Accidental arterial puncture during right internal jugular vein cannulation in cardiac surgical patients

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ABSTRACT

Background: The primary aim of this study was to compare the incidence of accidental arterial puncture during right internal jugular vein (RIJV) cannulation with and without ultrasound guidance (USG). The secondary end points were to assess if USG improves the chances of successful first pass cannulation and if BMI has an impact on incidence of arterial puncture and the number of attempts that are to be made for successful cannulation. Settings and Design: Prospective observational study performed at a single tertiary cardiac care center. Material and methods: 255 consecutive adult and pediatric cardiac surgical patients were included. In Group I (n = 124) USG was used for the right internal jugular vein cannulation and in Group II (n = 81) it was not used. There were 135 adult patients and 70 pediatric patients. Statistical analysis: Demographic and categorical data were analyzed using Student 't' test and chi-square test was used for qualitative variables. Results: The overall incidence of accidental arterial puncture in the entire study population was significantly higher when ultrasound guidance was not used (P < 0.001). In subgroup analysis, incidence of arterial puncture was significant in both adult (P = 0.03) and pediatric patients (P < 0.001) without USG. First attempt cannulation was more often possible in pediatric patients under USG (P = 0.03). In adult patients USG did not improve first attempt cannulation except in underweight patients. Conclusions: USG helped in the avoidance of inadvertent arterial puncture during RIJV cannulation and simultaneously improved the chances of first attempt cannulation in pediatric and in underweight adult cardiac surgical patients.

Key words: Blood vessels/injuries; Blood vessels/ultrasonography; Catheterization; Central venous/adverse effects

INTRODUCTION

Unintended arterial puncture can occur during central venous cannulation.\textsuperscript{[1]} Data from the American Society of Anesthesiologists (ASA) Closed Claims Project database suggested that a majority of mechanical complications associated with central venous cannulation are vascular injuries and “accidental puncture or laceration.”\textsuperscript{[1]} It is therefore important for anesthesia providers to be conversant with the tools and techniques that can help prevent arterial injuries. The current literature supports the use of ultrasound guidance (USG) for central venous catheterizations to minimize complications.\textsuperscript{[2,3]} This study was initiated with the hypothetical question whether USG could avoid accidental arterial puncture during right internal jugular vein (RIJV) cannulation as compared to landmark technique. The

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primary aim of this study was to compare the incidence of carotid artery puncture during RIJV cannulation with and without USG. The secondary end-points were to evaluate if the number of attempts for successful cannulation would be reduced under USG and if body mass index (BMI) influences the incidence of the inadvertent arterial puncture as well as to determine the difficulty of RIJV access in terms of the number of attempts made.

MATERIALS AND METHODS

After obtaining approval from the Institutional Medical Ethics and Scientific Research Committee (MESRC#50/2015), 205 consecutive patients undergoing cardiac surgery and who routinely need central venous access were prospectively included in this study. The patients in whom the RIJV cannulation was attempted were only included in the study. Of the 205 patients, there were 135 adult and 70 pediatric patients. In the adult patients, USG was used in 75 patients, and in pediatric patients, USG was used in 49 patients. The central venous access was performed in all patients under general anesthesia and strict aseptic precautions with standard ASA monitoring. The positioning of the patient in terms of head rotation, degree of head down tilt, support under the shoulders, etc., was similar in all patients. All cannulations were performed by experienced cardiac anesthesiologists with more than 10 years of experience in the field. The use of USG was based on the availability of the equipment. The patients in whom USG was used for RIJV cannulation were included into Group I (n = 124) and Group II (n = 81) included those patients who had jugular cannulation without USG. For USG during cannulation, out of plane imaging with a Philips L15-7i linear probe that is compatible with iE33 xMATRIX echocardiography machine (KPI Ultrasound, CA 92887, USA) was used. In the group without USG, a paracarotid approach was used with the site of skin puncture at the midpoint between the right mastoid process and sternal insertion of the sternocleidomastoid muscle. Successful internal jugular vein cannulation at the first attempt with a single skin puncture was considered the first-pass cannulation. Further skin punctures beyond the first were considered multiple attempts. Demographic data including age, weight, height, BMI (in adults), body surface area (in pediatric patients) and procedure-related data including the incidence of arterial puncture, and a number of attempts that were made were recorded. The arterial puncture was recognized either by pulsatile blood flow or by pressure transduction. The patients were categorized based on their BMI into underweight (BMI < 18.5), normal weight (BMI: 18.5-24.9), overweight (BMI: 25-29.9), and obese (BMI: ≥ 30). When USG was used, the relation of great vessels was also noted. Once an arterial puncture occurred, the external pressure was applied, and the central vein cannulation was performed at an alternative site.

