Effect of an indwelling nasogastric tube on gastric emptying rates of liquids in horses

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Objective—To evaluate the effect of an indwelling nasogastric tube on gastric emptying of liquids in horses.

Animals—9 healthy adult horses.

Procedure—A randomized block crossover design was used. For treatment group horses, a nasogastric tube was placed and 18 hours later, acetaminophen was administered; the nasogastric tube remained in place until the experiment was complete. For control group horses, a nasogastric tube was passed into the stomach, acetaminophen was administered, and the nasogastric tube was removed immediately. Serial blood samples were collected 15 minutes before and after administration of acetaminophen. Serum concentration of acetaminophen was determined by use of fluorescence polarization immunoassay. The variables, time to maximum acetaminophen concentration (T_{max}) and the appearance constant for acetaminophen (K_{app}), were determined. The values for K_{app} and T_{max} in horses with and without prolonged nasogastric tube placement were compared.

Results—No significant difference was found in K_{app} between horses with and without prolonged nasogastric tube placement; the median difference in K_{app} was 0.01 min^{-1} (range, –0.48 to 0.80 min^{-1}). No significant difference was found in T_{max} between horses with and without prolonged nasogastric tube placement; the median difference in T_{max} was 5 minutes (range, –30 to 50 minutes). Reanalysis of data following the removal of possible outlier values from 1 horse resulted in a significant difference in T_{max} between horses with and without prolonged nasogastric tube placement.

Conclusions and Clinical Relevance—Although no clinically important impact of 18 hours of nasogastric intubation was found on gastric emptying in healthy horses, considerable variability in K_{app} and T_{max} was found among horses. (*Am J Vet Res* 2005;66:642–645)

Gastric distention occurs as a primary or secondary event in horses with ileus resulting from a variety of gastrointestinal tract diseases, including colic, postoperative ileus, and duodenitis-proximal jejunitis.[1,2] To relieve gastric distension and pain caused by ileus, a **nasogastric (NG)** tube is passed into the stomach of affected horses to allow removal of ingesta and secretions from the stomach. When the amount of gastric contents is great and the probability that repeated aspirations of gastric contents will be required is high, the tube may be left in place to avoid the risks associated with repeated intubation. These risks include pharyngeal or esophageal mucosal irritation, laceration or perforation, epistaxis, and inadvertent intubation of the trachea.

Anecdotally, it has been the authors' experience that coincident with removal of an indwelling NG tube that has been in place for several days, the quantity of gastric contents removed from the stomach on subsequent attempts decreases. This has led to speculation that an indwelling NG tube decreases the gastric emptying rate, increases gastric secretion, or both. To the authors' knowledge, the effect of an indwelling NG tube on gastric emptying of horses has not been studied. However, the presence of a gastrointestinal tract tube in situ significantly retarded gastric emptying in humans,[3] and the presence of a duodenal tube delayed gastric emptying of a caloric liquid meal in humans.[4] On the basis of these published and anecdotal reports, we hypothesized that an indwelling NG tube would delay gastric emptying in horses.

The objective of the study reported here was to investigate the effect of an indwelling NG tube on gastric emptying, measured by the absorption of **acetaminophen (AP)**. Acetaminophen is absorbed almost exclusively in the proximal portion of the small intestine and can be measured in the serum after oral administration.[5] The rate-limiting step for absorption of AP is the rate of gastric emptying, provided that the small intestine is functioning normally.[5,6] The validity of the use of AP for the measurement of gastric emptying in horses and ponies has been documented.[7-12]

Materials and Methods

Animals—Nine healthy adult horses (body weights ranging from 400 to 525 kg) from the Texas A&M University research herd were used in this study. The protocol for this project was approved by the Texas A&M University Laboratory Animal Care Committee. All horses in the study met the criteria for inclusion of allowing passage of an NG tube (inside diameter, 1.0 cm; outside diameter, 1.6 cm;

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length, 2.75 m) with minimal restraint and standing in stocks for 4 hours. No horses had clinical signs of gastrointestinal tract disease during the study. All horses had a complete physical examination prior to use and were observed daily to be free of clinical signs of disease for at least 90 days prior to and during the study. Five geldings, 3 mares, and 1 stallion of various breeds were used. All horses were housed in paddocks and fed coastal Bermuda grass hay ad libitum and a mixed-grain concentrate twice daily.

