RESEARCH ARTICLE

ANATOMICAL VARIATIONS OF THE INTERNAL JUGULAR VEIN IN RELATION TO CAROTID ARTERY : AN ULTRASOUND STUDY

Siddharthkumar Parmar, Samira Parikh, Harshil Mehta
BJ Medical College, Ahmedabad, Gujarat, India

Correspondence to: Siddharthkumar Parmar (drsid25@gmail.com)

DOI: 10.5455/ijmsph.2013.2.215-220 Received Date: 05.12.12012 Accepted Date: 06.12.2012

ABSTRACT

Background: In developing country like India, central venous catheter is still inserted using anatomical landmark guidance with success rate up to 97.6% and complications up to 15%.

Aims & Objective: This study was aimed to determine the anatomical variations of the internal jugular vein (IJV) in relation with carotid artery (CA) with the help of 2-D ultrasound.

Material and Methods: This prospective randomized study was conducted in a teaching and tertiary care hospital on 100 young healthy volunteers of either sex, aged 20 years to 40 years. Each volunteer was placed supine with 15˚ down trendlenberg position with 45˚ neck rotation on contra-lateral side. Linear array probe with 7.5 M Hz of "Sonosite Micromaxx" ultrasound machine was placed perpendicular to the apex of the triangle formed by two heads of sternocleidomastoid muscle and clavicle. Vessels were visualized in transverse section in 2-D ultrasound. Exact location of IJV was identified in relation to the CA on ultrasound and recorded as lateral, antero-lateral, anterior, medial, and posterior. The diameter of IJV and CA, distance from skin to IJV were recorded on both sides of neck for each volunteer. Anterior position of IJV in relation to CA was defined as dangerous position. Small sized IJV was defined as diameter ≤7 mm. Data were analyzed using Graphpad prism software version 5.1. P value < 0.05 was taken as significant.

Results: The mean diameter of IJV was 13.23 (2.52) mm in right and 10.25(2.29) mm in left side of neck (p=0.0001). Small sized IJV was in 1% in right and 8% in left side (p=0.0349). 15% and 28% of volunteers had dangerous position of IJV in relation to CA on right and left side of neck respectively (p=0.0381).

Conclusion: Significant number of healthy young volunteers had anatomical variations in terms of size and position of IJV (left side > right side) in relation of CA by ultrasound screening. Thus, anatomical landmarks are not sufficient, alternative measures like ultrasound scanning should be implemented prior to catheterization to identify the individual with potentially difficult catheterization.

KEY-WORDS: Anatomy; Jugular Vein; Central Venous Catheterization; Ultrasonography

Introduction

Central venous cannulation is a common procedure and has become an integral part of management of critically ill patients. It is used for central venous pressure monitoring, inotropic supports, dialysis and long term parenteral nutrition. Internal jugular vein (IJV) is preferred because of external landmarks, low risk of pneumothorax. Subclavian route is less preferred because of haemothorax, pneumothorax and stricture. Immobilization, phlebothrombosis and infection is commonly associated with femoral route.

In developing country like India, central venous catheter (CVC) is still inserted using anatomical landmark guidance with success rate up to 97.6% and complications up to 15%.[1] Incidence of carotid artery (CA) puncture was from 5.7% to 13.3% with anatomical landmark guidance in IJV cannulation.[2]

Anatomical variations in size and position of IJV and unreliability of the external landmarks may be underlying cause for failure, difficult access, arterial puncture, and pneumothorax.

Modern ultrasound (USG) machine are compact, portable and handy with good resolution and real time guidance. Ultrasound guided interventions can save time and increase accuracy, efficacy and safety by reducing medical errors and improving medical care. Literature recommends that ultrasound guidance should be considered for central venous cannulation instead of anatomical landmark guidance.

Thus, objective of this study was to determine the anatomical variations of the IJV in relation with carotid artery with the help of 2-D ultrasound.

Materials and Methods

This prospective study was conducted in a teaching and tertiary care hospital. Total 100 young healthy volunteers of either sex, aged 20 years to 40 years, were randomly selected after getting their informed written consent. Exclusion criteria were scar, swelling or previous surgery in the neck, torticolis, short neck, obesity, fracture clavicle, prior catheterization in neck and refusal for the procedure.

