Verifying Feeding Tube Placement in Canine and Feline Neonates

Etienne Furthner (efurthner@gmail.com)  
University of Zurich

Mariusz Kowalewski  
University of Zurich

Paul Torgerson  
University of Zurich

Iris Reichler  
University of Zurich

Research Article

Keywords: intubation, ultrasonography, oesophagus, stomach, neonate, milk, colostrum.

DOI: https://doi.org/10.21203/rs.3.rs-141965/v1

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Abstract

**Background:** Tube feeding is a common procedure in neonatology. In humans, tube misplacement is reported to occur up to 59% 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, the current recommendations on tube feeding in canine and feline neonatology are based, at best, on studies made in adults. Our aim is to test ultrasonography as a tool, and to compare different anatomical predictive markers used in human, canine and feline neonates.

**Results:** Predictive tube length when held bent between the last rib to the mouth may induce trauma compared to when held straight. A strong positive linear correlation was found between the birthweight and the localization of the gastric cardia. Ultrasonography, compared to coeliotomy findings were similar. 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).

**Conclusion:** A weight-based equation is proposed to help predicting appropriate tube placement. Ultrasonography can be used as tube placement control. Less than one-day-old neonates have a lower stomach capacity. Further studies are required to evaluate whether older growing animals follow the same correlation compared to the weight. Further *in vivo* studies are warranted to determine a gold standard procedure for tube feeding in neonatal puppies and kittens.

Background

In neonatal care, orogastric tube insertion is a common procedure. Emptying the stomach filled with foetal fluid in hypoxic neonates reduces the pressure on the diaphragm and facilitates breathing (1). It allows colostrum or serum intake if neonates are not able to suckle colostrum by themselves, thereby preventing enteric diseases, immune deficiency and sepsis (2). The most common indication is tube feeding of normothermic neonates that are too weak to suckle or to be bottle-fed (3–5) or of orphans (6). Lactation failure of the dam, delayed onset of lactation, rejection of one or more of the littermates, too many offsprings, mastitis, metritis, or eclampsia are other indications for temporary feeding support of the neonates (7–9). Enteral feeding improves gastrointestinal maturation and feeding tolerance compared to parenteral options (10), in both naturally suckling and formula-fed puppies (11). Tube feeding is a quick procedure compared to bottle-feeding and allows better control on the amount of milk given to the puppy (12, 13). This procedure may be performed by breeders (13, 14) in order to achieve normal weight gain for all the puppies or kittens (15, 16), while reducing the owner’s time spent compared to bottle feeding, as well as the dam’s energy requirements (8, 12). Although inserting an orogastric tube in neonates is reported to be a simple procedure (12), there are multiple reported complications, such as regurgitations or injuries leading to bronchopneumonia or even death, with ruptured oesophagus and gastric hemorrhage (14, 17). Regurgitation and aspiration pneumonia are commonly mentioned as a risk (2, 5), hypothesized to be linked with hypothermia (3, 18), excessive volume (5), speed of feeding (18) and the size of the tube (2, 5, 6). It was also suggested that too deep insertion of the tube may create a loop.
inside the stomach thus increasing the risks for regurgitation and trauma (2, 14), or a kinking into the gastrointestinal tract (6). In humans, tube misplacement is reported to occur in up to 59% (19, 20) of all cases, and incidence of perforation due to gastric tubing in 1.1% (21) 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) (2, 5, 7, 17, 22–24). Others recommend using ¾ of that length (6, 12, 18, 25). So far, recommendations are mostly based on procedures performed in adult animals (oesophageal versus gastric tubing) (26–28). Feeding is repeated multiple times a day in neonates, radiographic control cannot be performed, in contrary to what is done as gold standard approach in adults (29–31), and in pediatric human medicine (32–35). The measurement of the length of tube insertion is therefore of prime importance. Among common predictive safety measurements performed in human neonates, a Nose-ear-mid-umbilicus (NEMU) measurement is described (36–38), as well as weight-based formulas (39, 40). Correct tube placement may also be assessed under ultrasonography control (41, 42). Other methodologies are used such as the auscultation of insufflated air (38), Carbone Dioxide detection (43, 44) and aspiration of gastric content, all of which pose reliability limitations in neonatology (38, 45).

This study aims to assess the reliability of ultrasonography control on tube placement, to compare different recommendations regarding the length of insertion of feeding tubes using dead puppies and kittens and offer a weight-based formula that may help predict where the cardia is located. The maximal stomach volume was also studied.

