ORIGINAL RESEARCH PAPER
Volume-6 | Issue-9 | September-2017 | ISSN No 2277 - 8179 | IF : 4.176 | IC Value : 78.46
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

VALUE OF ULTRASOUND FOR DETECTION OF CENTRAL VENOUS CANNULATION RELATED COMPLICATIONS IN CRITICALLY ILL PATIENTS BY TRAINEE ANESTHESIOLOGIST.

Anaesthesiology

Dr.Neeta Bose M.D., Associate Professor (Anesthesiology) Department of Anesthesia, Pramukhswami Medical College, Karamsad – 388325, Gujarat, India

Dr.Hitendra Kanzariya M.D.(Anesthesiology)Department of Anesthesia, Pramukhswami Medical College, Karamsad – 388325, Gujarat, India

Dr.Avani Shah D.A., D.N.B. (Anesthesiology) Department of Anesthesia, Pramukhswami Medical College, Karamsad – 388325, Gujarat, India

ABSTRACT

Introduction: Ultrasound is routinely used for central venous cannulation. After cannulation, a chest radiograph is obtained for detection of complications. Ultrasound also can detect pneumothorax and visualize catheter in central veins.

Objective: To evaluate the feasibility of ultrasound for detection of complications associated with central venous cannulation and its comparison with chest radiography.

Materials and Methods: A prospective observational study was conducted in surgical intensive care unit at a tertiary care teaching hospital. We evaluated 53 patients undergoing central venous cannulation with ultrasound guidance. After cannulation, a chest radiograph was obtained in all patients. Ultrasound was performed for detection of pneumothorax and catheter misplacement.

Results: Ultrasound examination for detection of central venous cannulation (CVC) related complications were satisfactory in 40 patients. None of the patients developed pneumothorax immediately after the procedure. Catheter misplacement occurred in 2 patients of which one was detected by ultrasound. The mean time required for ultrasound examination (8.27 ± 2.47 min) was significantly less than that of chest radiography (81.56±14.70 min).

Conclusion: The ultrasound is a useful modality to ensure correct catheter position and to detect pneumothorax after central venous cannulation in the hands of trainee anesthesiologists. It is time and cost effective and radiation exposure with chest radiography can be avoided. Chest radiography can be used when ultrasound examination is found unsatisfactory due to technical limitations.

KEYWORDS

catheterization, central venous; intensive care unit; ultrasonography

Introduction:

Ultrasound is now gaining widespread popularity in several aspects of perioperative and intensive care management [1,2]. With the availability of the portable ultrasound machines, it is easily accessible in the operation theatres (OTs), intensive care units (ICUs) and Emergency departments [3,4,5,6,7].

The real-time ultrasonic examination is being used more and more frequently by ICU physicians to assess cardiac function or hemodynamic status, and to diagnose pleural effusion, ascites, or obstructive renal insufficiency and to assess airway and its management [8]. Likewise, ultrasound has also shown great potential for detection of central venous cannulation (CVC) related complications like aberrant catheter tip position, pneumothorax, etc. and also for correction of the same by replacement and repositioning of the catheter under ultrasound guidance. Doing ultrasound evaluation is a non-invasive, inexpensive and safe way of detecting CVC related complications, and is a supplement to chest radiograph (CXR).

In the past, CVCs were done using anatomic landmark techniques without imaging guidance. Even if this procedure is for most of the time uneventful, complications may occur, and even lead to death [9,10]. In addition to evident difficulties such as the inability to locate or cannulate the vein, arterial puncture and hematoma, nerve injuries, catheter misplacement and pneumothorax can occur and are usually difficult to confirm in the absence of post procedural CXR [11]. With the use of ultrasound, the incidences of these complications have been reduced [12,13,14].

One of the purposes of obtaining post procedure CXR is to detect pneumothorax and second is to ensure that the catheter tip is in the superior vena cava (SVC) and not in the right atrium or right ventricle [15,16]. With the use of ultrasound, two major complications of CVC (e.g. pneumothorax and catheter misplacement) can be easily ruled out and use of CXR can be reduced.

