

**DIAGNOSTIC ACCURACY OF ULTRASONOGRAPHY TO
CONFIRM GASTRIC TUBE PLACEMENT IN
PATIENTS ADMITTED TO THE INTENSIVE CARE UNIT
IN HOSPITAL UNIVERSITI SAINS MALAYSIA**

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DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT
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TITLE PAGE

Title

Diagnostic accuracy of ultrasonography to confirm gastric tube placement in patients admitted to the intensive care unit in Hospital Universiti Sains Malaysia

Running head

Diagnostic accuracy of ultrasonography to confirm gastric tube placement

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LIST OF ABBREVIATIONS

USD	United States Dollar
i.e.	that is
pH	potential of hydrogen
CI	confidence interval
ICU	intensive care unit
USM	Universiti Sains Malaysia
Fr	French gauge
SPSS	Statistical Package for the Social Sciences
TP	true positive
TN	true negative
FP	false positive
FN	false negative
PPV	positive predictive value
NPV	negative predictive value
e.g.	for example
Etc	et. cetera
2D	two dimensional

TITLE

Diagnostic accuracy of ultrasonography to confirm gastric tube placement in patients admitted to the intensive care unit in Hospital Universiti Sains Malaysia

ABSTRAK

Latar belakang: Pemasukan tiub gastrik merupakan prosedur yang lazim di hospital. Pemastian kedudukan tiub gastrik penting kerana kesilapan dalam posisi tiub gastrik boleh menyebabkan komplikasi yang serius. Radiografi (X-ray dada atau abdomen) merupakan *gold standard* dalam penentuan posisi tiub gastrik. Walau bagaimanapun, terdapat kelemahan radiografi dalam tujuan ini di ICU, seperti memerlukan masa, tenaga jurugambar, tidak dapat dilaksanakan secara *real-time* dan risiko sinaran radioaktif kepada pesakit dan staf. Kajian keratan rentas ini bertujuan untuk menentukan ketepatan ultrasonografi dalam pemastian kedudukan tiub gastrik di kalangan pesakit unit rawatan rapi (ICU) Hospital Universiti Sains Malaysia.

Kaedah: Kami mengkaji 127 pesakit di ICU yang telah dimasukkan tiub gastrik. 3 cara ultrasound telah dilakukan (pendekatan leher, pendekatan gastrik dan ‘*dynamic fogging*’) untuk mengenalpasti posisi tiub gastrik. X-ray dada atau abdomen ditafsir mengikut protocol. Ketepatan diagnostik ketiga-tiga cara ultrasound ditentukan menggunakan *sensitivity*, *specificity*, *positive predictive value (PPV)* dan *negative predictive value (NPV)* dengan *confidence interval* 95%

Keputusan: Populasi kajian ini terdiri daripada 81 lelaki dan 46 perempuan, dengan umur purata 54 tahun (julat 18 – 85 tahun). 87% daripada peserta telah diintubasi atau mempunyai *tracheostomy*. 115 daripada 127 pesakit (91%) mempunyai kedudukan tiub gastrik yang betul; 12 daripada mereka (9%) mempunyai kedudukan tiub yang tidak betul. Ultrasound pendekatan leher mempunyai 99.1% *sensitivity* (*CI*: 95.3% - 100%), 0% *specificity* (*CI*: 0% - 26.5%), 90.5% *PPV* (*CI*: 90.3% - 90.6%) dan 0%

NPV. Ultrasound pendekatan gastrik menunjukkan *sensitivity* 70.4% (*CI*: 61.2% - 78.6%), *specificity* 100% (*CI*: 73.5% - 100%), *PPV* 100% dan *NPV* 26.1 (*CI*: 21.0% - 31.9%). Ultrasound pendekatan dynamic fogging pula menunjukkan *sensitivity* 98.3% (*CI*: 93.9% - 99.8%), *specificity* 91.7% (*CI*: 61.5% - 99.8%), *PPV* 99.1% (*CI*: 94.5% - 99.9%) dan *NPV* 84.6% (*CI*: 57.9% - 95.6%).