**Methods**

**Animal Population:**

Twenty-eight kittens and 25 puppies that died within the first 24 hours after parturition were collected with the consent of their owners 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, which died during delivery or within the 24 first hours of life were examined within 12 hours after death without being frozen. Only the neonates with less than 24 h of age were selected based on their history or on the presence of uteroverdine, placenta, placental fluid in the stomach, and umbilicus observation whenever more accurate data was missing.

**Feeding tubes and marking:**

Eight French diameter, 100 cm long nasogastric tubes were used (Nährsonde, Medicoplast, Germany). The tube was held along the outside puppy's body, bent, from behind the last rib, to the tip of the nose and the length was measured (BENT) (Fig. 1a) (7). Similar measurements were performed between the last rib and the tip of the nose, but with the tube, held straight (STRAIGHT) (Fig. 1b). Finally, as it is described in human neonates (36), the distance from the tip of the puppy's nose to the earlobe and then from the earlobe to the midway between the xiphoid process and the umbilicus (NEMU), was recorded (Fig. 1c). BENT ¾ values were calculated based on the three quarters of BENT measurements. These
measurements were performed without any markings on the tube to avoid any influence on the next measurements.

**Ultrasonography and visual observation:**

The stomach content and volume (length x width x height) before intubation were evaluated by ultrasonography, using LOGIC F8 (Scil, General Electric Healthcare, Switzerland) with a linear 12 MHz probe (Fig. 2a and 2b). 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 until the cardia is reached (CARDIA VISUAL) was measured and 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 t Student test of the difference between CARDIA VISUAL and CARDIA US, as well as 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 for power analysis. Assumption of normality was tested for skewness, kurtosis and a Shapiro-Wilk test was used. Fresh and frozen puppy groups were compared with repeated measures analysis of variance (ANOVA). A regression model was obtained for Cardia length (cm) with respect to weight (g). A P value of < 0.05 was considered significant and autocorrelation was evaluated by the Durbin–Watson ratio. The results of the linear regression were presented as scattered plots with the 95% confidence interval.

**Results**

**Animals:**

Causes of death of the neonates were a failure to be reanimated after C-section or dystocia, failure to suckle and death or euthanasia within 24 hours of life, with three kittens and one puppy that had a cleft palate. The mean weight was 70.2 ± 18.2 g (range 38 to 114) for the kittens (n = 28) and 216.4 ± 121.9 g (range 67 to 630) for the puppies (n = 25).

**Tube measurements in kittens:**

The mean difference between CARDIA US and CARDIA VISUAL was −0.04 ± 0.31 cm (range −0.6 to 0.7), (P = 0.47).
BENT ¾ was smaller than CARDIA US in 24 cases: The tube, when inserted up to ¾ BENT, was found in the oesophagus in 24/28 kittens, at a mean $-0.77 \pm 0.77$ cm (range $-1.9$ to $0.7$).

The mean difference between STRAIGHT and CARDIA US was $0.23 \pm 0.68$ cm (range $-1.1$ to $1.4$), ($P = 0.11$). In 18 kittens, STRAIGHT was longer than CARDIA US values: the tube, when inserted up to STRAIGHT, was found in the stomach in 18/28 kittens and in the oesophagus in 10/28 kittens. In one kitten, STRAIGHT exceeded MAX US1 and none exceeded either MAX US2 or MAX VISUAL (Table 1).

In 27 of the 28 kittens, BENT was longer than CARDIA US and in one kitten BENT was equal to CARDIA US, with a mean $1.59 \pm 1.01$ cm (range 0 to 3.4) difference between BENT and CARDIA US. In 14 kittens, BENT exceeded MAX US1, in four, BENT exceeded or were equal to MAX US2 and in one kitten, BENT exceeded MAX VISUAL (Table 1).

NEMU was longer than most of the maximal measurements of the tube when pushed against the stomach wall, at a mean $4.27 \pm 1.22$ cm (range 1.9 to 6.4) further than the cardia.

CARDIA US, MAX US1, MAX US2 and MAX VISUAL of all neonates are shown in Fig. 4. In most of BENT ¾ (84%) and in a few STRAIGHT (36%) measurements, the tip of the tube was located in the oesophagus, as shown in Fig. 4, below the blue area. In a few of BENT ¾ (16%), in half of BENT (50%) and in most STRAIGHT (61%) measurements, the tip of the tube was found in the stomach, i.e. in the blue area. One case of STRAIGHT (3%), half of BENT (50%) and all NEMU cases were found further away than MAX US1, as shown in Fig. 4, in the orange, red areas or above.

