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Venous Thrombosis of the Mammary Vein Following Peripherally Inserted Central Catheter for Total Parenteral Nutrition Relying on Ecg Tip Confirmation Technology

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ABSTRACT

Total parenteral nutrition (TPN) is a life-saving therapy for patients who are not able to utilize the gastrointestinal tract. There are several different types of central venous catheters (CVC) used to deliver TPN. To safely deliver hyperosmotic TPN solutions, CVC tip position should be in the in lower superior vena cava (SVC) or at the junction of SVC and right atrium (RA). New techniques such as intravascular electrocardiogram (ECG) are being used for tip confirmation to help facilitate expedient use of PICC lines replacing the need for chest x-ray (CXR) confirmation. We present a case of a TPN patient who had a PICC line placed, and ECG confirmed tip as being in the SVC. The patient developed chest pain with flushing of the PICC prompting surgical service to obtain a CXR. The CXR suggested the line was in the either in mammary vein or aorta and recommended replacement. Interventional radiology flushed a small amount of contrast through the PICC and fluoroscopy confirmed the PICC tip was in the left internal mammary vein with reflux of contrast in the left innominate vein.

The left innominate vein was occluded due to thrombosis and vasospasm. The patient required increased level of care (PCU) for 2 days, but was eventually discharged with home total parenteral nutrition and has done well. We conclude that care should be taken when using ECG confirmation for PICC tip placement and we feel that patients requiring hyperosmotic TPN should still require CXR confirmation to ensure tip appropriate tip location.

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Introduction

Parenteral Nutrition (PN) can be life-saving therapy for patients with the inability to utilize the gastrointestinal tract for nutrient absorption. Central venous catheters (CVC) are utilized if PN is to be provided in most cases with a very limited role for peripheral catheter delivery due to high PN osmolality. The type of CVC used depends primarily on length of need with peripherally inserted central catheters (PICC) being utilized for short term use and tunneled catheters being preferred for long-term or home going use. The two primary concerns with CVC and TPN delivery are thrombosis and catheter related blood stream infection [1,2].

Thrombosis remains the main clinical concern with malpositioned CVC. A small prospective randomized controlled study evaluated PICC tip position and rates of thrombosis. Subjects (n=39) were randomized to have the tip in the superior vena cava versus innominate vein. There was increased thrombosis in subjects with tips in the innominate vein compared with the superior vena cava (60% vs 21%, $p < 0.05$) [1,2]. There are several infection preventive measures we use in TPN patients such as catheter locks, site care, single lumen (versus double lumen) [3]. The main thrombosis prevention technique we employ in our home parenteral nutrition (HPN) patients is ensuring that the catheter tip is in the low SVC or at the junction of the SVC and right atrium (RA).

There have been some concerns with confirming PICC tip with CXR including additional expense, time delay waiting for specialists reading CXR, and small amount of additional radiation. Intravascular electrocardiography (iECG) has been developed and used to confirm tip position at the time of placement in a number of settings (operating room and intensive care unit) [4]. When the PICC tip is advanced until the p waves demonstrate max wave peak it is hypothesized to be at junction between the vena cava

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and right atrium and if the tip is advanced into the right atrium the p wave becomes biphasic [5]. Based on the potential benefits of the technology our institution adopted a policy to implement iECG in all adult PICC placements excluding those patients who have arrhythmias eliminating post placement CXR. We present a case where iECG alone was used during PICC placement in one of our HPN patients and developed post-procedural thrombosis.

Case Presentation

The patient is a 48-year-old female with a complex medical history including chronic diarrhea (almost 20 years) in the setting of multiple prior small bowel resections and right hemicolectomy for recurrent bowel obstructions. During her hemicolectomy, approximately five months prior to admission there was some concern for anastomotic leak in the setting of multiple intra-abdominal abscesses requiring antibiotics. During the right hemicolectomy, she had 30 cm of ileum resected. A CT scan was performed a month prior to admission and demonstrated a stable peripherally enhancing inflammatory mass just deep to the left abdominal wall (2.4 cm by 1.6 cm) in the right lower quadrant mesentery.

The inflammatory changes in the small bowel and remaining colon had increased from previous scans and was suggestive of Crohn's disease. Colonoscopy was performed and included random ileal and colonic biopsies, which were normal. The end to end ileo-colonic anastomosis was normal appearing with healthy appearing mucosa. The patient continued to have abdominal pain and fever (102˚F) with no explanation and repeat CT scan demonstrated enlargement of the inflammatory mass in the right lower quadrant mesentery that had involved matted loops of small bowel involved. Outpatient interventional radiology potential drainage was arranged but the pain continued and the patient was eventually seen in the Emergency Department and subsequently was admitted to the hospital for observation and workup.

