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RESEARCH ARTICLE

ULTRASONOGRAPHIC STUDY OF THE ANATOMICAL VARIATIONS OF THE INTERNAL JUGULAR VEIN IN RELATION TO THE COMMON CAROTID ARTERY

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ABSTRACT

The internal jugular vein is preferred for central venous cannulations due to its superficial position in the neck.Even though there is good success rate for landmarks based technique, close proximity to important structures like common carotid artery always poses a threat of inadvertent vascular puncture. This study aims to evaluate the variations in theposition of the internal jugular vein in relation to the common carotid artery with ultrasound guidance.The study was approved by the Institutional Review Board. Data from 200 patients who were scheduled for elective surgeries were obtained with the aid of ultrasonography. Anatomical variations of the internal jugular vein in relation to the common carotid artery, antero- posterior and transverse diameters of IJV, depth of the internal jugular vein from skin and congenital anomalies if any, were studied. Statistical analysis was done using SPSS 11 software. Continuous data were tested using Paired t-test and the statistical significance for categorical/qualitative data was tested using Fishers exact test. The data with P value < 0.05 was considered statistically significant. In our study the most common location of IJV was lateral to the commoncarotid artery. Small sized internal jugular vein (diameter $\leq$ 7 mm)was found in 9.5% of patients on the right side and in 13.5% patients on the left side and the difference was not statistically significant. Also, the transverse diameter and depth of IJV from the skin was more on the right side and was statistically significant.

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INTRODUCTION

The internal jugular vein is commonly utilized for central venous cannulation due to its superficial position in the neck. Even though the success rate for landmarks based technique is good, close proximity to important structures like the common carotid artery always poses a threat of inadvertent vascular puncture. And complications of up to 15% have been reported with landmark guided technique (Mc Gee, 2003). Inability to cannulate the internal jugular vein may occur in up to 19.4% of cases (Sznajder, 1986). National Institute of Clinical Excellence (NICE, 2002) guidelines recommends the use of 2D ultrasound for central venous cannulation in appropriate clinical circumstances. This study aims to observe the anatomical variations of the internal jugular vein in relation to the common carotid artery using ultrasonography.

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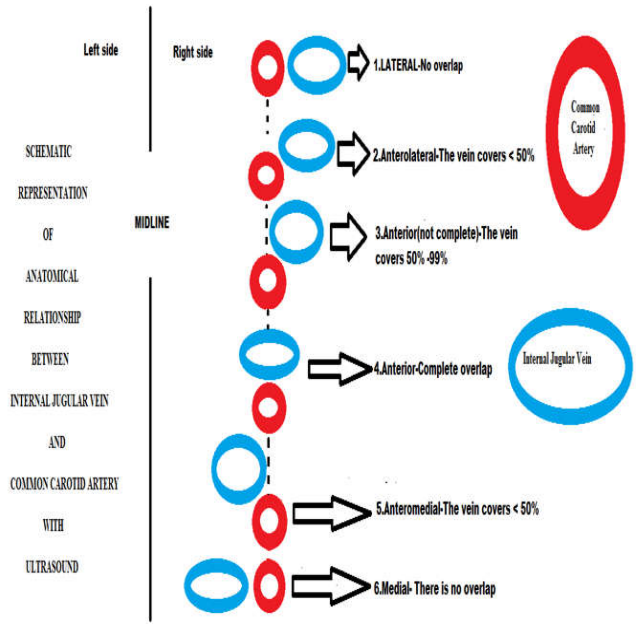
MATERIALS AND METHODS

The study was approved by the Institutional Review Board. Data from 200 patients who were scheduled for elective surgeries were obtained with the aid of ultrasonography. Anatomical variations of the internal jugular vein in relation to the common carotid artery, antero- posterior and transverse diameters of IJV, depth of the internal jugular vein from skin and congenital anomalies if any, were studied with the patient in the cannulating position, i.e, supine with 15° Trendelenberg tilt and 30° head rotation to the contralateral side. Patients of both genders, aged between 20 and 60 years, scheduled for elective abdominal and gynecological surgeries who consented for the study were included. Patients with neck scars, neck swellings, fractured clavicle, torticollis, short neck, obesity, prior IJV cannulation, and previous neck surgery were excluded. The requirement of the study was explained to the patients in detail and written informed consent was obtained.