Earlier studies have evaluated ultrasound as a tool for detection of post procedural complications in ICU. In our ICU, trainee anesthesiologist frequently uses US for cardiac function evaluation and pneumothorax detection. So, without any further advanced training in US, we assessed the feasibility of US for detection of CVC related complications in ICU patients by trainees.

Subjects and Methods:

This study was conducted in a 12-bed ICU in a 550-bed tertiary care teaching hospital after approval by Institutional Ethics Committee. Informed consent was obtained from each patient or the next of kin.

All patients >18yrs, in whom ultrasound guided CVC of internal jugular vein or subclavian vein was done for various indications in ICU were included.

CVCs performed without ultrasound guidance were excluded from the study. Other exclusion criteria were pre-existing central venous catheter and subcutaneous emphysema involving neck and chest, as these will interfere with interpretation of ultrasound examination.

The procedure of CVC and subsequent examination was carried out in the supine position. Portable ultrasound machine (sonosite micromaxx) with a linear probe (frequency 5-10 Mhz) and phased array probe (frequency 1-5 Mhz) was used. The central vein chosen for cannulation was evaluated for its anatomy and detection of pre-existing venous thrombosis with ultrasonography. The insertion site was changed if pre-existing venous thrombosis was found on ultrasonography.

After evaluation, CVC of internal jugular or subclavian vein was performed. A non-tunneled, 7F, 16-cm long single/dual/triple lumen catheter (certofix, B. Braun) was inserted with seldinger technique under ultrasound guidance (in plane approach) with all aseptic and antiseptic precautions. During insertion of guidewire, the probe was kept over the cannulated vessel and its venous doppler characteristics were confirmed to rule out arterial placement of guide-wire before dilatation. [Figure 1] After CVC insertion, CXR was ordered and time to receive CXR was recorded.

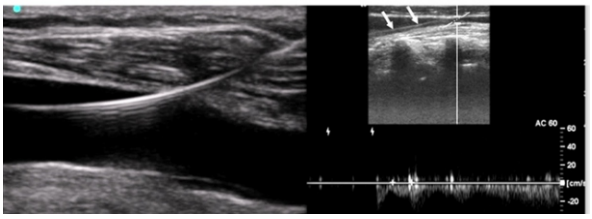

Figure 1: Confirmation of venous placement of guide wire

Ultrasound examination was done for detection of misplacement of the catheter and pneumothorax as follow: (1) examinations of the two SCV(subclavian vein) and IJV(internal jugular vein) with the vascular probe (10 MHz linear transducer) in longitudinal and transverse view were done for identification of the above mentioned aberrant positions. (Figure 2) (2) pneumothorax detection was done by the vascular probe in 3-5 intercostal spaces in parasternal and anterior axillary line on both sides of the chest to confirm the presence of lung sliding. (3) visualization of heart (right atrium) and IVC(inferior vena cava) through sub costal view for the distal position of the catheter. For that, the probe was changed from linear to phased array probe. The probe was kept in sub costal region to identify right atrium and IVC in subcostal short and long axis view for visualization of the catheter. The time required to perform the ultrasound examination was measured.

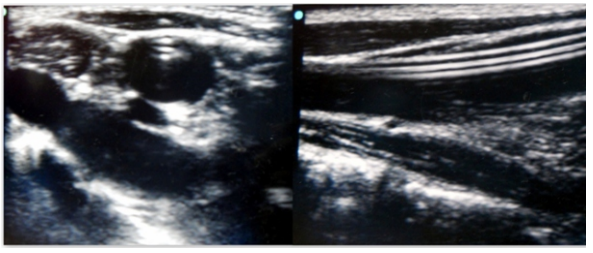

Figure 2: Ultrasound appearance of central venous catheter

Misplacement of catheter was defined when catheter was either in aberrant position(i.e. ipsilateral IJV or contralateral SCV in case of subclavian cannulation or ipsilateral SCV or contralateral IJV in case of internal jugular cannulation) or in distal position (i.e. catheter tip in right atrium or in IVC)

Pneumothorax was diagnosed by assessing lung-sliding and comet-tail artifacts on ultrasonography of lung. The interface between the thoracic wall and the lung appears as a hyperechogenic line. Lung-sliding appears because of to and fro movement of the hyperechogenic line. Comet-tail artifacts are vertical artifacts spreading from the hyperechogenic line. (Figure 3) The presence of lung-sliding is suggestive of absence of pneumothorax and absence of both lung-sliding and comet-tail-artifact indicates pneumothorax.

