Management of the neurosurgical patient

B. Meij
Yalelaan 108, 3508 TD, Utrecht, The Netherlands
Corresponding author: b.p.meij@uu.nl

Introduction
Canine and feline neurosurgical patients are challenging, both for the nurse technician and for the veterinary neurosurgeon. This Nurse Masterclass Series will cover the management of the neurosurgical patient. Items that will be covered are assessment of neurological deficits, basic aspects on advanced imaging techniques for the neurosurgical patient, preparation of the dog and cat for neurosurgery, neurosurgical instrumentation, special considerations during neurosurgery and the short term postoperative neuro-care which will be the primary responsibility of the nurse technician. But the nurse technician may also be involved in the long term postoperative care, revalidation, rehabilitation, and physiotherapy. The nurse technician plays an essential role in the management of the neurosurgical patient, both pre- and postoperatively, being the primary communicator between veterinarian, owner and animal physiotherapist.

The Masterclass will cover a variety of neurological disorders that require neurosurgical intervention such as: intervertebral disc (IVD) degeneration and herniation, degenerative lumbosacral stenosis (‘cauda equina syndrome’), caudal cervical spondylomyelopathy (‘wobbler syndrome’), spinal tumors, spinal trauma, surgical brain tumors including pituitary adenomas, and surgery of the peripheral nerves.

The Masterclass is aimed at the experienced Nurse Technician with advanced skills and a learning ambition that goes beyond the standard surgeries. By following this Masterclass the nurse technician will gain new knowledge in the field of the management of the neurosurgical patient which will allow him/her to contribute significantly in the surgical success of these patients.

Neurological examination
The neurological exam (and not imaging!) is the only exam that can give functional information on the spinal cord in a paretic or paralyzed dog. The veterinarian will usually do a neurological grading of the neurosurgical patient. This is especially the case for dogs with intervertebral disc disease (IVDD) that are presented with paresis (muscle weakness) or paralysis of the pelvic limbs (resp. paraparesis and paraparesis). In case of neurological deficits of all four limbs this is called tetraparesis or tetraparalysis / tetraplegia. Grading of neurological deficits is based on 1) postural reactions (propricoception = positional stance in space), 2) voluntary motor function (standing and walking from A→B), and 3) conscious nociception (= pain recognition by the brain).

Neurological grading:
Grade 0 = normal;
Grade 1 = spinal pain, no neurological deficits;
Grade 2 = paresis, decreased proprioception, ambulatory (able to walk from A→B);
Grade 3 = severe paresis, no proprioception, non-ambulatory (able to stand but not able to walk from A→B);
Grade 4 = Paralysis, no proprioception, non-ambulatory (not able to stand and not able to walk from A→B), decreased bladder function, conscious nociception present;
Grade 5 = Paralysis, no proprioception, non-ambulatory (not able to stand and not able to walk from A→B), no bladder function, conscious nociception absent.

With some practice, nurse technicians should be able to learn to grade patients using this grading system which will help the veterinary surgeon in the diagnostic work-up and decision tree when to wait, when to treat or when to refer. Also the grading will help to follow the success of treatment over time. Grading should be documented and dated in the medical records. In general, grades 1 and 2 can be treated conservatively (with medication) whereas grades 3, and especially grades 4 and 5 necessitate diagnostic work-up and immediate treatment to prevent further damage to the spinal cord.

Grading can also be used for the prognosis: in general the prognosis will worsen with increasing grade although many other factors, like breed, etiology, onset of disease, duration of deficits, body weight, and the owner’s motivation will influence the final prognosis. In case of grade 5, the prognosis is extremely poor for functional recovery when conscious nociception is absent for a period longer than 48-72 hours.

