Journal of Investigative Surgery, 27, 176–182, 2014

ISSN: 0894-1939 print / 1521-0553 online
DOI: 10.3109/08941939.2013.865818

NEW METHODOLOGIES

Central Venous Access via External Jugular Vein with CT-Venography Using a Multidetector Helical 16-Section CT

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ABSTRACT

Objective: To determine the success rate and complications of using the external jugular vein (EJV) for central venous access with a preoperative estimate of the detailed anatomical orientation of the cervical venous plexus using computed tomography venography (CT-V). *Design:* Prospective, observational human study. *Setting:* Surgical intensive care unit. *Patients:* Fifty-two patients who were undergoing EJV cannulations with CT-V using a Multidetector Helical 16-section CT (MDCT). *Intervention:* The preoperative anatomical estimation of the cervical venous plexus was performed with CT-V using an MDCT. In particular, the angulation between the EJV and the right subclavian vein (SCV) was measured. The anatomical abnormalities and the angulation between the EJV and the anterior jugular vein (AJV), transverse cervical vein (TCV), and suprascapular vein (SSV) were estimated. *Measurements and Main Results:* The success of CT-V was achieved in 52 of 52 patients (100%). The mean angulation between the right EJV and the right SCV was 144 ± 36 degrees in the obtuse-angle cases (88%) and 72 ± 28 degrees in the sharp-angle cases (12%). A plexus of veins under the clavicle was most commonly responsible for insertion of the central venous catheter (CVC). The EJV approach resulted in a 93% rate of successful cannulations. No complications of pneumothorax or carotid artery puncture occurred during insertion procedures. *Conclusions*: The EJV route is associated with comparable technical success and lower major procedural complication. The EJV approach with CT-V guidance is an option as the initial method when central venous cannulation must be performed under suboptimal conditions.

Keywords: external jugular vein (EJV); catheterization; central venous access; cervical venous plexus; multidetector helical 16-section computed tomography (MDCT); computed tomography venography (CT-V)

INTRODUCTION

Central venous access plays an important role in modern medical care. Central venous catheters (CVCs) are used for total parental nutrition, medication administration, chemotherapy, and hemodynamic monitoring [1]. The preferred access approach for CVC placement is the right subclavian vein (SCV) or the right internal jugular vein (IJV) [2, 3]. The percutaneous Seldinger method for catheter insertion into the SCV has been widely accepted, because of the ease of insertion when initially successful. This technique carries the risk of complications, including pneumothorax, hemothorax, and arterial puncture, that can cause significant morbidity [2, 4–6]. The right IJV approach should be considered as the primary access site for all patients [2, 7]. When the right IJV is not available for CVC placement, the second access site remains

Received 10 September 2013; accepted 11 November 2013.

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variable. Although the left IJV and both SCVs have been used for secondary access, several studies suggest that both the SCV and the IJV should be avoided because of a high incidence of procedural complications as well as central stenosis and thrombosis [4–6, 8]. These complications are increased in patients undergoing hemodialysis and in those with a history of multiple central venous catheterizations [4, 8].

The external jugular vein (EJV) approach for CVC placement has been reported [9, 10]. One reason to use the right EJV is its relatively straightforward course and short length, similar to the right IJV. A second reason is that the EJV is easily accessible, given its superficial location on the neck [11]. EJV catheterization as a CVC placement route is commonly believed to be difficult because of its anatomical problems. Variations at the terminal point and angulation of the EJV as it enters into SCV contribute to a high failure rate [12]. Of anatomic importance to catheterization is the fact that the EJV forms an acute angle at its insertion into the SCV, which may explain the higher rate of malpositioned catheters [13]. Venography performed from multiple access sites may be required to identify a suitable vein for central access.

Here, we describe our clinical experience with percutaneous venous access via the EJV with preoperative anatomical estimation through computed tomography venography (CT-V) using a multidetector helical 16-section CT (MDCT). We describe procedural techniques that improve the success rate in patients with more difficult venous access.

