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Comparison between classic short-axis out-of-plane approach and novel medial-oblique in-plane approach to ultrasound guided right internal jugular vein cannulation: A randomized controlled trial

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Abstract : *Purpose.* Short axis view for ultrasound (US) guided internal jugular vein (IJV) cannulation shows difficulties in visualizing puncture needle during cannulation. In contrast, medial oblique view may enhance needle visibility and decrease overlap between IJV and carotid artery and thereby increase the safety of US guided IJV cannulation.
Methods. In this randomized controlled trial 200 adult patients undergoing any surgery under general anaesthesia requiring an internal jugular vein cannulation were enrolled. In group M, IJV was cannulated with a medial oblique probe position with an in plane approach and in group S, IJV was cannulated in short axis out of plane approach.
Results. Needle tip visibility was significantly higher during IJV puncture in medial oblique probe position (68 of 98 *vs* 40 of 99; $p < 0.001$). Guide wire visibility during insertion was also significantly higher in patients where medial oblique probe position was used (59 of 98 *vs* 34 out of 99; $p < 0.001$). First insertion success rate for IJV puncture, venous access time, incidence of posterior wall of IJV puncture and time to cannulation were similar.
Conclusion. Medial oblique view may increase safety of US guided IJV cannulation by increasing needle and guide wire visibility during puncture.

Key words : IJV cannulation ; short axis ; medial oblique ; ultrasound.

Introduction

Internal jugular vein (IJV) cannulation is one of the most commonly performed procedures both in the perioperative period and intensive care unit. IJV cannulation is associated with various complications such as inadvertent carotid artery puncture, thrombosis, hemorrhage and hematoma formation, which may contribute to significant morbidity. Early mechanical complications from IJV cannulation may be as high as 18%, as reported in trauma settings (1). Carotid artery puncture is the most devastating acute complication that may be associated with stroke and death (2). Ultrasound (US) guide is considered as standard of care technique in IJV cannulation and American Society of Anesthesiologists practice guidelines[3] for central venous access has recommended that real-time US guidance to be used for IJV access. However, US guided short-axis approach presently used for IJV cannulation does not fully protect from inadvertent carotid artery puncture. Although meta - analyses (4) have shown that use of US is associated with a higher success rate at the first attempt and fewer number of attempts overall, incidence of carotid puncture up to 4% of IJV cannulation has been reported in some series (5). Moreover, needle visibility during venipuncture is poor with short axis view; often only the needle tip and not the whole needle shaft is visible. The needle shaft is often seen with difficulty or part of the needle shaft is visible as dot in cross

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The trial has been registered at National Clinical Registry of India (www.ctri.nic.in; ref no: Ref/2014/08/007418 ; Principal investigator : Dr Dalim Kumar Baidya)
Ethics : Ethical approval for this study (IEC/NP- 226/03-07-2014, RP-40/2-14) was provided by the Institute Ethics Committee, All India Institute of Medical Sciences, New Delhi, India (Chairperson Dr Shashi Wadhwa) on September 2nd, 2014.
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section and mistaken for tip. Real time visualization of the needle tip during vascular puncture might avoid inadvertent carotid artery puncture.

DiLisio et al. in 2012 described a new "medial oblique technique" for US guided IJV cannulation (6). The authors reported that this approach allows for optimal imaging of the IJV and the carotid artery side by side by following the needle throughout the insertion from skin to vessel penetration in a medial-cephalad to lateral-caudad direction. This technique combines the advantages of the short-axis and long-axis approaches and minimizes the risk of carotid puncture from a medial-to-lateral needle direction. Baidya DK et al. reported that medial oblique probe position is superior to short axis probe position in terms of increased transverse diameter of IJV and reduced overlapping between IJV and carotid artery (7). However, whether these sono-anatomic advantages can be translated into a clinical benefit have not been evaluated.

In this randomized controlled trial, these two sonographic views were compared to find out whether medial oblique view could improve needle visualization during IJV cannulation.

Methods

The study protocol (Protocol no: IEC/NP-226/03-07-2014, RP-40/2-14) was approved by the Institute Ethics Committee, All India Institute of Medical Sciences, Ansari Nagar, New Delhi-110029, India and registered in the National Clinical Registry of India (www.ctri.nic.in ; ref no : Ref/2014/08/007418 ; Principal investigator : Dr Dalim Kumar Baidya).

After approval of institute's ethical committee and obtaining written, informed consent from the patients, 200 patients aged between 18-50 years of either sex and American Society of Anesthesiologists' physical status I-III undergoing any surgery under general anaesthesia requiring an internal jugular vein cannulation, were enrolled for this study. Pregnant patients, patients having coagulopathy, previous neck surgery and patients having BMI < 18 kg/m^2 and > 30 kg/m^2 were excluded from the study. Patients underwent thorough preoperative evaluation and were checked against the exclusion criteria of this study.

