A STUDY ON EFFECTIVENESS OF USING RIGHT VENTRICLE INFLOW PARASTERNAL LONG AXIS VIEW IN DETECTING SUPRADIAPHRAGMATIC CENTRAL VENOUS CATHETER MALPOSITION IN COMPARISON TO CHEST RADIOGRAPH.

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TABLE OF CONTENT

List of Tables and Figures

List of Abbreviation

1) RVI PLAX: right ventricle inflow parasternal long axis view

2) CVC: central venous catheter

3) RASS: rapid atrial swirl sign

4) POCUS: point of care ultrasound

5) CXR: Chest radiograph

6) CEUS: Contrast enhanced ultrasound

7) SVC: Superior vena cava

8) RA: Right atrium

9) RV: Right ventricle

10) ICU: Intensive care unit

11) HDU: High dependency unit

12) TTE: Trans-thoracic Echocardiography

13) HUSM: Hospital University Sains Malaysia

14) USG: Ultrasound

15) IJC: Internal jugular catheter

16) A4C: Apical 4 chamber

17) LAX: Long axis

18) ECHO: Echocardiography

ABSTRAK

Latar Belakang: Sisi "RVI-PLAX" adalah salah satu sisi Echocardiogram yang mudah dilaksanakan untuk melihat struktur jantung hadapan seperti injap tricuspid, bahagian kanan ventrikel dan pengaliran darah keluar dari bahagian jantung. Oleh itu, kami ingin mengkaji dengan lebih mendalam tentang keberkesanan sisi "RVI-PLAX" dalam menentukan kedudukan hujung tiub "CVC" yang betul berbanding dengan kaedah X-ray dada konvensional. Selain daripada itu, dalam menentukan hujung tiub "CVC", kaedah ultrasound adalah jauh lebih cepat berbanding X-ray dada.

Methologi: Ini adalah kajian keratan rentas yang direka khas untuk menentukan keberkesanan paparan "RVI-PLAX" dalam menentukan penempatan hujung "CVC" yang betul. Kajian ini dijalankan dari Jun 2021 hingga Disember 2021. Persampelan yang mudah dan berkemungkinan telah digunakan, dan subjek telah disaring di wad perubatan am, ICU dan HDU perubatan HUSM dengan jumlah 105 pesakit yang memenuhi kriteria inklusi. Sosio-demografi tentang umur, jantina, etnik, komorbiditi, petunjuk dan jenis "CVC" telah direkodkan. Tanda vital pesakit dan sebarang sokongan inotropik atau pengudaraan akan direkodkan juga. Ultrasound sisi katil dilakukan oleh doktor/penyiasat tauliah menggunakan pandangan apikal 4 ruang, paparan "RVI-PLAX" serta pandangan subkostal (dalam pesakit tingkap ECHO yang sukar/ lemah) untuk menggambarkan hujung "CVC", setiap klip ultrasound akan dirakam. Selain itu, medium kontras yang digunakan dalam kajian ini termasuk 10 cc garam biasa untuk visualisasi yang lebih baik. Data deskriptif dilaporkan sebagai min dan sisihan piawai untuk data taburan normal dan sebagai median untuk data taburan tidak normal. Data kategori dilaporkan dalam peratusan dan kekerapan. Data berangka dipersembahkan sebagai min (SD) berdasarkan taburan normalitinya. Persetujuan ratal antara penyiasat pertama dan kedua dikira berdasarkan formula “Cohen’s Kappa Coefficient”

Keputusan:RASS yang tidak normal dalam RVI PLAX walaupun tidak sensitif (16.7%) tetapi tanda yang sangat spesifik (91.9%) bagi malposisi CVC. Tiada malposisi CVC intraaterial berlaku. Paparan “RVI PLAX” berjaya mengesan semua kedudukan hujung “CVC” intravena. Selain itu, "peraturan 2 saat" dan permulaan RASS tidak dapat menentukan sama ada hujung CVC diletakkan dengan betul. Terdapat perselisihan antara penilai sederhana antara penyiasat 1 dan penyiasat yang ke-2 dengan nisbah kebolehpercayaan interrater kappa sebanyak 0.456.

Kesimpulan: “CEUS” dengan paparan “RVI PLAX” adalah alat yang tepat dan boleh dihasilkan semula untuk mengesan malposisi “CVC” pada pesakit. Walau bagaimanapun, kajian prospektif perlu dilakukan pada skala yang lebih besar sampel untuk mengesahkan hasil kajian kami.

ABSTRACT

Background: Right ventricle inflow parasternal long axis view is one of the basic echocardiographic views that is easily performed bedside to visualize anterior cardiac structure such as tricuspid valve, right ventricle as well as right ventricle outflow tract. Likewise, we would like to explore the effectiveness of right ventricle inflow parasternal long axis view in determining the correct central venous catheter tip placement in comparison to conventional chest radiograph. As we know, that performing a bedside ultrasound is faster than X-ray, which involves confirming of placement.