MATERIALS AND METHODS

This study was approved by our hospital's institutional review board, and a waiver of consent was granted because EJV central venous access was judged one of several routine access technique. This was a prospective cohort study of consecutively treated adults (76–91 years of range) who underwent EJV central venous access attempts while receiving care in our hospital. We conducted a prospective observational study over an 18-month period from September 2011 through March 2013 of 52 patients. Women accounted for 53% ($n = 27$) of the study population, with a mean age of 82 years (range, 76–91 years). The mean age of the male participants was 78 years (range 74–88 years). The indication for CVC placement: 41 patients (78%) were for parenteral nutrition (TPN), 6 patients (12%) were for chemotherapy for solid and hematologic malignancies, and 5 patients (10%) were for long-term antibiotic administration. Fifty-two patients underwent CT-V guided CVC placement, for which informed consent was obtained. The catheter course and tip location were routinely verified by a radiograph on the 1st and 7th day after insertion. The data included inability to thread the catheter centrally, eventual CVC location, CVC adjustments needed, initial and late complications, operating time, dwell time, and catheter-related infection rate. These data, including follow up data catheter removal, were complete for all patients within our institution. These data were recorded on a uniform data sheet by a stuff surgeon.

Scanning Parameters

The CT-V was performed with a 16-MDCT scanner (BrightSpeed Elite SD, GE Healthcare). The CT-V of the cervical area involved scanning from the base of the C1 vertebral body to the level of pulmonary hila after a fixed 40-s delay between the onset of the contrast material injection and the start of scanning. A 100-mL volume of nonionic iodinated contrast material (Iopamiron 300^{TM}, Bayer HealthCare, Leverkusen, Germany) was injected into a right antecubital vein at a rate of 3 mL/s using a power injector. The following scanning and reconstruction parameters were used for the multidectector CT venogram acquisitions: a 1.25-mm collimation, pitch of 1.375, a 1.25-mm reconstruction increment, and a 0.8-s rotation time. A low-dose technique was used, with a tube current of 100–250 mAs and a peak kilovoltage of 120 kVp. The technique values for the multi-detector row CT used in this study (120 kVp, 50 mA) were chosen so that the image noise would match that found with the single-section technique (120 kVp, 70 mA). The pitch needed to be varied to account for differences in patient length so that the acquisition could be completed in 30 s. All of the CT-V examinations were performed under the direct supervision of a radiologist with the ability to immediately interpret the images to ensure optimum image quality. After scout images were acquired, images with the patient in the supine position were obtained. The MDCT scans were acquired from the level of the C1 vertebral body to the level of pulmonary hila with a z-axis coverage of 32–38 cm and with the patient in a supine position. Standard maximum intensity projection images of the major cervical venous structures were created by the three-dimensional (3D) laboratory. A primary two-dimensional (2D) evaluation technique (axial views, 2D-CT) was applied using multiplanar reformatted (MPR) images and a 3D view. The GE Navigator software enabled the simultaneous review of 3D-CT vessels, coronal and sagittal MPR, and axial images.

Image Analysis

Image processing was performed with a workstation (2LCD Workflow, GE, Healthcare for Linux) using a combination of soft-tissue windows (window width, 400HU; window level, 40 HU) and bone windows (window width, 2,000 HU; window level, 0 HU), multiplanar reformations, and 3D problem solving. The data were examined using transverse CT images with the concurrent display of both 2D and 3D reformed images for measuring the angulation between vessels with a 3D-workstation (BrightSpeed Elite SD). The reconstructed images were analyzed for parameters with implications for the CVC placement including the angle of the EJV at four locations: the angle between the left EJV and the SCV, the angle between the left EJV and the anterior jugular vein (AJV), the angle between the left EJV and the transverse cervical vein (TCV), and the angle between the left EJV and the suprascapular vein (SSV). We examined the data to assess which junction was most responsible for the insertion of CVC. The procedures were performed by a staff interventional radiologist.

