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SCIENTIFIC ARTICLE

Development and evaluation of a technique for spinal anaesthesia in broiler chickens

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ABSTRACT

Aims: To develop a technique for the injection of local anaesthetic into the spinal canal of broiler chickens by first determining the ideal location for needle placement based on anatomy and histology, and then using the developed technique to assess the onset and duration of action of three doses of lidocaine.

Methods: Two-month-old Ross broiler chickens (n = 30) were used in this study. Computed tomography imaging followed by anatomical examination of fresh cadavers (n = 6) were used to identify a suitable intervertebral space for injection of local anaesthetic, and landmarks to locate this space. Histological evaluation of the microanatomy of the caudal vertebral column in another six birds was used to examine the position of the spinal cord within the canal. Spinal anaesthesia was attempted using injection of lidocaine at 0.5 mg/kg (n = 6), 1 mg/kg (n = 6), and 2 mg/kg (n = 6) via the selected intervertebral space. Analgesia was tested by pinching the skin of the pericloacal area with thumb forceps to determine the onset and duration of analgesia. Respiratory rate, and cloacal temperature were measured at 0 minutes and every 10 minutes after injection until sensation returned.

Results: The space between synsacrum and first free coccygeal vertebra (synsacrococcygeal space) was selected as the most suitable site for spinal injection. In this region, the dura mater adhered to the internal wall of the spinal canal, and the subarachnoid space was large indicating that injection would be into the subarachnoid rather than the epidural space. The interval to onset of analgesia was similar for all doses of lidocaine (1.5 (SD 0.7), 2 (SD 1) and 1.3 (SD 0.5) minutes for 0.5, 1 and 2 mg/kg, respectively; p = 0.604). Duration of analgesia was longer following injection with 2 than 0.5 or 1 mg/kg lidocaine (21.3 (SD 2.5) *vs.* 4.5 (SD 3.5) *vs.* 11.3 (SD 2) minutes, respectively; p = 0.002). Mean cloacal temperature decreased between 0 and 20 minutes after injection with all doses of lidocaine (p = 0.021).

Conclusions and clinical relevance: Spinal anaesthesia in chickens is feasible and is a practical, inexpensive and simple technique for regional anaesthesia of the pericloacal area.

Abbreviation: CT: Computed tomography

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Broiler chicken; spinal anaesthesia; anatomy; computed tomography; feasibility; lidocaine

Introduction

Diseases and conditions associated with the perineal region or reproductive system in the birds are relatively common. These include egg retention and dystocia, cloacal and oviduct prolapse, trauma to the perineal area, and cloacoliths (Crosta *et al*. 2003; Stout 2016). In addition geese and ostriches are prone to phallus prolapse (Joyner 1994). If medical treatment for these conditions is not effective, surgical intervention may be necessary which requires local or general anaesthesia (Bowles 2002; Stout 2016). Although treatment of individual birds is uncommon in the commercial poultry industry, pet birds and valuable wild birds may require surgical intervention.

General anaesthesia is not without risks. A recent retrospective case series of 352 birds found that the mortality rate for inhalation anaesthesia was 14%, which was higher than that for other animals (Seamon *et al*. 2017). The main risk from inhalation anaesthesia in birds is hypothermia, especially in smaller species (Lierz and Korbel 2012), as well as cardiopulmonary depression and post-intubation tracheal obstruction (Sykes *et al*. 2013). These risks may be reduced for local anaesthesia under sedation. So, while physical restraint of conscious birds may be a cause of stress, local anaesthesia may be safer for minor procedures than general anaesthesia, especially in companion birds adapted to physical handling.

Lidocaine (lignocaine) is a local anaesthetic that is widely used in mammalian species. Reports of the use of lidocaine in birds include assessment of brachial plexus blockade in chickens (Figueiredo *et al*. 2008) and non-specific techniques such as S/C injection for mass removal or wound treatment, or in the form of ring block to amputate a digit (Lee and Lennox 2016).

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Spinal anaesthesia, also called subarachnoid or intrathecal block, is the injection of local anaesthetic into the subarachnoid space in order to produce surgical analgesia (Beecroft 2015). It produces profound nerve block in the caudal parts of the body while the patient remains conscious. The lumbosacral space is usually selected for intrathecal injections in horses, dogs, and goats (Skarda and Muir 2003; Kacar *et al*., 2007; Staffieri *et al*. 2009).