Anatomic landmarks which help in identifying the internal jugular vein include the sternal notch, clavicle, and sternocleidomastoid muscle and these landmarks were

identified. The internal jugular vein lies in the groove between the sternal and clavicular heads of the sternocleidomastoid muscle and mostly lies lateral and slightly anterior to the carotid artery. Sternocleidomastoid muscle was made prominent by making the patient lift the head actively. Ultrasound examination was done by an anaesthesiologist experienced in using ultrasonography for internal jugular veincannulation. GE Healthcare LOGIQ E portable ultrasound machine with linear probe 8 - 13 MHz was used.



The transducer was placed perpendicular to the skin of the neck in a transverse orientation at the apex of the triangle formed by two heads of sternocleidomastoid muscle. After proper transducer orientation, the vessels imaged were identified based on morphological characteristics. The internal jugular vein appears thin-walled, oval or round shaped, non-pulsatile and compressible. The common carotid artery appears thick walled, round shaped, pulsatile and non-compressible. The real-time scan images were made to freeze.

In each patient

THE FOLLOWİNG WERE RECORDED

- The location of the internal jugular vein in relation to the common carotid artery.It was noted as anterior, posterior, medial, lateral, antero-medial and antero-lateral according to the proportion of the common carotid artery overlapped by the vein
- Anteroposterior and transverse diameters of the internal jugular vein
- The depth of the internal jugular vein (distance from the skin to the anterior wall of the internal jugular vein)
- Anomalies of internal jugular vein if any
- The above observations were recorded on both sides of the neck.

RESULTS

Statıstıcal analysıs

Statistical analysis was done using SPSS 11 software. Continuous variables were described by means and standard deviations (SDs), while categorical or qualitative variables were described using counts and percentages.

Table 1. Demographic data

Gender	Frequency
Female	115
Male	85
Total	200

Observations were recorded numerically and graphically. Continuous data were tested using Paired *t*-test and the statistical significance for categorical/qualitative data was tested using Fishers exact test. The data with *P* value< 0.05 was considered statistically significant. The most common position of the IJV noted was lateral (40%) followed by anterolateral (38.5%), anterior (21.25%), and anteromedial (0.25%). While lateral position was the commonest on the right side (45%), the anterolateral position was commonest on the left (46%). None of the patients in our study had medial, posterior, posteromedial or posterolateral IJV.

Further, an analysis was done to find out whether there was any anatomical difference based on gender. Lateral was the most common location on both the sides in both males and females.

Table 2. Descriptive statistics

Variable	Minimum	Maximum	Mean
Age	24	88	54.92
Weight(kg)	30	102	58.04
Height(cm)	133	182	158.59

Table 3. Comparıson of locatıon of rıght and left ınternal jugular veın

Location of internal jugular vein'	Right side of neck (%)	Left side of neck (%)	P value
Lateral	90 (45%)	70 (35%)	0.132
Anterior	48 (24%)	37 (18.5%)	0.278
Antero lateral	62 (31%)	92 (46%)	*0.019
Antero medial	-	1 (0.5%)	-

Table 4. Gender wıse comparıson of locatıon of IJV by combınıng both sıdes

Location		Gender		Total
		Female	Male	
Lateral	Count	96	64	160
	%	24.00%	16.00%	40.00%
Anterior	Count	43	42	85
	%	10.75%	10.50%	21.25%
Anteromedial	Count	0	1	1
	%	0.00%	0.25%	0.25%
Anterolateral	Count	91	63	154
	%	22.75%	15.75%	38.50%
Total	Count	230	170	400
	%	57.50%	42.50%	100.00%