Insertion Technique for External Jugular Vein

The patient was placed in a 20-degree Trendelenburg position to distend the EJV, and puncture site and patency were confirmed by ultrasonography. The right side of the neck and the upper chest of the patient were prepared with sterile technique. An anesthetic patch was attached to the insertion site of the skin before catheter insertion. The right EJV was identified by visual inspection and palpation and then punctured. An EJV puncture was performed under sterile conditions with a 14-gauge introducing needle (over-the-needle Teflon catheter, BD Insyte I.V. Catheter^{TM}, Becton Dickinson, infusion Therapy Sysems Inc., Sandy, Utah, USA). The Seldinger technique was used to access the EJV with a 16-gauge polyurethane central venous catheter (Argyle Medicut Catheter^{TM}, Tyco Healthcare, Tokyo, Japan), which is 30-cm in length. In cases where the preoperative CT-V demonstrated a sharp angulation of the EJV to the SCV (EJV-SCV sharp-angle type), or a obtuse angulation between the EJV and the AJV (EJV-AJV obtuse-angle type) or a obtuse angulation between the EJV and the TCV or the SSV (EJV-TCV/SSV obtuse-angle type), which might cause difficulties in withdrawing the catheter or cause the catheter to become kinked or knotted, a guide wire (a 35 cm long, 0.089-cm diameter, flexible angiographic catheter guide wire: angle type, Radifocus guide wire M^{TM}, TERUMO, Tokyo, Japan) technique [14] was used under fluoroscopy. In cases where the preoperative CT-V demonstrated the EJV-TCV/SSV obtuse-angle type, an ultrasound-guided right femoral vein (FV) cannulation [15] was used. Chest radiographs (CXRs) were obtained after the procedure. Manipulation of the CVC was made as necessary for acceptable placement. The procedures were performed by a staff surgeon.

RESULTS

A total 52 patients were enrolled over the study. The success of CT-V was achieved in 52 of 52 patients (100%) (Figures 1a and b). There were no complications from the CT-V in any of the 52 patients. The mean angulation between the right EJV and the right SCV measured 144 ± 36 degrees in the obtuse-angle cases (88%) (Figure 1c) and 72 ± 28 degrees in the EJV–SCV sharp-angle type (12%) (Figure 1d). The mean angulation between the EJV and the AJV measured 121 ± 10 degrees in the EJV–AJV obtuse-angle type (6%) (Figure 2a) and 43 ± 8 degrees in the sharp-angle cases (94%) (Figure 2b). The mean angulation between the EJV and the TCV or SSV measured 135 ± 4 degrees in the EJV–TCV/SSV obtuse-angle type (6%) (Figure 2c) and 63 ± 22 degrees in the sharp-angle cases (94%) (Figure 2d) (Table 1). Central venous access via the EJV was obtained in 50 (93%) of 52 patients. Fully completed data sheet were obtained from 50 patients. The average of number of puncture attempts was 1.12 (range, 1–3). The average procedure time was 13 min (range, 7–21 min).

TABLE 1 Angulation between the right EJV and SCV or AJV or TCV/SSV

Angulation type	SCV	AJV	TCV/SSV
Sharp	72 ± 28 (12)	43 ± 8 (94)	63 ± 22 (94)
Obtuse	144 ± 36 (88)	122 ± 10 (6)	135 ± 4 (6)

Note. Data are mean angulation (degree), with percentage in parenthesis.
EJV, external jugular vein; SCV, subclavian vein; AJV, anterior jugular vein; TCV, transverse cervical vein; SSV, suprascapular vein.

In eight patients (15%) where the preoperative CT-V demonstrated an EJV–SCV sharp-angle type, or an EJV–AJV obtuse-angle type or an EJV–TCV/SSV obtuse-angle type, a guide wire technique was used under fluoroscopy [10]. In six patients of EJV-SCV sharp-angle type (4 patients) and EJV–AJV obtuse-angle type (2 patients), CVC placement via EJV was obtained using a guide wire technique under fluoroscopy. In two patients (4%) of EJV–TCV/SSV obtuse-angle type, the right FV cannulations were used after the EJV cannulations have failed. In the remaining 44 patients, the catheter was inserted via the right EJV without any problem. Catheter-tip location on initial CXR was in the upper right atrium (RA) in 2 patients (4%). Fluoroscopy was used to help manipulate the central line for acceptable catheter placement. In one patient, the CT-V could not identify the left IJV, EJV, or the right EJV (Figure 3a). The Doppler color ultrasound demonstrated significantly turbulent flow with a decreased flow velocity in the left IJV (Figures 3b and c). Central venous access via the right EJV was obtained in this patient without any problem.