Methods: This is a cross-sectional study specially designed to determine the effectiveness of right ventricle inflow parasternal long axis view in determine correct central venous catheters tip placement. This study was conducted from June 2021 till December 2021. Convenient and probable sampling were used, and subjects were screened in general medical ward, intensive care unit and medical high dependency unit, which involved a total of 105 patient that fulfilled the inclusion criteria. Socio-demographic, based on age, gender, ethnicity, comorbidities, central venous catheter indication and types were recorded. Patient vital signs and any inotropic or ventilatory support were recorded as well. Bedside ultrasound performed by credential doctor/ investigator using apical 4 chambers view, right ventricle inflow parasternal long axis view as well as subcostal views (in certain difficult/poor echocardiography window patient) to visualize the tip of central venous catheter, each ultrasound clip was documented. Moreover, the contrast medium used in these studies was 5-10 cc normal saline aided for better visualization. Descriptive data reported as means and standard deviations for normally distributed data and as median for abnormally distributed data. Categorical data were reported in percentages and frequencies. Numerical data were presented as mean (SD) based on their normality distribution. The ratal agreement between first and second investigator was calculated based on Cohen's kappa coefficient for interrater reliability.

Results: Abnormal rapid arterial swirl sign in right ventricle inflow parasternal long axis view was not a sensitive sign (16.7%) but a very specific sign (91.9%) of central venous catheter malposition. There were no intraarterial central venous catheter malposition occurred. Right ventricle inflow parasternal long axis views successfully detected all intravenous central venous catheter tip position. Moreover, the "2 second rule" and the onset of rapid arterial swirl sign could not determine whether central venous catheter tip was correctly positioned. There was a moderate interrater disagreement between 1^{st} and 2^{nd} investigator with the kappa interrater reliability ratio of 0.456.

Conclusions: Contrast enhanced ultrasound with right ventricle inflow parasternal long axis view is an accurate and reproducible tool to rule out central venous catheter malposition in patient. However, prospective studies performed on larger study sample are required to confirm our study result.

CHAPTER 1: BACKGROUND

1.1 Introduction

In early 19th century, during World War II, ultrasound was widely used in the military for identifying pathological specimen. Ian Donald introduced foetal ultrasound in 1956, integrating ultrasound usage widely in the world of medicine from the basic diagnostic test to the extent of intervention radiological procedures. Nowadays the ultrasound machine becomes more handy, portable, and high in accuracy. Point of care in ultrasound (POCUS) is a growing field that has gained a lot of attention for the past 20 years, as it leads to improve operational efficacy, and ultimately better patient outcomes.

Chest radiograph is conventionally used as the gold standard tool for confirming central venous catheter (CVC) placement prior to usage to mitigate possible complications arising from CVC malposition. These includes catheter-induced arrhythmia, perforations, and thrombus formation. The carina is radiologically identifiable in about 96% of all CXRs at the interspace between the fourth and fifth thoracic vertebrae (Venugopal et al., 2013).However, in certain circumstances, portable chest X-ray are not readily available, and it may delay the treatment thus POCUS is a good alternative to determine the correct CVC placement.

POCUS has been the practice-changing technology for emergency and critically ill patients, likewise, the similar concept can be applied in confirming the CVC tip placement as it has the ability to look into human body in real time without any risk of radiation (Smallwood and Dachsel, 2018).Furthermore, studies had shown that pooled sensitivity and specificity in detecting CVC malposition via POCUS ranges from 82-98.9% and 68.2-98% respectively (Wilson et al., 2017). Moreover, POCUS can pick up possible common procedure related complication such as pneumothorax and is more sensitive as compared to CXR.

There are numerous POCUS protocols that has been proposed. Among others, supraclavicular ultrasound, transthoracic echocardiography (TTE) and contrast enhanced ultrasound (CEUS), and the landmark that we usually use to indicate correct cannulation is to visualize the guidewire's J-tip in the Right atrium (Smit et al., 2018). Besides that, rapid atrial swirls sign (RASS) can be seen during contrast administration as opacification of the right atrium via 4 chamber echo view or subcostal views. On top of that, contrast enhanced, agitated saline can be used to confirm placement of CVC (Vezzani et al., 2010). RASS detection which indicates the correct CVC tip placement and vice versa is obtained almost immediately (within 2 seconds)

In addition, there are various ultrasound views that are used for better visualization of the heart structure. Namely, they are RVI-PLAX (right ventricle inflow parasternal long axis view), apical 4 chambers view, subcostal view, parasternal short axis view and others. These views enable for a better visualization of different structures of the heart. For instance, the RVI- PLAX view is to evaluate right atrium, tricuspid valve, right ventricle, inferior vena cava, coronary sinus, and Eustachian valve. Likewise, we apply the similar concept by utilizing those views to evaluate the CVC placement. The RVI-PLAX view is obtained by tilting the tip of transducer caudally to scan inferiorly from the parasternal LAX position. Since it is the easiest to master and least affected by the lungs shadowing, we are interested in studying its ability in detecting CVC malposition. Currently, there is no specific study focusing on RVI-PLAX view in confirming CVCs placement. Therefore, it is a worthwhile study that can be replicated in evaluating the accuracy of RVI-PLAX view in determining the placement of CVCs.

For the past few decades, new technology had greatly affected the means and manners in diagnosing a type of disease. Similarly, the advancement in evaluation of ultrasound machine has led to lighter, portable, user-friendly, and better images of ultrasound. Bedside ultrasound can be used to confirm CVC tip placement besides acting as a guide for central line insertion.

1.2 Objectives

1.2.1 General Objective:

To determine the effectiveness of ultrasound (RVI PLAX view) using contrast medium (non-agitated normal saline) in confirming supradiaphragmatic catheter placement.

