UNIVERSIDADE FEDERAL DO PARANÁ

ANDRÉ SALDANHA FERREIRA

TÓPICOS DE ATUALIZAÇÃO EM ANESTESIA DE ROEDORES E LAGOMORFOS

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Dissertação apresentada ao curso de Pós-Graduação em Ciências Veterinárias, Setor de Ciências Agrárias, Universidade Federal do Paraná, como requisito à obtenção do título de Mestre em Ciências Veterinárias.

Orientador: Prof. Dr. Rogério Ribas Lange
Coorientador: Prof. Dr. Juan Carlos Moreno Duque

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Os membros da Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação em CIÊNCIAS VETERINÁRIAS da Universidade Federal do Paraná foram convocados para realizar a arguição da Dissertação de Mestrado de **ANDRE SALDANHA FERREIRA** intitulada: **TÓPICOS DE ATUALIZAÇÃO EM ANESTESIA DE ROEDORES E LAGOMORFOS**, sob orientação do Prof. Dr. ROGERIO RIBAS LANGE, que após terem inquirido o aluno e realizada a avaliação do trabalho, são de parecer pela sua APROVAÇÃO no rito de defesa.

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Muito obrigado.

“*Don't raise your voice, improve your argument*”

Desmond Tutu

RESUMO

Pequenos mamíferos estão mais frequentes como animais de estimação pelo mundo. Coelhos, chinchillas, porquinhos-da-índia, ferrets, hamsters, degus, petauros e outras espécies apresentam diferentes demandas para cuidado, portanto há sempre uma opção para cada residência. Nesse cenário, os proprietários demandam qualidade do atendimento veterinário. Cirurgias e emergências serão mais frequentes na rotina clínica e as técnicas devem ser desenvolvidas, otimizando o sucesso e bem-estar dos pacientes. A anestesia de pequenos mamíferos pode ser desafiante, há peculiaridades anatômicas e fisiológicas, tamanho reduzido, alto metabolismo e a canulação e intubação endotracheal pode ser difícil. Visando uma anestesia efetiva com relaxamento muscular, analgesia e perda de consciência, protocolos balanceados devem ser buscados. O bloqueio do plano transverso (*TAP* block) provou ser uma técnica praticável em chinchilas, e provavelmente outras espécies de roedores e em coelhos. Apesar de a descrição anatômica da parede abdominal de chinchilas não ser completamente descrita, o *TAP block* foi realizado com sucesso empírico em dois animais. Bloqueios locorregionais são uma excelente opção para analgesia com efeitos sistêmicos reduzidos, o que é desejado em pequenos pacientes, especialmente herbívoros. O principal desafio de realizar o *TAP block* em chinchila é o tamanho do paciente o que requer material de tamanho adequado e treinamento prévio do profissional. O *TAP block* provê analgesia apenas da parede abdominal e deve ser utilizado como parte de um protocolo anestésico balanceado para cirurgias abdominais, otimizando analgesia trans e pos operatória. A intubação endotraqueal de coelhos é considerada complicada, especialmente às cegas. A técnica é descrita demandando várias tentativas, tempo longo e resultando em falhas e lesões de glote. A intubação com visualização indireta da glote por meio de endoscópio é considerada ótima para o processo, entretanto um equipamento de endoscopia pode ser grande e caro, nem sempre sendo acessíveis, ao contrário do dispositivo de *smartphone* descrito nesse trabalho. Ambas técnicas, às cegas e assistida por endoscópio, provaram ser confiáveis para intubação de coelhos, entretanto as vantagens do endoscópio não foram totalmente confirmadas, inclusive a anestesiologista foi mais eficiente na técnica às cegas. Sugerindo que o domínio da técnica, independente de qual, é essencial para otimizar o sucesso da intubação de coelhos.

Palavras-chave: Analgesia. Emergência. Exóticos. Silvestres.

ABSTRACT

Small mammals are being increasingly more frequent as pets worldwide. Rabbits, chinchillas, guinea-pigs, ferrets, hamsters, degus, sugar-gliders, and other species have different behaviors and demands for care, therefore there is always an adequate species for each residency. In this scenario, owners of these pets are demanding optimal veterinary care. Surgical and emergency cases will be more frequent in the veterinary routine and techniques must be improved to enhance success rate and welfare of these animals. Small mammals' anesthesia can be challenging, they have specific anatomic and physiological features, reduced size, high metabolism rates and catheterization and tracheal intubation can be challenging or even unsuccessful. Aiming an effective anesthesia with muscle relaxation, analgesia and loss of consciousness, balanced protocols must be pursued. The transverse plane block proved to be a feasible technique to be applied in chinchillas, and probably other rodent species and rabbits. Although the abdominal wall anatomy of chinchillas still not fully described, the technique was performed in two animals with empiric success. Regional blocks are excellent options for analgesia with minimal systemic effects, what is desired in many small patients, especially the herbivores. The main challenge for performing the TAP block in chinchillas is the size of the patient, requiring adequate size material and previous training of the professional. The TAP block only provides analgesia to the abdominal wall, and must be used as part of a balanced anesthetic protocol especially for abdominal surgeries, improving both trans as postoperative analgesia. Rabbit endotraqueal intubation is considered tricky, especially by the blind technique. It is reported to require many attempts, a considered amount of time and resulting in occasional failures and glottic lesions. Intubation with indirect visualization of the glottis through an endoscope is considered optimal to improve the process, however endoscopic systems may be large and expensive, being not always available, instead of the smartphone-based device reported in this study. Both blind and endoscope-assisted techniques were proved to be reliable for rabbit intubation, however expected differences were not confirmed. Reduced time and occurrence of complications expected for the endoscopic group were not confirmed in this study, however the anaesthesiologist performed better with the blind technique. Suggesting that mastering is essential for improved success of rabbit intubation independent of the technique.

Keywords: Analgesia. Emergency. Exotics.

SUMÁRIO

2 INTRODUCTION

Small mammals have been representing an increasing part of the pets in houses around the world (AVMA 2019, PMFA 2020, ABINPET 2019). They require less space than dogs and cats for maintenance, are not dependent of walkaways and require reduced daily care time and costs. Rabbits are the most frequent small mammal pet, but chinchillas, guinea pigs, ferrets and hamster also represent part of this group. Although many of these species are studied as laboratory animals, owners are demanding optimal medical practices for their pets, requiring veterinary practitioners to improve their clinical approach in an evidence-based reality.

Anesthesia in these patients can be challenging, they have specific anatomical features, size can be extremely reduced, many physiologic chains differ from dogs and cats, and metabolism rates are high (ALLWEILER 2016). However, balanced and efficient protocols can be applied providing reduced stress, muscle relaxation, analgesia and loss of consciousness for a successful surgical intervention.

2.1. CHINCHILLAS (*Chinchilla lanigera*)

Chinchillas are small rodents belonging to the family *Chinchillidae*, original from the Andes mountains, particularly Chile, currently the species is endangered in the wild (ROACH & KENNERLEY, 2016). Chinchillas have been commercially bred for decades due to its fur, it is possibly the thickest and warmest fur among mammals (MARTINO et al., 2016; SPOTORNO et al., 2004). Most captive chinchillas in the USA are probably descendants of a group of 12 animals imported in the 1920s (MARTIN, 2012; RIGGS & MITCHELL, 2009). Chinchillas have short body, large heads with round hairless ears and bushy tails, adults usually weigh from 400 to 600 grams, being females slightly larger than males (MARTIN, 2012). There are no chinchilla breeds, but besides the wild-type silver-grey goat with black thinning, in captive populations different coat color variations were selected from standard grey, silver, white, to ebony, related to five dominant and four recessive genes (ALWORTH & HARVEY, 2012; MARTIN, 2012). These mutations are popular among pet owners due to its variety and beauty.

Small mammals' anesthesia can be challenging due to their size, specific anatomic features and high metabolism rate (ALLWEILER, 2016). Catheterization and tracheal intubation may not always be achieved, making anesthesia more complicated than dogs and cats (ALLWEILER, 2016). This way, other anesthetic approaches are useful to obtain a balanced anesthesia providing muscle relaxation, loss of conscience and analgesia. Regional blocks are an excellent option in this scenario, however not many studies have been developed reporting regional blocks or even describing nerves anatomy in chinchillas and other rodents.

2.2. DOMESTIC RABBIT (*Oryctolagus cuniculus*)

Rabbits are small mammals of the Lagomorpha order, and not a rodent as many people imagine. The Lagomorpha order consists of two living families, Leporidae (rabbits and hares) and Ochotonidae (pikas). Different from rodents, lagomorphs have two pairs of maxillary incisors and a pair of mandibular incisors. They are crepuscular hindgut fermenter herbivores, strongly relying the cecotrophy behaviour aiming a healthy and functional digestive system.

The original wild European rabbit dispersed though the world (except Antarctica) during human mediation, being the first record o rabbits in captivity by the Romans around the 3rd century BC (NAFF & CRAIG, 2012). Nowadays rabbits are bred worldwide for meat, fur and also as pets. In 2017, 1,482,441 tonnes of rabbit meat were produced in the world (FAO, 2017). While pet rabbit population is estimated in 900,000 animals in the UK (PMFA, 2020) and 2,244,000 in the USA (AVMA, 2020). In Brazil, rabbits, other small mammals and reptiles represents 2,300,000 animals in the national pet population, with an increase of 5.7% from 2017 to 2018, while dogs' population increased 3.8% in the same period (ABINPET, 2019). The American Rabbit Breeders Association (ARBA) recognizes 49 breeds of rabbits, being many of them pet breeds, presenting different body sizes, conformations, weight, anatomical features and coats (ARBA, 2020). This heterogeneity among rabbit breeds imply in different clinical conditions and challenges for the veterinary practitioners. Most studies with rabbits are in experimental conditions, with homogenous animals and usually large breeds such as the New Zealand or the Standard Chinchilla, typical in bioteriums. While in the author clinical routine, pet rabbits are mostly represented by Lionheads, Angoras, Fuzzy and Mini Lops, Netherland dwarfs, and other small breeds.

Rabbits are obligate nasal breathers due to the anatomical disposition of the larynx and the nasopharynx, being the epiglottis lies dorsal to the soft palate (SOHN &

COUTO, 2012). Therefore, mouth breathing is not physiological. Rabbit intubation is considered challenging for many veterinarians and many techniques have been reported in order to increase success rate, reduce time and avoid lesions (VARGA, 2016). This breathing characteristic is associated to a small mouth that poorly opens, narrow oral cavity, large check teeth, the tongue has a torus in its base and the glottis is small, hardly visualized and prone to laryngospasm (VARGA, 2016; SOHN & COUTO, 2012). Intubation with indirect visualization by using an endoscope is considered optimal for the species, however, endoscopic systems may be large and expensive, being not always available (JOHNSON, 2010).

3 GENERAL OBJECTIVES

This work aimed to provide updates in anesthesia of small mammals by 1) describing the use of a local regional block technique already reported in other species, but not in any rodent, the Transversus Abdominis Plane Block and 2) systematically compare rabbit blind intubation and endoscope-assisted intubation using a portable and affordable smartphone-based otoscope. The objective is to provide knowledge for a more balanced and safer anesthesia for companion and wild small mammals patients improving welfare and success rate.

