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TITLE: Intraoperative and major postoperative complications and survival of dogs undergoing surgical management of epiglottic retroversion: 50 dogs (2003-2017)

AUTHORS: Mullins, R A; Stanley, B J; Flanders, J A; López, P P; Collivignarelli, F; Doyle, R S; Schuenemann, R; Oechtering, G; Steffey, M A; Lipscomb, V J; Hardie, R J; Kirby, B M; McAlinden, A B

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- 1 Surgical management of epiglottic retroversion
- 2
- 3 Intraoperative and major postoperative complications and survival of dogs undergoing surgical
- 4 management of epiglottic retroversion: 50 dogs (2003–2017)
- 5
- 6 Ronan A. Mullins, MVB¹
- 7 Bryden J. Stanley, BVMS, MVETSc, MACVSc, DACVS²
- 8 James A. Flanders, DVM, DACVS³
- 9 Pablo Pérez López, DVM⁴
- 10 Francesco Collivignarelli, DVM⁵
- 11 Ronan S. Doyle, MVB, DECVS⁶
- 12 Riccarda Schuenemann, DVM, DECVS⁷
- 13 Gerhard Oechtering, DVM, DECVAA⁷
- 14 Michele A. Steffey, DVM, DACVS-SA⁸
- 15 Victoria J. Lipscomb, MA VetMB, DECVS⁹
- 16 Robert J. Hardie, DVM, DACVS-SA, DECVS¹⁰
- 17 Barbara M. Kirby, DVM, MS, DACVS, DECVS¹
- 18 Aidan B. McAlinden, MVB, DECVS^{1,11}
- 19

20 ¹Section of Veterinary Clinical Sciences, University College Dublin, Belfield, Dublin 4, Ireland

21 ²Michigan State University, College of Veterinary Medicine, 736 Wilson Rd, East Lansing,
22 MI48824, USA

23 ³Department of Clinical Sciences, College of Veterinary Medicine, Cornell University, Ithaca,
24 NY14850, USA

25 ⁴Dick White Referrals, Station Farm, London Road, Six Mile Bottom, Cambridgeshire CB8
26 0UH, UK

27 ⁵Policlinico Veterinario Roma Sud, Via Pilade Mazza, 24, 00173 Roma RM, Italy

28 ⁶Davies Veterinary Specialists, Manor Farm Business Park, Higham Gobion, Hitchin, SG5 3HR,
29 UK

30 ⁷Small Animal Department, Ear Nose and Throat Unit, College of Veterinary Medicine,
31 University of Leipzig, D-04103 Leipzig, Germany

32 ⁸Department of Surgical and Radiological Sciences, School of Veterinary Medicine, University
33 of California-Davis, One Shields Avenue, Davis, CA 95616, USA

34 ⁹Department of Clinical Science and Services, Royal Veterinary College, Hawkshead Lane,
35 North Mymms, Hatfield, Hertfordshire, AL9 7TA, UK

36 ¹⁰University of Wisconsin, School of Veterinary Medicine, 2015 Linden Dr, Madison, WI
37 53706, USA

38 ¹¹Earlswood Veterinary Hospital, 93 Belmont Rd, Belfast, BT4 2AE, UK

39

40 **Corresponding author:** Ronan A. Mullins, University College Dublin, Dublin, Ireland.

41 ronan.mullins@ucd.ie

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58 **Objective:** Objectives of this study were (1) to report overall and procedure-specific incidence
59 and type of intraoperative and major postoperative complications in dogs treated surgically for
60 epiglottic retroversion (ER), (2) to compare the incidence of major postoperative complications
61 between different procedure types, and (3) to report survival of surgically treated dogs.

62 **Study Design:** Multi-institutional retrospective study.

63 **Sample Population:** Fifty dogs.

64 **Methods:** Medical records of dogs diagnosed with ER that underwent surgery from 2003-2017 at
65 11 institutions were reviewed. Complications were divided into intraoperative and major
66 postoperative.

67 **Results:** Fifty dogs underwent 78 surgical procedures. Intraoperative complications occurred
68 during 2/78 (2.6%) procedures. Twenty-two dogs experienced a total of 36 major postoperative
69 complications following 36 of 74 (48.7%) procedures. Postoperative complications occurred
70 following 7/12 (58.3%) non-incisional epiglottopexy, 23/43 (53.5%) incisional epiglottopexy, 2/4
71 (50%) partial epiglottectomy, 2/12 (16.7%) subtotal epiglottectomy and 2/3 (66.7%) other surgical
72 procedures. Epiglottopexy failure was the commonest major postoperative complication. No
73 significant difference in incidence of major postoperative complications was identified between
74 procedure types ($p=0.1239$); however, combined epiglottopexy procedures had a higher incidence
75 of complications than epiglottectomy procedures ($p=0.0485$). Median survival time was not
76 reached after a median of 716 days.

77 **Conclusions:** Overall incidence of major postoperative complications was high. Intraoperative
78 complications were uncommon. Epiglottopexy procedures had the highest incidence of major

79 postoperative complications. Long-term survival can be achieved in dogs treated surgically for
80 ER.

81 **Clinical Significance:** Dogs treated surgically for ER experience a high rate of major
82 postoperative complications, with epiglottopexy procedures associated with the highest rate of
83 complications.

