Comparative Anatomy of the Right and Left Internal Jugular Veins: Implications for Optimal Central Venous Catheter Placement

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Abstract

Background: Central venous catheters are essential for dialysis, with the internal jugular vein (IJV) being the preferred access site. Recognizing anatomical variations of the IJV is crucial to avoid accidental arterial puncture. This study aims to describe anatomical variations of the right and left IJVs.

Methods: We retrospectively reviewed neck CT scans from 123 patients who underwent imaging at our hospital between January 1, 2015, and December 31, 2019. We recorded the bilateral IJV diameter, depth from the skin, distance to the common carotid artery (CCA), and the IJV's positional relationship to the CCA. The IJV's position relative to the CCA was classified as lateral, anterior, anterolateral, medial, or posterior, based on its location at the level of the cricoid cartilage.

Results: Most IJVs (90.24%) were positioned lateral to the CCA, with the left side demonstrating greater anatomical variation. The left IJV overlapped the CCA more frequently than the right in the anterolateral position, and only left IJVs were found in the anterior position. Right IJVs were larger in 85.4% of patients, with a significantly greater mean diameter (16.04±3.51 mm vs. 12.57±3.30 mm, p <0.001) and were more superficial (13.06±3.46 mm vs. 14.28±3.26 mm, p <0.001) compared to the left.

Conclusions: Due to less anatomical variability and a more favorable puncture site, the right IJV is generally more suitable for vascular access than the left.

Keywords: double lumen catheter; hemodialysis; TCC; tunneled cuffed catheter

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การศึกษาเปรียบเทียบทางกายวิภาคของหลอดเลือดดำคอข้างขวาและข้างซ้าย: เพื่อเป็นแนวทางในการใส่สายสวนหลอดเลือดดำใหญ่

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บทคัดย่อ

บทนำ: สายสวนหลอดเลือดดำส่วนกลางมีความจำเป็นสำหรับการฟอกไต หลอดเลือดดำคอ (internal jugular vein, IJV) เป็นตำแหน่งที่นิยมใช้ในการเข้าถึงหลอดเลือด และจำเป็นต้องทราบถึงความหลากหลายทางกายวิภาคของหลอดเลือดนี้เพื่อป้องกันการแทงพลาดเข้าหลอดเลือดแดงโดยอุบัติเหตุ การศึกษานี้มีวัตถุประสงค์เพื่ออธิบายความหลากหลายทางกายวิภาคของหลอดเลือดดำคอทั้งสองข้าง

ระเบียบวิธีวิจัย: การศึกษานี้เป็นการศึกษาทบทวนข้อมูลผู้ป่วยย้อนหลังจำนวน 123 ราย ที่ได้รับการตรวจเอกซเรย์คอมพิวเตอร์บริเวณคอตั้งแต่วันที่ 1 มกราคม พ.ศ. 2558 ถึง 31 ธันวาคม พ.ศ. 2562 โดยบันทึกข้อมูลขนาดเส้นผ่านศูนย์กลางของหลอดเลือดดำคอทั้งสองข้าง ความลึกจากผิวหนัง ระยะห่างจากหลอดเลือดแดงคาโรติด และตำแหน่งของหลอดเลือดดำคอเทียบกับหลอดเลือดแดงคาโรติด จุดอ้างอิงสำหรับตำแหน่งของหลอดเลือดดำคอคือหลอดเลือดแดงคาโรติด โดยจำแนกตำแหน่งเป็น ด้านข้าง (lateral) ด้านหน้า (anterior) ด้านหน้าเฉียงข้าง (anterolateral) ด้านใน (medial) หรือด้านหลัง (posterior) ประเมินที่ระดับกระดูกอ่อนไครคอยด์

