Atlantoaxial Instability

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Past fellowship examination questions

FELLOWSHIP EXAMINATION
JUNE/JULY 2005
SMALL ANIMAL SURGERY
PAPER 2 – PRACTICE
• Write notes on the following:
  – Surgical repair of L7-S1 luxations.
  – Treatment options and published prognoses for a dynamic lesion at C5-6 in an 8-year-old Doberman FN (Female Neutered).
  – Surgical stabilization of congenital Atlanta-axial subluxation in a miniature poodle.

Fellowship Examination
June 2013
Small Animal Surgery
Paper 2
1. Answer all parts of this question:
a) After a traumatic incident at a park, a two-year-old Chihuahua presents with neurologic findings suggesting a lesion within the C1–C5 neuroanatomical segment.
  i. Detail the specific neurological examination findings you would expect in this patient. (6 marks)
  ii. Provide a list of differential diagnoses ranked in order of likelihood. (3 marks)
  iii. Describe and justify your plans for diagnostic investigation and pre-surgical management for this patient. (9 marks)
  iv. List two (2) techniques for dorsal stabilisation of the atlantoaxial joint, and two (2) techniques for ventral stabilisation of the atlantoaxial joint.
AAI - overview

- Anatomy
- Pathophysiology
- Signalment and clinical findings
- Diagnosis and differential diagnoses
- Treatment options
- Complications
- Prognosis
Atlantoaxial instability (AAI)

- Congenital or developmental malformation or trauma to bones, joint or ligaments of AA region
- Dorsal subluxation of the axis into the vertebral canal
- Direct compressive and concussive effects on the cervical spinal cord
Anatomy - Atlas

- First cervical vertebra
- Develops from three bony elements
  - Two neural arches and body (Intercentrum 1)
- No dorsal spinous process
- Large transverse processes (wings)
- Reduced vertebral body
- Articulates cranially with occipital condyles via cotyloid cavities
- Articulates caudally with axis via glenoid cavities
- Ventral process
- Transverse and lateral vertebral foraminae
Anatomy - Axis

• Second cervical vertebra
• Develops from seven bony elements
  • Centrum of proatlas, centrum 1 (C1), intercentrum 2, centrum 2, epiphysis and two neural arches
• Dens or odontoid process
• Prominent dorsal spinous process
Anatomy – AA joint

- Synovial joint
- No intervertebral disc
- Motion largely rotational with some lateral
- Dens located within fovea of the dens of atlas
- AA joint contiguous with atlanto-occipital joint
Anatomy – AA joint ligaments

Five major ligaments
1. Apical
2. Left alar
3. Right alar
4. Transverse
5. Dorsal atlantoaxial

Reber et al Vet Surg 2013
• Concluded alar ligaments to be the most important in preventing dorso-ventral shear
Pathophysiology

- Two main presentations
- Congenital/developmental
  - Dysplasia, hypoplasia or aplasia of dens
    - Abnormal physeal closure of dens in miniature breeds
    - deLahunter et al
      - Form of avascular necrosis of dens
    - Leads to failure of normal ligamentous development
  - Absent transverse ligament
  - Incomplete ossification of the atlas
    - Parry et al Vet Radiol Ultrasound 2010
      - Atypical breeds
      - 35 x more likely to have AAI
  - Block vertebrae
    - Results in supramaximal forces exerting on ligamentous stabilisers
Pathophysiology

Traumatic

- Any breed or age
- Severe neck flexion
  - Ligamentous or osseous damage
- Often related to underlying congenital defect

End result is dorsal angulation of axis and compression and concussion of spinal cord

Signalment and clinical findings

Signalment
- Toy and small breeds
  - Yorkshire terrier, Toy and Min Poodle, Chihuahua, Pomeranian, Pekingese
- Congenital AAI typically seen in young dogs (52-70% within first year)
- Traumatic AAI seen at any age

Clinical findings
- Can be acute or chronic onset
- Cervical pain
  - Up to 60% congenital
  - Most traumatic AAI
- Neurologic deficits
  - C1-C5 neuroanatomical localisation
  - UMN/GP ataxia
  - Range from ambulatory tetraparesis (up to 94%) to tetraplegia (10%) to death from respiratory arrest
Diagnosis and differential diagnoses

