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Investigation of the Morphometry and Topographic Anatomy of the Internal Jugular Vein in Patients Undergoing Neck Dissection

Investigación de la Morfometría y Anatomía Topográfica de la Vena Yugular Interna en Pacientes Sometidos a Disección Cervical

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SUMMARY: This study investigates the morphological-topographic anatomy of the Internal Jugular Vein (IJV) and its relationships with other vascular and neural structures in patients undergoing functional neck dissection. Thirty-two patients (27 males, 5 females; mean age: 63.03) were included. Preoperative computerized tomography (CT) imaging measured the transverse diameters of the IJV at the os hyoidea and cartilago cricoidea levels, along with morphometric measurements such as the IJV position relative to the Common Carotid Artery (CCA) and the distance between the IJV and CCA. The IJV length and number of branches entering the IJV were also recorded. During dissection, the IJV's anatomical relationship with the Accessory Nerve (AN) was noted. Findings showed that 67.7 % of IJV positions were lateral to the CCA, while 25.5 % were anterior, and 6.8 % were posterior. The most common IJV branch type was the five-branch type (61 %). Right IJV diameters were larger than the left, with no significant differences observed between neck sides and sexes. A positive correlation was found between the upper and lower IJV diameters. The distance between the IJV and CCA varied, with some measured at 1 mm and others at 4 mm. The majority of AN positions were anterior (55.9 %). Our study, which included measurements obtained both via CT imaging and during neck dissection, objectively clarifies the relative positions of the IJV to the CCA, providing measurable guidelines for surgical practice. Significant anatomical variations between the IJV, CCA and AN still pose significant risks during neck dissection surgeries and jugular vein catheterizations.

KEY WORDS: Accessory Nerve; Carotid Arteries; Jugular Veins; Multislice Computed Tomography; Neck Dissection

INTRODUCTION

The internal jugular vein (IJV) is the largest vein responsible for collecting venous blood from the brain, head, oral cavity, superficial parts of the face, and most of the neck. It runs vertically on the side of the neck, beginning at the foramen jugulare as a continuation of the sigmoid sinus. It has a superior and inferior bulb at the skull base and neck region (Kiray *et al*., 2005). During its vertical course along the neck, it is first located laterally to the internal carotid artery (ICA), and later to the common carotid artery (CCA).

The internal jugular vein is an important landmark for physicians performing central venous catheterization, surgeons conducting head and neck surgeries, anesthesiologists, and other medical professionals. In addition to being the largest vein in the head and neck, the IJV serves as a key surgical-anatomical landmark for adjacent structures such as the CCA, vagus nerve, and cervical lymph nodes.

Neck dissection, or cervical lymphadenectomy, is a common procedure for treating head and neck cancer. Radical neck dissection is a surgical technique with significant comorbidities and a high rate of postoperative complications (Prades *et al*., 2002; Hashimoto *et al*., 2012; Contrera *et al*., 2016). Therefore, during neck dissections, special attention is given to the IJV and accessory nerve to ensure the safety of these structures (Hashimoto *et al*., 2012; Contrera *et al*., 2016). Successful surgical management of patients undergoing neck dissection depends on the recognition of patient-specific anatomical variations that could increase the risk of complications. The literature reports that the average length of the IJV in the neck region

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is 15.0 ± 1.1 cm, with the upper diameter measuring 9.0 ± 0.5 mm and the lower diameter measuring 11.0 ± 1.3 mm (Tartière *et al*., 2009). Many studies also suggest that the right IJV has a larger diameter than the left (Lim *et al*., 2006; Tartière *et al*., 2009).

Although the relationship between the IJV and CCA is well-known and documented, there are significant variations in their relative positions (Lieberman *et al*., 2004; Turba *et al*., 2005; Asouhidou *et al*., 2008; Qin *et al*., 2010). These variations may lead to injuries during central venous catheterization or neck dissection surgeries (Sulek *et al*., 1996).

The accessory nerve is another important surgical landmark during functional neck dissection. However, the position of the accessory nerve relative to the IJV can vary. It can be found anterior, medial, lateral, or posterior to the IJV. If the accessory nerve is medial or posterior to the IJV, there is a higher risk of injury during the dissection. This study aims to investigate the morphological and topographic anatomy of the IJV and its relationship with other vascular and neural structures in patients who underwent functional neck dissection.

