Verifying Feeding Tube Placement in Canine and Feline Neonates

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Abstract

Background: Tube feeding is a common procedure 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 ± 0.77 cm (range − 1.9 to 0.7).

The mean difference between STRAIGHT and CARDIA US was 0.23 ± 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 ± 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 ± 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 ± 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 ± 1.27 cm (range − 2.75 to 1.55) from the cardia.

The mean difference between STRAIGHT and CARDIA US was 0.23 ± 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 ± 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 ± 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_{cardia} is the length of the tube to reach the Cardia, and X the weight of the neonate, are the following:

$Y_{cardia}=5.3 + 3.7*X/100$ in kittens

$Y_{cardia}=7.1 + 1.7*X/100$ 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:

$Y_{stomach}=6 + 4.7*X/100$ in kittens

$Y_{stomach}=8 + 2.1*X/100$ 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 ± 1.28 ml (range 0.30 to 3.66) by ultrasonography, and 2.04 ± 1.28 ml (range 0.51 to 5.59) when measured visually. In % of bodyweight, maximal volume of the stomach was 1.10 ± 0.87 % (range 0.09 to 2.88), by ultrasonography and 1.20 ± 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 ± 0.60 ml (range 0.14 to 2.34) by ultrasonography, and 1.34 ± 1.00 ml (range 0.46 to 4.81) when measured visually. In % of bodyweight, maximal volume of the stomach was 1.55 ± 0.86 % (range 0.30 to 3.65) by ultrasonography and 1.95 ± 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.

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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.

