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Surgical Management of Intrathoracic Tracheal Avulsion in Cats: Long-Term Results in 9 Consecutive Cases

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Objective—To evaluate the outcomes and complications in a consecutive series of cats undergoing surgical repair of intrathoracic tracheal avulsion injuries.
Study Design—Retrospective clinical study.
Animals—Nine client-owned cats.
Methods—The medical records of all cats undergoing surgical repair of intrathoracic tracheal avulsion injuries from 1994 to 1997 were reviewed. The results of physical examination, laboratory evaluations, radiography, tracheoscopy, surgery, and patient follow-up were reviewed. Complications that arose and long-term outcome were noted.
Results—Long-term resolution of clinical signs was achieved in all cats after resection of the damaged trachea and its repair by end-to-end anastomosis. Follow-up periods ranged from 12 months to 2.9 years. One cat developed unilateral left-sided laryngeal paralysis 2 to 3 months after surgery; however, this was transient and resolved without intervention within 6 months of surgery.
Conclusions—Surgical management of intrathoracic tracheal avulsion injuries in cats can be accomplished via a right lateral thoracotomy. Careful anesthetic technique is an integral part of the surgical procedure if a successful outcome is to be achieved. The incidence of both short-term and long-term complications was low. Care should be exercised to visualize and protect the left recurrent laryngeal nerve if postoperative iatrogenic unilateral left-sided laryngeal paralysis is to be prevented.
Clinical Relevance—This retrospective study documents the successful surgical correction of a series of clinical cases of intrathoracic tracheal avulsion in cats.

TRACHEAL AVULSION in cats has been reported sporadically in the veterinary literature.[1-9] The condition is considered a result of a blunt traumatic incident to the neck or thorax or both which probably includes a hyperextension injury of the head and neck. This stretches the trachea and ruptures it intrathoracically at a position 1 to 4 cm cranial to its bifurcation.[1-3,6,8-11]

After the avulsion injury, the airway lumen is thought to be maintained by either intact tracheal adventitia[1] or by thickening of mediastinal tissue leading to the development of a pseudotrachea[2] or pseudoairway.[8] Rupture and avulsion of the trachea results in stenosis of the lumen at both ends of the injury.[6,8] This could account for the delay in clinical signs associated with airway obstruction observed in some individuals.[8,10] Definitive therapy consists of resection of the stenosed ends of the injured trachea and subsequent repair by anastomosis.[8-11] This report describes 9 consecutive cases of intrathoracic tracheal avulsion in cats in which the injuries were surgically repaired.

MATERIALS AND METHODS

Case records from all cats with intrathoracic tracheal avulsion injuries seen by the authors covering a period from

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1994 through 1997 were reviewed. In all cases, diagnostic evaluation included a complete physical examination including thoracic auscultation, routine hematology and biochemistry profiles, FeLV and FIV status assessment, and survey lateral and dorsoventral radiographic views of the thorax. Tracheoscopy was performed in 4 cats to confirm the suspected diagnosis of tracheal avulsion.

Surgical Technique

The surgical technique has been previously described by White and Milner.[8] Briefly, all cats were premedicated with acepromazine (0.03 mg/kg) and meperidine (4 mg/kg), both administered intramuscularly, and atropine (0.04 mg/kg) administered subcutaneously. Anesthesia was induced with thiopental, and maintenance was achieved with halothane in an oxygen/nitrous oxide carrier gas. In the majority of cats, muscle relaxation was achieved by using pancuronium 0.06 mg/kg intravenously as part of the anesthetic regime.