Table 5. Safe and dangerous posıtıons of IJV

Percentage of safe and dangerous posıtıons of IJV on rıght sıde

Rıght ıjv	Frequency
Safe Position	152
Dangerous Position	48
Total	200

Percentage of safe and dangerous posıtıons of IJV on left sıde

Left ıjv	Frequency
Safe Position	162
Dangerous Position	38
Total	200

Table 6. Analysıs of sıze of IJV on rıght sıde

Right IJV	Frequency
Small	19
Adequate	181
Total	200

Table 7. Analysıs of sıze of IJV on left sıde

Left IJV	Frequency
Small	27
Adequate	173
Total	200

Table 8. Measurements of IJV

Variables	Side	Mean	Std. Deviation	P Value
Transverse-Diameter	Right(cm)	1.309	0.301	< 0.001
	Left (cm)	1.191	0.248	
Antero-Posterior Diameter	Right(cm)	1.684	8.695	0.252
	Left(cm)	0.9794	0.219	
Depth	Right(cm)	1.081	0.216	< 0.001
	Left(cm)	1.021	0.213	

Table 9. Anatomıcal characterıstıcs of IJV

Anatomical variant	Right side of neck (%)	Left side of neck (%)	*P* value
Safe position	152(76.0)	162(81.0)	0.223
Dangerous position	48(24.0)	38(19.0)	
Adequate size	181(90.5)	173(86.5)	0.210
Small size (≤7 mm)	19(9.5)	27(13.5)	

Dangerous positions

Anterolateral and lateral positions of the internal jugular vein in relation to the common carotid artery were considered as safe positions and all the other positions were considered as anatomical variations and dangerous for cannulation. 24% patients had dangerously positioned internal jugular vein on right side and on the left side it was 19% and the difference was not statistically significant.

Size of the internal jugular vein

Internal jugular vein with anteroposterior diameter more than 7 mm is considered to be normal size. In our study small sized internal jugular vein was found in 9.5% of patients on the right side and in 13.5% patients on the left side and the difference was not statistically significant.

IJV measurements

The mean transverse diameter of internal jugular vein was 13.0 mm on the right side and 11.91mm on the left side of the neck and the difference was statistically significant (P value < 0.0001). The mean depth of IJV from skin was 10.81mm on the right and 10.2mm on the left. This difference was statistically significant (P<0.0001)

DISCUSSION

Among the various sites for central venous cannulation, the internal jugular vein is usually preferred due to its superficial and easily accessible location in the neck.

The traditional method for percutaneous catheterisationof internal jugular vein is based on the external landmark methods and high success rates have been reported. Albeit the advantages, complications related to catheter insertion are common. The complications can vary from a small localised hematoma to a life threatening obstruction of the airway by an expanding hematoma following an arterial puncture. Dangerous complications like pleural puncture and secondary pneumothorax can also occur. Also physician inexperience, varying relation of internal jugular vein with respect to common carotid artery, small diameter of internal jugular vein, absent or hypoplastic internal jugular vein, thrombosed internal jugular vein, obesity masking surface anatomy, anatomical variation of internal jugular vein anatomy following surgeries in neck etc can make IJV cannulation risky and difficult. Ultrasound imaging for locating the vessel to guide its puncture has now replaced the landmark technique in majority of the centres. Use of ultrasound in the internal jugular vein cannulation was first described in 1984 by Legler and Nugent**.** It can be used either for prelocating the vein or for real time guidance during cannulation. It helps to visualise the vessels, identify the precise position of the target vein, detects anatomical variants and the presence of thrombus within the vessel.

In our study, the patients were placed in the supine position with 15° Trendelenberg tilt and 30° rotation of the head to the contralateral side as this is the optimal position for cannulation of the internal jugular vein.Studies by Sulek *et al*., 1996. Parmar *et al*., 2013 and other investigators Lieberman, 2004. Troianos, Apiliogullari, 2012. Reported that rotation of head of more than 30-45° increased the overlap of common carotid artery and internal jugular vein and the risk of common carotid artery puncture. Garcia *et al*., 2015. İn their study reported that the vein lies medial to the artery with significant rotation of the head.