The procedure of study was explained to the volunteers. Each subject was placed supine with 15˚ down trendlenberg position with 45˚ neck rotation on contra lateral side. Triangle formed by medial and lateral heads of the sternocleido-mastoid muscle and base by medial end of the clavicle, was identified and marked. This was the point where a needle would be inserted to access the central venous line in IJV. In case of query, subject was asked to lift the head against resistance to locate triangle easily. Surface marking and sonography was done by a single, experienced investigator (SBP). A portable ultrasound "Sonosite Micromaxx" machine with 7.5 M Hz Linear array (vascular) probe was used. Probe was placed perpendicular to the apex of the triangle formed by two heads of sternocleido-mastoid (SCM) muscle and clavicle. Vessels were visualized in transverse section in 2-D ultrasound. Care was taken to apply probe gently so as not to distort low pressure venous structure. Carotid artery was seen as a circular, pulsatile structure while IJV as an oval, non-pulsatile structure on ultrasound screen. On applying downward pressure with probe, IJV get compressed whereas CA remained as such.

Exact location of IJV was identified in relation to CA on USG and recorded as lateral, anterolateral, anterior, medial, and posterior. The diameter of IJV and CA, distance from skin to IJV was recorded. Anterior position of IJV in relation to CA was considered as dangerous position. Small sized IJV was defined as diameter ≤ 7 mm. The procedure was done on both sides of neck for each volunteer.

Figure-1: Methods of Positioning and Sonography

Figure-2: Anterior Position of IJV in Relation to CA on Ultrasound Screen

Figure-3: Anterolateral Position of IJV in Relation to CA on Ultrasound Screen

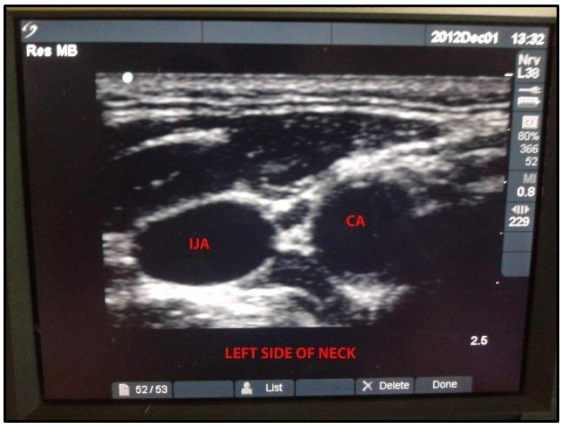

Figure-4: Lateral Position of IJV in Relation to CA on Ultrasound Screen

Statistical Analysis

Data were analyzed using Graphpad prism software version 5.1. We summarized descriptive data as mean (S.D.) or percentage. Student's t test was applied for quantitative data and Fisher exact test for qualitative data. P value < 0.05 was taken as significant.

Results

We were able to visualize the IJV and CA on USG in all volunteers. There was no absent or thrombosed IJV in any volunteer.

The mean diameter of IJV was 13.23 (2.52) mm in right side and 10.25(2.29) mm in left side of neck (p=0.0001). Small size (≤7 mm) IJV was in 1% of volunteers in right side and 8% of volunteers in left side. Thus, small size (≤7 mm) IJV was more on left side than right side of neck (p=0.0349). The mean diameter of CA was 6.14 (0.56) mm in right side and 6.2 (0.45) mm in left side of neck (p=0.4046).The mean distance of IJV to skin was 9.75 (1.88) mm in right side and 10.3 (1.87) mm in left side of neck (p=0.0394).

The commonest position of IJV in relation to CA was anterolateral; 81% on right side and 71% on left side of neck. Anterior position was 15% on right side and 28% on left side. Lateral position was 4% on right side and 1% on left side of neck. So, 15% of volunteers had dangerous position of IJV and 85% of volunteers had safe position of IJV on right side of neck. 28% of volunteers had dangerous position of IJV and 72% of volunteers had safe position of IJV on left side of neck. Thus, dangerous position of IJV in relation to CA was more on left side than right side of neck (p=0.0381).

Total anatomical variations in form of size and position were 14% of volunteers on right side and 29% of volunteers on left side of neck (p=0.0153).