In birds, the synsacrum is formed by fusion of the last thoracic vertebra, the lumbar vertebrae, the sacrum, and the first coccygeal vertebra. The spinous processes of these vertebrae are also combined and create the spinous crest. The intravertebral canal is relatively broad in the region of the unfused coccygeal vertebrae and, unlike mammals, the spinal cord runs the length of the vertebral canal. Coccygeal vertebrae have distinct and developed spinous processes. At the end of the vertebral column, the last caudal vertebrae are joined together and make the pygostyle (Maierl *et al*. 2016). Within the vertebral canal, the spinal cord is enclosed by the meninges, composed of the dura mater, the arachnoid, and the pia mater (Groen and Ponssen 1991). In birds, the dura mater is separate from the periosteum of the intravertebral canal with epidural space between the two layers only in the cervical and thoracic regions. From the caudal part of the thorax to the end of the tail, the periosteum and dura mater are attached to each other, except in the parts where the venous sinus exists (Baumel 1975). The epidural space is filled with connective tissue and fat (Nickel *et al*. 1977). A venous sinus extends within the epidural space on the dorsal surface of the dura mater over most of the length of the vertebral canal and is absent only in the synsacrum region. The pia mater attaches closely to the spinal cord with an extensive blood vessel network beneath. The subarachnoid space lies between the arachnoid and the pia mater (Baumel 1975), and there is a wide subarachnoid space in the lumbosacral region of birds (Necker 2005).

Despite the frequency with which conditions that require surgical intervention occur in the caudal aspect of birds, there are no reports of spinal or epidural regional anaesthesia in avian species (Hawkins and Paul-Murphy 2011). Moreover, the onset and duration of action of local anaesthetics, such as lidocaine, have not been studied in birds (Paul-Murphy 2013). The purpose of this study was to evaluate the feasibility of injection of local anaesthetic into the spinal canal of broiler chickens by first determining an ideal location for needle placement based on anatomy and histology, and then using the developed technique to assess the onset and duration of action of three doses of lidocaine. Broiler chickens were used for this study as a model species for similarly sized birds of the Phasianidae family such as peafowl, pheasant, francolin, partridge, and perhaps other bird families.

Materials and methods

Animals

Two-month-old female Ross broiler chickens (n = 30) weighing 2 (SD 0.3) kg were obtained from a local breeder and kept in separate cages fitted with negative pressure ventilation throughout the study. Water and commercial poultry food (Pas Dan 2; Faraz Daneh Avand, Takestan, Iran) were freely available. Environmental temperature was maintained at 21°C with a light/dark cycle of 12-hour intervals. A period of acclimatisation to their new environmental conditions was provided for 1 week before the start of the study. Animal management and use was based on the World Medical Association's statement on the use of animals in biomedical research (Anonymous 2017) and the study was approved by the Committee of Veterinary Research Ethics, University of Tabriz (Tabriz, Iran; code number: IR.FVM.REC.1396.936).

Identification of suitable site for injection of spinal anaesthesia

To generate a detailed picture of the bony components of the caudal spinal canal, computed tomography (CT) images of this region, in dorsoventral and lateral planes, were obtained for six chickens. The chickens were anaesthetised with I/M 25 mg/kg ketamine (Alfasan, Woerden, NL) and 3 mg/kg xylazine (Alfasan). They were positioned in ventral recumbency, and images were obtained using a two-detector CT scanner (Somatom Spirit; Siemens, Munich, Germany) with a rotation time of 1 second, slice thickness of 1 mm, reconstruction interval of 0.5–1 mm and pitch of 1. The X-ray tube potential and current were 130 kV and 105 mA, respectively. Intervertebral spaces caudal to the synsacrum were examined on reconstructed three-dimensional images of the vertebral canal to identify the largest space suitable for spinal injection.

To further characterise the anatomy of the intervertebral spaces, the same chickens that were examined using CT were sedated with I/M 3 mg/kg xylazine then subjected to euthanasia with I/V 18 mg/kg sodium thiopental (VUAB Pharma Inc., Roztoky, Czech Republic) followed by exsanguination from the carotid artery according to AVMA guidelines for the euthanasia of animals (Leary *et al.* 2013). Gross anatomical evaluations were carried out without fixation. The skin and S/C tissues overlying the vertebral column were dissected allowing examination of the intervertebral spaces between the last thoracic vertebra and the pygostyle to identify the largest intervertebral

space for needle insertion. The approximate depth of the spinal cord from the skin surface was measured using a digital calliper. Anatomical landmarks were also identified to allow location of the target intervertebral space in live birds. For closer examination of the proposed injection site, the skeleton of the area was prepared. Briefly, the pelvic part of the carcass was placed in a sodium hydroxide solution to digest soft tissues, and then were immersed in water containing ammonia solution for a few hours. The skeleton was heated in a water bowl to below boiling point, and then the water was allowed to cool. Finally, the bones were cleaned with a scalpel blade.

To determine the microanatomy of the spinal canal including the meninges, the epidural and subarachnoid spaces, and the position of the spinal cord within the canal, histological sections of the caudal vertebral column from an additional six chickens were examined. After euthanasia as described above, the abdominal region of the chickens was opened and the cadavers immersed in 10% formalin solution for 1 week after which the caudal part of the vertebral column was separated. After decalcification, 5 µm sections were cut sagittally and transversely, stained with H&E and examined under a light microscope.

Trial of spinal anaesthesia technique

Spinal anaesthesia was attempted using the selected intervertebral space and identified landmarks, and the efficacy of the anaesthesia produced was assessed. Three doses of lidocaine were tested: 0.5, 1 and 2 mg/kg (n = 6 chickens per dose). These doses were based on the standard dose used for epidural anaesthesia in dogs (4 mg/kg) (Campoy 2004), but reduced by half to account for injection into the subarachnoid space. Two lower doses were also included to allow for potentially greater sensitivity of birds to the toxic effect of lidocaine.