1.2.2 Specific objectives:

1. To determine the RASS characteristics in the RVI PLAX view.
2. To determine the sensitivity and specificity of immediate RASS detection via RVI PLAX view in confirming CVC malposition in comparison to CXR.
3. To determine the interrater agreement between the 1st and 2nd investigator's diagnosis of CVC malposition.

1.3 Hypothesis

Ultrasound RVI PLAX view is sensitive and specific in confirming CVC tip placement in comparison to conventional CXR.

1.4 Research Question

1. Is RVI PLAX view a sensitive echocardiographic view in detecting the RASS?
2. Is RASS detection via RVI PLAX view a sensitive and specific method of excluding CVC malposition?

CHAPTER 2: LITERATURE REVIEW

Central venous catheter placement has been identified as an essential tool in rapid resuscitation of critically ill patients. It allows rapid infusion of fluids, delivery of centrally acting medication and active hemodynamically monitoring (Wilson et al., 2017). Traditionally after CVC insertion, we will use CXR as a standard tool to confirm its placement and monitor for the possible complication that might arise, such as pneumothorax (Venugopal et al., 2013).

With the ever-changing landscape of health care delivery system in our country Malaysia, majority of patients are receiving care in hospital settings. As a result, significant efforts are made to improve promptness and accuracy for diagnostic testing. Point-of-care ultrasound has been long identified as a reliable procedural guiding tool to reduce complications associated with CVC placement (Leung et al., 2006). POCUS is advantageous over CXR because there is no radiation while able to verify the correct placement and lack of pneumothorax without delay (Ablordeppey et al., 2019).

POCUS contains various view that aim to evaluate different structure in our heart, for example, parasternal long axis view, parasternal short axis view, apical 4 chambers view, subcostal view, etc. Several studies involving various patients in a population have been conducted to measure the effectiveness of ultrasound in detecting CVC malposition and post-procedure pneumothorax. Most of the catheters were IJC and the catheters were inserted under US guidance. All these studies assessed the RA and RV via A4c or subcostal view. J-tip or catheter tip visualization in the RA indicates correct cannulation. (Bedel et al., 2013)

Transthoracic echocardiography with bubble test is an accurate, reproducible, and safe technique to verify the location of the tip of the central venous catheter.

(Nayeemuddin et al., 2013). Usually, immediate detection of turbulent flow in right atrium (can be speckled or prominent flow) indicates correct CVC placement. Besides that, measurement of "push-to-bubbles" time is a fast, accurate and highly reproducible tool for verifying the correct CVC position (Meggiolaro et al., 2015). Furthermore, agitated saline (bubble) transthoracic contrast echocardiography is a technique classically performed in diagnosing intracardiac and intrapulmonary shunt. Contrast used in previous studies include agitated saline or non-agitated saline, to prepare agitated saline, 10 ml of normal saline was used with 1 ml of air and shake vigorously. By using non-agitated normal saline, the RVI PLAX view can evaluate the correct placement of CVC adequately. The rapid atrial swirl sign (RASS) was ultrasound finding of an immediate appearance of turbulence entering the right atrium via superior vena cava after a rapid saline flush of the distal CVC port (Anthony J Weekes et al., 2016). Weekes *et al,* used non-agitated saline in their 2 studies (n=303) with the sensitivity and specificity of 75% and 100% respectively (A J Weekes et al., 2016; Anthony J. Weekes et al., 2014).

Central catheter malposition and pneumothorax are known complications that is related to CVC placement, and previously CXR used to be the only modality to confirm the above-mentioned complications, yet radiograph is often untimely. POCUS, (ultrasound) is better in terms of availability and convenience as compared to X ray. Mounting evidence suggests that POCUS enhances rapid decision-making, assists physicians in diagnostic capabilities, and improves patient safety during procedures. In addition, there are literatures that suggest that a post-procedure CXR is unnecessary when ultrasound is used to confirm catheter position and exclude pneumothorax (Ablordeppey et al., 2019). In fact, there are data to demonstrate that ultrasound provides equivalent diagnostic findings to CXR in confirming the catheter location besides excluding mechanical complications like pneumothorax in a faster mode. The mean catheter confirmation time by chest radiograph availability for viewing was 45.78 minutes (95% confidence interval, 37.03-54.54 minutes). Mean sonographic confirmation occurred 36.98 minutes sooner than radiography ($P< .001$). No discrepancy existed between sonographic and radiographic confirmation.(Gekle et al., 2015). Another study shows that the mean time for US performance was 2.83 min (95% CI: 2.77–2.89 min) min, while CXR performance took 34.7 min (95% CI: 32.6–36.7 min). (Smit et al., 2018)

In addition, various physical landmarks are used frequently for accurate CVC tip placement. *Weekes at el,* divides them into 4 zones whereby the first zone is located 3 cm above the carina on the right hemithorax, zone 2 is 3 cm below carina on the right hemithorax, zone 3 is the at the brachiocephalic vein for the left-sided CVCs and zone 4 is at the superior cavoatrial junction. The tip of catheter should be on the right side of the hemithorax in both first and second zone whereas if the tip is approaching 3rd zone, it signifies left-sided IJC placement. Last but not least, *Hill and Monreau at el,* mentioned that if the tip is found at the superior Cavo-atrial junction and upper right atrium, it is considered acceptable as well.