Table-1: Demographics of the Study

Demographic data	Mean (S.D.)
Age (years)	27.12 (4.41)
Gender (ratio)	1 : 1
Weight (kg)	61.98 (9.55)
Height (cm)	164.31 (7.82)

Table-2: Position of IJV in Relation to CA

Position of IJV in relation to CA	Right Side of Neck (%)	Left Side of Neck (%)
Anterolateral	81	71
Anterior	15	28
Lateral	4	1
Antero-medial	0	0
Medial	0	0
Posterior	0	0

Table-3: Measurements of IJV and CA

Parameter	Right Side of Neck Mean (S.D.)	Left Side of Neck Mean (S.D.)	P value
Diameter of IJV	13.23 (2.52)	10.25 (2.29)	0.0001
Diameter of CA	6.14 (0.56)	6.2 (0.45)	0.4046
Distance of IJV from skin	9.75 (1.88)	10.3 (1.87)	0.0394

Table-4: Demographics of the Validation Sample

Anatomical variant	Right Side of Neck (%)	Left Side of Neck (%)	P value
Safe position	85	72	0.0381
Dangerous position	15	28	
Adequate size	99	92	0.0349
Small size	1	8	

Discussion

In present study, we were able to visualize and identify the IJV and CA on ultrasound every time because investigator was trained and experienced for ultrasound guided central line placement. There was no absent or thrombosed IJV or CA in present study maybe because study was included healthy volunteers. Each volunteer was placed supine with 15˚ down trendlenberg position with 45˚ neck rotation on contra lateral side for ultrasound scanning as it was the commonest position used for central line placement in our institute.

In present study, total anatomical variations in term of size and position were 14% on right side and 29% on left side of neck (p=0.0153).Denys BG and Uretsky[3] found that 9.4% of patients had anatomical variations of IJV in their study. IJV width < 7 mm in 5% of patients and 4.4% had either thrombosed or absent IJV.

In our study, IJV has clinically and statistically smaller diameter on left side compared to right side. But previous study suggests that there was no difference in mean diameter of the IJV between

right and left side.[4] The left internal jugular vein is often smaller than the right and demonstrates a greater degree of overlap of the adjacent carotid artery during head rotation.[5]

In present study, IJV diameter ≤ 7 mm were more in left side (8%) than right side (1%). Thanaporn L et al[6] found 15% of patients having IJV width ≤ 7 mm; 10% in Right sided IJV. Mey et al[7] found in their study that there are high failure rates and complications associated with IJV diameter ≤ 7 mm in comparison with diameter 7 to 10 mm. Anatomically apex of left lung is higher than right lung, and injury to thoracic duct is possible in left sided catheterization. So, we recommend all catheterization in right sided IJV first. In case of failure of right sided IJV, we recommend experienced clinician to perform left sided IJV catheterization with caution as more chance of complications.
In present study, we found anterior position of IJV in relation to CA in 15% of volunteers in right side and 28% of volunteers in left side.

Trianos et al[8] found 54% rate of anterior position of IJV in 1136 surgical patients undergoing catheterization. But, difference may be due to more elderly patients in their study in contrast to young healthy volunteers in our study.

Bing Shi Lin et al[9] found anterior position of IJV was 16.4% in left side and 18.3 % in right side in their study with 'SiteRite" USG machine in ureamic patients undergoing catheterization. Difference may be due to: (1) they used small pillow under shoulders as ureamic patients can't tolerate head down position. (2) 15 - 30˚ head rotation rather than 45˚ head rotation in our study (3) they performed USG from high position (cricoid cartilage) rather than the low position. .

Caridi JG et al[10] found that anterior position of IJV to CA was 15%. Thanaporn L et al[6] found in their study in 100 awake, non-sedated, adult patients presenting for elective cardiac surgery. With 15˚ trendlenberg position and probe of 'Sonosite' USG machine was positioned at apex of the seldiot triangle and simulations were done in six different degrees of rotation of head: 0˚, 30˚, 60˚ for both right and left IJV. They found the simulated needle hit the IJV in 82% of the attempts. The CA is medial an deep to the IJV was only in 73 – 83% of the time, rest 20 – 25% of patients are at risk of CA puncture.

S. and V.P. Chandrashekaran[4] found anterior position of IJV was 19.8% on left side and 21% on right side in their study in 81 young volunteers. They used colour Doppler USG in contrast to 2-D USG in our study. Previous study[11] reported that 2-D USG guidance is more effective than Doppler USG guidance for more difficult procedures.