Chickens were manually restrained on a table, the feathers of the synsacrococcygeal area were cut off with a pair of scissors and the area was prepared aseptically with 10% povidone-iodine solution (Aburaihan Co., Tehran, Iran). Then, using the identified anatomical landmarks (spinous process of the first free coccygeal vertebra and approximate distance from the pygostyle and pubis bones), the space between the synsacrum and the first free coccygeal vertebra was detected by palpation and the skin was desensitised by S/C injection of 2 mg/kg of lidocaine (2% lidocaine without adrenaline; Aburaihan Co.). A 75 mm, 23 gauge, spinal needle with Quincke bevel (Vygon, Swindon, UK) was inserted in the sagittal plane while the tip of the needle was directed cranially 10–20 degrees from perpendicular to the skin and advanced approximately 15 mm until it passed through the ligamentum flavum, as determined by a sudden loss of resistance. Entry of the needle into the intravertebral canal was confirmed in the first chicken using lateral radiographic imaging of the caudal spine, but this was not repeated in the other birds. Lidocaine at 0.5, 1 or 2 mg/kg was then injected. The volume of injection was made up to 0.2 mL with normal saline.

Analgesia was tested by pinching the skin of the pericloacal area with rat-tooth thumb forceps using moderate pressure for 1 second, by a student who was blinded to the dose of lidocaine the chicken received. Analgesia was tested prior to injection (0 minutes), 1, 3, and 5 minutes after injection, and then every 5 minutes until the return of sensation as determined by vocalisation, escape reactions (lifting the leg, shaking the wings), or vigorous movements. The time interval between injection of lidocaine and the first lack of response to the painful stimulus was recorded as the onset of analgesia. The duration of analgesia was the interval from the onset of analgesia to return of sensation.

The birds were monitored closely for potential side effects of lidocaine including localised swelling, recumbency and inability to stand, and for signs of lidocaine toxicity including central nervous system stimulation (muscular activation, and subsequent seizures), cyanosis of the mucous membranes, and loss of consciousness after anaesthetic injection. Spinal anaesthesia may affect respiration rate and cloacal temperature, so these parameters were measured at 0 minutes and every 10 minutes after injection until sensation returned. Cloacal temperature was recorded using a digital thermometer (Adtemp 422; American Diagnostic Corporation, Hauppauge, NY, USA) and respiratory rate was measured before the pinch test by visually counting abdominal movements.

Statistical analyses

Statistical analyses were performed using Minitab 16.2.0 statistical software (Minitab Inc, State College, PA, USA). Data were tested for normality using the Kolmogorov–Smirnov test. The interval to onset and duration of analgesia were analysed using one-way ANOVA followed by Tukey's *post hoc* test to compare different doses of lidocaine. Cloacal temperature and respiratory rate were analysed using repeated measures ANOVA and mean values were compared between different times by Tukey's test.

Results

Identification of suitable injection site

A depression (the synsacrococcygeal space) cranial to the first free coccygeal vertebra was clearly visible in the CT images, suggesting this synsacrococcygeal space may be a suitable site for injection of anaesthetic

(Figure 1). In the grossly dissected chickens, the space between the first free coccygeal vertebra and synsacrum was more spacious than the intercoccygeal spaces (Figure 2) and was easily identifiable by palpation of the spinous process of the first free coccygeal vertebra. In intact chickens, the synsacrococcygeal space was located approximately 5–6 cm cranial to the tip of the pygostyle and 2.5–3 cm cranial to the caudal part of the pubis in the midline of the dorsal surface. The spinous process of the first free coccygeal vertebra was identified by palpation just caudal to this space (Figure 3). The spinal cord was located 15.4 (SD 3.3) mm beneath the skin surface.

Examination of sections of the caudal spinal canal prepared for histology revealed that the dura mater adhered to the internal wall of the spinal canal. In some locations, the arachnoid could be seen as a network-like layer (Figure 4a). The pia mater was located adjacent to the spinal cord and the subarachnoid space around the spinal cord was spacious. The distance between the spinal cord and interior lining of the bony canal, and the size of the spinal cord in relation to the diameter of the canal were easily visualised in transverse section (Figure 4b).

Therefore the synsacrococcygeal space was identified as the most suitable location for injection of local anaesthetic. It could be found by digitally palpating the spinous process of first free coccygeal vertebra approximately 5 cm cranial to the end of the pygostyle, and the histological findings indicated injection would be into the subarachnoid rather than the epidural space.

