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CASE REPORT

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Modified retrograde intubation through the cricothyroid membrane in a cat with temporomandibular joint ankylosis

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Abstract

A 6-month-old, 2.9-kg, male, Korean short hair cat was referred for inadequate mouth opening (4 mm), and condylectomy was scheduled for ankylosis of the left temporomandibular joint. Retrograde intubation via the cricothyroid membrane was planned since direct visualisation of the larynx was not possible. In dorsal recumbency, the cricothyroid membrane was punctured with an 18-gauge needle, and a J-tip guidewire, inserted via the needle, was advanced and identified at the mouth. A 6-Fr truncated feeding tube was inserted from the mouth to the cricothyroid membrane along the guidewire. The guidewire was removed, and the tip of the feeding tube was advanced as an anterograde guide to the inner trachea. Subsequently, an endotracheal tube was inserted along the feeding tube. Capnography was used to confirm correct intubation. Condylectomy was performed on the left temporomandibular joint, and the patient recovered from anaesthesia uneventfully. Retrograde intubation is less invasive than tracheostomy or cricothyroidotomy, and the cricothyroid membrane has been suggested as a suitable site for guidewire insertion in humans and dogs. However, when resistance is encountered during the advancement of endotracheal tube using the traditional technique without the anterograde guide, it may be difficult to distinguish where the resistance occurred leading to damage or oesophageal displacement in cats with relatively fragile airway. This report suggests that retrograde intubation via the cricothyroid membrane can be performed in cats with limited visualisation of the larynx, and an anterograde guide following the retrograde wire could reduce the potential damage or oesophageal displacement.

KEYWORDS
anaesthesia, anterograde guide, difficult airway, feline, retrograde intubation

1 | INTRODUCTION

Orotracheal intubation is a routine procedure that provides oxygen and inhalation anaesthetics during anaesthesia while facilitating ventilation and preventing fluid aspiration in cats (Fudge, 2015; Mosley, 2015). Routine intubation in cats rarely requires additional equipment other than a laryngoscope and a topical anaesthetic such as lidocaine (Fudge, 2015). However, the visibility of the laryngeal opening is limited in some cats with abnormal anatomical features (e.g., brachycephalic breeds), pathological upper airway obstruction, or difficulty in opening

the mouth, requiring specialised equipment/techniques, such as retrograde intubation (RI) (Fudge, 2015; Mosley, 2015).

The temporomandibular joint (TMJ) is a synovial joint between the mandibular condyle and the articular fossa of the temporal bone (Mohan et al., 2012). TMJ ankylosis is characterised by restricted mandibular movements with reduced mouth opening, and its anaesthetic management is challenging due to the limited visualisation of the larynx (Maas & Theyse, 2007; Shashidharreddy et al., 2017). Retrograde intubation can be used when at least a part of the glottis cannot be directly visualised (Fudge, 2015). However, the feline upper airway is more prone to damage than the upper airways of other companion animals when intubation is performed without direct visualisation (Hofmeister et al., 2007). This case demonstrates a modified RI technique in a cat.

1.1 | Case history

A 6-month-old, 2.9-kg, male Korean short hair cat was referred to the veterinary medical teaching hospital for inadequate mouth opening. Computed tomography (CT) scans had been previously obtained by the referring hospital under total intravenous general anaesthesia as the cat could not be intubated. The CT images showed decreased left TMJ space with sclerotic and proliferative changes in the adjacent bones. Clinical examination revealed a restricted mouth opening of 4 mm measured between the maxillary (101) and mandibular (401) incisors (Figure 1). A complete blood count, serum biochemical analysis, electrolytes analysis, and urinalysis yielded unremarkable findings. Thoracic radiography showed no remarkable findings except for open growth plates in the overall skeletal system due to young age. The patient was diagnosed with left TMJ ankylosis, and condylectomy of the left TMJ and osteotomy of the left zygomatic arch were scheduled.

As it was impossible to directly view the larynx because of inadequate mouth opening, the RI through the cricothyroid membrane was planned. The cat was classified with an American Society of Anesthesiologists score of 3 based on the difficult airway, and considering the possibility of RI failure, equipment for a temporary tracheostomy was prepared. The owner was made aware of the intubation procedure and provided written informed consent for the use of medical records and accompanying figures.