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Tables

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

Figures

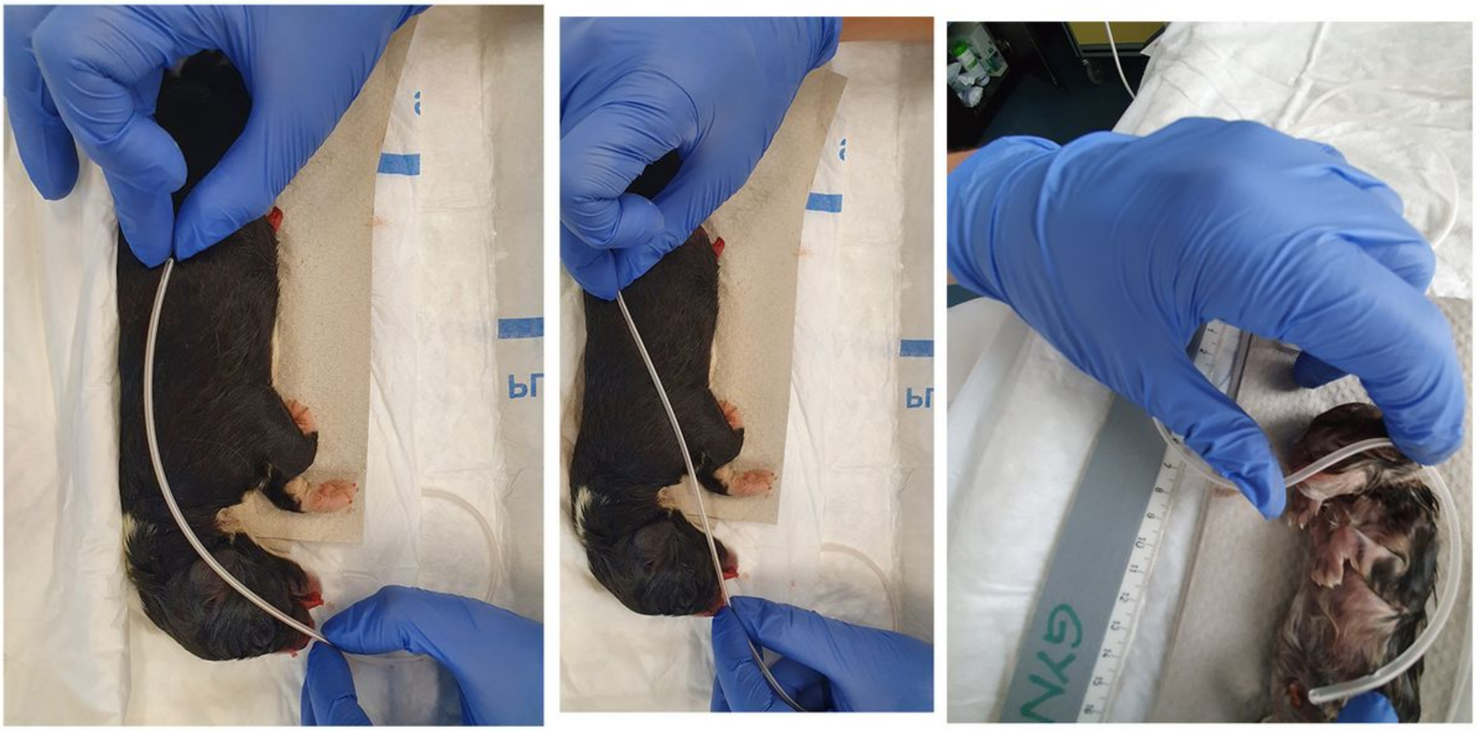

Figure 1

1a: BENT measurement in a neonate 1b: STRAIGHT measurement in a neonate 1c: NEMU measurement in a neonate