Logically, with anatomical landmarks and carotid palpation technique, attempts for catheterization in case of anterior position of IJV may result in failure and multiple attempts may lead to CA puncture along with double wall puncture of IJV. So, in this case, a technically perfect attempt even by an experienced clinician based on anatomical landmarks, these patients are at risk to the possible failure or CA puncture.

We believe that standard maneuver to increase size of IJV should be done in case of anterior position of IJV as these maneuvers prevent double wall puncture of IJV during catheterization and thereby CA puncture.

Literature analysis[12-17] reveals that USG guidance for catheterization increases success rate with minimizing attempts for cannulation and complications associated with catheterization. USG guidance for catheterization is potentially useful and recommended in obese patients as anatomical landmarks are not well defined and significant overlap between IJA and CA even in neutral position.[18]

Lewi G et al[19] found that overall success of IJV cannulation is significantly improved with the use of ultrasound guidance, without a significant difference in traumatic complications specifically in children above 1 year of age or 10 kg of weight. In critical and emergency conditions, USG guided catheterizations are quicker and safer in both adults and children.[11]

Ultrasound guided central venous cannulation by inexperienced junior doctors with minimal training is not only feasible, but also appears to

decrease complication and failure rates as well as increasing rates of first pass insertion.[14]

Modern USG machine are portable, compact, real time guidance and good resolution with no radiation. Besides that USG is a simple, reliable and quickest tool to identify pneumothorax with high specificity and sensitivity.

On the other side, the additional equipment and manipulation associated with real-time ultrasound guidance may increase the rate of catheter-related infections or dependence on this technology. Anthony and joel[20] found some benefit in using the 2D ultrasound probe in predicted difficult insertions to reduce the incidence of complications and time to placement of the central line but there was insufficient evidence to recommend that the probe be used for all cases of central line insertion, especially if taking into account the expertise and skill of the operator.

"The Stanford evidence based practice centre" has recommended ultrasound guidance in central venous catheter insertion as one of the 11- point recommendations in "A critical analysis of patient's safety practices" in 2001.[21]

"The agency for healthcare quality and research" (AHRQ), in its 2001 report on reducing medical errors in the United States, placed ultrasound guidance for CVC placement in the list of ways to reduce medical error.[22]

Based on meta-analysis in 2002, "National Institute for clinical excellence" in UK has recommended that the use of 2 D ultrasound guidance should be considered in the most clinical situations where a central venous line is necessary electively or in an emergency.[23]

The American Society of Anesthesiologists Task Force[24] reported in 2012 in their practice guidelines for Central Venous Access that either static or real time USG guidance should be considered for central venous catheterisation.

Authors believe that the actual no. of anatomical variations of IJV in relation to CA in patients may be higher than healthy volunteers. As central venous line was inserted mostly in patients who are already in a compromised state. So, every attempt should be made to reduce the medical error to improve the patient safety and quality care. We recommend that use of USG for catheterization is not only encouraged but made mandatory in clinical practice.

Study Limitation

The present study included healthy volunteers, not patients. So, the relationship between anatomical variations and complications associated with central venous catheterization was not studied. The present study did not include children and geriatric population. So, results may vary in them.

Conclusion

We concluded that significant number of healthy young volunteers had anatomical variations in terms of size and position of IJV in relation of CA by ultrasound screening. IJV was smaller in diameter and having anterior position more on left side than right side of neck.

The individuals were at risk of failure or carotid artery puncture during catheterization based on anatomical landmark technique. Thus, anatomical landmarks are not sufficient, alternative measures like ultrasound scanning should be implemented before catheterization to identify the individual with potentially difficult catheterization for the prevention of complications.

References

1. McGee DC, Gould MK. Preventing complications of central venous catheterization. N Engl J Med 2003; 348:1123-33.
2. Shah KB, Rao TLK, Laughlin S, El-Etr AA. A review of pulmonary artery catheterization in 6,245 patients. Anesthesiology 1984; 61:271-5.
3. Denys BG, Uretsky BF. Anatomical variations of internal jugular vein location: impact on central venous access. Crit Care Med 1991; 19:1516-9.
4. Chandrasekaran S, Chandrasekaran VP. Anatomical variations of the internal jugular vein in relation to common carotid artery in lesser supra clavicular fossa – a colour Doppler study. International Journal of Basic Medical Science. 2011; 1(5): 235-41.

