Aus der Klinik für kleine Haustiere
des Fachbereichs Veterinärmedizin
der Freien Universität Berlin

Evaluation of the possibility of the existence of low-grade positioning dependent iatrogenic nerve injuries in small animals on the feline model

Inaugural-Dissertation
zur Erlangung des Grades eines
Doktors der Veterinärmedizin
an der
Freien Universität Berlin

vorgelegt von
Pavel Slunsky
Tierarzt aus Sternberk
Tschechien

Berlin 2019
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Infinite diversity in infinite combination.

Gene Roddenberry

Table of contents

1 INTRODUCTION

The discipline of surgery requires the choreographed manipulation of the patient by the surgical team. Unfortunately, the patient is at risk of sustaining an iatrogenic injury at any step during this process.[1]

Anaesthesia inhibits a variety of the protective mechanisms, which are usually in place to protect the living individual from harm and prevent damage to vulnerable tissues. Patients often require positioning for surgery, which would be intolerable without anaesthesia; these positions may introduce hazards, which can lead to perioperative nerve injury.[2] Therefore, an optimal surgical positioning is crucial in order to prevent tissue damage, which can be very debilitating and lead to severe complications.[3]

Patient positioning as a cause of postoperative neuropathy was first recognised in humans by Halsted in 1908.[4] Current publications from human medicine report incidences of postoperative peripheral neuropathy ranging from 0.03% to 25%, depending on the criteria used to define neuropathy.[3,5,6]

The most likely pathological mechanisms of injury include stretching, compression, ischemia and metabolic/environmental abnormalities where some pre-existing risk factors and intraoperative conditions have been demonstrated[1,3,5,7,8] (diabetes mellitus,[1,3,5,8,9,10,11] tobacco use,[3,8,9,10,12] vascular disease,[1,3,8,10,12] extremes in weight,[1,3,5,8,13-15] atherosclerosis,[1,3,8] hypothermia,[5] hypotension,[5] heavy metal exposure,[8] infectious diseases,[8] anatomical aberrations,[5] gender[3,10,11,14,16] and age[3,9,14,15]). Damage to the nerve occurs through primary (direct) and secondary (indirect) effects. The extent of these primary and secondary injuries determines the amount of damage to a nerve and the potential for recovery.[7]

The effect on nerves depends on the duration of the insult, force imparted and size of the affected nerve fibre.[17] If the insult is mild, the conduction block can last only a few minutes. Prolonged, it can lead to Schwann cell damage and demyelination, taking hours to weeks to reverse. Severe injuries can cause axonal loss and/or Wallerian degeneration. The interval to recovery is, in this case, variable and is dependent on the regeneration of peripheral axons.[1,6,7,17-19]

In animals, iatrogenic nerve injuries caused by inappropriate perioperative positioning are well described in large animals and usually relate to cases of limb paresis or paralysis.[20-23] Information about iatrogenic nerve injuries in small animals caused by inappropriate perioperative positioning have been described experimentally and include studies in rodents.[24,25] High-grade neurological deterioration is represented only in a small group of human patients.[26] Low-grade, transitional motor and sensory

deficits are much more common in humans, but may still lead to significant health problems.[1] Diagnosis of this mild neurological deterioration is usually based only on a patient's oral communication. Thus, their exact confirmation and quantification is difficult without a well-aimed neurological examination and use of specific diagnostic methods (i.e. electrodiagnostic testing, urethral pressure profilometry, muscle and nerve biopsy).[1,3,6,19,26-28]

Direct oral communication with the patient is not possible in veterinary medicine and the determination of the correct diagnosis is strongly dependent on animal history, gained from the owner and the physical examination. Consequently, the question to ask is: "Do positioning dependent low-grade nerve injuries occur in cats and is it simply an under-diagnosed condition?"

This elementary question represents the cornerstone for the emergence of the presented work and formulation of these major goals:

- Foundational research part;
  - Selection of the appropriate animal model;
  - Evaluation of the anatomical changes of the spinal column during perioperative positioning in the animal model as a basis for the further clinical study;
- Applied research part;
  - Evaluation of the existence or non-existence of the postoperative neurological changes associated with the perioperative positioning in the animal model;
  - Evaluation of the clinical benefit for the model animal with regard to the reduction of the postoperative complications.