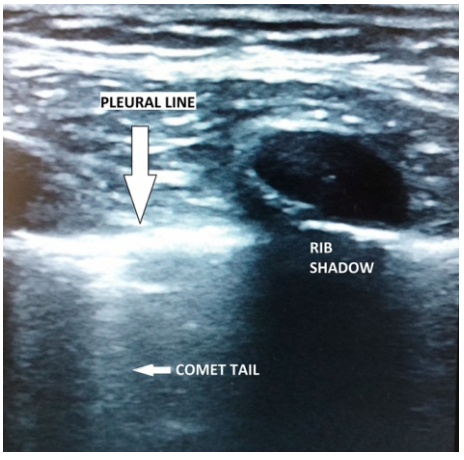

Figure 3: Ultrasound image of normal lung

Ultrasound guided CVC was done by the linear transducer (5-10MHz). In order to avoid frequent changes in transducer, central veins and lungs were examined first with the same probe followed by heart examination with the phased-array probe (1-5MHz).

Ultrasound examination was considered satisfactory when we were able to perform all the ultrasound procedures to diagnose complications related to CVC and to interpret ultrasound images otherwise it was considered unsatisfactory. The findings of ultrasound examination and CXR for misplacement of catheter and pneumoth orax were correlated.

Statistical analysis:

Statistical analysis was done using unpaired 't' test for finding the statistical difference between the means of quantitative data. A p value of < 0.05 was considered as significant, while a P value > 0.05 was considered as not significant. Statistical package SPSS Version 20.0 (Armonk, NY: IBM Corp) was used for the analysis of data.

Results:

We included 53 patients in our study aging >18 years undergoing ultrasound guided CVC in ICU. The characteristics of these patients are given in Table 1. SCV cannulation was done in 9 patients and IJV in 44 patients.

Table 1: Characteristics of 53 patients

Table 1:Characteristics of 53 patients	
	Number of Patient
Age1(yrs)	(44.84 ± 18.13)
Sex (male/female)	27/26
Ventilator support	35
Obese (BMI >30)	14
Hypotension (SBP ≤90)	18
Coagulopathy (INR >1.5)	17
Platelet <50,000	3
History of previous central venous cannulation	2
Upper abdomen surgical wound/dressing	5
1Mean ± standard deviation values	

The pre-procedure ultrasound evaluation revealed 2 patients with central venous thrombosis with one patient having a history of previous central venous cannulation. Ultrasound examination for detection of CVC related complications was satisfactory in 40 patients and unsatisfactory in 13 patients. In our study, there was no case of accidental arterial cannulation or pneumothorax. Catheter misplacement occurred in 2 cases. In the first case, there was coiling of the catheter in IJV and in the second case, a catheter inserted from right IJV landed in left brachiocephalic vein. The first case was detected on ultrasound and the later one was only revealed on CXR. (Table 2)

Table 2: Complications after Central Venous Catheter insertion

Table 2: Complications after Central Venous Catheter insertion		
Complication	US Examination	CXR
Catheter Misplacement	1	2
Pneumothorax	0	0
Numeric indicate number of patients		

Patients' characteristics of satisfactory and unsatisfactory US examinations are listed in Table 3.

Table 3: Patient Characteristics of Satisfactory and Unsati sfactory US examination

Table 3: Patient Characteristics of Satisfactory and Unsatisfactory US examination			
	Obesity (BMI >30)	Hypotension (SBP <90)	Upper abdomen surgical wound/dressing
Patients with Satisfactory US Examination (n=40)	12.5% (5)	30% (12)	0% (0)
Patients with Unsatisfactory US Examination (n=13)	69.23% (9)	46.15% (6)	38.46% (5)
US- Ultrasound			

The time required for CVC was 18.8 ± 6.8 min with a minimum of 10

min and a maximum of 40 min. The duration of ultrasound examination for detection of complications was 8.27 ± 2.47 min. The mean time for postprocedural CXR in ICU was 81.56±14.70 min. ($P < 0.001$)

Discussion:

Ultrasound is now routinely used for central venous cannulation. Studies have demonstrated improved success rate and lesser complication of CVC when done with ultrasound guidance [5,12].

