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Risk factors for early post-operative neurological deterioration in dogs undergoing a cervical dorsal laminectomy or hemilaminectomy: 100 cases (2002–2014)

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ABSTRACT

Early post-operative neurological deterioration is a well-known complication following dorsal cervical laminectomies and hemilaminectomies in dogs. This study aimed to evaluate potential risk factors for early post-operative neurological deterioration following these surgical procedures. Medical records of 100 dogs that had undergone a cervical dorsal laminectomy or hemilaminectomy between 2002 and 2014 were assessed retrospectively. Assessed variables included signalment, bodyweight, duration of clinical signs, neurological status before surgery, diagnosis, surgical site, type and extent of surgery and duration of procedure. Outcome measures were neurological status immediately following surgery and duration of hospitalisation. Univariate statistical analysis was performed to identify variables to be included in a multivariate model.

Diagnoses included osseous associated cervical spondylomyelopathy (OACSM; $n = 41$), acute intervertebral disk extrusion (IVDE; 31), meningioma (11), spinal arachnoid diverticulum (10) and vertebral arch anomalies (7). Overall 54% (95% CI 45.25–64.75) of dogs were neurologically worse 48 h post-operatively. Multivariate statistical analysis identified four factors significantly related to early post-operative neurological outcome. Diagnoses of OACSM or meningioma were considered the strongest variables to predict early post-operative neurological deterioration, followed by higher (more severely affected) neurological grade before surgery and longer surgery time. This information can aid in the management of expectations of clinical staff and owners with dogs undergoing these surgical procedures.

Introduction

Dorsal decompressive surgery for treatment of cervical spinal diseases is a well-established surgical approach (Sharp and Wheeler, 2005). Cervical dorsal laminectomies and hemilaminectomies are indicated for lesions located dorsally or laterally in the cervical vertebral canal. Disorders treated by this approach include osseous associated cervical spondylomyelopathy (OACSM), intervertebral disc extrusions (IVDE) with lateralised or dorsally located disc material, vertebral arch anomalies, spinal arachnoid diverticula (SAD), or where multiple ventral intervertebral disc protrusions are present (Gill et al., 1996; de Risio et al., 2002; da Costa, 2010; Faissler et al., 2011; De Decker et al., 2012a).

There have been differing reports pertaining to the outcome of dorsal cervical decompressive surgeries. Studies looking at outcomes in dogs undergoing cervical dorsal decompressive surgeries for OACSM have suggested that cervical dorsal laminectomy should be considered an invasive procedure with high risk of post-operative morbidity, many complications and prolonged hospitalisation and recovery times (de Risio et al., 2002; da Costa, 2010; Delamaide Gasper et al., 2014). The most important complication associated with this surgical approach is early post-operative neurological deterioration with prolonged recumbency after surgery (de Risio et al., 2002; Delamaide Gasper et al., 2014). Other studies describing use of dorsal decompressive surgeries for small or medium sized dogs with IVDE or vertebral arch anomaly have reported more favourable outcomes with limited hospitalisation and recovery times (Gill et al., 1996; Faissler, 2011; De Decker et al., 2012a).

It remains unclear why only some patients undergoing dorsal cervical procedures experience early post-operative neurological deterioration. The aim of this study was to evaluate potential risk factors for early neurological deterioration in dogs following cervical dorsal laminectomy or hemilaminectomy. It was hypothesised that the specific diagnosis would influence outcome: dogs diagnosed with acute IVDE may be less likely to have early post-operative neurological

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deterioration following surgery compared with dogs diagnosed with OACSM. Other factors thought to impact on early post-operative outcome and therefore explored included signalment, bodyweight, duration of clinical signs and neurological status before surgery, peri-anaesthetic hypotension, surgical site, type and extent of surgery and duration of procedure.

