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Research Article

Agreement Between Epigastric Auscultation and pH Measurement in the Confirmation of Nasoenteral Tube Placement

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Abstract

AIM: This study aimed to evaluate the agreement between epigastric auscultation and pH measurement in the confirmation of nasoenteral tube placement.

METHOD: A cross-sectional study carried out in a medium-sized private hospital in the interior of the state of São Paulo. Forty-nine patients who were submitted to ninety insertion procedures and confirmation of tube placement. aimed at evaluating the agreement of clinical methods used by nurses to confirm the positioning of a nasoenteral tube inserted blindly at the bedside, by measuring the parameters of sensitivity, specificity, positive predictive value, and negative predictive value.

RESULTS: The epigastric auscultation was the method that presented the highest sensitivity (100.0%), but lower specificity (2.0%). The measurement of the pH presented lower sensitivity (63.0%) than the auscultation, however, higher specificity (58%). Moreover, the positive predictive value of the pH measurement was 55% and the negative predictive value was 66%. There was no agreement between the epigastric auscultation and the pH measurement with the radiography.

CONCLUSION: The pH measurement did not allow for distinguishing between gastric and enteric positioning, due to the similarity of the esophageal and pulmonary pH with the pH of the intestine. Furthermore, external factors such as the use of medication and reduced fasting time may interfere with the pH value.

Keywords: Enteral nutrition, gastrointestinal intubation, hydrogen ion concentration, radiography

Introduction

Nasoenteral tubes are devices inserted directly into the stomach or intestine to facilitate the administration of nutrients or medications (Boullata et al., 2017). In Brazil, according to the Brazilian legislation, Resolution No. 619 of 2019 of the Federal Council of Nursing, it is up to the nurse to determine the insertion location (stomach and intestine) of the nasoenteral tube in each patient. In addition, the nurse must consider the inherent risks of the tube and observe patient-related factors such as the severity of illness, duration of enteral nutrition, anatomy, and gastrointestinal motility (Conselho Federal de Enfermagem, 2019).

In an integrative literature review conducted in 2018, 69 studies were identified that addressed serious and fatal adverse events related to the insertion of these tubes. Of these, 44 reported harm to the patient caused by incorrect positioning of the enteral tube in the respiratory tract. These events were mainly related to failures in confirming the positioning of the distal tip of the tube inserted blindly at the bedside and to the inconclusive results of these methods (Motta et al., 2021).

Methods for confirming nasoenteral tube placement that is not based on the best evidence, such as epigastric auscultation, increase the risk for adverse events (Lyman and Healey, 2018). However, this method is widely used in practice and no evidence in the literature indicates that auscultation is effective in determining the exact tube positioning (AACN, 2016).

Among the existing clinical methods, measuring the pH of the aspirate is the most sensitive. The pH reference values are typically distinct in the lung, stomach, and intestines. The gastric pH is acidic, with values ranging from 1 to 5.5 (Metheny et al., 2019). Values equal to or above 6 are indicative of intestinal or respiratory aspirate, the latter being more alkaline (American Association of Critical-Care Nurses, 2016). Therefore, values smaller than 6 indicate the gastric position of the nasoenteral tube and exclude possible displacement of the tube into the lungs (Metheny et al., 2019). However, they do not exclude the possibility that the distal tip of the tube is located in the esophagus.

Radiography is considered the gold standard for distinguishing the gastric and pulmonary position of nasoenteral tubes

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in countries such as the USA and Canada. However, the exam needs to be interpreted by a professional specialized in radiology because there are reports in the literature of adverse respiratory events caused by failures in the interpretation of the exam. The exam must show the entire path of the tube in the gastrointestinal tract (GTI), at the main anatomical points, rather than just the tip of the tube in the stomach or intestine (NPSA, 2011).

When analyzing the nasoenteral tube insertion protocol in a medium-sized hospital in the countryside of the state of São Paulo, it was found that, in this hospital, all silicone tubes are measured for post-pyloric positioning, regardless of the patient's characteristics, and that the clinical method used to confirm the position of the newly inserted tube at the bedside is epigastric auscultation followed by radiography (Duarte, 2020).