Spinal anaesthesia

The synsacrococcygeal space was easily located in all chickens and analgesia was successfully achieved. The interval to onset of analgesia was similar for all doses of lidocaine (1.5 (SD 0.7) minutes for 0.5 mg/kg; 2 (SD 1) minutes for 1 mg/kg and 1.3 (SD 0.5)

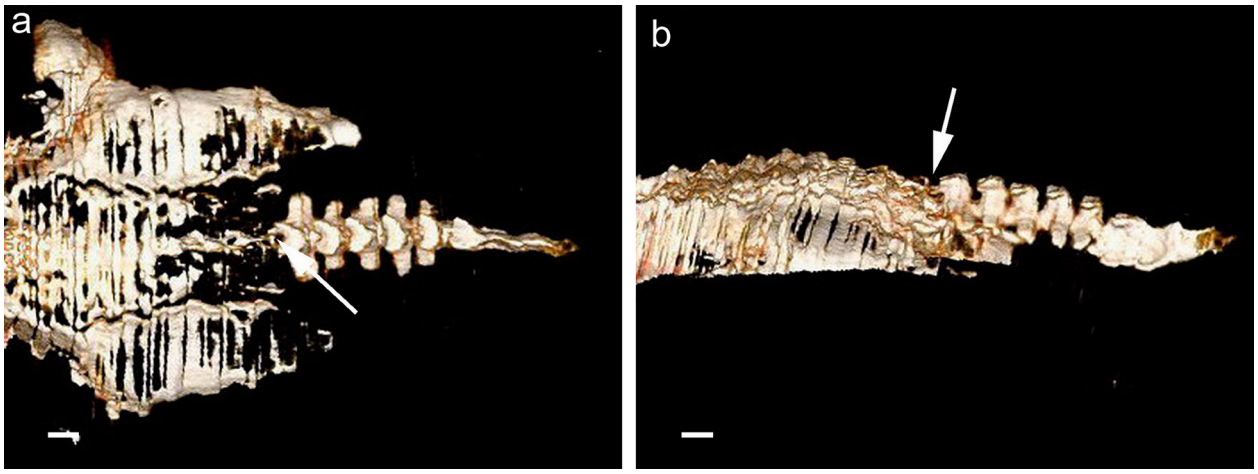

Figure 1. Three-dimensional computed tomography (a) dorsoventral and (b) lateral images of the caudal aspect of the vertebral column of a 2-month-old chicken, showing the space between the synsacrum and the first free coccygeal vertebra (white arrow) (bar = 1 cm).

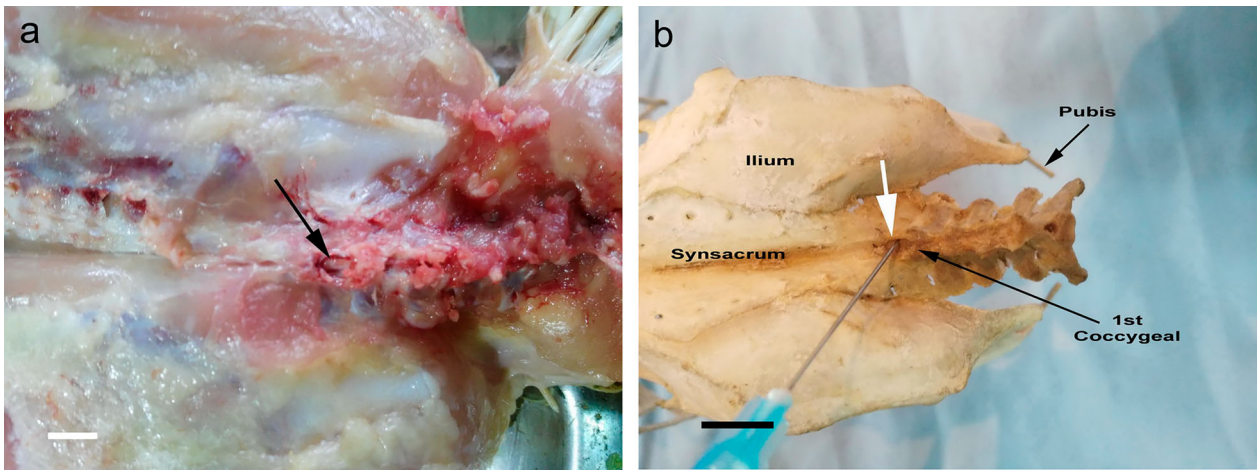

Figure 2. Photographs showing (a) gross dissection of the dorsal aspect of the pelvic region of a chicken and the location of the space between the synsacrum and the first free coccygeal vertebra (black arrow) (bar = 0.5 cm), and (b) the skeleton in the same region showing the synsacrococcygeal space (white arrow) and point of entry for a spinal needle (bar = 1 cm).

minutes for 2 mg/kg) ($p = 0.604$). The duration of action following injection of 2 mg/kg lidocaine (21.3 (SD 2.5) minutes) was longer than that following 0.5 mg/kg (4.5 (SD 3.5) minutes) or 1 mg/kg (11.3 (SD 2) minutes) ($p = 0.002$).

None of the anaesthetised chickens became recumbent after spinal injection of lidocaine, indicating that the nerves supplying motor function to the legs were not affected. Signs of lidocaine toxicity (e.g. seizure, cyanosis, loss of consciousness) or other potential adverse effects (e.g. swelling at the injection site) were not observed in any of the chickens.