Moreover , according to literature, “bubble test” shows 100% sensitivity and 99% specificity FOR CVC malposition with an inter-observer agreement of 99% (kappa 0.96 , $p <0.001$) (Meggiolaro et al., 2015). “Bubble test” using agitated contrast saline as contrast medium and the rationale for its use to verify the CVC position is that rapid and complete filling of the RA by micro-bubbles should be observed at echocardiography if the catheter tip is inside or very close to the atrium. Nonetheless, at present there are no paper discussing about using dextrose verses normal saline in adult patient particularly in confirming the CVC placement.

In summary, there are numerous advantages of confirming CVC tip using CEUS compared to conventional CXR. Thus, this study is aimed at by using CEUS on RVI PLAX view, we can determine the correct CVC tip placement in a faster and more convenient way. Immediate confirmation of CVC positioning allows for earlier clinical management that could affect patient outcomes, particularly in critically ill patients. A recent meta-analysis discover that POCUS is able to detect all pneumothoraxes and most catheter malposition following CVC placement more rapidly in comparison to CXR (Ablordeppey et al., 2017).

2.1 Conceptual Framework:

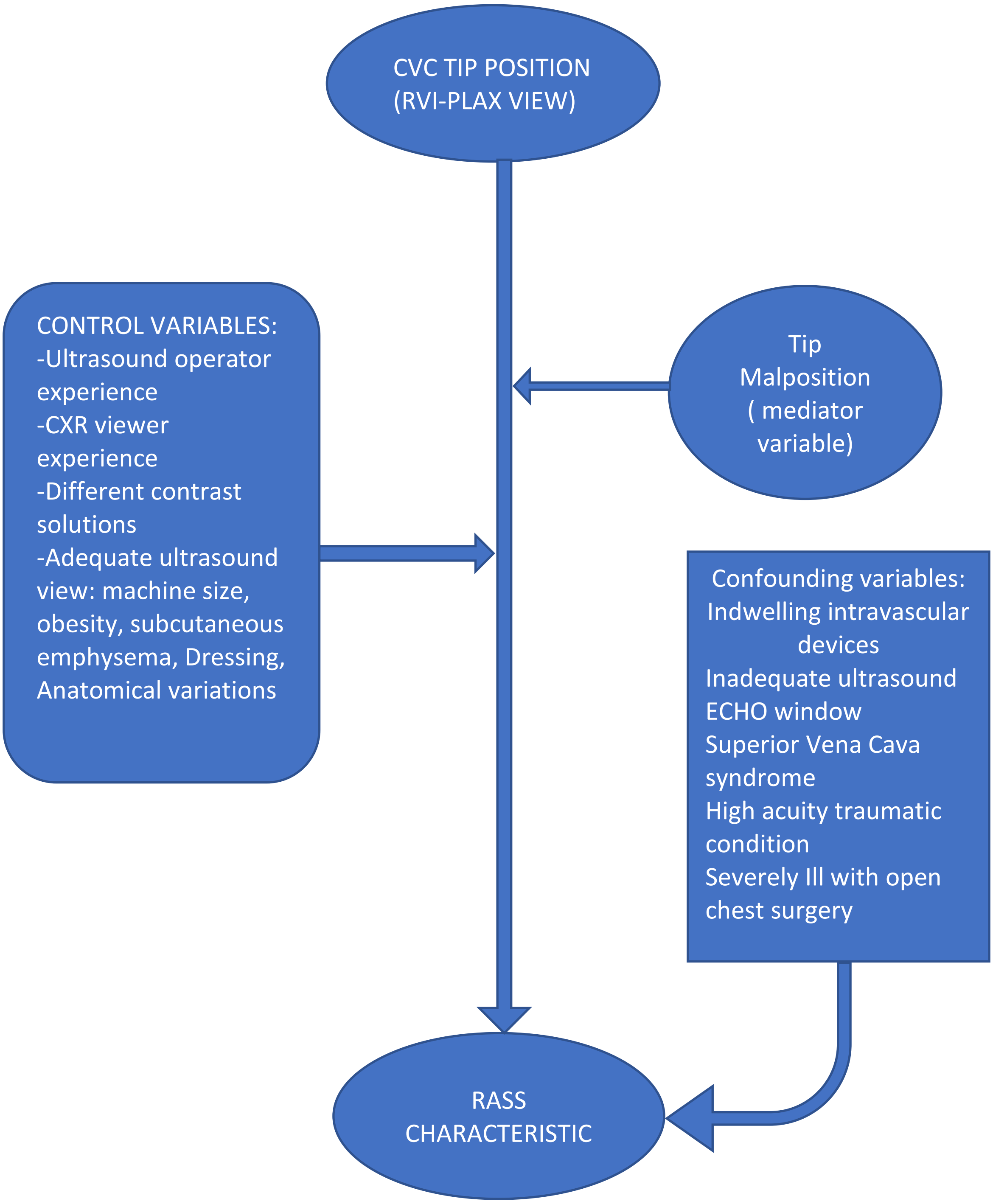


Figure 1: This is the conceptual framework of the study. In this cross-sectional study, the outcome of interest is sensitivity and specificity of RVI-PLAX view in detection of CVC malposition.

There are various methods in the literature that contribute to detection of CVC malposition. However, this study will only focus on RVI-PLAX view.

2.2 Rationale of Study

There are multiple echocardiography views that are used to evaluate the heart structure particular right atrium (RA) and right ventricular (RV), namely, apical 4 chamber view (A4C) and subcostal view. Yet, there are few limitations of acquiring these views as it needs repetitive training and experienced personnel and is operator dependant. Sometimes, in morbidly obese patient or post operation patient, especially open thoracotomy patient with central epigastric/ open thoracotomy wound, even trained radiology fellow has great difficulty in obtaining the appropriate view.