The above-mentioned major goals were evaluated in two subsequent studies published in an international peer-reviewed journal:

Slunsky, P. et al "Effect of intraoperative positioning on the diameter of the vertebral canal in cats during perineal urethrostomy (cadaveric study)." *J Feline Med Surg* 2018; 20: 38-44.

The objective of this study was:

- To standardise the positioning and fixation methodologies during perineal urethrostomy in cats and create the basis for further experiments;
- To quantify the changes in the diameter of the vertebral canal in the lumbosacral and sacrococcygeal column (L6–Co2) in cats in dorsal and ventral recumbency, simulating real body positioning during a perineal urethrostomy;
- To determine the more physiological position from an anatomical point of view.

Slunsky, P. et al "Effect of intraoperative positioning on the postoperative neurological status in cats after perineal urethrostomy." *J Feline Med Surg* 2018; 1098612X18809188.

The objective of this study was:

- To quantify the changes in the neurological status in cats after perineal urethrostomy performed in dorsal and ventral recumbency;
- To determine the more physiological position from a clinical point of view;
- To compare the conclusions of the first and second publication.

The results of the aforementioned studies form the basis of this presented cumulative dissertation.

2 RESEARCH PAPERS

2.1 Effect of the intraoperative positioning on the diameter of the vertebral canal in cats during perineal urethrostomy (cadaveric study)

Slunsky, P., Brunnberg, M., Lodersted, S., Brunnberg, L. (2018).
Journal of feline medicine and surgery, 20(1), 38-44.
https://doi.org/10.1177/1098612X17709645
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2.2 Effect of intraoperative positioning on the postoperative neurological status in cats after perineal urethrostomy

Slunsky, P., Brunnberg, M., Lodersted, S., Haake, A., Brunnberg, L. (2018).
Journal of feline medicine and surgery, 1098612X18809188.
https://doi.org/10.1177/1098612X18809188
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3 DISCUSSION

For clarity and better orientation, the individual parts and results of the study are listed and discussed in separate subchapters.

3.1 Foundational research part

All goals of the foundational research part were successfully fulfilled and are mentioned below.

3.1.1 Selection of the appropriate animal model

A model is a simplified, abstract and idealised representation of reality based on an ordered set of assumptions. As conventionally conceived, it is about a miniature representation, perhaps altered in scope or scale, but not in its essence.[29] Factors influencing choice of the appropriate animal model system include specific disease features, as well as their similarity to physiology and pathology to another species, to which the conclusions of the model should be applied. Altogether, the choice of the right species and available model is largely dependent on the interest of the study.[30]

Modelling can be used to study three main categories of problems: (1) prediction or output analysis, (2) reception or input discovery and (3) insight or transfer function identification.

Selection of an animal model for the prediction analysis was the first step of the foundational research part. Prediction simply answers the question: "What happens if…?".[31] In our case, the elementary question therefore was: "What happens with the hind limb spinal reflexes of a cat undergoing perineal urethrostomy, if this animal is perioperatively fixed in a non-physiological position?".

The use of experimental animals for the evaluation of the aforementioned hypothesis was rejected as non-feasible with regard to the consequent experiments and further goals. Clinical patients demonstrate higher variability in many variables (i.e. genotype, age, weight, etc.) compared to experimental animals and thus the conclusions of the clinical models are weaker than those from experimental models,[32-34] but from a legislative point of view and depending on the research question, using an animal model is often the only possible way.[35]

To the best of the author's knowledge, this work presents the first model of low-grade positioning dependent nerve injury in small animals. Therefore, basic specification of this model had to be selected first. Defined specifications were: group of animals of the same species, breed, sex, relatively homogenous in age and weight and the ability to undergo standardised surgery, which is possible in at least two different body positions.