In our study, CVC was done under ultrasound guidance where, in the majority of the patients (41/53), right IJV was cannulated. Cannulation of left IJV, right SCV and left SCV was done in 3, 8 and 1 patient respectively. We found 2 patients with previous central venous thrombosis. (Figure 4) It helped us to make a decision of changing the insertion site and thus could prevent multiple attempts of CVC.

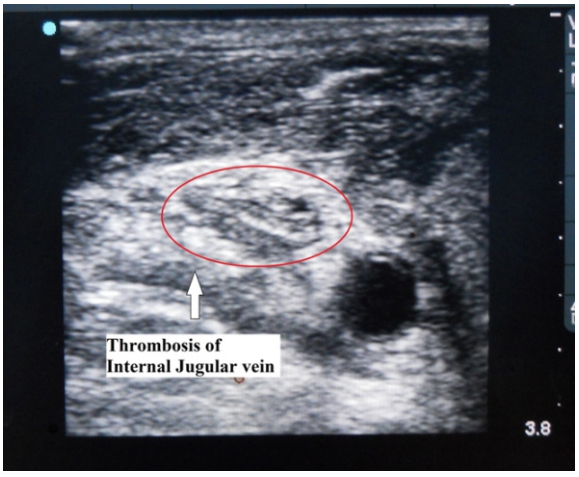

Figure 4: Thrombosis of Internal Jugular Vein

Catheter misplacement occurred in 2 patients. In first case, catheter coiled in right SCV and it was detected by ultrasonography and confirmed with CXR. In the second case, the catheter was misplaced in left brachiocephalic vein and was not detected by ultrasonography, but it was revealed on CXR. (Figure 5,6). The case, in which coiling of the catheter in right SCV was detected with ultrasonography, was later on repositioned correctly under ultrasound guidance. Hence, along with detection of complications, steps could be taken for correction and this can be considered as an extended use of ultrasound for CVC.

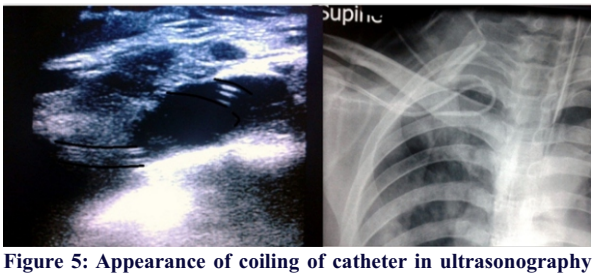

Figure 5: Appearance of coiling of catheter in ultrasonography and chest radiography

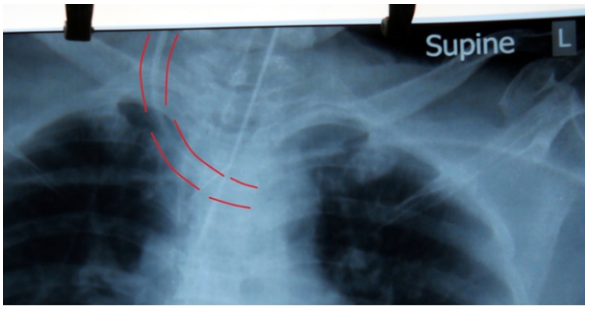

Figure 6: Catheter tip turned towards left brachiocephalic vein

In the majority of other studies, the incidence of misplacement detected by CXR was higher than that detected by ultrasonography (4% to 13.55% vs 2.5% to 6.77%). In some of the studies, the sensitivity of ultrasonography examination was 84-96% for catheter misplacement [17, 18, 19, 20]. **Vezzani et al [19]** in their study of 111 patients reported 28 catheter misplacements, of which 23 were detected by ultrasonography. Total 5 intra-cardiac catheter misplacements were not identified due to poor ultrasound image, obesity and large abdominal surgical wounds. Attempt to position catheter tip as close as possible to the SVC-right atrium junction and a large number of procedures carried out by young residents were reasons attributed to the high rate of catheter misplacement. In the study done by **Maury et al, [20]** 10 catheter misplacement were reported from 85 cannulation, of which only one could not be detected with ultrasonography because heart visualization was not satisfactory due to severe obesity. **Matshushima et al [18]** found 10 catheter misplacements from 83 cannulation. Ultrasonography detected 5 catheter misplacements. Of missed 5 catheter misplacements, in one case catheter was found in left brachiocephalic vein. In another case, ultrasound evaluation of IJV was not possible because of hemodynamic instability. Optimal visualization of central veins by ultrasonography can theoretically be impaired in hypovolemic or severely dehydrated spontaneously breathing patients and in some of the studies, it was observed that it could be avoided by a valsalva maneuver [19].

