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Doppler ultrasound-guided brachiocephalic central line insertion in cardiac surgery: an overlooked approach revisited

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SUMMARY

The insertion of central venous lines is sometimes challenging for both the physician and the patient. In a previous work from our institute, Badran et al. described brachiocephalic central line insertion as an overlooked approach and recommended its use in clinical practice. The aim of this study is to evaluate ultrasound-guided brachiocephalic central line insertion in patients undergoing cardiac surgery. Twenty-six low-risk patients undergoing coronary bypass surgery consented to participate in the study (14 male, 12 female). Ultrasound-guided brachiocephalic central line insertion was performed, and the main outcomes measured were the success rate and the ease of cannulation. The procedure was successful in 24 patients (92.3%), while it failed in two (7.7%). The single-puncture success rate was 79.3% (19 out of 24), with no acute or late complications. Using Doppler ultrasound guidance, the brachiocephalic vein is a suitable site for central venous catheter insertion in cardiac surgery.

Key words: Brachiocephalic central line – Ultrasound-guided cannulation

INTRODUCTION

Since the introduction of central venous catheterization (Aubaniac, 1952), this technique has become a standard procedure in surgical and intensive care patients. Commonly used insertion sites include the internal jugular veins, the external jugular veins, the subclavian veins, the femoral veins, and the arm veins. The selection of the insertion site takes into consideration the ease of the procedure and related risks; such risks include infection, thrombosis and mechanical complications.

During the early days of cardiac surgery, the brachiocephalic vein was reported to be used safely, easily and reliably in cardiac surgery patients (Wolppowitz, 1978). However, this route did not gain as much popularity as other approaches especially the internal jugular vein, the popularity of which has steadily

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increased among anesthesiologists (Kaplan et al., 2006).

Badran et al. (2002) described a total of 128 cadaveric catheterizations of the brachiocephalic veins as an overlooked approach of central venous catheterization. They reported a very high reproducibility of this approach, with a 97% success rate on the first attempt at catheterization on both the right and left sides, along with no injury to neighboring structures.

Schummer et al. (2003) successfully performed a Doppler-guided cannulation of the brachiocephalic vein along with the internal jugular and subclavian veins in patients with reduced and normal intracranial compliance. They stated that although the brachiocephalic venous lines have not become popular cannulation sites, they are suitable vessels for Doppler-guided cannulation, with 96% and 100% success rate in the first and second attempts respectively.

In this study, we performed 26 ultrasound-guided brachiocephalic central venous catheterizations in patients undergoing cardiac surgery in order to evaluate the reproducibility and success rate of the procedure for patients undergoing conventional aortocoronary bypass grafting.

Materials and Methods

Following the approval of the IRB committee of Jordan University Hospital (JUH) and the Scientific Committee of the Faculty of Medicine at the University of Jordan, an informed written consent was signed by each patient willing to participate in the study.

Between March and October 2007, a total of 26 right brachiocephalic central venous catheters were inserted in patients undergoing cardiac surgery at JUH. They were under the age of 70 and were undergoing coronary bypass surgery for the first time. Patients above the age of 70 years or having cardiac diseases other than coronary disease and patients having an additive Euroscore above five were not included in the study.

Patients were premedicated with 5 mg oral diazepam 2 hours preoperatively. On arriving in the operating room, they were monitored with a 5-lead ECG, pulse oxymetry, capnography, intermittent blood pressure monitoring and a bispectral index monitor. A standard protocol for anesthesia was applied. Induction and maintenance of anesthesia were performed with propofol and fentanyl, and muscle relaxation was achieved with rocuronium. The left radial artery was cannulated immediately after the induction of anesthesia and was connected to obtain a continuous blood pressure monitoring before the commencement of central venous cannulation.

Catheterization technique

To avoid operator-linked variances, all catheterizations were performed by one team, which consisted of an anesthesiologist and a radiologist. The cannulation procedures were performed while the patients were lying flat, without head tilt or being in a Trendelenburg position. The patients' arms were adducted along their sides.

The chest wall was cleaned with povidone-iodine and a sterile drape was applied. A sterile ultrasound transducer (Aloka Pro Sound SSD-5500, Tokyo-Japan) at a frequency of 7.5-MHz was positioned in the groove bounded by the clavicle, sternum and the first rib; it was directed toward the contralateral shoulder. The radiologist assessed the patency of the brachiocephalic vein before catheter placement. Color-flow Doppler imaging was used to delineate the arterial flow from the venous flow in the vessels visualized. When the right brachiocephalic vein was identified along its greater longitudinal axis, the vein was punctured under direct ultrasound visualization with a 16-gauge needle (Seldiflex® 7F- Triple lumen (PLASTIMED, Saint-Leu-La-Foret - FRANCE) placed anterior to the transducer. Subsequently; the anesthesiologist inserted the guide wire through the needle, and continued the procedure by dilating the puncture site and inserting the central line using a standard Seldinger technique. The needle depth from the skin to the encounter with the blood vessel was measured by ultrasound and then reconfirmed by measuring the needle depth. The catheter was then advanced for 5-7 cm inside the vessel.