Statistical analysis

The patient sample size was calculated based on a pilot study conducted earlier at our institute that showed an incidence of 15% inadvertent arterial puncture during RIJV cannulation when no USG was used. To totally avoid the incidence of an inadvertent arterial puncture, a minimum of 74 patients were needed in each group for a two-sided significance level (1 – α) of 95 and a power (1 – β) of 80.

Totally, 225 cardiac surgical patients were initially considered, and with the approximate adult to pediatric surgical list pattern at our institute being 2:1, this transcended into the inclusion of 150 adult and 75 pediatric cardiac surgical cases. Demographic and categorical data were compared using independent sample Student’s t-test. Qualitative variables were described by frequency distribution. Comparison between groups of qualitative variables was done using Chi-square test. A “P value” of 0.05 was taken as the level of significance with 95% confidence limits. Data analysis was performed using SPSS version 17.0 software (IBM, Corporation, TSS).

RESULTS

A total of 205 patients were assessed as eligible for the study. The CONSORT flow diagram is presented in Figure 1.
Despite the initial inclusion of 225 patients, RIJV cannulation could not be performed in 15 adult patients and 5 pediatric patients. The 15 adult patients were not considered as they had right carotid artery disease and RIJV cannulation was avoided at the request of the surgeons. Five pediatric patients also were not considered as three of them had sinus venosus atrial septal defects, and in two, a left thoracotomy was planned. It was deemed in these patients that left internal jugular vein cannulation would be more appropriate. Of the 205 patients who were finally analyzed, USG was used in 60% of the patients \( (n = 124) \). USG was used in 75 adult (55%) and 49 pediatric (70%) patients. Group II where USG was not used included 60 adult patients and 21 pediatric patients. Regardless of adult or pediatric patients, the demographic data were comparable between Group I and Group II patients [Table 1]. The overall incidence of an inadvertent arterial puncture in the entire patient population \( (n = 205) \) was 7% \( (14/205) \). In Group II, 12 out of 81 patients had an inadvertent arterial puncture. In patients in whom USG was used [Group I], only 2 out of 124 patients (2%) had an arterial puncture \( (P < 0.001) \). In adult patients \( (n = 135) \) when USG was not used, an arterial puncture occurred in 7 out of 60 patients (11.7%) [Group II] as compared to 2 out of 75 patients (2.7%) when USG was used \( (P = 0.03) \). In the pediatric population of seventy patients, the incidence was 5 out of 21 patients (23.8%) when USG was not used (Group II) as compared to no arterial puncture in the 49 patients with USG \( (n = 49) \) \( (P < 0.001) \) [Table 2].

In the entire population of 205 patients, RIJV was cannulated at the first instance in 91 patients (73.4%) in Group I \( (n = 124) \) and in 56 (69%) patients in Group II \( (P = 0.7) \). As for the pediatric patients, the first-attempt cannulation was possible in 36/49 patients (74%) when USG was used as compared to 10/21 (48%) \( (P = 0.04) \) [Table 3].

Five out of 23 patients who were in the underweight category had inadvertent arterial puncture \( (P < 0.001) \) when USG was not used as compared to no instance of arterial puncture when cannulation was performed under USG. Inadvertent arterial puncture was similar with and without USG in patients who were grouped into normal weight \( (P = 0.08) \), overweight \( (P = 0.9) \), and obese categories \( (P = 0.06) \) [Table 4].

### Table 1: Demographic data

| Patient population (below 12 months of age) | Group I | Group II | \( P^* \) |
|------------------------------------------|---------|----------|----------|
| Age (years)                             | 60.5±15 | 59±10.8  | 0.3      |
| Weight (kg)                             | 65.5±11.8 | 65±12.4  | 0.9      |
| Height (cm)                             | 159±8   | 162±10.2 | 0.5      |
| BMI                                     | 27.4±3.9 | 26.4±4   | 0.9      |
| Pediatric patients (above 12 months of age) |         |          |          |
| Age (years)                             | 2±1.9   | 2±1.4    | 0.4      |
| Weight (kg)                             | 12±1.8  | 12±1.7   | 0.8      |
| Height (cm)                             | 92±11.4 | 94±10.4  | 0.8      |
| BSA (m²)                                | 0.53±0.2 | 0.55±0.1 | 0.1      |