In our study, none of the patients developed pneumothorax immediately after the procedure and this was probably due to the fact that all cannulations were done under ultrasonography guidance. In other studies, the incidence of pneumothorax detected by CXR varies from 0% to 2% and the same detected by ultrasonography varies from 0% to 4% [21,22].

Matsushima et al [18] also didn't find pneumothorax in their study of 59 patients. In a study of **Maury et al [20]**, one patient developed pneumothorax out of 85 cannulation. **Vezzani et al [19]** in their study of 111 cannulations could detect pneumothorax in 4 patients based on the absence of lung sliding and identification of lung point, whereas CXR identified only two large sized pneumothorax. The reports on recognizing hidden pneumothorax have documented the superiority of ultrasonography compared with CXR performed with the patient in supine position. Ultrasonography examination can readily diagnose pneumothorax at bed side and treatment of this complication can be taken care of immediately in case of respiratory distress. **Wu ding et al [23]** demonstrated superior sensitivity and similar specificity in the use of ultrasonography compared with CXR for the diagnosis of pneumothorax. They also mentioned that bedside ultrasonography performed by clinicians other than radiologists is as accurate as CXR in detecting pneumothorax.

The incidence of delayed pneumothorax has been reported in 0.5% to 4% of patients [24]. In one of our patients we suspected pneumothorax 24 hrs after cannulation on the clinical ground, despite initial normal ultrasound and CXR. This was subsequently confirmed by CXR and required insertion of a chest tube.

Though arterial puncture during insertion is often well tolerated, arterial dilatation and cannulation may carry significant morbidity and potential mortality. Central line incident monitoring study reported that 50% of reports are due to accidental arterial injuries which have led to poor patient outcome [25]. Carotid artery injury can happen even under direct ultrasound guidance because of different direction of ultrasound beam and needle [26]. Clinical measures like bright red blood and pulsatile flow can be used to rule out arterial versus venous cannulation. However, in situations like hypotension and hypoxia these measures are unreliable or difficult to interpret. Other methods like needle pressure measurement and blood gas measurement are not routinely feasible. In our study, we utilized doppler and dynamic ultrasound visualization of the guidewire within the vein along its entire course as a method to confirm intravenous guide-wire placement prior to dilatation and we didn't find any arterial placement of guidewire or catheter.

We found ultrasound examination unsatisfactory in 13 patients. Ultrasound examination for identification of distal catheter tip position

was not possible in 5 patients due to upper abdominal surgical wounds and dressing. Ultrasound examination was not interpretable in 8 patients due to poor image acquisition. Among these, in one patient ultrasound images of veins were not interpretable due to obesity while in rest 7 patients, ultrasound images of heart and IVC were not interpretable due to obesity and abdominal distension. Obesity was present in 14 out of 53 patients. Ultrasound examination was unsatisfactory in more number of patients with obesity. Hypotension was present in 18 patients, and in the majority of these patients, ultrasound examination was found unsatisfactory. (Table 3)

Maury et al [20] studied 85 CVCs and were able to perform ultrasonography examination in all of their patients satisfactorily except heart examination in one patient (99.6% feasibility). Most of the patients included in their study were cannulated for chemotherapy, parenteral nutrition, hemodialysis, or absence of peripheral venous access. **Matsushima et al [18]** in their study of 83 patients, evaluated 59 patients satisfactorily. Incomplete studies were significantly more common in those with chest tubes, but they could detect misplacement (into the right atrium or ventricle, using the parasternal or apex view and into the IVC and atrio-caval junction through sub costal view) even in the patients with open abdomen, wound dressing with plastic sheet or drapes and also in morbidly obese patients. The sensitivity of ultrasound examination to identify catheter misplacement was 50% with a positive predictive value of 83% and negative predictive value of 91%. We were not able to evaluate this category of patients because in our study we had performed ultrasound examination with only sub costal window. **Vezzani et al [19]** also found that transthoracic echocardiography was not feasible in 11% of patient, the reasons being the same.