Materials and methods

Criteria for inclusion

Medical records of dogs that had undergone a cervical dorsal laminectomy or hemilaminectomy at the Royal Veterinary College between 2002 and 2014 and Davies Veterinary Specialists between 2008 and 2014 were reviewed. In order to be considered for inclusion in the study, dogs needed to have complete medical records and imaging studies available for review with clear data relating to neurological status before and after surgery. If the neurological status could not be clearly determined, then cases were excluded. Further information recorded included signalment, bodyweight, duration of clinical signs prior to surgery (acute <48 h, subacute 2–7 days and chronic >7 days), diagnosis, type, location, extent (number of vertebrae operated on) and duration of the surgery, intra-operative blood pressure (hypotension defined as blood pressure <70 mmHg), presence of perioperative complications during the period of hospitalisation and hospitalisation time.

Neurological grading

A scoring system modified from de Risio et al. (2002) was used to objectively grade each dog's neurological status as follows: normal neurological status (grade 0); cervical hyperaesthesia without neurological deficits (grade 1); mild ataxia without paresis and slight delay in postural reactions, with or without thoracic limb deficits and/or cervical hyperaesthesia (grade 2); noticeable ataxia and paresis with delayed pelvic limb postural reactions, with or without thoracic limb deficits and/or cervical hyperaesthesia (grade 3); paresis or absent pelvic limb postural reactions, with or without thoracic limb deficits and/or cervical hyperaesthesia, dogs are able to rise and make a few steps with assistance (grade 4); non-ambulatory tetraparesis, with or without cervical hyperaesthesia, patients are not able to rise independently (grade 5); tetraplegia with respiratory compromise (grade 6). Deterioration in neurological status by one or more grades was defined as post-operative neurological deterioration.

For patients that underwent surgery immediately following diagnostic imaging, preoperative neurological grade was assigned based on neurological status prior to diagnostic imaging; otherwise the neurological grade was assigned on the day of surgery. Postoperative neurological grade was assigned based on the neurological examination 48 h after surgery.

Diagnostic imaging

Included dogs underwent diagnostics including myelography, computed tomography (CT), computed tomography-myelography (CT-m) or magnetic resonance imaging (MRI) under general anaesthesia. None of the dogs had dynamic imaging studies performed. Although general anaesthesia protocols varied between individual cases, a commonly used protocol included premedication with acepromazine (0.01 mg/kg IV) and methadone (0.1–0.2 mg/kg IV), induction with propofol, (4–6 mg/kg IV) and maintenance of general anaesthesia with isoflurane in oxygen.

Myelography was performed by intrathecal injection of iohexol (Omnipaque, GE Healthcare) contrast medium between the L5 and L6 articulation (0.2 mL/kg; maximal dose 10 mL). CT imaging was performed using a 16-slice helical CT scanner (Mx8000 IDT, Philips). After completion of the transverse CT study, sagittal and dorsal reconstructions were made. MRI was performed with a 1.5 T (Intera, Philips Medical Systems) or 0.4 T (Aperto MRI, Hitachi) and included a minimum of T2- and T1-weighted sagittal and transverse images.

Localisation and categorisation of spinal cord compression

Information obtained from the radiology and surgery reports was used to determine the site of spinal cord compression and confirm the diagnosis. A Board-certified neurologist (SDD) reviewed the imaging studies for diagnostic accuracy. Dogs were divided into five categories based on diagnosis: (1) OACSM; (2) acute IVDE; (3) histopathologically confirmed meningioma; (4) SAD; (5) vertebral arch anomalies. Vertebral arch anomalies were defined as a well-defined and smooth hypertrophy of the dorsal lamina and spinous process of ≥2 adjacent vertebrae. No other osseous abnormalities were present in these dogs (De Decker et al., 2012a, 2012b, 2012c).

Lesions were classified according to their location within the cervical vertebral column with cranial lesions classified as those located between C1 and C4 vertebrae and caudal lesions classified as those from C4 to T1 vertebrae. If lesions affected both the cranial and caudal cervical vertebral column this was documented.

Surgery, post-operative care and outcome measures

All dogs had a dorsal laminectomy, hemilaminectomy or a combination. The surgical procedures were carried out by a Board certified neurologist using published techniques (Sharp and Wheeler, 2005; Platt and da Costa, 2012). Anaesthesia protocols varied for individual dogs based on attending anaesthetist's preference and specific patient requirements, but were typically as per the diagnostic imaging protocol. Perioperative analgesia included a combination of opioids, ketamine and non-steroidal anti-inflammatory drugs (NSAIDs).