Parasternal long axis view (PLAX) is a fundamental echocardiographic view which is among the easiest to acquire. Traditionally it is used to visualize the left chambers of the heart and a portion of the RV. It is easily learned and not affected much from lung shadowing. Slight fanning of the probe caudally towards the right hip from the PLAX position will optimize the RA, tricuspid valves (TV) and RV view, yielding the right ventricle inflow parasternal long axis view (RVI PLAX).

As a result, we explore the effectiveness of the RVI PLAX echocardiographic view in determining the correct CVC tip position in comparison to CXR.

CHAPTER 3: METHODOLOGY

3.1 Study Design:

This was a cross sectional study, which was conducted in hospital USM, Kubang Kerian, Kelantan, Malaysia from March 2021 till December 2021.

3.2 Study Area:

The study included intensive care unit, medical ward, and surgical intensive unit in HUSM

3.3 Study Population:

Any adult patient who is having supradiaphragmatic catheter insertion (IJC or subclavian catheter/ triple lumen).

3.4 Sample Size Estimation:

3.4.1. For objective 1: To determine the proportion of different RASS characteristics in the RVI PLAX view

Sample size calculation was based on single proportion utilizing the software by Arifin and using the following parameters (Arifin, 2017):

1 proportion - Estimation

Proportion (p):	0.97
Precision (± proportion):	0.05
Confidence level 100(1 - α):	95 %
Expected dropout rate:	10 %
Calculate	Reset
Sample size, n =	45
Sample size (with 10% dropout), n_{drop} =	50

Based on (Anthony J Weekes et al., 2016), 97% of RASS able to detect correct placement of CVC.

Total subjects for sample size will be 50

3.4.2: For objective 2: To determine the sensitivity and specificity of immediate RASS detection via RVI PLAX view in excluding CVC malposition as compared to CXR.

Sample size calculation was based on diagnostic study for comparing sensitivity and specificity utilizing the software by Arifin and using the following parameters (Arifin, 2017):

Sensitivity/Specificity - Estimation

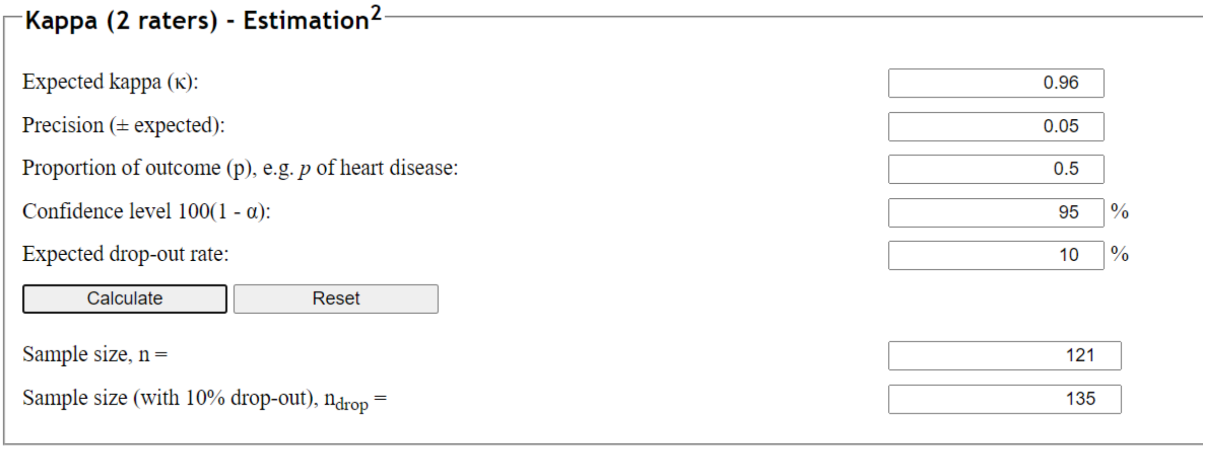
Expected sensitivity:	0.96
Expected specificity:	0.93
Prevalence of disease (p):	0.20
Precision (± expected):	0.10
Confidence level 100(1 - α):	95 %
Expected dropout rate:	10 %
Calculate	Reset
Sample size for sensitivity, n_{sen} =	74
Sample size for specificity, n_{spec} =	32
Final sample size (largest), n =	74
Final sample size (with 10% dropout), n_{drop} =	83

Based on (Vezzani et al., 2010) the visualization of turbulence or microbubbles within the RA within 2 seconds of the distal port flush confirms adequate CVC placement with a 96% sensitivity and 93% specificity.

Total subjects for sample size will be 83.

3.4.3: For objective 3: To determine ratal agreement between 1st investigator and 2nd investigator regarding RASS findings.

Sample size calculation was based on diagnostic study for Kappa coefficient utilizing the software by Arifin and using following parameter:



Kappa (2 raters) - Estimation[2]

Expected kappa (κ):	0.96	
Precision (± expected):	0.05	
Proportion of outcome (p), e.g. *p* of heart disease:	0.5	
Confidence level 100(1 - α):	95	%
Expected drop-out rate:	10	%
Calculate	Reset	
Sample size, n =	121	
Sample size (with 10% drop-out), n_{drop} =	135	

Based on (Meggiolaro et al., 2015), demonstrated that measurement of time from agitated saline infusion to echocardiographic opacification of the RA is a highly accurate and reproducible tool to rule out CVC malposition. (kappa 0.96, p <0.001).