Although previous reports accomplished a high success rate using a similar technique, [19, 20] no data about patients' characteristics or associated factors is available. The success rate of ultrasound examination for detecting complications related to CVC highly depends upon patients' characteristics. For example, surgical patients with dressings of upper abdominal surgical wounds are difficult cases for evaluation of complications by ultrasound where CXR is desirable.

In our study, we tried to compare the time required to detect CVC related complications by ultrasound and CXR, which was 8.16 ± 2.4 min and 81.56 ± 14.70 min respectively. So ultrasound was found to be much faster than CXR. **Maury et al [20]** showed entire time required to perform ultrasonography was 6.8 ± 3.5 min, and for CXR was 80.3 ± 66.7min. **Matsushima et al [18]** also showed that use of ultrasound required less time than CXR to detect complications (10.8 min vs 75.3 min). It is not uncommon for CVP monitoring or any other usage of the central venous catheter to be delayed for 1 hour after cannulation while awaiting confirmation of its position by conventional CXR. This golden hour can be utilized more expeditiously to resuscitate the patients with polytrauma or severe sepsis who are common in the SICU setting.

The cost of a portable CXR in ICU is reported to be greater than ultrasound examination [27]. Repeat CXR in the case of repositioning or replacement of catheter can be avoided by implementing CVC evaluation by ultrasound with significant cost reduction [18].

Limitations:

As incidences of various complications related to central venous cannulation are very low, large number of patients needs to be studied for usefulness of ultrasonography as a tool for detection of central venous cannulation related complications.

Scope of the study:

There is a scope to study different patients' characteristics responsible to determine the outcome of ultrasonography in detecting central venous catheter related complications, as previous studies have not been able to provide enough data to select the appropriate modality for detection of complications.

Conclusion:

Ultrasound can be used to ensure correct catheter tip positioning and to detect pneumothorax after central venous catheter cannulation. Ultrasound technique is rapid and safe. A chest radiograph is needed when the US is technically difficult to perform in patients with surgical wounds, obesity, and hypotension.