5. Parry G: Trendelenburg position, head elevation and a midline position optimize right internal jugular vein diameter. Can J Anaesth 2004; 51:379-81.
6. Thanaporn L, Ti LK, Manohara S, Lye ST, Tan S, Shen L, et al. Anatomical variations of the internal jugular vein: implications for successful cannulation and risk of carotid artery puncture. Singapore Med J 2012; 53(5):325-8.
7. Mey U, Glasmacher A, Hahn C, Gorschlüter M, Ziske C, Mergelsberg M et al. Evaluation of an ultrasound-guided technique for central venous access via the internal jugular vein in 493patients. Support Care Cancer 2003; 11:148-55.
8. Trianos CA, Kuwik RJ, Pasqual JR, Lim AJ, Odasso DP. Internal jugular vein and carotid anatomic relations as determined by ultrasonography. Anesthesiology 1996; 85: 43-8.
9. Lin BS, Kong CW, Tarng DC, Huang TP, Tang GJ. Anatomical variation of the internal jugular vein and its impact on temporary haemodialysis vascular access: an ultrasonographic survey in uraemic patients. Nephrol Dial Transplant 1998; 13: 134-8.
10. Cardi JG, Hawkins IF Jr, Wiechmann BN, Pevarski DJ, Tonkin JC. Sonographic guidance when using the right internal jugular vein for central vein access. Am J Roentgenol 1998; 171(5): 1259-63.
11. Hind D, Calvert N, Mc Williams R, Davidson A, Paisley S, Beverley C. Thomas S. Ultrasonic locating devices for central venous cannulation: meta-analysis. Br Med J 2003; 327: 361-4.
12. Paramythiotou E, Poularas I, Kalogeromitros A, Atsalakis I, Douma A, Karabinis A. A 3 year experience of ultrasound guided catheterization of internal jugular vein in an intensive care unit. Critical care 2004; 8 suppl 1:36.
13. Sulek CA, Bias ML, Lobato EB. A randomized study of left versus right internal jugular vein cannulation in adults. J Clin Anesth 2000; 12:142-5.
14. P Temblett, D Hope. Ultrasound guided central line insertion. Critical care 2004; 8 suppl 1:36.
15. Agrawal A, Singh DK, Singh AP. USG - A novel approach to central venous cannulation. Indian J Crit Care Med 2009; 13:213-6.
16. Troianos CA, Jobes DR, Elison N. Ultrasound guided cannulation of the internal jugular vein. A prospective, randomized study. Anesth Analg 1991; 72:823-6.
17. Gopal B. Palepu, Juneja Deven, M Subrahmanyam, S. Mohan. Impact of ultrasonography on central venous catheter insertion in intensive care. Indian J Radiol Imaging 2009; 19:191-8.
18. Fujiki M, Guta CG, Lemmens HJ, Brock-Utne JG. Is it more difficult to cannulate the right internal jugular vein in morbidly obese patients than in nonobese patients? Obes Surg. 2008; 18(9):1157-9.
19. Lewi G, Taylor DG, Reith E, Wasnick JD. Utility of ultrasound guided central venous cannulation in pediatric surgical patients: a clinical series. Paediatr Anaesth. 2005; 15(11):953-8.
20. Espinet A, Dunning J. Does ultrasound guided central line insertion reduce complications and time to placement in elective patients undergoing cardiac surgery. Interactive cardio Vascular and Thoracic Surgery 2004; 3: 523-7.
21. Shojania KG, Duncan BW, McDonald KM, Wachter RM, Markowitz AZ. Making health care safer: A critical analysis of patient's safety practices. Evid Rep Technol Access (Summ) 2001; 43:1-668.
22. Agency for healthcare Research and Quality (AHRQ). "Making health care safer". A critical analysis of patient safety practices. Evidence Reports/ Technology Assessments, No. 43. Available from: www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=erta43
23. National Institute for Clinical Excellence. Guidance on the use of ultrasound locating devices for placing central venous catheters. NICE technical report number 49; September 2002. Available from: http://www.nice.org.uk/nicemedia/live/11474/32461/32461.pdf
24. Practice guidelines for central venous access – a report by the American society of anesthesiologists task force on central venous access. Anesthesiology 2012; 116 (3):539-73.

Cite this article as: Parmar SB, Parikh SN, Mehta HK. Anatomical variations of the internal jugular vein in relation to carotid artery: An ultrasound study. Int J Med Sci Public Health 2013; 2:223-228.
Source of Support: Nil
Conflict of interest: None declared