4 USE OF TRANSVERSUS ABDOMINIS PLANE BLOCK FOR ABDOMINAL SURGERY IN CHINCHILLAS

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4.1. INTRODUCTION

Chinchillas and other small rodents are becoming increasingly popular pets, and veterinary anesthetic and surgical procedures are more frequently performed in these species. Many veterinarians consider small rodent anesthesia and surgery, particularly open laparotomy, to be high risk for the patient, although these procedures are well described in the literature (HAWKINS, 2012; BENNETT, 2012). The size and anatomy of chinchillas present several challenges to the veterinarian when performing surgery and anesthesia, and post-operative care is considered highly demanding.

A balanced anesthesia, in which a combination of drugs and techniques are used to obtain hypnosis, analgesia, muscle relaxation and cardiorespiratory stability with few of the side effects associated with high doses of general anesthetic, is a common practice in small animals. There is no reason not to adopt this as standard practice in exotic pets (WENGER, 2012). Different anesthetic protocols have been described for chinchillas (MAYER & MANS, 2017), however there is a paucity of scientific literature regarding local or regional anesthesia. Efficient regional blocks provide intra and postoperative analgesia, facilitating control of anesthesia and improving anesthetic recovery of the patient (McDONNEL et al., 2007B; PORTELA et al., 2018).

The transversus abdominis plane block (TAP block) has been described in people (McDONNEL et al., 2007A) and in a few animal species including dogs (PORTELA et al., 2014), cats (SKOUROPOULOUA et al., 2018) and a Canadian lynx (SCHROEDER et al., 2010). Anatomical studies have also been performed in calves (MIRRA et al., 2018) and ponies (BALDO et al., 2018). The local anesthetic is delivered into the fascial plane between the internal oblique and the transversus abdominis muscles (SCHROEDER et al., 2011), through which run the branches of thoracic and lumbar nerves that innervate the abdominal muscle layers (PORTELA et al., 2014). The TAP block provides a sensory block of the abdominal wall muscles, subcutaneous tissue, mammary glands, skin and parietal peritoneum (HERMANSON et al., 2009; SKOUROPOULOUA et al., 2018). There are no reports of the use of the TAP block in rodents or other small exotic pets. The current study describes the use of the TAP block in a balanced anesthetic protocol in two chinchillas presented with reproductive disorders, dystocia and myometra, that underwent therapeutic ovariohysterectomy through open laparotomy.

4.2. MATERIAL AND METHODS

4.2.1. Case 01

Case one, a nine-year-old, 530g, sexually intact female was presented with dystocia and a kit’s head in the vaginal canal. On ultrasonographic examination, the fetus was dead and emphysematous. In the mother peritonitis, reduced hepatic echogenicity suggestive of inflammatory process or systemic infection and signs of kidney disease were identified.

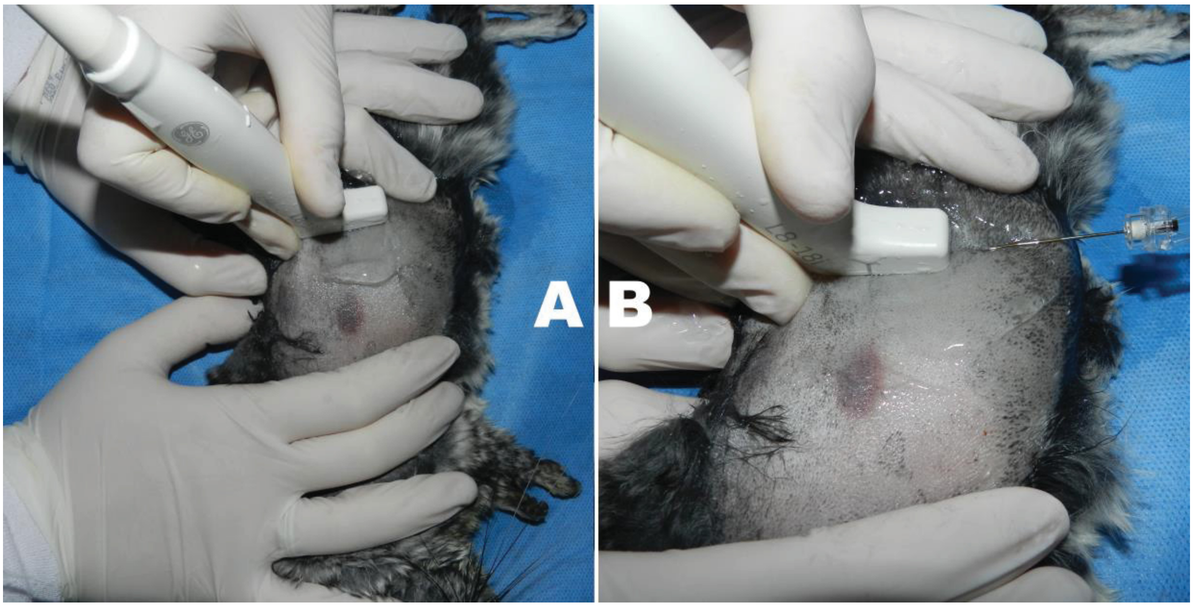
4.2.2. Case 02

Case two, a sixteen-month-old, 580g, sexually intact female chinchilla was presented with history of vaginal discharge for three days. The patient was bright, alert and responsive, but had been partially anorexic for 1 day. The animal had discreet abdominal pain, evidence of an enlarged left uterine horn and a whitish fluid vaginal discharge. Ultrasound examination showed an enlarged uterus with an irregular and thickened wall with the lumen was filled with echogenic material and signs of focal peritonitis.

4.2.3. Clinical procedure

Both animals underwent open laparotomy for therapeutic ovariohysterectomy. Chinchilla one was premedicated with dexmedetomidine 0.005 mg/kg (Dexdomitor; Zoetis, SP, Brazil), midazolam 0.3 mg/kg (Midazolam, Hipolabor, MG, Brazil) and butorphanol (0.5 mg/kg) and chinchilla two with dexmedetomidine 0.01 mg/kg (Dexdomitor; Zoetis, SP, Brazil) and butorphanol 0.5 mg/kg (Torbugesic, Zoetis, SP, Brazil), both intramuscularly in a single syringe. Anesthetic induction and maintenance were performed with inhalation of isoflurane at 1 to 1.5 V% delivered in 100% oxygen through a facemask. During surgery physiological parameters were monitored using a multiparametric monitor (Digicare Animal Health, LifeWindow TM LW9xVet, Rio de Janeiro – RJ, Brazil). For the TAP Block, the abdominal wall was clipped laterally on both sides from the 10th rib to the coxofemoral joint and from the vertebral transverse processes to the linea Alba, and the skin was surgically prepared. With the patients in lateral recumbency, an 18 MHz ultrasound probe (GE LOGIQ F6, L8-18i) was placed at the midpoint point between the tuber coxae and the last rib (Figure 1a) and the abdominal muscle layers were identified. Structures were identified as follow: skin and subcutaneous tissue, external abdominal oblique muscle, internal abdominal oblique muscle, transversus abdominis muscle and peritoneum (Figure 2a). A 22-gauge spinal needle was filled with 0.9% saline solution and, was introduced by an in plane approach (Figure 1b) until the tip reached the fascial plane between the internal abdominal oblique and the transversus abdominis muscle. To confirm correct needle positioning, 0.2 mL of 0.9% saline solution was injected and when a hypoechoic bleb between the muscle layers was seen the total anesthetic volume was injected (Figure 2b).

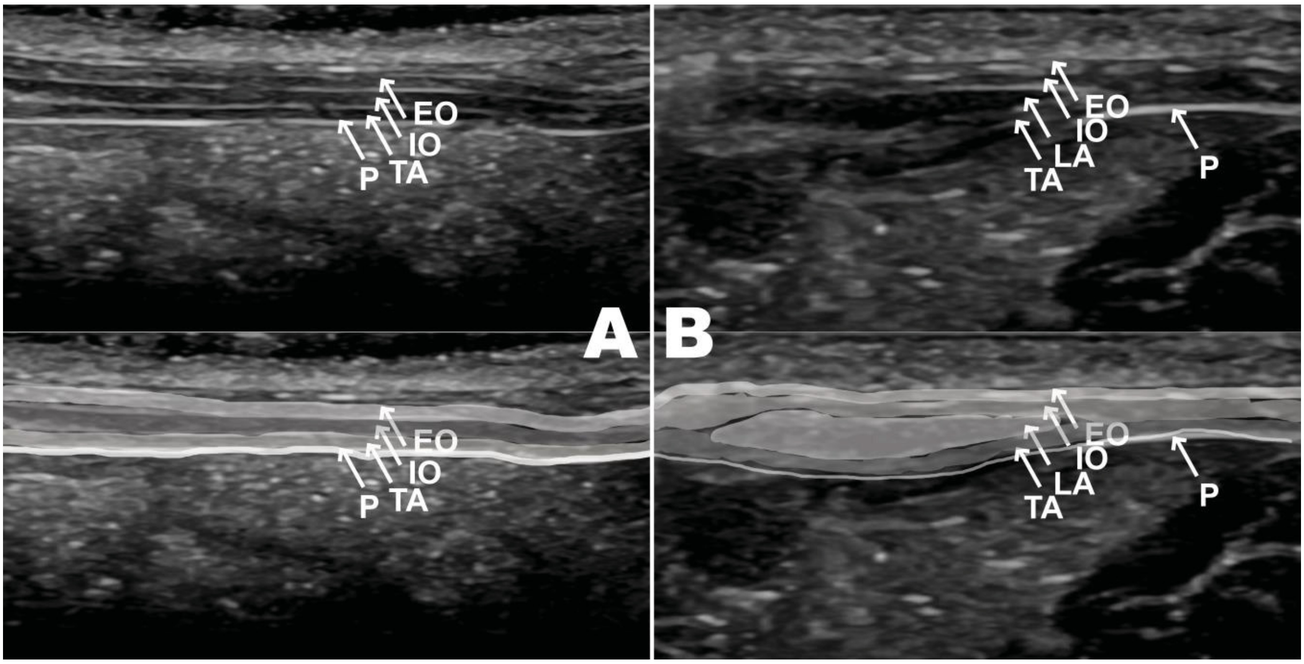
FIGURE 1 - TAP BLOCK ADMINISTRATION IN A CHINCHILLA. ABDOMINAL WALL WAS CLIPPED LATERALLY ON BOTH SIDES FROM THE 10TH RIB TO THE COXOFEMORAL JOINT AND FROM THE VERTEBRAL TRANSVERSE PROCESSES TO THE LINEA ALBA. THE ULTRASOUND PROBE WAS PLACED AT THE MIDPOINT POINT BETWEEN THE TUBER COXAE AND THE LAST RIB (A) AND THE NEEDLE INSERTED IN AN IN-PLANE APPROACH (B).



