Cogitare Enfermagem

ORIGINAL ARTICLE

Ultrasound in the assessment of enteral tube positioning in critically ill patients: accuracy compared to radiography

HIGHLIGHTS

1. Bedside ultrasound is effective in locating the enteral tube.
2. The fogging test was the most accurate criterion.
3. Gastric aspiration was effective in confirming the placement of the tube.
4. The fogging test was superior to the gastric aspirate.

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ABSTRACT

Objective: To analyze the accuracy of criteria for confirming the positioning of the enteral tube in the gastric position in critically ill patients via bedside ultrasound, compared to abdominal radiography. **Method:** an observational, cross-sectional, descriptive, exploratory, and quantitative study carried out at a university hospital in Rio de Janeiro - Brazil, from March to July 2024. Data was analyzed descriptively and exploratorily. **Results:** among the criteria used to verify the positioning of the enteral tube in the gastric antrum, the fogging test showed an accuracy of 91.30%, being the criterion with the highest agreement with abdominal radiography. **Conclusion:** The fogging test was more effective than ultrasound alone. The study made it possible to expand clinical assessment by nurses, strengthen autonomy and value advanced practice, minimize risks and confirmation time, as well as optimize cost-effectiveness and efficiency in care.

DESCRIPTORS: Ultrasonography; Intubation, Gastrointestinal; Radiography, Abdominal; Intensive Care Units; Nursing Care.

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INTRODUCTION

Technological imaging devices have been used in healthcare, revolutionizing the way patients are monitored. Among these devices, point-of-care ultrasound (POCUS) stands out for being a non-invasive method, performed at the bedside with real-time interpretation, and which does not need to expose the patient to ionizing radiation to obtain images[1]. When used by nurses with advanced skills and knowledge, POCUS is a powerful tool for semiology, capable of providing ultrasound images quickly and accurately[2].

Federal Nursing Council (COFEN) Resolution No. 0679 of 2021 regulates the use of POCUS in hospital and pre-hospital settings by nurses, provided they are trained. In this context, the use of ultrasound by nurses, as an auxiliary resource in the execution of procedures of greater technical complexity, has the potential to increase safety for both professionals and users[3].

POCUS can be used in a wide range of nursing applications, such as assessing urinary volume, and gastric residual volume to prevent pneumonia due to broncho-aspiration, confirming the passage of a bladder catheter, among others, and for invasive procedures such as peripheral venipuncture, an arterial puncture for the insertion of arterial catheters, the passage of feeding tubes, as well as confirming their positioning[2].

The use of a Nasoenteral Tube (NET) is a practice carried out in the in-hospital environment and has various indications, depending on the patient's needs, such as the administration of medication, hydration, gastric decompression, adequate nutritional intake for critically ill patients who are unable to eat orally, among others[4].

Despite being a routine practice, it is a procedure that involves risks for the patient, both when the tube is inserted and after it has been completely passed through, which can lead to injuries in the nasal and oropharyngeal cavities, stenosis and perforation of the esophagus, pneumothorax, insertion into the bronchi, making aspiration pneumonia and broncho-pulmonary infection possible. According to current legislation, this is a private practice for nurses as part of the nursing team, and the nursing technician is responsible for assisting and maintaining the device[5].

To ensure the safe insertion of the NET and its use, avoiding the complications mentioned above, it is necessary to follow the steps of the procedure and confirm the positioning of the tube. Abdominal radiography is still considered the gold standard for verifying the proper location of the enteral tube; however, delays in obtaining radiographic results can result in delays in administering the enteral diet and/or medication, due to the lack of immediate availability, as well as being a method that exposes the patient to radiation[6].

In this sense, ultrasound (USG) can be used to assess the insertion and positioning of naso/orogastric tubes in the ICU. The practicality of POCUS arises when the disadvantages of radiography are highlighted, although there is a need for a portable ultrasound machine to be available in the sector in question, and for a trained professional to use it, interpret the findings, and relate the images to the patient's clinical condition[6].