Surgical repair of the intrathoracic trachea was accomplished via either a 3rd or a 4th right intercostal space lateral thoracotomy. All cats were intubated with an uncuffed endotracheal tube and, once the pleural cavity was entered, respiration was maintained with manually performed intermittent positive pressure ventilation (IPPV). The pseudoairway was recognized (Fig 1) and entered, which allowed the stenosed distal tracheal opening to be observed. The distal stenosed tracheal segment was quickly transected, leaving a grossly healthy distal tracheal segment into which a sterile cuffed endotracheal tube was placed via the thoracotomy incision (Fig 2). The transection was performed through the annular ligament between 2 adjacent tracheal rings in an area of grossly normal trachea as close to the stenosed segment as possible. This allowed IPPV to be continued and kept the period of ineffective ventilation to a minimum. The stenosed proximal portion of trachea was then transected. This allowed the originally placed uncuffed endotracheal tube to be advanced into the distal tracheal segment after the removal of the second distal endotracheal tube. Three or four 4-0 polydioxanone traction sutures were preplaced in the proximal and distal tracheal segments to approximate and align the trachea. Manipulation of these traction sutures allowed the trachea to be rotated about its long axis so that sutures could be placed into the blind left wall of the tracheal anastomosis. Additional simple interrupted 4-0 polydioxanone sutures were placed either through or around the cartilaginous rings adjacent to the incision. Similarly, 2 or 3 simple interrupted sutures were placed through the trachealis muscle to appose the dorsal portion of the anastomosis. No additional tension-relieving sutures were placed in any of the cats. Care was taken during the surgical repair to recognize and protect the vagus nerve, both recurrent laryngeal nerves, the esophagus, and the cranial vena cava. Once anastomosis was complete, the site was lavaged with warm sterile saline to ensure an airtight seal.

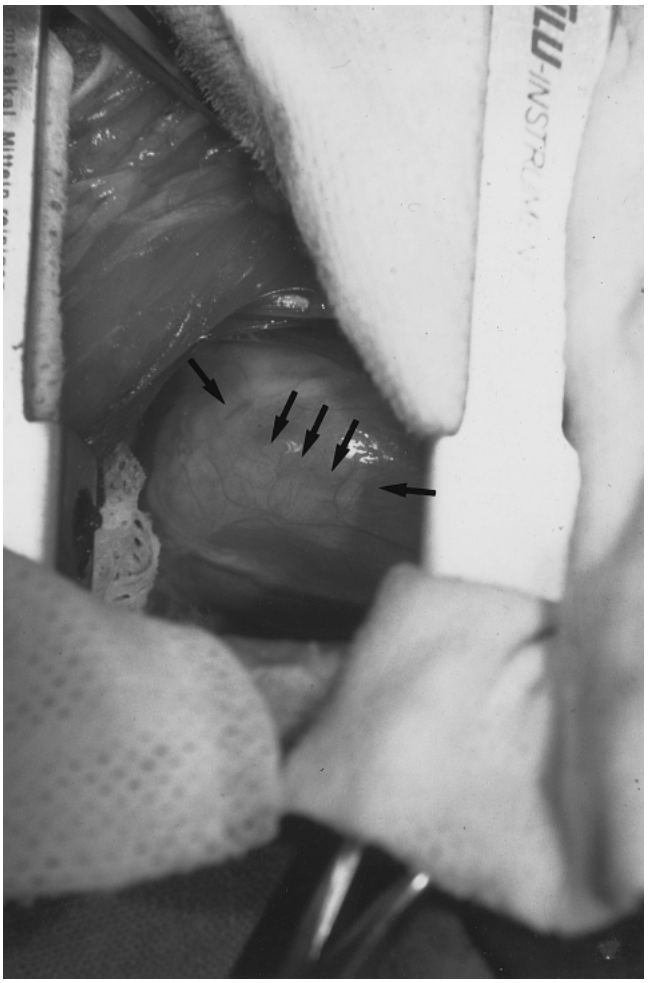

Fig 1. Surgical exposure of the pseudoairway (arrows) via a right 4th intercostal space lateral thoracotomy in case 7.

Any intraluminal tracheal secretions were aspirated by suction. A thoracic drain was placed, a bupivacaine local anesthetic intercostal nerve block was administered, and the thoracotomy incision was closed routinely. Any residual neuromuscular blockade was reversed with the intravenous administration of neostigmine (0.05 mg/kg).

A single intravenous dose of ampicillin (10 mg/kg) was administered to all the cats perioperatively and was continued orally for an additional 5 days. Additional analgesia using either pethidine (4 mg/kg, every 3 hours) intramuscularly or carprofen (4 mg/kg, once daily) subcutaneously was administered as required during this postoperative period. Thoracic drains were removed between 12 and 24 hours postoperatively.

