Verifying the placement and length of feeding tubes in canine and feline neonates

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Abstract: Background: Tube feeding is a common procedure in neonatology. In humans, tube misplacement reportedly occurs in up to 59% of all cases and may lead to perforation in 1.1% of preterm intubated neonates. While numerous studies on optimal tube placement have been performed in human neonates, current recommendations on tube feeding in canine and feline neonatology are based, at best, on studies performed in adult animals. Herein, we aimed to test ultrasonography as a tool to verify tube placement in puppies and kittens and to compare different anatomical predictive markers used in human, canine and feline neonates. Results: The predictive tube length when held bent between the last rib and the mouth may induce trauma compared to when held straight. A strong positive linear correlation was observed between birthweight and gastric cardia localization. Ultrasonography findings were similar to coeliotomy findings. Stomach volume was less than 2 mL per 100 g in the less-than-one-day-old studied puppies (n = 25) and kittens (n = 28). Conclusions: A weight-based equation was calculated to help predict appropriate tube placement. Ultrasonography can be used to control gastric tube placement, and neonates less than one-day-old have a smaller stomach capacity. Further studies are required to evaluate whether more-than-one-day-old puppies follow the same linear correlation with their weight. Further in vivo studies are warranted to determine the gold standard procedure for tube feeding in neonatal puppies and kittens.

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Verifying the placement and length of feeding tubes in canine and feline neonates

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Abstract

Background: Tube feeding is a common procedure in neonatology. In humans, tube misplacement reportedly occurs in up to 59% of all cases and may lead to perforation in 1.1% of preterm intubated neonates. While numerous studies on optimal tube placement have been performed in human neonates, current recommendations on tube feeding in canine and feline neonatology are based, at best, on studies performed in adult animals. Herein, we aimed to test ultrasonography as a tool to verify tube placement in puppies and kittens and to compare different anatomical predictive markers used in human, canine and feline neonates.

Results: The predictive tube length when held bent between the last rib and the mouth may induce trauma compared to when held straight. A strong positive linear correlation was observed between birthweight and gastric cardia localization. Ultrasonography findings were similar to coeliotomy findings. Stomach volume was less than 2 mL per 100 g in the less-than-one-day-old studied puppies (n = 25) and kittens (n = 28).

Conclusions: A weight-based equation was calculated to help predict appropriate tube placement. Ultrasonography can be used to control gastric tube placement, and neonates less than one-day-old have a smaller stomach capacity. Further studies are required to evaluate whether more-than-one-day-old puppies follow the same linear correlation with their weight. Further in vivo studies are warranted to determine the gold standard procedure for tube feeding in neonatal puppies and kittens.

Keywords: Intubation, Ultrasonography, Esophagus, Stomach, Neonate, Milk, Colostrum

Background

In neonatal care, orogastric tube insertion is a common procedure. It allows colostrum or serum intake if canine and feline neonates are unable to suckle colostrum by themselves, preventing enteric diseases, immune deficiency and sepsis [1]. Tube feeding is mostly recommended for normothermic neonates that are too weak to suckle or to be bottle-fed [2–4] and for orphans [5]. Temporary feeding support of neonates is also recommended in cases of lactation failure of the dam, delayed onset of lactation, rejection of one or more of the littermates, too many offspring, mastitis, metritis, or eclampsia [6–8]. Enteral feeding improves gastrointestinal maturation and feeding tolerance compared to parenteral options [9] in both naturally suckling and formula-fed puppies [10]. Tube feeding is a quick procedure compared to bottle feeding and allows better control of the amount of milk given to the puppy [11, 12]. This procedure may be performed by breeders [12, 13] to achieve normal weight gain for all puppies or kittens [14, 15], reducing the time spent compared to bottle feeding, as well as the dam’s energy requirements [7, 11]. Although inserting an orogastric tube in neonates is reportedly a simple procedure [11], multiple complications...
have been described, such as regurgitations or injuries, leading to bronchopneumonia or even death, with ruptured esophagus and gastric hemorrhage [13, 16]. Regurgitation and aspiration pneumonia are commonly mentioned as a risk of tube feeding [1, 4] and are commonly linked to hypothermia [2, 17], excessive volume [4], speed of feeding [17] and the size of the tube [1, 4, 5]. It has also been suggested that insertion of the tube too deep may create a loop inside the stomach, increasing the risks for regurgitation and trauma [1, 13] or kinking into the gastrointestinal tract [5]. In humans, tube misplacement reportedly occurs in up to 59% [18, 19] of all cases, and perforation due to gastric tubing occurs in 1.1% [20] of low birth weight infants. The most common recommendation regarding the length of insertion in dogs and cats is to measure the distance from the nose to the last rib, slightly bending the tube (BENT) [1, 4, 6, 16, 21–24]. Others recommend using ¾ of that length [5, 11, 17, 25]. To date, recommendations are mostly based on procedures performed in adult animals (esophageal versus gastric tubing) [26–28]. Feeding is repeated multiple times a day in neonates, and radiographic control cannot be performed, contrary to what is done for the gold standard approach in adults [29–31] and in pediatric human medicine [32–35]. Therefore, the measurement of the length of tube inserted is of prime importance. Among common predictive safety measurements performed in human neonates, a nose-earlobe-mid-umbilicus (NEMU) measurement has been described [36–38], as well as weight-based formulas [39, 40]. Correct tube placement may also be assessed under ultrasonography [41, 42]. Other methodologies are also used, such as the auscultation of insufflated air [38], carbon dioxide detection [43, 44] and aspiration of gastric content, all of which pose reliability limitations in neonatology [38, 45].