Kesimpulan: Kajian ini, menunjukkan bahawa ultrasound pendekatan leher tidak mempunyai ketepatan untuk mengesahkan kedudukan tiub gastrik. Pendekatan gastrik dapat mengenalpasti posisi tiub gastrik yang betul tetapi tidak memiliki *sensitivity* yang tinggi. Dynamic fogging merupakan cara yang paling tepat antara 3 pendekatan ultrasound yang diselidiki, menunjukkan *specificity*, *sensitivity*, *PPV* dan *NPV* yang tinggi.

Kata kunci: *ultrasonografi*, *dynamic fogging*, *radiografi*, *tiub gastrik*, *unit rawatan rapi*

CHAPTER 1: INTRODUCTION

1.1 Literature review

1.1.1 Background

Gastric tube insertion is a common procedure in the hospital setting. Each year, about 1 million patients in the United States require a gastric tube insertion (1). The indications for this procedure include decompression of the stomach, as well as providing a route for medications and nutrition (1). The gastric tube can be made from flexible polyurethane, latex or silicon (2). Administration of a gastric tube involves insertion of the tube via the nasal route (nasogastric tube) or the oral route (orogastric tube) (3).

Confirmation of gastric tube placement is essential as a wrongly positioned tube can lead to serious complications. Investigators found that in a total of 2000 large bore gastric tube insertions, approximately 1.3 to 3.2 percent of nasogastric tubes were malpositioned (4). Having the tip of gastric tube placed in the esophagus instead of the stomach increases risk of aspiration. The tube can be inserted into the tracheobronchial tree via the larynx due to its close proximity to the esophagus (1). Feeding into the trachea can result in pneumonia, pneumothorax, empyema , pulmonary hemorrhage, and even death (1).

The current recommendation for confirmation of gastric tube placement include radiography and non-radiographical methods. Indeed, visualization of the gastric tube on radiography (chest X-ray or abdominal X-ray) is considered the gold standard to differentiate between gastric and pulmonary placement (5–7), demonstrating high

accuracy provided the x-ray is performed properly and interpreted accurately (8). Radiography has its pitfalls, including radiation exposure, and causing discomfort to the patient. Subjects have to change their body position to have a hard plate placed on their back, or stand up for scanning and have tubes hanging from their nose or mouth (1). In ventilated patients, there is a potential for catheters and tube dislodgement upon positioning for radiography. It is also associated with high costs, with a single chest or abdominal radiography costing USD 100 and above (8). Furthermore, it requires a qualified radiographer to perform, and causes delay in establishing enteral feeding (9).

1.1.2 Alternative tests to confirm placement of gastric tube

Respiratory distress

Having signs of respiratory distress such as coughing and dyspnea may indicate improper placement of gastric tube into the airway, especially in patients with impaired consciousness (10). This should prompt the practitioner to withdraw and reinsert the gastric tube.

Capnography

This method does not have sufficient accuracy in confirming gastric tube placement, failing to detect half of malpositioned tubes (11). It also is unable to determine the location of the tip of tube in the gastrointestinal tract, i.e esophagus or stomach(12).

Aspirate methods

Gastric tube can be aspirated and assessed either visually or biochemically(3). Healthcare providers are able to differentiate between gastric and intestinal aspirates

with high accuracy (90% of the time) but are unable to distinguish between gastric and pulmonary aspirates (13).

Various biochemical tests can be done on the gastric tube aspirate. Commonly described is pH testing of the aspirate, with the agreement that $\text{pH} < 5$ is representative of gastric secretions (14). However, it is important to note that gastric pH can be altered by gastric acid suppressants (15), frequently prescribed for patients in the ICU setting, and also continuous enteral feeding which buffers gastric acid.

Other forms of tests have been described, such as bilirubin, pepsin, trypsin, lipase with reliability of approximately 91%(16), as compared to pH testing of 84-97% (17). However, such tests require laboratory services and therefore are more cumbersome and results in delay.

Additionally, having nil aspirates does not exclude gastric placement because the tube could be at the proximal stomach or resulted in collapse during aspiration (18).