ผลการวิจัย: หลอดเลือดดำคอส่วนใหญ่ (90.24%) อยู่ทางด้านข้างของหลอดเลือดแดงคาโรติด โดยหลอดเลือดดำคอข้างซ้ายแสดงความหลากหลายของตำแหน่งมากกว่า หลอดเลือดดำคอข้างซ้ายมีการซ้อนทับกับหลอดเลือดแดงคาโรติดในตำแหน่งด้านหน้าเฉียงข้างบ่อยกว่าข้างขวา พบหลอดเลือดดำคอข้างซ้ายเท่านั้นที่อยู่ในตำแหน่งด้านหน้า หลอดเลือดดำคอข้างขวามีขนาดใหญ่กว่า (85.4%) โดยมีขนาดเส้นผ่านศูนย์กลางแตกต่างกันอย่างมีนัยสำคัญ (16.04±3.51 มม. เทียบกับ 12.57±3.30 มม., p <0.001) และอยู่ตื้นกว่า (13.06±3.46 มม. เทียบกับ 14.28±3.26 มม., p <0.001)

สรุป: หลอดเลือดดำคอข้างขวาเหมาะสมสำหรับการเข้าถึงหลอดเลือดมากกว่าข้างซ้าย เนื่องจากมีความหลากหลายทางกายวิภาคน้อยกว่าและมีตำแหน่งที่เอื้ออำนวยต่อการแทงมากกว่า

คำสำคัญ: หลอดเลือดดำคอ; ฟอกเลือดด้วยเครื่องไตเทียม; ฟอกเลือด; ล้างไต; หลอดเลือดดำส่วนกลาง; สายสวนฟอกไต

Background

In 2019, the global burden of chronic kidney disease was estimated to account for 41.5 million cases.[1] The increasing burden of kidney impairment is attributed to an aging society and the rising prevalence of risk factors such as diabetes and hypertension.[2] The decision to implement hemodialysis is based on clinical situations and laboratory status. For emergency conditions, the optimal mode of hemodialysis care involves central venous double-lumen catheter cannulation.[3] The placement of a dialysis

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catheter is a necessary initial step in starting renal replacement therapy in acute settings. The potential insertion sites of dialysis catheters to access the intravascular space for renal replacement therapy include the internal jugular, subclavian, and femoral veins.[4]

Complications from vascular access in dialysis patients are a significant cause of morbidity and mortality. Overall, central venous catheterization-related complications are reported in 5 to 19 percent of cases.[5] Subclavian venous catheterization is not recommended due to the associated risk of severe acute complications, such as hemothorax, pneumothorax, incompressible vascular hemorrhage, and subsequent venous stenosis.[6,7] The internal jugular vein (IJV) is a common site for catheter insertion. However, the IJV is located adjacent to the common carotid artery (CCA), and complications may arise from the cannulation procedure, such as accidental carotid arterial puncture with serious consequences, including massive bleeding, carotid pseudoaneurysm, arteriovenous fistula, and stroke.[8] Successful catheterization relies on a thorough understanding of the anatomy of the neck. Anatomic variations in the size and location of the internal jugular vein may lead to increased procedural complications.[9] This study aimed to analyze the anatomical variations of the bilateral internal jugular veins and their relationship to the common carotid artery.

Materials and Methods

Study design and study population

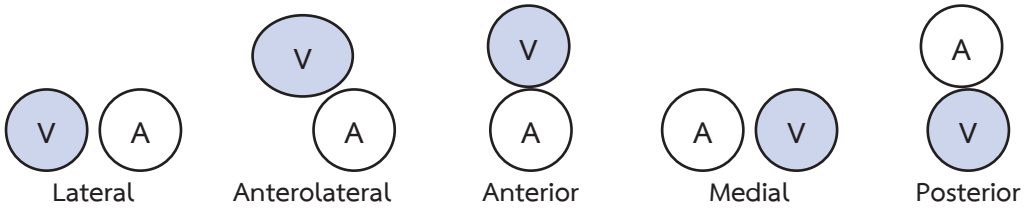
A retrospective review was conducted on 123 patients over the age of 18 from a general hospital cohort who underwent a computed tomography angiography scan of the neck at Srinagarind Hospital of Khonkaen University between January 1, 2015, and December 31, 2019. Patients with known abnormal neck anatomy, neck tumors, previous neck surgery or trauma, or neck radiation were excluded from this study.

The study was approved by the Center for Ethics in Human Research at Khon Kaen University (KKUEC), with the committee's reference number HE631566. All patient identifiers were removed following data collection from medical records. Informed consent was waived due to the retrospective nature of the study. The study was conducted in accordance with the Declaration of Helsinki.