On the day of admission, the patient was evaluated by General Surgery service who specialize in fistulas and based on the CT scans they thought that she had developed a fistulous process after her right hemicolectomy. They felt the there was a fistulous communication to the sub-fascial abscess in the anterior midline which then secondarily communicated with the small inflammatory mass in the anterior abdominal wall. Upper GI and small bowel follow through examination was performed and demonstrated no evidence of Crohn's disease with impending extra-luminal fistulae to the urinary bladder and sigmoid colon, likely complications from her prior hemicolectomy.

Sinugram performed in Interventional Radiology eventually did confirm the fistula communication between the small bowel and the inflammatory mass. A drain was placed to facilitate cavity drainage. Bacterial cultures from the drain grew *Enterobacter cloacae and Enterococcus faecalis* and appropriate antibiotic coverage was started based on sensitivities. Due to the formation of the fistula and abscess the surgeons recommend HPN for 3-6 months.

Prior to the decision for HPN the surgeons had recommended a PICC placement for TPN initiation on admission while the workup for determining the etiology of the pain and as CT scan findings were being evaluated. The day after admission, PICC line was placed in the left upper extremity. One year prior to admission, our institution had implemented a policy in which post PICC placement confirmation CXR was eliminated. PICC tip location in the superior vena cava was confirmed by ECG technology (BARD 3CG tip locator system) and the PICC was deemed to be in a safe position for infusion (Figure 1).

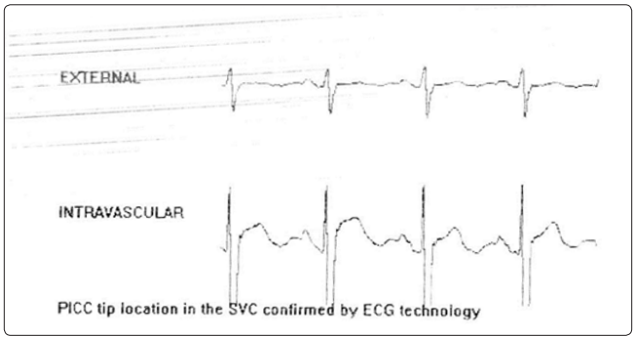

Figure:1

TPN was started using the PICC line one day after admission. After the 24 hour TPN infusion was complete she had acute stabbing chest pain which occurred immediately following the flushing of her left PICC line. The patient rate rated the chest pain 2/10, which was reproducible on palpation and with deep breaths. She was hemodynamically stable with a blood pressure of 113/72 saturating 98% on room air. ECG demonstrated normal sinus rhythm, incomplete right bundle branch block, and nonspecific T wave abnormalities and Troponin T was negative (<0.01 ng/mL). CXR showed abnormal course of the PICC line over the left heart which was concerning for either an abnormal course through the left subclavian artery into the aorta or placement into the left internal mammary vein through the innominate vein (Figure 2).

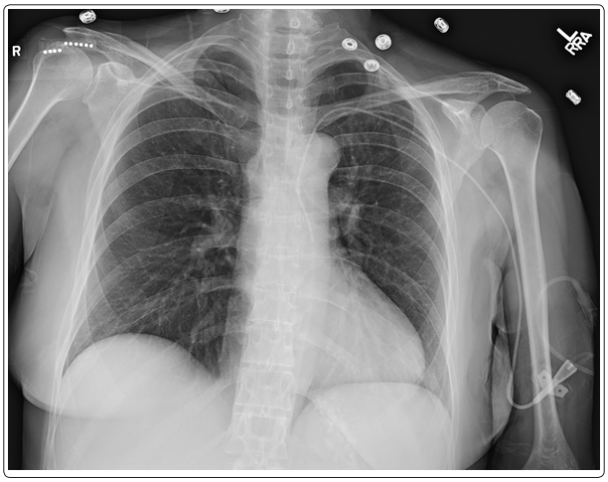

Figure 2: PICC line position confirmation in the lower 1/3rd of SVC

The patient was transferred to the PCU for higher level observation, PICC line use was discontinued, and because her INR was 2.7 due to anticoagulation for history of thrombosis and Factor V Leiden deficiency the PICC line was evaluated in interventional radiology. In interventional radiology, initial ultrasound evaluation demonstrated the left PICC to be within the left brachial vein. Radiographically confirmed venous placement clinically correlate with venous return when the PICC had been used. Scout film images demonstrated the PICC to be situated in the left chest anteriorly. A small volume of contrast was injected through the PICC demonstrated that catheter was situated in the left internal mammary vein. The left internal mammary vein was determined to be occluded due to thrombus and vasospasm.

The PICC was pulled back into the subclavian vein and removed over a guide wire and a new PICC was placed and the tip was

radiographically confirmed to be at the vena cava/atrial junction. The patient did not have any subsequent chest pain and eventually had a single lumen tunnel catheter placed, was trained to perform HPN, and was dismissed home.