Auscultation

This method involves instilling air through the gastric tube while auscultating for the sound of air over the epigastric region is no longer recommended (3). It is deemed being unreliable, unable to distinguish between gastric and tracheal placement, gastric and esophageal placement as well as between gastric and small bowel placement (5).

Ultrasound

There has been increasing interest over the years in utilization of ultrasound as an aide to confirm gastric tube placement. It is seen to cause less discomfort to the patient (19), and has the advantage of being easily portable hence appealing for pre-hospital

examinations (20).

A systematic review conducted by Tsujimoto and colleagues looked at ultrasound accuracy to confirm gastric tube placement found that the sensitivity ranges from 0.50-0.98 whereas specificity lies between 0.17-1.00 (1). Notably, specificity estimates have a wide confidence interval due to the small number of misplaced tubes available for analysis. Indeed, out of the 10 studies which had 560 gastric tube insertions, there were only 43 tubes (7.7%) that were misplaced (1).

A review and meta-analysis published by Lin et al. produced similar findings. 5 studies with 420 patients in a pre-hospital, emergency department or intensive care setting were included (21). The pooled sensitivity of ultrasound in confirming correct gastric tube positing was 0.93 (95% CI: 0.87-0.97), while the specificity was 0.97 (95% CI: 0.23-1.00) (21). In conclusion, the authors of both these reviews agree that ultrasound is a valuable alternative to X-ray in confirming gastric tube placement, but is not suitable to diagnose tube misplacement (1,21).

A few ultrasound imaging techniques have been described in literature. In general there are 3 visualization methods used: (i) the neck approach (22), (ii) the stomach (epigastric) approach (19,20,23), or (iii) a combination of both views (24,25). For the neck approach, the probe was placed transversely on the anterior neck just superior to the suprasternal notch in midline at the level of the thyroid gland and focused on the visible part of the esophagus, with longitudinal and transversal viewing (24). As for the stomach approach, the probe was placed at the subxiphoid area and oriented towards the left upper abdominal quadrant to visualize the stomach, also with

longitudinal and transversal viewing. The antrum was visualized in the transversal plane in the epigastric area using the left lobe of the liver as a landmark, angling the transducer towards the left subcostal area imaged the body (24). The ability to visualize hyperechogenic structure in the esophagus or stomach indicates a positive test. Additionally, some researchers inject air or saline via the gastric tube to induce signals detected in Doppler mode, also known as ‘dynamic fogging’, when the gastric tube is visualized in the esophagus but not in the stomach(19,24,26). This latter maneuver improved detection success rate.

Across studies, the personnel conducting the ultrasound examinations included trained nurse (27), emergency physicians (23,24), intensive care physicians following a 2-hour training course (19), emergency physician following a one-day training course (20), and prehospital service doctors trained in e-FAST (extended focused assessment with sonography for trauma) examination (28).

1.2 Problem statement

Current evidence shows that the ultrasound method is useful in determining correct tube placement but is not suitable to diagnose a misplaced gastric tube (1,21). However, several studies have utilized the color doppler ultrasound to increase the accuracy of the examination, demonstrating both high sensitivity and high specificity (24,26).

1.3 Rationale and justification of study

The potential benefits of the ultrasound modality in determining gastric tube placement include being faster and less harmful compared to the current gold standard of X-ray imaging. Previous studies have demonstrated high sensitivity and specificity of ultrasound method in confirming position of gastric tubes (20,29).

However, there are some limitations from available data that precludes usage of ultrasound as replacement for X-ray. Current evidence shows that the ultrasound method is useful in determining correct tube placement but is not suitable to diagnose a misplaced gastric tube (1,21). This is mainly due to studies having small numbers of misplaced gastric tubes to produce adequately powered results, reflected in their wide confidence intervals. For example, Brun and his team (24) found a 100% specificity for the ultrasound method with a 95% CI of 40% - 100%. A study by Kim and colleagues (23) recorded a 67% specificity with 95% CI of 9% - 99%.