Measurements

We measured the bilateral diameter of the IJVs, their depth from the skin surface at the level of the cricoid cartilage, and the shortest linear distance between the IJVs and CCAs. The reference points for determining the IJVs' location were the CCAs at the same level of the axial slice at the level of the cricoid cartilage. The measurement was performed by a qualified surgeon.

We classified the locations into five categories: lateral, anterolateral, anterior, medial, and posterior **(Figure 1)**.[10]



- Lateral: The IJV is positioned lateral to the CCA.
- Anterolateral: The IJV lies anterolateral to the CCA, partially overlapping by 50–99%.
- Anterior: The IJV is located directly anterior to the CCA, with complete (100%) overlap.
- Medial: The IJV is positioned medial to the CCA.
- Posterior: The CCA lies anterior to the IJV, with complete (100%) overlap.

Figure 1 Schematic showing the anatomical relationship between the internal jugular vein and the common carotid artery (A: Common carotid artery, V: Internal jugular vein).

Statistical analysis

The sample size for this study was determined based on existing literature, requiring a total of 84 cases.[11] Continuous variables are presented as means with standard deviations. Comparisons of continuous data were performed using either the Student's t-test or the Mann–Whitney U-test, as appropriate. Categorical variables were compared using the Chi-squared test or Fisher's exact test. Statistical analyses were conducted using IBM SPSS Statistics, Version 28. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 123 cases with 246 IJVs were evaluated and analyzed retrospectively. Eighty-six cases (69.92%) were male. The patients' ages ranged from 18 to 84 years old, with a mean age of 53.32±15.34 years **(Table 1)**. In most cases (105 out of 123, or 85.4%), the diameter of the right internal jugular vein (IJV) was larger than that of the left. This difference in diameter was statistically significant, as indicated in **Table 2**. The smallest recorded diameter was 6.1 mm on the right side and 5.43 mm on the left. There was significantly more distance between the IJV and CCA walls on the right side. The number of cases with a distance of less than 1 mm from IJV to CCA was higher on the left side. In the neutral position of a neck CT scan, most of the IJV is located at the lateral aspect of the CCA on both sides, followed by the anterolateral position. The left IJV overlaps the CCA in the anterolateral position more than the right. We found the anterior position of the IJV only on the left side **(Table 3)**.

Table 1 Demographic data of all patients

Parameters	Values
Age (year), mean (SD)	53.32±15.343
Sex, n (%) • Male • Female	 86 (69.9) 37 (30.1)

Table 2 Characteristics of the internal jugular vein

Parameters	Right (n = 123)	Left (n = 123)	*p*
Diameter (mm, mean±SD)	16.04±3.51	12.57±3.30	<0.001
Number of the right IJV larger than the left, n (%)	105/123 (85.4%)		-
Depth from skin surface (mm, mean±SD)	13.06±3.46	14.28±3.26	<0.001
Relative distance from CCAs (mm, mean±SD)	1.61±0.72	1.32±0.54	<0.001
Distance ≤1 mm away from CCAs, n (%)	15 (12.2%)	28 (22.8%)	-

Table 3 Anatomical relationship between the internal jugular vein and the common carotid artery

Position of the internal jugular vein	Right (n = 123)	Left (n = 123)	Total %
Lateral, n (%)	119 (96.7%)	103 (83.7%)	90.24%
Anterolateral, n (%)	4 (3.3%)	17 (13.8%)	8.54%
Anterior, n (%)	-	3 (2.4%)	1.22%
Medial, n (%)	-	-	-
Posterior, n (%)	-	-	-

Discussion

Central venous catheterization is crucial for providing acute hemodialysis via a catheter. It is also essential to administer intravenous fluid resuscitation for hemodynamically unstable patients. Proper placement of the catheter requires anatomical knowledge and good surgical techniques. Complications from this procedure can lead to life-threatening conditions such as vascular injury, uncontrolled hemorrhage, stroke, or hemopneumothorax.[12]