*Two-sample independent \( t \)-test. BMI: Body mass index, BSA: Body surface area, SD: Standard deviation

### Table 2: Incidence of arterial punctures

| Patient population | Arterial puncture | Group I (USG*) | Group II (no USG), (%) | Overall incidence of arterial puncture (%) | \( P \) |
|--------------------|-------------------|----------------|------------------------|-------------------------------------------|-------|
| Total population \( (n=205) \) | Present           | 2/124 (2%)*** | 12/81 (15)***          | 14/205 (7)***                             | <0.001** |
| Adult population \( (n=175) \) | Present           | 2/75 (3%)***  | 7/60 (12)***           | 7***                                     | 0.03** |
| Pediatric population \( (n=70) \) | Present           | None/49       | 5/21 (24)***           | 7***                                     | <0.001** |

*USG: Ultrasound guidance, **Chi-square test, ***Percentage rounded to the nearest decimal point

### Table 3: First-attempt success in cannulation

| Patient population | First-attempt success | Group I (USG*), (%) | Group II (no USG), (%) | Overall incidence of first-attempt success (%) | \( P \) |
|--------------------|-----------------------|---------------------|------------------------|-----------------------------------------------|-------|
| Total population \( (n=205) \) | Success             | 91/124 (73)***     | 56/81 (69)***          | 147/205 (72)***                             | 0.5** |
| Adult population \( (n=175) \) | Success             | 55/75 (73)         | 46/60 (77)             | 75***                                      | 0.685** |
| Pediatric population \( (n=70) \) | Success             | 36/49 (74)***      | 10/21 (48)***          | 66***                                      | 0.037** |

*USG: Ultrasound guidance, **Chi-square test, ***Percentage rounded to the nearest decimal point
The success rate of the first-attempt cannulation was higher in low weight category ($P < 0.05$). The first-pass success rate was similar in patients categorized on the basis of BMI into normal weight ($P = 0.08$), overweight ($P = 0.4$), and obese categories ($P = 0.2$).

Of 124 adult and pediatric cases, USG revealed an anteroposterior relation of the carotid artery to the RIJV in 22 patients (17.7%).

**DISCUSSION**

All patients who were included in this prospective observational study had successful central venous cannulation. The overall incidence of inadvertent arterial puncture with and without USG in the entire 205 adult and pediatric cardiac surgical patients was 7%. There was a significant reduction in the number of arterial punctures in the entire patient population included in the study when RIJV cannulation was performed with USG ($P < 0.001$). In subgroup analysis, USG resulted in decreased incidence of arterial puncture during RIJV cannulation in adult patients ($P = 0.03$). The absence of arterial puncture incidence was more noteworthy in the pediatric age group when USG was used ($P < 0.001$). As for RIJV cannulation at the first attempt, it was found that USG did not contribute much in the entire patient population and adult patients ($P = NS$). However, USG improved the first-attempt success rate significantly in pediatric patients ($P = 0.037$). When adult patients were categorized based on the BMI, USG reduced the incidence of an inadvertent arterial puncture in underweight patients ($P < 0.001$). USG did not contribute significantly in reducing the arterial puncture incidence in normal weight, overweight, and obese individuals. The success rate of the first-attempt cannulation was higher in low weight category ($P < 0.05$). The success rate with the first-attempt cannulation was similar with and without USG in patients categorized on the basis of BMI into normal weight, overweight, and obese categories ($P = NS$). The hypothesis that USG would avoid accidental arterial puncture during RIJV cannulation was proved right only in pediatric patients and underweight adult patients.

Central venous access is important in cardiac surgical cases as it provides central venous pressure monitoring and allows infusion of medications, rapid fluid administration, insertion of pulmonary artery catheters, etc. In the scenario of cardiac surgery where the patients are anticoagulated, an inadvertent arterial puncture attains significance. First, accidental carotid arterial cannulation could result in cancellation of the procedure with attention diverted toward the management of the iatrogenic complication. Second, when venous access sites are scarce, the carotid puncture could lead to the abandonment of the procedure with a failure in providing above-mentioned functions. Third, arterial puncture with ensuing heparinization of cardiac patients could be a problem as the ensuing hematoma could compromise cerebral circulation. This fear of compromise of cerebral circulation may result in delays if not cancellations of the surgical procedure. Finally, a dissecting hematoma into the ascending aorta following an accidental carotid arterial puncture could interfere with cannulation of the aorta, especially in pediatric and neonatal surgical cases. Hence, it is important that arterial puncture should be avoided, and all precautions should be taken to avert this complication.