After the measurements of CARDIA VISUAL and MAX VISUAL, we attempted to force tube to go further than MAX VISUAL in 14 kittens, leading to looping of the tube in 8 kittens (Fig. 3c), perforation in 4 kittens (Fig. 3d), or the impossibility to force further than MAX VISUAL in 2 kittens. **Tube measurements in puppies:**

CARDIA US, MAX US1, MAX US2 and MAX VISUAL are shown together with BENT ¾, STRAIGHT, BENT and NEMU in Fig. 5.

The mean difference between CARDIA US and CARDIA VISUAL was $0.20 \pm 0.58$ cm (range $-0.9$ to $1.5$), ($P = 0.10$). The groups of fresh and frozen puppies were not different ($p = 0.62$).

BENT ¾ was smaller than CARDIA US and found in the oesophagus in 18 cases; BENT ¾ was at a mean $-0.99 \pm 1.27$ cm (range $-2.75$ to $1.55$) from the cardia.

The mean difference between STRAIGHT and CARDIA US was $0.23 \pm 1.28$ cm (range $-2.4$ to $3.3$), ($P = 0.37$). The groups of fresh and frozen puppies were not different ($p = 0.08$). STRAIGHT was longer than CARDIA US 15/25 puppies and in the oesophagus in 10/25 puppies. STRAIGHT exceeded MAX US1 in 2 puppies, none exceeded MAX US 2 or MAX VISUAL (Table 1).
BENT was longer than CARDIA US in all 25 puppies, with a mean $2.3 \pm 1.3$ cm (range 0.3 to 4.7) difference. BENT exceeded MAX US1, MAX US 2 and MAX VISUAL in five, four and one cases respectively (Table 1).

NEMU was found longer than most of the maximal measurements, at a mean $5.56 \pm 2.00$ cm (range 2 to 11) from than the cardia.

**Formula of Cardia placement based on weight:**

The position of the Cardia follows a linear regression compared to the weight with a strong correlation rate in cats ($r^2 = 65\%$) (Fig. 6) and in puppies ($r^2 = 81\%$) (Fig. 7). The formulas, where $Y_{\text{cardia}}$ is the length of the tube to reach the Cardia, and $X$ the weight of the neonate, are the following:

$$Y_{\text{cardia}} = 5.3 + 3.7 \times X/100 \text{ in kittens}$$

$$Y_{\text{cardia}} = 7.1 + 1.7 \times X/100 \text{ in puppies}$$

Implementing 1.96 standard deviations to the previous formula allows us to place the tube above the cardia - in the stomach - with 97.5% confidence:

$$Y_{\text{stomach}} = 6 + 4.7 \times X/100 \text{ in kittens}$$

$$Y_{\text{stomach}} = 8 + 2.1 \times X/100 \text{ in puppies}$$

Using the formula on the 28 kittens of this study, 13 values exceeded MAX US1, three values exceeded MAX US2 and zero MAX VISUAL. In the 25 puppies, 11 values exceeded MAX US1, one Max US2 and zero MAX VISUAL (Table 1).

**Stomach Volume:**

The maximal volume of the stomach in puppies was found to be $1.56 \pm 1.28$ ml (range 0.30 to 3.66) by ultrasonography, and $2.04 \pm 1.28$ ml (range 0.51 to 5.59) when measured visually. In % of bodyweight, maximal volume of the stomach was $1.10 \pm 0.87\%$ (range 0.09 to 2.88), by ultrasonography and $1.20 \pm 0.57\%$ (range 0.33 to 2.61) when measured visually.

The maximal volume of the stomach in kittens was found to be $1.10 \pm 0.60$ ml (range 0.14 to 2.34) by ultrasonography, and $1.34 \pm 1.00$ ml (range 0.46 to 4.81) when measured visually. In % of bodyweight, maximal volume of the stomach was $1.55 \pm 0.86\%$ (range 0.30 to 3.65) by ultrasonography and $1.95 \pm 1.21\%$ (range 0.51 to 5.60) when measured visually.

