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Anaesthetic management of two cats for tracheal surgery – A case report

Tapauskertomus kahden kissan nukutuksesta henkitorven leikkausta varten

SUMMARY

Two cats were anaesthetised for tracheal surgery: one for removal of a tracheal foreign body and another one for tracheal resection and anastomosis due to a large endotracheal mass. For both cases, total intravenous anaesthesia was used, either for the short period when the trachea was open to the atmosphere (case 1) or for the whole duration of anaesthesia (case 2). During tracheal surgery, the cat in case 1 was ventilated with a manually operated jet ventilator. The cat in case 2 was intubated with a sterile endotracheal tube through the operation field, distal to the mass, once the tracheal incision was made. Both surgeries were successful and the cats recovered well.

YHTEENVETO

Tämä tapauskertomus kuvaa kahden kissan nukutusta henkitorven leikkausta varten. Molemmat leikkaukset tehtiin oikean kyljen torakotomiaviillon kautta. Ensimmäisellä kissalla oli vierasesine henkitorvessa, toisella taas iso kasvain, joka vaati henkitorven osittaisen poiston. Molemmissa tapauksissa käytettiin suonensisäistä anestesiaa. Tapauksessa 1 anestesia rajoittui aikaan, jolloin henkitorvi oli avoinna. Tapauksessa 2 se kesti koko leikkauksen ajan. Molempien kissojen henkitorvet intuboitiin aluksi suun kautta, ja kumpaakin ventiloitiin koko leikkauksen ajan. Ensimmäisen kissan keuhkot tuuletettiin käsikäyttöisellä jet-ventilaattorilla henkitorven ollessa avoinna (happi puhallettiin kovalla paineella ohutta ruokintaletkua myöten henkitorveen). Toisen kissan henkitorvi intuboitiin steriilillä hengitysputkella leikkaushaavan kautta sen jälkeen, kun henkitorvi oli avattu kasvaimen distaalipuolelta. Molemmat kissat toipuivat hyvin.

INTRODUCTION

Tracheal surgery is a challenge for both the surgeon and the anaesthetist; especially so when the surgery involves a small animal such as a cat. Both teams have to work closely and the anaesthetist has to allow visualization of the surgical field to the surgeon while maintaining the patient's oxygenation and pulmonary gas exchange. Traditional anaesthetic methods cannot often be used. In addition, careful preparation and improvisation skills are essential for the anaesthetist in order to deal with unexpected events. We describe the anaesthetic management of two cats; one with a tracheal foreign body and another one with a tracheal mass.

DESCRIPTION OF THE CASES

Case 1

A 1-year-old female cat was referred to the University Veterinary Hospital (UVH) with acute onset respiratory distress. Physical examination could not be completed due to severe dyspnoea. The re-

YDINKOHDAT:

- The anaesthetist must be prepared to deal with unexpected events.
- Approaches discussed include standard orotracheal intubation, sterile intubation through the operation field distal to the tracheal incision, jet ventilation and one-lung ventilation.
- Adequacy of ventilation with a jet ventilator is assessed by observation of chest wall movement and confirmed with blood gas evaluation.
- Respiratory distress can lead to respiratory and cardiac arrest.

ferring veterinarian's thoracic radiographs showed a mineralised foreign body within the tracheal lumen at the level of the carina, nearly completely occluding the trachea. As the foreign body was too large to be removed by the bronchoscope and forceps combination available in our hospital, we decided to perform an emergency thoracotomy to gain access to the trachea at that level.