FONTE: O autor (2020)

In both cases a volume of 0.3 mL/kg was used for each hemiabdomen. The local anesthetic solution used was 0.5% bupivacaine in case one, and 0.5% bupivacaine with 1 µg/mL dexmedetomidine in case two. During both surgeries isoflurane concentration was maintained at 0.7 ± 0.2 V% and physiological parameters were monitored with values of heart rate 136 ± 24 bpm and 154 ± 9 bpm, respiratory rate 34 ± 12 rpm and 64 ± 10 rpm, oxygen saturation 97 ± 3% and 100%, rectal temperature 32.40 ± 0.82 ºC and 37.8 ± 0.88 ºC for case one and two, respectively (Figure 03). A ventral midline incision was made midway between the umbilical scar and the pubis then uterus, uterine horns and ovaries were identified. Suspensory ligaments were ligated with polyglactin 910 and transected, broad ligaments were stripped, and the uterus and vessels were ligated with an encircling ligature cranial to the cervix. In case two, the abdomen was irrigated with heparinised warm saline before closure to avoid adhesions. In each case the abdomen was closed with 4-0 polyglactin 910 suture material, Sultan single sutures were used for linea alba and subcutaneous closure was made using a continuous pattern. Tissue adhesive was used to oppose the skin. Post-operative medication included enrofloxacin (10 mg/kg subcutaneously, twice daily), carprofen (2.2 mg/kg, subcutaneously, twice daily) and crystalloid fluids (100 mL/kg, subcutaneously, daily divided in 4 applications), case two received metoclopramide (0.5 mg/kg, subcutaneously, twice daily). Both animals recovered from anesthesia with no complications and ate the following day, however syringe feeding (30 mL/kg orally daily) was performed for the first five days to guarantee minimal feed consumption. Patient one developed sepsis and died 14 days after surgery despite medical efforts. Patient two recovered well and was discharged 7 days post-surgery.

FIGURE 2 - ULTRASOUND IDENTIFICATION OF THE MUSCLE LAYERS (A) AND DELIVERY OF LOCAL ANESTHETIC (B). EO – EXTERNAL OBLIQUE MUSCLE; IO – INTERNAL OBLIQUE MUSCLE; TA – TRANSVERSE ABDOMINAL MUSCLE; P – PERITONEUM (A) IDENTIFICATION OF THE MUSCLE LAYERS IN US GUIDED APPROACH (B) LOCATION OF THE 22-GAUGE SPINAL NEEDLE (N) DELIVERING THE LOCAL ANESTHETIC (LA) BETWEEN THE INTERNAL OBLIQUE MUSCLE AND THE TRANSVERSE ABDOMINAL MUSCLE.



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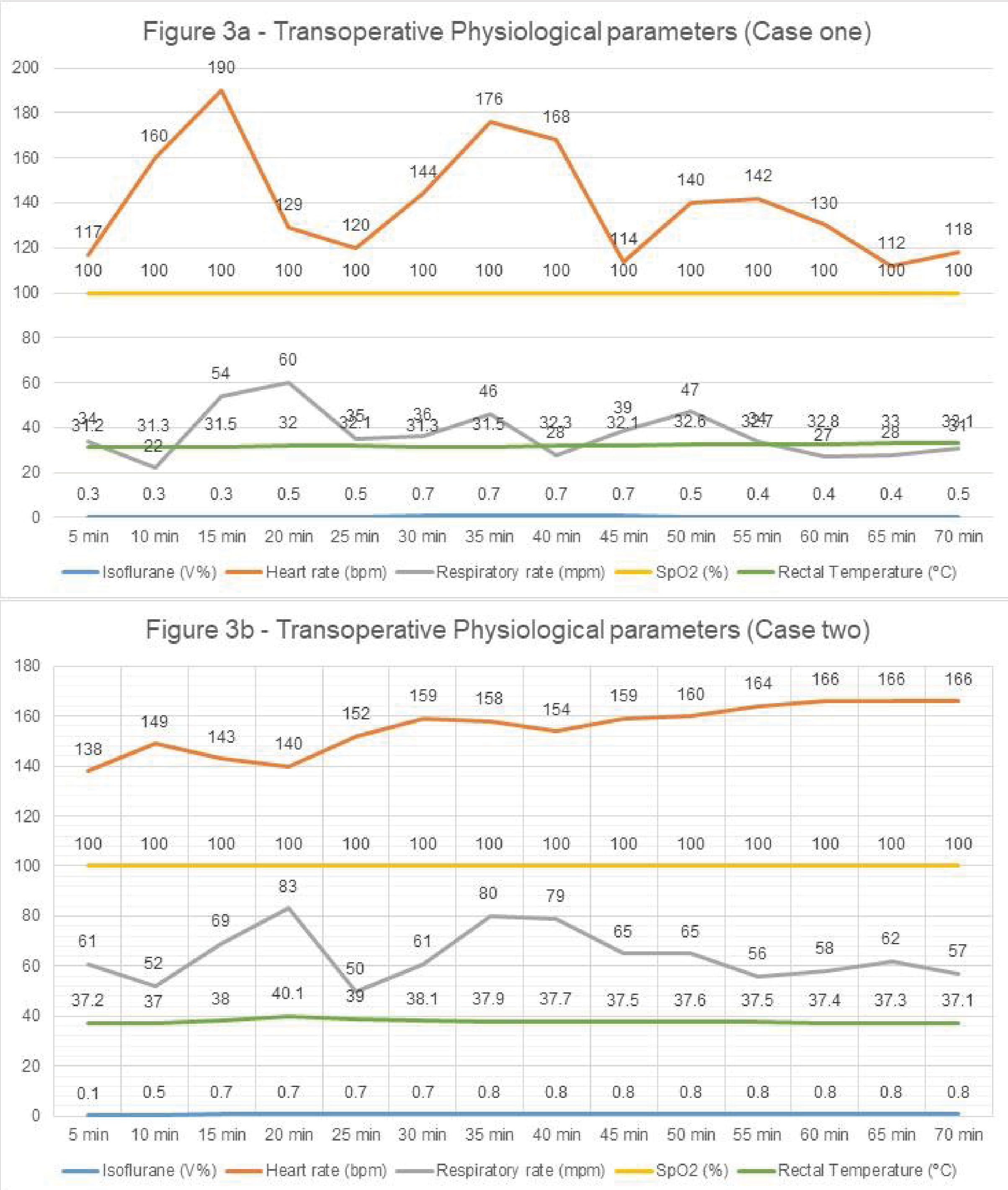
3.3. DISCUSSION

One of the challenges in exotic animal surgery is post-operative management. Bennett (2012) reports acute unexplained death during the days following surgery and, in addition, general discomfort and pain can lead to apathy and anorexia slowing the patient's recovery. This is the first report of a TAP block in chinchillas or any other rodent, and this is the smallest species reported to receive this regional anesthetic technique. This block is challenging to perform adequately in such small patients, however the use of a high frequency ultrasound probe – 18 MHz, and appropriately sized needle – 22-gauge, favoured the success of the procedure. A trained anaesthesiologist, with experience of TAP blocks in other species such as dogs and cats, is also recommended. Regional anesthesia is widely used for analgesia in exotic animals, providing a pre-emptive and multimodal approach for antinoception, reduced requirement for general anesthetics, contribution to an adequate surgical plane and smoother anesthetic recovery (RIOJAGARCIA, 2015; ROMANO et al., 2016; KETTNER et al., 2011). In veterinary medicine, the TAP block has been documented in dogs undergoing mastectomy (ROMANO et al., 2016) and cats undergoing ovariectomy (SKOUROPOULOUA et al., 2018), also a catheter TAP block was used to control abdominal pain in dogs (FREITAG et al., 2018). In exotic species a single report of its use in exploratory laparotomy in a Canadian lynx has been published (SCHROEDER et a.,l 2010). A blind approach for TAP block is possible in humans in the inferior lumbar triangle, also known as Petit's triangle (JANKOVIC et al., 2009). However, for pediatric human patients (ABU et al., 2016; VENKATRAMAN et al., 2016) and in veterinary medicine (SCHROEDER et al., 2011; DROZDZYNSKA et al., 2016) an ultrasound guided technique is preferred to avoid accidental intraperitoneal injection. In this report, an ultrasound guided conventional approach was chosen, delivering the anesthetic solution at the midpoint between the last rib and the tuber coxae, as in the traditional technique used in people, dogs and cats. The TAP block is already used in human patients in a variety of abdominal surgeries as an alternative to epidural analgesia. Patients receiving TAP Block have decreased visual analogue scores and reduced postoperative opioid requirements lasting up to 48 hours postoperatively (BLUMENKOPF & LIPMAN, 1991; McDONNEL et al., 2007B; McDONNEL et al., 2008). The block is indicated for a wide range of human abdominal procedures such as liver transplants (MILAN et al., 2011), radical gastrectomies (WU et al., 2013), appendectomy (NIRAJ et al., 2009), cholecystectomy (EL-DAWLATLY et al., 2009), cesarean section (BELAVY et al., 2009) and hysterectomy (CARNEY et al., 2008). The fascial plane between the internal abdominal oblique and transversus abdominis muscles contains afferent branches of thoracic and lumbar nerves innervating the abdominal muscles, abdominal subcutaneous tissue and parietal peritoneum (HERMANSON et al., 2009). Bruggink et al. (2012) described the pattern of TAP block injection in dog cadavers exploring nerve anatomy and appropriate anaesthetic volume. The number of dermatomes covered by local anesthetic was determined on a weight-based volume of injection and, according to this author, the volume of 1 mL/kg covered most dermatomes within the hemi-abdomen.

FIGURE 3 - SUMMARY OF PHYSIOLOGICAL PARAMETERS OF CASE ONE (3A) AND CASE TWO (3B) DURING TRANSOPERATIVE.



FONTE: O autor (2020)

However, the total dose and potential complications relating to local anaesthetic toxicity should be considered, especially in small patients such as chinchillas. Dexmedetomidine was selected as an adjuvant for the TAP block in case two due to its potential to enhance duration of analgesia. Agarwal et al. (2014) demonstrated analgesia three times longer in brachial plexus block when used in combination with dexmedetomidine and bupivacaine in people. Almarakbi & Kaki (2014) reported prolonged analgesia and better pain control in people when TAP block was used in addition to bupivacaine, patients in that study did not require analgesics until 470 minutes post-surgery compared with 280 minutes for those that received only bupivacaine. Karhade et al. (2018) showed an earlier onset of sensory and motor blockade with this combination than with local anesthetic alone.

Dexmedetomidine is a selective alpha 2 (α2) adrenergic agonist with analgesic and sedative properties, although the mechanism of improved analgesia with this combination is not fully elucidated, vasoconstriction and action through α2 adrenoceptors agonist effect are plausible explanations (COURSIN et al., 2001, MASUKI et al., 2005). Although dexmedetomidine might be associated with side-effects such as hypotension, bradycardia and sedation, no difference was noticed from other surgical procedures previously performed in chinchillas by the authors, despite the fact that dexmedetomidine was also used intramuscularly in the preanesthetic medication. Brummett et al. (2008) administered a high-dose of dexmedetomidine in combination with bupivacaine perineurally in rats, enhancing blocking effects without inducing neurotoxicity. It is important to realise that the TAP block only provides regional anesthesia and analgesia of the abdominal wall with no effect on visceral components. However, abdominal surgery produces both somatosensory pain from the surgical wound in the abdominal wall and visceroperitonitic pain from surgical trauma (AIDA et al., 1999), and the TAP Block is able to provide significant somatosensory analgesia in the postoperative period (SKOUROPOULOUA et al., 2018, McDONNEL et al., 2007B) enhancing the patients' overall condition in post-surgery period. In summary, bupivacaine TAP block with or without dexmedetomidine are options for chinchilla analgesia that provide better post-operative recovery following abdominal surgery.