There were no significant procedural complications (pneumothorax, expanding hematoma, or carotid artery puncture) during the 50 catheterization attempts.

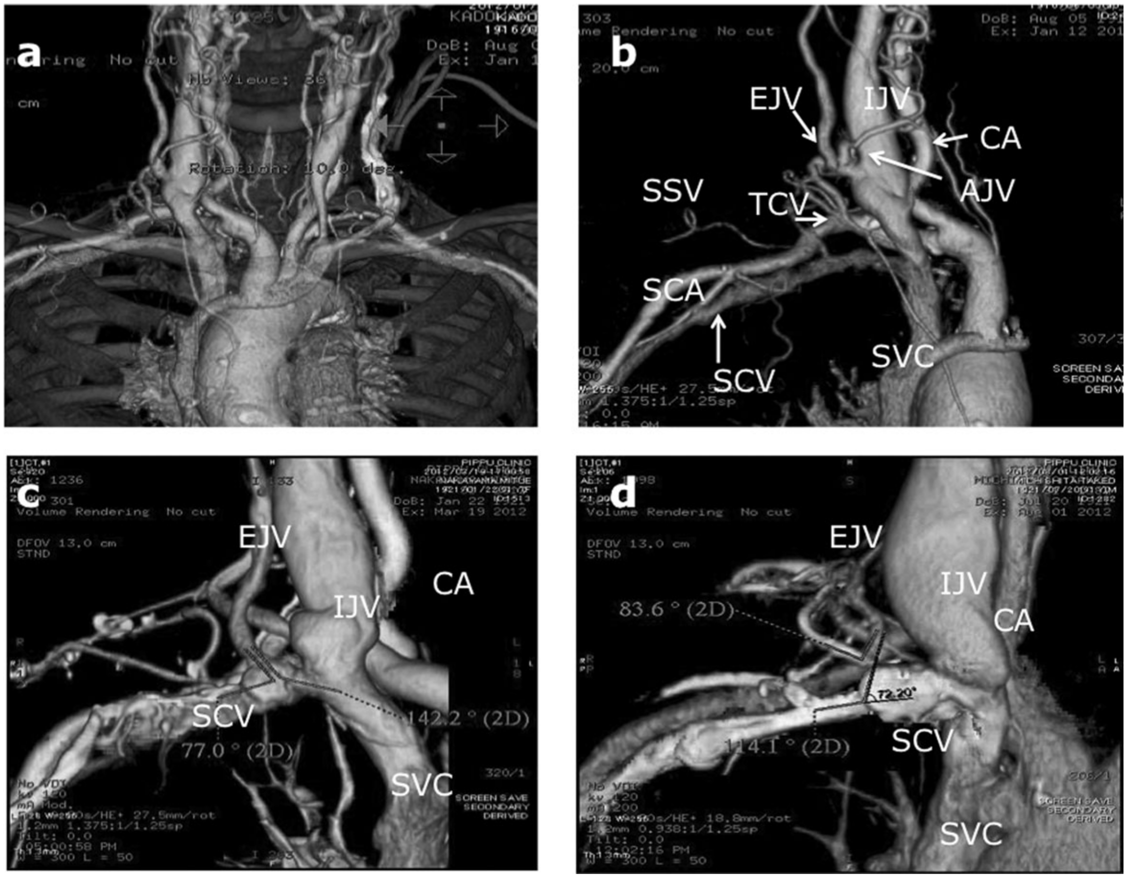

FIGURE 1 (a and b) MDCT venography of the cervical venous plexus: anteroposterior (AP) and lateral volume-rendered (VR) images. The CT-V showed a detailed cervical venous plexus and the central venous system. The CT-V clearly revealed individual vascular anatomies around the EJV and SCV junction. EJV, external jugular vein; IJV, internal jugular vein; CA, carotid artery; AJV, anterior jugular vein; TCV, transverse cervical vein; SSV, suprascapular vein; SCA, subclavian artery; SCV, subclavian vein; SVC superior vena cava; AA, aortic arch. The CT-V showed the angle between the left EJV and the SCV. The mean angulation between the right EJV and the right SCV measured 144 ± 36 degrees in the obtuse-angle cases (c) and 72 ± 28 degrees in the sharp-angle cases (d).

In three patients (6%), the small amount of subcutaneous oozing of the blood over the EJV was observed. The catheter dwell time ranged from 14 to 70 days, with a mean dwell time of 35.2 days. Catheter-related infections were observed in 2 patients (4%). No thrombotic complications were demonstrated on the clinical examination, follow-up MDCT study or ultrasonography in 50 cases during the study.

DISCUSSION