MATERIAL AND METHOD

This study was conducted with the approval of our university's local clinical research ethics committee, dated 27.10.2021, and numbered E-16214662-050.01.04-77561-196. Thirty-two patients aged between 18 and 90 years who underwent functional neck dissection (Mean age: 62.08; 63.2 for males, 58 for females) were included in the study over a period of 13 months. All patients who underwent neck dissection have obtained written informed consent. A total of 59 internal jugular veins from the 32 patients were examined.

All patients underwent standard preoperative diagnostic neck CT. Patients were asked to hold their breath for approximately 15 seconds after full inspiration, with the head in a neutral position while supine. For each case, the neck and mediastinum, from the skull base to the superior vena cava, were included in the imaging field. In the CT scans, the transverse diameters of the IJV at the levels of the hyoid bone and cricoid cartilage were measured and recorded in the patient charts. Both sides of the CCA's were used as reference points for localizing the IJV. The position of the IJV relative to the CCA (anterior, posterior, medial, or lateral) was also assessed, along with the morphometric measurements between the IJV and the CCA at the level of the cricoid cartilage. The distance between the IJV and the CCA was measured at the level of the cricoid cartilage (Fig. 1), with measurements below 1 mm recorded as 1 mm and those above 4 mm recorded as 4 mm.

During the neck dissection operation, the fascia surrounding the IJV was dissected from the level of the digastricus muscle venter posterior to the level of the clavicle. The number of branches joining the IJV was recorded in the patient charts. The length of the IJV was measured from the level of the digastric muscle belly to the level of the clavicle and recorded in the patient charts. After the patients underwent functional neck dissection, photographs were taken when the IJV was exposed. Photographs were captured using a Nikon D3200 digital camera (AF Micro Nikkor 105 mm, 1:2.8D, Nikon Corp, Japan). Additionally, anatomical variations of the IJV and its relationship to the AN were examined.

After the determined values were recorded in the patient charts, the patients' findings were documented, and statistical analyses were performed to compare variables such as age, sex, and neck side.

Statistical analysis was conducted using IBM SPSS version 20.0 software for Windows (IBM Corporation, Armonk, New York, USA). Mean ± standard deviation was used for continuous variables, while percentage values were used for categorical variables. Kolmogorov-Smirnov analysis was performed for normality distribution, and non-parametric tests were applied based on the results of this analysis. The Mann-Whitney U test was used for pairwise comparisons between groups, while the chi-square test was used for the comparison of categorical variables. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 59 internal jugular veins from 32 patients (27 males, 5 females) who underwent surgery for head and neck cancer were examined. Out of the 59 neck dissections, 30 right IJVs and 29 left IJVs were analyzed. No statistically significant difference was found between the groups based on neck side and sex ($P = 0.759$).

Regarding the position of the IJV in relation to the CCA, the IJV was found to be in the lateral position in most cases (Table I). In CT, the anteriorly located IJV is presented as an example in Figure 1. Specifically, it was located lateral to the CCA in 40 (67.7 %) necks, anterior to it in 15 (25.5 %) necks, and posterior to it in 4 (6.8 %) necks. Of the 4 posteriorly located IJVs, all were found in male patients, while no posteriorly located IJVs were observed in female patients. When the position of the IJV relative to the CCA was analyzed by neck side and sex, no statistically significant difference was found ($P > 0.05$).

Table I. Position of IJV relative to CCA according to patients neck side and sex.

	Anterior	Lateral	Posterior	P Value
Male (n: 50)	14 (28 %)	32 (64 %)	4 (8 %)	
Female (n: 9)	1 (11 %)	8 (89 %)	-	0.387
Side				
Right (n: 30)	8 (26 %)	21 (70 %)	1 (4 %)	
Left (n: 29)	7 (24 %)	19 (65 %)	3 (10 %)	0.403

Internal jugular vein (IJV), common carotid artery (CCA)

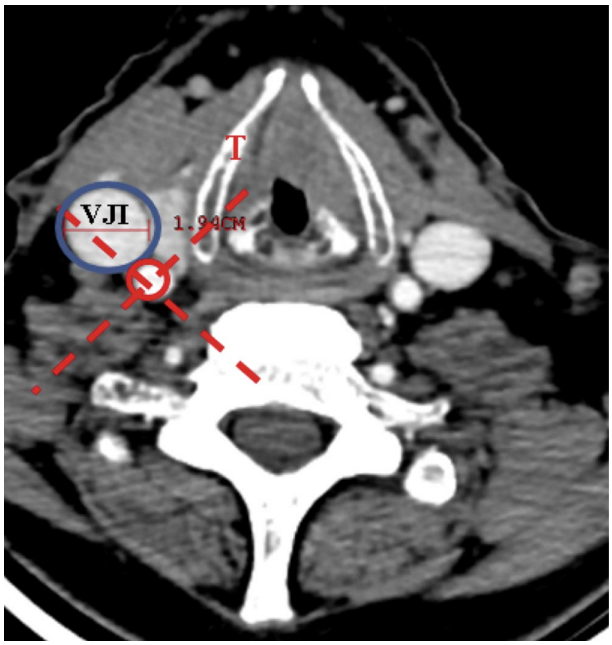

Fig. 1. Anteriorly positioned IJV on computed tomography, T (Thyroid cartilage), IJV (Internal jugular vein).