The cat's body weight was 4 kg and anaesthesia was induced with ketamine (Narketan 10, 100 mg/ml, Vétoquinol) at 12.5 mg/kg and diazepam (Diazemuls 5 mg/ml, Actavis Group PTC ehf) at 0.625 mg/kg intravenously. No premedication was given, because we were conscious of the risk that sedation might worsen the dyspnoea. The trachea was intubated with a 4 mm cuffed endotracheal tube (the distal tip of the tube positioned cranial to the foreign body), connected to a non-rebreathing system (Ayres T-piece). Anaesthesia was maintained with isoflurane (Vetflurane 100%, Virbac Ltd) in 100% oxygen (O_2 flow rate 3–4 l/min). Intermittent positive pressure ventilation (IPPV) (SAV03, Vetronic Services Ltd) was started immediately. Ketamine continuous rate infusion (CRI, 10 µg/kg/min) was started 35 min after induction, and additional analgesia was provided with morphine (Morphine 10 mg/ml, Antigen Pharmaceuticals) at 0.2 mg/kg intramuscularly. Intravenous fluids (compound sodium lactate, CSL) (Vetivex 11, Dechra Limited) were given at a rate of 10 ml/kg/h throughout the anaesthesia, and the combination of amoxicillin and clavulanic acid (Augmentin 500 mg/100 mg, GlaxoSmithKline Ltd) at 20 mg/kg was given intravenously every 90 minutes.

The concentration of end-tidal isoflurane (ET iso) and end-tidal carbon dioxide ($ETCO_2$) (Capnomac ultima, Datex Instrumentarium Corp.), respiratory rate, oscillometric blood pressure measurement (Cardell Veterinary Monitor 9402 BP/SpO_2, Sharn Veterinary Inc.), heart rate and rhythm, pulse oximetry (SpO_2, the probe attached to the tongue) (Minimon 7138 plus, Kontron Instruments Ltd) and oesophageal temperature (Minimon 7138 plus, Kontron Instruments Ltd) were monitored during anaesthesia. Attempts to place an arterial catheter for direct blood pressure measurement were unsuccessful. ET iso was 0.8% throughout the anaesthesia, apart from the first 25 minutes, when the ET iso concentration ranged between 1.0 and 1.3% and during jet ventilation when the isoflurane vaporizer was turned off. To treat intraoperative hypotension (mean arterial pressure < 60 mmHg), the cat received hetastarch solution (Voluven, Fresenius Kabi Limited), three 5 ml/kg boluses; total volume 15 ml/kg, and dobutamine CRI (Dobutamine 12.5 mg/ml, Hospira UK Limited) at 2 µg/kg/min intravenously. Mean arterial blood pressure (MAP) was 37–60 mmHg before dobutamine and 48–78 mmHg after dobutamine was started. A right lateral thoracotomy was performed through the 6th intercostal space.

Initially, positive pressure ventilation was successful, but during

FIGURE 1 KUVA

Jet ventilator with a paediatric feeding tube attached.

Jet-ventilaattori, johon on kiinnitetty ohut ruokintaletku.

FIGURE 2 KUVA

Jet ventilator close-up. Feeding tube not attached.

Lähikuva jet-ventilaattorista. Ruokintaletku ventilaattorin vieressä.

surgery the foreign body suddenly moved, completely occluding the trachea and obstructing gas exchange. At this point the isoflurane vaporizer was turned off and an emergency tracheotomy was performed just cranial to the carina (distal to the foreign body). The surgeon unsuccessfully tried to intubate the left mainstem bronchus through the operation field using a sterile endotracheal tube. A sterile 5-French paediatric feeding tube (Vygon) was then advanced through the tracheotomy site into the right mainstem bronchus and connected to a manual jet ventilator (Manujet III, VBM Medizintechnik GmbH), allowing the right lung to be ventilated, while the tracheal incision acted as a pathway for exhalation. Intermittent manual low-frequency (15 breaths/min) jet ventilation was continued for 20 minutes with 100% oxygen until the foreign body was removed. During this period anaesthesia was maintained with ketamine CRI at 20 µg/kg/min. Adequacy of ventilation was judged by observing the chest movement, lung expansion and SpO_2.

$ETCO_2$ remained low (3.0–4.5 kPa) throughout anaesthesia; it was especially low (2.0–2.5 kPa) during one-lung manual jet ventilation. SpO_2 was maintained at 95–98% except during jet ventilation, when it decreased to 93–95%. During surgery the cat's body temperature was maintained with a water-circulating heating pad (Gaymar T/PUMP, Gaymar Industries Inc.) and a forced-air warming blanket (Cocoon™ convective warming system, Care Essentials PTY Ltd); oesophageal temperature ranged from 35.2 °C to 35.8 °C. When the trachea was sutured, manual jet ventilation was replaced by regular IPPV, the isoflurane vaporizer was turned back on and ketamine CRI decreased to 5 µg/kg/min.

