DIAGNOSTIC ACCURACY OF CONTRAST-ENHANCED ULTRASOUND WITH DEXTROSE 50% IN DETECTING SUPRADIAPHRAGMATIC CENTRAL VENOUS CATHETER MALPOSITION

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MUHAMMAD SUHAIRI BIN ADANAN

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LIST OF ABBREVIATION

A4c	Apical four-chamber
CEUS	Contrast-enhanced Ultrasound
CVC	Central venous catheter
CXR	Chest radiograph
HUSM	Hospital Universiti Sains Malaysia
ICU	Intensive Care Unit
PFO	Patent Foramen Ovale
POCUS	Point of Care ultrasound
RA	Right atrium
RASS	Rapid atrial swirl sign
RV	Right ventricle
RVI PLAX	Right ventricle inflow- parasternal long axis
SHDU	Surgical High Dependency Unit
SVC	Superior vena cava
TOF	Tetralogy of Fallot
TTE	Trans-thoracic echocardiogram
US	Ultrasound

ABSTRAK

Latar belakang: Pemasangan kateter vena sentral (CVC) merupakan prosedur biasa yang dilakukan ke atas pesakit di dalam wad. Tujuan penggunaannya berbeza-beza, contohnya untuk pemberian ubat, resusitasi dan hemodialisis. Kebiasaannya penentuan kedudukan CVC yang betul ialah dengan menggunakan kaedah x-ray dada. Selain itu, penggunaan ultrasound berkontras (CEUS) mampu mengesan malposisi kateter sebagaimana yang telah ditunjukkan oleh kajian-kajian lepas. Kebanyakan kajian menggunakan saline sebagai cairan kontras.Selain saline, penggunaan Dextros 50% (D50%) sebagai cairan kontrast dibandingkan dengan saline dilaporkan meemberikan ciri ultrasonik yang lebih baik. Kami meneliti keberkesanan penggunaan Dextrose 50% sebagai cairan kontras untuk mengesan malposisi CVC di bahagian atas diaphgram di Hospital Universiti Sains Malaysia (HUSM).

Metodologi: Ini adalah kajian keratan rentas yang melibatkan pesakit yang telah dipasangkan CVC menngikut indikasi dan praktis klinikal yang standard. Persampelan mudah digunakan dan subjek telah ditapis dari pesakit-pesakit di dalam wad HUSM. Kami membandingkan pengesanan malposisi kateter menggunakan ciri-ciri Rapid Atrial Swirl Sign (RASS) oleh CEUS menggunakan D50% dan pengesanan hujung tiub CVC yang terpapar di dalam filem x-ray dada. Kami juga membandingkan persetujuan di antara penyiasat pertama dan kedua berkenaan ciri-ciri RASS.

Keputusan: Secara keseluruhannya, kami melibatkan 99 orang pesakit. Terdapat 7 malposisi kateter yang telah dikesan menggunakan x-ray dada, dan dari jumlah ini, hanya 1 yang berjaya dikesan oleh CEUS. Sensitivisi untuk mengesan malposisi kateter dengan menggunakan CEUS D50% ialah 14.3%, dan spesifisiti ialah 95.5%. Terdapat persetujuan yang sederhana di antara penggunaan ultrasound dan x-ray dada, dengan nilaian Cohen's Kappa coefficient sebanyak 0.533.

Kesimpulan: CEUS menggunakan D50% di dalam kajian ini tidak dapat menggantikan x-ray dada dalam menentukan malposisi kateter. Namun begitu, ianya mampu menentukan posisi CVC yang betul di dalam vena setelah kateter dimasukkan berdasarkan jumlah persetujuan yang tinggi dalam mengesan posisi kateter yang tepat di antara dapatan CEUS menggunakan D50% dan x-ray dada.

Kata kunci: *CEUS, D50%, malposisi kateter, RASS, x-ray dada*

ABSTRACT

Background: Central venous catheter (CVC) insertion is common in an in-patient medical setting. The usage varies from the administration of drugs, resuscitation, and haemodialysis. A standard practice to confirm CVC placement is by using a chest radiograph. Similarly, the usage of contrast-enhanced ultrasound (CEUS) can also detect catheter malposition, as shown by previous studies. Most studies used saline as a contrast, however it has been observed that using Dextrose 50% (D50%) as a contrast solution instead of saline results in better ultrasonic features. We explored the diagnostic accuracy of using D50% as a contrast solution to detect supradiaphragmatic central venous catheter malposition in Hospital Universiti Sains Malaysia (HUSM).