Given the above, this study aims to evaluate the agreement of clinical methods (epigastric auscultation and pH measurement of the gastric aspirate) to confirm the positioning of newly inserted blind nasoenteral tubes at the bedside in comparison with radiography.

Method

Study Design

This is a cross-sectional study to evaluate the agreement between the clinical methods (epigastric auscultation and pH measurement of the gastric aspirate) used by nurses to confirm the placement of the nasoenteral tube. The Standards for the Reporting of Diagnostic Accuracy Studies (STARD) guidelines for studies on diagnostic accuracy were used to evaluate the integrity and diagnostic accuracy of the methods (Cohen et al., 2016).

Sample

The study was conducted in a medium-sized private hospital located in the city of Franca, São Paulo, Brazil. It is a reference hospital in medium and high complexity care, accredited by the National Accreditation Organization and the Instituto Qualisa de Gestão, with 120 beds, clinical and surgical. The medical and surgical clinics and the emergency medical care were selected because they assist adult patients who need the insertion of nasoenteral tubes, performed by nurses, blinded. The study was conducted from January 2018 to June 2020.

Patients aged 18 years or older and with an indication for nasoenteral tube use during hospitalization and/or at emergency medical care were included.

Convenience sampling was used, which included all adult hospitalized patients who required a nasoenteral tube during their hospitalization and/or those who required a nasoenteral tube during their emergency department visit. A total of 49 patients were included in the study, in which 90 nasoenteral tube insertion procedures were observed. These patients met the inclusion criteria and voluntarily agreed to participate in the research by providing written consent (Hulley, 2015).

Data Collection Tools

An electronic form was prepared to contain therapeutic variables composed of dichotomous alternatives (yes or no) for restrictions in the ingestion of proton pump inhibitor and/or H2 receptor antagonist drugs, liquid and solid food, epigastric auscultation, and obtaining gastric aspirate. The time spent, in minutes, for the nasoenteral tube procedure, obtaining the gastric aspirate, measuring the pH, and taking the radiography was counted. The pH value (1 to 14) and the position of the distal tip of the tube were also checked by radiography (projection at the esophagogastric, gastric, enteric, or post-pyloric junction and non-visible tube). The electronic form was reviewed by five judges, regarding face and content, and a pilot study was conducted to assess its suitability.

Data Collection

Execution and Sequence of Clinical Methods

The clinical methods performed by the researcher in the study to confirm the nasoenteral tube placement were: (i) epigastric auscultation and (ii) pH measurement of the gastric aspirate, following this same sequence of execution (i and ii). The auscultation method was performed according to the institutional protocol, which consisted of placing the stethoscope in the epigastric region, injecting from 10 to 20 mL of air through the tube, and performing simultaneous auscultation of the borborygmus sound.

The method for measuring pH was performed by the researcher and based on the flow chart proposed by the UK's National Patient Safety Agency (NPSA, 2011) which consists of gently aspirating the gastric residue with a 20 mL syringe; testing the aspirated residue on a pH indicator reagent tape for use in human gastric aspirate; and verifying the test result (the pH should indicate between 1 and 5). In the absence of the aspirate, the following auxiliary techniques were used, in sequence: (i) position the patient in DLE; (ii) inject 10–20 mL of air through the tube; and (iii) wait 15–30 minutes before aspirating again.

After performing both methods (i and ii), the researcher, all patients underwent abdominal radiography, considered the gold standard for confirming the placement of nasoenteral tubes. Subsequently, the reports were prepared by a radiologist and a thoracic and abdominal specialist, according to the flowchart (Figure 1).