Mean cloacal temperature decreased between 0 and 20 minutes after injection and this decrease was greater in chickens injected with 2 than 0.5 or 1.0 mg/kg lidocaine (time by group interaction $p = 0.036$) (Table 1). Mean respiration rate increased between 0 and 10 minutes after injection in chickens injected with 0.5 and 1 mg/kg lidocaine, but not in those receiving 2 mg/kg (time by group interaction $p = 0.005$) (Table 2).

Discussion

Computed tomography and anatomical dissections were used to identify the synsacrococcygeal space as an appropriate site for injection of local anaesthetic into the vertebral canal of chickens. Examination of histological sections confirmed that injection into the intravertebral canal in this region would be into the subarachnoid space. Spinal injection of 2 mg/kg of lidocaine resulted in approximately 20 minutes of analgesia in caudal areas of the chickens.

Spinal injection is not possible through the lumbosacral or sacrococcygeal spaces in birds because these spaces are fused. In the current study, anatomical evaluation of the vertebral column in the caudal part of the chickens indicated that the space between the first

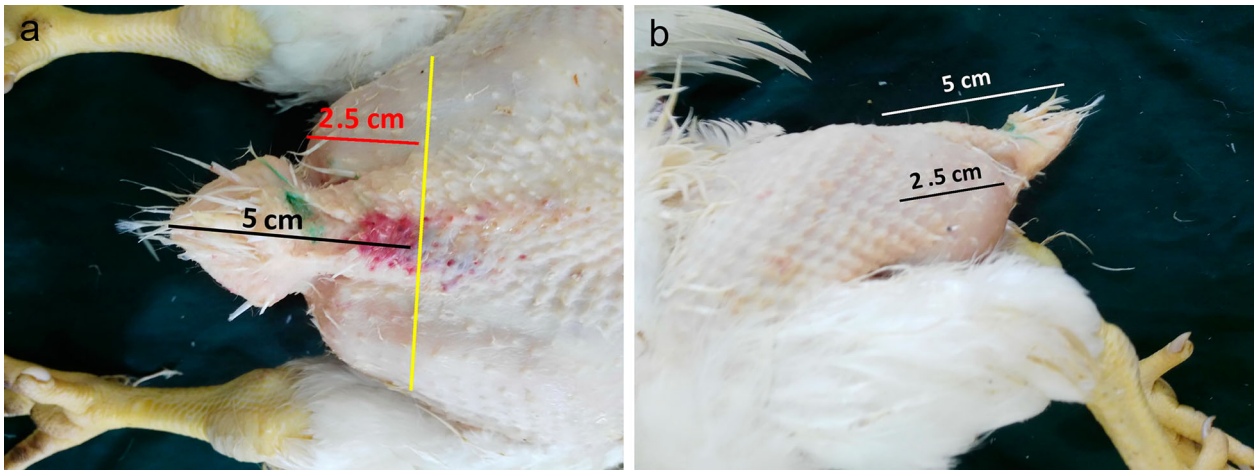

Figure 3. Photographs of the (a) dorsal and (b) lateral view of the caudal region of a chicken showing anatomical landmarks for location of the space between the synsacrum and the first free coccygeal vertebra. The injection site for spinal anaesthesia is 5–6 cm cranial to the tip of the pygostyle and 2.5–3 cm cranial to the caudal part of the pubis.

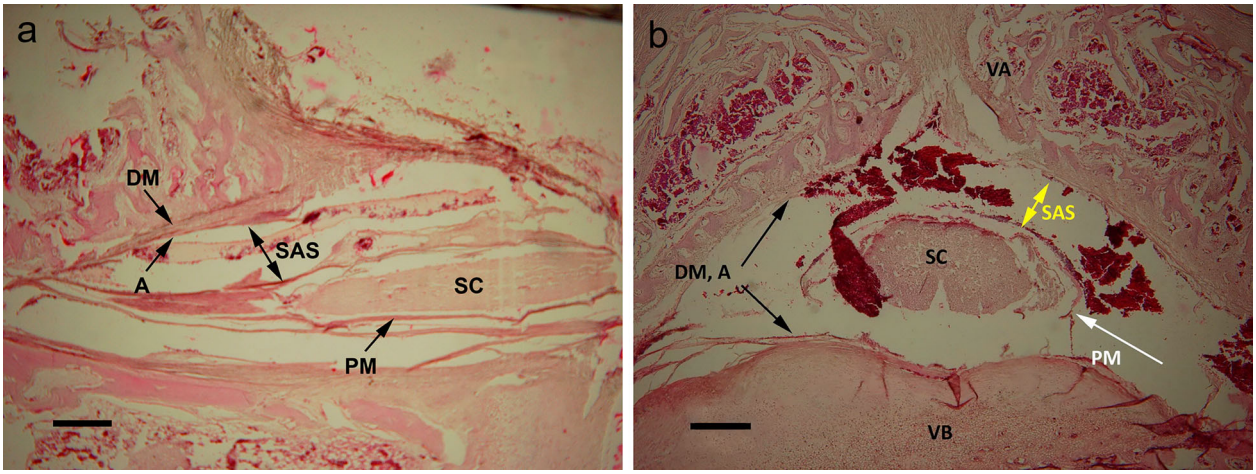

Figure 4. Photomicrographs of (a) sagittal and (b) transverse sections of the vertebral column of a chicken between the caudal end of the synsacrum and cranial aspect of the first free coccygeal vertebrae. A = arachnoid; DM = dura mater; PM = pia mater; SAS = subarachnoid space; SC = spinal cord; VA = vertebral arch; VB = vertebral body (H&E, bar = 300 µm).