European Shorthair cats with feline lower urinary tract disease (FLUTD) undergoing perineal urethrostomy qualify best for these requirements. The same species and breed guarantees a relatively stable genotype and phenotype of the animals. FLUTD is a well described disease affecting only male cats;[36] age and weight intervals are relatively narrow,[37-39] perineal urethrostomy is a standard surgical intervention[40] and two perioperative fixation positions exist.[41] Furthermore, no evidence-based data providing information that one method of fixation is superior to another exists in literature, which made this model additionally interesting for an eventual clinical application. Cats with FLUTD seemed to be an ideal animal model for the purpose of further experiments with regard to the numerous occurrences of FLUTD in the feline population and the frequency of perineal urethrostomy being performed.

3.1.2 Standardisation the positioning and fixation methodologies during perineal urethrostomy in cats and creating a basis for further experiments

The methodology of fixation was chosen with the intent to achieve maximal consistency within the usual clinical practice. Since a method of fixation in dorsal and ventral recumbency during perineal urethrostomy is only vaguely described in literature,[41] the fixation method had to be standardised first.[42,43]

For dorsal recumbency, the thoracic limbs were tied in a caudal direction and the pelvic limbs in a cranial direction using gauze. The tail hung free over the testing apparatus/surgical table. Ventral recumbency was accomplished by tying the thoracic limbs in a cranial direction and the pelvic limbs over the edge of the testing apparatus/surgical table in a ventrolateral position. The tail was hyperextended and secured with tape/gauze to the testing apparatus/surgical table, thus ensuring access to the perineal region.[42,43]

Forces acting on the extremities and tail were not quantified and unified. The extremities were tied down and the tail taped/tied to the testing apparatus/surgical table, representing common intraoperative positioning to access the perineal region, but

only with application of minimal forces necessary for stable positioning and an adequate surgical view. [42,43]

3.1.3 Evaluation and quantification of the changes of the vertebral canal in the lumbosacral and sacrococcygeal column (L6–Co2) in cats in dorsal and ventral recumbency, simulating real body positioning during a perineal urethrostomy

The change in diameter of the vertebral canal in the lumbosacral and sacrococcygeal column was evaluated by positioning in neutral position, dorsal and ventral recumbency. Twenty-one male feline cadavers were enrolled in the study and all feline cadavers were evaluated by computed tomography.[42]

Sagittal vertebral canal diameters (VCDs) were obtained by measuring the distance between the ventral and dorsal aspects of the vertebral canal in the middle of the intervertebral space. This methodology was inspired by the original work by Ramos et al[44] where the investigators quantified the changes of the VCD in the cervical vertebral column in Great Danes after application of tension–compression and complex loads of flexion and extension forces. This initial idea was further adapted for this research purpose and is described in detail elsewhere.[42]

A comparison of the VCDs between L6 and L7, L7 and S1, S3 and Co1, Co1 and Co2 in neutral position vs dorsal recumbency revealed a reduction of 0.27 mm (14.6%; P <0.001) between S3 and Co1 and 0.26 mm (18.1%; P <0.001) between Co1 and Co2. No differences were seen when comparing L6–L7 and L7–S1. The VCDs were decreased in all segments when comparing neutral with ventral recumbency. This study revealed a reduction of 0.13 mm between L6 and L7 (3.3%; P = 0.003), 0.14 mm between L7 and S1 (4.1%; P = 0.003), 0.61 mm between S3 and Co1 (32.5%; P <0.001) and 0.63 mm between Co1 and Co2 (44.1%; P <0.001). Comparison of the VCD between dorsal and ventral recumbency in L6–L7, L7–S1, S3–Co1 and Co1–Co2 revealed a decrease in the VCDs in ventral recumbency of 0.13 mm (3.3%; P <0.001), 0.12 mm (3.6%; P <0.001), 0.34 mm (21.0%; P <0.001) and 0.37 mm (31.7%; P <0.001), respectively.[42]

These findings demonstrate that the sagittal vertebral canal diameter is significantly decreased in dorsal recumbency between S3–Co1 and Co1–Co2; in ventral recumbency, a significant reduction in the VCDs was seen in all evaluated vertebral segments. The degree of reduction was significantly higher in ventral compared with dorsal recumbency.[42]

To the best of the author's knowledge, this work presents the first published information regarding evaluation and quantification of the changes of the vertebral canal in the lumbosacral and sacrococcygeal column in cats in dorsal and ventral recumbency. Comparison of above-mentioned findings with other sources from literature was not possible, as there was no related information available at the time of writing this thesis.