**Discussion**

Studies on live neonates concerning proper tube feeding placement are lacking, probably due to the difficulty to offer ethical ways to analyze tube placement and their complications. Therefore, we used
dead neonates in order to give new insights on tube feeding management. This study shows that appropriate placement of the tube can be performed under ultrasonography control: stomach wall deformation and stomach volume could be visualized accurately. Furthermore no difference was found between frozen and fresh puppies, however further validation is required in live animals.

The description of tube placement using BENT ¾, STRAIGHT, BENT or NEMU is aimed to assess potential risks on the integrity of the gastric wall and to determine whether the tube is placed in the oesophagus, in the stomach or further. It is not known whether oesophageal or gastric feeding have a relationship with increased regurgitation risks. Both techniques are used in adults (28) and no statistical difference in regurgitation rates was found in adult dogs (29). The tips of feeding tubes are mostly presented with lateral openings. Using a tube with the flared end trimmed may reduce regurgitation risks, as previously suggested (7). Reduced contractility of the gastrointestinal tract was observed in human preterm neonates (46, 47), and in canine neonates, with a progressive increase of contractility 3–7 days after birth (48). Canine gastrointestinal maturation is a quick process implying that significant changes in the gastrointestinal tract may occur within the first days of life, which is why this study was limited to less than one day old neonates.

BENT was the only measurement allowing gastric intubation in 100% of cases; therefore, this length should be used for the indication of stomach emptying to reduce diaphragmatic pressure during neonatal resuscitation. However, concerning injury risks, tube placement with BENT is not always harmless since BENT exceeded the MAX US1, MAX US2, and MAX VISUAL in 19, 8 and 2 neonates respectively (Table 1). Using rigid tubes such as 8 Fr adult feeding tubes may induce stomach damage to the neonates (Fig. 3d). It should be self-evident that forcing the tube to go further than MAX VISUAL breakpoint should be avoided. It induced stomach perforation in 4 kittens and looping in 8 kittens (Fig. 3c) as previously described as complications (2, 6). The authors do not recommend using rigid tubes such as adult 8 Fr adult feeding tubes with BENT on neonates, although the incidence of gastric perforations in this study may be overestimates due to autolysis: prevalence of perforations is considered to be 1.1% in low birth weight human neonates (21). Using softer tubes (2, 7) may reduce the risks for complications such as stomach injuries, although looping, regurgitation or kinking of the tube remain possible other risk factors (2, 6). For the feeding of the neonates STRAIGHT seems more suitable. It is mainly found close to the area of the cardia with 32/53 cases found in the stomach (60%). BENT ¾ might be used, even if it is found most often in the oesophagus with 45/53 cases (85%). Concerning risks for injuries, STRAIGHT exceeded MAX US1 in three cases, while BENT ¾ never exceeded MAX US1. The authors conclude gastric injuries are minimized using either of these two measurement techniques, although prevalence of regurgitations should be assessed in live animals. Measurements with NEMU are not appropriate in puppies or kittens compared to human babies, because of an excessive length of intubation (Table 1). Concerning the diameter to be used for tube feeding, some recommend 5 Fr diameter for < 300 g neonates and 8 Fr for > 300 g animals (22–24). Others discourage the use of small size catheters due to the increased risks for looping (2) some recommend to use the largest tube that passes easily (5). Further studies are needed on that subject in order to reach a consensus.
During measurements performed in this study, it became clear that without ultrasound control, a residual risk always remains with tube insertion. Since the position of the cardia can be predicted very well using the bodyweight, as shown by the strong correlation rate in cats ($r^2 = 65\%$) (Fig. 6) and in dogs ($r^2 = 81\%$) (Fig. 7), we would recommend to use weight-based formulas to determine the tube length. Whenever this formula is used in puppies and kittens, values exceeding maximum measurements are reduced compared to BENT (Table 1), which shows that this formula may avoid extreme measurements, which are precisely the ones that might induce trauma.

Maximal stomach volume was found to be 1.2% and 1.9% of the bodyweight of feline and canine neonates. This is in apparent contradiction to most the guidelines indicating a maximal amount of milk given per single feeding of 4 to 5 ml / 100 g of bodyweight (6, 7, 12, 22, 23), but is in agreement with data found on 4 newborns in the original study of Andersen (49). Maximal stomach size in neonates is more than half smaller than older ones. Safety rules should be adapted according to age, in order to avoid overfeeding and regurgitation. Nevertheless, our model has several limitations. The loss of tonicity of the pyloric sphincter, the flaccid oesophagus, the changes of compliance and autolysis are parameters different to live animals. Many morphologic variations may be observed among canine breeds, the findings may not be representative to all the canine breeds. BENT and STRAIGHT measurements were performed on dead neonates, while BENT ¾ was calculated based off the values of BENT. The variations found in this study are therefore underestimated compared to live, moving animals, increasing potential discussed risks for injuries in vivo. Using the herein presented formula, the probability of being at the preferred position is increased, thus reducing the risks to the neonate.