Table 1. Mean (±SD) cloacal temperature (°C) of chickens following spinal injection at the synsacrococcygeal space of lidocaine at three doses until the return of sensation.

	Time (minutes)			
Dose (mg/kg)	0	10[a]	20[a]	30
0.5	41.6 ± 0.05^{x}	41.5 ± 0.02^{y}	41.4 ± 0.03^{z}	NT
1	41.6 ± 0.06^{x}	41.5 ± 0.01^{y}	41.4 ± 0.05^{z}	NT
2	41.5 ± 0.07^{x}	41.2 ± 0.04^{y}	41.1 ± 0.04^{z}	41.1 ± 0.03^{z}

[a]Values differ between groups ($p = 0.025$).
[xyz]Values differ between times within group ($p = 0.21$).
NT = not tested

Table 2. Mean (±SD) respiratory rate (breaths per minute) of chickens following spinal injection at the synsacrococcygeal space of lidocaine at three doses until the return of sensation.

	Time (minutes)			
Dose (mg/kg)	0	10	20	30
0.5	44.0 ± 1.65^{x}	48.5 ± 0.85^{y}	48.0 ± 0.60^{y}	NT
1	40.0 ± 1.04^{x}	45.3 ± 1.42^{y}	47.3 ± 1.02^{y}	NT
2	48.0 ± 1.40^{x}	47.0 ± 0.56^{x}	46.7 ± 1.02^{x}	54.0 ± 1.03^{y}

[xyz]Values differ between times within group ($p = 0.001$).
[xyz]Values differ between times within group ($p = 0.001$).
NT = not tested

free coccygeal vertebra and synsacrum (the synsacrococcygeal space) was the most suitable location for injection of spinal anaesthesia. In the chickens we examined (aged 2 months, weighing approximately 2 kg), this space could be located approximately 5–6 cm proximal to the end of the pygostyle and about 2.5–3 cm cranial to the caudal part of the pubis. These landmarks are useful because the spinous processes of the first free coccygeal vertebra may be confused with the spinous processes of more distal caudal vertebrae or may be difficult to palpate. These measures may vary with the age and size of chickens. However, the ratio between these two distances is not likely to change with age. Thus, twice the distance between the tip of the pygostyle and the caudal part of the pubis can be measured in the dorsal midline to find the desired location. We believe the use of this site for spinal anaesthesia in poultry is practically feasible, and veterinarians may, with practice, perform spinal anaesthesia in these birds with a high probability of success.

In this study, anatomical and histological investigations of the aforementioned area showed that the dura was adhered to the internal wall of the spinal canal, and there was no epidural space. The arachnoid was seen in some parts as a network-like layer and the pia was located adjacent to the spinal cord. The subarachnoid space was sufficiently spacious to allow the injection of anaesthetic into this space. Therefore, epidural anaesthesia is not possible in this area and subarachnoid or spinal anaesthesia is feasible. Furthermore, as spinal cord length is equal to the length of the vertebral canal in birds (Orosz 1996), unlike mammals, there is no epidural space caudal to the spinal cord.

Birds may be more susceptible to local anaesthetics than mammals, as toxic effects have been observed at lower doses than in dogs (Hocking *et al*. 1997). It has been suggested that the dose of lidocaine in birds should not exceed 4 mg/kg, otherwise seizure and cardiac arrest may result (Machin 2005). Typically, 4 mg/kg of lidocaine is used for epidural anaesthesia in dogs (Campoy 2004). In spinal anaesthesia, the anaesthetic is in direct contact with the spinal cord and the roots of the spinal nerves below the dura mater, therefore a lower dose is required than for epidural anaesthesia (Campoy 2004). We observed no difference in the onset of action of different doses of lidocaine but the duration of analgesia increased with increasing dosage. Injection of 2 mg/kg lidocaine resulted in approximately 20 minutes of analgesia, although. this is a shorter duration than reported in mammals. For example, subarachnoid injection of lidocaine produced approximately 66 minutes of analgesia in goats (DeRossi *et al*. 2003). The elimination half-life of I/V lidocaine in chickens anaesthetised with isoflurane was 2–4 times shorter than dogs, cats, or rabbits (Da Cunha *et al*. 2012), which may be related to the high basal metabolic rate of birds and lead to the shorter duration of analgesia seen in this study.