This study aimed to assess the reliability of ultrasonography control for tube placement in canine and feline neonates to compare different recommendations regarding the length of insertion of feeding tubes using deceased puppies and kittens and to offer a weight-based formula that may help predict cardia location. The maximal stomach volume of puppies and kittens up to 1 day old was also examined.

Methods
Animal population
Twenty-eight kittens and 25 puppies that died within the first 24 h after parturition were collected, the informed consent of their owners was obtained to be used for teaching and research purposes. Twenty-five of these kittens and 20 puppies were first stored at –80°C and then thawed at ambient temperature for 24 h before measurements. Three feline and five canine neonates that died during delivery or within the first 24 h of life were examined within 12 h after death without being frozen. Only neonates less than 24 h of age were selected based on their history or on the presence of uteroverdin, placenta, placental fluid in the stomach, and umbilical observation [46] whenever more accurate data were missing.

Feeding tubes and marking
Eight Fr diameter, 100-cm-long nasogastric tubes were used (Nährsonde, Medicoplast, Germany). The tube was held alongside the body of the puppy and was bent from the last rib to the tip of the nose, and its length was measured (BENT) (Fig. 1a) [6]. Similar measurements were performed between the last rib and the tip of the nose, but with the tube, held straight (STRAIGHT ) (Fig. 1b). Finally, we adjusted the NEMU method, which is used to predict the gastric tube insertion length in children [36], to our neonates, using the pinna instead of the earlobe: we recorded the distance from the tip of
the puppy’s nose to the pinna and then to the midway between the xiphoid process and the umbilicus (Fig. 1c). BENT ¾ values were calculated based on the three-quarter BENT measurements. These measurements were performed without any markings on the tube to avoid any influence on subsequent measurements. One single operator (corresponding author) measured all parameters of this study.

**Ultrasonography and visual observation**

Stomach content and volume (length x width x height) before intubation were evaluated by ultrasonography using GE LOGIQ S8 Vet (Sil, General Electric Healthcare, Switzerland) with a linear 4–15 MHz scanhead. We measured the longest possible stomach length using the transverse scanhead position, together with the width (Fig. 2a). The scanhead was then rotated 90° in the sagittal position (Fig. 2b), where the height of the stomach was measured. Water was used to increase contact and image quality without clipping the hair or using gel. The tube was then inserted adjacent to the palate through the mouth until the tip was visible at the cardia of the stomach by ultrasonography (CARDIA US) (Fig. 2c). The tube was pushed further until the tip touched the stomach and deformed the wall (MAX US1) (Fig. 2d). The stomach was then filled with water at a constant rate of 2 mL/min (120 mL/h) using an automatic infusion pump until the stomach could not expand any further (length x width x height). While the stomach was full, the tip of the tube was pushed further until it touched the stomach and deformed the wall (MAX US2) (Fig. 2e). Then, the abdominal cavity was opened, the length of intubation to the cardia (CARDIA VISUAL) was measured until the tube deformed the stomach wall (MAX VISUAL) (Fig. 3a). The stomach volume was measured visually (length x width x height) (Fig. 3b).

**Statistical analysis**

Statistical significance was evaluated using a one-sample two-tailed Student's t-test of the difference between CARDIA VISUAL and CARDIA US, as well as between STRAIGHT and CARDIA US, using a confidence interval of 95%. $P < 0.05$ was considered statistically significant. Statistical analysis was performed using IBM SPSS Statistics 26 (SPSS Inc., Chicago, IL, USA), and GPower 3.1.9.4 (Düsseldorf, Germany) was used for power analysis. Assumption of normality was tested for skewness and kurtosis, using the Shapiro-Wilk test. Fresh and frozen puppy groups were compared using repeated measures analysis of variance (ANOVA) on the following parameters: the difference between CARDIA VISUAL and CARDIA US and between STRAIGHT and CARDIA US. A regression model was obtained for cardiac length (cm) with respect to weight (g). A $P$-value of <