Food was withheld for 12 h prior to anaesthesia. The left cephalic vein was catheterised with a 24-gauge over-the-needle polyurethane catheter, and crystalloid fluid (Plasma solution A; HK inno.N Crop., South Korea) was administered intravenously (IV) at a rate of 5 ml/kg/h. The cat was pre-treated with cefazolin (33 mg/kg, Cefazolin; Chong Kun Dang Corp., Korea) IV 30 min prior to pre-medication. Heart rate and rhythm were monitored continuously with a multi-parameter monitor (CARESCAPE Monitor B650; GE Healthcare, USA). The blood pressure (BP) was measured with an oscillometric BP monitoring device (Vet25; SunTech Medical, Inc., Morrisville, NC, USA). The patient was pre-medicated with intravenous remifentanil (4 μg/kg, Hana Pharma Corp., Korea) and ketamine (0.5 mg/kg, Yuhan Pharmaceutical, Korea) following pre-oxygenation with 100% oxygen via flow-by. Then, a constant rate infusion with a combination of remifentanil (6 μg/kg/h) and ketamine (0.6 mg/kg/h) was started. Intravenous anaesthesia was induced using ketamine and alfaxalone (Alfaxalone; Jurox Pty Ltd, NSW). After the administration of 2 mg/kg ketamine, 2 mg/kg of alfaxalone was titrated against the response of the patient. During the procedure, 0.5 mg/kg of alfaxalone and 1 mg/kg of ketamine were added every 5 min.

FIGURE 1 A cat with an inadequate mouth opening. The mouth was forced open using two feeding tubes hung on the upper and lower jaws. It revealed a 4-mm mouth opening with minimal space between the maxillary and mandibular incisors

The cat was positioned in dorsal recumbency, the cricothyroid space was palpated, and the skin of the neck was clipped and aseptically prepared for the RI technique. An 18-gauge needle was advanced with a 45° angle in the rostral direction, and the cricothyroid membrane was punctured (Figure 2). Correct insertion of the needle tip into the trachea was confirmed by air aspiration throughout the needle with a 3-ml syringe (KOREAVACCINE Co., Ltd., Korea). A J-tip guidewire (Percutaneous Sheath Introducer Set, SI-09600, Arrow International Inc., USA) was inserted through the needle and advanced to the mouth opening; the guidewire came out through the nose during the first two attempts and through the mouth opening on the third attempt. Subsequently, the needle was removed from the cricothyroid membrane. The cat was repositioned in lateral recumbency, and a 6-Fr feeding tube (JMS Co., Ltd., Korea) with the tip cut off was inserted along the guidewire from the mouth, through the glottis, and to the level of the cricothyroid space. While the guidewire was removed, the feeding tube was further advanced to the thoracic inlet region as an anterograde guide, whose correct placement within the trachea was reconfirmed with a lack of resistance to air aspiration using a 3-ml syringe through the feeding