Study design—A randomized incomplete-block design was used with 5 horses receiving NG tube placement first and the control treatment 7 days later and the other 4 horses receiving treatments in the reverse order. Each horse served as its own control. Food and water were withheld from horses for 18 hours prior to administration of AP. For treatment group horses, 18 hours before AP administration, the tube was passed nasogastrically and left in place with approximately 180 to 200 cm of tube in the horse. Horses were muzzled to prevent inadvertent removal of the tube. Control group horses were also muzzled 18 hours prior to AP administration. Intravenous catheters were aseptically placed in each horse's jugular vein prior to administration of AP. Treatment group horses received AP (20 mg/kg, PO) in 1 L of water via the indwelling NG tube, followed by 800 mL of air to empty all liquid from the NG tube, and the tube was left in place until the experiment was completed.[a] For control group horses, an NG tube was passed to the stomach, the AP was administered followed by 800 mL of air, and the tube was removed immediately. Neither group was allowed access to feed or water during the period of sample collection. Blood samples (10 mL each) for the determination of AP concentrations were collected into vacuum tubes from the IV catheter at 15 minutes before and 5, 10, 15, 20, 25, 30, 45, 60, 75, 90, 120, 150, 180, 210, and 240 minutes after administration of AP. Serum was separated by centrifugation and stored at –80°C until samples were analyzed. Serum concentration of AP was determined by use of a **fluorescence polarization immunoassay (FPIA)** in the Texas A&M University College of Veterinary Medicine Clinical Pharmacology Laboratory.[b] Lower limit of quantification of the AP assay was 2.0 µg/mL. The inter- and intra-assay coefficients of variation were < 10%. Analysis was performed on single samples.

The variables, **time to maximum AP concentration (T_{max})** and the **appearance constant for AP (K_{app})** were determined by use of commercially available software.[c] A Wilcoxon signed rank test was used to compare the values for K_{app} and T_{max} with and without the indwelling NG tube. A commercially available statistical software package was used to analyze the data.[d] A value of $P < 0.05$ was considered significant.

Results

The median K_{app} for horses when the NG tube was not in place was 0.19 min^{-1} (range, 0.07 to 0.55 min^{-1}). The median K_{app} for horses when the NG tube was in place was 0.16 min^{-1} (range, 0.07 to 0.90 min^{-1}). The median difference in K_{app} between when the tube was not in place versus when the tube was in place was 0.01 min^{-1} (range, –0.48 to 0.80 min^{-1}); this difference was not significant ($P = 0.65$).

The median T_{max} for horses when the NG tube was not in place was 30 minutes (range, 15 to 75 minutes). The median T_{max} for horses when the NG tube was in place was 25 minutes (range, 10 to 45 minutes). The median difference in T_{max} between when the tube was not in place versus when the tube was in place was 5 minutes (range, –30 to 50 minutes). Subtraction of T_{max} values with the NG tube in place from T_{max} values without the NG tube in place revealed that only 1 horse had a negative difference in T_{max} and 1 horse had no difference in T_{max}. Although the remaining 7 horses had positive differences in T_{max} (ie, intubation expedited gastric emptying; **Figure 1**), this difference was not significant ($P = 0.07$).

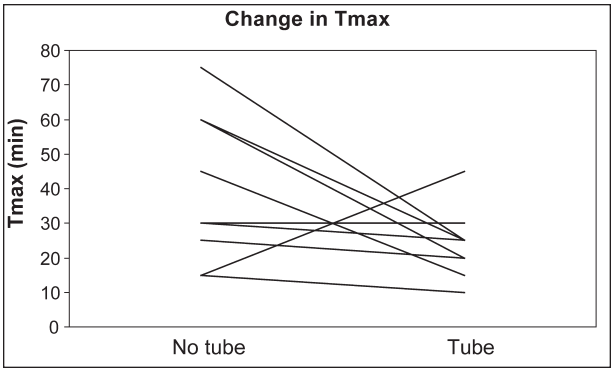

Figure 1—Time to maximum serum acetaminophen concentration(Tmax) of 9 horses with and without a nasogastric tube in place.

Our power to detect a difference of 10 minutes in T_{max} was approximately 90%; however, our power to detect a difference of 5 minutes was only approximately 33%. Because of the small study size and the possibility of outlier values, data from the horse with the negative difference in T_{max} were removed; the remaining data were reanalyzed. The median difference in T_{max} between when the tube was not in place versus when the tube was in place was then significant ($P = 0.03$); however, the difference in K_{app} was not significant ($P = 0.11$).

Discussion

In our study, no significant difference was found in gastric emptying rates between horses with an indwelling NG tube in place for 18 hours and horses without an indwelling NG tube. These findings are not what we predicted on the basis of reports[3,4] from human studies. A number of possible explanations for this discrepancy exist. The human studies involved duodenal intubation, whereas in our horses, the tube most likely remained in the stomach.[13] It is also possible that species differences exist in response to intubation. Furthermore, the duration of intubation (18 hours) may not have been sufficiently long to induce a delay in gastric emptying. Clinically ill patients requiring intubation may have the nasogastric tube in place for multiple days. A longer duration of intubation might exert a different effect on gastric emptying rates than we found in our study.