When surgery was completed, isoflurane was turned off, but the ketamine infusion was continued. However, the cat recovered very slowly, and 1 hour later the ketamine infusion was stopped in order to speed up the recovery. The cat was extubated 110 min after isoflurane anaesthesia ended (50 minutes after ketamine infusion stopped). The surgery lasted 100 min and anaesthesia 135 min. Postoperative analgesia was provided with bupivacaine (Marcain Polyamp Steripack 0.5%, AstraZeneca UK Ltd) at 1 mg/kg as an intercostal block, ketamine CRI 2.5–5 µg/kg/min as needed, fentanyl patch (Durogesic DTrans 25 micrograms/hour, Janssen-Cilag Ltd) 25 µg/h, partially covered and bupivacaine at 1 mg/kg injected into chest drain (Vygon PCV 12-French thoracic drain) every 5 hours until the drain was removed. No non-steroidal anti-inflammatory drugs (NSAIDs) were given as the cat had received dexamethasone from the referring veterinarian. The cat had neurological deficits after recovery from surgery, but they resolved progressively during the following days, and the cat appeared neurologically normal at the time of discharge from the hospital 5 days after the operation. On the recheck 11 days later the cat was doing well.

Case 2

Case 2 involved a 3-year-old female cat, weighing 3.9 kg. It was referred to the UVH with a 2-day history of acute onset respiratory difficulty. Radiographs taken by the referring veterinarian revealed the presence of an intra-luminal tracheal broad-based mass at the level of the 4th intercostal space. Physical examination was incomplete due to severe inspiratory and expiratory dyspnoea. The cat was anaesthetised for removal of the mass.

Anaesthesia was induced with propofol (Rapinovet 10 mg/ml, Schering-Plough Animal Health) given to effect (6.4 mg/kg) and fentanyl (Sublimaze 50 µg/ml, Janssen-Cilag Ltd) at 5 µg/kg intravenously. The trachea was intubated with a size 4.5 mm, cuffed endotracheal tube, and connected to 100% oxygen (2.5–3 l/min) via an Ayres T-piece. The distal tip of the tube was positioned cranial to the mass. The cat was mechanically ventilated throughout anaesthesia (SAV03, Vetronic services Ltd) to maintain $ETCO_2$ between 4.5 and 6.5 kPa. Anaesthesia was maintained with propofol CRI (initially 0.21 mg/kg/min; towards the end of surgery it was decreased to 0.17 mg/kg/min) and fentanyl CRI (initially 0.36 µg/kg/min, increased to 0.4 µg/kg/min).

No NSAIDs were given perioperatively because the cat had received dexamethasone from the referring veterinarian. Intravenous fluids (CSL) were administered at 8.5 ml/kg/h throughout anaesthesia; amoxicillin-clavulanic acid at 20 mg/kg was administered every 90 minutes intravenously. To treat intraoperative bradycardia (heart rate < 100 beats/min), the cat received glycopyrrolate (Robinul 200 micrograms/ml, Anpharm Limited) at 5 µg/kg intravenously.

Parameters monitored during anaesthesia were as in case 1, except that blood pressure was monitored directly via an arterial catheter in the dorsal pedal artery (Edwards Lifesciences GmbH). MAP remained between 60 and 100 mmHg and SpO_2 was over 95% during the whole anaesthetic period. Intraoperative oesophageal temperature ranged from 33.0 to 37.2 °C, increasing towards the end of anaesthesia.