We emphasize that the nasoenteral tubes were inserted in the patients by the nurses of the hospital according to the institutional protocol (the length of the tube used consisted of: the tip of the nose to the earlobe and from the earlobe to the xiphoid appendix plus 20 cm to the mark) (Lyman and Healey, 2018; Turgay & Khorshid, 2010), the same type and brand of the enteral tube was used (12-French caliber tubes, made of silicone, transparent, radiopaque, and with a distal Tungsten tip. The guide wire was stainless steel with a polyurethane tip with silicone-based lubricant).

Statistical Analysis

To evaluate the agreement between clinical methods (epigastric auscultation and pH measurement) and radiography in determining the correct positioning of the nasoenteral tube,

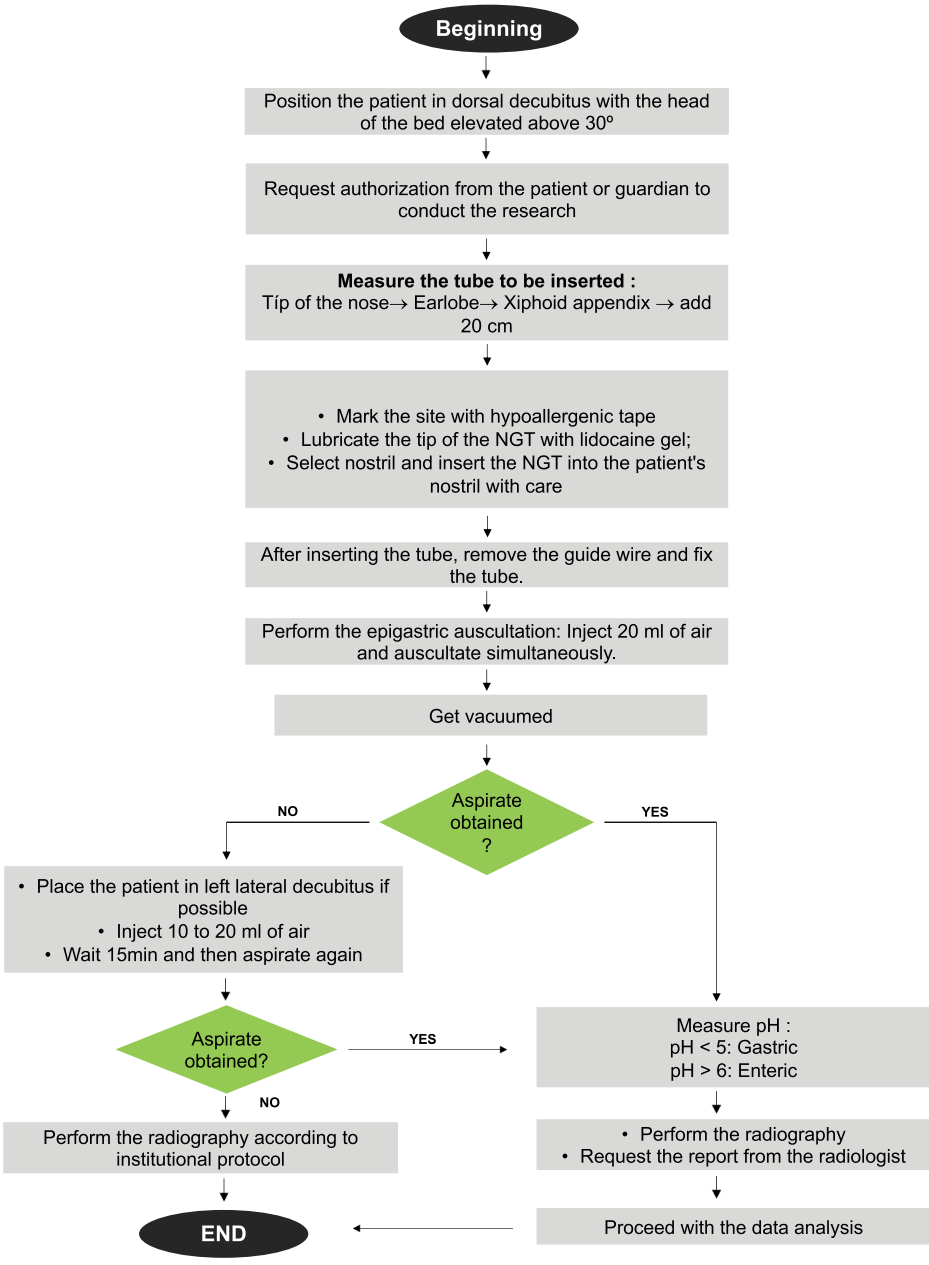

Figure 1.
Nasogastric Tube Positioning Verification Flow.