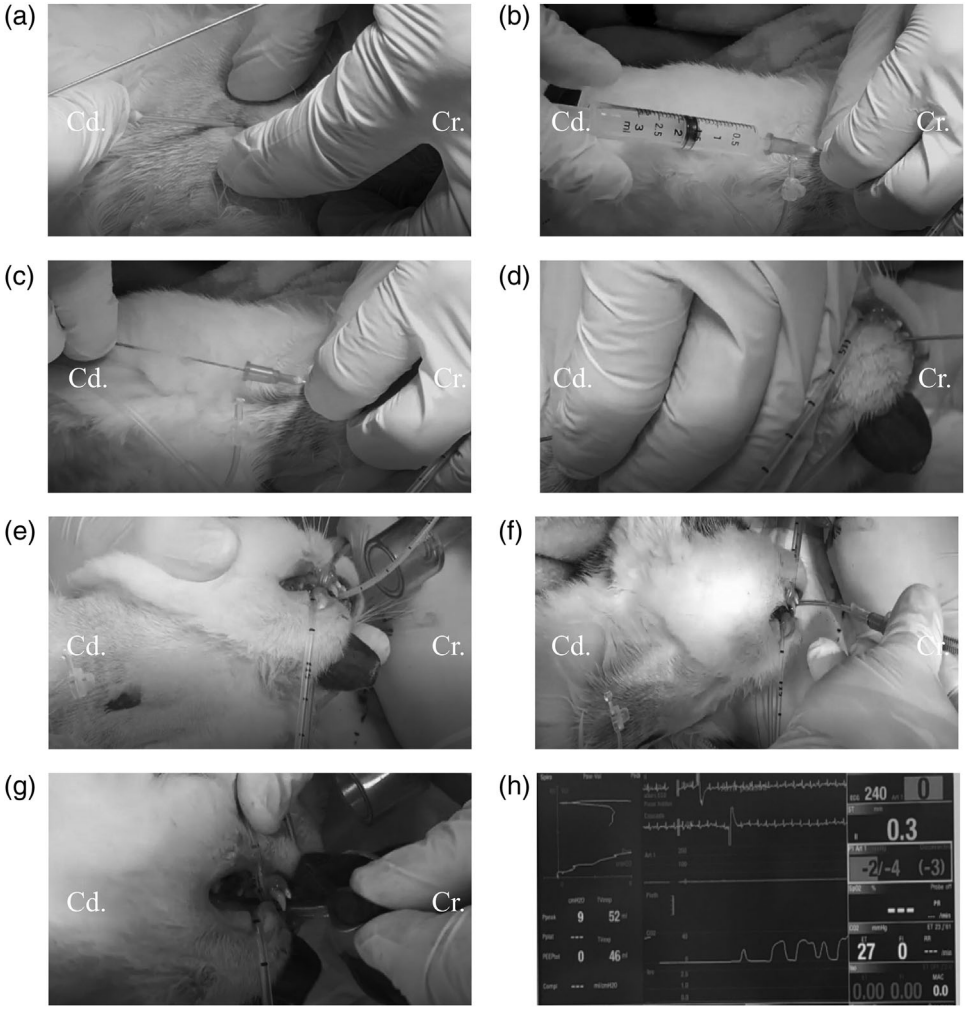

FIGURE 2 Modified retrograde intubation through the cricothyroid membrane in a cat. (a) An 18-gauge needle was advanced in the rostral direction with the cat in dorsal recumbency, and the cricothyroid membrane was punctured. (b) Correct insertion of the needle tip into the trachea was confirmed by air aspiration throughout the needle with a 3-ml syringe. (c) The J-tip guidewire was inserted through the needle. (d) The guidewire was advanced to the mouth opening, and the needle was removed from the cricothyroid membrane. (e) In lateral recumbency, a 6-Fr feeding tube with the tip cut off was inserted along the guidewire from the mouth to the cricothyroid cartilage; the guidewire was removed, and the feeding tube was advanced to thoracic inlet region. (f) An endotracheal tube was advanced along the feeding tube, while the mouth was forced open to facilitate tube passage. (g) The feeding tube was removed, and the endotracheal tube was inserted to the thoracic inlet region (h) Correct intubation was confirmed using capnography. Cd, caudal; Cr, cranial

tube. To prevent the kinking of the feeding tube during intubation, the guidewire was inserted into the feeding tube, and an endotracheal tube (ETT; a cuffed armoured-type tube with inner and outer diameters of 3 and 4.6 mm, respectively) was advanced along the feeding tube while the mouth was forced open to facilitate the tube passage. The cat had a limited mouth opening of 4 mm between the maxillary and mandibular incisors, which was so narrow that an ETT with an outer diameter of 4.6 mm could barely pass on forcefully opening the jaw. The ETT was passed with mild force through the space between the maxillary and mandibular incisor teeth, and there was no additional resistance during the ETT advancement. The feeding tube was removed, and correct intubation was confirmed using capnography (Figure 2). The ETT was attached to the anaesthetic rebreathing system, and the cuff was inflated immediately. The ETT was tied using twill tape with cow hitch knot and then tied to the tube with a quick-release knot on the upper jaw. The total time to complete the RI technique was approximately 10 min. A small amount of blood was observed within the ETT. The haemorrhage was considered to be caused by needle puncture of the cricothyroid membrane. Arterial blood gas analysis (ABL90 flex; Radiometer, Westlake, OH, USA) showed no remarkable findings associated with the respiratory system; the partial pressure of oxygen and carbon dioxide were 550 mmHg and 34 mmHg, respectively.