A right lateral thoracotomy was performed through the 4th intercostal space. When the trachea was incised distal to the mass, a sterile 3.5 mm endotracheal tube was

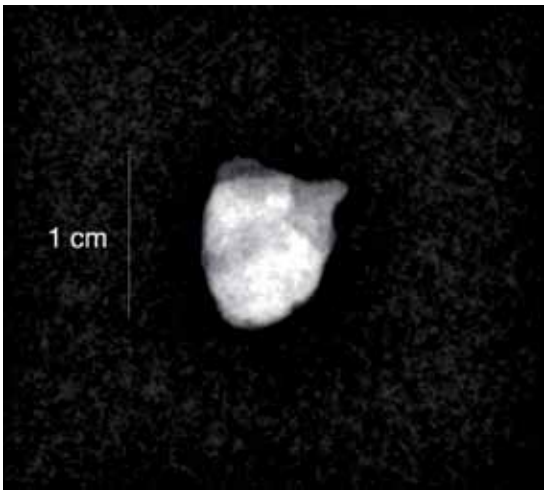

FIGURE 3 KUVA

The foreign body removed from case 1. It appears to be either a stone or a mineralised particle of unknown origin.

Ensimmäisestä kissasta poistettu vierasesine. Esine on todennäköisesti joko kivi tai mineralisoitunut tuntematon kappale.

inserted into the tracheal opening through the operation field and the cuff inflated. Ventilation was continued through this tube. Five tracheal rings were removed together with the mass. Once the resection was completed, the distal endotracheal tube was removed and the oral tube was advanced past the resected area into the distal trachea and the cuff inflated. Tracheal end-to-end anastomosis was then performed, after which the endotracheal tube was withdrawn proximal to the anastomosis. Arterial blood gases measured after the trachea was sutured were normal.

Fentanyl CRI was stopped 30 minutes before the end of surgery, and propofol CRI when the surgery was completed. The cat was extubated 60 minutes later. The surgery lasted 140 min and the anaesthesia 235 min. Postoperative analgesia was provided with bupivacaine at 1 mg/kg as an intercostal block and injected into chest drain (Vygon 12-Fr) every 5 hours until the drain was removed. In addition, a fentanyl patch (25 µg/h) was applied and morphine administered at 0.2 mg/kg slowly intravenously at the end of anaesthesia, followed by morphine at 0.1 mg/kg intramuscularly every 4 hours until the fentanyl patch was working. On the following day the cat received meloxicam (Loxicom 5 mg/ml, Norbrook Laboratories Limited), which was continued for 7 days. The cat was discharged 3 days after surgery. Microscopic examination of the tracheal mass revealed features characteristic of a round cell sarcoma. Three weeks after the surgery the owner reported that the cat was doing well.

DISCUSSION

A surgical procedure involving the trachea poses unique problems for the anaesthetist: the surgeon needs free access to the surgical field, while the anaesthetist must ensure that the patient is adequately ventilated and oxygenated despite an airway which is open to the atmosphere.[1-8] Several approaches to anaesthetic management have been described both in medical and veterinary literature, including standard orotracheal intubation, sterile intubation through the operation field distal to the tracheal incision, jet ventilation, one-lung ventilation (OLV) and cardiopulmonary bypass.[3-6,9-12] The anaesthetist needs to be well prepared to ventilate the patient with more than just one method in case the operation does not go as planned.

In case 1, difficulties with ventilation and oxygenation were anticipated as the cat was severely dyspnoeic due to the foreign body in the tracheal lumen. Initially, IPPV was easy and oxygenation, as judged by SpO_2 level, was adequate. However, during the surgery the foreign body moved, acting as a ball valve, causing complete obstruction. An attempt to perform a sterile through-the-operation-field intubation failed, and before manual one-lung jet ventilation was established, the cat had become mildly hypoxaemic. Hypoxaemia was suspected, because SpO_2 decreased to 93% (corresponding to PaO_2 of approximately 8 kPa). Moreover, the cat displayed neurological deficits after recovery, although they later resolved. Set up of the one-lung jet ventilation required a few minutes, despite the fact that the anaesthetist had the jet ventilator and sterile paediatric feeding tube prepared for such a situation. The SpO_2 was mildly subnormal during jet ventilation; this could represent inadequate oxygenation due to one-lung ventilation and a greater intrapulmonary shunt fraction.[13,14] Unfortunately arterial blood gases were not available to confirm the extent of this problem.