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98 **Introduction**

99 Epiglottic retroversion (ER) is increasingly recognized as a cause of intermittent upper airway
100 obstruction in dogs.¹⁻⁴ First described affecting two dogs in 2009¹ and subsequently in two case
101 reports and one retrospective case series,²⁻⁴ it is characterized by dynamic or persistent
102 retroflexion/caudal displacement of epiglottis, and obstruction of the rima glottidis.¹⁻⁴ The etiology
103 remains unknown, although several theories have been proposed including epiglottic fracture or
104 malacia, hypothyroidism-associated peripheral neuropathy, and hypoglossal/glossopharyngeal
105 nerve degeneration.¹ It is most commonly reported in small-to-medium breeds, with Yorkshire
106 terriers over-represented.¹⁻⁴ A condition similar to that recognized as ER in the current literature,
107 epiglottic entrapment, was previously described by Leonard.⁵ He described entrapment of the
108 epiglottis against the laryngeal opening as a cause of inspiratory dyspnea in dogs.⁵ Failure of the
109 hyoepiglotticus muscles to draw the epiglottis rostrally and ventrally to counteract the negative
110 pressures generated during inspiration was the suspected cause.⁵

111

112 Described surgical techniques for management of ER include temporary-epiglottopexy (herein
113 non-incisional-epiglottopexy [NI-EP]), permanent-epiglottopexy (herein incisional-epiglottopexy
114 [I-EP]), partial epiglottectomy (PE) and subtotal epiglottectomy (STE).¹⁻⁴ The goal of
115 epiglottopexy is to maintain the epiglottis in a horizontal position by securing it to the tongue
116 base.¹⁻³ Partial epiglottectomy involves excision of an area of the rostral epiglottis to permit airflow
117 through the dorsal aditus laryngis.^{4,5} Subtotal epiglottectomy involves epiglottic excision across
118 its widest base and has been described as a salvage option for recurrent ER.^{2,3} The most effective
119 treatment method for ER remains unknown, with the decision to perform any of these procedures
120 based on surgeon preference.

121

122 Information regarding the incidence and type of intraoperative and major postoperative
123 complications in dogs treated surgically for ER is limited to case reports^{1,2,4} and one retrospective
124 case series,³ describing a total of 23 surgically treated dogs. Within these reports, a high incidence
125 of complications has been reported with both NI-EP and I-EP procedures.^{2,3} In a study involving
126 19 surgically treated dogs,³ 36.8% of index temporary-epiglottopexy and 62% of revision
127 permanent-epiglottopexy procedures failed, while 31.6% of those 19 dogs developed aspiration
128 pneumonia (AP). In that study, at time of last follow-up, approximately one third of dogs had been
129 euthanized, most commonly due to respiratory complications.³ Information regarding
130 complications and outcomes of dogs undergoing PE is limited to four dogs,^{4,5} while that related to
131 STE is limited to two.^{2,3}

132

133 Objectives of this study were (1) to report the overall and procedure-specific incidence and type
134 of intraoperative and major postoperative complications in dogs treated surgically for ER, (2) to
135 compare the incidence of major postoperative complications between different procedure types,
136 and (3) to report survival of surgically treated dogs. Our hypotheses were that (1) the overall rate
137 of major postoperative complications would be high, (2) dogs undergoing epiglottopexy
138 procedures would experience a higher rate of major postoperative complications than those
139 undergoing epiglottectomy procedures, and (3) most dogs would experience long-term survival.

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143 **Materials and Methods**

144 **Inclusion criteria**

145 Medical records of dogs presented to 11 veterinary institutions from 2003-2017 that underwent
146 NI-EP, I-EP, PE, STE and/or other surgical procedures for management of ER were retrospectively
147 reviewed. Dogs with incomplete medical records and follow-up <6 weeks from diagnosis were
148 excluded.

149

150 **Data collection**

151 Data retrieved from medical records included signalment, concurrent/historical respiratory and
152 comorbid conditions, details of previous airway surgery, presenting clinical signs, physical
153 examination findings, details of diagnostic investigations performed, epiglottic procedure(s) and
154 additional procedures performed under the same anesthetic, intraoperative and major postoperative
155 complications and follow-up/survival. Duration of clinical signs was recorded as acute (<2 weeks'
156 duration) or chronic (≥ 2 weeks). Cases were stratified as primary or concomitant ER depending
157 on whether they had concurrent/historical airway (laryngeal, pharyngeal, tracheal and/or
158 bronchial) disorders at diagnosis. Epiglottic retroversion was defined as a persistently upright or
159 caudally displacing epiglottis during inspiration on laryngoscopy, endoscopy or fluoroscopy,
160 resulting in static or dynamic obstruction of the rima glottidis (**Figures 1 and 2**). Non-incisional-
161 epiglottopexy was defined as placement of suture(s) between the lingual surface of the epiglottis
162 and tongue base, without mucosal incision/resection.¹ Incisional-epiglottopexy was defined as
163 mucosal incision/resection in the glossoepiglottic fold, followed by placement of suture(s), to

164 create permanent fibrous adhesion between the epiglottis and tongue base.^{1,2} Partial and subtotal
165 epiglottectomy were defined as resection of <50% or ≥50% epiglottis, respectively (**Figures 3-5**).²

166

167 Intraoperative complications included any unanticipated event that required intervention to
168 resolve. Major postoperative complications included requirement for revision epiglottic surgery;
169 development of AP; development of severe dyspnea deemed directly related to ER/epiglottic
170 surgery or requirement for temporary tracheostomy; and in cases where a non-epiglottic procedure
171 was performed to manage ER (eg, permanent tracheostomy), requirement for revision surgery to
172 address a complication related to that surgery. At last follow-up, if a dog had been euthanized due
173 to dyspnea without further investigation, this was recorded as a major complication unless a cause
174 unrelated to ER/ epiglottic surgery performed could be confirmed. Major postoperative
175 complications were subdivided into short-term (<6 months following a surgical procedure) and
176 long-term (≥6 months). Follow-up data were retrieved from in-hospital records and/or telephone
177 conversations with clients and/or referring veterinarians.