Total subjects for sample size will be 135.

The biggest sample size required for objective 3 is 135. Thus, the final sample size required for my study is 135

3.5 Sampling Method and Subject Recruitment:

Sampling was done by convenience sampling method. All patients above 18 years old that were admitted to the general medical ward and intensive care unit in HUSM and required CVC insertion were screened using the inclusion and exclusion criteria for eligibility to be part of the study.

3.6 Subject criteria:

<u>Inclusion criteria:</u>

1) Adult patients age ≥ 18 years old

2) Those who are having IJC or subclavian catheter insertion.

<u>Exclusion criteria:</u>

1) Patient who is having any indwelling intravascular devices

2) Patient who is having inadequate ultrasound window such as those who were diagnosed with superior vena cava syndrome.

3) Patient who has severe high acuity traumatic condition.

4) Patient who is severely ill with open chest surgery

3.7 Operational Definition:

1) Immediate RASS – turbulence appearance in right atrium from superior vena cava and migrating toward right ventricle within 2 seconds, indicating correct CVC placement.

2) Delayed RASS- turbulence appearance entering RA from the superior vena cava and migrating toward right ventricle more than 2 seconds, indication of CVC malposition.

3) Absent RASS- absence of turbulence flow within Right atrium or ventricle, signify CVC malposition.

4) 1st investigator – trained ultrasound operator (doctor who had obtained fellowship in ultrasound)

5) 2nd investigator- senior Emergency physician and radiologist

3.8 Study Tool

1) CVC insertion

   All IJC and subclavian catheter usually inserted by using ultrasound guided method, subsequently using CXR for confirming the placement.

2) Ultrasound Machine

   Phased array transducer (3-5 MHz) is used to scan the precordium, whereas 5-10 MHz linear transducer is used for CVC insertion.

3) Normal Saline flush ECHO protocol

   Assistant will flush 5 cc of normal saline into the CVCs while the trained ultra-sonographer performs the scan immediately to observe for turbulent flow using RVI PLAX view. Immediate RASS is the appearance of turbulence flow within 2 second in right atrium and indicated correct placement. On the contrary, delayed RASS (more than 2 second), absence RASS, RV turbulence flow or TV migrating into RA are all indicator for CVC malposition. Ultrasound clip will be stored for review by radiologist later.

4) CXR review protocol

   The CXR post procedure will be reviewed by a senior radiologist. Both emergency physician / senior radiologist will be “blinded” from the ultrasound findings prior to CXR. CVC tip is considered rightly placed when it is in zone 1 (3 cm above the carina on the right hemithorax), zone 2 (3 cm below the carina over the right hemithorax), zone 3 (brachiocephalic vein for left-sided CVCs), and zone 4 (superior cavoatrial junction).

3.9 Data Collection method:

All IJC and subclavian catheters were inserted by a trained medical officer. The catheters were either double- or triple-lumen based on various indication. All patients who had fulfilled the inclusion criteria were selected once warded in HUSM, with either verbal or written consent obtained prior to patient included in the study. Important socio-demographic, clinical data as well as CVC position were recorded in the pro-forma.

A nurse assisted the medical officer during the procedure. The medical officer use ultrasound machine as a guide during the CVC insertion. The 1st investigator (credentialed doctor who had obtained a fellowship in ultrasound) performed the echocardiography bedside via RVI-PLAX view to determine CVC placement. The first investigator used a handheld, portable Clarius C3 ultrasound machine (Clarius Mobile Health, Vancouver, BC V5M 4X7 Canada). Eventually the CVC was threaded into the vein using Seldinger technique. Next, first assistant will flush 5 ml of normal saline into CVC ports while the 1st investigator observed the RASS at the RVI PLAX view. 1st Investigator is a trained doctor who had obtained ultrasound fellowship programme from HUSM.

Immediate RASS was defined as the sonographic turbulence seen within the RA or entering the RA from the superior vena cava and migrating toward the RV within 2 seconds. The immediate RASS indicates correct CVC placement. Delayed RASS (more than 2 seconds), absent RASS, turbulence appeared first in the RV or migrating from the tricuspid valve into the RA were CVC malposition indicators. The timing of RASS detection after flushing was measured using a stopwatch. The first investigator stored the US clips for review. CXR was ordered after the CVC insertion.

Subsequently 2nd investigator (senior emergency physician) relooked into the recorded ultrasound clip to determine the RASS findings' agreement. CXR for those selected patient reviewed by senior radiologist. All the investigators were blinded throughout.

3.10 Statistical Analysis:

Data were entered and analysed using Statistical Product and Service Solutions (SPSS) for Windows, SPSS Inc.© (Version 26, SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to summarise the socio-demographic and clinical characteristics of the patients. Categorical data were presented as frequency (n) and percentage (%). Numerical data were expressed as mean (SD) based on their normality distribution. Kappa coefficient test was performed to determine the ratal agreement between 1st and 2nd investigators regarding RASS characteristic. We determined sensitivity and specificity of CVC malposition using RVI-PLAX view and CXR.