Randomization and blinding

A computer generated random number list was used to prepare serially numbered opaque envelopes, which contained the details of ultrasonography technique to be used. The sealed envelope was handed over to the anaesthetic team (not part of the investigating team), who opened and followed the mentioned technique. An anaesthesiologist who was unaware about the group allocation analyzed data obtained from the ultrasound-generated picture. Although the anaesthesiologist who assessed the images, was unaware about group allocation; images were self-explanatory to the group allocation and blinding of the outcome assessor was not possible.
After induction of general anaesthesia with intravenous technique and securing the airway with appropriate size endotracheal tube, the patient's neck was draped under aseptic conditions. Patients were placed in the 30-degree Trendelenburg position with the head turned 15 degrees to the left side. We used 10% povidone iodine as disinfectant agent and the operators used cap, mask, sterile gown and gloves during cannulation. The US device/screen (SonoSite M-Turbo® ultrasound system) was positioned on the same side where the probe was placed. A linear US probe (13-6 MHz) was covered in a sterile sleeve and placed between the heads of the sternocleidomastoid muscle to capture an image of the carotid artery and IJV as per randomization sequence of the patients. Three investigators (DKB, BRR and SM), all right handed and with an experience of more than 100 US guided IJV cannulations, performed cannulation in all patients to maintain uniformity.

In patients belonging to group M, IJV was punctured with a medial oblique probe position with an in plane approach. In patients belonging to group S, IJV was cannulated with the ultrasound probe in short axis out of plane approach. In either group of patients, the following steps were followed: After successful aspiration of blood, a J-shaped guide wire was inserted through the hollow needle, and after single passage of a dilator through the guide wire, the central line was rail-roaded over the guide wire. The guide wire was withdrawn and all ports of the central line were checked for free flow of blood. After suturing, a transparent dressing was applied over the area of insertion.

Visibility of needle tip was noted during insertion and at the time of blood aspiration. Success rate of vascular puncture at the first attempt was also noted. 'Venous access time' (time from skin puncture to guide-wire insertion) and 'cannulation time' (time from skin puncture to catheter insertion) were noted by a single unblinded observer who was not part of the investigating team. Timing of cannulations and the occurrence of complications were noted in real time and needle visibility and guide-wire visibility

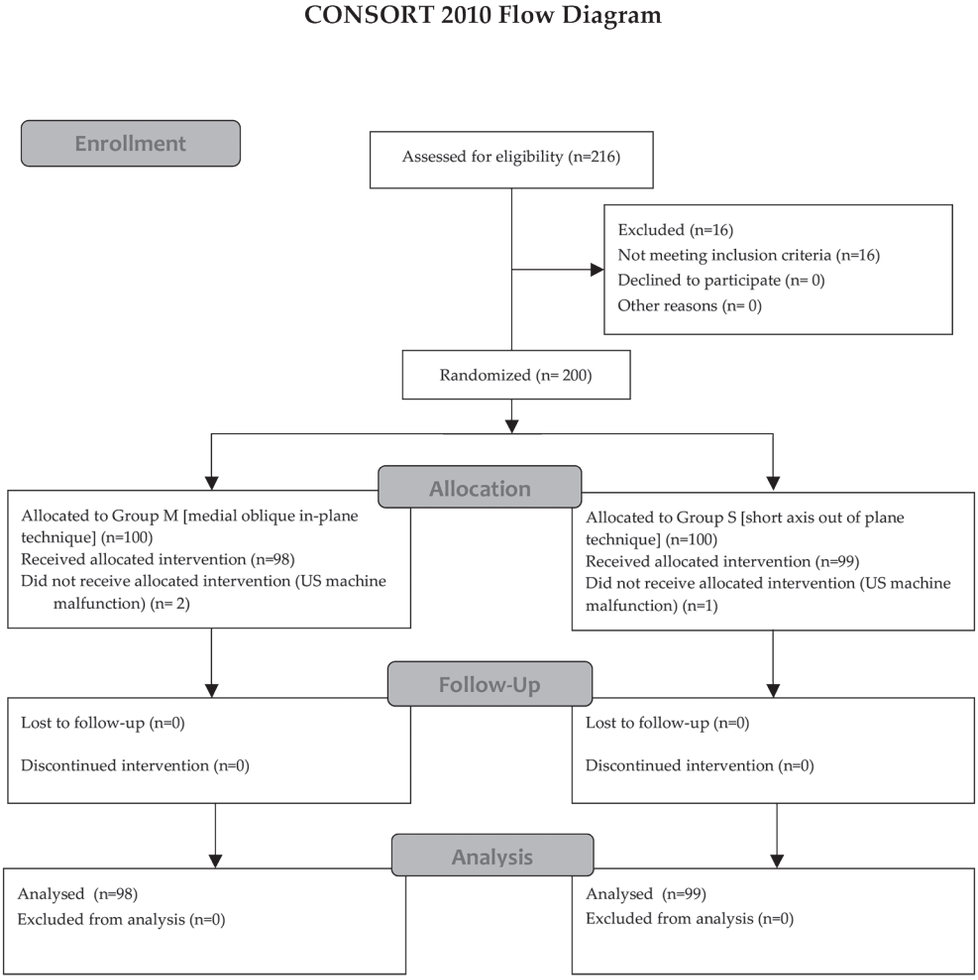

Fig. 1. — CONSORT diagram showing stages of patients' recruitment to data analysis.