178

179 **Statistical analysis**

180 Continuous data were tested for normality using the Shapiro-Wilk test. Normally distributed data
181 were presented as mean and standard deviation. Non-normally distributed data were presented as
182 median and range. Categorical data were presented as frequency and percentage. Overall and
183 procedure-specific incidence of intraoperative and major postoperative complications were
184 presented as frequency and percentage (with 95% confidence interval [CI]). Pearson's chi-squared
185 and Fisher's exact tests were used to detect differences in incidence of major postoperative

186 complications between NI-EP, I-EP, PE, and STE, and combined epiglottopexy and
187 epiglottectomy procedures, respectively. Other surgical procedures were not included in these
188 comparisons. For dogs that died of causes unrelated to ER/epiglottic surgery or underwent elective
189 revision epiglottic surgery <2 weeks following an index procedure, that procedure was not
190 included in the statistical analysis concerning major postoperative complications. Due to paucity
191 of published data regarding complication rates with these procedures, a power analysis was not
192 performed. Survival/follow-up time was recorded from index surgery until the date of death/last
193 recorded alive. Kaplan-Meier methodology was used to calculate overall survival time. At last
194 follow-up, dogs were recorded as alive, lost-to-follow-up (LTFU) or dead. If a dog had died, death
195 was recorded as ER-related/possibly ER-related or non-ER-related. Statistical significance was set
196 at $p < 0.05$. Statistical analyses were performed using commercially available software.^a

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207 **Results**

208 **Signalment**

209 Fifty dogs were included in the study. Individual signalments are listed in **Appendix Table 1**.
210 Details of four dogs have partially been reported previously.^{1,2,4} The most common breeds included
211 Yorkshire terrier (n=13), Chihuahua (n=7) and Shih Tzu (n=4). There were 27 spayed females,
212 seven entire females, 11 neutered males and five entire males. Mean age was 72.3 months
213 (SD±35.8). Median weight was 6kg (range, 1.3-43.0kg).

214

215 **Concurrent/historical respiratory and comorbid conditions**

216 Concurrent/historical respiratory disorders documented prior to ER diagnosis were recorded in 17
217 (34%) dogs and included tracheal collapse (n=5); elongated soft palate (ESP) (n=5); two each of
218 stenotic nares, bronchitis, bronchial collapse, laryngeal collapse, and rhinitis; and one each of
219 unspecified brachycephalic airway syndrome (BAS), tonsillitis, pharyngeal collapse, aberrant
220 turbinates, and nasal septum deviation. One dog developed AP following partial staphylectomy
221 (PS) five days prior to ER diagnosis and subsequent epiglottic surgery. Non-respiratory
222 comorbidities were recorded in 13 (26%) dogs and included mitral valve disease (n=3),
223 hypothyroidism (n=2), previous cervical bite trauma (n=2); and one each of epilepsy, intestinal
224 leiomyosarcoma, corpora quadrigeminal cyst, meningoencephalitis-of-unknown-origin (MUO),
225 benign splenic nodules, tricuspid insufficiency, food allergy, inflammatory bowel disease, and
226 hepatic microvascular dysplasia.

227

228 **Previous respiratory tract surgery**

229 Eight (16%) dogs had undergone previous airway surgery a median of 261.5 days (range, 3-618
230 days) prior to epiglottic surgery. These included PS (n=7), rhinoplasty (n=3), temporary
231 tracheostomy (n=2); and one each of laryngeal ventriculectomy, nasopharyngeal foreign body
232 removal, tonsillectomy, bilateral cuneiformectomy, and laser-assisted turbinectomy.

233

234 **Presenting clinical signs**

235 Most common presenting clinical signs included dyspnea/tachypnea (n=43); upper respiratory
236 noise (n=30; stridor [n=16], stertor [n=5], other [n=7], unspecified [n=6]), coughing (n=19);
237 exercise intolerance (n=14); sneezing/reverse sneezing (n=11); cyanosis (n=10); syncope/collapse
238 (n=8); gagging/throat-clearing (n=7); five each of lethargy, snoring, regurgitation;
239 retching/vomiting (n=4), and excessive panting (n=3); and two each of dysphonia, wheezing,
240 choking when eating/drinking, nasal discharge, heat intolerance, and
241 anxiety/agitation/restlessness. Overall, six dogs had acute respiratory signs and 43 had chronic
242 signs (not recorded [n=1]).

243

244 **Physical examination findings**

245 Most common physical examination findings included upper respiratory tract noise (n=34; stridor
246 [n=20], stertor [n=12], other [n=1], unspecified [n=7]), dyspnea/tachypnea (n=26), increased body
247 condition/overweight (n=16), cyanosis (n=8), referred upper airway noise on auscultation (n=5),
248 hyperthermia (n=4), stenotic nares (n=5), cardiac murmur (n=4), increased/adventitious lung

249 sounds (n=4), and excessive panting (n=2). Eight dogs required emergency sedation and/or oxygen
250 supplementation at time of presentation.