Method: This is a cross-sectional study involving patients who had CVC inserted according to standard indication and clinical practice. Convenient sampling was used, and subjects were screened from in-patient ward HUSM. We compared catheter malposition detection using Rapid Atrial Swirl Sign (RASS) features by CEUS with D50% and central venous catheter tip on chest radiograph. Additionally, we compared the agreement between first and second investigators regarding RASS features.

Result: In total, we included 99 patients. Seven catheter malpositions were detected by chest radiograph, and from this, only 1 was detected by CEUS. The sensitivity of detecting catheter malposition by CEUS D50% was 14.3%, and specificity was 95.5%. There was a moderate agreement between ultrasound and chest x-ray film with a Cohen's Kappa coefficient of 0.533.

Conclusion: In this study, CEUS using D50% cannot replace CXR to detect catheter malposition. However, it can determine the correct CVC position in the venous following insertion.

Keywords: *CEUS, D50%, catheter malposition, RASS, chest radiograph*

CHAPTER 1: INTRODUCTION

Patients admitted to the medical ward may require central venous catheterisation, and the majority of patients admitted to the intensive care unit (ICU) will. In these patients, the central venous catheter (CVC) is used to administer fluids and medications, monitor hemodynamic parameters, or provide vascular access for hemodialysis. However, central venous catheterisation is associated with a number of adverse events that can potentially harm the patients. These adverse events could be immediate or delayed. The immediate complications include arterial puncture, hematoma, pneumothorax, and malposition, while the delayed complications such as infection and thrombotic events may be provoked by malposition of CVC (1).

Live fluoroscopy is the gold standard to assess the correct CVC position. However, it is not widely and readily available in various hospitals (2). Therefore, CXR is considered the most practical radiologic modality to detect CVC malposition. It was used as a control in most studies to confirm the position of the CVC tip within the superior vena cava. Various landmarks were used to determine correct CVC tip placement. Weekes et al. defined the correct tip location using three zones on antero-posterior CXR. The first zone is located 3 cm above the carina, whereas the second zone is located 3 cm below it. In both zones, the tip should be on the right side of the hemithorax. The innominate (brachiocephalic) vein is the third zone, which is considered acceptable for left-sided IJC or subclavian CVC (3,4). Placement of the tip at the superior cavoatrial junction and upper right atrium is also regarded as acceptable (5).

Despite this, there are many drawbacks of CXR compared to ultrasound. These include radiation exposure to patients and being time-consuming in performing and interpreting the CXR. The new CVC will not be used until the CXR are performed and interpreted. The mean time for CXR performance and interpretation is significantly longer than ultrasound (US).

Performing US confirmation of CVC malposition takes less time compared to CXR, with an average time of 2.83 min (95% CI: 2.77–2.89 min) for US; 34.7 min for CXR performance (95% CI: 32.6–36.7 min) and 46.3 min (95% CI: 44.4–48.2 min) for CXR interpretation (1). Thus, the waiting time to determine the safety of the CVC used is shorter and, hypothetically, should result in earlier catheter use. In addition, the safe omission of routine post-procedure CXR could save significant healthcare costs and allow immediate use of the CVC for the administration of potentially life-saving medications or hemodialysis (5,6).

The use of point-of-care ultrasound (POCUS) has been growing for the past decade with the advent of more portable and affordable ultrasound machines as well as the expanding knowledge in POCUS. POCUS has been studied as an alternative modality to determine correct IJC placement. It is faster to perform and poses no ionizing radiation risk to patients. Pooled sensitivity and specificity of detecting CVC malposition via POCUS ranges from 82-98.9% and 68.2-98%, respectively. POCUS after CVC insertion can also detect pneumothorax, which is a common complication of the procedure. In several studies, the detection of iatrogenic pneumothorax with ultrasound is as sensitive, if not better, than CXR (6,7).

Various POCUS protocols have been used to determine correct supradiaphragmatic CVC position, including supraclavicular ultrasound, transthoracic echocardiography (TTE), and contrast-enhanced ultrasound (CEUS). CEUS allows real-time imaging at a high frame rate and is relatively inexpensive, highly portable, and readily repeatable.