3.11 Confidentiality and Privacy:

The subjects were identified by a unique serial number. No identifiable data were shared publicly. Upon completion of the study, all data were stored in CDs, and the database on the computer was erased. The data were retained by the researchers for knowledge purposes only. Neither the name nor any identifying information was used in any publication or presentation resulting from this study.

3.12 Ethical Consideration:

The study was approved by Human Research Ethics Committee of Universiti Sains Malaysia (Approval no. USM/JEPeM/20060334).

3.13 Study Flowchart:

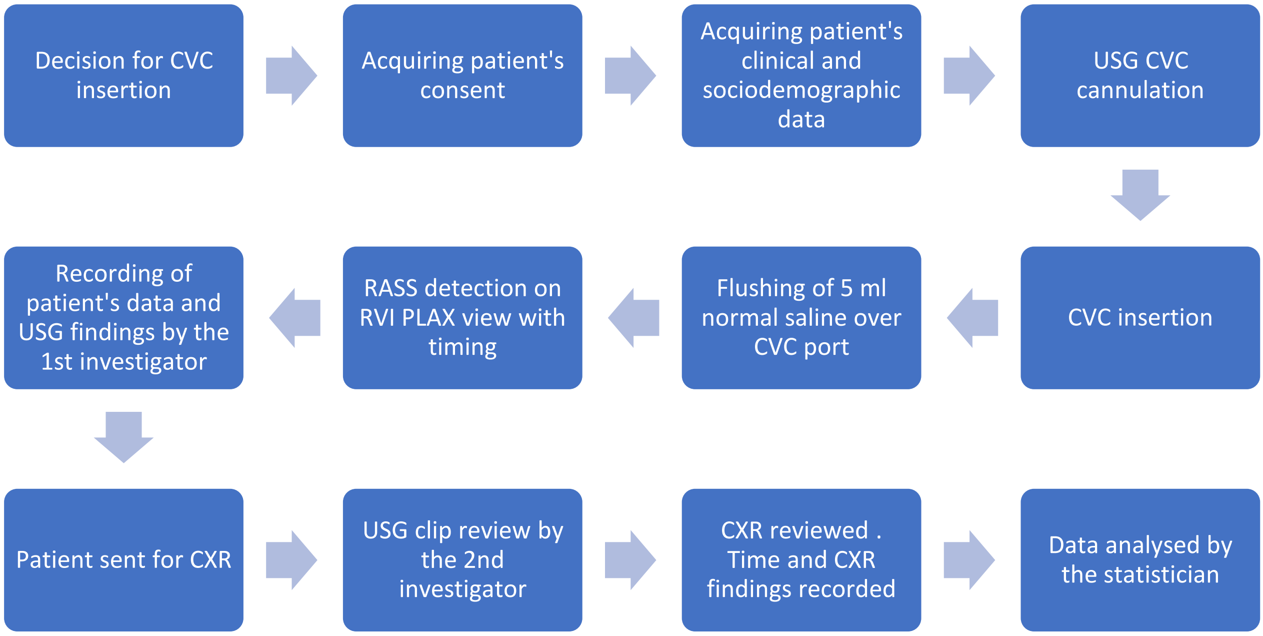


Figure 2: Study Flow Chart.

CHAPTER 4: MANUSCRIPT

A STUDY ON EFFECTIVENESS OF USING RIGHT VENTRICLE INFLOW PARASTERNAL LONG AXIS VEIW IN DETECTING SUPRADIAGHRAMATIC CENTRAL VENOUS CATHETER MALPOSITION IN COMPARISON TO CHEST RADIOGRAPH.

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A STUDY ON EFFECTIVENESS OF USING RIGHT VENTRICLE INFLOW PARASTERNAL LONG AXIS VIEW IN DETECTING SUPRADIAGHRAMATIC CENTRAL VENOUS CATHETER MALPOSITION IN COMPARISON TO CHEST RADIOGRAPH.

Abstract

Background: Right ventricle inflow parasternal long axis view is one of the basic echocardiographic views that is easily performed bedside to visualize anterior cardiac structure such as tricuspid valve, right ventricle as well as right ventricle outflow tract. Likewise, we would like to explore the effectiveness of right ventricle inflow parasternal long axis view in determining the correct central venous catheter tip placement in comparison to conventional chest radiograph. As we know that performing a bedside ultrasound is much faster than having to wait to have chest radiograph.

Methods: This is a cross-sectional study specially designed to determine the effectiveness of right ventricle inflow parasternal long axis view in determine correct central venous catheters tip placement. This study was conducted from June 2021 till December 2021. Convenient and probable sampling were used, and subject were screened in general medical ward, intensive care unit and medical high dependency unit with a total of 105 patients that fulfilled the inclusion criteria. Patient's socio-demographic, like age, gender, ethnicity, comorbidities, central venous catheter indication and types were recorded. Patient vitals sign and any inotropic or ventilatory support was recorded as well. Bedside ultrasound performed by credential doctor/ investigator using apical 4 chambers view, right ventricle inflow parasternal long axis view as well as subcostal views (in certain difficult/poor echocardiography window patient) to visualize the tip of central venous catheter, each ultrasound clip will be recorded. Moreover, the contrast medium used in these studies was 5-10 cc normal saline aided for better visualization. Descriptive data reported as means and standard deviations for normally distributed data and as median for abnormally distributed data. Categorical data were reported in percentages and frequencies. Numerical data presented as mean (SD) based on their normality distribution. The ratal agreement between first and second investigator calculated based on Cohen's kappa coefficient for interrater reliability.