251

252 **Diagnostic-investigations**

253 Upper airway examination was performed by rigid laryngoscopy/flexible endoscopy and a
254 diagnosis of ER was made in all dogs. Individual epiglottic findings are listed in **Appendix Table**
255 **1**. Premedication/sedation for upper airway examination varied widely among institutions.
256 Additional upper respiratory tract abnormalities identified at time of laryngoscopy/endoscopy
257 were recorded in 28 (56%) dogs and most commonly included ESP/thickened soft palate (n=20),
258 laryngeal collapse (n=8), everted/enlarged/hyperplastic palatine tonsils (n=4), laryngeal
259 paralysis/paresis (n=4); and two each of pharyngeal collapse, laryngeal edema, pharyngeal edema,
260 and everted laryngeal ventricles. Abnormal nasopharyngoscopic findings were recorded in six
261 dogs (**Appendix Table 2**). Tracheobronchoscopy was performed in 24 (48%) dogs, with
262 abnormalities identified in 11 (45.83%). Radiographs of the thorax and head/neck were obtained
263 at presentation in 38 (76%) and 26 (52%) dogs, with abnormal findings recorded in nine (23.7%)
264 and 12 (46.2%) dogs, respectively. Fluoroscopy of the upper and lower airways was performed in
265 16 (32%) dogs, with abnormalities identified in 14/16 (87.5%) and findings consistent with ER in
266 7/16 (43.75%). Specific findings are listed in **Appendix Table 2**.

267

268 **Overall incidence and type of intraoperative and major postoperative complications**

269 Fifty dogs underwent a total of 78 procedures (**Figure 6**); however, three dogs had NI-EP
270 electively converted to I-EP within four days and a fourth was euthanized three days following

271 STE due to seizure activity, and were excluded from statistical analysis concerning major
272 postoperative complications. Intraoperative complications occurred during 2/78 (2.6%) procedures
273 (**Table 1**). Twenty-two (44.0%) dogs experienced a total of 36 major postoperative complications
274 following 36 of 74 (48.7%) procedures (**Table 1, Appendix Table 4**). Major postoperative
275 complications occurred following 7/12 (58.3%) NI-EP, 23/43 (53.5%) I-EP, 2/4 (50.0%) PE, 2/12
276 (16.7%) STE and 2/3 (66.7%) other surgical procedures (**Table 2**). Epiglottopexy failure was the
277 commonest major postoperative complication, having occurred following 23/55 (41.8%)
278 epiglottopexy procedures. Type of failure was not recorded in all cases but most commonly
279 involved stretching of mucosa and suture cut-out. Aspiration pneumonia occurred or was suspected
280 following 4/74 (5.4%) procedures (3/55 [5.5%] epiglottopexy procedures and 1/16 [6.3%]
281 epiglottectomy procedures). No significant difference in the incidence of major postoperative
282 complications was identified between the four surgical procedures ($p=0.1239$) (**Table 2**); however,
283 epiglottopexy procedures were associated with a significantly higher rate of major postoperative
284 complications than epiglottectomy procedures ($p=0.0485$).

285

286 **Primary versus concomitant ER**

287 On the basis of diagnostic investigations and previous airway surgery, 15 dogs had primary ER
288 while 35 had concurrent/historical airway disorders and were classified as concomitant ER.
289 Twenty-eight dogs with concomitant ER underwent ≥ 1 epiglottopexy procedure and 12 (42.6%)
290 developed failure on ≥ 1 occasion. Nine dogs with primary ER underwent ≥ 1 epiglottopexy
291 procedure and five (55.6%) developed failure on ≥ 1 occasion. The remaining 13 dogs underwent
292 epiglottectomy or other surgical procedures.

293

294 **Non-incisional-epiglottopexy**

295 Fifteen dogs underwent a total of 15 NI-EP procedures, using absorbable (n=10) and non-
296 absorbable suture (n=3) (not recorded [n=2]). In all cases, NI-EP was performed as an initial step
297 to assess the response to epiglottic fixation and confirm the diagnosis. Conversion to I-EP was
298 electively performed in four dogs after a median of 3.5 days (range, 3-41 days); three performed
299 ≤ 4 days were excluded from statistical analysis concerning major postoperative complications. Six
300 of 12 were classified as primary ER and six as concomitant ER. No intraoperative complications
301 occurred. Seven dogs experienced a total of seven short-term major complications following 7 of
302 12 (58.3%) procedures; epiglottopexy failure (n=7) (polydioxanone [n=4], polyamide [n=1], not
303 recorded [n=2]). Seventeen days after NI-EP, one dog with severe tracheal collapse underwent
304 extraluminal tracheal ring placement, subsequently developed laryngeal paralysis and severe
305 laryngeal edema, underwent left cricoarytenoid lateralization (CAL), which failed, and resulted in
306 euthanasia (not recorded as a major complication). No long-term major complications occurred in
307 the remaining two dogs after 350 and 1212 days, respectively (one dog LTFU at 43 days, one dog
308 electively converted to I-EP at 41 days). Overall, seven dogs experienced a total of seven major
309 postoperative complications (NI-EP failure) following 7 of 12 (58.3%) procedures, after a median
310 of 27 days (range, 2-113 days). Failure was not recorded following the remaining five procedures
311 after a median of 43 days (range, 17-1212 days).