It is worth mentioning that, in addition to radiography, there are other techniques commonly used to confirm the positioning of the enteral tube, such as capnography, which identifies the presence of carbon dioxide when the tube is positioned in the respiratory tract; aspiration of gastric contents, to visualize its appearance and/or measurement of Hydrogen potential (pH), presence of cough or dyspnea, among others[7].

The Brazilian Society of Parenteral and Enteral Nutrition (BRASPEN) Guideline on Oral, Enteral, and Parenteral Nutritional Therapy recommends that the professional responsible for installing the device performs the aforementioned confirmation techniques before requesting the X-ray, to ensure a more assertive procedure. It is worth noting that gastric auscultation tests and immersing the tip of the tube in a glass of water are no longer recommended due to the difficulty in distinguishing the sound produced in the gastrointestinal tract from the respiratory tract, and the risk of broncho-aspiration[7].

USG is a promising method for confirming enteral tube positioning and is being introduced into clinical practice as the fifth element of the physical examination, aiding clinical reasoning and the development of nursing diagnoses and interventions[2]. Thus, the justification for the study arose from the researchers' concern about the blind positioning of the enteral tube, which puts patient safety at risk, the criteria currently used to confirm the positioning of the enteral tube, and the frequent radiation to which patients are subjected in Intensive Care Units. (ICUs).

The research aims to contribute to providing evidence on the accuracy of using bedside ultrasound to determine the positioning of the enteral tube in the gastric position, compared to radiography, the gold standard method, by promoting evidence-based clinical practices and improving patient safety in critical settings.

Thus, the research hypothesis of this study is that bedside ultrasound-guided enteral tube feeding in critically ill patients is effective in adjusting the positioning of the tube, when compared to abdominal radiography. Based on the above, the study aimed to analyze the accuracy of criteria for confirming enteral tube positioning in critically ill patients via bedside USG, compared to abdominal radiography.

METHOD

This is an observational, cross-sectional, descriptive, exploratory study with a quantitative approach, carried out in three clinical-surgical ICUs of a university hospital located in the city of Rio de Janeiro (RJ), Brazil, between March and July 2024.

The researcher who collected the data and passed the enteral tubes meets the requirements for the use of ultrasound devices, the evaluation of ultrasound findings for decision-making within the scope of nursing, and the performance of ultrasound-guided nursing procedures.

The participants were patients admitted to the hospital's ICUs during the data collection period. Patients over 18 years of age and with a medical indication and prescription for an enteral tube were included. Patients with malignancies/malformations affecting the gastrointestinal tract, patients with an indication for post-pyloric probing by endoscopy, previous surgery on any part of the gastrointestinal tract, and those with any conditions preventing ultrasound examination of the abdomen, such as the presence of wounds/wound dressings, were excluded from this study.

Data was collected by filling in a Google Forms form. After the indication and medical prescription for an enteral tube, the materials for the procedure were organized and the patient was prepared. It should be noted that both data collection and the insertion of the enteral tube were carried out by a single researcher, and all participants received the same intervention. The passage of the enteral tube followed the institution's

protocol, introduced up to the previously established marking, and then scanned in the epigastric region with the low-frequency convex transducer (2-5MHz) in the transverse and longitudinal axis, in an attempt to locate the gastric antrum positioned posteriorly and inferiorly to the margin of the left lobe of the liver and anteriorly to the inferior vena cava or abdominal aorta. After locating the anatomical reference points, the transducer was tilted towards the subcostal area to visualize the gastric antrum[8-11].

The location of the enteral tube in the gastric antrum was visualized as a double hyperechoic linear image when using the longitudinal axis, or as a hyperechoic circle when using the transverse axis. The following procedures were then carried out to confirm the location: the gastric aspirate test to visualize the color of the contents, which varied between clear, colorless, greenish, and brown. It should be noted that this test is considered a confirmation technique prior to abdominal radiography, as recommended by BRASPEN[7,9].