The spinal trauma patient
The spinal trauma patient may have other organ failures besides an unstable spine and should be approached with the greatest care and special considerations. Dogs with spinal fractures are usually extremely painful (when not completely paralyzed) and are usually brought in on stretchers. The pitfall is not to examine these patients for other ailments and not do a proper neurological exam the first time the animal enters the clinic. There are usually other
traumata than the traumatized spine and these patients may have thoracic trauma (pneumothorax, diaphragmatic herniation, contusio of the heart), abdominal trauma (hemo-abdomen, bladder rupture), shock, hypovolemia, or other limb fractures. The grading may be hampered by the inability to examine the animal due to pain. The first line of treatment is directed at the life threatening diseases and not at the spinal fracture. The pain should be dealt with immediately with intravenous analgesics and the patient should be immobilized as best as possible (e.g. with a vacuum support cushion or a stretcher with braces). Extreme caution should be taken when giving these patients muscle relaxants since the muscle tone around the spine may be the last stabilizing factor in fractures of multiple vertebral compartments. When the patient has been stabilized and the organs have been taken care off, imaging should be performed as soon as possible. However, this presents another dilemma: imaging of the awake patient is usually not possible due to the pain, will lead to low quality radiographs, and may pose a greater risk of dislocation of vertebral. On the other hand, sedation or anesthesia will take away muscle tone and therefore may contribute to spinal instability, which may worsen and even transect the spinal cord, when animals are handled without care. In the end, anesthesia is mandatory when imaging spinal fractures, it provides analgesia and allows the production of high quality radiographs. However, it is essential to support the spine, preferably in a vacuum cushion, and the personnel should transfer the cushion (with dog) from table to table and not the dog itself. Also, all personnel should be informed that the patient is a spinal fracture so accidental traction on the spine in different directions will not occur.

**Imaging of the neurosurgical patient**

Radiography and contrast radiography are still considered valuable diagnostic techniques to diagnose conditions that require neurosurgery. Contrast radiography includes myelography and epidurography. Radiography of the spine is best performed under sedation to produce high quality radiographs. Oblique views when aiming for optimal ventrodorsal or latero-lateral views make precise radiographic interpretation of the spine very difficult due to overlapping bony structures. Myelography is performed under anesthesia and the contrast agent is injected in the subarachnoid space around the spinal cord between the skull and C1, or between L4-L5 or L5-L6. Especially with cervical myelography, the contrast agent may leak into the brain and cause convulsions when the dog wakes up from anesthesia. This may be prevented by elevating the head after contrast injection. Myelography may show extradural compression by a space occupying lesion (like a herniated disc). Myelography is able to image the dynamic nature of a disc herniation, e.g. in case of caudal cervical spondylomyelopathy (CCSM, wobbler disease). Flexion/extension, traction and axial compression views of the cervical region are indicated for confirmation of the diagnosis CCSM.

The developments in veterinary neurosurgery have been advanced by imaging techniques like computed tomography (CT) and/or magnetic resonance imaging (MRI). These imaging techniques are a neurosurgeon’s delight! CT is a radiographic technique producing transverse slices of the spine or skull. Indications for CT are spinal fractures, skull fractures, IVDD, degenerative lumbosacral stenosis, discospondylitis, spinal cord tumor and pituitary and brain tumors. Pituitary tumors are enhanced by a contrast agent because the pituitary gland is outside the blood-brain barrier. Brain tumors are enhanced by a contrast agent because of damage or loss of the blood-brain barrier by the tumor.

MRI is a technique that depends on the magnetic dipole of the hydrogen proton. MRI involves 1) a hardware component (magnetic field, radio-transmitter that excites the protons, and a radio-receiver that receives radio-signals), 2) the contrast agent (magnetization or spin density of tissue, relaxation times e.g., T1, T2, and a contrast agent like gadolinium), and 3) the software component that generates pulse sequences (timing diagram) through mathematical calculations (Fourier transformation) on the radio-signals. Indications for MRI are IVDD, degenerative lumbosacral stenosis (cauda equina disease), caudal cervical spondylomyelopathy (wobbler disease), discospondylitis, spinal cord tumor and, pituitary and brain tumors. In contrast with CT, MRI is also able to visualize edema of spinal cord parenchyma and is diagnostic for spinal cord infarction or fibrocartilaginous thrombo-embolic myelopathy (FCE). Also, the result of an acute type 1 extrusion of nucleus pulposus in chondrodystrophic dogs (e.g. French Bulldog) that severely damages the spinal cord and starts a negative spiral of edema, ischemia and spinal cord necrosis (called myelomalacia), is visible on T2-weighted MRI as a hyperintense signal in the spinal cord parenchyma.

During neurosurgery, the veterinary surgeon usually requires on hand all the available imaging data (radiographs, myelogram, CT and MRI) for localization of the correct surgical approach and intra-operative feedback of surgical findings in relation to the imaging findings. Also pre-operative planning and 3D measurements on sizes of space-occupying lesions and tumors are an enormous help for the surgeon.