312

313 **Incisional-epiglottopexy**

314 Thirty-one dogs underwent a total of 43 I-EP procedures. Twenty-one were index procedures, 22
315 were revision procedures (including four elective). Incisional-epiglottopexy was performed using
316 absorbable (n=26), non-absorbable (n=11), or a combination of both materials (n=2) (not recorded
317 [n=4]). Additional surgery performed in 19 dogs included PS (n=13), rhinoplasty (n=4), folded
318 flap palatoplasty (FFP) (n=3), bilateral tonsillectomy (n=2), laryngeal ventriculectomy (n=2); and
319 one each of CAL, resection of redundant ventral epiglottic mucosa, tracheal stenting, cystotomy,
320 and debridement of a small area of marginal necrosis of rostral epiglottis (following failure of
321 previous index NI-EP and revisional I-EP). Five of 31 were classified as primary ER and 26 as
322 concomitant ER. Intraoperative complications occurred in one dog; excessive hemorrhage
323 following excision of ventral epiglottic and tongue mucosa. Twelve dogs experienced a total of 17
324 short-term major complications following 17 of 43 (39.5%) procedures, and included
325 epiglottopexy failure (n=12) after median of 20 days (range, 2-154 days); development of AP
326 (n=2); and one each of development of dyspnea/cyanosis and inability to extubate following I-EP
327 and PS in a dog with concurrent grade II laryngeal collapse, which necessitated temporary
328 tracheostomy and ultimately resulted in respiratory arrest four days postoperatively; development
329 of pharyngeal swelling following I-EP and FFP, which necessitated temporary tracheostomy; and
330 I-EP abscessation and requirement for suture removal, which resulted in recurrence of respiratory
331 signs. One dog demonstrated similar but less severe signs two weeks following I-EP; however,
332 repeat laryngoscopic examination/surgery were not advised on the basis of overall improvement.
333 Another dog developed partial mucosal dehiscence after I-EP; however, deeper epiglottopexy
334 sutures remained intact and further surgery was not required. Neither were recorded as major
335 complications. Six dogs experienced a total of six long-term major complications following 6 of
336 43 (14%) I-EP procedures and included epiglottopexy failure (n=4) after median of 455.5 days

337 (range, 183-733 days); possible aspiration pneumonia (n=1) and one dog that developed dyspnea
338 704 days postoperatively and was euthanized without further investigation/necropsy. Overall, 16
339 dogs experienced a total of 23 major postoperative complications following 23 of 43 (53.49%)
340 procedures. Failure occurred following 16/43 I-EP (37.2%) procedures in 12 dogs after a median
341 of 50.5 days (range, 2-733 days). Three failures were converted to STE, one dog was euthanized
342 and the remaining 8 dogs were successfully treated with revision I-EP. Failure was not recorded
343 in 19 dogs after median of 724 days (range, 4-1945), although one dog had the epiglottopexy
344 removed after four days due to abscessation.

345

346 **Partial epiglottectomy**

347 Three dogs underwent a total of four PE procedures, three as index surgery and one which required
348 revision. Two were classified as primary ER and one as concomitant ER. Additional procedures
349 were not performed in any dog. Intraoperative complications did not occur. Two dogs experienced
350 a total of two short-term major complications following 2 of 4 (50%) procedures and included
351 cyanosis/airway obstruction during recovery in a dog with concurrent laryngeal collapse, and
352 persistence of upper airway noise, which necessitated revision PE 21 days after index surgery to
353 resolve, respectively. Long-term major complications did not occur following 449 and 1690 days
354 in two dogs, and 1058 days after revisional PE in the third.

355

356 **Subtotal epiglottectomy**

357 Thirteen dogs underwent a total of 13 STE procedures, nine as index surgery and four as revision
358 surgery. Six were classified as primary ER and seven as concomitant ER. Additional procedures

359 performed in four dogs included PS (n=3); and one each of bilateral tonsillectomy, rhinoplasty,
360 and temporary tracheostomy. Intraoperative complications occurred in one dog; difficulty closing
361 mucosa over exposed epiglottic cartilage. One (7.7%) short-term major complication occurred in
362 one dog; airway obstruction after extubation, which resolved with rostral tongue traction until
363 awake. One (7.7%) long-term major complication occurred in one dog; development of severe
364 seizures, AP and death six months postoperatively (STE could not be excluded as the cause of AP
365 in this case). A number of dogs experienced postoperative complications and/or underwent
366 additional surgical procedures not related to ER/epiglottic surgery. These included one dog with
367 concurrent tracheal collapse that experienced difficult anesthetic recovery attributed to collapsing
368 trachea; one dog that was euthanized three days following STE due to seizures (not included in
369 statistical analysis concerning major postoperative complications); one dog with concurrent BAS
370 that underwent STE as well as rhinoplasty, PS, and temporary tracheostomy that developed an
371 episode of dyspnea due to tracheostomy tube blockage; another dog that required additional FFP
372 due to residual upper airway noise attributed to prominent mucosa at nasopharyngeal ostium; and
373 two dogs that required permanent tracheostomy for concurrent bilateral laryngeal paralysis and
374 collapse, and intraluminal tracheal stenting for tracheal collapse, both of whom were subsequently
375 euthanized 280 and 323 days after STE, respectively, due to complications relating to these
376 subsequent procedures. None of these six dogs were recorded as having developed major
377 complications.

378

379 **Other surgical procedures**

380 Three dogs underwent a total of three other surgical procedures, two as index and one as revision
381 surgery, and included permanent tracheostomy and hyoepiglotticus imbrication, and

382 hyothyropexy, respectively. No additional procedures were performed in any dog. Intraoperative
383 complications did not occur. Short-term major complications occurred in two dogs. This included
384 one dog in whom laryngoscopic examination eight days following hyoepiglotticus imbrication
385 identified persistent ER. This dog was re-presented after 638 days due to ongoing respiratory signs
386 and subsequently underwent I-EP. A second dog with concurrent grade III laryngeal collapse that
387 underwent permanent tracheostomy experienced intermittent tracheostomy obstruction due to
388 redundant skin folds and required temporary skin suture placement. No long-term major
389 complications occurred following these other procedures after 638, 904 and 621 days, respectively.

390

391 **Anesthesia and analgesia**

392 Anesthetic and postoperative analgesia protocols varied widely depending on the institution and
393 preference of attending anesthesiologist/surgeon but most commonly included partial/pure mu
394 agonist opioids or butorphanol.

