Construction of a full mouth speculum facilitating oral examinations, bronchoscopy and gastric tubing in elephants

Konstruktion eines Maulgatters zur Untersuchung der Maulhöhle, Durchführung von Bronchoskopie und Sondierung des Magens bei Elefanten

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Abstract

Objective: Here we tested the application of a full mouth speculum to sedated elephants in human care to gain access to the oral cavity, the trachea (bronchi) and esophagus (stomach) and therefore improve diagnostic and therapeutic options in elephant medicine. The construction of this oral speculum for elephants and the procedure are described.

Material and methods: For the elephant mouth speculum, a steel construction consisting of two bite plates of 0.8 x 60.0 x 8.0 cm attached between two threaded guiding poles (40 cm) was build. Through crank handles, the metal plates are dispersed once placed between the elephant´s jaws infront of the molars. The oral speculum was applied in 26 elephants during standing sedation, 6,16 animals belonged to the Asian elephant species, and 1,3 were African elephants.

Results: All sedated elephants tolerated the positioning of the mouth opener and subsequent manipulations well. The mouth opener was applied for the following procedures: inspection of the oral cavity (n=2), placing a stomach tube (n= 16), and /or performing endoscopic examinations such as bronchoscopy (n=20) and / or gastroscopy (n=8).

Conclusion: This method provides a new possibility to open the jaws to gain access to the molars, larynx and pharynx in captive elephants without full immobilization. Valuable samples for diagnostics may be obtained or animals medicated via stomach tube with this application.

Clinical relevance: The mouth opener provides veterinarains with a new option to perform necessary diagnostic and therapeutic procedures around the oral cavity, airways and stomach in captive elephants during standing sedation with no need for a full anaesthesia.

Keywords: Endoscopy, Elephant, Mouth Opener, Nasogastric tube, Oral cavity

Zusammenfassung

Gegenstand und Zie: Ziel der Untersuchungen war, den Einsatz eines Maulgatters für Elefanten zu erproben. Dieser Artikel beschreibt die Anwendung am sedierten Elefanten zur Spreizung der Kiefer, um den Zugang zu Maulhöhle, Trachea (Bronchien) und Oesophagus (Magen) für diagnostische und therapeutische Zwecke zu ermöglichen. Die Konstruktion des Maulgatters und Anwendungsmöglichkeiten werden beschrieben.

Material und Methoden: Das Maulgatter ist eine stabile Stahlkonstruktion bestehend aus zwei Flacheisen von 0.8 x 60.0 x 8.0 cm Größe, die über zwei Gewindestangen von 40 cm Länge verbunden sind. Über zwei Handkurbeln können die Gewindestangen gedreht und somit die Flacheisen auseinander bewegt werden. Das Maulgatter wurde an 26 Individuen (1,3 *Loxodonta africana* und 6,16 *Elephas maximus*) mit unterschiedlichen Anwendungen getestet.

Ergebnisse: Bei insgesamt 26 Elefanten wurde das Maulgatter erfolgreich unter Standsedation eingesetzt, um die Maulhöhle zu kontrollieren (n=2), eine Magenschlundsonde zu legen (n=12) und/ oder um eine Bronchos –(n=20) oder Gastroskopie (n=8) durchzuführen.

Schlussfolgerung: Da durch die besondere Anatomie des Elefanten Oesophagus und Trachea nicht wie beim Pferd einfach über die Nasenöffnung zu erreichen sind, kann mit einem Maulgatter auf unkomplizierte Weise am stehend sedierten Tier der direkte Zugang gewählt werden, um Endosokpien durchzuführen, Proben zu nehmen oder Medikamante zu verabreichen.

Klinische Relevanz : Die beschriebene Methode ist eine neue Möglichkeit für diagnotische und therapeutische Zwecke beim Elefanten ohne Vollnarkose die Molaren, Pharynx und Larynx, und somit Oesophagus und Magen oder Trachea und Lungenbronchien zu erreichen.

Schlüsselwörter: Endoskopie, Elefant, Oralspekulum, Maulhöhle, Magenschlundsonde

Introduction

The Asian elephant (*Elephas maximus*) is classified as endangered by the IUCN Red List with the subspecies *E. m. sumatranus* even recognized as critically endangered (1). Asian elephants have been kept under human care for millennia and besides several hundred elephants populating zoological facilities around the world today, roughly 30% of the range country population in Southeast Asia is also captive (2). African elephants (*Loxodonta africana*), also less threatened, are equally popular in zoological facilities and tourist camps across southern Africa. Elephants in captivity require special veterinary care due to their unique anatomy and physiology which does not compare to any domestic animal species. Therefore, constant development of custom-made tools and specialized protocols is warranted for improved diagnostics and therapy. While transrectal ultrasound is commonly applied in elephants for reproductive diagnostic imaging (3), access to mouth, teeth and airways for example, is limited for imaging techniques and mostly requires full anesthesia.