3.1.4 Determination of the more physiological position from an anatomical point of view

The above-mentioned findings exhibit that the reduction in diameter of the vertebral canal was significantly higher in ventral compared with dorsal recumbency. The results provide evidence that, from an anatomical point of view, perineal urethrostomy performed in dorsal recumbency should be preferred.[42]

Reduction of the vertebral canal diameter arising from body positioning could potentially, directly or indirectly, cause iatrogenic nerve injuries and influence neuronal pathways in affected regions, but further clinical study to verify these findings was necessary.[42]

The verification of this hypothesis in clinical patients was the main objective of the subsequent applied research part.

3.2 Applied research part

Here, results of the applied research part are discussed and compared with the foundational research part.

3.2.1 Evaluation of existence and quantification of the postoperative neurological changings associated with the perioperative positioning in the animal model

The changes in neurological status in cats undergoing perineal urethrostomy, either in dorsal or ventral recumbency, were evaluated and quantified.[43]

Twenty male cats with FLUTD presented for perineal urethrostomy were enrolled in the study. Indications for surgery were: obstructions that could not be conservatively unblocked, recurrence of urethral obstruction despite conservative therapy or urethral trauma secondary to obstruction. Surgery was performed either in dorsal (group A)

or in ventral recumbency (group B). Motor response of patellar tendon, gastrocnemius muscle, pelvic limb withdrawal and perineal reflex, as well as the presence of spinal pain in the lumbosacral region, motor function of the tail and faecal continence were examined prior to surgery, 24 hours and 14 days after surgery.[43]

All tested parameters of the neurological examination performed prior to surgery were considered normal in both groups ($P = 1$). The comparison between neurological examinations (perineal reflex and spinal pain) before and 24 hours after surgery revealed a significantly decreased briskness of the perineal reflex and an increased occurrence of spinal pain 24 hours after surgery ($P = 0.043$ and $P = 0.031$, respectively). However, the changes of aforementioned parameters were statistically insignificant ($P = 0.249$, $P = 0.141$) between groups A and B. The other parameters (patellar tendon, pelvic limb withdrawal and gastrocnemius muscle reflexes; motor function of the tail and faecal continence) were statistically insignificant ($P = 1$) before surgery and 24 hours after surgery, as well as between groups A and B 24 hours after surgery. Results of all tested parameters were statistically insignificant ($P = 1$) before surgery and 14 days after surgery, as well as between groups A and B 14 days after surgery.[43]

To the best of the author's knowledge, this work presents the first published information regarding evaluation and quantification of the changes in neurological status in cats undergoing perineal urethrostomy in dorsal or ventral recumbency. A comparison of the above-mentioned findings with sources from literature related to the animal model used in this work was not possible, as there was no information available at the time of writing this thesis. A comparison with the data published for other species or humans was also not possible, because of differing anatomy, different positioning during surgery and kind of surgery performed.

3.2.2 Determination of the more physiological position from a clinical point of view

The briskness of the perineal reflex was significantly decreased and the occurrence of spinal pain significantly increased 24 hours after surgery, therefore a parallel with a low-grade positioning dependent nerve injury as described in human medicine may be drawn. However, no positioning method has been proven to be superior to the other.[43]

3.3 Comparison between conclusions from the foundational and applied research part

The foundational research part evaluated the biomechanics of the lumbosacral and sacrococcygeal column in cats fixed in dorsal and ventral recumbency. On the basis of the recorded data, the hypothesis postulated the existence and describes the possible mechanism of origin for positioning dependent nerve injuries in this animal model.

This hypothesis has been validated in the subsequent clinical trial. Non-physiological perioperative fixation led to statistically significant worsening of the neurological status in the cats 24 hours after surgery; therefore the existence of low-grade positioning dependent nerve injuries in cats was demonstrated. To the best of the author's knowledge, this work presents the first published information describing this health issue in small animals.