395

396 **Follow-up/survival**

397 Follow-up examinations were inconsistently performed depending on the institution and surgical
398 response. Repeat laryngoscopic examinations were performed at variable postoperative times on
399 ≥ 1 occasion in 26 (52%) dogs, most commonly at time of revision epiglottic surgery, either
400 electively or due to recurrence/persistence of signs, or at the time of intubation for another
401 procedure/surgery. Follow-up fluoroscopy was performed in seven (14%) dogs. At the time of
402 writing, 30 (60%) dogs were alive after a median of 928 days (range, 114-2805 days), eight (16%)
403 were lost to follow-up after a median of 411 days (range, 43-1158 days) and 12 (24%) were

404 dead/euthanized after a median of 301.5 days (range, 3-1212 days). Overall MST was not reached
405 after a median of 716 days (range, 3-2805 days) (**Figure 7**). Death was classified as ER-related or
406 possibly ER-related in four dogs, and non-ER-related in eight dogs (**Appendix Table 3**). Of those
407 that had not died of ER-/possible ER-related causes, 15 (32.6%; n=7 primary ER, n=8
408 concomitant) of 46 were free of respiratory signs at last follow-up/death. Ongoing clinical signs
409 were recorded at last follow-up/death in 31/46 dogs (67.4%; n=7 primary ER, n=21 concomitant)
410 (**Appendix Table 3**).

411

412 **Discussion**

413 The results of this study support our first hypothesis that dogs undergoing surgical management
414 of ER experience a high overall rate of major postoperative complications. Postoperative major
415 complications occurred following 48.7% of all surgical procedures in our study (**Table 2**). In
416 contrast, intraoperative complications were uncommon. Our second hypothesis, that dogs
417 undergoing epiglottopexy procedures would experience a higher rate of major postoperative
418 complications than those undergoing epiglottectomy procedures was also confirmed. Our third
419 hypothesis, that most dogs treated surgically for ER would experience long-term survival was also
420 supported by our results, with MST not reached after a median of 716 days (range, 3-2805 days).

421

422 A high incidence of ongoing respiratory signs was recorded at last follow-up/death in dogs that
423 had not died of ER/possible ER-related causes. However, this should be interpreted in light of
424 the high incidence of concurrent respiratory tract disorders at time of ER diagnosis and their
425 possible contribution to these ongoing signs. In a previous study,³ cases of ER were stratified as

426 primary or secondary based on the presence of concurrent/historical upper airway disease at
427 presentation. We propose classification of the latter cases as concomitant, as the term secondary
428 suggests a causal relationship between concurrent disorders and ER, which remains unknown. If
429 ER were to occur secondarily to a concurrent upper airway disorder, an epiglottopexy may be
430 considered desirable if treatment of the concurrent disorder were possible (eg, elongated soft
431 palate). In our study; however, 42.6% of dogs with concomitant ER that underwent
432 epiglottopexy developed failure on ≥ 1 occasion.

433

434 Complications reported in our study are similar to those reported elsewhere (**Appendix Table 4**).³
435 Epiglottopexy failure was the commonest major postoperative complication, occurring following
436 23/55 (41.8%) epiglottopexy procedures. In a previous study,³ temporary-epiglottopexy was
437 performed as index surgery in 19 dogs and failure occurred in 36.8% after a mean of six months.
438 In our study, NI-EP failure occurred in 58.3% of dogs after median of 27 days, accounting for all
439 major postoperative complications following NI-EP. Non-incisional-epiglottopexy was most
440 commonly performed using absorbable suture as a therapeutic trial to confirm the diagnosis;
441 however, failure occurred earlier than expected in many cases. Development of AP was the second
442 most common complication in our study, suspected or confirmed following 5.41% of all
443 procedures. These dogs had no other risk factors for development of AP, although one dog
444 experienced uncontrollable seizures, which may have permitted false passage. A significantly
445 higher rate of AP was reported in a previous study,³ wherein 31.6% of dogs that underwent
446 epiglottopexy developed AP. While it may be anticipated that epiglottectomy procedures, in
447 particular STE, would be associated with a very high risk of AP, this was not supported by our
448 results. Aspiration pneumonia occurred following only 1/16 (6.3%) STE procedures in our study,

449 following initial failed NI-EP. In an experimental study,⁶ Medda et al reported no increased
450 incidence of aspiration during swallowing following epiglottectomy in decerebrated cats. In that
451 study, glottal closure, consisting of adduction and approximation of vocal cords and arytenoids,
452 constituted the primary preventative mechanism against aspiration during swallowing, while
453 epiglottis provided no apparent airway protection.⁶ The importance of active glottal closure in
454 prevention of aspiration is further supported by the well-recognized risk of aspiration in dogs with
455 laryngeal paralysis, despite a normally functioning epiglottis.⁷ In human literature, conflicting
456 reports exist as to whether epiglottectomy increases risk of aspiration.⁸⁻¹⁴ Abscessation of I-EP
457 occurred in one dog in our study following initial failed hyoepiglotticus imbrication and has not
458 been reported as a complication in previous studies.

459

460 Incisional-epiglottopexy may be seen as a more definitive method of epiglottic fixation on the
461 basis that mucosal resection will result in formation of fibrous union between the epiglottis and
462 tongue base.^{1,2} Despite this, failure occurred following 16/43 (37.2%) I-EP procedures in our
463 study. Skerrett et al reported failure of almost two thirds of I-EP procedures; however, all were
464 revision surgeries.³ It may be anticipated that repeated surgical manipulation/trauma would lead to
465 increased fragility/deformity of epiglottis and increased rate of epiglottopexy failure. This was not
466 investigated in our study due to the relatively small numbers of dogs that underwent individual
467 procedures. Variations in epiglottopexy technique were identified in our study including
468 differences in suture type and whether epiglottopexy was performed with full-thickness bites of
469 epiglottic cartilage, and whether there was incorporation of the basihyoid bone. In humans,
470 placement of epiglottopexy sutures full-thickness through epiglottis and tongue base and tied in a
471 subcutaneous location in ventral neck has been proposed to reduce risk of failure in cases of grade

472 III laryngomalacia.¹⁵ We did not evaluate the effect of differences in surgical technique on
473 epiglottopexy failure in our study.

