Original Article

Comparison of ultrasound-guided internal jugular vein cannulation versus supraclavicular approach to brachiocephalic vein cannulation- A prospective, single-blind, randomised study

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ABSTRACT

Background and Aims: The internal jugular vein (IJV) is the most common site for central venous cannulation. Ultrasonography (USG)-guided brachiocephalic vein (BCV) cannulation has been described recently. The objective of this study was to compare the first attempt success rate, overall success rate and procedural ease between two techniques. **Methods:** This was a prospective, single-blinded, randomised clinical study. Patients were randomly allocated into two groups using computer generated random table. Group IJV included 55 patients of USG-guided out-of-plane approach to the right IJV cannulation and group BCV included 55 patients for USG-guided supraclavicular in-plane approach to right BCV cannulation. The success rate, number of redirections needed, vein and needle tip visualisation, cannulation time and complication rate were compared between the groups. **Results:** Demographic parameters were similar between the groups. Success rate of cannulation was 98.5% in IJV group and 100% in group BCV (P = 0.31). The first attempt success rate was 76.3% and 81.81% in IJV and BCV group, respectively (P = 0.42). IJV was collapsed in 14.5% cases and BCV was collapsed in 0.9% cases. The needle visualisation was better in BCV group (94.54%) compared to IJV (80%) (P = 0.02) group, which was statistically significant. The numbers of redirections of needle were more in IJV group. Thus the procedural ease was better with BCV than IJV. **Conclusion**: Supraclavicular USG-guided in-plane BCV cannulation is a good alternative to USG-guided out-of-plane IJV cannulation, because of good calibre of the vein and better needle visualisation in the BCV group.

Key words: Brachiocephalic veins, catheterisation, central venous, jugular veins, subclavian vein, ultrasonography

INTRODUCTION

Ultrasonography (USG) guided internal jugular vein (IJV) cannulation has been the common approach for central venous cannulation (CVC). This is mainly due to easier visualisation, higher success and fewer complications noted by use of ultrasound, when compared to landmark approach. Even though USG-guided supraclavicular subclavian vein (SCV) cannulation was described by Yonei in 1988, the technique did not gain much popularity as landmark IJV cannulation was widely practised and there was limited use of USG at that time[1] Breschan *et al.*[2] placed the USG probe in the supraclavicular region, and obtained the longitudinal view of the junction of the IJV, the superior vena cava, and the BCV. They gave the first successful description of USG-guided supraclavicular BCV cannulation. Advantages of supraclavicular approach to SCV or BCV are better patient comfort (no restriction in neck

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movement), fewer infections, thrombosis, lesser risks of pneumothoraces and better final placement of the catheter tip when compared to IJV or femoral central lines.[3,4] With the advent of USG, supraclavicular BCV cannulation is gaining interest due to the ease of cannulation with visualisation of the entire needle path with the help of USG, superficial location and no bone overlyingthe vein. Many centres use supraclavicular USG-guided BCV as a routine in paediatric patients and hence there are studies on this in the paediatric population. But its use in the adult patients is limited. A retrospective study involving 994 patients suggested that USG-guided BCV is a safe and viable alternative to IJV.[5] Recently, studies have been done on supraclavicular BCV cannulation in adults and various approaches to BCV and their success rates have been described.[6,7] But there are not many prospective studies comparing USG-guided supraclavicular BCV with USG-guided IJV cannulation, for success rate, ease of insertion and complication rates.

The primary objective of this study was to compare USG-guided out-of-plane approach to right IJV cannulation with USG-guided in-plane supraclavicular approach to right BCV cannulation in adults for first attempt success rate. The secondary objective was to compare collapsibility of the vein, needle tip visualisation, ease of cannulation and complications rates.