REFERENCES

1. Kundra P, Mishra SK, Ramesh A. Ultrasound of the airway. Indian J Anaesth. India; 2011 Sep;55(5):456–62.
2. Hatfield A, Bodenham A. Ultrasound: an emerging role in anaesthesia and intensive care. Br J Anaesth. England; 1999 Nov;83(5):789–800.
3. Pirotte T. Ultrasound-guided vascular access in adults and children: beyond the internal jugular vein puncture. Acta Anaesthesiol Belg. Belgium; 2008;59(3):157–66.
4. Griffin J, Nicholls B. Ultrasound in regional anaesthesia. Anaesthesia. England; 2010 Apr;65 Suppl 1:1–12.
5. Di Domenico S, Licausi M, Porcile E, Piaggio F, Troilo B, Centanaro M, et al. Introducing ultrasound-guided vein catheterization into clinical practice: A step-by-step guide for organizing a hands-on training program with inexpensive handmade models. J Ultrasound. Italy; 2008 Dec;11(4):135–42.
6. Gray AT. Ultrasound-guided regional anesthesia: current state of the art. Anesthesiology. United States; 2006 Feb;104(2):368–73, discussion 5A.
7. Green JS, Tsui BCH. Applications of ultrasonography in ENT: airway assessment and nerve blockade. Anesthesiol Clin. United States; 2010 Sep;28(3):541–53.
8. Manno E, Navarra M, Faccio L, Motevallian M, Bertolaccini L, Mfochive A, et al. Deep impact of ultrasound in the intensive care unit: the "ICU-sound" protocol. Anesthesiology. United States; 2012 Oct;117(4):801–9.
9. Scott WL. Complications associated with central venous catheters. A survey. Chest. United States; 1988 Dec;94(6):1221–4.
10. Gladwin MT, Slonim A, Landucci DL, Gutierrez DC, Cunnion RE. Cannulation of the internal jugular vein: is postprocedural chest radiography always necessary? Crit Care Med. United States; 1999 Sep;27(9):1819–23.
11. McGee DC, Gould MK. Preventing complications of central venous catheterization. N Engl J Med. United States; 2003 Mar;348(12):1123–33.
12. Randolph AG, Cook DJ, Gonzales CA, Pribble CG. Ultrasound guidance for placement of central venous catheters: a meta-analysis of the literature. Crit Care Med. United States; 1996 Dec;24(12):2053–8.
13. Aslamy Z, Dewald CL, Heffner JE. MRI of central venous anatomy: implications for central venous catheter insertion. Chest. United States; 1998 Sep;114(3):820–6.
14. Nakazawa N. Challenges in the Accurate Identification of the Ideal Catheter Tip Location. J Assoc Vasc Access [Internet]. 2010;15(4):196–201. Available from: http://www.sciencedirect.com/science/article/pii/S1552885510700428
15. Reynolds N, McCulloch AS, Pennington CR, MacFadyen RJ. Assessment of distal tip position of long-term central venous feeding catheters using transesophageal echocardiology. JPEN J Parenter Enteral Nutr. United States; 2001;25(1):39–41.
16. Stonelake PA, Bodenham AR. The carina as a radiological landmark for central venous catheter tip position. Br J Anaesth. England; 2006 Mar;96(3):335–40.
17. Lanza C, Russo M, Fabrizzi G. Central venous cannulation: are routine chest radiographs necessary after B-mode and colour Doppler sonography check? Pediatr Radiol. Germany; 2006 Dec;36(12):1252–6.
18. Matsushima K, Frankel HL. Bedside ultrasound can safely eliminate the need for chest radiographs after central venous catheter placement: CVC sono in the surgical ICU (SICU). J Surg Res. United States; 2010 Sep;163(1):155–61.
19. Vezzani A, Brusasco C, Palermo S, Launo C, Mergoni M, Corradi F. Ultrasound localization of central vein catheter and detection of postprocedural pneumothorax: an alternative to chest radiography. Crit Care Med. United States; 2010 Feb;38(2):533–8.
20. Maury E, Guglielminotti J, Alzieu M, Guidet B, Offenstadt G. Ultrasonic examination: an alternative to chest radiography after central venous catheter insertion? Am J Respir Crit Care Med. United States; 2001 Aug;164(3):403–5.
21. Palepu GB, Deven J, Subrahmanyam M, Mohan S. Impact of ultrasonography on central venous catheter insertion in intensive care. Indian J Radiol Imaging. India; 2009;19(3):191–8.
22. Cavanna L, Civardi G, Vallisa D, Di Nunzio C, Cappucciati L, Berte R, et al. Ultrasound-guided central venous catheterization in cancer patients improves the success rate of cannulation and reduces mechanical complications: a prospective observational study of 1,978 consecutive catheterizations. World J Surg Oncol. England; 2010 Oct;8:91.
23. Ding W, Shen Y, Yang J, He X, Zhang M. Diagnosis of pneumothorax by radiography and ultrasonography: a meta-analysis. Chest. United States; 2011 Oct;140(4):859–66.
24. Kusminsky RE. Complications of central venous catheterization. J Am Coll Surg. United States; 2007 Apr;204(4):681–96.
25. Singleton RJ, Webb RK, Ludbrook GL, Fox MA. The Australian Incident Monitoring Study. Problems associated with vascular access: an analysis of 2000 incident reports. Anaesth Intensive Care. Australia; 1993 Oct;21(5):664–9.
26. Blaivas M. Video analysis of accidental arterial cannulation with dynamic ultrasound guidance for central venous access. J Ultrasound Med. England; 2009 Sep;28(9):1239–44.
27. Cullinane DC, Parkus DE, Reddy VS, Nunn CR, Rutherford EJ. The futility of chest roentgenograms following routine central venous line changes. Am J Surg. United States; 1998 Sep;176(3):283–5.