The second test was the rapid injection of 50 milliliters (ml) of air through the enteral tube with the transducer positioned so as to visualize the gastric antrum being taken over by a dynamic nebulization or "flash of air"[9,12-13]. The enteral tube was properly secured, the guide wire was removed, and an abdominal X-ray was requested to confirm the standardized positioning. The enteral tube was only released for use after radiographic confirmation by the doctor, in accordance with institutional standards.

The data collected on the Google Forms form was exported to a Microsoft Office Excel version 2021 spreadsheet and then analyzed descriptively and exploratorily using Stata/IC v.16 software, which calculated proportions for categorical variables and measures of position and dispersion for quantitative variables. To consider the adequacy of the positioning of the enteral tube in the gastric position by bedside ultrasound, the distributions of the variables were compared using the two criteria adopted in this study: location of the tube in the gastric antrum by USG, nevus sign visualized in the gastric antrum with the injection of 50ml of air and only nevus sign visualized in the gastric antrum with the injection of 50ml of air.

The proportions of agreement were calculated, along with the respective 95% Confidence Intervals (CI), between the criteria evaluated and the reference standard, which is the radiographic examination. Fisher's exact and chi-square tests of independence were used to verify the association between sociodemographic and clinical characteristics and the appropriate positioning of the NET, considering the criteria adopted in this study. The results made it possible to indicate which of the criteria showed greater agreement compared to the reference standard. The significance level adopted throughout the analysis was 5%.

The study was approved by the Research Ethics Committee (REC) of the State University of Rio de Janeiro (UERJ), under CAAE number 76775423.2.0000.5282 and approval number 6.681.760, in accordance with Resolution 466/12 of the National Health Council (NHC) of the Ministry of Health[14].

RESULTS

Twenty-three patients took part in the study, with a predominance of males and a predominant age range of 26 to 59 years. Respiratory tract diseases were the most prevalent diagnoses. Most of the patients had an orotracheal tube or tracheostomy and were on mechanical ventilation (Table 1).

Table 1. Sociodemographic and clinical characterization of the participants. Rio de Janeiro, RJ, Brazil, 2024

Variables	n	%
Sex		
Female	9	39.13
Male	14	60.87
Age group		
26 to 59 years old	13	56.52
60 years old and over	10	43.48
Diagnostics		
Respiratory Tract Diseases	8	34.78
Others	8	34.78
Renal Diseases	4	17.39
Cardiovascular Diseases	3	13.04
Ventilation		
OTT[†]	11	47.83
TQT[‡] + mechanical ventilation	5	21.74
Oxygen support	4	17.39
Ambient air	3	13.04
Level of consciousness (patients without sedation)		
Awake	8	72.73
Confused	1	9.09
Drowsy	1	9.09
Torporous	1	9.09
RASS[§] (patients with sedation)		
-5	6	50.0
-4	4	33.33
-3	1	8.33
+1	1	8.33

Caption: [†] Tubo orotraqueal; [‡] Traqueostomia; [§] Richmond Agitation and Sedation Scale.
Source: The authors (2024).

Table 2 shows the characterization of the tubing and tube positioning performed on the participants. The most frequent indication for probing was feeding/medication of sedated/intubated patients, with a predominance of nasal probing. The average measurement mark for the introduction of the NET, in centimeters, was 64, with a minimum of 50 and a maximum of 70. The convex transducer was the only one used to visualize the gastric antrum, with the transverse axis predominating. The abdominal X-ray confirmed the correct positioning of the enteral tube in all participants, and the nevus sign visualized in the gastric antrum was more accurate in locating the tube than the abdominal X-ray findings.