Follow-up

The majority of cats were examined 2 to 3 months after surgery. Evaluation included a survey lateral thoracic radiograph and tracheoscopy. Progress thereafter was monitored

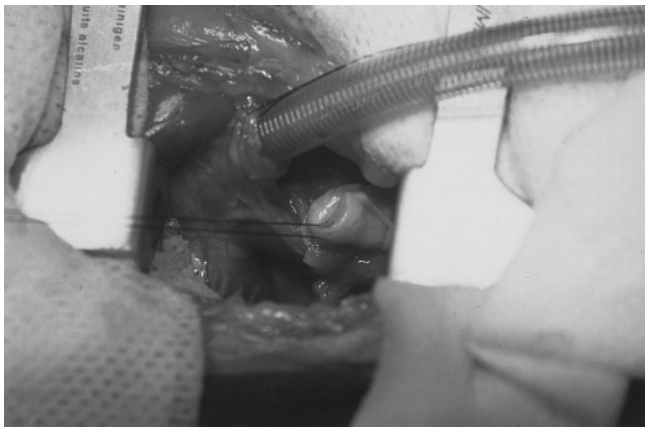

Fig 2. Surgical exposure of case 7. The pseudoairway has been entered, the distal stenosed tracheal segment has been resected, and a sterile cuffed endotracheal tube has been placed. The stenosed proximal portion of trachea is being held with a traction suture.

by telephone contact with both the referring veterinarian and the owner for a minimum period of 12 months. The veterinarians and owners were asked to comment on the animals' respiratory status and on any recurrence of the initial presenting signs.

RESULTS

All cats were presented to the referring veterinarian for the investigation of respiratory clinical signs. Nine cats, ranging in age from 11 months to 7 years (mean, 3 years), were included in the study. The signalment and clinical details for these cats are listed in Table 1. In all cats, the presenting clinical signs included dyspnea, exercise intolerance, and exertional respiratory distress. No other respiratory, cardiovascular, or neurologic abnormalities were identified on physical examination. Seven cats presented with a known cause for the injury. Only 1 of these cats (case 4) was presented to the referring veterinarian within 24 hours of the traumatic episode. The 6 remaining cats with a known cause were presented between 1 and 3 weeks after the injury. No abnormalities were detected in hematologic or biochemical screens, and all cats were FeLV and FIV negative.

Radiographs of cat 4, which had an acute presentation, showed pneumomediastinum and focal intrathoracic tracheal disruption at the level of the 4th intercostal space on the lateral projection. In all the remaining cases, thoracic radiographs revealed evidence of a well-defined spherical dilation at the level of the tracheal rupture with no evidence of a pneumomediastinum (Fig 3). In all cats, the tracheal ruptures occurred at the level of the 2nd, 3rd, or 4th thoracic vertebra. No individuals showed radiographic evidence of either pulmonary contusions or pneumothorax.

In cat 4, tracheoscopy showed circumferential tracheal ring disruption within the intrathoracic tracheal segment. The tracheal disruption prevented further distal advancement of the endoscope into the distal tracheal segment. The degree of luminal compromise was at least 75%.

In all the remaining cats in which tracheoscopy was performed (cases 3, 5, 6), a marked tracheal stenosis was observed at the avulsed proximal tracheal segment. The stenosis was such that further distal passage of the endoscope into the pseudoairway and the distal tracheal segment was not possible. Again, the degree of luminal compromise was at least 75%.

Table 1. Clinical Data for 9 Cats Undergoing Surgical Repair of Tracheal Avulsion Injuries

No.	Breed	Age (yr)	Sex	Cause	Duration of Injury (d)	Lateral Thoracic Radiographic Findings	Follow-up Period (mo)	Postoperative Complications
1	Bengal	1	ME	RTA	7	Pseudotrachea	35	None
2	DSH	3	FN	Unknown	Unknown	Pseudotrachea	24	None
3	Siamese	3	MN	Fell from tree	10	Pseudotrachea	23	None initially. Left-sided laryngeal paralysis confirmed at 3 mo. Clinically normal at 17 mo after surgery.
4	DSH	7	FN	RTA	1	Pneumomediastinum, focal tracheal disruption at 4th intercostal space	18	None
5	DLH	5	FN	Unknown	Unknown	Pseudotrachea	16	None
6	Burmese	1.5	FN	RTA	11	Pseudotrachea	12	None
7	DSH	11 mo	F	RTA	21	Pseudotrachea	24	None
8	DSH	5.5	FN	RTA	14	Pseudotrachea	14	None
9	DSH	1	MN	RTA	14	Pseudotrachea	15	None

Abbreviations: DLH, domestic longhair; DSH, domestic shorthair; FN, neutered female; ME, entire male; MN, neutered male; RTA, road traffic accident.

