter analysis of the vascular component of the mass revealed low to no echogenicity. The mass and liver were separated by the diaphragm. On CT, the mass was observed to involve the bronchus in the right caudal lung lobe. The margin was enhanced and the center was not, indicating that the mass was a cyst containing liquid (Fig 2C and D). No metastasis was observed in any other organs or lymph nodes.

Premedication, induction, and maintenance of anesthesia and antibacterial prophylaxis were carried out in the same way as in Case 1. Nerve block was not applied in this case. The patient received fentanyl continuous rate infusion during surgery and for 12 hours after surgery, and a fentanyl patch was used for analgesia during hospitalization. Thoracotomy was performed through the ninth intercostal space. After confirming that adhesions were not present, the right caudal lung lobe was retracted gently out of the thorax and the bronchus and pulmonary artery and vein were identified. A TA stapler (TA3035S, TA3035L; Covidien) was used to insert two rows of staples over the normal lung tissue containing the bronchus and pulmonary artery and vein, and the lung lobe, including the mass, was excised (Fig 3D and E). Additional sutures were placed over the bronchus and vessels to ensure effective seals. Bleeding and air leakage were not observed and the thorax was closed with routine placement of chest tubes (4). The patient received antibiotics and the dressing was changed every day during seven days of hospitalization. There was no recurrence after 5 months of follow-up.

On macroscopic examination of the mass, the encapsulated mass was firm and contained blood. Microscopic examination of the mass revealed a densely cellular, unencapsulated, poorly demarcated, infiltrative epithelial lung mass consisting of variably sized and irregularly shaped tubular structures lined by cuboidal to polygonal cells and surrounding a moderately fibrovascular stroma. In addition, there was differentiation toward stratified squamous epithelium with abundant glassy eosinophilic cytoplasm and pleomorphic nuclei, as well as marked anisocytosis and anisokaryosis with moderate mitotic activity. Extensive foci of tumor necrosis, along with moderate suppurative inflammation, were present. Therefore, adenosquamous carcinoma with inflammation was confirmed (Fig 4B).

## Discussion

Lung lobectomy can be performed as a partial or total lobe resection and is indicated for lobar pneumonic consolidation,

lung lobe torsion, and isolated lung tumor (4). Partial lung lobectomy can be used to remove one-half to two-thirds of the lung lobe; therefore, this technique was used in Case 1 with a relatively small mass, while total lung lobectomy was indicated in Case 2 with a fluid-filled mass occupying the whole lung lobe.

The TA stapler has a versatile length and cartridge width and can be applied in various organs. DST series single-use TA staplers have various staple cartridge widths including 30, 45, 60, and 90 mm. The cartridges are also color-coded. White cartridges are 30 mm wide and apply three rows of staples with a staple length of 2.5 mm; the tissue is compressed to a height of 1.0 mm. This cartridge can be used for large vascular pedicles, right atrial appendage tumors, and lung lobectomy. Blue cartridges are 30 mm wide, apply two rows of staples with a staple length of 1.5 mm, and compress the tissue to a height of 1.5 mm. These staples can be used in lung lobectomy, liver lobectomy, and splenectomy (8). It is recommended that 2.5 mm vascular staples or 3.5 mm staples be used for dogs and cats following lung lobectomy, but staple size should be selected on the basis of the width and height of the entire organs, including the edges (4,9).

In human medicine, surgery with a TA stapler has been performed for over 30 years (10), and video assisted thoracoscopy (VAT) has been used for over 20 years (5). This combination therapy has been applied in dogs and cats (11), but the procedure involving VAT was not suitable for our small patients and would have required more surgical time than the thoracotomy procedure used in our patients (5). One advantage of TA stapling is that it is easy to apply because dissection and ligation are not necessary (3). It would not have been easy to approach the bronchi to apply sutures deep in the thorax behind the large mass in Case 2, but the stapling technique enabled an easy and efficient approach. The TA stapling technique with open thoracotomy decreased the surgical time relative to conventional suture techniques or VAT in our geriatric patients, which might have facilitated a good recovery.

Air leakage and hemorrhage are major complications of partial or total lung lobectomy (3,4,10) and may occur because of excessively thick or fibrotic organs (4). In a previous study on lung lobectomy with a TA stapler in 46 dogs, there was no hemorrhage and only one dog experienced air leakage, which was controlled within 24 hours (5). If air leakage or

hemorrhage occurs, additional continuous sutures should be performed (4). In our two cases, no complications regarding leakage occurred.

In conclusion, these two cases revealed that partial and total lung lobectomy using a TA stapler has advantages over conventional suture techniques, such as decreased difficulty, less surgical time, and fewer complications, in small-breed dogs. For these reasons, use of a TA stapler in lung lobectomy may be recommended for small-breed dogs.

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