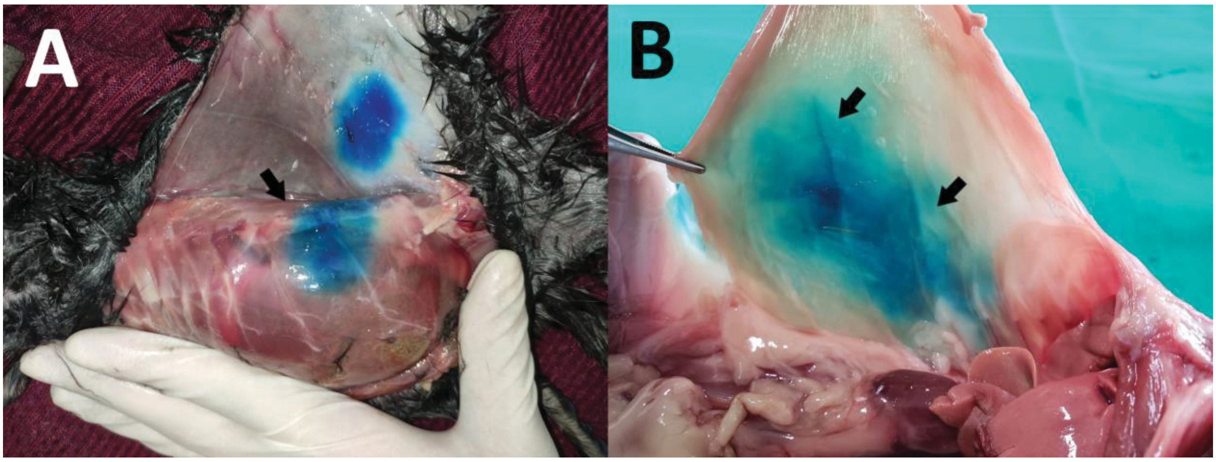
3.4. LIMITATIONS

The limitation of this technique is that the small size of the patient making it challenging to perform. Because of the small size of the structures involved a degree of experience is needed to avoid accidental infiltration of the solution into the peritoneal cavity. The correct equipment and experience are essential for a successful approach. Besides that, only the clinical application of the technique was described in this opportunity, no evidence of clinical effectiveness was proved.

3.5. FURTHER STUDIES

As discussed in the limitations, no clinical effectiveness nor the more adequate approach for the TAP Block in chinchillas has been stated. Further studies are required to determine detail for the technique in this species proving its clinical value. Complementary studies are being developed aiming an evidence-based medicine regarding this technique. First, the abdominal plane nerves are not described for chinchillas and, even it being expected to be quite similar to other mammals, it must be described in detail. Calguner et al. (2005) described the innervation of the rat anterior abdominal wall, from the 6^{th} to the 13^{th} intercostal nerves while ashdown et al. (1967) described the abdominal wall of chinchillas. Form, size, origin and insertion of the main muscles are described, but no nerves are exploited. Knowing the anatomic detail of the abdominal wall of chinchillas, the best approach for the TAP Block can be tested associating both the anatomic reference points and the local anesthetic volumes. Following these statements, a cadaveric study is being developed to accurate describe the local anesthetic dispersion in different volumes of methylene blue (0.3mL/kg and 0.6mL/kg) to confirm nerves by staining (Figure 4).

FIGURE 4 - METHYLENE BLUE INJECTION IN A CHINCHILLA CADAVER. STAIN DISPERSION EVIDENT IN (A) ALLOWING MEASUREMENT AND EVALUATING MUSCLE LAYERS AFFECTED. IN (B), ABDOMINAL NERVES STAINING EVALUATED, THE NUMBER AND WHICH NERVES ARE STAINED ARE BEING EVALUATED, BUT ALSO LENGTH OF THE STAIN IN EACH NERVE. ABDOMINAL CAVITY IS EVALUATED TO CONFIRM IF THE DYE WAS NOT INJECTED INTO THE PERITONEUM.



Fonte: O autor (2020)

Comparing different volumes of methylene blue, an adequate local anesthetic volume can be determined to provide analgesia with minimum side-effects for the patient. Canine cadaveric study assessing the influence of volume on the coverage of nerve roots when performing a single TAP block injection midway between the last rib and the iliac crest found that mean dermatome coverage (i.e. number of ventral nerve roots stained by the dye) increased significantly with increases in injection volume (BRUGGINK et al., 2012). Injection of 1 mL/kg of solution resulted in the the largest spread, covering four dermatomes. However, a smaller injection volume of 0.25 mL/kg still provided adequate coverage for three dermatomes (BRUGGINK et al., 2012). Innervation to the canine abdominal wall and peritoneum is provided by the branches of T11, T12, and T13 cranially and branches of L1, L2, and L3 caudally (HERMANSON et al. 2009). SCHROEDER (2011) reported that canine cadavers injected with 1mL of methylene blue/bupivacaine by the conventional one-point approach TAP block adequately stained segmental branches of T11, T12, T13, L1, L2, and L3 in 20%, 60%, 100%, 100%, 90%, and 30% of the cases, respectively. Johnson et al. (2018) described a better staining of branches of nerve L3 with a two-point approach TAP block compared to the single point injection, however, thoracic nerves that also innervates the abdominal wall in dogs did not stain adequately. It is expected by the authors that a single point-approach will be effective for nerves staining in chinchillas due to their size and body conformation, however, if it proves inefficient, a two-point approach may be required to be investigated. The viscosity of the dye and the needle orientation are factors discussed by other authors as affecting the dye (and probably the local anesthetic) spread in dogs and must be considered also in chinchillas. After the abdominal wall nerves and the dye spread be described in chinchillas, a clinical trial must be performed to prove this local anesthetic block real effectiveness for rodent anesthesia.

3.6. LITERATURE CITED

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4 COMPARISON OF CLASSICAL BLIND INTUBATION AND A SMARTPHONE-BASED ENDOSCOPE-ASSISTED INTUBATION IN RABBITS

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AUTHORS' CONTRIBUTIONS

AS: study design, data collection and analysis, statistical analysis and preparation of manuscript. **EM:** study design, data collection and analysis. **FAVF:** study design. **EMUG:** study design, data collection and management. **DB:** Data collection and management. **TRF:** Reviewing the manuscript. **RRL:** Reviewing the manuscript. **JCDM:** Study design, interpreting the results, reviewing the manuscript.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

4.1. ABSTRACT

Objective To compare success rate, number of attempts, time to complete procedure and occurrence of complications in rabbit endotracheal intubation (ETT) using the classical blind and a 5.5mm USB smartphone-based endoscope-assisted techniques.

Study design Prospective clinical study

Animals Thirty-four rabbits of different breeds divided into four groups: exotic pet specialist blind and endoscopic intubation and anesthesiologist blind and endoscopic intubation.

Methods Rabbits were sedated, underwent anesthetic induction, were randomly assigned to a group and then ETT was performed. Propofol dose, number of attempts (AT), total time for success (TTS), time for success (TS), occurrence of cyanosis, blood in the tube and glottic lesions were recorded. Data were analysed by t-test for independent means, Wilcoxon-Mann-Whitney or chi-square tests when appropriate. Correlation coefficient for body weight and TS and TTS was performed using Pearson correlation test. All data were compared both between operators and techniques.

Results Both blind and endoscope-assisted intubation of rabbits was feasible. Blind intubation success rate was 77.8% for the exotic specialist and 88.9% (8/9) for the anesthesiologist. Total and median AT, TTS, TS and propofol dose were 24, 3 (1 - 5), 136 ± 92 and 38 ± 16 seconds and 1.5 (0 - 4.5) mg/kg for the exotic pet specialist group, and 19, 2 (1 - 5), 79 ± 65 and 30 ± 20 seconds and 3.1 (0 - 6.2) mg/kg for the anesthesiologist group. Endoscope-assisted intubation success rate was 87.5% for both operators. Total and median AT, TTS, TS and propofol dose was 11, 1 (1 - 4), 56.5 (27 - 432) and 55 (26 - 79) seconds and 3.2 (0 - 6) mg/kg for the exotic specialist group, and 22, 3 (1 - 5), 170.5 (65 -368) and 46 (22 - 150) seconds and 2.5 (1.3 - 7.4) mg/kg in the anesthesiologist group. In the anesthesiologist groups, blind intubation was more quickly performed, propofol dose was lower and cyanosis less frequent than in the endoscope group. No differences were noted between any of the variables within the exotic specialist groups.

Conclusions and clinical relevance Blind and endoscope-assisted intubation are both reliable techniques to maintain a patent airway in rabbits weighing between 1.5 and 4.2 kg from a variety of breeds. Best results are achieved when the operator is experienced in the technique. The smartphone-based device is small, affordable and

can be extremely useful for patients with anatomic alterations. The smartphone-based device is small-sized, affordable and can be extremely useful for patients with anatomic alterations.

4.2. INTRODUCTION

Increasing numbers of exotic animals are being kept as pets, and rabbits are one of the most common species (AVMA 2020). Therefore rabbits are being presented more often to the veterinary practitioner and owners are seeking high-quality medical care for their pets. Airway management is essential in surgical procedures to avoid hypoxemia, and is also required for effective cardiopulmonary resuscitation. According to Brodbelt et al. (2008), 1.39% of anesthetised rabbits die during anesthesia, most as a result of cardiorespiratory problems. This contrasts with mortality rates in other domestic species as dogs (0.17%) and cats (0.24%). A contributing factor for these anesthetic deaths may be that only 29% of anesthetized rabbits are routinely intubated (BRODBELT et al., 2008). Rabbit intubation can be difficult because of their large incisors, narrow oral cavity (which is largely occupied by the tongue with a torus in its base), limited mouth opening and a small glottis that is prone to laryngospasm (VARGA, 2017; AL-MAHMODI, 2016; SUCKOW et al., 2002). Although face masks are accessible and easy to use, these increase dead space and do not provide a reliable airway seal, allowing leakage of volatile anesthetics. Airway obstruction is not prevented by masks and appropriate ventilation is not provided (ALLWEILER, 2016; BATEMAN et al., 2005). Alternatives to face masks and endotracheal intubation (ETT), such as v-gel and laryngeal masks are more expensive and may not always be available. Blind ETT can result also in traumatic injuries of both larynx and trachea in rabbits, resulting in hemorrhage, edema and even respiratory arrest (PHANEUF et al., 2006; GRINT et al., 2006). In an attempt to reduce these risks, a number of intubation techniques and variations have been published, including intubation guided by lighted stylets (SU et al., 2013), catheters (THOMPSON et al., 2017), capnography (LEE et al., 2019) and with direct and indirect visualization of the glottis (VARGA, 2017; JOHNSON, 2010). Visualization of the larynx at intubation is considered optimal. Intubation techniques assisted by endoscopes are described in small mammals for indirect visualization of the larynx, reducing the risk of traumatic lesions and allowing evaluation of the oral cavity for food, foreign bodies, secretions and anatomic abnormalities (MIRANDA et al., 2016; WORTHLEY et al., 2000). Endoscopic systems can be expensive and difficult to transport, and few studies have compared the advantages of endoscope-assisted intubation with blind techniques (MIRANDA et al., 2016; TRAN et al., 2001). Medical use of smartphones and a smartphone-based device is an increasing trend in both human and veterinary medicine. Buchholz et al. (2016) report that 94% of physicians and medical students own a smartphone and 82% of them have used this at least once in a clinical setting. It is likely that a similar scenario occurs in veterinary medicine (HUYNH, 2019). Airtraq is a human intubation device which can be equipped with a smartphone for indirect visualization of the glottis. Rabbit intubation assisted by endoscope is more rapid and results in fewer upper airway lesions than the blind technique. This study aimed to compare rabbit intubation by two methods: the classical blind technique and intubation assisted by a 5.5 mm diameter portable human medical semi rigid otoscope as described by Freitag et al. (2019).