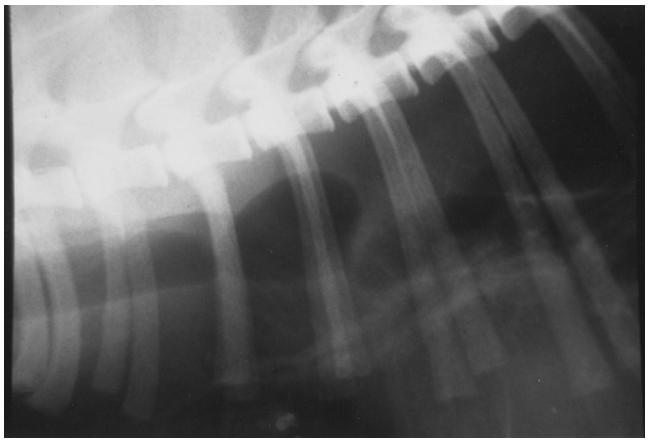

Fig 3. Lateral thoracic radiograph of case 6 showing a gas-filled spherical pseudoairway at the level of 3rd intercostal space.

The pseudotrachea was immediately recognizable in the majority of cats after reflecting the right cranial lung lobe from the surgical field (Fig 1). The pseudotrachea was grossly part of, and contained within, the cranial mediastinum. Incision into the pseudoairway allowed the proximal and distal stenosed tracheal openings to be observed. These structures were both relatively mobile within the mediastinum, which allowed their transection with minimal peritracheal dissection (Fig 2). In cat 4, the focal tracheal disruption was observed after blunt dissection of the peritracheal tissues of the cranial mediastinum. Local peritracheal adhesions made this dissection procedure more difficult in this individual than in the cats with a pseudotrachea. In all cats, the surgical procedure resulted in the resection of between 4 and 8 tracheal rings.

All the cats made a complete recovery from the repair procedure. Six of the cats (cases 1, 3-6, 9) were reexamined between 2 and 3 months after surgery. Lateral thoracic radiographs were considered unremarkable in all 6 cases (Fig 4). Tracheoscopy revealed no evidence of tracheal stenosis at the anastomosis site in any of these 6 cats (Fig 5). Intraluminal suture material was still evident at the anastomosis site in all cats endoscopically examined at this time.

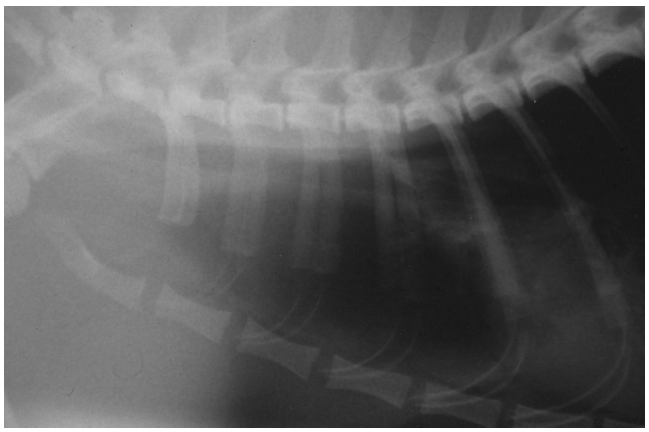

Fig 4. Follow-up (2 months after surgery) lateral radiograph of case 6 showing no apparent tracheal abnormalities.