Dynamic fogging is a newer method being employed to identify position of gastric tube. Available research incorporating this method were mostly done in smaller populations (23,24,26,30). One study including a larger group of patients (n=130) demonstrated a sensitivity of 98.3% (95% CI 94% - 99.5%) and specificity of 100% (95% CI 75.7% - 100%) (20).

Additionally, there is lack of such studies performed in the ICU setting. Majority of the investigations were conducted in prehospital (20,24,28) and emergency department patients (23).

1.4 Study objectives

1.4.1 General Objective

To evaluate the efficacy of ultrasonography in confirming accurate gastric tube placement in patients admitted to the Intensive Care Unit, Hospital Universiti Sains Malaysia.

1.4.2 Specific Objectives

- i. To determine the sensitivity and specificity of ultrasound (neck approach) in confirming gastric tube placement in patients admitted to the Intensive Care Unit, Hospital Universiti Sains Malaysia.
- ii. To determine the sensitivity and specificity of ultrasound (gastric approach) in confirming gastric tube placement in patients admitted to the Intensive Care Unit, Hospital Universiti Sains Malaysia.
- iii. To determine the sensitivity and specificity of ultrasound (dynamic fogging) in confirming gastric tube placement in patients admitted to the Intensive Care Unit, Hospital Universiti Sains Malaysia.
- iv. To determine the positive predictive value and negative predictive value of ultrasound (neck approach) in confirming gastric tube placement in patients admitted to the Intensive Care Unit, Hospital Universiti Sains Malaysia.
- v. To determine the positive predictive value and negative predictive value (gastric approach) in confirming gastric tube placement in patients admitted to the Intensive Care Unit, Hospital Universiti Sains Malaysia.
- vi. To determine the positive predictive value and negative predictive value (dynamic fogging) in confirming gastric tube placement in patients admitted to

the Intensive Care Unit, Hospital Universiti Sains Malaysia.

- vii. To compare the diagnostic accuracy of various approaches in confirming gastric tube placement in patients admitted to the Intensive Care Unit, Hospital Universiti Sains Malaysia.

1.5 Null hypothesis

- i. Ultrasound modality to confirm gastric tube placement has a low sensitivity and specificity when compared with X-ray imaging.
- ii. Ultrasound modality to confirm gastric tube placement has a low positive predictive value and negative predictive value when compared with X-ray imaging.
- iii. Dynamic fogging has a lower or similar accuracy compared to gastric and neck approach in confirming gastric tube placement.

1.6 Alternative hypothesis

- i. Ultrasound modality to confirm gastric tube placement has a high sensitivity and specificity when compared with X-ray imaging.
- ii. Ultrasound modality to confirm gastric tube placement has a high positive predictive value and negative predictive value when compared with X-ray imaging.
- iii. Dynamic fogging has a higher accuracy compared to gastric and neck approach in confirming gastric tube placement.

CHAPTER 2: STUDY PROTOCOL

2.1 Research methods and methodology

2.1.1 Study setting

Adult Intensive Care Unit of Hospital Universiti Sains Malaysia

2.1.2 Study design

Cross-sectional study to assess diagnostic accuracy

2.1.3 Study time and duration

June 2021 – November 2022

2.2 Study criteria

2.2.1 Inclusion criteria

Patients 18 years and above admitted to ICU who require a gastric tube (nasogastric / orogastric)

2.2.2 Exclusion criteria

- Pregnant women
- Post upper gastrointestinal surgery
- Intrabdominal pathology
- Post head and neck surgery

2.3 Sample size estimation

In order to determine the number of assessments needed to analyze the accuracy of the ultrasound method in confirming gastric tube placement against the gold standard examination of X-ray, the formula designated for sensitivity and specificity studies described by Buderer was applied (31). Estimates of Sensitivity (0.93), Specificity (0.97) and Prevalence (0.9) was obtained from previous studies (21,24,26). A precision level of 10% is chosen, with a confidence level set at 95% ($1 - \alpha$) and dropout rate of 10%.