Table 2. Characterization of tubing and tube positioning in participants. Rio de Janeiro, RJ, Brazil, 2024

Variables	n	%
Tube indication		
Feeding/medication of sedated/intubated patients	9	39.13
Feeding/medication of patients with swallowing complications due to mechanical or motor issues	7	30.43
Other indications	7	30.43
Passageway		
Nasal	21	91.3
Oral	2	8.7
Positive gastric aspirate test		
Yes	18	78.26
No	5	21.74
Transducer used for insonation of the gastric antrum		
Convex	23	100.0
Best axis used for insonation of the gastric antrum		
Transversal	13	56.52
Longitudinal	10	43.48
The enteral tube was located in the gastric antrum by USG†		
Yes	14	60.87
No	9	39.13
Fogging test visualized in gastric antrum		
Yes	21	91.3
No	2	8.7
NET‡ confirmed in gastric position by abdominal x-ray		
Yes	23	100.0

Variable	Mean (±SD)	Median (IIQ)	Minimum/ Maximum
Length of measurement	64.13 (±7.17)	65 (15)	50/ 75

Caption: † Ultrasound; ‡ Nasoenteral tube.
Source: The authors (2024).

Table 3 shows the analyses of the association between sociodemographic and clinical characteristics and the appropriate positioning of the NET by USG, contrasting the findings between the use of double criteria (location of the tube in the gastric antrum and nevus sign visualized in the gastric antrum), and single criteria (nevus sign visualized in the gastric antrum).

Regardless of the criteria used, the appropriate positioning of the tube was not associated with sex, age group, diagnosis, type of ventilation, level of consciousness, indication of the tube, and the best axis used for insonation of the gastric antrum. The route by which the tube was passed was associated with proper tube positioning in both diagnostic criteria.

Table 3. Association between verification of adequate NET positioning by USG and sociodemographic and clinical characteristics. Rio de Janeiro, RJ, Brazil, 2024

Variable	Positioning appropriate - gastric antrum + Fogging test		p-value	Proper positioning - Fogging test		p-value
	Yes n (%)	No n (%)		Yes n (%)	No n (%)	
Sex			0.311‡			0.742‡
Female	7 (77.78)	2 (22.22)		8 (88.89)	1 (11.11)	
Male	8 (57.14)	6 (42.86)		13 (92.86)	1 (7.14)	
Age group			0,673†			0.846‡
26 to 59 years old	8 (61,54)	5 (38,46)		12 (92,31)	1 (7,69)	
60 years and over	7 (70,0)	3 (30,0)		9 (90,0)	1 (10,0)	
Diagnostics			0,723‡			0.757‡
Respiratory Tract Diseases	6 (75.0)	2 (25.0)		7 (87.5)	1 (12.5)	
Others	4 (50.0)	4 (50.0)		6 (85.71)	1 (14.29)	
Renal Diseases	3 (75.0)	1 (25.0)		4 (100.0)	0	
Cardiovascular Diseases	2 (66.67)	1 (33.33)		4 (100.0)	0	
Type of ventilation			0.314‡			0.496‡
OTT§	7 (63.64)	4 (36.36)		9 (81.82)	2 (18.18)	
TQT†† + Mechanical ventilation	2 (40.0)	3 (60.0)		5 (100.0)	0	
O2 support	4 (100.0)	0		4 (100.0)	0	
Ambient air	2 (66.67)	1 (33.33)		3 (100.0)	0	
Level of consciousness			0.898‡			0.087‡
Awake	5 (62.5)	3 (37.5)		8 (100.0)	0	
Other	2 (66.67)	1 (33.33)		2 (66.67)	1 (33.33)	
Sedated			0.879†			0.949‡
Yes	8 (66.67)	4 (33.33)		11 (91.67)	1 (8.33)	
No	7 (63.64)	4 (36.36)		10 (90.91)	1 (9.09)	
Tube indication			0.319‡			0.495‡
Feeding/medication of sedated/ intubated patients	7 (77.78)	2 (22.22)		9 (100)	0	
Feeding/medication of patients with swallowing complications due to mechanical or motor issues	5 (71.43)	2 (28.57)		6 (85.71)	1 (14.29)	
Other indications	3 (42.86)	4 (57.14)		6 (85.71)	1 (14.29)	
Passage of NET ‡‡			0.043‡			0.020‡
Via nasal	15 (71.43)	6 (28.57)		20 (95.24)	1 (4.76)	
Via oral	0	2 (100.0)		1 (50.0)	1 (50.0)	
Best axis used for insonation of the gastric antrum			0.179†			0.648‡
Transversal	10 (76.92)	3 (23.08)		19 (90.48)	2 (9.52)	
Longitudinal	5 (50.0)	5 (50.0)		2 (100.0)	0	

Legenda: § Tubo orotraqueal; †† Traqueostomia; ‡‡ Sonda nasoenteral.