4.3. MATERIAL AND METHODS

Data from thirty-four adult pet rabbits undergoing anesthesia and intubation for elective procedures were enrolled in this study. This project was approved by the local commission on ethics on the use of animals of the Federal University of Parana (UFPR, Brazil; no. 047/2019). Animals included a variety of breeds, ages and sex. Physical and blood exams (CBC and biochemistry) were performed and were ASA 1 or 2 patients. Rabbits were not fasted and were sedated with dexmedetomidine 30 μg/kg (Dexdomitor; Zoetis, SP, Brazil), midazolam 1 mg/kg (Midazolam, Hipolabor, MG, Brazil) and butorphanol 0.5 mg/kg (Torbugesic, Zoetis, SP, Brazil) in the same syringe given intramuscularly in the hindlimb. Ten minutes later, the marginal ear vein was clipped, numbed with lidocaine 2% gel (Labcaína; Pharlab; MG; Brazil) and catheterized with a 24-gauge catheter. Animals were pre-oxygenated for 2 minutes by facemask, induced with propofol (2mg/kg/min) and righting reflex, corneal reflex, palpebral reflex, ear-pinch and toe-pinch reflexes and, jaw muscle tone were evaluated. When jaw muscle tone was completely absent the propofol dose was recorded and intubation was performed. Animals were randomly assigned to four groups, seventeen rabbits for each operator: an exotic specialist (AS) and an anaesthesiologist (EM), both with previous experience of intubating rabbits. Each operator intubated nine rabbits using the blind technique and eight assisted by the smartphone endoscope. Endotracheal tube size was selected by each operator based on experience (uncuffed, 2–2.5 mm ID Endotracheal tube, Solidor; SP; Brazil).

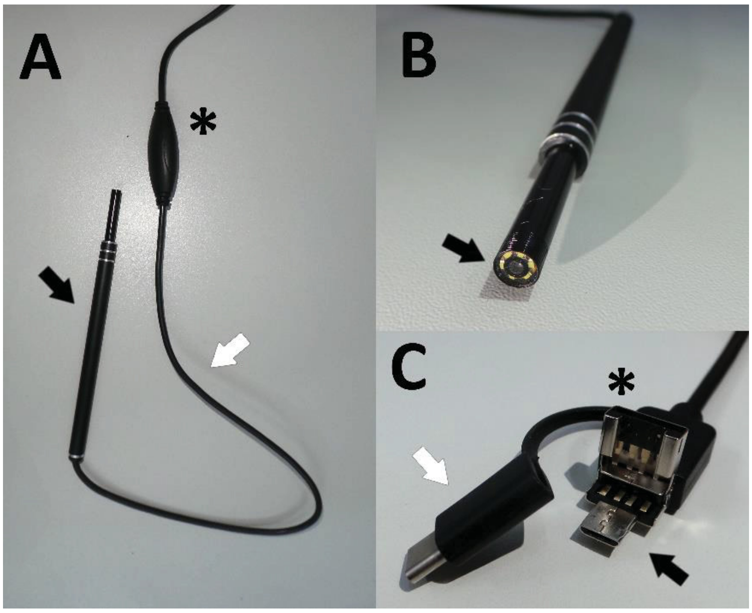
4.3.1. Blind intubation

With the rabbits in sternal recumbency, the head was held in dorsiflexion by an assistant, the neck was kept straight in a dorsal position, front feet touching the table so the operator had both hands free to introduce the tube. The endotracheal tube (ET) was lubricated with lidocaine gel 2% (Labcaína; Pharlab; MG; Brazil) and a stylet was used by both operators. The blind intubation technique was guided by breath sounds and tube clouding. If intubation had not been successful after 4 attempts the fifth attempt was endoscope-assisted, if this was unsuccessful, a face mask was used to maintain anesthesia. Each attempt was limited to 180 seconds or until cyanosis developed, in both cases the procedure was interrupted, the animal was oxygenated and another attempt was made. Events such as coughing and/or gagging, water vapour inside the ET, breath sounds, reservoir bag movement synchronized with respiratory effort were noted and successful intubation was confirmed by capnography.

4.3.2. Endoscope-assisted intubation

With the rabbits in sternal recumbency the head was held in dorsiflexion by an assistant, the neck was kept straight in a dorsal position, front feet touching the table so the operator had both hands free to introduce the tube. The operator used the subordinate hand for the endoscope and the dominant hand to introduce the ET. A 5.5mm IP67 Waterproof USB semi-rigid otoscope (Visual ear cleaner i98; RoHS, China) was used (Figure 01), connected to different Android (Google LLC, CA, USA) smartphones through the micro-USB port (USB-C and Lightning adapter available). Images were captured through “Endoscope” app (freely available at Google Play Store, similar apps available in AppStore). Although this device was originally developed as a human otoscope, it was used and referred to in this study as an endoscope. The ET was lubricated with lidocaine gel 2% (Labcaína; Pharlab; MG; Brazil) and no stylet was used by either operator. For larynx visualization, the endoscope lens was cleaned with chlorhexidine to avoid clouding and it was placed over the lingual torus, gently pushed ventrally and carefully advanced until the glottis was visualized (Figure 2). Once the glottis was visualized, the ET was introduced lateral or dorsal to the endoscope and placed into the glottis (side-by-side approach). Four attempts were allowed in each rabbit, if these were all unsuccessful a fifth attempt was made using the classical blind approach. If the rabbit was still not intubated a face mask was used to maintain anesthesia. Each attempt was limited to 180 seconds or until cyanosis developed, in either case the procedure was interrupted, the patient was oxygenated and another attempt was made. Success of intubation was confirmed by direct visualization of the ET in the trachea and capnography.

FIGURE 1 - A: OVERALL VIEW OF THE USB ENDOSCOPE. THERE IS A 14.5CM RIGID SECTION (BLACK ARROW) FOLLOWED BY THE FLEXIBLE CABLE (WHITE ARROW) WHICH IS ATTACHED TO THE USB CONNECTOR. AFTER THE RIGID PART THERE IS A SCROLL CONTROLLER TO REGULATE THE LEDS INTENSITY (ASTERISK). B: ANTERIOR CLOSE VIEW OF THE RIGID PART OF THE ENDOSCOPE, SHOWING 5.5MM BY 2.75CM TIP FOLLOWED BY A 7.5MM BY 11.75CM DIAMETER HOLDER. THE 90º LENS (BLACK ARROW) DOES NOT PROVIDE AS WIDE A VIEW AS A 30º ENDOSCOPE. THERE ARE SIX LEDS AROUND THE LENS, ALL COVERED BY A GLASS PROTECTOR. C: USB CONNECTOR OF THE ENDOSCOPE, MAIN CONNECTOR IS A MICRO-USB PORT (BLACK ARROW) WITH A COUPLED USB ADAPTER (ASTERISK). THERE IS ALSO AN USB TYPE-C ADAPTER ATTACHED (WHITE ARROW).



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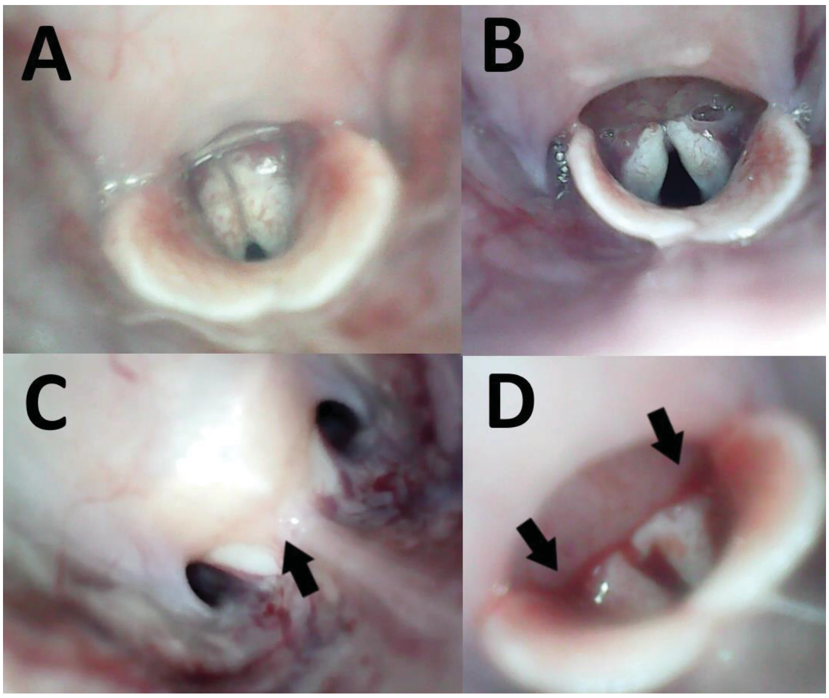
4.3.3. Variables

Endotracheal tube size (ETS) and its relation to body weight (ET/BW), propofol dose, number of attempts, total time required for success (TTS) and time of the successful attempt (TS) were recorded for each rabbit. An “attempt” was characterized as inserting the ET in the animal's mouth until successful intubation or withdrawal from the mouth. For each attempt: time spent, volume of propofol injected, occurrence of cyanosis and presence of blood in the tip of the ET were recorded. The TTS was calculated as the sum of time taken for all the attempts for each rabbit, while TS was the time only of the successful attempt. At the end of the procedure, the endoscope was used to visually evaluate the glottis of each rabbit, looking for any lesion induced by the procedure, hyperemia, sores and/or bleeding were considered as lesions.

FIGURE 2 - A: INDIRECT VISUALIZATION OF THE RABBIT GLOTTIS AT THE END OF EXPIRATION, NOTE THE CARTILAGES TOUCHING EACH OTHER MEDIALLY. B: INDIRECT VISUALIZATION OF THE RABBIT EPIGLOTTIS DURING INSPIRATION, CARTILAGES MOVE LATERALLY OPENING THE TRACHEAL LUMEN FACILITATING INTUBATION. C: PALATAL FOLD TOUCHING THE EPIGLOTTIS SHOWING WHY RABBITS ARE PREFERRED NASAL BREATHERS. ETT IS IMPOSSIBLE IN AN ANIMAL IN THIS POSITION, THE PALATAL FOLD MUST BE DISPLACED FIRST. D: INDIRECT VISUALIZATION OF THE RABBIT GLOTTIS AFTER EXTUBATION. NOTE THE LARYNGEAL LESION WITH BLOODY SECRETION AROUND THE GLOTTIS.