With that, the sample size for sensitivity, $n_{\text{sen}} = 28$;

Sample size for specificity, $n_{\text{spec}} = 112$

Final sample size (largest), $n = 112$

Final sample size (with 10% dropout), $n_{\text{drop}} = 125$

2.4 Sampling method

All patients admitted to the Intensive Care Unit of Hospital Universiti Sains Malaysia who fulfil the inclusion criteria and do not have any exclusion criteria will be recruited in the study. This will be a convenience sampling method.

2.5 Research tools

- a) Search databases: “Research Gate”, “Pubmed”, “Google Scholar” will be used.
- b) Ultrasound machine: Portable ultrasound machines available in the Intensive Care

Unit of Hospital Universiti Sains Malaysia will be used for this study, namely:

- i) Samsung HS40 portable ultrasound: Linear array transducer LN5-12 (Frequency 5 – 12MHz); Curved array transducer CA2-8AD (Frequency 2 – 8MHz)
- ii) Samsung HM70A portable ultrasound: Linear array transducer L5-13IS (Frequency 6 – 12 MHz); Curved array transducer SC1-6 (Frequency 1 – 6 MHz)
- c) USM Online radiology viewer (GE Healthcare Centricity™ Universal Zero Footprint Client): X-ray images (chest or abdominal X-rays) of patients will be accessed via USM's online radiology web-based platform.
- d) Data collection sheet: Data sheet created for recording subject's demographic and clinical details, as well as results of the index (ultrasound) and reference (X-ray) tests.

2.6 Operational definitions

2.6.1 Index test (*Ultrasound*)

a) Neck approach

Positive: ability to visualize the gastric tube as a hyperechogenic circle structure posterior to the thyroid, adjacent to the trachea.

Negative: inability to visualize the gastric tube as a hyperechogenic circle structure posterior to the thyroid, adjacent to the trachea.

b) Gastric approach

Positive: ability to visualize the gastric tube as a hyperechogenic line in the stomach.

Negative: inability to visualize the gastric tube as a hyperechogenic line in the stomach.

c) Dynamic fogging

Positive: ability to detect color flow (dynamic fogging) at same time of air injection.

Negative: inability to detect color flow (dynamic fogging) at same time of air injection.

2.6.2 Reference test (X-ray)

Positive: The gastric tube must be seen -

- Passing vertically in the midline, or near the midline, below the level of the carina.
- Not following the course of the right or left main bronchi
- Passing vertically in the midline down to the level of the diaphragm where it passes through the gastro-esophageal junction
- The tip of the tube must be visible below the diaphragm and on the left side of the abdomen - 10 cm or more beyond the gastro-esophageal junction

Negative: Not fulfilling all the above criteria for a “positive” test

2.7 Data collection

2.7.1 Index test (Ultrasound)

All index tests using the ultrasound will be performed at patient's bedside in the Intensive Care Unit. Informed consent will be obtained beforehand. Patient's neck and abdominal area will be exposed adequately for the test.

a) Neck approach (24)

The linear transducer will be placed transversely on the anterior neck just superior to the suprasternal notch in midline at the level of the thyroid gland and focused on the visible part of the esophagus, with longitudinal and transversal viewing.

b) Gastric approach (24)

The curvilinear transducer will be placed in the subxiphoid area and oriented toward the left upper abdominal quadrant to visualize the stomach, with transverse and longitudinal viewing.

c) Dynamic fogging (24,26)

The curvilinear will be placed in similar fashion as the gastric approach as described above.

40mls of air will injected via the gastric tube.

The researcher performing the ultrasound examinations will be blinded to the results of the chest/ abdominal X-rays. The primary investigator underwent privileging of

neck and gastric ultrasound under a supervisor with expertise in ultrasonography (Winfocus More Than Basic Echo: Echodynamic - Provider).

In the event that the ultrasound image is poor in the neck / gastric approach, which resulted in difficulties in identification of the esophagus / stomach / gastric tube, the result of those approaches will be marked as 'negative'.

2.7.2 Reference test (X-Ray)

The subjects will have a chest X-ray or abdominal X-ray taken to confirm placement of gastric tube. The test can be done either at bedside or at the radiology department.