Although the existence of low-grade positioning dependent nerve injuries in cats based on the clinical neurological examination was proved, the pathophysiology of their origin remains unclear. A reduction of the vertebral canal diameter between L7-S1,[42] stretching of the peripheral nerves,[45] direct pressure on the peripheral nerves,[46] ischemic myopathy and/or ischemic neuropathy[47] and dorsal hyperflexion of the tail in cats positioned in ventral recumbency[42] may all be possible ethological factors leading to reduced briskness of the perineal reflex. Hyperalgesia of the paralumbar musculature in the lumbosacral region may reflect a non-specific lesion of the spinal cord in this area[48] or ischemic myopathy caused by pressure on the paralumbar muscles.[49]

3.4 Evaluation of the clinical benefit for the model animal with regard to the reduction of the postoperative complications

Urinary tract infection (UTI) is a well-documented complication after perineal urethrostomy (PU) in cats and accounts for 17–57% of all long-term complications associated with this surgical procedure.[37,50-52]

The pathophysiology of this condition is still not fully understood and is mostly characterised as multifactorial.[53] Traditionally suggested possible causes include: postoperative use of indwelling catheters,[54] reduction of the urethral length,[53] creation of a stoma with a larger opening and closer proximity to the anus,[53] decrease of the urethral tonus,[55] removal of the part of the urethral mucosal barrier[53] and damage to the neurological structures during dissection.[55]

Iatrogenic nerve injuries of the lumbosacral plexus caused by inappropriate perioperative positioning with subsequent development of urinary distress are well known in human medicine.[5,26,28] Related information is missing in the field of veterinary medicine.

The above-mentioned data provides evidence that the perineal reflex was significantly decreased 24 hours after surgery. This reflex evaluates the spinal cord segments S1 and S3.[56] The motoneurons originate in the spinal cord segments between (L7); S1–S2; (S3) for the pudendal nerve[57] and (S1); S2–S3 for the pelvic nerve.[58] The pudendal nerve provides somatic innervation to the periurethral striated muscle at the bladder neck (external urethral sphincter). The external urethral striated muscle remains in a state of steady contraction, contributing to active urethral resistance during urine storage and is inhibited during reflex urination. The parasympathetic pelvic nerve initiates reflex detrusor muscle contraction and subsequent urination. Injury of these nerves lead to a decrease of active urethral resistance in the case of pudendal nerve injury and to urine retention and subsequent urine overflow in the case of pelvic nerve injury.[59]

From this point of view, perioperative fixation may be one additional factor contributing to the development of UTI in cats after perineal urethrostomy.

The conclusion of the foundational research part hypothesised that PU in cats performed in dorsal recumbency is superior to PU in ventral recumbency with regard to the risk of positioning dependent iatrogenic nerve injury.[42] This hypothesis could not be confirmed in the applied research part. The neurological status was not statistically significant different in the animals on which PU was performed in dorsal (group A) or ventral recumbency (group B). The result may reflect the clinical insignificance between dorsal and ventral positioning during PU surgery. However, the lack of statistical significance in this study could also be due to the small animal population or the relatively low sensitivity of the performed neurological examination.[60-62]

The duration of the operation and the associated fixation time were not documented and statistically evaluated. As known from human medicine, the effect on nerves depends on the duration.[17] Therefore, even thought a perineal urethrostomy is a standardised operation technique[40] with an established time investment, the disregard of this parameter may constitute a bias and should be taken into consideration in subsequent studies.

Extremes in weight is a predisposing factor for the development of postoperative peripheral neuropathy in humans.[1,3,5,8,13-15] In this study, weight differences in both groups were non-significant. It is possible that, with increasing weight of the animals, the frequency of positioning dependent injuries could increase. This, however, remains speculative und should be evaluated further.

Neurological examination is a semi-quantitative diagnostic method, which is considerably subjective and strongly investigator dependent.[63-65] Other more sensitive methods like electrodiagnostic or urethral pressure profilometry could be more suitable.[55,66] Unfortunately, these methods are relatively invasive, requiring general anaesthesia and are time consuming. Therefore, from a legal, and more importantly an ethical point of view, such diagnostic methods on otherwise healthy animals are not justifiable. Thus, the author was constrained to restrict the diagnostics to a neurological examination.