Fonte: As autoras (2024).

Table 4 shows the agreement between proper positioning determined by abdominal X-ray, considered the gold standard, and four other criteria for proper positioning of the enteral tube, in order of accuracy: fogging test, gastric aspirate test, fogging test visualized in the gastric antrum concomitant with USG visualization of the gastric antrum, and USG localization of the tube in the gastric antrum.

Table 4. Concordance between criteria to define tube positioning and abdominal radiography. Rio de Janeiro, RJ, Brazil, 2024

Criteria for positioning the enteral tube	Concordance with abdominal X-ray	
	n (%)	IC95%
Fogging test visualized in the gastric antrum	21 (91.30%)	71.96%; 98.92%
Gastric aspirate test	18 (78.26%)	56.29%; 92.53%
Fogging test visualized in gastric antrum + ultrasound localization of tube in the gastric antrum	15 (65.22%)	42.73%; 83.62%
Ultrasound localization of the tube in the gastric antrum	14 (60.87%)	38.54%; 80.29%

Source: The authors (2024).

DISCUSSION

According to the results presented regarding the sociodemographic and clinical characterization of the participants, the data is in line with the literature regarding the prevalence of male participants[15]. The fact that the study participants were predominantly under the age of 60 differs from the trends observed in current studies, which indicate that around 60% of ICU beds are occupied by patients over the age of 65[15]. This divergence can be attributed to the small sample size, limiting the generalizability of the results.

The clinical diagnoses in this study were grouped into categories by the system, and respiratory tract complications were the most prevalent, including respiratory failure, bacterial pneumonia, COVID-19 pneumonia, pleural effusion, and lung cancer. Diseases of the respiratory system are frequent causes of ICU admissions (21%), second only to diseases of the circulatory system (43%)[16]. In the hospital where the study was carried out, there is a cardiology ICU, which may justify the below-average percentage of cardiovascular complications in the ICU surveyed.

Data from the literature has shown that 40% of patients in ICUs are submitted to Invasive Mechanical Ventilation (IMV)[17]. In these sectors, most patients are sedated due to the severity of their condition and the need for multiple invasive devices[18]; however, the majority of patients in this study were awake.

This finding can be considered positive, as it shows a reduction in the use of sedative drugs for patients on IMV. A randomized study of 60 patients undergoing IMV for more than 24 hours found that patients undergoing continuous sedation stayed two to three times longer in the hospital and consequently had a higher risk of complications[17]. The use of an enteral tube is indicated on several occasions, with nutritional support for patients unable to receive oral nutrition being the main recommendation, as shown in this study[4].

The gastric aspirate test was carried out immediately after passing the enteral tube in the study participants. Visualization of the aspirate is a recommended technique with a moderate level of evidence; it can have a clear, green, brown, orange, or even colorless appearance[7]. In one study, the finding of 78.26% of positive tests indicated accuracy as a criterion for locating the tube in the gastric antrum; however, it was inferior to the fogging test.

After installation, to better visualize the enteral tube, the convex transducer was used in all study participants, due to its low frequency (2-5MHz), ideal for deep structures such as the abdominal organs. In this sense, the transverse axis was considered the best axis for visualizing the tube, with the gastric antrum being visualized with an ovoid appearance, described as a "bull's eye" pattern when it is empty or semi-empty, and round with thin walls and hypoechoic or anechoic contents when it has a volume of gastric secretions and/or liquids[9-10].