**The brain patient**

The patient that undergoes brain or pituitary surgery requires special care. Apart from the routine monitoring devices, it is imperative in brain surgery to have some type of monitoring of blood pressure and possibly also intracranial pressure. Infusion with mannitol is used to lower the intracranial pressure.
The temperature of the surgical unit should be kept below room temperature. A ‘cold’ brain requires less oxygen. Brain and pituitary surgery requires some type of magnification (operating loupes) or an operating microscope, also for the assisting nurse technician. Postoperative neurosurgical care is done in the intensive care unit and patients are kept sedated for some hours after brain surgery before waking them up. As soon as they are awake the first neurological exam is done to assess brain function. In case of pituitary surgery in dogs for tumors that cause Cushing’s disease (the pituitary tumor produces excess adrenocorticotropic hormone = ACTH) the post-operative monitoring includes electrolytes (sodium, potassium). In the ICU, the dogs are stimulated to drink immediately after surgery to regulate their water balance. The hormonal substitution therapy in dogs after hypophysectomy includes thyroxine, cortison and desmopressin (a synthetic vasopressin analogue). In cats with acromegaly (the pituitary tumor produces excess growth hormone = GH) undergoing pituitary surgery the same considerations are taken into account as for dogs with Cushing’s disease but, in addition, these cats usually have insulin-dependent diabetes mellitus which will resolve quickly after surgery. Therefore continuous monitoring of glucose levels is imperative in the postoperative phase and short acting insulin medications should be administered to prevent hypoglycemic events.

Neurosurgical indications and procedures
The following diseases are the most common indications for neurosurgery:

1. Intervertebral disc disease (IVDD) with cervical disc disease (C2-3, C3-4, C4-5) and thoracolumbar (T11-12, T12-13, T13-L1, L1-2, L2-3) disc disease in chondrodystrophic dogs (e.g. French Bulldog, Dachshund). Disc herniations are usually type 1 (extrusion) herniations of the nucleus pulposus. In the cervical region a ventral approach is used called a ventral fenestration (incision of the annulus fibrosus) and decompression (ventral slot of the vertebral bodies). In the thoracolumbar area a left or right-sided approach is used called hemilaminectomy and lateral fenestration.

2. Degenerative lumbosacral stenosis in non-chondrodystrophic dogs (e.g. German Shepherd). Disc herniations are usually type 2 (protrusion) herniations of the annulus fibrosus and nucleus pulposus. In the lumbosacral area the most common approach is dorsal laminectomy, followed by dorsal fenestration of the disc and nucleotom (removal of the nucleus pulposus).

3. Caudal cervical spondyloymelopathy (wobbler disease) in nonchondrodystrophic dogs (e.g. Dobermann). In this disease, the type 2 disc herniation is usually more dynamic in nature and requires decompression but also stabilization using a variety of techniques like screw and washer, pins and polymethylmethacrylate (PMMA), or cervical locking plates.

4. Atlanto-axial instability in miniature dogs (e.g. Chihuahua). The most common approach is the ventral approach with lag screw fixation. The nurse technician should be aware of post-operative respiratory depression and apnea in this condition since the respiratory center is close to the surgical field and may be temporarily affected. Some of these patients needs to be ventilated postoperatively for some time.

5. Spinal cord tumors. The approach is dependent on the localization but usually the approach is not a standard technique. In the cervical area and thoracolumbar, lumbar, and lumbosacral area spinal tumors are best approached by dorsal laminectomy. In the thoracolumbar area, dorsal laminectomy leads to an unstable spine which requires some type of fixation afterwards like Lubra plates, vertebral plates or pin-PMM fixation technique.

6. Brain tumors. Tumors of the neurocranium can be approached through craniotomy. The term craniectomy is used when the bone flap that is created during craniotomy is not replaced. The location of the tumor dictates the approach. The most common approaches to the calvarium are 1) rostrotemporal transparietal or transfrontal craniotomy with or without osteotomy of the zygomatic arch, 2) unilateral or bilateral transfrontal sinus craniotomy, 3) caudotemporal craniotomy, or 4) suboccipital craniotomy. Craniotomy approaches can be combined or modified to improve exposure to various aspects of the cerebral hemispheres and cerebellum. Most craniotomies are performed with the cat in sternal recumbency. A head stand, a vacuum cushion and/or surgical tape is used to stabilize the head during the surgical procedure.