Maintenance of anaesthesia was achieved with the delivery of isoflurane (isoflurane concentrations of 1.1–1.5%) vaporised in oxygen using a rebreathing system (Datex Ohmeda 9100c; GE Healthcare Finland Oy, Finland) after intubation. A 24-gauge catheter was inserted into the coccygeal artery and connected to a fluid-filled transducer system (Edwards Lifesciences LLC, California) for invasive

arterial blood pressure measurement. The zero-level reference of this system was set at the level of the right atrium. The heart rate, respiratory rate, peripheral oxygen saturation, direct BP, and oesophageal temperature were monitored continuously with a multi-parameter monitor and recorded at 5-min intervals. Spirometry, end-tidal partial pressure of carbon dioxide, and end-tidal isoflurane concentration were monitored continuously with an infrared gas analyser (CARESCAPE respiratory module E-sCAiOVX, GE Healthcare Finland Oy, Finland). Mechanical ventilation (Vent-V; Multiplus, Royal Medical Corporation, Korea) was applied to maintain an end-tidal carbon dioxide level of 35–45 mmHg. If needed, a warm air blanket (Bair hugger; 3 M, USA) and fluid warmer (iWarm; Midmark Corporation, France) were used to maintain the core body temperature. After the application of the monitoring instruments, the left infraorbital and mandibular nerve blocks with a 1-ml mixture of 2% lidocaine (Daihan Pharm Co., Ltd., Korea) and 0.5% bupivacaine (Myungmoon Pharm. Co., Ltd., Korea) were administered with the cat in right lateral recumbency. After surgical scrubbing of the left face and neck, the patient was transferred to the operation room.

The patient's heart rate ranged between 140 and 210 beats/min; systolic BP, between 60 and 150 mmHg; mean BP, between 40 and 100 mmHg; diastolic BP, between 25 and 80 mmHg; body temperature, between 35°C and 38°C and oxygen saturation, between 96% and 99% during surgery. Ephedrine (0.2 mg/kg, IV) and glycopyrrolate (20 μg/kg, IV) were used to increase the heart rate and BP. Cefazolin (33 mg/kg) was administered intravenously every 2 h throughout the surgery. The extent of the maximum mouth opening was 38 mm at the incisors after the surgery, and the patient was transferred to the CT room. Postoperative CT scans were performed, after which the delivery of isoflurane and the constant rate infusion of remifentanil and ketamine were discontinued. Mechanical ventilation was maintained until the patient showed attempts to breathe spontaneously. After the operation, the larynx was visually inspected and confirmed to show no anatomical and functional abnormalities. The total anaesthesia time lasted 155 min and the patient recovered from anaesthesia without further events related to the RI.

2 | DISCUSSION

Orotracheal intubation in veterinary patients often requires no special equipment other than a laryngoscope and familiarity with the normal anatomy (Mosley, 2015). However, in rare circumstances, including conformational (such as species, breed and size) and pathological (such as upper airway obstruction and locked jaw) factors, orotracheal intubation is difficult (Mosley, 2015; Mathis, 2017). A variety of alternative intubation techniques have been used to manage a difficult airway, including wire- or tube-guided techniques, RI, fibreoptic laryngoscopy, supraglottic airway devices and tracheostomy (Mathis, 2017). Intubation using fibreoptic laryngoscopy or a laryngeal mask airway device can be performed when the mouth opening is restricted and the larynx is not directly visible. Fibreoptic laryngoscopy is the ideal alternative for tracheal intubation of patients with restricted mouth opening because it permits the visualisation of the glottis through the oral route. However, its use is limited by the cost and availability of fibreoptic laryngoscopy (Fudge, 2015; Vieitez et al., 2018). Supraglottic airway devices offer an easy, effective and non-invasive method of securing the airway in cats (Cassu et al., 2004), but they cannot be used in animals with restricted mouth opening. Tracheostomy or cricothyroidotomy can be performed when oro- or nasotracheal intubation is not possible (Mosley, 2015). Tracheostomy or cricothyroidotomy can be used in cases involving oral or pharyngeal surgery, potentially life-threatening upper airway obstruction or critically ill patients on long-term ventilator support (Hartsfield, 2007).

The RI is an effective and minimally invasive technique for cases in which the larynx cannot be visualised. The main advantage of RI in comparison with intubation using fibreoptic laryngoscopy in difficult airways is that it can be performed when secretions or supraglottic masses obscure a clear view of the larynx inlet (Lama & Shrestha, 2008). In addition, RI does not require expensive equipment that is tailored to be small enough to pass through the restricted mouth opening. Commercially available RI kits are preferable; however, a standard venous catheter or introducer needle and a urinary catheter, epidural catheter, or J-tip guidewire can be used in the RI technique (Mosley, 2015; Vieitez et al., 2018). In this case, needle and J-tip guidewire were used for RI technique. When using an introducer needle, if the needle is not firmly fixed, the needle tip may penetrate the airway lumen or puncture the dorsal tracheal membrane (Asselin et al., 2018; Kim et al., 2016). There were no special problems in this case, but the RI technique may be more stable when applying an intravenous catheter.