The behavioural response of the birds to an acute painful stimulus was used in this study to determine the onset and duration of analgesia. There are significant differences in the behavioural responses of birds to painful stimuli, and there is no comprehensive indicator of pain in these species (Machin 2005). Birds may respond to pain by trying to escape or avoid the painful stimulus, e.g. by lifting or shaking a leg or wing. When escape is not possible, they may become disturbed or restless, vocalise, or become aggressive (Paul-Murphy and Ludders 2001). We observed these behaviours when the painful stimulus (pinch) was applied to non-anaesthetised chickens.

In the current study, spinal injection of lidocaine reduced the cloacal temperature. The chickens were not premedicated before spinal injection, because most sedatives may affect physiologic parameters, thus this change in temperature was due to spinal injection of lidocaine alone. Cloacal temperature is a measure of core or deep body temperature (McCafferty *et al*. 2015). However, as all three doses of lidocaine used in this study caused only small decreases in cloacal temperature, this effect may not be clinically important. Spinal anaesthesia in humans has been shown to cause hypothermia due to a reduction in vasomotor tone caused by anaesthesia of sympathetic nerves and, as a result, vasodilation and loss of body heat. In addition, anaesthesia of motor nerves inhibits compensation for hypothermia through shivering (Kurz *et al*. 1993; Frank *et al*. 2000).

Keeping in mind that there is no diaphragm in birds and thoracoabdominal muscles are responsible for respiration (Heard 1997), the slight decrease in the respiratory rate in chickens which received 2 mg/kg lidocaine could be due to the effect of lidocaine on

intercostal muscles (Beecroft 2015). However, this decrease was insignificant. After 20 minutes the respiratory rate of birds that received 2 mg/kg lidocaine increased, indicating a gradual disappearance of the analgesic effect, so that acute pain (pinch test) and manual restraint led to increased respiration rate. Similarly, the increase in respiratory rate in chickens given lower doses of lidocaine could indicate incomplete analgesia. Pain increases respiration rate, flow, and volume in humans (Jafari *et al.* 2017), and acute pain may also increase respiration rate in birds (Lierz and Korbel 2012). So, in this study, the stress of physical restraint and the pain caused by the pinch test may have increased the respiratory rate of the chickens in the absence of any obvious escape reaction. Therefore, doses of 0.5 and 1 mg/kg lidocaine may not have resulted in complete regional anaesthesia.

Although it is an important factor in anaesthesia, the heart rate of the chickens was not measured in this study. Birds have a high heart rate which could not be easily measured and furthermore, physical restraint tends to cause alterations in this rate. Thus, we considered that heart rate would not be a reliable measure for interpreting the effect of anaesthesia. We also did not take myelographic images during spinal injections which could have confirmed that the site of injection was within subarachnoid space.

In conclusion, this study showed that spinal anaesthesia can be easily performed in chickens and could therefore be considered a low-cost and relatively simple option for analgesia during surgery of the pericloacal area instead of general anaesthesia. Further studies are necessary to determine whether this technique is safe for the cardiac system of chickens. The use of this technique in other avian species should be investigated individually as anatomical differences may affect feasibility. Furthermore sedation of wild birds may be required to reduce the stress of physical restraint.

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References

***Anonymous**. WMA statement on animal use in biomedical research. https://www.wma.net/policies-post/wma-statement-on-animal-use-in-biomedical-research (accessed 10 February 2019). The World Medical Association, Inc., Ferney-Voltaire, France, 2017

***Baumel JJ.** Aves nervous system. In: Getty R (ed). *Sisson and Grossman's the Anatomy of the Domestic Animals*. 5th Edtn. Pp 2044–52. W.B. Saunders, Philadelphia, PA, USA, 1975

Beecroft CL. Spinal anaesthesia. *Anaesthesia and Intensive Care Medicine* 16, 563–5, 2015

Bowles HL. Reproductive diseases of pet bird species. *Veterinary Clinics of North America: Exotic Animal Practice* 5, 489–506, 2002

Campoy L. Epidural and spinal anaesthesia in the dog. *In Practice* 26, 262–9, 2004

Crosta L, Gerlach H, Bürkle M, Timossi L. Physiology, diagnosis, and diseases of the avian reproductive tract. *Veterinary Clinics of North America: Exotic Animal Practice* 6, 57–83, 2003

Da Cunha AF, Messenger KM, Stout RW, Barker SA, Nevarez JG, Queiroz-Williams P, Tully TN Jr. Pharmacokinetics of lidocaine and its active metabolite monoethylglycinexylidide after a single intravenous administration in chickens (*Gallus domesticus*) anesthetized with isoflurane. *Journal of Veterinary Pharmacology and Therapeutics* 35, 604–7, 2012

DeRossi R, Junqueira AL, Beretta MP. Analgesic and systemic effects of ketamine, xylazine, and lidocaine after subarachnoid administration in goats. *American Journal of Veterinary Research* 64, 51–6, 2003

Frank SM, El-Rahmany HK, Cattaneo CG, Barnes RA. Predictors of hypothermia during spinal anesthesia. *Anesthesiology* 92, 1330–4, 2000

Figueiredo JP, Cruz ML, Mendes GM, Marucio RL, Ricco CH, Campagnol D. Assessment of brachial plexus blockade in chickens by an axillary approach. *Veterinary Anaesthesia and Analgesia* 35, 511–8, 2008