In equine medicine, oral specula are widely used, mostly for dental work (4). The development of such a mouth opener device for elephants for improved assessment of the oral cavity and upper gastrointestinal and respiratory tract was desired therefore.

The unique anatomical conditions and the skull shape of elephants (Fig. 1), as a result of the evolution of trunk and tusks, required some preliminary considerations: The mandibles are strong, but relatively short bones, that sharply fuse cranially. The lower and upper jaws contain each a set of pre-molar and molars which combine in elephants and are usually just referred to as “molars” (5). In the upper jaw, the upper lip fuses into the nose to form the base of the trunk. The thick and fleshy tongue is not much maneuverable due to the tip being fixed to the bottom of the mouth (6).

In the following, we describe the construction and successful implementation of a full mouth speculum for both, Asian and African elephant species for several diagnostic and therapeutic applications.

Fig. 1 Oral inspection in a trained male Asian elephant *(Elephas maximus sumatranu*s) in direct contact demonstrating the anatomical conditions. On command, this bull opens the mouth and upper molars and tongue are easily visible. Lower molars are only revealed if the elephant is spreading the cheeks. Few elephants allow this and in a protected contact situation (elephants are trained behind barriers with no direct handling), the close inspection becomes difficult.

Abb.1 Foto zur Demonstration der anatomischen Gegebenheiten bei einem trainierten Asiatischen Elefanten (*Elephas maximus*) im direkten Kontakt. Inspektion der Maulhöhle eines adulten Bullen auf Kommando des Pflegers. Die oberen Molaren und die Zunge werden sichtbar, während die unteren Molaren nur dann gut zu sehen sind, wenn der Elefant die Wangen spreizt. Nur wenige Elefantn sind gut genug trainiert für dieses Kommando und im geschützen Kontakt (Elefanten werden nicht direkt gehändelt, sondern nur noch durch ein Absperrgitter) wird eine genaue Adspektion schwierig.

Material and Methods

Animals

The mouth opener was applied in total in 26 captive elephants, of which 22 (6,16) were Asian elephants. More specific, four males and six females belonged to the Sumatran subspecies (*Elephas maximus sumatranus)* and were kept in government run camps across Sumatra. The remaining animals were mainland Asian elephants (*Elephas maximus indicus*) kept in European zoological or private facilities. Another four (1,3) animals were zoo housed African savannah elephants (*Loxodonta africana)*. Apart from one subadult Asian elephant bull aging 8 years, all animals were adult ranging in age from 17 to 52 years. The mouth opener was in all instances applied for clinical reasons (diagnostic and/or treatment) by specialized zoo and

wildlife veterinarians, nevertheless animals were handled in accordance to the European Convention on the protection of animals used for scientific purpose, Revised Directive 86/609/EEC.

Standing sedation

Captive Sumatran elephants received a standing sedation with an IV dose of 0.1 – 0.13 mg/kg xylazine (Ilium Xylazil-100, Troy Laboratories PTY Limited, 35 Glendenning Road, Glendenning, NSW2761, Australia) and 0.033 – 0.04 mg/kg ketamine (Ilium Ketamil-100, Troy Laboratories PTY Limited, 35 Glendenning Road, Glendenning, NSW2761, Australia). The zoo elephants were sedated with 0.013-0.02mg/kg detomidine (Domosedan®, Orion Pharma, Orion Corporation, 02002 Espoo, Finland, distributed by Zoetis Inc.) and 0.01-0.025 mg/kg butorphanole (Alvegesic® Alvetra GmbH, 24539 Neumünster, Germany) intramuscularily (IM) as described elsewhere (7,8). If necessary, a dose top up of 10-15mg butorphanole and 10-15 mg detomidine was administered through an auricular vein. The effect of detomidine in zoo elephants was reversed by a total dose of 75 mg Atipamezol IM (15 ml Anstisedan® Orion Corporation, 02002 Espoo, Finland).