the AC1 statistic developed by Gwet was used (Gwet, 2008; Metheny et al., 2019). In the case of pH measurement, the gastric position of the nasoenteral tube was considered when the values were in the range of 1 to 5. The nasoenteral tube was considered in the enteric position when pH values were above 6. In addition to assessing agreement, positive predictive value (PPV) and negative predictive value were also calculated.

Ethical Considerations

The project was approved by the Research Ethics Committee on January 29, 2019 (CAAE no. 03240918.3.0000.5393). All patients included in the research accepted to participate voluntarily and in accordence with the ethics and research committee.

Results

Forty-nine patients participated in the study, and 90 tube insertion procedures were performed.Everyone agreed to participate voluntarily.

The radiography was performed after all procedures (90; 100.0%), and their results showed that most nasoenteral tubes were in enteric or post-pyloric position (46; 51.1%) (Table 1).

Table 1.
Distribution of Variables Related to Clinical Methods Used in the Confirmation of Nasoenteral Tube Placement (N = 90)

	Frequency	
Variables	***n***	**%**
Epigastric auscultation		
+	89	98.9
–	1	1.1
Gastric aspirate obtained		
Yes	81	90.0
No	9	10.0
Time to obtain the aspirate		
<15 minutes	63	77.8
>15 minutes	18	22.2
Not obtained	9	10.0
pH value		
<5	42	46.6
>6	39	43.3
Not obtained	9	10.0
Nasoenteral tube projection by x-ray		
Enteric or postpyloric	46	51.1
Gastric	41	45.6
EGJ	2	2.2
Not visible	1	1.1
pH < 5 (*n* = 42)		
Stomach	23	54.8
Intestine or postpyloric	19	45.2
EGJ	0	0.0
Not visible	0	0.0
pH > 6 (*n* = 39)		
Intestine or postpyloric	24	61.5
Stomach	12	30.8
EGJ	2	5.1
Not visible	1	2.6
Not measured (*n* = 9)		
Stomach	6	66.7
Intestine or postpyloric	3	33.3
EGJ	0	0.0
Not visible	0	0.0

Note: EGJ = Esophagogastric junction.

Regarding the clinical methods used to confirm the position of the nasoenteral tubes, gastric aspiration was obtained in 81 (90.0%), the values were <5 in 42 (46.6%), and the mean was 2.7 (2 ± 1.4). In 39 (43.3%) procedures, the pH result was greater than 6 and the mean was 7.2 (7 ± 0.8). The mean time spent to confirm the position of the tube by this method was 56.8 minutes (35.5 + 64.3).

For pH measurement, information was collected on the use of receptor antagonists and fasting time. In 84 (93.3%) procedures, the patients were not using H2 receptor antagonists or had not used these drugs in the four hours before data collection. Regarding fasting time, all patients (90; 100.0%) had not consumed food or liquids for two hours and had no solid food for at least four hours.

Of the total nasoenteral tubes with pH value < 5 (42; 46.6%), 23 (54.8%) were positioned in the stomach according to the radiography. Also, of the total number of nasoenteral tubes with a pH value > 6 (39; 43.3%), the majority (24, 61.5%) were actually in the intestine. In nine (10.0%) procedures, it was not possible to obtain the aspirate to measure the pH, and in six (66.7%) of these cases, the tube was positioned in the stomach.