METHODS

The study was a prospective, single-blinded, randomised clinical study conducted in a tertiary health care institute. Ethical approval for this study was provided by the institutional ethics committee (IEC number –SDMIEC/PG/0161/2018). The study was registered with the Clinical Trials Registry of India (CTRI/2019/02/017824) and was conducted in accordance with the principles of the declaration of Helsinki. Patients above 18 years of age requiring CVC cannulation were considered for the study. Patients who were uncooperative, refused to give consent, had significant coagulopathy, infection at cannulation site, had a CVC catheter in the past 72 hours or had cervical trauma with neck immobilisation were excluded from the study. The study was conducted between February 2019 and October 2020 in the operating rooms and intensive care units. Informed consent was obtained from all the patients for participation in the study. One hundred and ten patients willing to be part of this study were randomly allocated into two groups of 55 patients each, Group IJV and group BCV. Randomisation was performed by a computer-generated random-numbers table.

Monitoring consisted of pulse oximetery, electrocardiogram and non-invasive blood pressure for all patients. For patients on mechanical ventilation, the amount and extent of positive end-expiratory pressure (PEEP) was noted. Two clinicians performed the procedures, a senior clinician who had more than five years of experience with USG-guided CVC and a junior clinician who had two years of experience with USG-guided CVC insertions. Both clinicians had performed more than 20 USG-guided IJV and BCV cannulations before the study. The patient was placed in the supine position with the arms adducted and neck turned to the left side. A portable USG scanner in bi-directional (2D) mode with a linear transducer probe of 5-12 MHz was used. Under aseptic precautions, preparation and draping of the cannulation site was done. Before the start of procedure, in all patients, a preliminary scanning was done with gentle pressure on the USG transducer and the calibres of IJV and BCV were noted and graded as “patent good calibre” or “collapsed”.

For the patients in group IJV, a sterile transducer covered with USG gel was placed in the transverse position (short axis view) to the patient’s neck axis, lateral to cricoid cartilage. IJV was identified as a compressible, non-pulsatile structure. After positioning the right IJV in the centre of ultrasound screen, holding the probe in left hand and giving local anaesthesia at the insertion site, the vein was punctured with an18 gauge needle with out-of-plane technique. Needle visualisation was done using USG and graded as “good” or “not good”. Guide wire was passed. Guide wire location was confirmed within the IJV by using short axis view of USG. Central venous catheter was inserted by Seldinger’s technique and was fixed at 13cm from the skin in all patients.

For patients in group BCV, USG probe was placed transversally on the neck to get the short axis view of the right IJV. The probe was then slid caudally till contacting the clavicle and then it was tilted caudally to visualise the confluence of IJV, SCV, and BCV [Supplementary Video]. The longitudinal view of BCV was obtained for cannulation, local anaesthesia was infiltrated at the insertion site and the vein was punctured with an 18 gauge needle to get flashback of dark venous blood in the syringe [Figure 1].The needle

tip was visualised in-plane using USG and was graded as "good" or "not good". The guidewire was passed and its location was confirmed with USG. The vein was cannulated using Seldinger's technique, and the catheter was fixed at 13cm from the skin surface in all patients. Sterile dressing was applied after suturing the CVC catheter firmly in place.

Inability to locate the vein at the chosen site after three attempts/redirections was considered as 'procedural failure'. Number of redirections needed for successful vein localisation was noted. In case of arterial puncture, the site was compressed for 2 min and one more attempt was done. Repeat arterial puncture was defined as failure, and in such patients, CVC catheter was placed in the alternative site. After locating the vein with needle, if there was difficulty/inability in passing the guidewire, it was defined as 'difficulty in the passage of guidewire'. Time from scanning of the vein to puncturing the IJV/BCV was noted as "puncture time" or "a". Time from vein puncture to passage of guidewire and its confirmation within the vein with USG probe was noted as "guidewire time" or "b". Time from guidewire passage to CVC passage and its confirmation with blood aspiration in all three ports was noted as "cannulation time" or "c". 'Total CVC time' was recorded as a + b + c, that is, from the scanning for the vein to the successful CVC insertion. If the cannulation failed, time from the initial puncture to the CVC insertion in the alternative site was considered as the cannulation time.Correct placement of the CVC within the intended vein and aspiration of blood freely from all the three ports of CVC was defined as "Successful cannulation". Occurrence of ventricular arrhythmia during the passage of guidewire or CVC was noted. Post-procedural chest radiograph was taken in all patients within 24 hours and complications such as pneumothorax or haemothorax were noted.