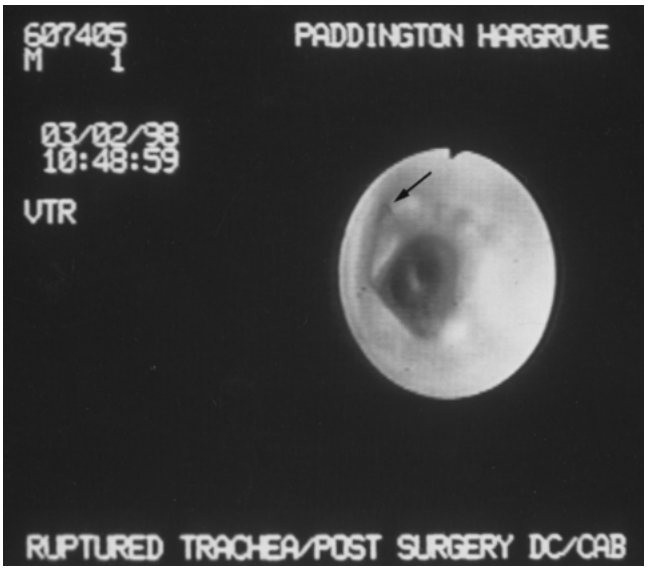

Fig 5. Follow-up (2 months after surgery) tracheal endoscopy of case 6 showing the surgical site. Although there is a mild degree of tracheal ring disruption, there is no evidence of tracheal stenosis. Dorsolaterally there is evidence of intraluminal suture material (arrow).

Reexamination and telephone survey revealed that 8 cats had no complications arising from the surgery, and no respiratory signs were reported during the follow-up period (range, 12 months to 2.9 years; mean, 1.7 years). One cat (case 3) developed exercise-related respiratory embarrassment and stridor 2 months after surgery. Endoscopic reexamination of the cat 3 months after surgery confirmed a left-sided laryngeal paralysis. The cat was managed conservatively and was reported clinically normal at 17 months after surgery. At 23 months after the surgery, the cat was still reported to be clinically normal. Long-term surgical results were assessed as excellent in all cats.

DISCUSSION

In this series of 9 consecutive cases of intrathoracic tracheal avulsion in cats, the tracheal rupture occurred intrathoracically at the level of the 2nd, 3rd, or 4th thoracic spine. These findings are in agreement with previous reports.[1-9] The underlying cause of tracheal

avulsion injuries in cats remains speculative, although the injury appears to produce 2 distinct clinical presentations.[8] The first is an acute onset dyspnea and respiratory compromise which occurs almost immediately after the tracheal injury. The second presentation is a more chronic onset dyspnea, exercise intolerance, and exertional respiratory distress which becomes significant some days to weeks after the traumatic episode. The respiratory distress in these individuals is associated with the severe circumferential luminal stenosis of the proximal and distal ends of the trachea at the site of rupture. All of the cats that presented chronically (cases 1-3, 5-9) showed a well-defined pseudoairway which was represented radiographically as a spherical dilation at the level of the tracheal rupture. None of the chronic presentation cats showed radiographic evidence of a pneumomediastinum. A concurrent pneumomediastinum was documented in 1 cat (case 4) in this study. This cat showed an acute clinical presentation. Only 1 other cat has been reported with a tracheal avulsion injury and concurrent pneumomediastinum, and the clinical history in this case was similarly acute in nature.[9] In fact, this case showed a resolution in the pneumomediastinum before the development of a pseudoairway. We propose that the presence of a pseudoairway denotes chronicity of the tracheal avulsion injury. We further propose that formation of circumferential luminal stenosis at both the proximal and distal ends of the rupture site produces a nonlaminar airflow through the trachea at the site of the avulsion injury. This turbulent airflow may result in changes in airway pressures at the level of the avulsion, leading to the formation of the characteristic pseudoairway. It may prove difficult to confirm this proposal without performing studies to measure the airflow and pressures within the affected trachea of clinical cases.

Proposed causes for the avulsion injury include blunt trauma to the neck and/or thorax which includes an overextension injury to the neck.[11] In all cases reviewed in this study, the tracheal avulsion lesion occurred in the cranial thorax. Because the intrathoracic trachea is afforded some protection by the thoracic wall, it is possible that the intrathoracic tracheal wall is most likely to rupture when exposed to luminal and longitudinal traction. The authors propose that the avulsion injury is caused by a sudden, dramatic increase in tracheal intraluminal pressure (produced when the abdomen or thorax are compressed and the glottis is closed) in combination with a whiplash extension injury to the neck. Although an hypothesis such as this may explain the production of the tracheal avulsion injury, the absence of other respiratory, neurologic, or cardiovascular injuries in any of the cats in this study remains somewhat surprising.