The epigastric auscultation was positive in 89 (98.9%) procedures, although radiography revealed that in only 41 (46%) the distal tip was positioned in the stomach, of which 12 (30.7%) had pH > 6.

Of the total number of tubes with the distal tip projecting into the intestine on a radiograph (46; 51.1%), all presented positive auscultation (46;100%), 24 (61.5%) presented pH > 6, and 19 (45.2%) presented pH < 5, revealing discordance between clinical methods and radiography (Figure 2).

In two (2.2%) procedures, auscultation was positive, pH was higher than 6, and the tube was positioned in the esophagogastric junction (EGJ). In one (1.1%) procedure, it was not possible to visualize the distal tip of the tube or its path.

Among the two clinical methods used in this study to confirm the tube placement, epigastric auscultation showed greater sensitivity (100.0%); however, specificity was lower (2.0%) compared to pH. Positive auscultation suggested that the tube was in the stomach, when in fact it was in the intestine (46; 51.1%) or in the EGJ (2; 2.2%). In one of these cases, the location of the distal tip of the tube could not be verified by radiography. The pH, when compared to auscultation, showed lower sensitivity (63.0%), but higher specificity (58.0%) and PPV (55%) (Table 2).

There was no agreement between epigastric auscultation and radiography, according to the AC1 statistic developed by Gwet (AC1 = 0.109; $p = .372$), and neither between the pH measurement and the radiological examination (AC1 = 0.206; $p = .066$) (Table 3).

Discussion

All tubes inserted in the patients of this study were measured for positioning in the bowel because it is an institutional protocol. The American Society for Parenteral and Enteral Nutrition clarifies that the nasoenteral tube is not indicated for all patients. These tubes are appropriate for people with pyloric obstruction,

Auscultation	pH	Radiography
+	2	Enteteric protection

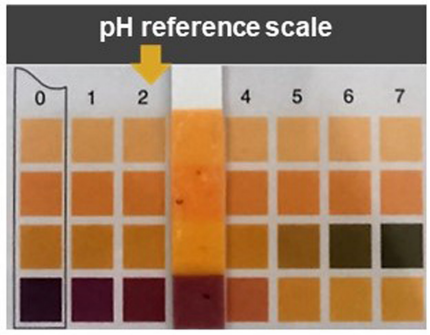

Figure 2.
Disagreement Between the pH Value and the Radiography, With the Tube in Enteric Positioning.

severe gastroparesis, reflux, and aspiration suggestive of gastric contents (Boullata et al., 2017; Lord, 2018).

In a literature review of 14 international guidelines, radiography was considered the most accurate method, although it is not routinely recommended in all patients and health services, and may not be an option for in-home care and long-stay institutions (Metheny et al., 2019).

In contrast to radiography, the pH measurement, besides being easy to apply, presents results in a few minutes. The method can be performed at the bedside, at home, in acute care, or long-stay institutions, besides being less expensive and reducing the patient's exposure to radiation (Metheny et al., 2019).

It was possible to measure the pH in 90.0% of the procedures, whose values were <5 in 46.6%. The pH of the stomach ranges from 1 to 5, while the pH of the lungs and intestine is equal to or greater than 6. Thus, pH measurements less than or equal to 5.5 are indicative of gastric positioning. However, some medications, as well as prolonged fasting and enteral feeding, can alter the pH of the stomach, limiting the use of the method (Boeykens et al., 2014). Furthermore, factors such as bleeding or obstruction of the GTI can alter the pH, making the method unfeasible in certain patients. According to researchers, pH < 5 precludes the pulmonary placement of a nasoenteral tube (Boeykens et al., 2014; Metheny et al., 2019). However, in this study, pH < 5 was identified in tubes positioned in the intestine (21.1%).

In a research carried out to evaluate the confirmation of the positioning of nasoenteral tubes inserted in patients in intensive care units, the authors found that the pH measurement was not accurate, since many factors could have contributed to the alteration of the test (Moore & Thomson, 2013). In the study by Turgay and Khorshid, 60% of the patients receiving H2 receptor antagonists had pH values < 6, suggesting that some drugs, such as antacids, may increase the pH value (Turgay & Khorshid, 2010).