Full mouth sepculum construction

Due to the strengths of the elephant´s jaws, a heavy-duty metal construction is important for the frame of the mouth opener. More particularly, the mouth gate consists of six main parts: i) the two bite/gum blades for upper and lower jaw, ii) the threaded rods between which the bite blades are mounted and iii) the crank handles connected to the lower part of each threaded rod (Fig. 2). The bite blades measure 0.8 x 60.0 x 8.0 cm (height x length x width) each while the threaded rods are 40 cm in length and measure 2.5 cm in diameter. To fix the oral sepculum properly within the elephants´ mouth, there are two nylon straps (each 2.4 m) that can be attached to both sides of the mouth gate and wrapped around the elephants' head and behind the ears (Fig. 3). Both straps have fast-release buckles. While the incisor teeth are used in horses for support of the mouth gate´s bite blades (4,9), these blades must sit on the gingiva in front of the upper molars or the lower lips, respectively (Fig.1, 3 B). In order to avoid pressure sores, the bite blades are covered with rubber.

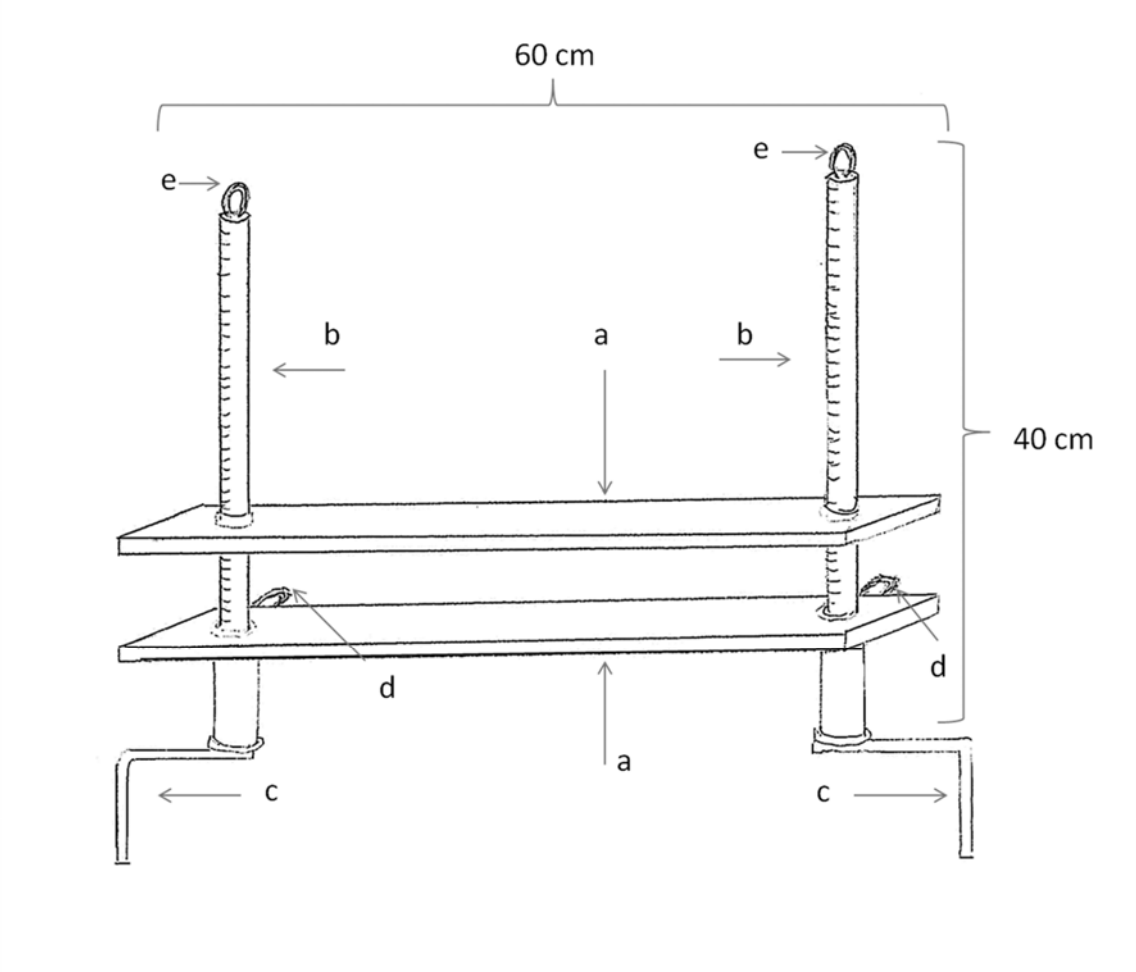

Fig. 2 Schematic drawing of the elephant oral speculum steel construction: a. bite blade (these parts rest on upper and lower jaw, respectively, b. threaded rods, c. crank handles, d. lower loop for nylon strap and e. upper loop for nylon strap (for fixation of the mouth opener around the elephants head).