Interpretation of the chest/ abdominal X-ray using the online radiology viewer will be done by the attending medical officer/ registrar/ anaesthesiologist in charge of the patient, who will be blinded to the results of the ultrasound examination.

In the event that the gastric tube is not visualized at all due to suboptimal exposure, a repeated X-ray will be ordered to confirm tube placement.

2.8 Duration of participation

Once consent is obtained, the bedside ultrasound scan of all 3 approaches will take approximately 10-15 minutes.

The X-ray images will be reviewed from the hospital online radiology viewer. If X-ray has not been performed or deemed suboptimal, a new X-ray will be ordered.

After the bedside ultrasound has been performed and the necessary X-ray available, the participation of the subject is complete and no follow up is required.

2.9 Data recording

A data collection sheet will be used to record information which includes:

- Patient's age and gender
- Clinical diagnosis
- Intubated / not intubated
- Gastric tube size in Fr
- Feeding status (clamped/ ongoing enteral feeding/ free flow)
- Gastric tube visualization in neck approach, stomach approach and presence of dynamic fogging
- Gastric tube position on X-ray

2.10 Data analysis

Continuous variables will be expressed as means with standard deviation. Categorical variables will be expressed as numbers with percentages. Sensitivity, specificity, positive predictive value and negative predictive value will be calculated, along with 95% confidence interval, to assess the diagnostic accuracy of the ultrasound methods studied in this research.

The SPSS for Windows version 26.0 will be used to perform statistical analysis.

2.11 Expected outcomes

The outcome of both the index test (ultrasound) and reference test (X-ray) will be dichotomous, which can be displayed in a table such as below:

		X-ray	
		Gastric tube in correct position	Gastric tube in wrong position
Ultrasound Approach	Positive	TP	FP
	Negative	FN	TN

Whereby:

- i) TP: True positive
- ii) FP: False positive
- iii) TN: True negative
- iv) FN: False negative

Using these values, the measures of accuracy can be calculated as such:

a) Sensitivity = $\frac{TP}{TP+FN}$

b) Specificity = $\frac{TN}{TN+FP}$

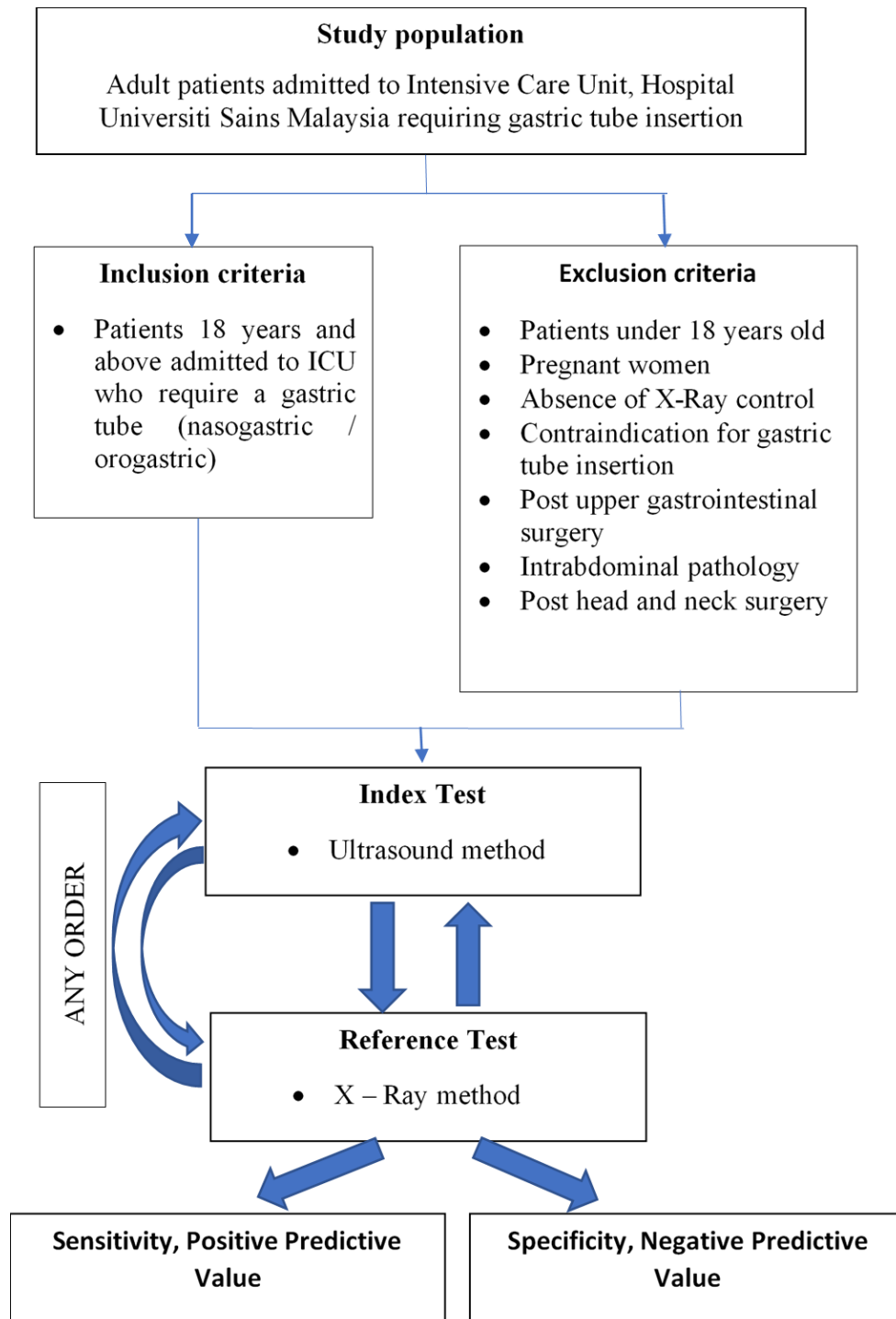
c) Positive Predictive Value (PPV) = $\frac{TP}{TP+FP}$

d) Negative Predictive Value (NPV) = $\frac{TN}{TN+FN}$

2.12 Gantt chart

	2021												2022									
Activities	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10
Writing introduction	◆	◆																				
Writing literature review	◆	◆																				
Proposal presentation		◆																				
Ethics application						◆	◆	◆	◆	◆	◆	◆										
Data collection											◆	◆	◆	◆	◆	◆	◆					
Data entry																◆	◆	◆	◆			
Analyzing data																		◆	◆			
Writing results																			◆	◆		
Writing discussion																				◆	◆	
Writing conclusion & recommendation																				◆	◆	
Thesis submission																						◆

2.13 Study flow chart



2.14 Ethical considerations

2.14.1 Subject vulnerability

- Patients with full capacity to consent will be given full freedom to agree or refuse to partake in this study with the assurance that his/ her medical treatment will not differ from the standard of care.
- For patients who are unable to provide consent (e.g intubated, sedated, partially or fully unconscious, etc), their caretakers will be the ones providing consent to participate in this study, with the assurance that the patient's medical treatment will not differ from the standard of care.
- The potential for ultrasound to cause adverse effects has been well established in experimental animals. Some of the biological changes include cellular, neural and pulmonary tissues as well as genetic (32). Main mechanisms responsible for these are thermal and mechanical forces. With that said, there have been no major reports of harm secondary to ultrasound usage in humans, whereby any effects, if any, would likely be too subtle or rare to escape detection.
- Patient's dignity will be maintained at all times during the ultrasonography process.

2.14.2 Declaration of absence of conflict of interest

- This study is not sponsored or influenced by any party
- The investigator will not be receiving any form of incentive from any party

2.14.3 Privacy and confidentiality

- All data collection forms are anonymous and will be entered into a master data sheet in Microsoft Excel and SPSS software.

- Data will be used to compute results of the study population without identifying the individual participants.

2.14.4 Community sensitivities and benefits

- Establishing the accuracy of ultrasound to confirm gastric tube placement provides an alternative to X-ray imaging
- The findings from this study which is conducted in the intensive care unit can be compared with previous studies performed in different settings.