Conclusion

Ultrasonography is a reliable tool for correct gastric tube placement in neonates. However, whenever ultrasonography is not available, the proposed weight based formula is a good option for choosing the correct length of tube insertion. Beside the possible complications of tube feeding, it is important to be aware of the reduced stomach capacity of neonates. More studies are required in order to assess regurgitation risks with regard to oesophageal versus gastric intubation in canine and feline neonates.

Abbreviations

BENT: Length of the tube, held along the outside puppy's body, bent, from behind the last rib, to the tip of the nose.

BENT ¾: Three quarters of the length of the tube, held along the outside puppy's body, bent, from behind the last rib, to the tip of the nose.

STRAIGHT: Length of the tube, held along the outside puppy's body, straight, from behind the last rib, to the tip of the nose.

NEMU: Nose-Earlobe-Mid-Umbilicus measurement.
CARDIA US: Length of the tube until it reaches the cardia, by ultrasonography.

CARDIA VISUAL: Length of the tube until it reaches the cardia, visually after coeliotomy.

MAX US 1: Length of the tube until it deforms the wall of an empty stomach, by ultrasonography.

MAX US 2: Length of the tube until it deforms the wall of a full stomach, by ultrasonography.

MAX VISUAL: Length of the tube until it deforms the wall of a full stomach, visually, after coeliotomy.

**Declarations**

**Availability of data and materials**

The datasets during and/or analyzed during the current study available from the corresponding author on reasonable request.

**Ethics approval and consent to participate**

This project was performed in accordance with the Swiss Animal Welfare Act (SR 455). All animals died due to reasons unrelated to the study. The consents were obtained from all the owners of the deceased animals to be used for teaching and research purposes. We do not report experiments on live vertebrates. Formal ethical approval was not required due to the post-mortem nature of the study.

**Competing interests**

The authors declare that they have no competing interests.

**Funding**

No specific funding was received by authors for this work.

**Contributions**

Etienne Furthner: Conceptualization, methodology, investigation, data curation, formal analysis, writing, original draft preparation, statistical analysis. Iris M Reichler: Supervision, conceptualization, methodology, resources, reviewing and editing, Mariusz P Kowalewski: Methodology, reviewing and editing. Paul Torgerson: Statistical analysis.

**Acknowledgments**

The authors wish to thank Pr Tarigan for her help on the statistical analysis and the breeders who allowed us to collect the animals.

**References**
1. Macintire DK. Intensive care management. In: Hoskins JD, editor. Veterinary Pediatrics: Dogs and Cats from Birth to Six Months WB Saunders, Philadelphia 2001.

2. Lawler DF. Neonatal and pediatric care of the puppy and kitten. Theriogenology. 2008;70(3):384–92.

3. Munnich A, Kuchenmeister U. Causes, diagnosis and therapy of common diseases in neonatal puppies in the first days of life: cornerstones of practical approach. Reprod Domest Anim. 2014;49 Suppl 2:64–74.

4. Boothe DM, Bucheler J. Drug and blood component therapy and neonatal isoreythrolysis. In: Hoskins JD, editor. Veterinary Pediatrics: Dogs and Cats from Birth to Six Months. WB Saunders, Philadelphia 2001. p. 35–56.

5. Johnston SD, Root Kustritz MV, Olson PNS. The neonate - From birth to weaning. In: Johnson JA, Root Kustritz MV, Olson PNS, editors. Canine and Feline Theriogenology 2010. p. 162–3.

6. Root Kustritz MV. How are orphan puppies and kittens best fed? Clinical canine and feline reproduction, evidence-based answers 2010. p. 285–7.

7. Lawler DF, Chandler ML. Indications and Techniques for Tube-Feeding Puppies. Canine Pract. 1992;17(1):20–3.

8. Fontbonne A, Levy X, Fontaine E, Gilson C. Intubation gastrique du nouveau-né. Guide pratique de reproduction clinique canine et féline. Medcom ed 2007. p. 212–3.