Visualisation of the guidewire’s J-tip or the CVC tip in RA using CEUS indicates correct cannulation. CEUS uses agitated or non-agitated saline as the contrast. Rapid atrial swirl sign (RASS) is opacification of the RA after flushing the saline contrast, which is commonly detected by echocardiography via RVI-PLAX, A4c, or subcostal views. Immediate (within 2 seconds) RASS detection indicates correct CVC tip position in SVC. Absent or delayed RASS (more than 2 seconds) indicates CVC malposition (3,4).

The contrast used in previous studies includes agitated saline or non-agitated saline. To prepare agitated saline, 10-20ml of normal saline with 1ml of air is shaken vigorously. Excess air is removed from the syringe before being administered in 5 to 10ml aliquots. Blans et al. used this and had found the sensitivity was 98% (89.4-100%, n=53) (8). A similar method was employed by Kamalipour et al. in a larger study population (n=116) had found the sensitivity was lower (68.8%) with a specificity of 97.7% (9). Baviskar et al. used agitated microbubble saline in their study with both sensitivity and specificity of 100% (n=25) (10). Weekes et al. used non-agitated saline in their two studies (n=303) with 75% and 100% sensitivity and specificity, respectively (3,11).

Other than saline, the application of dextrose solution as a contrast agent has been found to give better ultrasonic features when compared to the saline solution. Dextrose solution of 5% and 50% concentration had been used as a contrast agent in echocardiography to diagnose cardiac diseases such as patent foramen ovale (PFO) and tetralogy of Fallot (TOF). D50% solution enables ultrasound technicians to easily observe the flow and detect the shunt across the PFO (12,13). A study by Malakan *et al.* showed the D5% solution as effective as saline in contrast to echocardiography (13). Similarly, Li et al. in their study (n=48), discovered that the sensitivities for detecting PFO with contrasted trans-thoracic echocardiogram (cTTE) using physiologic saline and D50% were 83% and 100%, respectively. In this study, they found that the peak time, effective duration, and duration of microbubbles produced by D50% were all longer than those produced by the physiologic saline(12).

Incidence of hyperglycaemia post flushing with D5% was negligible even in diabetic patients due to the low volume of D5% used (10ml)(13). In a study involving 25 healthy subjects, administration of 50mls of D50% (1700 kcal/L) causes a significant transient rise of capillary blood glucose (13.6 +/- 2.5 mmol/L at 5 min, 8.1 +/- 2.9 mmol/L at 15 min) up till 30 minutes (4.9 +/- 1.6 mmol/L) (14). 10mls of D50% provides 17 kcal, equivalent to a quarter of a white bread slice (27.3g) or 22mls of Glucerna formula milk (14–16). Therefore, in theory, 5-10ml of D50% should result in a negligible and transient rise of blood glucose level in both fasting and non-fasting patients. This theory is supported by a study from Che Rahim et al. which found that using D50% as a contrast agent only resulted in a transient and mild (<1 mmol/ L) rise in blood sugar level (17).

Based on the current literature review, TTE and CEUS-guided confirmation of CVC tip position is a reliable, safe, and fast method. We hypothesised that D50% CEUS is a sensitive and more feasible method to detect CVC malposition compared to the standard of care.

CHAPTER 2: OBJECTIVES OF STUDY

Main Objective

To determine the diagnostic accuracy of contrast-enhanced ultrasound (RVI PLAX, apical four-chamber, subcostal view) using D50% as a contrast medium in confirming supradiaphragmatic catheter placement.

Specific Objectives

1. To determine the proportion of different RASS characteristics with CEUS using D50%.
2. To determine sensitivity and specificity of CEUS using D50% in the detection of supradiaphragmatic central venous catheter malposition compared to CXR.
3. To compare agreement between first and second investigators on CVC malposition with CEUS using D50% regarding RASS features.

CHAPTER 3: MANUSCRIPT

TITLE: Diagnostic accuracy of Contrast-Enhanced Ultrasound with Dextrose 50% In Detecting Supradiaphragmatic Central Venous Catheter Malposition.

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Abstract

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Result:

Conclusion: In this study, CEUS using D50% cannot replace CXR to detect catheter malposition. However, it can determine the correct CVC position in the venous following insertion.