4 CONCLUSION

Positioning dependent nerve injuries present a very well known aetiological unit in human medicine with serious consequences for the patient. In the most serious cases they can lead to permanent infliction and even death.[5] Fortunately, these grave complications are relatively rare. Low-grade positioning dependent neurologic injuries are much more common.[26] Despite the fact that they are marked by a low mortality, the morbidity for the patient is usually high.[67] In humans, they lead to a decreased quality of life, development of concomitant diseases and, last but not least, a high financial compensation to the affected patients.[5,26,67,68] It is therefore a matter of concern that this topic has been completely beyond the scope of research in the field of veterinary medicine.

This work proves the existence of low-grade positioning dependent nerve injuries in a small animal model. This finding may help open a new field of research in small animal medicine, which may change the viewpoint of the treatment of the animals during surgical procedures and improve the treatment outcome and wellbeing of the patients.

5 SUMMARY

Positioning dependent neurological injuries present a well-known aetiological factor in human medicine with serious negative consequences for the patient.

In animals, iatrogenic nerve injuries caused by inappropriate perioperative positioning are well described in large animals, but evidence-based information about the existence of this issue in small companion animals is missing.

This cumulative dissertation consists of a foundational and applied research part.

1) The goals of the foundational research part were:

- Selection of the appropriate small animal model;
- Standardisation of the positioning and fixation methodologies;
- Evaluation and quantification of the anatomical changes of the spinal column during perioperative positioning in the animal model as a basis for the further clinical study;
- Determination of the more physiological perioperative position from an anatomical point of view.

European Shorthair cats with feline lower urinary tract disease (FLUTD) undergoing perineal urethrostomy were selected as an animal model. The positioning and fixation methodologies were standardised. Twenty-one male feline cadavers were enrolled in the study. All feline cadavers were evaluated by CT. Examinations were performed with the cadaver in a neutral position and dorsal and ventral recumbency. Sagittal vertebral canal diameters (VCDs) were obtained by measuring the distance between the ventral and dorsal aspects of the vertebral canal in the middle of the intervertebral space.

A comparison of the VCDs between L6 and L7, L7 and S1, S3 and Co1 and Co1 and Co2 in neutral position vs dorsal recumbency revealed a reduction of 0.27 mm (14.6%; P <0.001) between S3 and Co1 and 0.26 mm (18.1%; P <0.001) between Co1 and Co2. No differences were seen when comparing L6–L7 and L7–S1. The VCDs were decreased in all segments when comparing neutral with ventral recumbency. This study revealed a reduction of 0.13 mm between L6 and L7 (3.3%; P = 0.003), 0.14 mm between L7 and S1 (4.1%; P = 0.003), 0.61 mm between S3 and Co1 (32.5%; P <0.001) and 0.63 mm between Co1 and Co2 (44.1%; P <0.001). Comparison of the VCD between dorsal and ventral recumbency in L6–L7, L7–S1, S3–Co1 and Co1–Co2 revealed a decrease in the VCDs in ventral recumbency of 0.13 mm (3.3%; P

<0.001), 0.12 mm (3.6%; P <0.001), 0.34 mm (21.0%; P <0.001) and 0.37 mm (31.7%; P <0.001), respectively.

The results provide evidence that, from an anatomical point of view, perineal urethrostomy performed in dorsal recumbency is superior to ventral recumbency, but further clinical study to verify these findings was needed.

2) The goals of the applied research part were:

- Evaluation and quantification of the postoperative neurological changes associated with the perioperative positioning in the animal model and the determination of the existence or non-existence of positioning dependent nerve injury;
- Determination of the more physiological position from a clinical point of view.

Twenty male castrated cats with FLUTD presented for perineal urethrostomy were enrolled in this study. Surgery was performed either in dorsal (group A) or in ventral recumbency (group B). Motor response of the patellar tendon, gastrocnemius muscle, pelvic limb withdrawal and perineal reflex, as well as the presence of spinal pain in the lumbosacral region, motor function of the tail and faecal continence were examined prior to surgery, 24 hours and 14 days after surgery.