9. Baines FM. Milk substitutes and the hand rearing of orphan puppies and kittens. J Small Anim Pract. 1981;22(9):555–78.

10. Owens L, Burrin DG, Berseth CL. Minimal enteral feeding induces maturation of intestinal motor function but not mucosal growth in neonatal dogs. J Nutr. 2002;132(9):2717–22.

11. Schwarz SM, Heird WC. Effects of feeding on the small intestinal mucosa of beagle pups during the first 5 d of life. Am J Clin Nutr. 1994;60(6):879–86.

12. Casal M. Management and critical care of the neonate. In: England G, Von Heimendahl A, editors. BSAVA Manual of Canine and Feline Reproduction and Neonatology. 2nd ed. Gloucester, UK: British Small Animal Veterinary Association; 2010. p. 135–46.

13. Chastant S, Mila H. Passive immune transfer in puppies. Animal Reproduction Science. 2019;207:162–70.

14. Gill MA. Perinatal and late neonatal mortality in the dog [PhD]: University of Sidney; 2001.

15. Mosier JE. The puppy from birth to six weeks. Vet Clin North Am. 1978;8(1):79–100.

16. Sheffy BE. Nutrition and nutritional disorders. Vet Clin North Am. 1978;8(1):7–29.

17. Prendergast H. Care of the orphaned puppy and kitten. In: Peterson ME, Kutzler MA, editors. Small Animal Pediatrics 2011. p. 67–72.

18. Moxon R, England G. Care of puppies during the neonatal period: Part 2 Care of the sick neonate. Veterinary Nursing Journal. 2012;27:61–5.

19. Ellett ML, Cohen MD, Perkins SM, Croffie JM, Lane KA, Austin JK. Comparing methods of determining insertion length for placing gastric tubes in children 1 month to 17 years of age. J Spec Pediatr Nurs.
20. Quandt D, Schraner T, Ulrich Bucher H, Arlettaz Mieth R. Malposition of feeding tubes in neonates: is it an issue? J Pediatr Gastroenterol Nutr. 2009;48(5):608–11.

21. Thanhaeuser M, Lindtner-Kreindler C, Berger A, Haiden N. Conservative treatment of iatrogenic perforations caused by gastric tubes in extremely low birth weight infants. Early Hum Dev. 2019;137:104836.

22. Little S. Playing mum: successful management of orphaned kittens. J Feline Med Surg. 2013;15(3):201–10.

23. Macintire DK. Pediatric fluid therapy. Vet Clin North Am Small Anim Pract. 2008;38(3):621-7, xii.

24. Hoskins JD. Nutrition and nutritional problems. Veterinary Pediatrics, dogs and cats from birth to six months. 3rd ed 2001. p. 476–89.

25. Pierson P, Grandjean D, Sergheraert R, Pibot P. Guide Pratique de l’élevage canin. 7th edition ed. Rivière S, editor. Aimargues, France: Royal Canin SAS; 2018.

26. Han E. Esophageal and gastric feeding tubes in ICU patients. Clin Tech Small Anim Pract. 2004;19(1):22–31.

27. Armstrong PJ, Hand MS, Frederick GS. Enteral Nutrition by Tube. Vet Clin N Am-Small. 1990;20(1):237–75.

28. Chan DL. The Inappetent Hospitalised Cat: clinical approach to maximising nutritional support. J Feline Med Surg. 2009;11(11):925–33.

29. Yu MK, Freeman LM, Heinze CR, Parker VJ, Linder DE. Comparison of complication rates in dogs with nasoesophageal versus nasogastric feeding tubes. J Vet Emerg Crit Care (San Antonio). 2013;23(3):300–4.

30. Jolliet P, Pichard C, Biolo G, Chiolero R, Grimble G, Leverve X, et al. Enteral nutrition in intensive care patients: a practical approach. Clin Nutr. 1999;18(1):47–56.

31. Abood SK, Buffington CA. Enteral feeding of dogs and cats: 51 cases (1989–1991). J Am Vet Med Assoc. 1992;201(4):619–22.

32. Irving SY, Rempel G, Lyman B, Sevilla WMA, Northington L, Guenter P, et al. Pediatric Nasogastric Tube Placement and Verification: Best Practice Recommendations From the NOVEL Project. Nutr Clin Pract. 2018;33(6):921–7.