474

475 Diagnosis of ER in our study was made by laryngoscopy/endoscopy, combined with fluoroscopy
476 in a limited number of cases. Findings related to the epiglottis were quite varied; however, two
477 broad patterns of epiglottic dysfunction were recognized.³ In some cases, the epiglottis was
478 observed to spontaneously displace caudally during inspiration (**Video-Clip S1-6**), in others, it
479 was identified in a persistent upright position, appearing “entrapped” caudal to soft palate against
480 the aditus laryngis, similar to that described by Leonard.⁵ The caudal aspect of soft palate should
481 be elevated dorsally in suspect cases to confirm that epiglottic displacement occurs independent
482 of soft palate movement/contraction. Strategies to increase the sensitivity to diagnose ER include
483 avoidance of tongue traction and downward pressure of the laryngoscope on the epiglottis.^{3,5}
484 Downward pressure in region of epiglottic frenulum should also be avoided. In our study, NI-EP
485 was performed to assess the clinical response to epiglottic fixation in a horizontal position and
486 support a tentative diagnosis of ER. This strategy can also prove useful in cases where diagnosis
487 of ER is uncertain, particularly in dogs with concomitant ER.¹ Depending on response observed,
488 suture(s) can be removed, left in-situ, or converted to I-EP.^{1,2} In approximately 50% of dogs, a
489 more definitive surgery was planned if a positive response were observed. In remaining cases,
490 further surgery was not always advised unless recurrence of signs occurred. On the basis of high
491 rate of concurrent airway disorders in these dogs, fluoroscopy may also be useful to evaluate for
492 concurrent pharyngeal and/or tracheal disorders. In our study, findings consistent with ER were
493 recorded in only 7/16 (43.75%) dogs, which may have been due to failure to evaluate for ER in
494 some cases or reflect the intermittent nature of this condition. Abnormal fluoroscopic findings

495 pertaining to epiglottis were similar to those identified during laryngoscopy/endoscopy; the
496 epiglottis was observed to dynamically displace caudally during inspiration, resulting in contact
497 with the dorsal pharyngeal wall (**Video-Clip S7**), or remain in a fixed upright position.

498

499 A high rate of major postoperative complications was identified following PE in our study;
500 however, this should be interpreted in light of the small number of dogs that had this procedure
501 performed. Excision of the rostral epiglottic tip, as performed in our study, has been described in
502 only a single case of ER.⁴ In that report,⁴ epiglottic resection led to long-term resolution of dyspnea
503 without postoperative complication. Leonard⁵ described excision of one third of the epiglottis
504 along its abaxial borders for management of epiglottic entrapment in three dogs, which resulted in
505 complete resolution of inspiratory dyspnea in all cases. More extensive epiglottectomy techniques
506 including subtotal/total epiglottectomy have previously been reported in only four dogs, two for
507 management of recurrent ER^{2,3} and two for epiglottic chondrosarcoma.^{16,17} No major postoperative
508 complications were reported in any case, although follow-up time was not clearly stated in two
509 dogs.^{3,17} In remaining two dogs, no significant complications were reported up to 12 and 17 months
510 postoperatively, respectively.^{2,16} This procedure has not been performed as index surgery in
511 previously reported cases of ER so our results cannot be compared with others.

512

513 A number of alternative techniques were performed in our study including permanent
514 tracheostomy, hyoepiglotticus imbrication and hyothyropexy. These were not included in
515 statistical analysis due to their low individual numbers and heterogeneity. Hyoepiglotticus
516 imbrication was performed in one dog and involved placing a figure-of-eight suture in the

517 hyoepiglottis to shorten it, followed by closure of overlying mucosa. Hyothyropexy was performed
518 as revision surgery in one dog on the basis that by translating the basihyoid bone caudally towards
519 thyroid cartilage, ceratohyoid bones and attached hyoepiglotticus muscles would displace
520 caudoventrally, resulting in epiglottic anteversion. Whether this technique will maintain the
521 epiglottis in an anteverted position or permit further stretching of hyoepiglotticus muscles in the
522 future is unknown.

523

524 We acknowledge a number of limitations in this study. Inherent to all retrospective studies,
525 accuracy of recorded data relies on completeness of medical records. Dogs were treated at different
526 institutions by multiple surgeons, with variations in surgical technique and case management. The
527 decision to perform any of these procedures was not randomized but based on surgeon preference.
528 Follow-up examinations were inconsistently performed at various postoperative time-points
529 depending on response to surgery. Follow-up airway examinations were typically performed only
530 if there was recurrence or persistence of clinical signs, and usually immediately prior to revision
531 surgery. In some cases, repeat airway examination and/or revisional surgery may not have been
532 recommended on the basis of a perceived improvement in clinical signs, which may have
533 underestimated the incidence of major complications (e.g., epiglottopexy failure). Timing of major
534 postoperative complications may not always have been accurate as a complication may have
535 occurred but the dog may not have been re-presented immediately. A number of dogs in our study
536 experienced adverse outcomes following a subsequent non-epiglottic surgery. In such cases, a
537 subjective assessment was made as to whether previously performed epiglottic surgery contributed
538 to this outcome. This may have underestimated the incidence of major complications. Conversely,
539 in cases where a dog had died/been euthanized due to respiratory signs postoperatively without

540 further investigation, classification of such cases as having developed a major complication may
541 have overestimated incidence of complications.