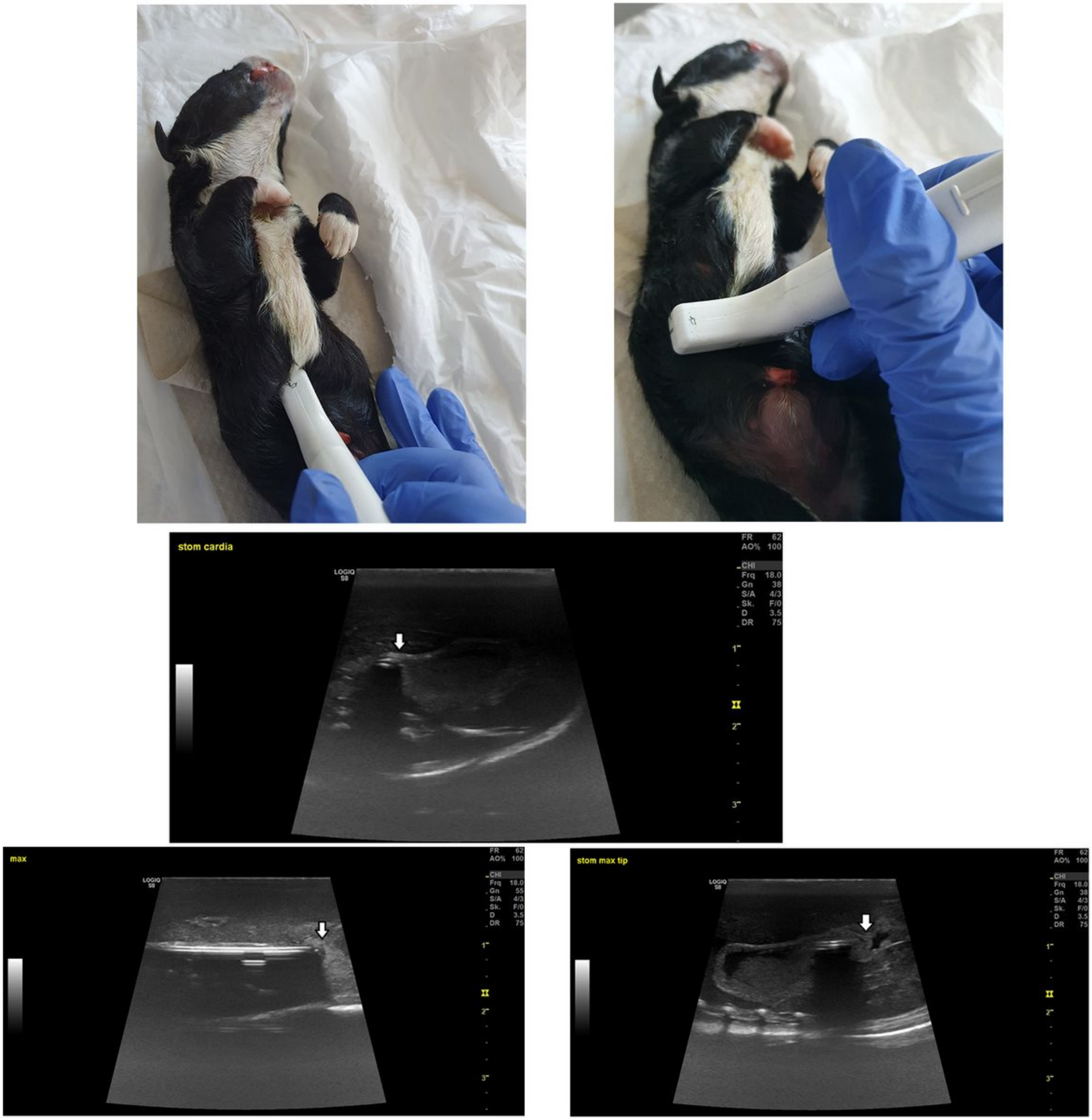

Figure 2

2a: Ultrasonography longitudinal probe position 2b: Ultrasonography transversal probe position 2c: feeding tube entering the gastric cardia (CARDIA US), by ultrasonography. Arrow: tip of the tube entering the cardia 2d: tip of the tube deforming the empty stomach cavity (MAX US1), by ultrasonography. Arrow: deformed gastric wall 2e: tip of the tube deforming a full stomach (MAX US2), by ultrasonography. Arrow: deformed gastric wall