33. Irving SY, Lyman B, Northington L, Bartlett JA, Kemper C, Group NPW. Nasogastric tube placement and verification in children: review of the current literature. Nutr Clin Pract. 2014;29(3):267–76.

34. Roubenoff R, Ravig WJ. Pneumothorax due to nasogastric feeding tubes. Report of four cases, review of the literature, and recommendations for prevention. Arch Intern Med. 1989;149(1):184–8.

35. Farrington M, Lang S, Cullen L, Stewart S. Nasogastric tube placement verification in pediatric and neonatal patients. Pediatr Nurs. 2009;35(1):17–24.

36. Beckstrand J, Cirgin Ellett ML, McDaniel A. Predicting internal distance to the stomach for positioning nasogastric and orogastric feeding tubes in children. J Adv Nurs. 2007;59(3):274–89.
37. Ellett ML. Important facts about intestinal feeding tube placement. Gastroenterol Nurs. 2006;29(2):112–24; quiz 24 – 5.

38. Society of Pediatric Nurses Clinical Practice C, Committee SPNR, Longo MA. Best evidence: nasogastric tube placement verification. J Pediatr Nurs. 2011;26(4):373–6.

39. Nguyen S, Fang A, Saxton V, Holberton J. Accuracy of a Weight-Based Formula for Neonatal Gastric Tube Insertion Length. Adv Neonatal Care. 2016;16(2):158–61.

40. Freeman D, Saxton V, Holberton J. A weight-based formula for the estimation of gastric tube insertion length in newborns. Adv Neonatal Care. 2012;12(3):179–82.

41. Atalay YO, Aydin R, Ertugrul O, Gul SB, Polat AV, Paksu MS. Does Bedside Sonography Effectively Identify Nasogastric Tube Placements in Pediatric Critical Care Patients? Nutr Clin Pract. 2016;31(6):805–9.

42. Atalay YO, Polat AV, Ozkan EO, Tomak L, Aygun C, Tobias JD. Bedside ultrasonography for the confirmation of gastric tube placement in the neonate. Saudi J Anaesth. 2019;13(1):23–7.

43. Ellett ML, Croffie JM, Cohen MD, Perkins SM. Gastric tube placement in young children. Clin Nurs Res. 2005;14(3):238–52.

44. Gilbert RT, Burns SM. Increasing the safety of blind gastric tube placement in pediatric patients: the design and testing of a procedure using a carbon dioxide detection device. J Pediatr Nurs. 2012;27(5):528–32.

45. Khair J. Guidelines for testing the placing of nasogastric tubes. Nurs Times. 2005;101(20):26–7.

46. Omari TI, Miki K, Davidson G, Fraser R, Haslam R, Goldsworthy W, et al. Characterisation of relaxation of the lower oesophageal sphincter in healthy premature infants. Gut. 1997;40(3):370–5.

47. Rayyan M, Omari T, Debeer A, Allegaert K, Rommel N. Characterization of esophageal motility and esophagogastric junction in preterm infants with bronchopulmonary dysplasia. Neurogastroenterol Motil. 2020;32(7):e13849.

48. Spedale SB, Weisbrodt NW, Morriss FH, Jr. Ontogenic studies of gastrointestinal function. II. Lower esophageal sphincter maturation in neonatal beagle puppies. Pediatr Res. 1982;16(10):851–5.

49. Andersen AC. Digestive system. In: Andersen AC, editor. The Beagle as an experimental dog p. 226 – 31.

Tables

Due to technical limitations, table 1 is only available as a download in the Supplemental Files section.

Figures
Figure 3

3a: tip of the tube deforming the stomach cavity (MAX VISUAL) in a neonate after coeliotomy. 3b: measurement of stomach volume 3c: tube looping after forcing the tube further than MAX VISUAL in a neonate 3d: Tube perforating the stomach after forcing further than MAX VISUAL in a neonate
Figure 5

Tube lengths of BENT ¾, BENT, STRAIGHT and NEMU (in cm), with regard to the weight (in g) in puppies. Blue area: area between CARDIA US and Max US1. Orange area: area between Max US1 and Max US2. Red area: area between Max US2 and Max VISUAL.
Figure 6

linear correlation between weight and Cardia in kittens
Figure 7

Linear correlation between weight and cardia in puppies, with upper and lower 95% confidence interval

Supplementary Files

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- Table1.pptx