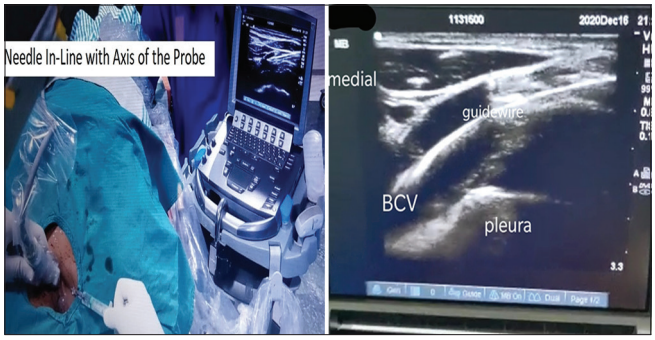

Figure 1: Ultrasound-guided BCV cannulation. (a) USG probe orientation and needle insertion for BCV (b) Guide wire inside the right BCV. BCV –Brachiocephalic Vein

Pneumothorax, haemothorax, arterial puncture and thyroid puncture (diagnosed via immediate USG visualisation) were defined as major complications, whereas haematoma and vein transfixion were defined as minor complications.

Leung J *et al.*[8] noted first attempt success rate for USG-guided IJV cannulation as 94%. First attempt success rate for USG-guided brachiocephalic vein cannulation from a previous study was 90%.[5] For a difference of 20% in first attempt success rate with an alpha error of 0.05%, 45 patients were needed in each group to achieve 80% power. Considering possible dropouts, we included 55 patients in each group.

All the data was entered and analysed using Statistical Package for the Social Sciences (SPSS Inc.,Chicago, IL, USA) version 22 for windows. Categorical data was analysed using Chi-square test and continuous data was analysed using independent sample t-test. Qualitative data was represented as frequency and percentages. Quantitative data was represented using mean ± standard deviation. Independent sample t test was used to compare difference in the mean between the groups. A P value of < 0.05 was considered statistically significant.

RESULTS

All the 110 patients who were randomised, completed the study and were analysed [Figure 2]. Demographic variables were comparable between the two groups [Table 1]. Success rate was 98.5%

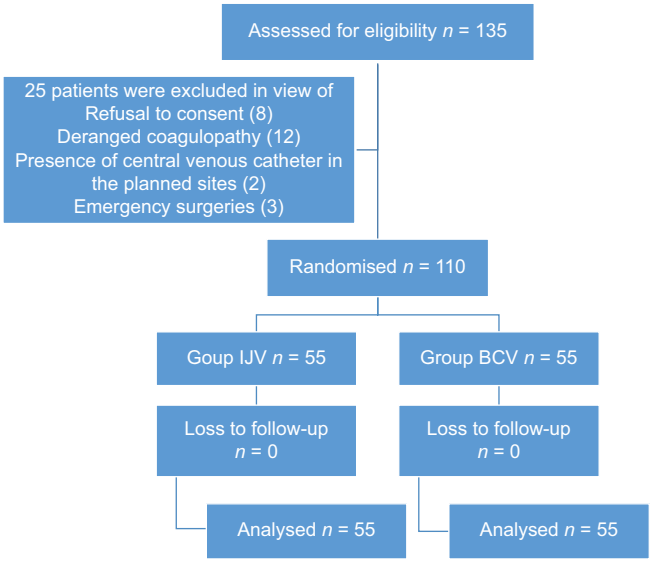

Figure 2: Consolidated Standards of Reporting Trials (CONSORT) flow chart

in group IJV and 100% in group BCV. First attempt success rate was 76.32% and 81.81% in group IJV and group BCV, respectively, which were statistically not significant [Table 2]. There was significant difference in the vein collapsibility, with BCV having good calibre in more patients compared to IJV [Table 3]. Needle tip visualisation with in-plane method for BCV was significantly better than out-of-plane approach for IJV. There was no significant difference in complication rate, puncture time, guidewire passage time or total CVC time between the groups. The central venous catheter tip was malpositioned into the right IJV in one case of BCV cannulation. Central venous catheter was placed inside the right atrium or right ventricle in 6 and 11 cases of IJV and BCV groups, respectively.