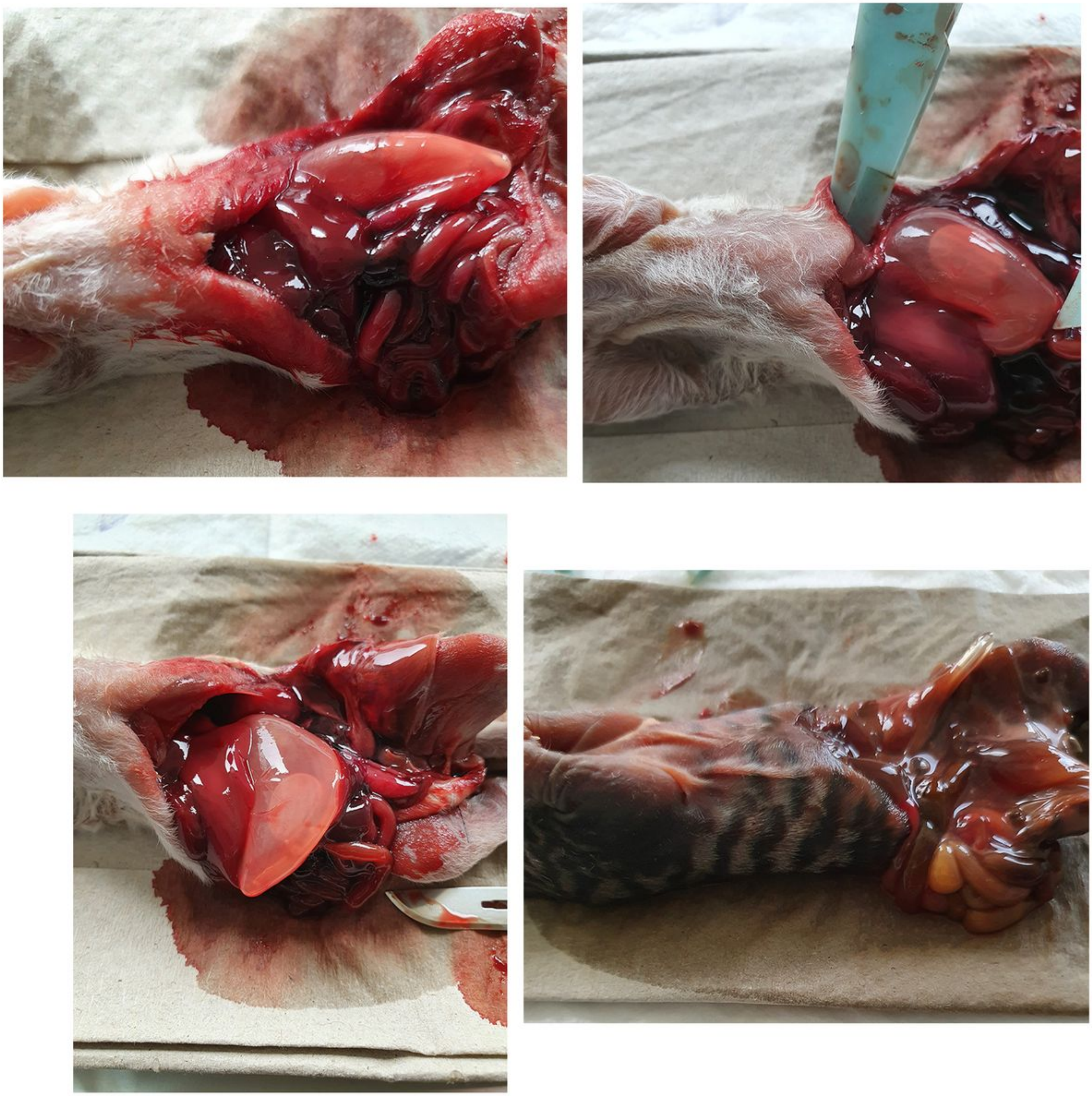

Figure 3

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

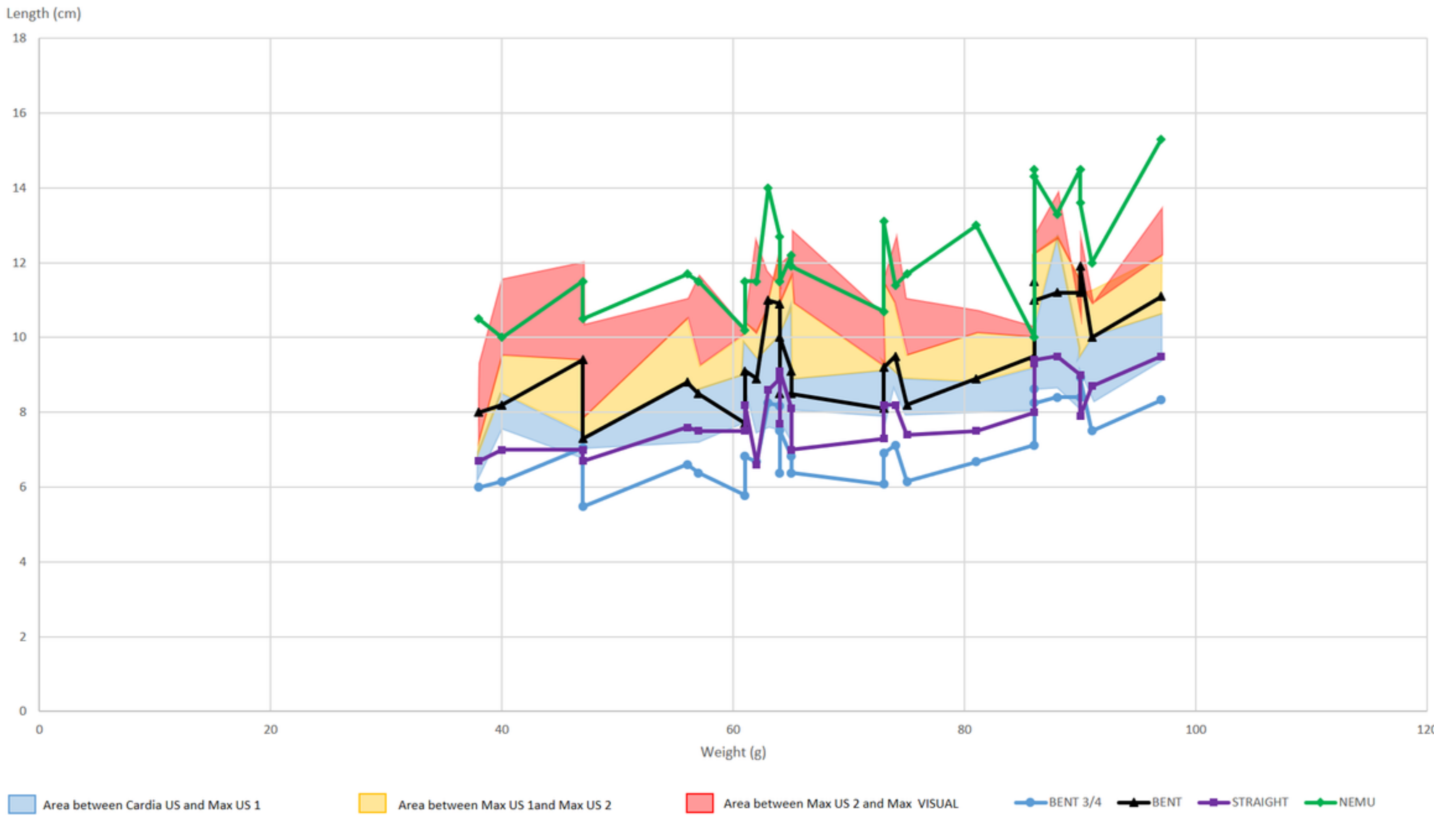

Figure 4

Tube lengths of BENT ¾, BENT, STRAIGHT and NEMU (in cm), with regard to the weight (in g) in cats. 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. Measurements found below the blue area (area defined by Cardia US and Max US1) are in the oesophagus. Values found in the blue, orange, red areas or above, are found in the stomach or further (looped, perforated or in the duodenum)