The mean weight of animals was 5.07 ± 1.08 kg with a mean age of 6.12 ± 1.85 years. Weight and age were not significantly different between groups A and B (both $P = 0.897$). All tested parameters of the neurological examination performed prior to surgery were considered normal in both groups ($P = 1$). The comparison between neurological examinations (perineal reflex and spinal pain) before and 24 hours after surgery revealed a significantly decreased briskness of the perineal reflex and an increased occurrence of spinal pain 24 hours after surgery ($P = 0.043$ and $P = 0.031$, respectively). However, the changes of aforementioned parameters were statistically insignificant ($P = 0.249$, $P = 0.141$) between groups A and B. The other parameters (patellar tendon, pelvic limb withdrawal and gastrocnemius muscle reflexes; motor function of the tail and faecal continence) were statistically insignificant ($P = 1$) before surgery and 24 hours after surgery, as well as between groups A and B 24 hours after surgery. Results of all tested parameters were statistically insignificant ($P = 1$) before surgery and 14 days after surgery, as well as between groups A and B 14 days after surgery.

The briskness of the perineal reflex was significantly decreased and the occurrence of spinal pain significantly increased 24 hours after surgery. A parallel with

a low-grade positioning dependent nerve injury as described in human medicine may be drawn. However, no fixation method has been proven to be superior to the other.

6 ZUSAMMENFASSUNG

Untersuchung auf ein mögliches Vorkommen von geringgradigen lagerungsbedingten iatrogenen Nervenschäden beim Kleintier im Katzenmodell

Lagerungsbedingte neurologische Schäden sind in der Humanmedizin wohlbekannte ätiologische Faktoren mit ernstzunehmenden Konsequenzen für den betreffenden Patienten.

Beim Großtier sind iatrogene Nervenschäden durch inadäquate Positionierung des Patienten peri operationem gut beschrieben, evidenzbasierte Daten zu ihrem Vorkommen beim Kleintier fehlen jedoch.

Diese kumulative Dissertation besteht aus einem Grundlagen- und angewandten Forschungsteil.

1) Ziele des Grundlagenteils waren:

- die Auswahl eines geeigneten Kleintiermodells;
- die Standardisierung der Positionierung und der Fixationsmethoden;
- die Evaluation und Quantifizierung anatomischer Veränderungen im Bereich der Wirbelsäule während der perioperativen Lagerung im Tiermodell als Basis für die weiterführende klinische Studie;
- festzustellen, welche Art der perioperativen Positionierung aus anatomischer Sicht eher als physiologisch anzusehen ist.

Als Tiermodell wurden Europäisch Kurzhaarkatzen mit Feline Lower Urinary Tract Disease (FLUTD) gewählt, bei denen eine perineale Urethrostomie durchgeführt wurde. Die Positionierung und Fixationsmethoden wurden standardisiert. Einundzwanzig Kadaver männlicher Katzen wurden in diese Studie eingeschlossen. Alle Katzenkadaver wurden mittels Computertomographie (CT) untersucht. Die Untersuchungen der Kadaver wurden in Neutralposition sowie in Rücken- und Bauchlage durchgeführt. Die sagittalen Diameter des Wirbelkanals (VCDs) wurden durch Messung der Abstände zwischen ventralem und dorsalem Rand des Wirbelkanals mittig auf Höhe der Intervertebralspalten ermittelt.

Ein Vergleich der VCDs zwischen L6 und L7, L7 und S1, S3 und Co1 sowie Co1 und Co2 in Neutralposition und Rückenlage ergab eine Reduktion des VCDs um 0,27 mm (14,6%; P <0,001) zwischen S3 und Co1 sowie um 0,26 mm (18,1%; P <0,001)