Table 2.
Results of the Accuracy Analysis of Two Clinical Methods Used to Confirm the Position of the Newly Inserted Nasoenteral Tube Blindly at the Bedside (N = 90)

	Total (*N* = 90)					
Method	**Correct**	**Incorrect**	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**
Auscultation						
+	40	49	100.0	2.2	46.0	100.0
–	1	0				
pH						
+	23	58	62.8	58.1	55.0	65.7
–	6	3				

Note: PPV = Positive predictive value; NPV = Negative predictive value.

Table 3.
Results of the Agreement Analysis Between Clinical Methods (Epigastric Auscultation and pH Measurement) and Radiography, According to the AC1 Statistic Developed by Gwet

	Total (*N* = 90)			
Method	**Correct**	**Incorrect**	**AC1**	***p***
Radiography	–	–	–	–
	41 (45.6)	49 (45.4)	–	–
Auscultation			–	–
	40 (44.4)	50(55.6)	0.119	.372
pH				
	23 (26)	67 (74)	0.206	.066

Note: AC1 = First-order agreement coefficient.

Regarding the clinical methods used to confirm the position of the nasoenteral tube measured for enteric or post-pyloric positioning, epigastric auscultation was positive in 98.9% of the procedures, although the tube was positioned in the bowel in 51.1%. The results corroborate with a study conducted in 2015. The study showed that there was no agreement between epigastric auscultation and radiography in confirming the positioning of the nasoenteral tube in the gastric position. The authors concluded that the method should not be used in isolation, because the sound, caused by the inflated air, can be radiated regardless of whether the tube is positioned in the lung, esophagus, stomach, duodenum, or jejunum (Beghetto et al., 2015). In addition, the absence of signs of respiratory distress does not confirm the correct position of the tube in the stomach, since some patients show no signs of respiratory distress when the tube is inadvertently inserted into the respiratory tract (Metheny et al., 2019).

In this study, there was disagreement between the two clinical methods used to confirm nasoenteral tube position compared to radiography, considered the gold standard in confirming the positioning of newly inserted tubes blindly at the bedside. The results corroborate those of other studies (Boeykens et al., 2014; Kim et al., 2012; Moore & Thomson, 2013; Tai et al., 2016).

The epigastric auscultation presented high sensitivity (100%), but low specificity (2%) and there was no agreement between this method and the radiography ($p = .372$). Kim et al. also found a sensitivity of 100% for epigastric auscultation, but the specificity was 33.3% (Kim et al., 2012). In another study, the authors found a sensitivity of 79% and a specificity of 61% (Boeykens et al., 2014). The three studies demonstrated high sensitivity of the auscultatory method; however, in this study, the specificity value was lower than the other two studies. This result may be related to the length of the tube used in all patients (tubes measured for enteric positioning) since the tip of the tube was positioned directly in the bowel in 51.1% of the procedures performed blinded at the bedside. In two studies, all tubes were measured for gastric positioning (Boeykens et al., 2014; Kim et al., 2012; Moore & Thomson, 2013).

Researchers have shown that epigastric auscultation was little concordant with radiography images and recommended not using it alone but combined with other more sensitive and accurate methods, such as pH (Boullata et al., 2017; Lord, 2018).

In this study, pH showed lower sensitivity (63.0%) compared to epigastric auscultation, but higher specificity (58.0%) and PPV (55%). However, there was no agreement between this method and radiography ($p = .066$).

In a study by Kim et al., auscultation presented a sensitivity of 100% and specificity of 33.3%, while pH presented a sensitivity of 55.1% and specificity of 66.7%, both compared to radiography (Kim et al., 2012). These results are similar to this study, except for auscultation, which presented a specificity of 2%.