$ETCO_2$ of case 1 was low throughout the anaesthesia, possibly indicating hypothermia,[15,16] decreased cardiac output,[15,17] hyperventilation,[10,15] fresh gas sample dilution during low tidal volume ventilation[10] or increased alveolar dead space ventilation and ventilation-perfusion mismatch due to OLV. However, the effect of OLV on $ETCO_2$ is only transient.[18] The cat in case 1 was mildly hypothermic throughout anaesthesia despite two warming blankets; also MAP, as monitored non-invasively, was low during a good part of the anaesthesia. These subnormal values together with a short period of OLV may have contributed to the low $ETCO_2$. In case 1 however, it is also possible that the cat was hyperventilated throughout the

anaesthesia as no arterial blood gases were measured. MAP of the cat 1 was low despite colloid boluses and dobutamine CRI, improving only towards the end of the surgery. This could represent true hypotension, which could potentially have some effect on $ETCO_2$. The blood pressure was measured with an oscillometric device, which in cats may underestimate arterial pressure.[19,20] The accuracy of an automated oscillometric blood pressure monitor depends in general on the placement, width and tightness of the cuff.[20,21] In retrospect, it would probably have been better to monitor the blood pressure with a Doppler ultrasonic method, as it is considered more reliable in cats than oscillometric method.[20]

Most of the literature discussing jet ventilation describes the use of high-frequency jet ventilation (HFJV) in tracheal surgery; however two authors[2,24] have published case reports where manual low-frequency jet ventilation (LFJV) has been successfully used in human patients undergoing tracheal procedures. HFJV is a form of artificial respiration, which utilizes a ventilation rate that is much higher than physiological at tidal volumes equal or lower than the anatomical dead space.[22] This results in low peak airway pressure decreasing the occurrence of barotrauma.[23] LFJV on the other hand utilizes lower respiratory rates and higher peak airway pressure than the HFJV. However, if during LFJV the airway is open to the atmosphere so that the cross-sectional area for passive exhalation is large enough to prevent air trapping and increased expiratory resistance, it should attenuate the jet and minimize the risk of barotrauma and lung hyperinflation.[24] It has been recommended to monitor airway pressure during jet ventilation to detect elevated pressures due to expiratory flow obstruction.[2,4,25] but in this case it was not monitored. Instead, observation of chest movement and lung inflation through the surgical incision were used to assess adequate pulmonary filling and emptying.

In case 2, conventional orotracheal intubation was first performed with a cuffed endotracheal tube. The tube was slightly longer than normal in order to later advance it past the tracheal resection site. After discussions with the surgeon, a decision was made to intubate the cat with a sterile endotracheal tube through the operation field, distal to the mass, once the tracheal incision was made. Distal tracheal intubation has been described in the literature,[6,26] and although it makes ventilation quite easy, it has been criticized for not granting optimal surgical access or visualization of the tracheal circumference.[3,12] In this case the working conditions were adequate for the surgeon, and although preparations were made, it was not necessary to switch to jet ventilation. With this method the patient's pulmonary gas exchange and oxygenation were well maintained, as judged by $ETCO_2$, SpO_2 and arterial blood gases.

The cat in case 2 had a stable blood pressure throughout the anaesthesia. The arterial blood pressure was monitored with an invasive technique. Although direct blood pressure measurement carries its own potential for error,[27] it is considered the standard method to which other methods are compared.[19] It is possible that the blood pressure remained stable due to the anaesthetic agents given. In an experimental study on cats, the values for MAP were higher during propofol infusion than those obtained during isoflurane-only anaesthesia.[28] In one study,[34] arterial blood pressure of cats anaesthetised with infusions of propofol and fentanyl was better maintained than the blood pressure of cats anaesthetised with the combination of isoflurane and fentanyl.