zwischen Co1 und Co2. Es wurde kein Unterschied beim Vergleich der VCD'S zwischen L6 und L7 sowie L7 und S1 festgestellt. Die VCD'S waren beim Vergleich von Lagerung in Neutralposition und Lagerung in Bauchlage in allen untersuchen Wirbelsäulenabschnitten reduziert. Zwischen L6 und L7 um 0,14 mm (3,3%; P = 0,003), zwischen L7 und S1 um 0,14 mm (4,1%; P = 0,003), zwischen S3 und Co1 um 0,61 mm (32,5%; P <0,001) und zwischen Co1 und Co2 um 0,63 mm (44,1%; P <0,001). Ein Vergleich zwischen Lagerung in Bauch- und Rückenlage ergab ebenfalls eine Reduktion der VCD'S in Bauchlage in den Abschnitten L7, L7–S1, S3–Co1 und Co1–Co2 von jeweils 0.13 mm (3.3%; P <0.001), 0.12 mm (3.6%; P <0.001), 0.34 mm (21.0%; P <0.001) und 0.37 mm (31.7%; P <0.001).

Entsprechend dieser Ergebnisse ist, nach anatomischen Kriterien, eine perineale Urethrostomie in Rückenlage des Patienten der in Bauchlage vorzuziehen. Um diese Ergebnisse zu verifizieren, war eine weiterführende klinische Studie von Nöten.

2) Ziele des angewandten Forschungsteils:

- Evaluation und Quantifizierung der mit der perioperativen Lagerung assoziierten neurologischen Veränderungen im Tiermodell und Feststellung der Existenz oder nicht-Existenz von lagerungsbedingten Nervenschäden;
- Feststellung der aus klinischer Sicht als physiologischer anzusehenden Positionierung.

In diese Studie wurden zwanzig männliche kastrierte Katzen mit FLUTD, die zur Durchführung einer perinealen Urethrostomie vorgestellt wurden, eingeschlossen.

Die chirurgische Versorgung erfolgte entweder in Rücken- (Gruppe A) oder Bauchlage (Gruppe B). Der Patellarsehnenreflex, die Reflexantwort des M. gastrocnemius, der Flexorreflex der Hintergliedmaße und der Perinealreflex, sowie auch das Vorhandensein von Schmerzen im Bereich des lumbosakralen Wirbelsäulenabschnittes, der Schwanztonus und die fäkale Kontinenz wurden direkt prä operationem und 24 Stunden und 14 Tage post operationem beurteilt.

Das durchschnittliche Gewicht der Tiere lag bei 5,07 ± 1,08 kg, das durchschnittliche Alter bei 6,12 ± 1,85 Jahren. Gewicht und Alter der Tiere unterschied sich nicht signifikant zwischen den Gruppen A und B (jeweils P = 0,897). Alle Parameter der neurologischen Untersuchung, die prä operationem beurteilt wurden, wurden in beiden Gruppen als normal eingestuft (P = 1).

Der Vergleich der Ergebnisse der neurologischen Untersuchung (Perinealreflex und Schmerzen im lumbosakralen Wirbelsäulenabschnitt) prä operationem und

24 Stunden post operationem ergab einen signifikant reduzierten Perinealreflex und ein vermehrtes Auftreten von Schmerzen im lumbosakralen Wirbelsäulenabschnitt (P = 0,043 und P = 0,031). Die Veränderungen der oben genannten Parameter waren jedoch zwischen den Gruppen A und B statistisch nicht signifikant (P = 0,249 und P = 0,141). Die anderen Parameter (Patellarsehenenreflex, Flexorreflex der Hintergliedmaße und Reflexantwort des M. gastrocnemius, Schwanztonus und fäkale Kontinenz) unterschieden sich statistisch nicht signifikant (P = 1) vor und 24 Stunden nach der Operation, sowie auch zwischen den Gruppen A und B 24 Stunden nach der Operation. Die Ergebnisse aller untersuchten Parameter unterschieden sich nicht signifikant (P = 1) prä operationem und 14 Tage post operationem, sowie zwischen den Gruppen A und B 14 Tage post operationem.

Ein reduzierter Perinealreflex und das Auftreten von Schmerzen im lumbosakralen Wirbelsäulenabschnitt war 24 Stunden post operationem signifikant häufiger. Eine Parallele mit geringgradigen lagerungsbedingten Nervenschäden, wie in der Humanmedizin beschrieben, kann hier gezogen werden. Jedoch war keines der untersuchten Lagerungsmodelle dem anderen eindeutig überlegen.

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