We placed the ultrasound probe perpendicular to the skin at the apex of the Sedillot's triangle (formed by the two heads of the sternocleidomastoid and the clavicle). This is the short axis view and is preferred. The description of location of IJV in relation to the common carotid artery in our study is similar to that previously reported by various authors (Lin *et al*., 1998; Troianos *et al*., 1996; Caridi *et al*., 1998). The most common position observed in our study was lateral compared to (Parmar and Mehta, 2013; Lorchirachoonkul *et al*., 2012) who found anterolateral position as the most common location in his study. An anterior position where the internal jugular vein lies partially or completely over the artery carries a high risk for arterial puncture during venous cannulation (Maecken *et al*., 2011; Bailey *et al*., 2006; Sibai *et al*., 2006). The proportion of subjects in whom the artery overlaps the vein fluctuates between 15% and 54% (Lobato *et al*., 1999). In our study IJV was placed anteriorly in 24% on the right and in 18.5% of the patients on the left (p value=0.278). We observed one anteromedially located internal jugular vein on the left. Troianos *et al*., 1996 has reported an anteromedial internal jugular vein in a patient with history of neck surgery. Anteromedial and posterolateral internal jugular veins have been observed by Dolla *et al* also (Dolla *et al*., 2001). Medially located internal jugular vein by Lin *et al*., 1998 comprised 3.9% in comparison with reports of 1.1% by Lim *et al*., 1998 and 0.53% by Turba *et al*., 2005. Other than lateral and anterolateral locations of the internal jugular vein, all other locations are considered dangerous for cannulation.

In the study by Saya Raghavendra Prasad *et al*., 2014, dangerously positioned internal jugular vein was observed in 13.66% patients on right side and in 15% on left side of neck Chandrasekharan *et al*., 2011 in their study on anatomical variations of the internal jugular vein found safely positioned internal jugular vein (lateral and anterolateral) in 86.66% of volunteers on the right side and in 85% of volunteers on left side of neck and the commonest position observed was anterolateral**.**

The mean transverse diameter of internal jugular vein was 13.09 mm on the right side and 11.91 mm on the left side of the neck and the difference was highly significant statistically ($P < 0.001$) in our study. This is comparable to the findings from the study by Prasad *et al*., 2011, Parmar and Mehta, 2013; Parmar *et al*., 2013; Legler and Nugent, 1984 who reported that mean transverse diameter of internal jugular vein was more on the right side. Studies comparing anteroposterior diameter of IJV on both the sides by Saya Raghavendra Prasad *et al*., 2014 and Lorchirachoonkul *et al*., 2012 showed no statistically significant difference. This was further substantiated in our study. We observed more small sized IJVs on the left ($p=0.210$). Similar studies by Lorchirachoonkul *et al*., 2012, Saya Raghavendra Prasad *et al*., 2014, Parmar and Mehta, 2013; Parmar *et al*., 2013 and Denys, Denys and Uretsky, 1991 also showed small sized internal jugular vein (≤7 mm) in less than 15% patients.

Conclusıon

The commonest position of the internal jugular vein in relation to the common carotid artery noted was lateral followed by anterior and anterolateral. The mean transverse diameter of the internal jugular vein was significantly more on the right side. The depth of the internal jugular vein on both the sides also showed a statistically significant difference. From this study, we conclude that anatomical variations of internal jugular vein in relation to common carotid artery exists and should not be neglected because of the inadvertent complications that can happen following cannulation for central venous catheterization. National Institute for Clinical Excellence and the American Society of Anaesthesiologists Task Force unanimously recommend USG guidance for central venous access in both elective and if possible in emergency situations.

Lımıtatıons of the study

We did not analyse the changes of location of internal jugular vein with various degrees of head rotation. We measured internal jugular vein only at the apex of triangle. We did not scan along the course of the internal jugular vein and did not analyse it by placing the probe in the longitudinal plane.

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