The only problem observed during the anaesthesia in case 2 was relative bradycardia. Bradycardia seen in this case was most likely caused by fentanyl, as it started soon after the fentanyl loading dose was given and continued until the fentanyl infusion was stopped. Fentanyl has a negative chronotropic action on the heart, which is believed to be vagally mediated.[29] In addition, fentanyl given together with propofol may have further exacerbated the bradycardia, as propofol alone can induce bradycardia.[30,31] One experimental study reported that concomitant administration of a fentanyl infusion did not further decrease the heart rate of cats anaesthetised with propofol infusion.[31] However, the infusion rate of fentanyl was one third of the rate in our case 2. The bradycardia of case 2 was treated with glycopyrrolate due to its prolonged action compared to atropine.[32] We preferred the prolonged effect of glycopyrrolate as the bradycardia observed in this case was most likely due to the negative chronotropic action of fentanyl CRI rather than acute vagal stimulation. Glycopyrrolate was repeated four times during the surgery when the heart rate decreased below 100 beats/min.

Severe respiratory distress can cause the patient to deteriorate rapidly and lead to respiratory and cardiac arrest. Handling of a dyspnoeic animal induces stress and anxiety that can precipitate a crisis, and immediate anaesthesia (without premedication) may be necessary. The induction agent should be rapidly acting and safe. The induction techniques used in our cats have been recommended for anaesthetising emergency patients with upper airway obstruc-

tion.[33] Although the onset time of ketamine (up to 2 minutes) may be considered a little long for a respiratory emergency, both techniques provided excellent conditions for intubation.

For both cases, total intravenous anaesthesia (TIVA) was chosen, either for the short period when the trachea was open to the atmosphere (case 1) or for the whole length of anaesthesia (case 2). TIVA refers to maintenance of anaesthesia with intravenous drugs only, without the use of inhalation anaesthesia. Anaesthetic management of patients undergoing open tracheal surgery mandates an intravenous technique to prevent exposure of operation room staff to waste gases. In addition leakage will result in inconsistent alveolar concentration, whereas continuous infusion of intravenous anaesthetic drugs results in a stable plane of anaesthesia with little variation in the plasma levels.

The cat in case 1 received ketamine infusion as an adjunct to inhalation anaesthesia to decrease minimum alveolar concentration (MAC) of isoflurane, and to provide analgesia. Pascoe et al[34] reported that a ketamine CRI dose of 23 µg/kg/min resulted in 45 ± 17% reduction in the MAC of isoflurane in cats. Their dose of ketamine was twice as high as the dose administered in case 1, but the reduction in the MAC of isoflurane was similar in magnitude. Cats in that study received ketamine and isoflurane anaesthesia for a prolonged period (over 12 hours) with an increasing ketamine dose, and as a consequence recovered slowly.[34] Our patient also recovered relatively slowly, requiring nearly 2 hours from the end of inhalation anaesthesia until extubation.

The infusion rate of propofol in case 2 was based on clinical and experimental data obtained from previous studies in cats,[28,31,35-37] alone or together with fentanyl. The fentanyl infusion rate has been previously given to client-owned cats together with propofol or isoflurane.[35] Maintenance of anaesthesia with the above-mentioned combination of propofol and fentanyl was stable. However, recovery was delayed. In retrospect, the propofol infusion should probably have been stopped before the surgery ended. One author[37] reported significant delays in recovery times when cats were anaesthetised with a 150-minute infusion of propofol. Average infusion rates used in the study were similar to the one used in this case report.

Both cats received bupivacaine intercostal nerve blocks at the end of surgery and bupivacaine interpleural instillation for postoperative analgesia. In addition, they received 25 µg/h transdermal fentanyl patches. One author[38] recommends using partial exposure of the patch in small cats, as was done in case 1. Another author[39] reported significant decreases in plasma fentanyl concentration in cats with partial exposure of the patch. In cats undergoing ovariohysterectomy, no significant differences in subjective pain assessments were observed between full and partial exposure to a 25 µg/h transdermal fentanyl patch.[39] However, this reduced dosing might not be sufficient for a cat recovering from thoracotomy. Therapeutic plasma concentration of fentanyl is reached in 12–18 hours in cats.[39,40] Until then both cats in this case report received additional analgesia. NSAIDs were withheld perioperatively because both cats had received corticosteroids.[41] Additional analgesia could have been provided with an epidural injection of morphine. Both cats appeared comfortable postoperatively although no epidural analgesia was given.

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