It is in this context that USG gains importance. To reduce vascular complications during central venous cannulation, USG and pressure transduction have been suggested as reliable techniques.$^{[1]}$ The Agency for Healthcare Research and Quality strongly supported the use of USG during central venous cannulation.$^{[4]}$ The National Institute of Clinical Excellence also recommended the routine use of ultrasound for central venous catheterization.$^{[5]}$ The issue lies in the fact that despite compelling evidence that USG should be used for central venous access, compliance with this suggestion is found to be lacking. A report by the Society of Cardiovascular Anesthesiologists suggested that 67% of those surveyed

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*USG: Ultrasound guidance, **Chi-square test, ***Percentage rounded to the nearest decimal point. BMI: Body mass index
do not use or rarely use USG during central venous cannula placement.[6]

We embarked on this study explicitly to demonstrate the incidence of an inadvertent arterial puncture in our institute and drive home the importance of USG for RIJV cannulation among the service providers. We presumed that despite reported incidence in literature of arterial puncture during central venous cannulation, a closer assessment of the problem in our institute would motivate clinicians performing the procedure to adhere to the standard of care recommendation.

Although the value of USG is well established, it is important to recognize that the frequency of arterial puncture is reduced but not entirely eliminated, especially in adult population as is evident from our study. Hameeteman et al. reported a high incidence of arterial puncture despite USG during internal jugular vein cannulation by surgical trainees.[7] Hameeteman et al. study stresses the fact that USG alone would not avoid inadvertent arterial puncture but it is the continuous practice with USG that might help reduce arterial punctures.

Troianos et al. found that USG reduced the incidence of arterial puncture from 8.4% to 1.4% during internal jugular vein cannulation.[8] In our study, the incidence of arterial puncture without USG in both adult and pediatric patients combined was 15% that was reduced to 2% with USG.

We also looked at BMI of adult patients influencing the incidence of the inadvertent arterial puncture as well as affecting first-attempt success. There was a significant impact of the underweight category on both these aspects.

We found that in about 17.7% of patients, the RIJV was located just anterior to the carotid artery which was evident during ultrasonography. This anteroposterior relation of the carotid artery to the RIJV probably could contribute to the risk of inadvertent arterial puncture, especially if a landmark technique is adopted.

The shortcomings of this study are as follows: It is not a randomized study. The use of USG was limited by its availability. The second aspect is the patient population. Probably, we could have recruited more subjects.

**CONCLUSION**

The importance of USG guidance during RIJV cannulation in cardiac surgical patients is highlighted. USG avoided the incidence of arterial punctures in pediatric age groups with a higher first-pass success rate. USG was found to be more useful in underweight adult patients. Although simple measures such as transducing central venous catheters and manometry aid in the detection of improperly placed central lines, combining these measures with the use of ultrasound technology decreases the incidence of complications during central venous cannulation. The routine use of USG during central venous cannulation is strongly suggested to make the procedure safer.

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**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Bowdle A. Vascular complications of central venous catheter placement: Evidence-based methods for prevention and treatment. J Cardiothorac Vasc Anesth 2014;28:358-68.
2. Keenan SP. Use of ultrasound to place central lines. J Crit Care 2002;17:126-37.
3. Slama M, Novara A, Safavian A, Ossart M, Safar M, Fagon JY. Improvement of internal jugular vein cannulation using an ultrasound-guided technique. Intensive Care Med 1997;23:916-9.
4. Polderman KH, Girbes AJ. Central venous catheter use. Part 1: Mechanical complications. Intensive Care Med 2002;28:1-17.
5. National Institute for Health and Care Excellence. Guidance on the use of ultrasound locating devices for placing central venous catheters. NICE technology appraisal guidance no. 49. NICE; 2002. Available from: http://www.nice.org.uk/nicemedia/live/11474/32461/32461.pdf. [Last accessed on 2016 Mar 10].
6. Bailey PL, Glance LG, Eaton MP, Parshall B, McIntosh S. A survey of the use of ultrasound during central venous catheterization. Anesth Analg 2007;104:491-7.
7. Hameeteman M, Bode AS, Peppelenbosch AG, van der Sande FM, Tordoir JH. Ultrasound-guided central venous catheter placement by surgical trainees: A safe procedure? J Vasc Access 2010;11:288-92.
8. Troianos CA, Jobes DR, Ellison N. Ultrasound-guided cannulation of the internal jugular vein. A prospective, randomized study. Anesth Analg 1991;72:823-6.