Groen RJ, Ponssen H. Vascular anatomy of the spinal epidural space: considerations on the etiology of the spontaneous spinal epidural hematoma. *Clinical Anatomy* 4, 413–20, 1991

Hawkins MG, Paul-Murphy J. Avian analgesia. *Veterinary Clinics of North America: Exotic Animal Practice* 14, 61–80, 2011

Heard DJ. Avian respiratory anatomy and physiology. *Seminars in Avian and Exotic Pet Medicine* 6, 172–9, 1997

Hocking PM, Gentle MJ, Bernard, R, Dunn LN. Evaluation of a protocol for determining the effectiveness of pretreatment with local analgesics for reducing experimentally induced articular pain in domestic fowl. *Research in Veterinary Science* 63, 263–7, 1997

Jafari H, Courtois I, Van den Bergh O, Vlaeyen JW, Van Diest I. Pain and respiration: a systematic review. *Pain* 158, 995–1006, 2017

***Joyner KL.** Theriogenology. In: Ritchie BW, Harrison GJ, Harrison LR, Worth L (eds). *Avian Medicine: Principles and Application*. Pp 748–804. Wingers Publishing Inc, Lake Worth, FL, USA, 1994

Kacar CI, Ozaydin I, Oral HA, Kilic E, Gurbulak K, Aksoy O. Intrathecal slow infusion of isobaric bupivacain in low-dose for ovariohysterectomy in dogs. *Bulletin-Veterinary Institute In Pulawy* 51, 89–92, 2007

Kurz A, Sessler DI, Schroeder M, Kurz M. Thermoregulatory response thresholds during spinal anesthesia. *Anesthesia and Analgesia* 77, 721–6, 1993

***Leary S, Underwood MW, Anthony R, Gwaltney-Brant S, Poison AS, Meyer R.** *AVMA Guidelines for the Euthanasia of Animals: 2013 Edition*. Pp 62–3. American Veterinary Medical Association, Schaumburg, IL, USA, 2013

Lierz M, Korbel R. Anesthesia and analgesia in birds. *Journal of Exotic Pet Medicine* 21, 44–58, 2012

Lee A, Lennox A. Sedation and local anesthesia as an alternative to general anesthesia in 3 birds. *Journal of Exotic Pet Medicine* 25, 100–5, 2016

Machin KL. Avian analgesia. *Seminars in Avian and Exotic pet Medicine* 14, 236–42, 2005

***Maierl J, Liebich HG, Konig HE, Korbel R.** Head and trunk. In: Konig HE, Korbel R, Liebich HG (eds). *Avian Anatomy, Textbook and Colour Atlas*. Pp 31–3. 5M Publishing Ltd, Sheffield, UK, 2016

McCafferty DJ, Gallon S, Nord A. Challenges of measuring body temperatures of free-ranging birds and mammals. *Animal Biotelemetry* 3, 33, 2015

Necker R. The structure and development of avian lumbosacral specializations of the vertebral canal and the spinal cord with special reference to a possible function as a sense organ of equilibrium. *Anatomy and Embryology* 210, 59–74, 2005

***Nickel R, Schummer A, Seiferle E.** *Anatomy of the Domestic Birds*. Verlag Paul Parey, Berlin, Germany, 1977

Orosz SE. Principles of avian clinical neuroanatomy. *Seminars in Avian and Exotic Pet Medicine* 5, 127–39, 1996

***Paul-Murphy J.** Pain management. In: Harrison GJ, Lightfoot TL (eds). *Clinical Avian Medicine*. Vol 1, Pp 233–40. Spix Publishing Inc, Palm Beach, FL, USA, 2013

Paul-Murphy J, Ludders JW. Avian analgesia. *Veterinary Clinics of North America: Exotic Animal Practice* 4, 35–45, 2001

Rosen LB. Avian reproductive disorders. *Journal of Exotic Pet Medicine* 21, 124–31, 2012

Skarda RT, Muir III WW. Analgesic, behavioral, and hemodynamic and respiratory effects of midsacral subarachnoidally administered ropivacaine hydrochloride in mares. *Veterinary Anaesthesia and Analgesia* 30, 37–50, 2003

Seamon AB, Hofmeister EH, Divers SJ. Outcome following inhalation anesthesia in birds at a veterinary referral hospital: 352 cases (2004–2014). *Journal of the American Veterinary Medical Association* 251, 814–7, 2017

Staffieri F, Driessen B, Lacitignola L, Crovace A. A comparison of subarachnoid buprenorphine or xylazine as an adjunct to lidocaine for analgesia in goats. *Veterinary Anaesthesia and Analgesia* 36, 502–11, 2009

Stout JD. Common emergencies in pet birds. *Veterinary Clinics of North America: Exotic Animal Practice* 19, 513–41, 2016

Sykes IV JM, Neiffer D, Terrell S, Powell DM, Newton A. Review of 23 cases of postintubation tracheal obstructions in birds. *Journal of Zoo and Wildlife Medicine* 44, 700–13, 2013

*Non-peer-reviewed