were assessed from saved images of the procedure. Any complications in either group such as carotid artery puncture, hematoma, and pneumothorax were also noted. A CONSORT flow diagram is illustrated in figure 1 to delineate course of the patients in this study (Fig. 1).

Sample size estimation & statistical analysis

At the time of designing the study, no previous study assessed the clinical efficacy of medial oblique view for IJV cannulation. Hence, we recruited 100 patients in each group on pilot basis to investigate the efficacy of medial oblique view in US guided IJV cannulation. Demographic data are expressed as mean ± SD (age, weight, height) or proportion (sex and ASA physical status). Venous access time and cannulation time are expressed as median and inter-quartile range and are compared by Mann-Whitney U test. Categorical variables were compared by Chi-square test and a two-tailed p-value of less than 0.05 was considered significant. All statistical analyses were performed by SPSS statistical software (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.)

Results

Two hundred patients were recruited in this study; amongst them data from 197 patients were included in the analysis as we excluded three patients due to ultrasound machine malfunctioning. Patients were comparable in two groups in terms of age, sex, body weight and ASA PS (Table 1). Needle visibility was significantly higher during IJV puncture in medial oblique probe position (68 of 98 patients in group M *vs* 40 of 99 patients in group S; $p < 0.001$, chi-square test; odds ratio 3.34, 95% CI 1.857, 6.019). Guide wire visibility during insertion was also significantly higher in patients where medial oblique probe position was used (59 of 98 in group M *vs* 34 out of 99; $p < 0.001$, chi-square test). First insertion success rate for IJV puncture, venous access time, incidence of posterior wall of IJV puncture and time to cannulation were similar in both groups (Table 2). Inadvertent carotid

Table 1
Demographic characteristics of the patients in each group (data expressed as mean ± SD or proportions)

Parameters	Group M (n=98)	Group S (n=99)	Significance
Age (years)	57.6±8.9	55.3±9.2	p=0.07
Body weight (kg)	54.6±10.4	53.2±11.5	p=0.372
ASA PS (I/II)	36/62	41/58	p=0.500
Sex (Male/ Female)	57/41	54/45	p=0.712

SD : Standard deviation, ASA PS : American Society of Anesthesiologists' Physical status.

Table 2
Characteristics of right IJV cannulation in each group (data expressed as median [inter-quartile range] or proportions)

Parameters	Group M (n=98)	Group S (n=99)	Significance
Needle visibility (n/total)	68/98	40/99	p=0.00002
Guide wire visibility (n/total)	59/98	34/99	p=0.00013
Cannulation time (s)	128 [96-220]	134 [98-220]	p=0.165
First insertion success rate (n/total)	87/98	85/99	p=0.538
Venous access time (s)	14[8-25]	14[9-28]	p=0.631
Carotid artery puncture (n/total)	1/98	0/99	p=0.99
Through and through IJV puncture (n/total)	1/98	5/99	p=0.22

IJV : Internal jugular vein, SD : standard deviation.

artery puncture was reported in one patient in medial oblique group and no haematoma formation and pneumothorax could be seen on routine chest x-ray after 12 hours in any of the patients.

Discussion

We found a significantly better needle tip visibility and guide wire visibility during ultrasound guided right IJV cannulation with "medial-oblique" probe position compared to classic short axis probe position.

Traditional anatomic landmark-guided IJV cannulation poses the risk of accidental carotid artery puncture, haematoma formation, pneumothorax, haemothorax, and other complications. Ultrasonography provides "real time" imaging, that is, the needle can be visualized entering the vein,

Fig. 2. — Medial oblique and short axis position of ultrasound probe.

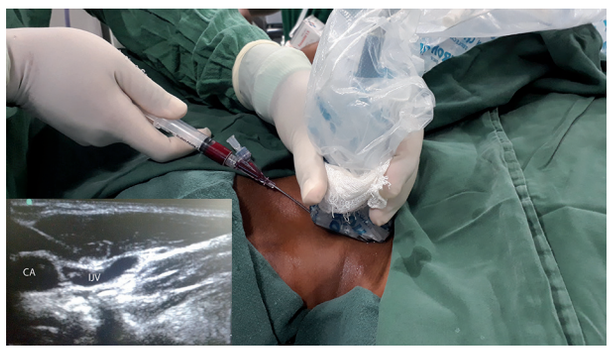

Fig. 3. — Medial-oblique position of ultrasound probe, puncture needle and ultrasound image of right internal jugular vein cannulation by medial oblique in-plane technique with the needle shaft and tip seen as a white line.