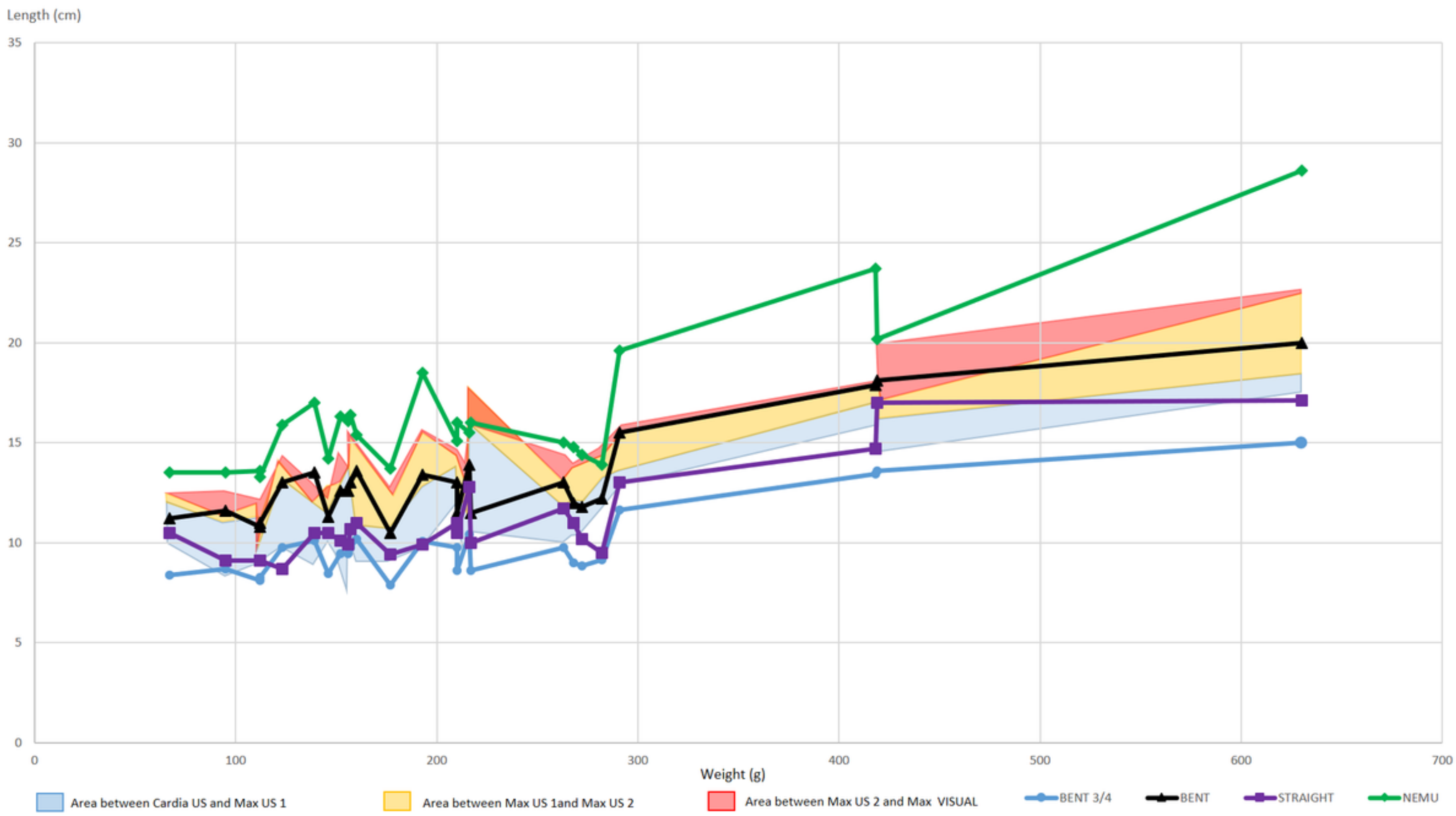

Figure 5

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

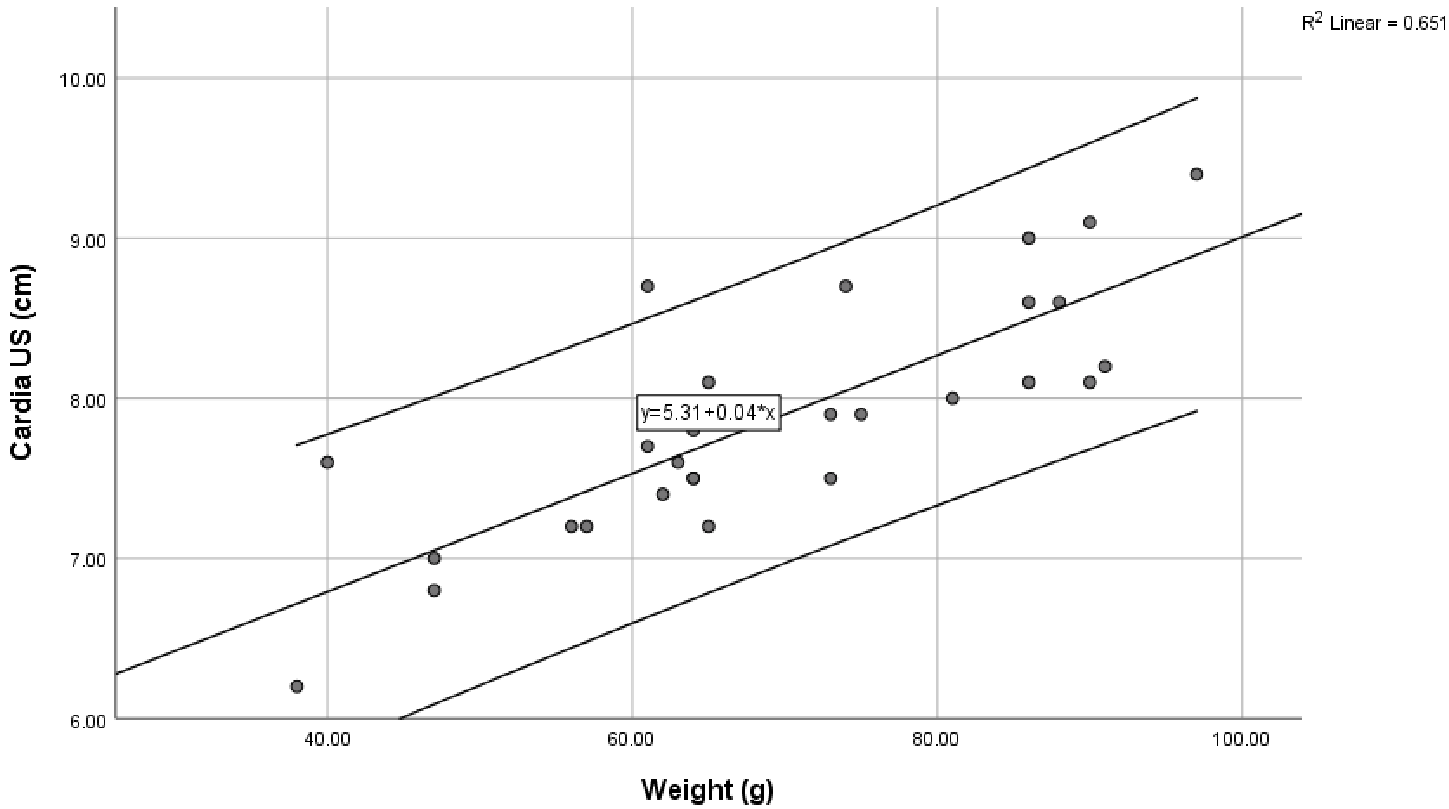

Figure 6

linear correlation between weight and Cardia in kittens