Abb. 2 Schematische Zeichnung der Bestandteile des Maulgatters (aus Stahl gefertigt): a. Kieferplatten, b. Gewindestangen, c. Handkurbel, d. untere Seilösen für die Fixierung mittels Nylongurt, e. obere Seilösen (für die Fxierung mittels Nylongurt um den Kopf des Elefanten).

Results

In all cases, the mouth gate was applied successfully and endoscopy, sampling or application of fluid and medication via gastric tube were performed. The mouth opener was applied in 2 cases to assess molars; in 16 cases a gastric tube was placed (6 cases for paraffin oil and water or nutrient or medication administration during colic or tetanus treatment and 10 cases to obtain stomach fluid for diagnostic purposes); in 20 cases a

bronchoscopy and broncho-alveolar lavage (BAL) was performed; and a gastroscopy was performed in 8 cases.

The standing sedation was rated deep enough to place the mouth speculum, once the elephant stopped moving, the trunk tip was permanently rested on the ground and the elephant did not respond anymore to manipulations on the head. Time lapse until the mouth opener could be placed was between 15-65 minutes, depending on the dose and route of drug administration and necessary top-ups to receive desirable sedative effect. An IV dose top up was required in 11 cases to either deepen or prolong sedations. Total procedure time was between 25 to 55 minutes once the mouth speculum was in place.

For the positioning, the mouth speculum was fully closed (the bite plates touch each other). The jaws of the Asian elephant were relatively relaxed during sedation and the blades could be advanced into the mouth gap up to the corners of the mouth (Fig. 3 a). In African elephants, the lower jaw is shorter compared to the Asian species and needed to be opened first by placing a rope around the mandibles to pull them down. The threaded guiding rods were situated left and right of the elephant's head. The placement and opening of the mouth gate required at least two operators, standing on either side of the elephant's head (Fig. 3 b). The crank handles were turned on both sides to start opening the mouth speculum. The tongue was moved on top of the lower bite blade as soon as the oral speculum was opened enough to place a hand into the mouth gap. This needed to be done prior to full opening as otherwise the tongue got caught and pinched under the lower bite blade.

Care was given to the extent of forcefully opening the jaws, not inflicting damage to the temporomandibular joints. Once the jaws were sufficiently winched apart the straps were placed around the head to hold the mouth speculum in place (Fig. 3 a,c). Now the oral cavity was inspected directly with a torch or via endoscopy (Fig. 3 c). The larynx and pharynx were palpated at arm length and the flexible endoscope could be placed either into the trachea or the esophagus depending on envisaged procedure. Also, an equine nasogastric tube could be advanced through the mouth and pharynx into the stomach for sampling of gastric fluid or administration of water, oil or nutrients.

Fig. 3 Photographs showing the placement and positioning of the elephant full mouth speculum in Asian elephant females. A. sedated female, closed oral speculum slipped into the mouth gap like a horse bite of a horse's bridle; B. Mouth speculum hold in place by operators on both sides of the elephants´ head while simultaneously opening the bite plates by crank handles, fixation of the device by nylon straps (blue); C. Fully opened oral speculum and fixation, manual placement of a flexible video endoscope into trachea or esophagus.

Abb. 3 Die Fotos zeigen das Anlegen des Maulgatters bei Asiatischen Elefantenkühen (*Elephas maximus*): a. das geschlossene Maulgatter wird in die Maulspalte eines sedierten Elefanten eingeführt (*Elephas maximus*), das untere Halteseil ist bereits in Position; b. das Maulgatter wird an beiden Seiten des Kopfes in Position gehalten und durch gleichzeitiges Drehen der Handkurbeln geöffnet und zusätzlich mit Nylongurten fixiert (blau); c. volle Spreizung der Kiefer durch maximale Öffnung des Maulgatters, jetzt ist die manuelle Platzierung eines flexiblen Endoskops in den Ösophagus oder in die Trachea möglich.

Discussion

In equine medicine, gastroscopy and bronchoscopy are common medical applications (10). In elephants, to date, this diagnostic imaging technique has not been applicable. Through the described full mouth speculum, this type of endoscopy is now possible without full anesthesia. For procedures of up to one hour, the mouth opener appears ideal. However, after 30-40 minutes, it should be released or partly closed to allow reperfusion of the gingiva and relaxation of the temporomandibular joints.