DISCUSSION

In our study, the success rate of CVC cannulation was 100% and 98.5% in group BCV and group IJV, respectively. In a retrospective study, Beccaria *et al*.[5] compared USG-guided supraclavicular BCV with IJV cannulation in 994 cases and they noted that the success rate was 96.6% (685 out of 709 cannulations) in IJV group and 96.4% (275 out of 285 cannulations) in BCV group. A prospective study performed by Aydın *et al*.[6] compared, USG-guided in-plane supraclavicular approach to BCV versus out-of-plane approach to IJV cannulation in 86 patients. They noted an overall success rate of 97.6% with BCV cannulation and 97.7% with IJV cannulation and concluded that the novel supraclavicular approach is non-inferior to IJV cannulation. The overall success rate for supraclavicular BCV cannulation in adults was around 98.3% to 100% in few other studies.[9-11] Sun X *et al*.[12] in their retrospective study, analysed 915 CVCs, namely, USG-guided BCV or USG-guided SCV cannulation. They noted an overall success rate of 98.99% for BCV and 96.87% for SCV, and the difference was significant. Several studies in the paediatric population for USG-guided supraclavicular BCV have reported a success rate of 95% to 100%.[2,13,14] Thus, the success rate of USG-guided BCV and IJV cannulation noted in the present study are in concurrence with other studies.

The first attempt success rate in our study was 81.81% (45 out of 55) in group BCV and 76.36% (42 out of 55) in group IJV, and the difference was not significant. Similar studies in adults on supraclavicular BCV cannulation noted a first attempt success rate of 95.34% to 100%.[5,9,10] Most paediatric studies showed a first attempt success rate of 65.4-81% for supraclavicular BCV cannulation.[2,13,15,16] Paediatric anatomical variations could be the reason for lower first attempt success rate for supraclavicular BCV cannulation.

In the present study, we noted that IJV was collapsed in more patients than BCV and the BCV remained large and patent with good calibre in almost all the patients studied. We did not measure the size of either veins directly, rather we assessed the size categorically as "collapsed" or "patent and good calibre" since USG is

Table 1: Demographic variables

	Group IJV (*n*=55)	Group BCV (*n*=55)	*P*
Age in years (mean±SD)	52.0±15.5	50.8±13.8	0.67
Gender (Male: Female)	33:22	31:24	0.69
Ventilation status (ventilated: non-ventilated)	50:5	50:5	1.00
Weight in kilograms (mean±SD)	60.89±9.55	61.07±11.53	0.92
Height in centimetres (mean±SD)	165.07±7.29	165.03±8.05	0.98
BMI in kg/m^2 (mean±SD)	22.32±3.03	22.17±3.69	0.81

SD –standard deviation, *n* –number. BMI: Body Mass Index

Table 2: Success and complications of CVC cannulation

	Group IJV (*n*=55)	Group BCV (*n*=55)	*P*
Overall success rate (percentage)	54 (98.5%)	55 (100%)	0.31
First attempt success rate (percentage)	42 (76.32%)	45 (81.81%)	0.48
Needle visualisation (good: not good)	44:11	52:3	0.02*
Number of redirections with needle (mean±SD)	1.23±0.42	1.18±0.38	0.48
Difficulty in guide wire passage (percentages)	4 (7.2%)	3 (5.4%)	1.00
Total number of complications noted:	2	3	0.85
(Haematoma/arterial puncture)	(1/1)	(1/2)	
Time for needle puncture (mean±SD) in seconds. "Time a"	85.10±48.01	82.61±46.91	0.78
Time for guidewire passage (mean±SD) in seconds. "Time b"	46.14±30.39	43.83±26.27	0.67
Time for CVC insertion (mean±SD) in seconds. "Time c"	175.61±58.55	150.70±64.26	0.03*
Total CVC time (mean±SD) in seconds. Time "a+b+c"	309.18±87.09	277.54±116.96	0.11
Arrhythmia noted during CVC cannulation (percentages)	17 (30.9%)	11 (20%)	0.17