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Introduction

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The primary goal of this study was to measure the diagnostic accuracy of using D50% as a contrast agent in detecting the supradiaphragmatic catheter malposition compared to the chest radiograph. Additionally, the first specific objective of this study was to determine the proportion of different RASS characteristics with CEUS using D50%, the second objective was to determine sensitivity and specificity of CEUS using D50% in the detection of supradiaphragmatic CVC malposition compared to CXR, and the third objective was to compare agreement between first and second investigators on CVC malposition with CEUS using D50% regarding RASS features.

Methodology

This cross-sectional study involved patients aged 18 years and older who underwent internal jugular catheter (IJC) or subclavian catheter insertion between January 2021 and October 2021 at Hospital Universiti Sains Malaysia. We excluded patients with indwelling intravascular devices (cardiac pacemakers, defibrillators, existing temporary or permanent CVC), superior vena cava syndrome, patients with inadequate US windows, high acuity traumatic conditions, diabetic ketoacidosis, and hyperglycaemic hyperosmolar syndrome. We obtained informed consent from all participants or their legal representatives and collected clinicodemographic data during screening. This study was approved by the Research Ethics Committee (Human) School of Medical Sciences (PPSP) University Sains Malaysia (JEPeM Code: USM/JEPeM/20060334).

Study Procedure

All IJC and subclavian catheters used were either double or triple lumen catheters, depending on the indication. All catheters were inserted by a trained medical officer according to standard aseptic technique. The assisting medical officer then flushed 5 ml of D50% through one of the CVC ports while the first investigator, a trained ultrasound fellow in critical care and emergency ultrasound observed the RASS features at the RVI-PLAX, A4c, or subcostal view and recorded the clips. The ultrasound images were acquired using a handheld, battery powered Clarius C3 ultrasound machine (Clarius Mobile Health, Vancouver, BC V5M 4X7, Canada).

RASS characteristics were then categorized into immediate, delayed, or absent. Immediate RASS is defined as sonographic turbulence seen within the RA or entering the RA from the superior vena cava and immediately migrating toward the RV (subjectively estimated within 2 seconds). The immediate RASS indicates correct CVC placement. Whereas delayed

RASS (more than 2 seconds), absence of RASS, turbulence appearing first in the RV, or migrating from the tricuspid valve into the RA are all indicators for CVC malposition (4,17).

The ultrasound image acquisition would not interfere with the ongoing management of any patient. Following a CVC placement, treating physicians continued a standard practice to order a CXR. The second investigators (certified emergency physician in critical care US) then reviewed the recorded ultrasound clips to determine the agreement of the RASS findings. The second investigators were blinded to the RASS and CXR findings of the first investigator.

The third investigator (senior radiologist) reviewed the post-procedure CXR and categorized the placement of the CVC tip based on the CXR. Correct CVC placement is defined as the position of the CVC tip in Zone 1 (3 cm above the carina on the right hemithorax), Zone 2 (3 cm below the carina on the right hemithorax), Zone 3 (brachiocephalic vein for left-sided CVCs), and Zone 4 (superior cavoatrial junction). The third investigator was blinded to the other investigators' findings.

Statistical Analysis

All statistical analyses were performed using SPSS version 27. We used descriptive statistics to summarise the sociodemographic and clinical characteristics of the patients. Categorical data was presented as frequency (n) and percentage (%). Numerical data was presented as mean (standard deviation (SD)) or median (interquartile (IQR)) based on their normality distribution. We determined the sensitivity and specificity of CEUS using D50% in detecting supradiaphragmatic central venous catheter malposition. The Kappa coefficient test was performed to measure the agreement between the first and second investigators' RASS findings.

Results

Clinicodemographic characteristics of participants

A total of 101 patients participated throughout the study duration (Table 1). However, two patients were excluded for data analysis due to missing data. Male patients accounted for a greater proportion of participants (59 (59.6%)) than female patients (40 (40.4%). The mean (SD) age of patients was 55 (16) years old. In 55 (55.6%) of patients, the catheters were inserted for venous access, while 44 (44.4%) were inserted for hemodialysis. Most catheters were inserted on the right side (85 (85.9%)). The majority of catheters were IJC triple lumen (49 (49.5%)) and IJC double lumen (43 (44.4%). Twenty-nine (29.3%) patients were on inotropic support, and 40 (40.4%) patients were ventilated.