The RI technique essentially involves a needle or catheter inserted into the airway either between the upper two tracheal rings or through the cricothyroid membrane (Fudge, 2015; Mosley, 2015). Some studies have applied this technique to rabbits, llamas and mice, with the needle inserted into the trachea (Byers et al., 2009; Corleta et al., 1992; Zhao et al., 2006). The cricothyroid membrane is located between the cricoid and thyroid cartilages (Hardjo et al., 2019), which helps in the palpation of the structure. Moreover, the cricothyroid membrane is located more cranially than the tracheal cartilage, reducing the incidence of complications such as pneumothorax or mediastinal damage (Hansen & Eriksen, 2014). The cricothyroid membrane shows lesser blood vessel distribution and is a fibrous membrane, thereby minimising bleeding (Hansen & Eriksen, 2014; Katos & Goldenberg, 2007). In addition, unlike the laryngeal and cricoid cartilage, the tracheal cartilage is absent dorsally; thus, the possibility of damage to the dorsal tracheal membrane and oesophagus is more likely in a tracheal approach than when the needle is inserted through the cricothyroid membrane (Mace & Hedges, 2004). In a canine case reported in 2018, the cricothyroid membrane approach was used, as it was useful in the localisation, puncture and facilitation of the introduction of the guide (Vieitez et al., 2018). These advantages related to the cricothyroid membrane could also be observed in cats.

The feline airway is smaller, more delicate, and sensitive to trauma than the canine airway (Brodbelt et al., 2007; Grubb et al., 2020); therefore, direct visualisation is recommended to avoid laryngeal trauma during orotracheal intubation (Mosier et al., 2015). In a feline

case report, intubation delivered to the larynx with moderate force caused the rupture of the arytenoid cartilage (Hofmeister et al., 2007), suggesting that confirmation of resistance during intubation, especially in blind intubation, is necessary. On the traditional RI technique without an anterograde guide, ETT advancement is stopped when a resistance is encountered in the cricothyroid membrane, but there may always be another resistance at the laryngeal inlet. In addition, intubation may fail if the guidewire is removed when resistance is encountered at the laryngeal inlet. In humans, oesophageal displacement may occur during guide removal as the distance between the cricothyroid membrane and the vocal cord is short (Lenfant et al., 2006). Lenfant et al. (2006) described that the modified RI technique using an anterograde over a retrograde guide prevented oesophageal displacement and enhanced the success rate, compared to the traditional technique. In the present feline case, the modified RI technique was employed to prevent the potential damage to the larynx glottis and oesophageal displacement during the procedure.

A few reports have described the complications of RI in human medicine, including sore throat, hypoxaemia, laryngospasm/bronchospasm, cough (American Society of Anesthesiologists Task Force on Management of the Difficult Airway, 2003), incorrect tube-placement site, development of haematoma, procedure time greater than or equal to 3 min, pneumomediastinum (Francois & Mehdi, 2006), subcutaneous emphysema (Bowes & Johnson, 1994), infection and bleeding (Wijesinghe & Gough, 2000). However, the RI technique was shown to result in no complications in llamas (Byers et al., 2009), rabbits (Corleta et al., 1992), mice (Zhao et al., 2006) and dogs (Vieitez et al., 2018). In the present case, although a self-limiting minor airway bleeding occurred, no further complications were noted.

3 | CONCLUSION

This case involved a cat with TMJ ankylosis and limited mouth opening that was successfully intubated by a modified RI technique via the cricothyroid membrane. Since the larynx and trachea of cats are fragile, the traditional RI technique was carefully considered as it is associated with the risk of airway damage by the ETT tip or intubation failure. The modified RI technique with an anterograde guide following the retrograde wire can be considered to reduce the potential damage to the glottis and to prevent the oesophageal displacement in cats. Nevertheless, the RI technique in cats is associated with the risk of damage to the upper airway; therefore, caution is required while performing this procedure.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ETHICS STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. Submission of the manuscript by the authors is an original work and not published previously and is not being considered for publication by another source.

AUTHOR CONTRIBUTIONS

Dalhae Kim: Investigation; visualisation; writing – original draft. Inhyung Lee: Funding acquisition; supervision. Won-gyun Son: Conceptualisation; funding acquisition; methodology; resources; supervision; validation; visualisation; writing – review & editing.

DATA AVAILABILITY STATEMENT

All date supporting the author's techniques are included in this study.

PEER REVIEW

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