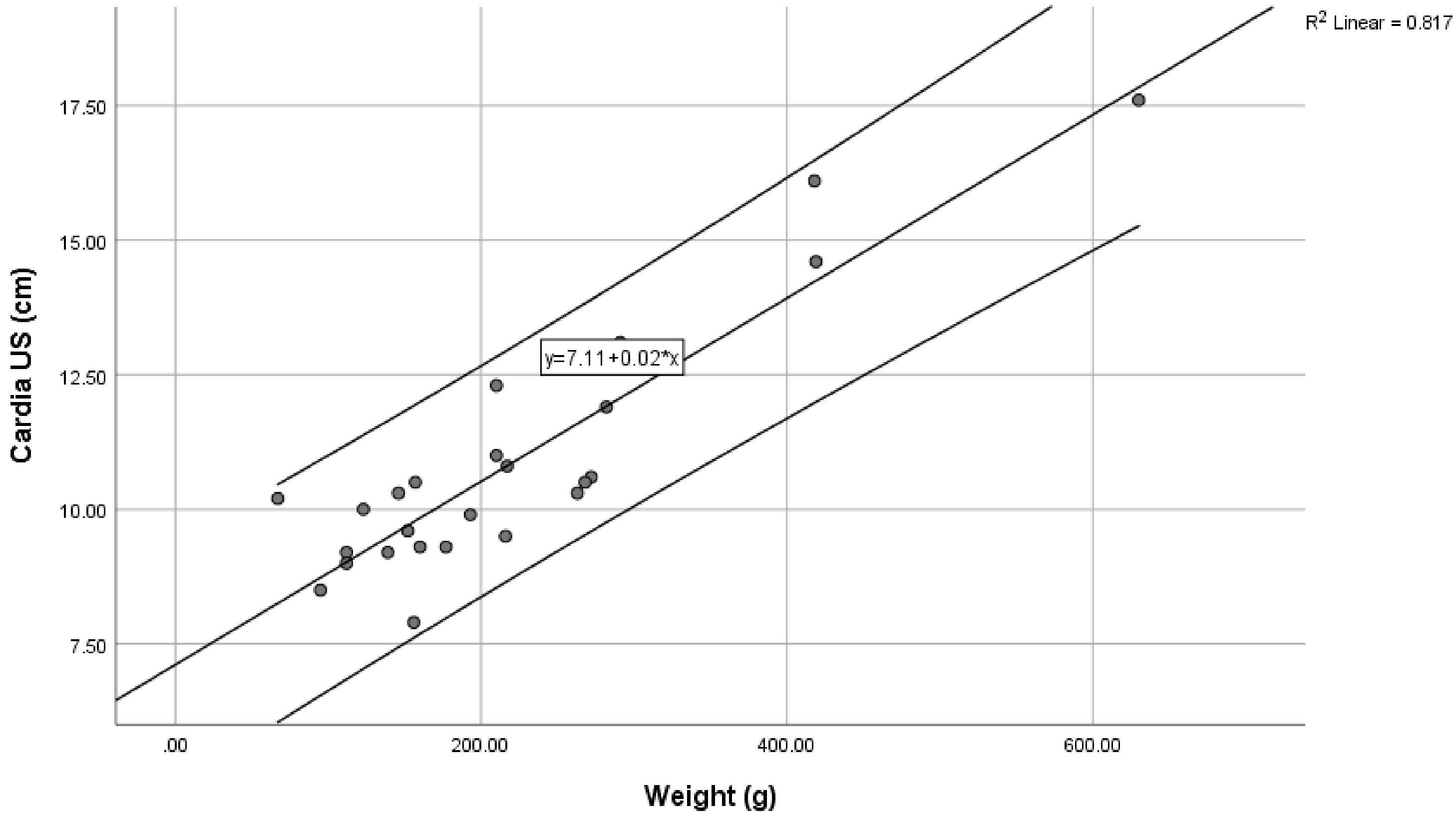

Figure 7

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

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Table1.pptx