Various anesthetic techniques have been described for the management of cats with tracheal avulsion injuries.[6-9] The technique described in this series of cases is relatively simple and does not require any expensive equipment. It proved effective, reliable, and safe for the management of all 9 consecutive cases of intrathoracic tracheal avulsion injury. Griffiths et al[9] described forcing a narrow endotracheal tube blindly across the tracheal rupture and pseudoairway to obtain a "bridged" endotracheal airway. The degree of stenosis encountered in the majority of the chronic cases seen in this study would prevent this bridging intubation technique from being performed without an undue risk of pseudoairway rupture or failed distal tracheal intubation. Therefore, we do not believe this procedure is suitable for the majority of avulsion injuries encountered, and it should only be undertaken with extreme caution. We believe that the use of muscle relaxants as part of the anesthetic protocol is a matter of personal preference. Maintenance of an adequate depth of anesthesia should be considered important not only in preventing the perception of pain, but also in helping to abolish any cough reflex that could be initiated on transection of the tracheal ends. During the tracheal resection procedure, an adequate depth of anesthesia may be achieved very effectively by using an anesthetic regime that does not include a muscle relaxant.

The surgical approach via a right 3rd or 4th intercostal space thoracotomy allowed good access for the repair procedure. Resection of between 4 and 8 tracheal cartilages allowed anastomosis without excessive tension. The surgical techniques available for tracheal anastomosis in the dog have been previously investigated and reviewed.[12,13] To our knowledge, there are no equivalent studies available for the cat. In the dog it is suggested that although a simple continuous suture technique is more rapidly performed, it results in greater anastomotic stenosis compared with a simple interrupted technique.[13] In the cats in this study, a simple interrupted suture pattern was used. Three or 4 sutures were preplaced and utilized as traction sutures. Manipulation of these rotated the trachea about its long axis, allowing additional interrupted sutures to be placed in the blind left wall of the tracheal anastomosis. This technique negated the requirement of additional tag suture placement described

by Fingland et al for the approximation of the proximal and distal tracheal segments.[13] Suture material was clearly evident within the tracheal lumen in all individuals endoscoped between 2 and 3 months after surgery.

The fact that 1 cat (case 6) developed left-sided unilateral laryngeal paralysis after surgery highlights the possibility of iatrogenic damage to the recurrent laryngeal nerves. The delayed onset of the laryngeal paralysis in this cat may suggest that the damage to the nerve resulted after surgery. It is possible that the polydioxanone sutures used to repair the anastomosis on the left side may have been in contact with the recurrent laryngeal nerve, leading to the development of the paralysis. Intraoperative iatrogenic trauma to the nerves is also a potential problem. Right-sided laryngeal paralysis is less likely to be induced, because the right recurrent laryngeal nerve passes from the right vagus nerve and around the right subclavian artery at an anatomic position that is cranial to this tracheal anastomosis site. Successful surgery for laryngeal paralysis in the cat has been reported,[14] but the resulting respiratory compromise seen in this case was considered insufficient to warrant surgical intervention. The spontaneous recovery from paralysis without intervention may have been associated with the complete absorption of the suture material by 6 months after surgery.

Fingland et al[13] also concluded that radiography was a poor technique for assessment the of anastomosis cross-sectional area. In this study, radiographic and endoscopy findings were in agreement, because none of the cats evaluated showed evidence of postoperative tracheal stenosis. Therefore, it was not possible to compare these 2 techniques for the assessment of postoperative tracheal stenosis.

CONCLUSION

Surgical management of intrathoracic tracheal avulsion injuries in cats can be readily accomplished via a right lateral thoracotomy. Careful anesthetic technique should be considered an integral part of the surgical procedure if a successful outcome is to be achieved. The intrathoracic tracheal resection and anastomosis technique performed appears to be associated with few short- or long-term complications. Care should be exercised to visualize and protect the left recurrent laryngeal nerve if postoperative iatrogenic unilateral laryngeal paralysis is to be prevented.

ADDENDUM

Since the time of writing, we have used the surgical procedure described to successfully manage similar intrathoracic tracheal avulsion injuries in 3 additional cats.

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