542

543 In this study, dogs that underwent surgical management of ER experienced a high overall rate of
544 major postoperative complications, particularly those that underwent epiglottopexy procedures.
545 Conversely, intraoperative complications rarely occurred. A significant difference in the
546 incidence of major postoperative complications between individual surgical procedures was not
547 identified; however, combined epiglottopexy procedures had a higher incidence of postoperative
548 complications than epiglottectomy procedures. While the optimal surgical treatment method for
549 ER remains unknown, results of our study emphasize the high possibility of requirement for
550 revision surgery. Epiglottectomy procedures were well tolerated in this study and associated with
551 a relatively low rate of occurrence of AP. Long-term survival can be achieved in dogs treated
552 surgically for ER.

553

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559

560 **Disclosure Statement**

561 The authors report no conflict of interest.

562

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601

602 **Footnotes**

603 a. GraphPad, USA

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607

608 **Figure 1:** Videoendoscopic image of case 26 - The epiglottis contacts the dorsal pharyngeal roof
609 and occludes the rima glottidis. Image courtesy of Dr. Gerhard Oechtering.

610 Figure 2: Same dog as in Figure 1. The epiglottis can be seen folding into the rima glottidis.

611 **Figure 3:** Subtotal epiglottectomy in case 37.

612 **Figure 4:** Subtotal epiglottectomy in case 46. Image courtesy of Dr. Bryden J. Stanley.

613 **Figure 5:** Same dog as in Figure 1 following partial epiglottectomy - Airflow through the dorsal
614 aditus laryngis is facilitated. Image courtesy of Dr. Gerhard Oechtering.

615 **Figure 6:** Flow-diagram illustrating case management and postoperative complications among
616 50 dogs diagnosed with ER.

617 **Figure 7:** Kaplan-Meier survival of 50 dogs treated surgically for ER.

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| Timing of complications | Non-incisional epiglottopexy | Incisional epiglottopexy | Partial epiglottectomy | Subtotal epiglottectomy | Other |
|--------------------------------|---|--|--|---|--|
| Intraoperative | <ul style="list-style-type: none"> ▪ None | <ul style="list-style-type: none"> ▪ Hemorrhage (n=1) | <ul style="list-style-type: none"> ▪ None | <ul style="list-style-type: none"> ▪ Difficulty closing mucosa over exposed epiglottic cartilage (n=1) | <ul style="list-style-type: none"> ▪ None |
| Short-term | <ul style="list-style-type: none"> ▪ Epiglottopexy failure (n=7) | <ul style="list-style-type: none"> ▪ Epiglottopexy failure (n=12) ▪ Aspiration pneumonia (n=2) ▪ Inability to extubate, requirement for temporary | <ul style="list-style-type: none"> ▪ Cyanosis/airway obstruction during recovery (n=1) ▪ Persistent airway noise (n=1) | <ul style="list-style-type: none"> ▪ Transient airway obstruction after extubation (n=1) | <ul style="list-style-type: none"> ▪ Continued ER (n=1) ▪ Permanent tracheostomy obstruction due to skin |

| | | | | | |
|------------------|--|---|--|---|--|
| | | <p>tracheostomy, death (n=1)</p> <ul style="list-style-type: none"> ▪ Pharyngeal swelling, requirement for temporary tracheostomy (n=1) ▪ Epiglottomy abscessation necessitating removal, recurrence of signs (n=1) | | | <p>folks (n=1)</p> |
| Long-term | <ul style="list-style-type: none"> ▪ None | <ul style="list-style-type: none"> ▪ Epiglottomy failure (n=4) | <ul style="list-style-type: none"> ▪ None | <ul style="list-style-type: none"> ▪ Severe seizures, aspiration pneumonia | <ul style="list-style-type: none"> ▪ None |

| | | | | | |
|--|--|---|--|---|--|
| | | <ul style="list-style-type: none"> ▪ Possible aspiration pneumonia (n=1) ▪ Dyspnea 704 days postoperatively possibly ER-related (n=1) | | <p>a and death 6 months postoperatively (n=1)</p> | |
|--|--|---|--|---|--|

628 **Table 1:** Timing and type of intraoperative and major postoperative complications among
629 procedures.

630

| Surgical procedure | Major postoperative complications |
|--|--|
| | % (95% CI) |
| Non-incisional-epiglottopexy (n=15 procedures*) | 7/12 procedures* 58.3% (31.95-80.67) |
| Incisional-epiglottopexy (n=43 procedures) | 23/43 procedures 53.5% (38.92-67.49) |
| Combined epiglottopexy procedures (n=58 procedures*) | 30/55 procedures* 54.5% (41.53-66.98) |

| | |
|---|---|
| Partial epiglottectomy (n=4 procedures) | 2/4 procedures 50% (15-85) |
| Subtotal epiglottectomy (n=13 procedures ⁺) | 2/12 procedures ⁺ 16.7% (4.7-44.81) |
| Combined epiglottopexy procedures (n=17 procedures ⁺) | 4/16 procedures ⁺ 25% (10.18-49.5) |
| Other surgical procedures (n=3 procedures [†]) | 2/3 procedures [†] 66.7% (20.77-93.85) |
| Overall (n=78 procedures ^{*+†}) | 36/74 procedures ^{*+†} 48.7% (37.61-59.82) |

631 **Table 2:** Incidence of major complications among surgical procedures.

632 *Three dogs converted to I-EP electively <4 days and excluded from NI-EP group.

633 ⁺One dog euthanized after three days unrelated to ER/STE and excluded from STE group.

634 [†]Not included in statistical comparisons among other four groups.