The ease of venous cannulation was assessed by the success of the first needle pass and the number of venous puncture attempts. Resistance to the introduction of the guide wires was also recorded. We also took special note of the needle direction. After the procedure, adequate catheter function was indicated by the ability to aspirate greater than 5 mL/port without resistance.

Acute complications such as arterial puncture, pneumothorax, mediastinal hematoma, emphysema or hemothorax were recorded. If three attempts failed and/or the artery was punctured, the procedure was immediately abandoned, and a right subclavian vein cannulation was performed instead.

Proper placement of the tip of the central venous catheter was examined intraoperatively by the cardiac surgeon after the sternotomy and visualization of the superior vena cava. The catheter was considered properly placed if its tip was at the junction of the superior vena cava and the right atrium. If the catheter was not seen or palpated by the cardiac surgeon, a post operative CXR was performed to identify the location of the catheter tip. The surgeons were asked to report other related complications such as mediastinal hematoma, hemothoax or pneumothorax.

Statistics

All values are expressed as numbers and percentages. For the BMI and needle depth the mean ± SD was used. For the ASA (American Society of Anesthesiologists) clinical status score, the median ASA was expressed. Statistical analysis was performed using Statgraphics Centurion (Statpoint Inc., Herndon, Virginia, USA).

Results

A total of 63 patients were approached, only 26 of them consented and were approved to participate in the study (14 male and 12 female). The patients' ages ranged from (37-70) years, with a mean Body Mass Index (BMI) of (30.11 ± 3.5). All patients were classified as ASA III. (Table1).

Table 1. Demographics of the patients and needle depth.

Parameter	*Value*
Age (Mean ± SD)	57.7 ± 9.7
Male / female	14/12
BMI (Mean ± SD)	30.11 ± 3.5
ASA class (Median)	ASA III
Needle Depth (Mean ± SD)	3.78 ± 0.47 cm

The procedure was successful in 24 patients (92.3%); from the first attempt in 19/26 patients (73.1%), from the second attempt in 4/26 patients (15.4%), and from the third attempt in 1/26 patients (3.8%). In two patients (7.7%), the brachiocephalic vein could not be cannulated and the procedure was abandoned because of arterial punctures (Table 2).

Table 2. Attempts and success rates of the procedure (n=26).

	Number of Patients	*%*
Success from the 1st attempt	19	73.1
Success from the 2nd attempt	4	15.4
Success from the 3rd attempt	1	3.8
Failures	2	7.7
Total	26	100

In all patients the needle was directed toward the tip of the opposite shoulder passing through the sternal notch at an angle of ≈ 60°. The veins were encountered at variable distances from the skin, with a mean needle depth (3.78 ± 0.47), and the catheter tip was advanced for a further 5-7 cm inside the vein. This distance was adequate to reach an appropriate location in all patients, except in one, where the catheter was not palpable by the surgeon intraoperatively. A postoperative chest X-ray revealed a catheter migration to the left subclavian vein.

There were no problems in introducing the guide wire, dilating the entrance site, or sliding the central venous catheter over the guide wire. All inserted catheters were functioning properly according to the criteria used.

Apart from two arterial punctures that did not result in any surgical consequences, there were no acute complications such as pneumothorax, mediastinal hematoma, emphysema or hemothorax.

Discussion

Although central venous catheterization is one of the most frequently performed procedures in clinical practice, the best placement site with the lowest complications and the highest success rate is still debatable (Albuquerque and Vasconcelos, 1998). None of the known techniques for central venous cannulation is regarded as ideal, and the success rate is strongly related to personal beliefs and experience (Whitman, 1996; McGee and Gould, 2003). Occasionally, catheter insertion is a really challenging problem, especially when the anatomical landmarks are hard to identify or when the insertion sites are thrombosed or occluded, particularly in patients with repeated central catheter insertions such as chronic renal failure patients. These problems and

others make the search for alternative approaches for catheter insertion a mandatory, and sometimes life-saving matter.

The use of ultrasound-guided technique for the placement of central lines reduces the incidence of mechanical complications, the number of catheter placement failures and the time required for insertion (Teichgräber et al., 1997). It had been shown that using ultrasound is superior to the landmark technique, and it should be the method of choice in high-risk patients (Karakitsos et al., 2006).