Conventional access sites include the IJV and the SCV. The former should be considered as the primary access site for all patients [11]. The incidence of technical complications associated with SCV insertion is high [2, 4–6]. The major complications of central venous catheterization may prove to be serious, particularly in critically ill patients. When the right IJV is not available for CVC, the second access site remains variable. Before utilization of the SCV, the EJV should be used [4, 7]. The benefits inherent in the use of the EJV include its large size and a greater ability to accommodate larger or multilumen catheters more easily than many peripheral insertion sites, the superficial location, the ability to visualize the EJV and the ease of access in reaching the SVC. The technique of central venous catheterization via the EJV was reported in 1974 [10]. The EJV approach has not been popular because of its low success rate [16], which is due to further anatomical considerations. The temporal and occipital veins drain into to EJV. The EJV flows in a curved and nonfixed course through the neck from the angle of the mandible obliquely to the base of the neck. At lower segments of the EJV, the AJV, TCV, and SSV drain to the EJV at the entrance to SCV, the EJV runs in a lateral direction, potentially leading to the arm rather than the thorax. In approximately 4% of the population, there is a plexus of veins under the clavicle [17]. Variations of these veins at the terminal point and angulation of the EJV to the SCV contribute to the insertion failure rate [10]. The EJV has two sets of valves, one at the entrance to the SCV and the other located 4 cm above the clavicle. These conditions cause difficulty in withdrawing catheters that have become kinked or