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4.3.4. Statistics

The power calculation was based on the calculation of Wenger et al. (2016). The free software G*Power (Version 3.0.10, University Düsseldorf, Germany) was used to perform an analysis for a two-tailed t-test with power 0.95, an alpha error of 0.05 and an effect size of 2.8. This effect size was based on the results for blind intubation time of Wenger et al. (2016) (315 ± 147 seconds) and endoscope assisted intubation time of Freitag et al. (2019) (22 ± 11 seconds). The results of this preliminary analysis suggested that 4 rabbits would be sufficient to detect significant differences in time required for intubation between the two techniques. However, from consulting colleagues, the endoscope-assisted intubation was believed to be on average 66% quicker than the blind intubation, resulting in an effect size of 1.89 and a minimum sample size of 7 animals, therefore the authors opted to include at least 8 animals in each group. Data were tested for normality with Shapiro-Wilk test. Results are presented as mean ± standard deviation for normally distributed data and as median (range) for non-normally distributed data. Data were compared with t-test for the independent means for normally distributed data, and Wilcoxon-Mann-Whitney for non-normally distributed data. Presence of blood in the ET, cyanosis and glottic lesions were compared by Exact Fisher's and chi-square tests. Blood and cyanotic events were registered at each attempt, therefore more than once for each rabbit, whereas the glottic lesions were only evaluated once at the end of the procedure. Correlation coefficient for body weight and TS and TTS was performed by Pearson correlation test. All data were compared both between operators and techniques. Significance was set at $p < 0.05$. Statistical tests were performed with software R i386 (version 3.6.1).

4.4. RESULTS

Average weight was 2.57 ± 0.79 kg. Intubation was possible in all rabbits, nevertheless in some rabbits the second technique was necessary after the fourth attempt. Results are summarized in Table 01.

TABLE 1 - SUMMARY OF RESULTS BOTH BY TECHNIQUE (BLIND OR ENDOSCOPE) AND OPERATOR (AS OR EM). MEDIAN AND TOTAL NUMBER OF ATTEMPTS (AT), SUCCESS RATE, TOTAL TIME FOR SUCCESS (TTS), TIME FOR SUCCESS (TS), PROPOFOL DOSE, OCCURRENCE OF LESIONS, CYANOSIS AND BLOOD IN THE ET TIP, BW AND ET/BW RATIO ARE PRESENTED FOR ALL FOUR GROUPS.

	Blind		*Endoscope*	
	AS	**EM**	**AS**	**EM**
Median AT (n)	3 (1 - 5)	2 (1 - 5)	1 (1 - 4)	3 (1 - 5)
Total AT (n)	24	19	11	22
Success rate (%)	7/9 (77.8%)	8/9 (88.9%)	7/8 (87.5%)	7/8 (87.5%)
TTS (seconds)	136 ± 92	79 ± 65	56.5 (27-432)*	170.5 (65-368)*
TS (seconds)	38 ±16	30 ± 20	55 (26-79)	46 (22-150)
Propofol dose (mg/kg)	3.1 (0-6.2)	1.5 (0-4.5)†	3.2 (0-6)	2.5 (1.3-7.4)†
Lesion (n)	0	0	3	1
Blood (n)	0	0	1	0
Cyanosis (n)	2	0†	2*	5*†
ET/BW	0.98 ± 0.3	0.91 ± 0.2	0.98 ± 0.16	0.96 ± 0.29
BW (kg)	2.48 ± 0.98	2.69 ± 0.79	2.4 ± 20.54	2.44 ± 0.95

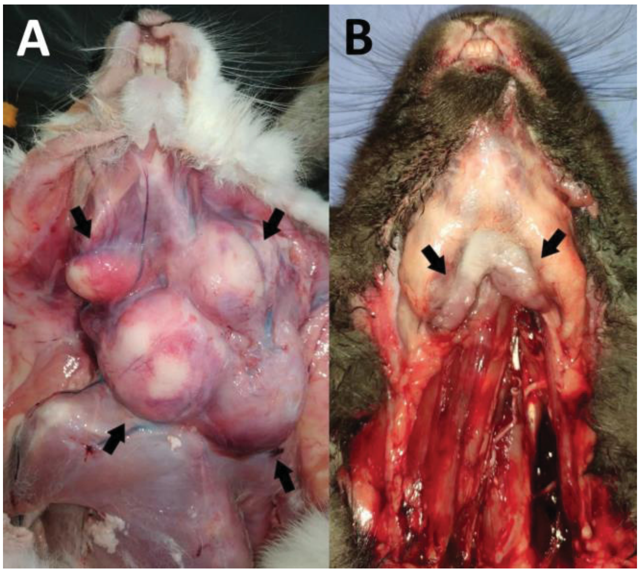
Parametric data is presented by mean ± standard deviation and were tested by t-test for independent means.
Non-parametric data is presented by median (range) and were tested by Wilcoxon-Mann-Whitney test.
Marked parameters presented statistical differences between operators (*) or techniques (†) ($p < 0.05$)

Fonte: O autor (2020)

4.4.1. Blind technique

Overall success rate for the blind technique was 15/18 (83%). In three rabbits intubation was not achieved after four attempts and endoscope-guided intubation was required. Two of these animals had anatomic alterations compromising tube insertion; the first had enlarged tonsils visualized after the endoscope utilization (Figure 03A). The other rabbit had cervical subcutaneous abscesses identified on physical exam (Figure 03B). Total and median AT, TTS and TS were 24, 3 (1 - 5), 136 ± 92 and 38 ± 16 seconds for AS, and 19, 2 (1 - 5), 79 ± 65 and 30 ± 20 seconds for EM, with a success rate of 77.8% (7/9) and 88.9% (8/9), respectively (Figure 04). Propofol dose for EM was 1.5 (0 - 4.5) mg/kg against 3.1 (0 - 6.2) mg/kg for AS. The ET/BW ratio did not differ between operators, 0.98 ± 0.3 for AS and 0.91 ± 0.2 for EM. Blood was not noticed following any blind intubation attempts, while cyanosis occurred on two occasions for AS and none for EM. Post-intubation lesions (presence of bloody secretion and hyperemia) occurred in two rabbits for EM. No BW correlations were strong, TTS for AS (r = 0.36, p = 0.33) and EM (r = 0.05, p = 0.9) were weak as well as with TS for AS (r = -0.34, p = 0.45) and EM (r = -0.04, p = 0.91) (Figure 05).

FIGURE 3. TWO OF THE ANIMALS NOT POSSIBLE TO INTUBATE BLINDLY. A: ANIMAL PRESENTED MULTIPLE SUBCUTANEOUS MASSES (ABSCESSES), DISPLACING THE LARYNGE AND REDUCING SPACE FOR THE ET. B: ANIMAL PRESENTED ENLARGED TONSILS REDUCING LARYNGEAL SPACE AND MAKING DIFFICULT THE ET INSERTION. BOTH ANIMALS WERE SUCCESSFULLY INTUBATED USING THE SMARTPHONE-BASED ENDOSCOPE.



Fonte: O autor (2020)

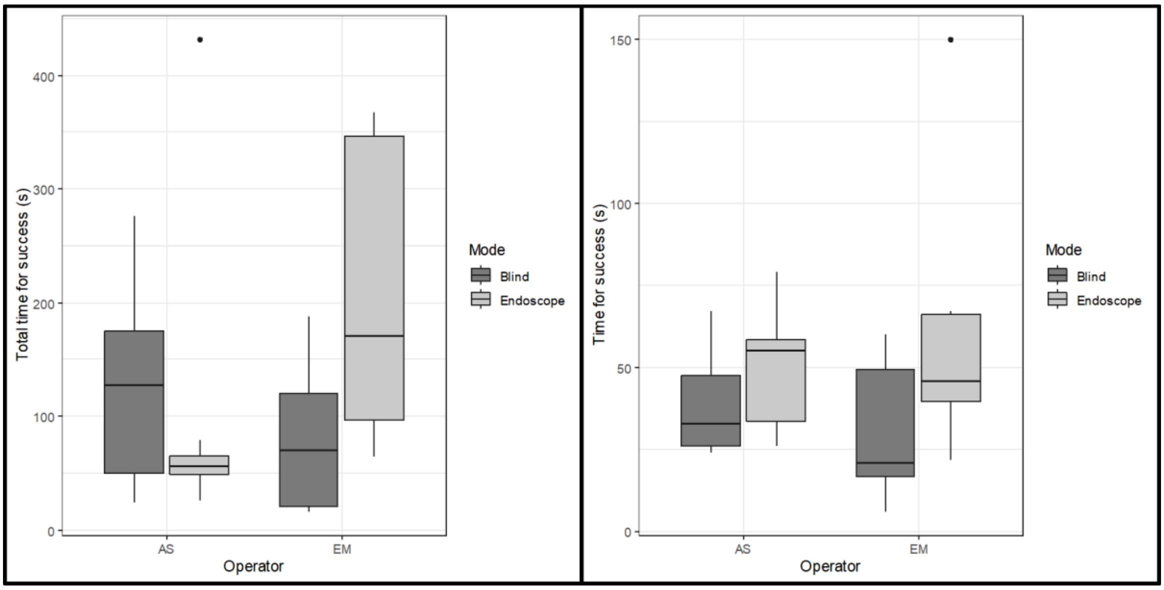
4.4.2. Endoscope-assisted technique

Overall success rate for the endoscope-assisted technique was 14/16 (87.5%). In two rabbits intubation was not achieved after four attempts and blind intubation was required. In one animal the oral cavity was too narrow for both the endoscope and the ET, and even with glottis visualization, intubation was not possible after the endoscope-guided attempts. This rabbit was then intubated by the same operator in 18 seconds using the blind technique. The second rabbit could not be intubated after four attempts and was blind intubated in 15 seconds. Total and median AT, TTS and TS was 11, 1 (1 - 4), 56.5 (27 - 432) and 55 (26 - 79) seconds for AS, respectively, and 22, 3 (1 - 5), 170.5 (65 -368) and 46 (22 - 150) seconds for EM, respectively, with a success rate of 87.5% (7/8) for both operators (Figure 4). Propofol dose for AS was 3.2 (0 - 6) mg/kg and 2.5 (1.3 - 7.4) mg/kg for EM. Blood was noticed in the ET in one rabbit after extubation in AS group, while cyanosis occurred twice for AS and five times for EM. A post-intubation lesion was present in one rabbit for each operator. The TTS was the only parameter that was statistically different between operators in the endoscope-assisted technique (p = 0.02). No BW correlations were strong, TTS was moderate for AS (r = 0.67, p = 0.07) and weak for EE (r = -0.04, p = 0.92), while for TS correlations were weak for AS (r = -0.48, p = 0.26) and moderate for EM (r = -0.55, p = 0.20) (Figure 05).