RASS features and CVC malposition

Almost all (94 (94.9%)) RASS were immediate (Table 2). The immediate RASS is defined as ultrasound appearance of turbulence entering the RA from the superior vena cava and migrating toward the RV within 2 seconds and this indicates no catheter malposition. RASS was detected flowing into RA in 65 (65.7%) patients, 27 (27.3%) flowing within RA, and 2 (2.0%) flowing within right ventricle (RV). RASS was absent in remaining 5 patients (5.1%)

CVC malposition detection

Seven malpositions (7.1%) detected using CEUS with D50% (Table 3). From this, 1 catheter was a true malposition (located in deep atrium) based on CXR and detected using CEUS (Table 4). Remaining 6 (6.1%) catheter tips were correctly positioned based on the CXR and detected as malposition by CEUS with D50% (false positive) (Table 5).

Seven malpositions of CVC tip placement were detected by CXR (Table 3), and the incidence rate was 7% during this study period. From all these 7 malpositions, the CVC tip was detected in deep atrium (n=4), left brachiocephalic (n=1), right brachiocephalic (n=1), and inferior vena cava (IVC) (n=1) (Table 6). Proximal SVC was considered the correct position for the CVC tip. There were six false negatives in which CEUS with D50% did not detect malposition despite true malposition based on CXR (Table 5).

In 87 of our 99 patients, there was concordance between CEUS with D50% and chest radiograph findings (both showed correct placement in 86 patients, and both showed malposition in 1 patient). CEUS detected correct CVC tip placement in 84 of 92 patients with correct CVC tip placement as determined by CXR. Table 5 summarises the characteristics of the 12 patients in whom there was lack of concordance between radiography and CEUS. There was no intraarterial CVC malposition occurred based on CXR. Sensitivity was 14.3% for catheter malposition detected on CEUS with D50%, while specificity was 95.5%. There was a moderate agreement between the first and second investigators’ diagnosis of CVC malposition detected on CEUS (ƙ 0.533), as demonstrated in Table 7.

Discussion

The main findings of this study, comparing CEUS using D50% with chest radiograph to detect catheter malposition, are a sensitivity of 14.3% and specificity of 95.5%. Malposition occurred in 7% (n=7) of all central line placements. From this, only 1 malposition was detected by CEUS. Although RASS produced by D50% can confirm that there is venous placement of CVC as demonstrated in our study, it cannot accurately confirm catheter malposition.

According to systematic review and meta-analysis by Smit et al., the diagnostic accuracy of US to detect CVC malposition are a pooled specificity and sensitivity of 98.9 (95% CI: 97.8–99.5) and 68.2 (95% CI: 54.4–79.4), respectively (6). Most previous studies used CEUS with apical 4 chamber and subcostal view for CVC malposition detection (4). In addition to these two views, we have included the RVI-PLAX view in our study. All the views will provide visualization of right atrium and right ventricle. Based on a study that used D50% with the RVI-PLAX view, it revealed that D50% RASS in the RVI-PLAX view helps in determining intravenous catheter position (17). Post D50% flush capillary blood glucose was not measured in this study as a previous study has demonstrated that 5-10 mls of D50% flush will only cause a mild and transient elevation (<1 mmol) of blood sugar (17).

Previous studies primarily used saline or agitated saline as a contrast solution (6,8,10). In this study, we used D50% flush instead of saline, and there is no study yet comparing D50% with saline as a contrast solution in CEUS. According to Li et al., the use of D50% in contrasted trans-thoracic echocardiography (TTE) examination is better in terms of ultrasonic features than saline (12).

During D50% flushing, the pressure generated by the syringe is operator dependent and is influenced by other factors that need to be considered, such as central venous pressure, fluid viscosity as well as catheter diameter and length (1). In this study, there were different types of catheters, with IJC double lumen and IJC triple lumen being the most inserted. A short catheter can significantly increase flow velocity and deliver D50% faster to the right atrium. This also applies to the catheter with a larger diameter. The delivery of D50% is also dependent on central venous flow velocity. In case of high cardiac output, one can hypothesise that the D50% is more quickly delivered to the right atrium, and the 2-seconds cut-off value could produce a false-negative test in case of a malpositioned central venous catheter. Considering these assumptions, reducing the duration to less than 2 seconds can produce a higher sensitivity (1). A study that used a cut-off value of 500 milliseconds reported a sensitivity of 100% and a specificity of 99% for CVC malposition (19). Weekes et al. discovered that optimally positioned CVC displayed turbulence within 1.1 s of the rapid saline flush (4). Lowering 2-seconds cut off value may reduce the number of false-negative and thus increase sensitivity in this study. Nevertheless, visualization of D50% RASS in the right atrium within 2 seconds ascertains intravenous CVC position and an unimpaired fast delivery of medication into the right atrium.