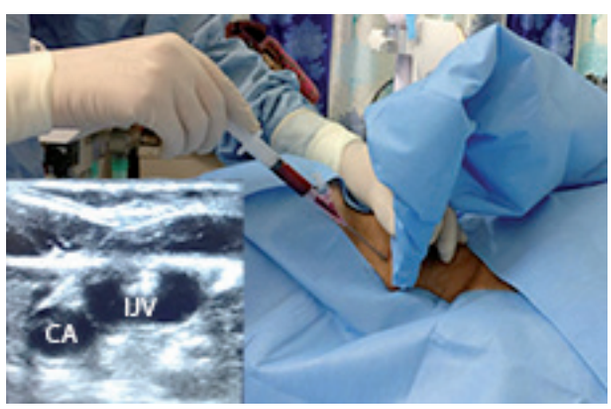

Fig. 4. — Short-axis position of ultrasound probe, puncture needle and ultrasound image of right internal jugular vein cannulation by short axis out-of-plane technique with the tip of the needle seen as a white dot.

thus reducing the incidence of complications and increasing the success rate. Dilisio and Mittnatch in 2012 suggested medial oblique probe position where they mentioned that in this view benefit of both short axis and long axis could be obtained (6). They also mentioned that in this view needle entry path could be followed from skin to the vessel. Phelan and Hagerty (7) also described the oblique view where both needle shaft and tip along with IJV and carotid artery were visualized. In medial oblique view, the ultrasound beam is transmitted through an oblique axis over the IJV. So, a longer length of IJV is being scanned in oblique axis, which will increase effective transverse diameter. As the

transverse diameter is increased, percentage of overlap between IJV and carotid artery is decreased.

Previously a cross over study by Baidya DK et al. reported that transverse diameter of IJV increase significantly in medial oblique view with a concomitant decrease of overlap between IJV and carotid artery (8). Though this study reported an anatomical superiority of medial oblique view, up to date no clinical trial has assessed medial oblique view and compared it with classic short axis view. In medial oblique probe position, IJV is visualized in oblique axis and carotid artery is visualized medial to IJV in short axis. Stone et al. reported a needle tip visibility of 23% during US guided IJV cannulation in short axis view (9). Lack of needle tip visibility increases the possibility of inadvertent carotid artery puncture and through and through IJV puncture. Possibility of carotid artery puncture increases particularly when there is a significant overlap between these two vessels. Troianos et al. found that IJV overlaps the CA in 54% of patients in an US imaging plane positioned in the direction of a cannulating needle (10). In <10% of patients, the classic IJV was found lateral to the carotid artery. As IJV cannulation with medial oblique approach decreases overlapping and improves needle tip visibility, possibility of inadvertent IJV puncture may also be decreased. Though we have not found any difference in carotid artery puncture, we can assume that a much higher sample size would have been required to arrive at a statistically significant difference as carotid artery puncture is a rare event with experienced operators. It is worth mentioning that all the cannulations in this study were done by anaesthesiologists who had an experience of at least 100 ultrasound guided IJV cannulation. Currently, the incidence of carotid artery puncture even with US guidance is reported to be up to 4%. We believe that, relatively inexperienced physicians often do IJV cannulations in emergency department; where our findings may be even more clinically relevant. Though we have found a similar through and through IJV puncture between the two approaches Batllori et al. reported a lower incidence of posterior wall puncture with oblique axis approach in comparison to short axis or long axis approach (11). In this study we have not found any increase in cannulation time with medial oblique view. One interesting finding of our study was that in 30% cases in medial oblique approach, needle visibility was poor despite of in-plane needle insertion. Poor needle visibility may be due to two reasons although the operators were experienced in US guided IJV cannulation: experience of medial-oblique technique was far less than short axis technique and as the needle puncture point was higher in 'medial-oblique' technique, the chin of the patients could have interfered with needle manipulation.

It is obvious, that the catheter exit site was higher in medial oblique approach and it might be a reason for patients discomfort particularly in patients with short neck and if IJV catheter is required for prolonged period.

Limitations

Primary outcome of our study was needle tip visibility, which may not be the only determinant of carotid artery puncture. A larger randomized controlled trial is required to prove clinical superiority of medial oblique view over short axis view.

Conclusion

Medial oblique view increases needle tip visibility during IJV cannulation over the classic short axis view. However, further research is required whether increased visibility can be translated into a less probability of serious complications such as carotid artery puncture.

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