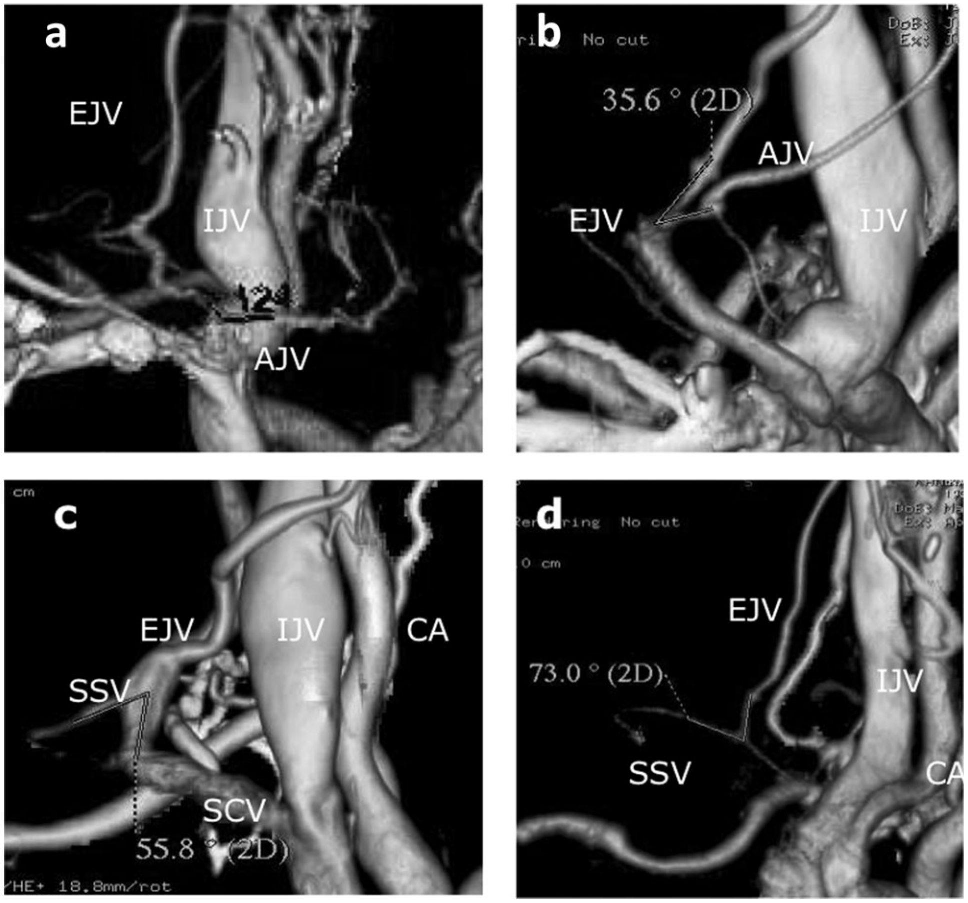

FIGURE 2 (a–d) MDCT venography: AP VR images. The CT-V showed the sharp angulation between the EJV and the AJV (a), and the EJV–AJV obtuse type (b). The sharp anglulation between the EJV and the SSV/TCV (c), and the EJV-TCV/SSC obtuse type (d).

knotted in the EJV [18]. Catheterization from the EJV requires a detailed anatomical orientation of these vessels including the central vascular system before the insertion procedure. Three-dimensional CT-V using MDCT clearly revealed individual vascular anomalies around the EJV and the SCV junction and could play an important role in safe cannulization. In our study, the angulation between the EJV and the TCV/SSV was most responsible for insertion success. Multiple access sites may be required to identify a suitable vein for central access. The CT-V can be an excellent tool for preprocedural mapping in more difficult venous access patients (4). MDCT venography has been shown to be as accurate as digital subtraction venography in central venous mapping [19, 20]. In some cases, the major problem encountered in threading an intravenous catheter through the EJV into the SCV without using a guide wire is the inability to pass the venous valve and the acute angles of tortuous veins. The J-wire easily transverses tortuous vessels, slides past valves, and navigates sharp angles [11]. When compared with the IJV or SCV sites, the EJV site offers a small risk of bleeding, puncture of the carotid artery, or pneumothorax in frail, elderly patients [10, 11, 21–24]. In this study, CT-V could not identify the left IJV, the EJV, or the right EJV in one case. The Doppler color ultrasound demonstrated significantly turbulent flow with decreased flow velocity of the left IJV. We could find this problem, which might cause complications with preoperative CT-V. Before utilization of the opposite side of IJV, the EJV should be used after the accurate estimation of condition of those vessels. Our results demonstrate percutaneous EJV cannulation to be safe for central venous access, with a high success rate compared with other sites [10, 11, 24]. However, it should be noted that the superficial location of the EJV and the small amount of subcutaneous tissue over the EJV may lead oozing of the blood. A short time simple manual compression can control subcutaneous oozing [11]. Superficial hematoma was the only problem found with the EJV route, and it was observed most often in the failed attempts. The site for percutaneously inserted catheters is determined by multiple factors, including the clinical status of patients, the purpose of central access, anticipated length of time it will be needed, and physician experience [25]. However, because of its high cost (CT-V cost: $238) and limited availability, the described procedure is not yet used for the routine diagnosis of venous