2.15 Honorarium and incentives

No honorarium or incentive will be given to patients.

CHAPTER 3: MANUSCRIPT

3.1 ABSTRACT

Background: Gastric tube insertion is a common procedure in the hospital setting. Confirmation of gastric tube placement is important as wrongly positioned gastric tubes can lead to serious complications. Radiography (chest or abdominal X-ray) is the current gold standard in determining gastric tube position. However, radiography has certain pitfalls, such as time consuming, requiring radiographer's services, unable to be performed real-time, and radiation exposure to patients and staff. This cross-sectional study aims to determine the accuracy of ultrasonography in confirming gastric tube placement in patients admitted to the intensive care unit of Hospital Universiti Sains Malaysia.

Methods: We recruited 127 patients admitted to the intensive care unit who had received gastric tube insertions. 3 ultrasound approaches were performed (neck approach, gastric approach and dynamic fogging) at bedside to identify the gastric tube position. Chest or abdominal X-ray images were interpreted as per protocol. The diagnostic accuracies of the ultrasound methods were determined using sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) with 95% confidence intervals.

Results: The study population comprises of 81 males and 46 females, with a mean age of 54 years old (range 18 -85 years old). 87% of the subjects were either intubated or on tracheostomy. 115 out of 127 patients (91%) had correct gastric tube placements; 12 of them (9%) were malpositioned. The ultrasound neck approach had 99.1%

sensitivity (CI: 95.3% - 100%), 0 % specificity (CI: 0% - 26.5%), 90.5% PPV (CI 90.3% - 90.6%) and 0% NPV. The ultrasound gastric approach showed a sensitivity of 70.4% (CI: 61.2% - 78.6%), specificity of 100% (CI: 73.5% - 100%), PPV of 100% and NPV of 26.1 (CI: 21.0% - 31.9%). Finally, dynamic fogging demonstrated 98.3% sensitivity (CI: 93.9% - 99.8%), 91.7% specificity (CI: 61.5% - 99.8%), 99.1% PPV (CI: 94.5% - 99.9%) and 84.6% NPV (CI: 57.9% - 95.6%).

Conclusion: This study shows that the ultrasound neck approach lacks the accuracy to confirm correct gastric tube placement. The gastric approach is able to identify correct tube placement but does not have a high sensitivity. Dynamic fogging is the most accurate across all 3 ultrasound approaches, showing high sensitivity, specificity, positive predictive value and negative predictive value.

Keywords: *ultrasonography, dynamic fogging, radiography, gastric tube, intensive care unit*

3.2 INTRODUCTION

Gastric tube insertion is a common procedure in the hospital setting. Each year, about 1 million patients in the United States require a gastric tube insertion (1). Confirmation of gastric tube placement is essential as a wrongly positioned tube, with an incidence as high as 10%, can lead to serious complications such as aspiration, pneumothorax, empyema and even death (1).

The gold standard for gastric tube position confirmation is X-ray, which can be a chest or abdominal radiography (5). However, concerns such as radiation exposure, cost, patient discomfort and requirement of qualified radiographer have to be considered (1)

Various alternatives to the X-ray have been studied with the aim to expedite the confirmation process, save cost (8), and also to avoid the disadvantages associated with X-ray. The ultrasound modality has gained popularity in recent years in view of the increased availability and portability of ultrasound devices (20,24). Performing a bedside ultrasound scan is non-invasive and has the advantage of being relatively quick, with no radiation risk. Studies have demonstrated high sensitivity and specificity of ultrasound in confirming gastric tube placement (20,29). These findings are of clinical importance especially in the pre-hospital setting.

Current evidence shows that the ultrasound method is useful in determining correct tube placement but is not suitable to diagnose a misplaced gastric tube (1,21). However, several studies have utilized the color doppler ultrasound, also known as ‘dynamic fogging’, to increase the accuracy of the examination, demonstrating both high sensitivity and high specificity (24,26), albeit in smaller populations.