In recent studies on the subject, in cases where it is difficult to visualize the enteral tube in the stomach, by injecting saline solution, dextrose, or air, this technique causes the formation of a dynamic nebulization, also described as fogging test, "flash" of air, among others, which make it easier to visualize the tip of the tube. The volume of air injected varies between 40 and 50ml, and syringes that can hold this volume must be used. The volume of saline solution used ranges from 5 to 300ml, but there is a preference for injecting air due to the risk of iatrogenesis6. For this reason, only air was used in this study.

In this study, the adequacy of enteral tube positioning by USG was determined by these two criteria: visualization of the tube in the gastric antrum and the fogging test (double criterion) and only the fogging test (single criterion). Regardless of the criteria used, respectively, the proper positioning of the tube showed a significant association ($p<0.05$) only with the chosen route of passage. The choice of the nasoenteral route prevailed over the oral enteral route for various reasons, including the comfort of communicating. The oral enteral tube is recommended for patients who have suffered head trauma, according to the participants who received the tube orally[7].

In the concordance analysis to determine the accuracy of the criteria for confirming the positioning of the NET adopted in this study, ultrasound showed less accuracy when compared to previous studies when locating it in the gastric region[10,12,19]. The patient's movement during the examination, the presence of gas, and obesity may explain this divergence[1]. Consequently, the accuracy of the double criterion "location of the tube in the gastric antrum" together with "the fogging test" also showed low accuracy, but still higher than ultrasound localization of the NET alone.

The haze sign as an isolated criterion showed greater precision and agreement when compared to the gold standard, visualized in 21 (91.30%) of the 23 participants, with a CI of 71.96 to 98.92%. A Spanish study of 30 patients using Color Doppler US (CDUS) to visualize haze with air instillation showed a correlation between CDUS and abdominal radiography ($p <0.001$)[13].

To date, there have been no robust studies showing the accuracy of the fogging test alone, using USG without Doppler. In recent studies, the fogging test or dynamic nebulization was only performed in cases of difficulty in visualizing the enteral tube in the gastric region, as an additional confirmation[10,12].

With regard to the gastric aspirate test, a well-established method for confirming the positioning of the NES[7], it showed good agreement with the abdominal X-ray and was not visualized in five participants.

In the combination of locating the tube in the gastric antrum and the fogging test, USG technology became less precise than the technique traditionally used, i.e. gastric aspiration. In this context, it is worth highlighting the nevus sign technique individually, where it becomes quite concordant with the gold standard, being a counterpoint to the literature.

The fogging test, therefore, proved to be a practical, economical, and highly accurate criterion for verifying the position of the NET in a small group of adult critically ill patients, when compared to the gold standard. Therefore, studies are needed with a larger population, using clinical tests that corroborate the positioning of the enteral tube[6].

A limitation to the feasibility of an accuracy analysis was the absence of abdominal X-ray results showing inappropriate positioning, since when incorrect positioning was suspected in the respiratory tract, such as bronchospasm, desaturation, and coughing, the researcher decided to immediately remove the NET and perform a new passage, not postponing it until after the X-ray, following the principle of non-maleficence.

Other limitations were the small sample size due to the few opportune moments for data collection, the interference of the presence of gases in the stomach for image visualization, and the fact that USG is operator-dependent, requiring nurse training.

CONCLUSION

The fogging test, a simple and low-cost technique, showed high accuracy in confirming the positioning of the enteral tube in critically ill patients and was more effective than ultrasound alone. This result indicates that this technique can be a practical and affordable alternative to radiographic examination, particularly in units with limited resources.

The study makes relevant contributions to nursing, enabling nurses to expand their clinical assessment and, consequently, promoting autonomy and appreciation of advanced nursing practice, as well as reducing tube confirmation time, minimizing the risks of blind insertion and frequent exposure to radiation, and improving the cost-effectiveness and efficiency of care. However, more studies with larger samples are needed to validate its applicability and effectiveness on a large scale.

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