7. Pituitary tumors. The pituitary tumor is usually approached by the oral route to the brain via a transoral, transnasal microsurgical transsphenoidal hypophysectomy. The dogs and cats are in sternal recumbency and the maxilla is supported on a metal bar attached to the operating table. The mandible is reflected downwards and the approach to the base of the skull is through the soft palate, through the nasopharynx and through the sphenoid bone. The surgery is considered a contaminated surgery because the approach is through the mouth and nose.

Special considerations during neurosurgery
Neurosurgical instrumentation for the approach and detachment of muscles include periosteal elevators and Gelpi retractors. Laminecotomies are performed with an electrical or air-powered burr unit. The advantage of an electrical burr is that the speed of rotations can be fine-tuned. Foot pedal-controlled burring is preferred over hand console-controlled burring since this adds to stability of the burr in the
Proceedings of the 14th Chulalongkorn University Veterinary Conference  
CUVC 2015: Responsible for Lives  
April 20-22, 2015, Bangkok, Thailand

surgeon’s hand. Also, irrigation can be automatically integrated in the hand burr but continuous lavage with saline from a syringe by the nurse technician is just as efficient and more reliable than equipment! Copious lavage is a prerequisite in neurosurgery to provide cooling during burring, to remove the bone shavings and to keep the surgical field free of blood. Once the surgeon has entered the spinal canal or the bony calvarium, the spinal cord, nerves and brain are explored with fine ball-tipped neurosurgical probes. Long instruments are preferred which keeps the hands out of the surgical field.

During neurosurgery hemostasis is primarily controlled by bipolar electrocautery. Approaches to the spine require detaching of muscular attachments and this causes profuse bleeding. This can be kept to a minimum by pre-cauterizing muscular attachments with bipolar electrocautery before cutting the attachments. Typically a nurse technician can assist and speed up this phase of the surgery. Bipolar electrocautery has the advantage over monopolar electrocautery that the current will pass between the tips of the bipolar forceps and will not affect the adjacent muscle tissue or nerves (or spinal cord). In monopolar electrocautery the current goes from the tip of the monopolar to the contact plate which may cause unwanted twitching and movements of the surgical field.

During most neurosurgical procedures some type of magnification is required to assess the condition of nerves, spinal cord, or brain and to assess the sharp margins between normal and affected tissue. Especially in spinal cord and brain tumor surgery, the surgeon is moving on the cutting edge between normal and affected (=tumor) tissue. In neurosurgery it may not be possible to take safe margins with tumor excision so the aim is tumor management by debulking (cytoreduction) rather than complete tumor excision. This requires a different mind set than in standard tumor surgery.

**Rehabilitation of the neurosurgical patient**

Neurosurgery is only the first step in recovery of the patient off its legs. Canine rehabilitation should start on the first day after surgery whenever possible and practical. The paralyzed patient requires intensive care an it’s owner guidance. Bedding of the patient should be kept dry, clean and soft at all times. The animal should be turned at regular intervals. Paralyzed patients frequently have no voluntary urination. ‘Bladder’ management requires catheterization or frequent attempts to empty the bladder by manual abdominal pressure. Animals that soil the perineal region with urine and feces in the postoperative period run a great risk of development of decubitus ulcers or dermatitis in the perineal region. Urine weakens the skin barrier and enables bacteria to enter through the skin and cause redness and infection. As long as the animal is not urinating spontaneously and has to be catheterized, there is and indication to treat with systemic antibiotics. This may even take up to 2 weeks after surgery. Pain medication postoperatively may include non-steroidal anti-inflammatory drugs (e.g. carprofen) and/or morphine-like substances (e.g. oral tramadol or fentanyl patches). The use of postoperative steroids after laminectomies is highly controversial. Rehabilitation of the paralyzed patient may include frequent bathing, muscle massage, exercising standing with support bags, wheelchair walking, hydrotherapy with an underwater treadmill, swimming, and exercises for proprioception, etc. The veterinary surgeon may refer the animal to an animal physiotherapist within the practice or outside. A referral letter is made to inform the physiotherapist on the medical history and to provide a channel for feedback on follow up. Postoperative recovery of conscious nociception is fast (24 tot 48 hours), recovery of motor function may take 6 weeks and recovery of postural reactions (proprioception) may take up to 6 months!