The most suitable location for puncture to insert the catheter is at the level of the cricoid cartilage due to the superficial and relatively bulkier nature of the IJV at this point.[13] We rely on the anatomical landmarks of the IJV and CCA at the level of the cricoid cartilage for guidance. Compared to ultrasonography, a CT scan offers advantages by eliminating operator-dependent variations, no external compression to the veins as is done during ultrasound, and allowing for the assessment of any anatomical irregularities in the head and neck that might affect the characteristics of the vessels.[14]

There are circumstances under which ultrasonography may be unavailable, especially in emergency central venous access. The technique utilizing external anatomical landmark guidance for accessing the IJV is considered safe. The anatomical landmark for central venous access is usually deemed reliable.[15,16] Nonetheless, anatomical variations of the IJV may arise, resulting in potential risks of complications.

Anatomic variability has been implicated as the cause of difficulty in cannulation. Both variations in size and location of the IJV may result in complications following external landmark-guided cannulation.[17] The failure rate of IJV cannulation in general medical and surgical patients has been estimated to be between 4.7% and 17.6%, and the complication rate has been reported to be between 3.9% and 14.3%.[18] During central venous placement, preventing arterial puncture and cannulation is essential to minimize serious sequelae. Ultrasound has been used to assess the normal IJV anatomy and guide safe venous access.[19] The information derived from this study can potentially enhance the success rates of venous catheter placement for hemodialysis while concurrently decreasing procedural complications.

The literature shows a lower anatomical variation of the right IJV than that of the left IJV.[20,21] The size of the right and left IJV is often asymmetrical due to more drainage of blood through the right dural venous sinuses than through the left. The right IJV is often larger than the left IJV.[22] This study demonstrates that the right IJV manifested a significantly larger diameter and a more superficial position, facilitating the puncture technique. The findings of this study are consistent with the CT-evaluated IJV anatomy of Maneenai et al[10], which also indicates that the right IJV is located more superficially (16.3±4.2 mm vs. 17.0±4.4 mm) and has a greater diameter compared to the left IJV (14.9±4.0 mm vs. 11.6±3.8 mm, $p < .0001$). Another retrospective evaluation using CT imaging has also reported that the mean right IJV diameter was 14.1 mm compared to the mean left IJV diameter of 11.74 mm.[23]

Additionally, the right IJV exhibits less variation in its anatomical position, particularly located at the lateral aspect of the CCA (96.7% vs 83.7%), resulting in a reduced risk of CCA injury if the cannulating needle traverses the IJV compared to the anterolateral or anterior positions. Another CT imaging also manifested the majority of IJVs in the lateral position (85.2%), with the left IJV position varying more than the right side in relation to the CCA.

The excessive head rotation during IJV catheterization revealed a predisposition to the increasing overlap of the IJV over the CCA. A study simulating a 60-degree rotation of the neck reported that the incidence of patients with the CCA overlapped by the IJV after simulated rotation significantly increased (from 20%-30% to 50%).[24] The findings emphasize the need to avoid extreme head rotation during puncture. Moreover, the right internal jugular vein (IJV) presents a more direct and efficient pathway to the superior vena cava and the right atrium.[15] The associated risk of pneumothorax is notably reduced due to the lower position of the pleural dome on the right side.[25] Furthermore, the likelihood of injuring the thoracic duct on the right side remains minimal.[26] The study revealed that the difficulty of IJV cannulation was

significantly greater on the left side than the right across all positions of head rotation[27]

In conclusion, different anatomical variations of the IJVs can occur, increasing the potential for complications when placing a hemodialysis catheter. It is crucial to be aware of these variations. In general, the right IJV is considered more suitable for access than the left side due to its tendency to have less anatomical variation and a more feasible location for puncture.

Authors' contributions

Panu Teeratakulpisarn contributed to the conception, design, review and editing of the manuscript. Parichat Tanmit verified the data, conducted formal analysis and drafted the original manuscript. Kritthee Tiyanuchit collected and interpreted the data. Phati Angkasith, Narongchai Wongkonkitsin, and Supatcha Prasertcharoensuk contributed to the methodology and data analysis. Chaiyut Thanapaisal served as a scientific advisor. All authors participated in the review and approved the final version of the manuscript.

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