**Diagnosis**
- Signalment/CSx
  - Young, small breed dog with C1-C5 neurolocalisation and cervical pain
- Plain radiography
- Fluoroscopy
- Myelography
- CT
- MRI

**Differentials**
- IVDD
  - Traumatic
  - Degenerative
- Meningomyelitis
- Syringohydromyelia
- Discospondylitis
- Vertebral fracture or other luxation
Radiography

- Unsedated if possible
- Lateral view
  - detect increase in space between C1 dorsal lamina and C2 dorsal spinous process

_McLear et al Vet Radiol Ultrasound 2000_
- Atlantoaxial angle <162 deg predictive of instability

- VD view
  - Evaluate dens
  - Severe cases detect malalignment

- Dynamic flexion views obtained under fluoroscopy with extreme care
- Myelography typically of little benefit
Advanced imaging

CT
- Modality of choice
- Dens morphology
- Atlantal morphology
- Fractures
- AO overlap
- Implant positioning

MRI
- Parenchymal pathology
  - Haemorrhage
  - Oedema
  - Syringohydromyelia
  - Myelomalacia
- AA ligaments
  - *Middleton et al Vet Radiol Ultrasound 2012*
Treatment options

Non surgical

Surgical
- Dorsal techniques
- Ventral techniques
Non-surgical treatment

Stability achieved via fibrotic ankylosis
Consists of
• External coaptation with head in extension
  • Ventral splint
• Minimum 6 weeks cage confinement
• Analgesia
Indications
• Acute onset
• Minimal neurologic deficits
• Normal dens radiographically
• Young patients
• Owner constraints
Good outcome significantly associated with duration of clinical signs (<30 days)
Complications
• Continued instability, corneal ulcers, splint migration, hyperthermia, dermatitis, respiratory compromise, anorexia and otitis externa

Havig et al JAVMA 2005
• Successful outcome in 10/16 (63%)
Surgical treatment

Dorsal techniques

- Atlantoaxial wire
- Atlantoaxial suture
- Dorsal suture
- Kishigami AATB
- Dorsal cross-Pinning
- Nuchal ligament technique

Ventral techniques

- Transarticular lag screws
- Transarticular pins +/- PMMA
- Screws and PMMA
- Pins and PMMA
- Plates and screws

Indications

- Chronic or recurrent disease
- Conservative management failed
- Mature vertebrae
- All dogs??
Dorsal techniques

Advantages
- Provide decompression and stabilisation in dorso-ventral plane
- Approach simple
- Reduction readily performed
- Biomechanically advantageous

Disadvantages
- Unable to resist movement in all directions
- Long term stability relies on fibrous ankylosis
- Paucity of bone for fixation
- Odontoidectomy not possible

Indications
- Small dogs (<2kg)
- Failed ventral fixation

Contraindications
- Dorsal deviation of the dens
Atlantoaxial wire/suture

- Loop of 20-24g orthopaedic wire
- Passed under dorsal arch of C1 and through two tunnels in dorsal spinous process of C2

**Denny et al JSAP 1988** and **McCarthy et al Compendium 1995**
  - 14/27 (52%) successful outcome with atlantoaxial wire

- Suture can also be used

**Chambers et al JAAHA 1977** and **McCarthy et al 1995**
  - 5/10 (50%) successful outcome with dorsal suture
Kishigami AATB

- Commercially available implant
- Hooks over cranial aspect of dorsal arch of C1 in epidural space
- Secured to dorsal spinous process of C2 with orthopaedic wire

*Pujol et al Vet Surg 2010*

- 6/8 (75%) good to excellent outcome
Dorsal suture

- 3-0 nylon double suture
- Placed from obliquus capitas cranialis to obliquus capitas caudalis bilaterally and tied near occiput

*Sánchez-Masian et al VCOT 2014*

- 10/15 (66%) had successful outcome with another 2 successfully revised
- Recommended for dogs <1.5kg
Dorsal cross-pinning

- Paired 0.045 inch k-wires
- Dorsal spinous process of C2 into the wings of C1
- Dorsal bone burred and bone graft placed
- Wires cut, bent and incorporated into PMMA

Jeffery ND JSAP 1996

- Single case report successfully treated
Ventral techniques

Advantages
• Potential for AA arthrodesis
• Increased availability of bone stock
• Odontoidectomy possible