Stress related to the procedure of intubation immediately before testing might have impacted gastric emptying in control group horses such that their emptying times were delayed to an extent similar to the intubated horses. Physical restraint (lip twitch or skin twitch) was used as needed to divert the horse's attention during intubation. Not all horses were twitched because we wanted to induce as little stress as possible. If a horse required twitching to facilitate passing of the NG tube, it was twitched for the treatment as well as the control. We think the effect of stress is an unlikely

explanation of our findings because only minimal restraint was needed and horses did not appear subjectively to be distressed. In humans, stress does not cause a significant delay in gastric emptying.[14,15]

The authors are unaware of any previous studies in horses documenting the effects of an indwelling nasogastric tube on the liquid phase of gastric emptying. Lohmann et al[7,9] performed 2 studies on gastric emptying comparing the use of nuclear scintigraphy with AP absorption. Results from these studies indicate that only the absorptive indices T_{max} and K_{app} are significantly correlated with the half-time of liquid-phase gastric emptying. Therefore, we chose to evaluate these parameters.

Results of previous studies in horses[7,9] and humans[16] indicate that considerable variation exists among individuals in the parameters evaluated in our study. By use of a paired design and paired analysis, we minimized the effect of variation among horses. By comparing each horse to itself (each horse served as its own control), variation is minimized.

The extent to which our findings relate to diseased horses is not known. There could be a difference in the response to intubation of a healthy horse's stomach, compared with that of an ill horse, such as those with postoperative ileus. Neural and inflammatory pathways influence gastrointestinal tract motility and contribute to the pathogenesis of postoperative ileus.[17-20] Some or all of these same mechanisms may be present in horses with gastric reflux, thereby contributing to the amount of gastric contents produced.

In our study, it is possible that the intubated horses have a greater volume of residual gastric contents that could have resulted in dilution of AP and, hence, affect absorption parameters. However, to the authors' knowledge, no reliable method exists to detect a greater volume of residual gastric contents.

Endotoxemia causes a delay in gastric emptying in horses.[10-12] Endotoxemia is usually preceded by inflammation of the gastrointestinal tract. The neuronal and inflammatory pathways that cause ileus of the gastrointestinal tract are likely to be initiated when a horse has clinical signs of endotoxemia, including an increase in sympathetic nerve activity.[21]

Acetaminophen absorption has been validated as a measure of liquid-phase gastric emptying in horses.[7,9] Compared with nuclear scintigraphy, it is cheaper and safer and does not require specialized equipment. Liquid-phase emptying was chosen for our study because nearly all horses with clinical ileus have inappetence or have food withheld intentionally, making liquid emptying the clinically relevant parameter to measure. Alterations in intestinal blood flow as a result of endotoxemia may effect the absorption of AP.[22] Endotoxemia can alter splanchnic blood flow and effect hepatic metabolism, which could also effect serum concentrations of AP.[23] These factors are unlikely in our horses because the study was performed on clinically normal horses. In addition to effects of endotoxemia or splanchnic blood flow, the phase of gastric motility during which AP is administered to dogs influences the absorption of AP.[24] Differences in the phase of gastric motility during which AP was administered may have had an influence on the variability of AP absorption observed in our study.

Although we had limited power to detect a slight difference of 10 minutes between groups because of the small number of horses in the study, we feel that a difference of < 10 minutes in T_{max} is not likely to be clinically perceptible. The acceleration of emptying, although not significant, was nonetheless interesting. It is conceivable that an indwelling NG tube could expedite gastric emptying. One possible explanation for this would be if the tube pressing against the wall of the stomach stimulated stretch receptors that resulted in reflex acceleration of gastric emptying.

One horse in the group had a result that seemed to be the opposite of that observed for most horses. The reason for this is unknown. Although no overt clinical signs of disease were observed, a subclinical condition that affected gastric emptying could have altered our results. For reanalysis, data were excluded from the horse that had an increase in T_{max} and a decrease in K_{app}, with the tube in place relative to without the tube in place. When data from this horse were excluded, results of reanalysis revealed that the presence of the tube significantly decreased the T_{max} (ie, significantly expedited gastric emptying). Reasons for the presence of an indwelling tube expediting gastric emptying have been previously discussed. This horse may have had outlier values that reflected the interindividual variability in gastric emptying among horses. However, results obtained after excluding data from this horse should be interpreted with caution because we had no a priori or statistical (ie, absolute values for this horse's T_{max} and K_{app}) basis for excluding this horse's data.

In our study, no clinically important impact of 18 hours of nasogastric intubation was found on gastric emptying in healthy horses. If the same effects occur in ill horses as were observed in the horses of our study, there appears to be no negative effects of an indwelling NG tube for a period of approximately 1 day on gastric emptying.

a. Sigma-Alrich Biotechnology LP, St Louis, Mo.
b. List No. 9536-69 TDx/TDxFLx acetaminophen assay system, Abbott Laboratories, Diagnostic Division, Abbott Park, Ill.
c. WinNonlin, Pharsight Corp, Mountain View, Calif.
d. S-Plus 6.0, Insightful Inc, Seattle, Wash.

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