In the early beginnings of cardiac surgery, the brachiocephalic vein was used safely, easily and reliably (Wolpowitz, 1978), but its use did not gain popularity, while the use of other approaches, especially the internal jugular vein, has steadily increased among anesthesiologists (Kaplan et al., 2006). However, puncturing the carotid artery is still a major concern with the internal jugular vein approach, especially in elderly atherosclerotic patients.

In a previously published post-mortem study from our institute, Badran et al. (2002) placed emphasis on the constant anatomical landmarks of the brachiocephalic veins, the easy access to such veins and on the fact that they are distant from important anatomical structures, which minimizes the risk of complications. They recommended the introduction of this technique into clinical practice.

The availability of sonographic guidance for central venous catheterization encouraged us to revisit and evaluate the brachiocephalic approach in cardiac surgery patients. The choice of cardiac surgery patients is based on several issues. First, all these patients need central venous catheters for the measurement of central venous pressure and the administration of certain drugs that should preferably be given through a central line. Second is the fact that cardiac surgeons are already going to open the sternum and the pericardium, and thus will be able to assess the proper placement site of the catheter tip. They will also be able to identify and deal with any complication that may occur due to the cannulation procedure. Here, to guarantee maximum patient safety, a single team of a senior anesthesiologist and a senior radiologist performed all the procedures together.

In our patients, the right brachiocephalic vein lay superficially (2.5-4.6 cm) behind the medial end of the clavicle and the first rib. This made the bony landmarks forming the slit composed by the clavicle, the first rib and the sternum (Figure 1) an easily identifiable set of borders for the placement of the ultrasound probe and the needle. The anatomical location of the brachiocephalic vein distant

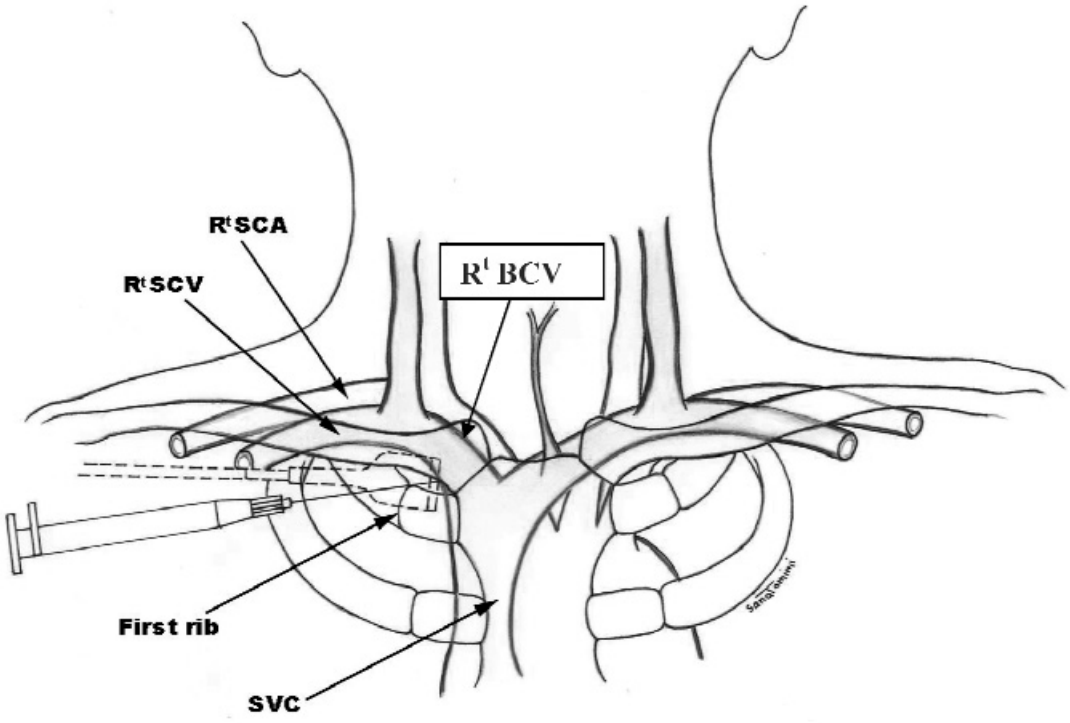

Figure 1. The technique of the ultrasound-guided brachiocephalic line insertion. Right subclavian artery (R^t SCA), right subclavian vein (R^t SVC), superior vena cava (SVC), right brachiocephalic vein (R^t BCV).

from important structures, and the short puncture distance, make this approach better than other puncture sites.