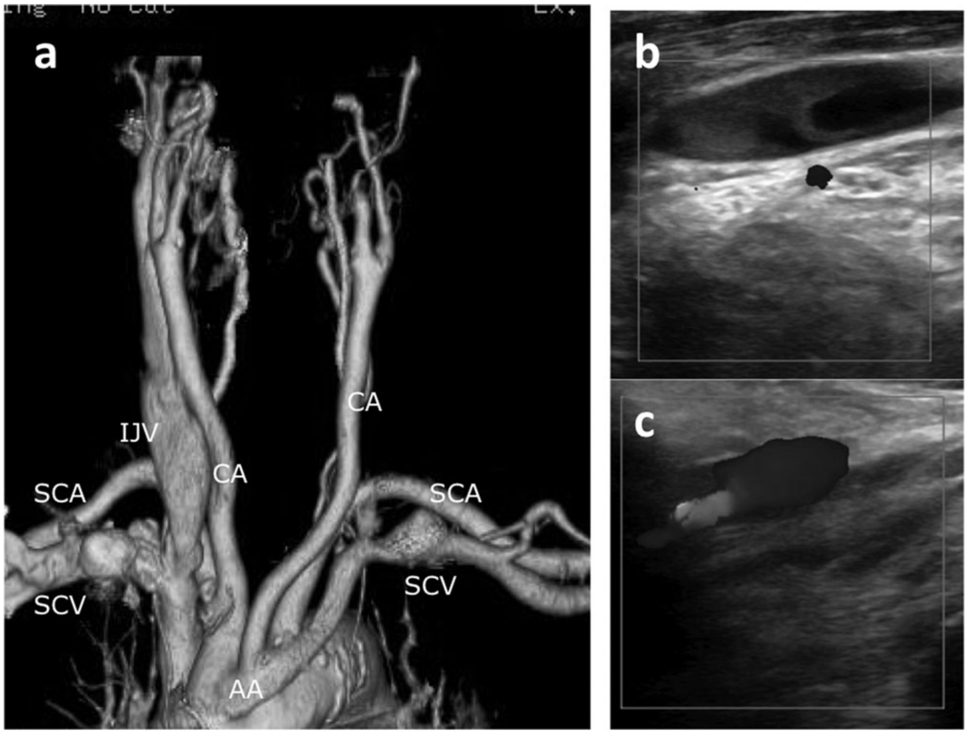

FIGURE 3 (a) MDCT venography and echo study: AP VR images. The CT-V could not identify the left IJV, the EJV, or the right EJV. The disappearance of the left IJV on CT-V image is characteristic. (b) Flow is demonstrated in the proximal section of the IJV and SCV by an ultrasound study. The Doppler color ultrasound demonstrates significantly turbulent flow with decreased flow velocity of the left IJV (c). No thrombosis was detected.

occlusion or estimation of the detailed anatomical orientation of the cervical venous plexus. The most important advantage is the absence of major complications. In regard to related patient safety, it is worth nothing that in the relatively recent past the use peripherally inserted central catheters has obviated some of the risks involved with more central access sites. Therefore, central venous access via the EJV seems to be an option to consider for vascular access in patients given our findings of a high success rate and a low complication rate [24]. The number of cases of reported is relatively small, which implies the need for a study involving a large patient population that would permit more precise assessment. Further studies are needed to determine how these advances in central access with compare to the safety profile of EJV technique.

CONCLUSIONS

Three-dimensional CT-V using MDCT clearly revealed individual vascular anatomies around EJV–SCV junction including the cervical venous plexus and could play an important role in safe cannulization. The EJV route is associated with comparable technical success and lower major procedural complication. The EJV approach with CT-V guidance is an option when central venous cannulation must be performed in patients under suboptimal conditions and patients in whom serious complications may prove to be fatal and with previous multiple central venous cannulations, especially those in hemodialysis or with long catheter indwelling periods, since because they are at higher risk of central venous occlusion.

Declaration of interest: The authors report no conflict of interest. The authors alone are responsible for the content and writing of the article.

No funds supported this study. Written informed consent was obtained from the patients for publication of this manuscript and any accompanying images. Copies of the written consent are available for review by the Editor-in-Chief of this journal.

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