4.4.3. Techniques

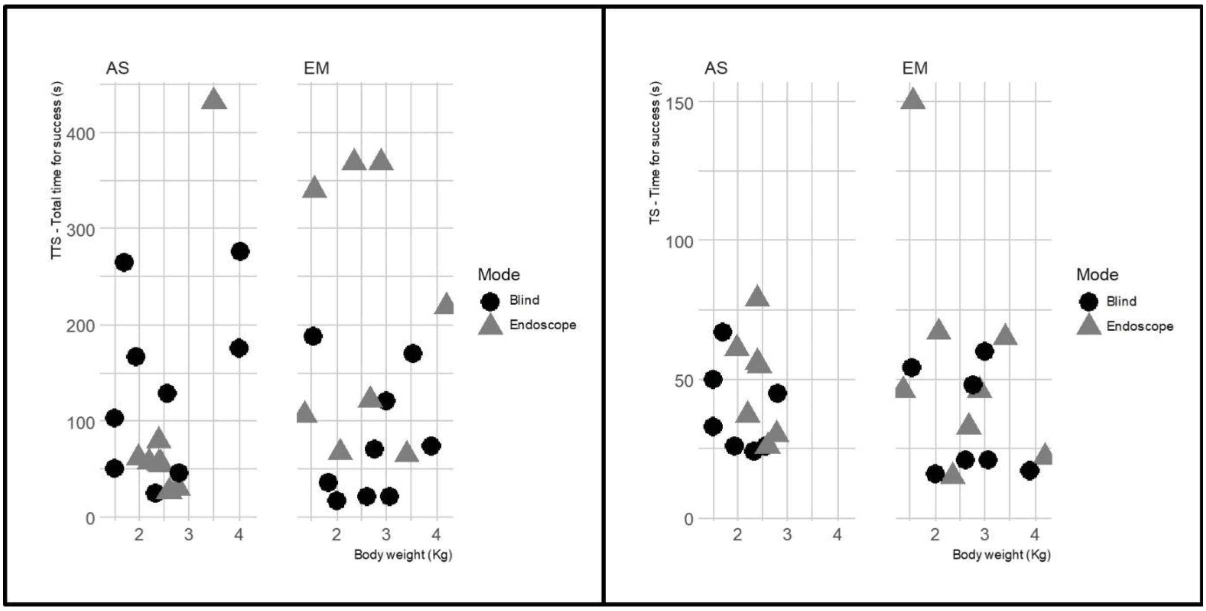
No statistical differences were noted in any parameter evaluated for blind and endoscope groups for AS. While, for EM, TTS (p = 04), propofol dose (p = 0.03) and cyanosis (p = 0.05) were statistically different. EM performed blind intubation more quickly (TTS = 79 ± 65 seconds) than the endoscope-guided intubation (TTS = 170.5 [65 - 368] seconds). The propofol dose in the blind group was also lower than in the endoscope group for EM, 1.5 (0 - 4.5) against 2.5 (1.3 - 7.4) mg/kg. Cyanosis was not reported using the blind technique but was more frequent with the endoscopic technique (5 events).

FIGURE 4 - BOXPLOT REPRESENTATION OF TTS (A) AND TS (B) FOR BOTH BLIND AND ENDOSCOPE GROUPS DIVIDED BY OPERATORS, AS AND EM. AS REQUIRED MORE TIME TO BLIND INTUBATE THE RABBITS THAN WITH THE ENDOSCOPE. HOWEVER, THE SUCCESSFUL ATTEMPT WAS QUICKER FOR THE BLIND GROUP. FOR EM INTUBATIONS, THE ENDOSCOPE-ASSISTED INTUBATION WAS STATISTICALLY SLOWER THAN THE BLIND INTUBATION (TTS) AND ALSO THE SUCCESSFUL ATTEMPT TOOK LONGER.



Fonte: O autor (2020)

FIGURE 5 - SCATTER PLOT OF TTS AND TS FOR AS AND EM IN BOTH INTUBATION TECHNIQUES – BLIND AND ENDOSCOPE-ASSISTED, ACCORDING TO RABBIT BW. TTS AND TS IN ALL FOUR GROUPS DOES NOT PROPORTIONALLY VARIATE ACCORDING TO BW INCREASE – WEAK CORRELATION.



Fonte: O autor (2020)

4.5. DISCUSSION

The current study compared rabbit intubation using the blind technique and a smartphone-based endoscopic technique. Both techniques were found to be reliable methods and, with practice, can be quickly performed by both clinicians and anesthesiologists. Patient size is not a limiting factor, nor does it correlate with ETT difficulty. Furthermore, in experienced operators, there is no statistical difference between techniques for occurrence of undesirable events such as lesions on the glottis and cyanosis.

Rabbit ETT is considered challenging by many authors for both clinicians and anaesthesiologists. A commonly used alternative for ETT is the use of facemask that, although functional for many procedures, does not provide a secure airway, leaks volatile anesthetics, increases dead space, and is affected by apnea and does not allow efficient ventilation (ALLWEILER, 2016). Other alternatives have been compared to ETT, such as use of laryngeal mask, v-gel device and nasotracheal intubation (WENGER et al., 2016; DEVALLE, 2009). However, Wenger et al. (2016) reported ETT as the only method reliable for when high airway pressure ventilation is needed during anesthesia. Different approaches for ETT have been described in rabbits, such as the use of a laryngeal tube (YAMAMOTO et al., 2007), a miniature lighted stylet (SU et al., 2013), polypropylene catheters (THOMPSON et al., 2017), transesophageal cannulation (FALCÃO et al., 2011), a modified retrograde technique (CORLETA et al., 1992) and an alternative blind method similar to that used in horses (MORGAN & GLOWASKI, 2007). Despite these alternatives the classical blind intubation is most consistently described (KRUGER et al., 1994; ALEXANDER & CLARK, 1980; FICK & SCHALM, 1987), although this often assisted by capnography (LEE et al., 2019). A number of authors report the classical blind technique to be time consuming, requiring multiple attempts, extra dose of anesthetic agents and resulting in occasional failure (ENGBERS et al., 2017; TOMAM et al., 2015; JOHNSON, 2010; TRANQUILLI et al., 2007; SMITH et al., 2004). Allweiler et al. (2010) considered 8.8% of the rabbits in their study as having 'poor' blind intubations – ETT not being achieved within five minutes of induction or requiring more than four attempts. Endoscopic intubation has more recently been widely applied in small mammal practice (MIRANDA et al., 2016; JOHNSON, 2010; HERNANDEZ-DIVERS & MURRAY, 2004; WORTHLEY et al., 2000). Both side-by-side and over-the-endoscope approaches are described for rabbit intubation (MIRANDA et al., 2016; JOHNSON, 2010). Different endoscopy systems exist, mainly the 2.7 mm 30º Hopkins rod-lens telescope, the 1.9 mm semirigid fiber optic endoscope and the 1.0 mm semirigid fiber optic endoscopes by Karl Storz and MDS (JOHNSON, 2010). The 2.7mm 30º Hopkins rod-lens telescope endoscope provides a large field of view and is considered ideal for rabbit side-by-side intubation. These endoscopic systems require not only the endoscope, but also a light source and an eyepiece or a video camera and a video display. This equipment can be expensive and is usually not portable (MIRANDA et al., 2016; JOHNSON, 2010; HERNANDEZ-DIVERS & MURRAY, 2004). Portable digital laryngoscopes for indirect visualization of the glottis had been described in human medicine allowing more rapid identification of the epiglottis, quicker intubation, and easier tracheal tube insertion, especially in pediatric patients (DESAI et al., 2019; HOSHIJIMA et al., 2018; OWADA et al., 2017; LEE et al., 2016). Vanderhal et al. (2009) demonstrated improved intubation success in human infants using indirect visualization, even among experienced operators. In rabbits, Worthley et al. (2000) reported 100% success in ETT in New Zealand rabbits by inexperienced physicians with a standard disposable fibreoptic laparoscope. All animals were successfully intubated within 5 minutes with an average time of 60.8 ± 8.8 seconds and only one episode of traumatic injury was noted after the sixth intubation of the same animal. Portable endoscopes are reported in veterinary medicine (HUYNH, 2019), the semi-rigid endoscope used in this study was reported by Freitag et al. (2019), but no comparison to the blind technique was provided. Although Freitag et al. (2019) claim it allows direct visualization of the glottis, indirect visualization is a more appropriate term since the image is seen through the camera on the smartphone screen.

In our study there were no differences in success rates of rabbit intubation between the operators or techniques. However, TTS was statistically different for endoscope-assisted intubation for EM, both compared to AS endoscope group (p=0.02) and to EM blind group (p=0.04), therefore it can be assumed that EM was faster at blind intubation and was not as effective using the smartphone device. For TS, no differences were noted between any groups, the successful attempt is usually straightforward, requiring less than a minute to perform. Therefore, differences in TTS are probably due to the increased number of attempts at intubation, although no statistical differences were noted in AT of any groups. Uzun et al. (2015) compared rabbit intubation with ET, laryngeal mask and v-gel and reported the last to require fewer attempts and a shorter time than the other methods, Cruz et al. (2000) also reported the laryngeal mask to require fewer attempts than ETT. Wenger et al. (2016) expected similar results, but they found no statistical difference in the number of attempts between v-gel, laryngeal mask and ETT. Both operators in this study were experienced in rabbit intubation although had more commonly practiced blind intubation. They had however used the same endoscope a few times before the study, but lack of familiarity with the technique may have affected the results. Potentially, if the smartphone endoscope was used for a time as the first option for rabbit intubation and this study was repeated after some months, performances may improve and the differences noted between the techniques for EM could disappear. The effect of experience with the technique may explain the average time of 22±10 seconds presented by Freitag et al. (2019), the authors reported use of the endoscope for more than 8 months and in more than 30 rabbits, and did not specify size or breed of the animals nor the experience of the authors with the blind intubation. Tran et al. (2001) reported success in intubating 60 New-Zealand rabbits using an over-the-endoscope technique with procedures taking 30 to 120 seconds with no previous operator training. The size of the device used in this study does not allow over-the-endoscope approach (Figure 01). In addition, the lens is not angled, making it more difficult to achieve a perfect image of the glottis. Body weight was not strongly correlated ($r>0.7$ or $r<-0.7$) to TTS or TS in both groups for AS and EM, demonstrating that the operator skill has a bigger influence on intubation time than animal size. TTS for AS endoscope group was the only parameter to moderately correlate to BW, however a single rabbit of 3.5 kg may have had a significant impact on this data due to the small sample size (Figure 5). Therefore, it appears that size is not a limiting factor for either blind or endoscope-assisted rabbit ETT.