Discussion

The use of CVCs is associated with common complications such as catheter displacement, thrombosis, central line associated blood stream infection (CLABSI) and can also include life threatening complications such as cardiac tamponade, tension pneumothorax and arrhythmias [6]. Existing data show that improperly positioned PICC lines are at risk of tip mal-positioning, thrombophlebitis and catheter dysfunction compared to CVCs and the risks are even higher with long term use [7]. As majority of our patients on HPN service typically need PICC lines for longer duration and with high osmolality of the PN infusion, accurate tip positioning is critical. With growing evidence of improved cost effectiveness and accuracy of iECG in confirmation of PICC position, our medical center adopted iECG wave technology as the standard of care excluding CXR from the standard protocol [8].

The accuracy of iECG to determine the tip position is validated, however using it alone can increase the risk of complications related to malposition. Therefore, to emphasize the role of radiographic confirmation in HPN patients, we present a case of a 48-year female with a complex medical history of Crohn's requiring TPN who developed internal mammary vein thrombosis after the confirmation of the tip position in the SVC using iECG alone. On the 2nd day of PICC placement, patient developed severe pain on flushing of the PICC line and the following CXR showed an abnormal path taken by the catheter. On IR fluoroscopy, the catheter was seen in the internal mammary vein and vein occlusion was noted secondary thrombus formation and vasospasm. She eventually had her PICC removed and replaced with CXR to confirm the tip location.

With an increasing use of PICC lines in TPN, we recently published a case series evaluating the effectiveness of intravascular ECG for confirmation of tip location in patients undergoing PICC placement for HPN [9]. Patients were included in the study if the PICC tip was present in the SVC on iECG during the procedure and also had a post PICC CXR for confirmation of the position. For the study purpose, the position of the catheter tip in the low SVC or SVC-RA junction was defined to be satisfactory and any other location was considered unsatisfactory. Out of the 17 patients included in the study only 59% (n=10) had a satisfactory tip position on the CXR. The tip position was unsatisfactory in 41% (n=7) of the patients. Four out of the 7 patients with unsatisfactory position had the tip located in mid to high SVC and three patients had it in the brachiocephalic vein.

The osmolality of the PN solution obtained at time of CXR in patients with unsatisfactory position was above 1100mOsm/L, suggesting caution for the use of iECG alone in patients receiving TPN. At the time of the case series publication, this patient was not eligible for inclusion in the study, as she developed post procedural thrombosis followed by a PICC line replacement.

In a retrospective observational study, Johnson et al evaluated the effectiveness of Sherlock 3CG TCS in PICC line placement [10]. The Sherlock 3CG TCS system uses an electromagnetic sensor that allows to track the distal tip of the catheter and can generate an ECG waveform based on its position, assisting in accurate placement of the catheter tip. In this study, a total of 239 patients were analyzed who underwent a PICC line placement with the use of iECG technology and had a post-procedural confirmatory CXR. To report the malposition rates with iECG, two definitions were used to define adequate positioning.

Position of the tip in the mid/low SVC, cavo-atrial junction or RA was an ideal location and the tip in the low SVC or at cavo-atrial junction was also considered to be a satisfactory position. With the adequate positon as mid/low SVC, cavo-atrial junction or high RA (<2cm from cavo-atrial junction) the malposition rate was only 20.5% (n=49/239; 95% CI: 16-26%). However, when analysis included only low SVC/cavo-atrial junction, a position preferred as ideal for HPN, the rate of malposition was around 56.1% (n=134/239; 95% CI: 50-62%). In the post hoc analysis, the malposition rates were down to 4.3% (n=10/239; 95% CI: 2.3-7.5%) when the high atrium was set between 0-4cm from the cavo-atrial junction.

The study also provided key insights into the PICC positioning using iECG and concluded that the probability of inserting the PICC line further beyond high RA was more common than being placed in a high SVC position (40/239 vs 9/239). iECG is extremely helpful to avoid gross mal-positioning and in targeting the SVC and cavo-atrial junction, but we feel CXR must be done prior to the use of PICC line for HPN as the ideal positioning of at the low SVC/cavoatrial junction has shown to reduce mechanical and thrombotic events. In event of such complications as this patient, it increases the hospital costs and days of hospitalization.

Novel technological methods are being studied to successfully place the PICC lines at the cavo-atrial junction with precision. One of the recently published in-vivo animal study, evaluated the use of Dual-wavelength reflectance spectroscopy of SVC in PICC line placement [11]. This method was successful in placement of the PICC line within 5mm from the cavo-atrial junction. Another recent advancement in confirmation of the PICC position is the use of a fully automated deep learning system as a part of machine learning, utilizes two convolutional neural pathways to determine the PICC location [12]. These technologies are in their early stages of investigation and require a larger efficacy studies to be implemented in to clinical practice.

In conclusion, the PICC placement in the ideal location is essential to reduce complications of malposition and thrombosis. As mentioned in the discussion, radiographic confirmation of the PICC tip can be extremely useful in patients who are anticipated to be on long-term HPN. This can prevent added hospital costs and days of hospitalization.

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Conflict of interest: RTH Consultant for Nestle Nutrition and has research grant from Zealand. MSM has research grants from Fresenius Kabi, Nestle, and Realfood Blends and is on advisory board for Fresenius Kabi, Baxter.

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