Disadvantages
• Reduction more difficult
• Approach more difficult
• Increased potential for iatrogenic trauma
• Bulk of implants

Indications
• Mature dogs >2kg
• Atlantoaxial fractures
• Dorsal dens deviations
• Failed dorsal fixation

Contraindications
• Small, immature dogs
Approach for ventral AA techniques

Two options

- Routine ventral midline approach to AA joint
- Modified ventral midline/parasagittal

*Shores et al vet Surg 2007*

- Incision between right sternothyroid and sternocephalic muscles
- Gives improved exposure of AA joint and protection of regional structures

- AA joint exposed, cartilage debrided and ACBG placed to encourage arthrodesis
AAI reduction ventral techniques

**Pike et al Vet Surg 2012**

**Forterre et al VCOT 2012**

- Small gelpi retractors placed from the intercondyloid notch/incisure cranially and a small slot in the cranial endplate of C3/4 caudally.
- Second pair placed orthogonal to retract the longus colli muscles

**Platt et al Vet Surg 2004**

- Screw in caudal ventral C2 attached to wire and used to lever up C3
Transarticular lag screws/pins

- Bilateral implants directed across AA joint

**Reves et al Vet Surg 2013**
  - 40 deg medial to lateral and 20 deg ventral to dorsal
  - Mean corridor length 7mm (4.5mm-8mm) and width 3-5mm

- Aim for medial aspect of alar notch

- Technical issues include correct angulation, erroneous implant placement and fracture of the cranial axis

**Denny et al JSAP 1988**
  - 90% success rate with lag screws without grafting
Screws and PMMA

- Cortical bone screws 1.5mm-2.0mm
- Placed in ventral C1 and C2 and encased in PMMA
- Ensure PMMA is not bulky

**Platt et al Vet Surg 2004**
  - Transarticular pins
  - 2-3 screws in atlas and 2 in axis
  - 16/19 (84%) considered to have a successful outcome

**Sanders et al JAAHA 2004**
  - 2-3 screws in atlas and 4 in axis
  - Joined by small pins secured by wire
  - 11/12 (92%) successful
Pins and PMMA

• 0.035-0.062 inch pins inserted into C1, C2 and transarticular

• Cut 10mm from bone and entombed in PMMA

Aikawa et al Vet Surg 2013

• 46/49 (94%) improved neurologically

Schultz et al vet Surg 1997

• 8/9 (89%) considered successful
Plates and screws

- 11 cases in total
  - Successful outcome in 8/11 (73%)

Dickomeit et al VCOT 2011

- Locking butterfly plates resulted in excellent outcomes in 3/3 dogs
Surgical complications

- Seen in 9 - 70% of reports

Neurologic deterioration
  - Surgical manipulation or erroneous implant placement

Respiratory system compromise
  - Ventral techniques
  - Surgical retraction or implant related compression
  - Can result in laryngeal paresis, tracheal obstruction or necrosis
  - Aspiration pneumonia

Implant failure
  - Migration or breakage of implant
  - May result in destabilisation

Atlas or axis fracture
  - Thin or soft bone predisposes

Ongoing pain or neurological signs
  - Inadequate decompression or fixation failure
  - Failure of arthrodesis
**Postoperative care**

**Post-op imaging**
- Radiographs
- CT

**Monitor neurological and respiratory systems**

**Analgesia**
- Opioids
- NSAIDs, CCSs?

**Physiotherapy**

**External coaptation?**

**Strict cage confinement**
- 6-8 weeks

**Exercise modification**

**Avoid neck collars/games etc.**
Prognosis

• Fair to good if clinical signs mild-mod and guarded if severe

Conservative
• Influenced by duration of clinical disease (>30 days negative prognostic indicator)
• 50-63% success rate
• Lack of long term follow up

Surgery
• Overall success rates 47-94%
• Positively influenced by
  • Age < 24 months
  • Duration of CSx < 10 months
  • Lower neurologic grade
• Perioperative mortality rates 0-30% with most recent reports <10%

Dorsal techniques
• 50-75% success rate (average 61%)

Ventral techniques
• 47-94% success rate
• Recent reports average 90%
Important review articles/references


References

Questions