SD – standard deviation; *n* –number, CVC –central venous cather. *significant *P* value

Table 3: Visualisation of internal jugular vein (IJV) and brachiocephalic vein (BCV) on ultrasound

	IJV visualisation in both groups (number=110)	BCV visualisation in both groups (number=110)
Patent good calibre	94 (85.45%)	109 (99.1%)
Collapsed	16 (14.54%)	1 (0.9%)

Values are the number of patients (percentages)

very subjective for measurement of vein diameters and the size of these veins do change with many factors like pressure on ultrasound probe, PEEP level, hydration status, phase of respiration etc. A study by Oulego-Erroz *et al*.[16] on CVC in the paediatric population aged 0-14 years concluded that the cannulation of BCV to be superior to IJV, possibly because of greater average vein diameter of BCV (5.4mm) compared to IJV (4.9mm). Not many studies comparing objective measurements of the cross-sectional diameter of BCV and IJV, in adults, were found. But the average diameter of IJV as noted by Tartière D *et al*. in adults was about 17 mm and of BCV as noted by Badran *et al*.was 22 mm.[17,18] Since BCV receives blood from both IJV and SCV, it is expected to have greater lumen size and good calibre. Beccaria *et al*.[5] also noted lower incidence of procedural difficulty with brachiocephalic vein and suggested that the possible mechanisms could be due to the presence of thin tissue trabeculae within the BCV. They suggested that BCV is held open by trabeculae, irrespective of the haemodynamic status or the phase of respiration, thus making it more patent and non-collapsing.

The visualisation of the introducer needle of the CVC catheter was better in the in-plane BCV group when compared to the out-of-plane IJV group. The number of redirections with needle was less in group BCV than group IJV. Aydın *et al*.[6] noted good USG visualisation of the introducer needle and guide wire but catheter visualisation was not good in both groups.Many studies have compared the in-plane and out-of-plane access to CVC cannulation in different neck veins. Studies suggest that though the success rate is similar with both approaches, the incidence of posterior wall penetration is much less with the in-plane than out-of-plane approach.[19-24] It has been well documented that the needle tip visualisation in the in-plane approach is better than in the out-of-plane approach, as the needle advancement is more controlled.[25,26] In the out-of-plane approach, part of the needle visualised need not be the tip, hence the needle tip which may be further deep may cause other complications, especially in the hands of novices.

The total cannulation time was higher in group IJV than in group BCV (309.18 ± 87.09 versus 277.54 ± 116.96 seconds respectively), which was statistically not significant. Aydın *et al*.[6] noted no significant difference in cannulation time between the groups. They noted no significant difference in mean ease score of cannulation between BCV and IJV groups (8.78 ± 1.13 versus 8.67 ± 1.23 respectively). We observed that BCV has several advantages over the IJV for cannulation including a greater lumen, better visibility in USG and does not overlap with carotid arteries and brachiocephalic arteries.

One of the limitations of the present study is that the operator could not be blinded. Many of the parameters assessed such as vein patency, calibre and procedural ease are subjective and they are dependent on many other factors and hence prone for bias.

CONCLUSION

USG-guided out-of-plane approach for cannulation of IJV is comparable to the in-plane approach of BCV cannulation, with regard to the overall success rate and first attempt success rate and complication rate. The procedural ease with USG-guided in-plane BCV is better than USG-guided out-of-plane IJV cannulation. USG-guided in-plane BCV cannulation is very useful and can be considered as an alternative to the out-of-plane approach to IJV.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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