Rabbit ETT must only be attempted once jaw tone is absent (VARGA, 2017). However, reduction in propofol doses reduces side effects and risks for the patient, such as hypoventilation, hypoxemia, apnea and hypotension (BRANSON & GROSS, 1994), therefore the induction window mirrors the skill level of the operator (JOHNSON, 2010). Propofol dose requirements did not differ statistically between operators in either group ($p=0.09$ for blind group, $p=0.63$ for endoscope group), but did differ between EM groups ($p=0.03$). This may be related both to the lack of experience of the operator with the endoscope compared to the blind technique, resulting in a longer time for intubation (TTS) and probably less accurate placement. Wenger et al. (2016) reported no difference in propofol requirements within v-gel, laryngeal mask and ETT intubation groups. All groups in this study required reduced propofol doses compared to the doses reported in the literature (FISHER & GRAHAM, 2017) and this was probably due to the pre-anesthetic agents used, providing sedation and muscle relaxation. Muscle relaxation is essential to successfully intubate a rabbit, jaw muscle tone must be absent and the animal must be fully relaxed, allowing appropriate head and neck positioning as well as a gentle introduction of the ET with no laryngotracheal reflex. Although ETT provides excellent access to airways in anesthesia and emergencies, the ET size must be selected correctly for effective intubation. According to the Poiseuille law there is an inverse power to the fourth relationship between the ETS and airway resistance. This means that halving the ETS increases airway resistance 16 times. Additionally, uncuffed 2.0 and 2.5 ETs were used in this study and these must fit have a tight fit with the tracheal lumen to reduce anesthetic leakage and oral content aspiration. Uncuffed ETs are commonly used in rabbits since the cartilage tracheal rings and blood supply in this species, are prone to mucosal ischemia and consequent necrosis (PHANEUF et al., 2006). Smith et al. (2004) found no difference in isoflurane leakage between cuffed and uncuffed ETs in rabbits, but correct ETS showed no air leak at 16 cm H20 under controlled mechanical ventilation (WENGER et al. 2016). No statistical differences in the ET/BW ratio were noted between the groups, Loewen & Walner (2000), reported that the rabbit subglottis does not vary significantly with animal body weight, both dorsoventral and lateral ranges seem to be consistent independent of weight in New Zealand Rabbits from 2.3 to 5.1 kg. No studies have evaluated subglottis and tracheal dimensions in other pet rabbit breeds. The ET/BW ratio was used in this study as an index for ETS compared to body volume, although BW may not give an accurate representation of the animal size due to different body conditions. Visualization of the glottis may minimize laryngeal trauma, allowing the operator to make instant decisions regarding ETS. No lesions were noted in blind intubated rabbits by either operator, this may have been due to their familiarity with the technique. Four animals with lesions were noted in the endoscope group. Most of the lesions (3) and the single finding of blood in the ET were in the exotic pet specialist group. This was attributed to the unfamiliarity of the operator in evaluation of laryngeal size and accurate selection of appropriate ETs. AS was more confident with the indirect visualization method, while in the blind approach chose a more conservative ET. Another reason for the increased trauma in AS was that had difficulty introducing the ET during inspiration. It was evident from watching the intubation videos that the ET was forced into the glottis at the incorrect phase of respiration. With the blind approach, factors other than visual cues are used to determine the exact moment to introduce the ET, such as the clouding rhythm, or breathing cycles, and both operators were more familiar with these techniques. Traumatic intubation lesions may result in glottal edema and necrosis and must be avoided. Blind intubation is believed to carry significantly higher risks of upper airway trauma, however this was not confirmed in our study. One consideration is that the use of lidocaine gel on the tip of the ET may have influenced frequency of lesions. During blind intubation the ET is introduced more slowly and the anesthetic probably contacts the mucosa more efficiently. In the endoscopic group the glottis was visualized and ET was promptly advanced, with no time for contact of the anesthetic with the mucosa. Therefore, the authors suggest the instillation of a small volume (0.2-0.3 mL) of 2% lidocaine solution through the ET as a more efficient method for anesthesia, especially when using the endoscope. Operator skill and familiarity with the technique seem to be more important than the intubation technique itself for the creation of trauma. Phaneuf et al. (2006) evaluated tracheal injury in 15 intubated rabbits from 3 different institutions, however tracheal lesions were more evident at the tip of the tracheal tube and not at the larynx. Although multiple intubation attempts may exacerbate injuries, lesions were also diagnosed in rabbits where intubation had been achieved on first attempt. This study only evaluated immediate laryngeal lesions through endoscope indirect visualization after extubation. Histopathological investigation would be more precise in determining the occurrence and degree of injury. Lingual cyanosis is commonly reported when using devices such as v-gel and laryngeal mask in rabbits (KAZAKOS et al., 2007; BATEMAN et al., 2005); however, this tongue discoloration may not be due to reduced oxygen saturation, but in fact to occlusion of blood flow in the lingual artery (VARGA, 2017). Wenger et al. (2016) noticed this similar condition in rabbits under 2.5kg in the v-gel group, in our study cyanosis was noted in a total of 6 rabbits, 3 of them under 2.5kg. Kazakos et al. (2007) reported normal lingual coloration 30 seconds after moving of the laryngeal masks, and the same was noted in the animals in our endoscope group, however as oxygen supplementation was immediately provided, it is not possible to confirm ischemia. The relatively large size of our device (5.5 mm) may explain the tendency to develop lingual ischemia, especially in small animals and when the operator is not skilled in manipulating the device.

A large variety of breeds (including Lionheads, Fuzzy Lops, Mini Lops, Chinchillas, Netherland dwarves and mixed breeds) and sizes (1.35-4.2 kg) were used in this study, resulting in different scenarios and challenges in each intubation, which is in contrast to the homogenous animals usually used in experimental studies. For example, in one case of intubation failure with the endoscope, the operator (AS) reported little space to introduce both the endoscope and the ET to efficiently insert the ET into the glottis. Nevertheless, this animal was uneventfully intubated in less than 20 seconds with the blind technique. Although it was not a small rabbit (3.5kg), it was a Lionhead, therefore an overweight brachycephalic animal. Two of the rabbits that could not be intubated with the blind technique had anatomic anomalies, tonsil enlargement (Figure 3A) and subcutaneous neck abscesses (Figure 3B), both were successfully intubated with the assistance of the endoscope. Therefore, animals where anatomic alterations are anticipated may benefit from endoscope-assisted intubation. Since most rabbits undergoing anesthesia may have pathological conditions (e.g., dental procedures, abscesses), endoscopy may improve the overall success rate in clinical practice. Engbers et al. (2016) reported a difficult intubation in a rabbit with fecal pellet lodged in the caudal oropharynx, a visual inspection with an otoscope, laryngoscope or endoscope would have allowed prompt diagnosis of the foreign body and allowed intubation.

The 5.5 mm USB semi-rigid endoscope (otoscope) proved to be a useful tool for rabbit intubation, particularly if anatomic alterations are expected. It is a very affordable and portable device, allowing any practitioner to have it available for use at any facility such as in clinics, zoos and even in the field. The semi-rigid characteristic is useful since the rigid part is used to displace the tongue ventrally and visualize the glottis and the flexible cable allows optimal positioning of the smartphone. Image quality is not ideal with this device, but is sufficient for visualization of the structures and provides good evaluation of format, aspect and color. More expensive devices are available around $50, compared to $15 for this one, and image quality may be better in these. It is more challenging to use the device in animals with small oral cavities, but it is not impossible. Camera orientation takes some time to master and camera focus is limiting since it relies entirely on the device lens. Despite the advantages of the endoscope, the blind technique proved to be as efficient as the endoscope-assisted intubation for experienced operators. It would therefore be wise not to rely completely on the use of the endoscope since it may not be always available, or the animal may chew and damage the device and airway management will still be necessary.

4.6. LIMITATIONS

One source of bias is that the operators had previous experience in rabbit blind intubation and only some experience with the smartphone-based endoscope. The more frequent use of the device may improve their technique, reducing the number of attempts and total intubation time. Introducing both techniques to veterinarians or veterinary students not familiar with rabbit intubation may result in a preference for the endoscope with improved time and success rates. Lesions evaluation was performed by immediate indirect visualization of the glottis with the endoscope, no further investigation was done. Histopathological evaluation may have shown higher rates of upper airway tract lesions, although no animals showed complications after the procedure.

4.7. CONCLUSIONS

Both blind and endoscope-assisted techniques are reliable methods for rabbit ETT independent of size and breed. Reduced time and complications expected for the endoscopic group were not confirmed in this study. Instead, for the anesthesiologist, blind intubation was more quickly performed requiring lower anesthetic doses and resulted in fewer complications than the endoscope-assisted group. No differences were noted for the exotic pet specialist, suggesting that mastery of the technique is essential for improved results in any intubation technique. The smartphone-based endoscope is small and affordable and may be extremely useful for animals where blind intubation is difficult due to anatomic alterations or other anomalies.

4.8. FURTHER STUDIES

This study has demonstrated that both blind and endoscope-assisted intubation are reliable techniques for rabbit ETT. The main bias of the results is the previous skills of the operators with the blind intubation. Their skills may have played a role in TTS and undesired events such as lesions, corroborating with overall literature. Morgan & Glowaski (2007) evaluated two different blind intubation approaches compared within students and instructors, this type of study can be similarly developed with the endoscope. It is possible that the blind technique requires more practice to master and reach results as the operators described in this study. Therefore evaluating students with no previous training may suggest the endoscope as an extremely useful tool for beginners. Besides that, the endoscope can be an important didactic tool, being possible to visually demonstrate the procedure to a large number of students with a single animal through a large screen.

Besides that, Loewen & Walner (2001) described rabbits’ subglottis and trachea dimensions in cadavers, while Wenger et al. (2016) described the interface of ET, v-gel and laryngeal masks with the rabbits’ upper airway through computed tomography. However, both studies were based on New Zealand rabbits, and the results may be biased by the breed. No differences were noted in rabbits’ glottis dimension besides of the animals’ weight, but it has not been confirmed for different pet breeds. Nor ETT relationship to rabbits' trachea were evaluated. Size of the ET is an important factor, if it is underestimated air leakage may occur and ventilation may not be satisfactory, while oversized ET contributes to glottis and tracheal injuries resulting in postintubation complications immediately after extubation or days later. Animals in this study were submitted to CT exams, rabbits' upper airway and its relationship with the ETT are being described and measured for the different rabbit pet breeds.

4.9. LITERATURE CITED

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5 GENERAL CONCLUSION

The increasing number of small mammals as pets worldwide demands clinical techniques to be studied, developed and improved in order to provide an excellent medicine practice based on evidences for exotic pets. Anesthesia is one of the bottlenecks in surgical management of small mammals, therefore developing efficient processes improves success of the procedures and welfare of the patients. Although size, anatomy and physiology represents challenges in the exotic pet medicine, it is not limiting. Adequate resources combined with practice results in a higher success rate and is able contribute for balanced anesthetic protocols. Locorregional blocks should be further studied and improved for these species, aiming to reduce doses of systemic anesthetics and their side effects, besides improving analgesia and postoperative recovery. Although rabbit ETT is considered tricky, this study demonstrated the blind intubation as efficient as endoscope-assisted intubation, suggesting that both approaches are feasible, especially after mastering them. Expected improvements in time for intubation and reduced undesired effects such as cyanosis and glottis lesions by using the endoscope were not confirmed in this study. Size also did not strongly correlate with ETT difficulty, and rabbits from 1.5kg were successfully intubated within average number of attempts and total time. The smartphone-endoscope device presented in this study proved to be useful for anatomic variations that may impair blind intubation. It is a portable and affordable device that should be considered by both anesthesiologists and exotic pet practioners to have with you.

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