Results: Abnormal rapid arterial swirl sign in right ventricle inflow parasternal long axis view is not a sensitive sign (16.7%) but a very specific sign (91.9%) of central venous catheter malposition. There were no intraarterial central venous catheter malposition that occurred. Right ventricle inflow parasternal long axis views successfully detected all intravenous central venous catheter tip position. Moreover, the "2 second rule" and the onset of rapid arterial swirl sign could not determine whether central venous catheter tip is correctly positioned. There was a moderate interrater disagreement between 1st and 2nd investigator with the kappa interrater reliability ratio of 0.456.

Conclusions: Contrast enhanced ultrasound with right ventricle inflow parasternal long axis view is an accurate and reproducible tool to rule out central venous catheter malposition in patients. However, prospective studies performed on larger study sample are required to confirm our study results.

Introduction

In the early 19th century, especially during World War II, ultrasound was widely used in military for identifying pathological specimen. Ian Donald, first introduced foetal ultrasound in 1956, integrating ultrasound usage widely in the world of medicine from the basic diagnostic test to the extent of intervention radiological procedures. Nowadays the ultrasound machine becomes more handy, portable, and high in accuracy. Point of care in ultrasound (POCUS) is a growing field that has gained a lot of attention for the past 20 years, as it leads to an improved operational efficacy, and ultimately better patient outcomes.

Chest radiograph (CXR) is conventionally used as the gold standard tool for confirming central venous catheter (CVC) placement prior to usage to mitigate possible complications arising from CVC malposition, for instances, catheter-induced arrhythmia, perforations, and thrombus formation. The carina is radiologically identifiable in about 96% of all CXRs at the interspace between the fourth and fifth thoracic vertebrae (Venugopal et al., 2013).However, in certain circumstances, portable CXR is not readily available, and it may delay treatment. Thus, POCUS is a good alternative to determine the correct CVC placement.

POCUS has been the practice-changing technology for emergency and critically ill patients. Likewise, the similar concept can be applied in confirming the CVC tip placement as it has the ability to look into human body in real time without the risk of radiation (Smallwood and Dachsel, 2018).Furthermore, studies had shown that pooled sensitivity and specificity in detecting CVC malposition via POCUS ranges from 82-98.9% and 68.2-98% respectively (Wilson et al., 2017). Moreover, POCUS can pick up possible common procedure related complications such as pneumothorax and is more sensitive as compared to CXR.

There are numerous POCUS protocols such as supraclavicular ultrasound, transthoracic echocardiography (TTE) and contrast enhanced ultrasound (CEUS), and the landmark that we usually use to indicate the correct cannulation is to visualize the guidewire's J-tip in the Right atrium (Smit et al., 2018). Besides that, rapid atrial swirls sign (RASS) can be seen during contrast administration as opacification of the right atrium via 4 chamber echo view or subcostal views. On top of that, contrast enhanced, agitated saline method can be used to confirm placement of CVC (Vezzani et al., 2010).

As a conclusion, immediate (within 2 seconds) of RASS detection indicate correct CVC tip placement and vice versa.

Besides that, there are various ultrasound views which are used for better visualization of heart structure, namely RVI-PLAX (right ventricle inflow parasternal long axis view), apical 4 chambers view (A4C), subcostal view, parasternal short axis views etc. These views are created for a better visualization of different structures in the heart for instance, the RVI- PLAX view can evaluate right atrium, tricuspid valve, right ventricle, inferior vena cava, coronary sinus, and Eustachian valve. Likewise, we apply the similar concept by utilizing those view to evaluate the CVC's placement. The RVI-PLAX view can be obtained by tilting the tip of transducer caudally to scan inferiorly from the parasternal LAX position. Since it is the easiest to master and least affected by the lung shadowing, as a result, we are interested in studying its ability in detecting CVC malposition. Surprisingly, there are no specific article that investigate RVI-PLAX view in confirming CVCs placement. Therefore, it is worthwhile study that can be the pilot project in evaluating the accuracy of RVI-PLAX view in determining the placement of CVCs.

For the past few decades, new technologies had greatly affected the means and manners in which we diagnose a disease. Similarly, the advancement in evaluation of ultrasound machine had also led to lighter, portable, user-friendly, and better images ultrasound. Bedside ultrasound can be used to confirm CVC tip placement besides acting as a guide for central line insertion.

Methodology:

Data collection:

This was a cross sectional study. All IJC and subclavian catheters were inserted by a trained medical officer. The catheters were either double- or triple-lumen based on various indication. Patients that were admitted in HUSM, were selected using the inclusion criteria. Either verbal or written consent were obtained prior to the commencement of the study. Important socio-demographic, clinical data as well as CVC position were recorded in the pro-forma.

A nurse assisted the medical officer during the procedure. The medical officer used ultrasound machine as a guide during the CVC insertion. The 1st investigator performed the echocardiography bedside via RVI-PLAX view to determine CVC placement. The 1st investigator used a handheld, portable Clarius C3 ultrasound machine (Clarius Mobile Health, Vancouvre, BC V5M 4X7 Canada). Eventually the CVC was threaded into the vein using Seldinger technique. Next, assistant flushed 5 ml of normal saline into CVC ports while the first investigator observed the RASS at the RVI PLAX view. 1st Investigator is a credentialed doctor who had undergone ultrasound fellowship programme from HUSM.