Pneumothorax is an important and feared complication that should be avoided. In their large retrospective survey, Pittiruti et al. (2000) found that the only method for avoiding pneumothorax is to avoid direct puncture of the subclavian vein, and they proposed different techniques. In our study, none of the patients had pneumothorax, since the puncture site was away from pleura, and puncturing the subclavian vein was avoided. Theoretically, pneumothorax in this approach would occur in hyperinflated emphysematous lungs like as COPD patients. The short dwelling time of catheters in cardiac surgery patients (1-2 days) did not allow us to determine the incidence of catheter-related thrombosis. This complication is known to be affected by the diameter of the catheter in relation to the vessel, the length of the catheter inside a vein segment (Clagette and Eberhart, 1994), and the site of insertion of the central catheters (McGee and Gould, 2003), the lowest incidence being in the subclavian vein. If this occurs, it could be explained by the resulting pressure of the catheter on the caudal aspect of the subclavian vein as it bends to enter the superior vena cava (Schillinger et al., 1992). Since the brachiocephalic vein diameter is larger than that of the subclavian vein, and the length of the catheters to reach the proper placement site inside the vein is only 5-7 cm, bending is avoided anatomically and thus the incidence of catheter-related thrombosis in brachiocephalic venous catheterization might be the lowest among all other approaches. However, this point needs further evaluation.

In spite of using the ultrasound guidance, we had two cases of brachiocephalic arterial punctures. Although this complication had no sequelae after the surgery, it could be a limiting factor for this technique, especially in patients with a tendency to bleed or an abnormal coagulation profile. Ultrasound guidance has been promoted as a method for reducing the risk of complications during central venous catheterization, but it does not completely prevent complications (Teichgräber et al., 1997; Randolph et al., 1996). The anatomical relationship between the brachiocephalic vein and the brachiocephalic artery, and the relatively limited experience with its use might hinder catheter insertion and could result in arterial puncture instead of vein puncture.

In patients with reduced intracranial compliance, the head-down position is deleterious, and the use of ultrasound guidance, while avoiding the Trendelenburg position to facilitate venous cannulation, is of great importance for patient safety and success. In their study, Schummer et al. (2003) showed that the first-pass success rate of brachiocephalic cannulation using Doppler ultrasound was similar to those found for other sites, even when the procedure was performed in the head-up position. The authors stated that this approach is very suitable for Doppler-guided cannulation even without the Trendelenburg position.

The brachiocephalic vein is also used for the placement of tunneled hemodyalisis catheters. These accesses can sometimes be challenging in patients when the more common access sites such as the internal jugular veins or other alternative sites are no longer available, or the insertion of catheters in alternative access sites becomes necessary and life-threatening. In his study, Abigail (2006) reviewed the insertion of tunneled brachiocephalic hemodyalysis catheters in 33 patients. In this procedure; the transducer was positioned just above the clavicle and was angled toward the mediastinum, directing the ultrasound beam posterior to the clavicle. The transducer was angled medially and caudally and was sometimes difficult. The needle was placed posterior to the transducer and the procedure was completed by inserting the catheter and tunneling from the venotomy site to the lateral chest wall. All the procedures in this study were technically successful, and the long-term follow up was excellent. In our approach we positioned the transducers below the clavicle, at the slit made by the clavicle, the sternum and the first rib. The beam was directed toward the sternal notch and the needle was placed anterior to the transducer. The probe head was at 7.5-MHz (9.5-MHz in Abigail's study), and we had no problems in visualizing the vein in any of our patients.

The risk of catheter-related infection with his approach needs further evaluation. In our institution, our practice is to remove the central venous catheter on the first day postoperatively in non-complicated cardiac surgery, and when there is no need for the line for the administration of certain drugs that should be administered centrally. We removed all the

catheters in our patients on the first day post-operatively, and all the catheter tips were free from bacterial growth. We feel that brachiocephalic cannulation could be as good as the subclavian approach, which is considered as the route of choice in term of the blood stream infection rate (Timsit, 2002). Nevertheless, further evaluation of the blood stream infection rate with this approach is needed.

Although we did not measure the cannulation time, it was never more than 7-10 minutes, a time that is comparable —if not less- than in the non-ultrasound guided technique.

One limitation of our study is the lack of randomization of the patients –since it was a non-comparative study– and the participation of only two physicians (an anesthesiologist and a radiologist) in performing the procedure. We were obliged to do this because patient safety was our major concern, and we wished to start implementing this technique in selected non-high-risk patients, with the aid of the radiologist to ensure good hand-eye coordination. Another point to mention is the relatively limited number of low-risk patients currently undergoing aortocoronary bypass grafting, especially with the extensive use of cardiac stenting.

In conclusion, using Doppler ultrasound guidance for the insertion of brachiocephalic vein central venous catheters in cardiac surgery is an easy and successful alternative, with very few complications.

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