Medical dental conditions, such as malformed or broken teeth or improper loss of molars (normal exchange and replacement every 10 years) may warrant extended manipulation and a mouth speculum could be useful in these cases. Another great advantage is the direct access to the epiglottis which is easily palpable. While gastroscopy

and bronchoscopy or stomach tubing are performed through the nostrils in horses (10), this access route is due to the up to two-meter-long trunk suboptimal. Although there has been a report on tracheal lavage through the trunk in elephants using an extra-long flexible endoscope (11), with the construction of a mouth opener, any regular horse gastroscope may be applied. A flexible video endoscope of at least 2.0 -3.0 meter length may be placed into the trachea and allows for bronchoscopy. Especially, if samples are taken for culture or PCR of *Mycobactrium tuberculosis*, the access through the mouth appears more practical since deep bronchi are reachable and at the same time, samples from the stomach may be obtained through gastric tubing. Combined samples from bronchial and gastric lavage for direct smear or culture are regarded as the method of choice in human patients with suspected pulmonary tuberculosis, incapable of sputum production (12).

The esophagus is accessed when passing the epiglottis and reaching further caudal and either an endoscope for gastroscopy or a regular large horse nasogastric tube can be inserted manually and moved into the stomach. Fluid, medication or paraffin oil may be applied via this route. In four cases, Sumatran elephants with tetanus induced lock jaw and muscular rigidity were supplied with water and nutrients trough a stomach tube after placing the mouth speculum and spreading of the tense jaws. The same procedure is an option in colic patients and was also used here to treat suspected obstipation.

Especially in elderly or compromised elephants, this method bears advantages since general anesthesia is not necessary. Full recumbency may be associated with reduced muscle perfusion and other complications and sometimes weak elephants may not be able to stand up without assistance after full immobilization (8). For all the above mentioned reasons, we feel that the described elephant full mouth speculum adds value to elephant veterinary medicine.

Conclusion

The simple elephant mouth speculum construction is a helpful tool when evaluation of teeth, or endoscopic assessment of esophagus, stomach or trachea/bronchi needs to be performed. This application is furthermore useful for substance administration via gavage in elephants without full immobilization.

Acknowledgement

The authors thank all elephant mahouts and keepers for assistance and supporting veterinarians.

Conflict of interest statement

None of the authors of this paper has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

References

(1) Williams C, Tiwari SK, Goswami VR, et al. Elephas maximus. The IUCN Red List of Threatened Species 2020: e.T7140A45818198. Online: https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T7140A45818198.en; retrieved: 14.03.2021.

(2) IUCN SS Asian elephant Specialist Group. Brochure. Online: https://www.asesg.org/ https://d2ouvy59p0dg6k.cloudfront.net/downloads/WWFelep3.pdf; retrieved: 17.03.2021.

(3) Lueders I, Niemuller C, Gray C, et al. Luteogenesis during the estrous cycle in Asian elephants (Elephas maximus). Reproduction 2010; 140(5): 777.

(4) Simhofer HJ, Schramel P. Development of a novel equine full mouth speculum for dental examination and treatment. Wiener Tierärztl Monatsschr 2008; 95(1/2): 3.

(5) Shoshani J. Skeletal and other basic anatomical features of elephants. In: The Proboscidea: Evolution and Palaeoecology of Elephants and Their Relatives. Shoshani J, Tassy P, eds. Oxford, UK, Oxford University Press, 1996; 9–20.

(6) Dumconceaux GA. Digestive System. In: Biology, medicine, and surgery of elephants. Fowler ME, Mikota SK, eds. Ames, Iowa, USA: Blackwell Publishing 2006; 299-307.

(7) Neiffer DL, Miller MA, Weber M, et al. Standing sedation in African elephants (*Loxodonta africana*) using detomidine-butorphanol combinations. J Zoo Wildl Med 2005; 36: 250–256.

(8) Steffey EP. Chemical Restraint and General Anaesthesia. In: Biology, medicine, and surgery of elephants. Fowler ME, Mikota SK, eds. Ames, Iowa, USA: Blackwell Publishing 2008; 91-118.

(9) Tremaine WH. Dental endoscopy in the horse. Clin Tech Eq Prac 2005; 4(2): 181-187.

(10) Sweeney CR, Weiher J, Baez JL, et al. Bronchoscopy of the horse. Am J Vet Res 1992; 53(10): 1953-1956.

(11) Hermes R, Saragusty J, Moser I, et al. Bronchoalveolar lavage for diagnosis of tuberculosis infection in elephants. Epidemiology & Infection 2018; 146(4): 481-488.
(12) Rizvi N, Ra NA, Hussain M. Yield of gastric lavage and bronchial wash in pulmonary tuberculosis. Int J Tuberculosis Lung Dis 2000; 4(2): 147-151.