Post-operative analgesia at 48 h typically included 0.1–0.2 mg/kg methadone IV every 4 h combined with an NSAID. Ninety-six per cent of patients received post-operative physiotherapy, the remaining did not because of severe complications ($n = 3$) or aggressive behaviour ($n = 1$). All dogs underwent a daily neurological assessment by a Board certified neurologist and information pertaining to their assessment was recorded in medical records.

Statistical analysis

All variables were treated as categorical except for age, weight, number of vertebrae on which surgery was performed, duration of surgery and duration of hospitalisation, which were continuous. Early post-operative neurological deterioration by one or more grades was defined as the primary outcome measure. A secondary outcome measure was defined as duration of hospitalisation. Univariate analysis identified variables associated with early post-operative neurological deterioration. Statistical comparisons between mean values of normally distributed data were made using a one-way analysis of variance (ANOVA), with additional pairwise comparisons with Bonferroni adjustment as required for significant variables. Median values for non-parametric data were compared with either Mann–Whitney or Kruskal–Wallis tests with post-tests as required. Statistically significant results are displayed where $P < 0.05$. Unless otherwise stated normally distributed data are presented as means ± standard deviation and non-parametric data as median and range. Computations were performed using SPSS (Statistical Package for the Social Sciences v. 21.0.1; SPSS Inc.).

Prior to inclusion in a binary logistic regression model, multinomial modelling was performed to identify associations between input variables. All biologically important confounders (age, weight, surgery time) and independent factors (onset of clinical signs, neurological grade preoperatively) with $P < 0.3$ were included in the multinomial model. Factors shown to be significantly associated with diagnosis included age ($P = 0.001$), weight ($P = 0.001$) and onset of clinical signs ($P = 0.009$). These variables were substituted for the single input variable 'diagnosis' in subsequent binary logistic regression.

Binary logistic regression modelling was undertaken to identify factors associated with early post-operative neurological deterioration. Variables were considered for inclusion in binary logistic regression if $P < 0.30$ and retained in the final model if $P < 0.05$, based on the likelihood ratio test. Binary logistic regression was carried out using a forced entry method to examine associations between included variables with a significance level of $P < 0.05$. Results are presented with odds ratios (OR) and 95% confidence intervals (CI) for variables associated with early post-operative neurological deterioration.

Results

The study population comprised 100 dogs. Breeds included were Dalmatian ($n = 10$), Labrador Retriever ($n = 9$), Great Dane ($n = 8$), Dogue de Bordeaux ($n = 7$), Bullmastiff ($n = 7$), Rottweiler ($n = 6$), English Cocker Spaniel ($n = 6$), Doberman ($n = 4$), Boxer ($n = 3$), Basset Hound ($n = 3$), English Pointer ($n = 3$), Jack Russell terrier ($n = 2$), Dachshund ($n = 2$), West Highland White terrier ($n = 2$), Beagle ($n = 2$) and Bernese Mountain dog ($n = 2$); there were 13 breeds represented by one dog each and 11 crossbreeds. Of the study population 75 dogs were male and 25 dogs were female; overall 45 of the dogs were neutered. At the time of surgery the median age of dogs was 5.2 years (range 0.4–11.0 years; Table 1). Dogs with OACSM (median age 2.7 years) were significantly younger than dogs with IVDE (median 6.7 years; $P = 0.001$) or meningioma (median 7.5 years; $P = 0.006$). The median weight was 32.5 kg (range 5–80 kg; Table 1). Dogs with OACSM (median weight 44 kg) were significantly heavier than dogs with IVDE (median 25 kg; $P = 0.001$), meningioma (median 25 kg; $P = 0.004$) or vertebral arch anomalies (median 32 kg; $P = 0.024$).

Diagnoses included OACSM ($n = 41$), acute IVDE ($n = 31$), meningioma ($n = 11$), SAD ($n = 10$) and vertebral arch abnormalities ($n = 7$; Table 1). Duration of clinical signs prior to surgery was classified as acute ($n = 15$), subacute ($n = 21$) or chronic ($n = 64$). Dogs