In a research conducted by Tai et al. (2016), the epigastric auscultation presented a sensitivity of 91.3% and specificity of 100%, while the pH presented a sensitivity of 55.1% and specificity of 100% (Tai et al., 2016). As it was not possible to obtain the aspirate in all patients, and the pH measurement presented false-positive results, the method was not recommended by the researchers. In all these studies, the researchers did not discard the use of the epigastric auscultation method in the confirmation of the tube positioning but recommended that it be associated with other non-radiological methods, such as ultrasonography (Kim et al., 2012; Tai et al., 2016).

Several studies have demonstrated the diagnostic accuracy of pH measurement, alone or combined with other methods, to distinguish between gastric and enteric tube positioning (Boeykens et al., 2014). The American Association of Critical Care Nurses (AACN) recommends the association of at least two methods at the bedside, while the NPSA recommends only pH measurement. For patients using a feeding tube positioned in the bowel, confirmation of the positioning must be done exclusively by radiography or endoscopy (AACN, 2016; Metheny et al., 2019; NHS, 2016; NPSA, 2011).

The results of this study point to important gaps in both methods that may expose patients to risks. In research, radiography is considered the first-line method in countries such as the United States of America and Canada (Metheny et al., 2019). In Europe and Australia, this test is performed only when the result of the pH measurement is inconclusive or when the patient presents a high risk of aspiration. Four of these guidelines pointed out that a pH between 1 and 5.5 indicates the gastric position and can replace radiography in patients with a tube measured for positioning in the stomach (Metheny et al., 2019).

According to the researchers, radiography is the most accurate method to distinguish the gastric and pulmonary position of a nasoenteral tube (Metheny et al., 2019). However, the exam needs to be interpreted by a professional specialized in radiology, since there are reports in the literature of adverse respiratory events caused by failures in the interpretation of the exam by the medical professional (AACN, 2016; Metheny et al., 2019; NPSA, 2011; Singh et al., 2019). Furthermore, accurate confirmation of position by this method requires checking the entire path of the tube at major anatomical landmarks, rather than just the tip of the tube (Lyman and Healey, 2018).

Study Limitaions

The limitations of the study include the relatively small sample size, the absence of precise information about the fasting time, and the use of medications that may have interfered with the pH result. Another limitation is related to the time to obtain the aspirate, which was not predetermined since the study focused on the agreement of clinical methods used to confirm the position of nasoenteral tubes inserted blindly at the bedside.

Conclusion and Recommendations

There was no agreement between epigastric auscultation and pH measurement with radiography in confirming the positioning of newly inserted nasoenteral tubes blindly at the bedside. The methods presented important limitations that may expose patients to risks.

Epigastric auscultation, although widely used in clinical practice, showed a specificity of 2% and is not recommended in clinical practice. However, in places where auscultation is still used, it is recommended to associate it with another method, such as radiography.

In this study, pH did not allow for distinguishing between gastric and enteric positioning due to the similarity of the esophageal and pulmonary pH with the pH of the intestine. Furthermore, external factors such as the use of medication and reduced fasting time may interfere with the pH values.

It is hoped that the results of this study can be used by the hospital leadership and incorporated into the institutional protocols to guide professionals in the area and reduce the risks related to the malposition of enteral tubes.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of School of Nursing of Ribeirão Preto, University of São Paulo. (Approval no: 03240918.3.0000.5393, Date: January 29, 2019).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – J.M.M.D., F.R.E.G.; Design – J.M.M.D., F.R.E.G.; Supervision – F.R.E.G.; Resources – J.M.M.D.; Materials – J.M.M.D.; Data Collection and/or Processing – J.M.M.D.; Analysis and/or Interpretation – J.M.M.D., A.R.R., M.C.G.R., R.A.P., F.R.E.G.; Literature Search – J.M.M.D., A.R.R., M.C.G.R., R.A.P., F.R.E.G.; Writing Manuscript – J.M.M.J., A.R.M., M.C.G.R., R.A.P., F.R.E.G.; Critical Review – J.M.M.D., A.R.R., M.C.G.R., R.A.P., F.R.E.G.

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