Ultrasound used in this study was a handheld ultrasound, as it offers greater mobility than conventional cart-type ultrasound. This will be easily accessible in ward or ICU settings and to healthcare providers. With high specificity in this study (95.5%), the use of ultrasound to confirm the correct position will reduce the time before utilising the catheter as compared to CXR. In addition, the use of POCUS to detect CVC malposition and pneumothorax can be done even by POCUS non-expert after 30 minutes of training, and it has demonstrated adequate diagnostic accuracy in CVC position confirmation (20).

There was moderate agreement between the first and second investigators' diagnosis of CVC malposition detected on CEUS (Ꝁ = 0.533). A study by Weekes et al. showed a higher agreement (Ꝁ = 0.76), while a study by Che Rahim found almost perfect agreement (Ꝁ = 1.0) (3,17). Disagreement between investigators in this study is likely due to differences in clip quality once exported to a different format. The first investigator viewed the clip on the handheld ultrasound device, while the second investigator viewed it after it was exported as MP4 format. There was some disagreement among investigators due to differences in clip quality when exported to different formats. However, the disagreement was resolved after both investigators reached an agreement after viewing the clip in DICOM format together. Higher agreement indicates that the RASS is easily identified and reproducible.

Our study has several limitations. First are small numbers of patients, and only involved a single centre. Due to the low prevalence of CVC malposition, prospective, multicentre clinical trials with a larger sample size are envisaged in the future. Secondly, there was only one experienced operator with ultrasound in our study who performed the ultrasound examination. With good training in ultrasound for the non-expert, it is possible to include other operators with a varying amount of experience to perform the ultrasound examination. Therefore, the study could have demonstrated that ultrasound protocol is easy to learn and perform. Thirdly, the type of CVC inserted into our patients was different in diameter and size. Another study with uniformed size of catheters is required to determine whether catheter size differences affect the timing of RASS. Additionally, the future study should compare D50% with saline (agitated or non-agitated) as this solution is readily available in hospitals.

Conclusion

The main findings from this study using CEUS with D50% as contrast in detecting malposition following CVC insertion are a low sensitivity and high specificity. CEUS with D50% cannot be an alternative to detect catheter malposition in this study. However, due to high concordance between CEUS with D50% and CXR in determining correct intravenous catheter position after insertion, this tool may be useful in replacing CXR in patients who require urgent usage of the catheter, but CXR will still be required to confirm malposition.

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Tables and Figures

Table 1. Clinicodemographic characteristic of patient using D50% as contrast agent in CEUS (n=99)

Characteristics	n / Frequency (%)
Age (years)	55 (16)[a]
Gender	
Male	59 (59.6)
Female	40 (40.4)
CVC indication	
Hemodialysis	44 (44.4)
Venous	55 (55.6)
CVC type	
IJC double lumen	43 (43.4)
IJC triple lumen	49 (49.5)
IJC Tri-flow	1 (1.0)
Subclavian	6 (6.1)
Side of insertion	
Right	85 (85.9)
Left	14 (14.1)
Blood pressure (mmHg)	144 (26)[a] / 71 (15)[a]
Pulse rate (bpm)	85 (17)[a]
Inotropic support	
Yes	29 (29.3)
No	70 (70.7
Ventilatory support	
Yes	40 (40.4)
No	59 (59.6)

[a]Mean (SD)

Table 2. RASS features (n=99)

RASS features	n (%)
Immediate	
Into RA	65 (65.7)
Within RA	27 (27.3)
Within RV	2 (2.0)
Absent	5 (5.1)

Table 3. CVC malposition detection (n=99)

	CXR for CVC tip location		
	Correct	**Malposition** n (%)	**Total**
CEUS with D50%			
Correct	86 (95.5)	6 (85.7)	92
Malposition	6 (6.5)	1 (14.3)	7
Total	92	7	99

Table 4. Characteristics of patients in whom ultrasound correctly detect malposition

Patient	Indication	Catheter side	RASS findings	CXR findings
1	Intravenous	Right	Within RV	Deep Atrium