In the CT scans, it was determined that both the upper and lower diameters of the right IJVs were larger than those of the left IJVs (Table II). The average upper diameter of the right IJV was measured as 11.87 ± 3.27 mm, while the left IJV measured 11.38 ± 3.78mm. Similarly, the average lower diameter of the right IJV was 14.23 ± 2.97mm, while the left IJV was 13.72 ± 4.15 mm. The average IJV length was 12.36 ± 1.17 cm in males and 12.33 ± 1.41cm in females (Table II). On the right neck side, the average IJV length was 12.43 ± 1.30 cm, while on the left neck side, it was 12.27 ± 1.09 cm. When the upper and lower diameters of the IJV and its length were statistically evaluated by neck side and sex, no significant differences were found (Table II). However, on both neck sides and in both sexes, the average lower diameter of the IJV was thicker than the upper diameter, and a statistically significant positive correlation was found ($P = 0.005$, $r = 0.732$).

When the distance between the IJV and the CCA was examined, the distance between the IJV and the CCA was found to be 1 mm in 15 (25.4 %) neck sides, and 4 mm in 3 (5 %) neck sides. The average distance between the right IJV and the CCA was 2.13 ± 0.77 mm, while the average distance between the left IJV and the CCA was 2.07 ± 0.92 mm. When analyzed by sex, the distance between the IJV and the CCA was 2.14 ± 0.85 mm in males and 1.88 ± 0.78 mm in females. Statistically, no significant difference was found between neck sides or sexes regarding the distance between the IJV and CCA ($P > 0.05$) (Table II).

The number of branches entering the internal jugular vein was as follows: 17 (28.8 %) of the 59 neck sides had a four-branch IJV, 36 (61 %) had a five-branch IJV and 6 (10.2 %) had a six-branch IJV. Thus, the five-branch IJV type was the most common. No statistically significant differences in the number of branches were found when analyzed by neck side or sex (Table III).

Table II. Upper and lower diameter, length and distance of IJV from CCA according to sex and neck side.

	Right side (n: 30)	Left side (n: 29)	P value	Male (n: 50)	Female (n: 9)	P Value
Upper diameter (mm)	11.87 ± 3.27	11.38 ± 3.78	0.132	11.36 ± 3.52	13.11 ± 3.14	0.132
Lower diameter (mm)	14.23 ± 2.97	13.72 ± 4.15	0.783	13.88 ± 3.53	14.56 ± 3.97	0.783
Distance to VJI – ACC	2.13 ± 0.77	2.07 ± 0.92	0.445	2.14 ± 0.85	1.89 ± 0.78	0.445
Length of VJI (cm)	12.43 ± 1.30	12.27 ± 1.09	0.782	12.36 ± 1.17	12.33 ± 1.41	0.782

Internal jugular vein (IJV), common carotid artery (CCA)

Table III. Number of branches of IJV according to sex and neck side.

	Internal jugular vein tributaries			
Sex	Four Branched	Five Branched	Six Branched	P Value
Male (n: 50)	16	29	5	
Female (n: 9)	1	7	1	0.438
Side				
Right (n: 30)	9	17	4	
Left (n: 29)	8	19	2	0.664

Table IV. Position of accessory nerve relative of internal jugular vein.

Sex	Anterior	Lateral	Posterior	P Value
Male (n: 50)	28 (56 %)	19 (38 %)	3 (6 %)	
Female (n: 9)	5 (56 %)	4 (44 %)	-	0,773
Side				
Right (n: 30)	15 (50 %)	13 (43 %)	2 (7 %)	
Left (n: 29)	18 (62 %)	10 (34 %)	1 (4 %)	0,612

Regarding the position of the accessory nerve (AN) relative to the IJV, it was predominantly found in the anterior position (55.9 %). When the position of the accessory nerve relative to the IJV was analyzed by neck side and sex, no statistically significant difference was found (P > 0.05) (Table IV). Figures showing the accessory nerve coursing posteriorly (Fig. 2) and laterally (Fig. 3) are provided.

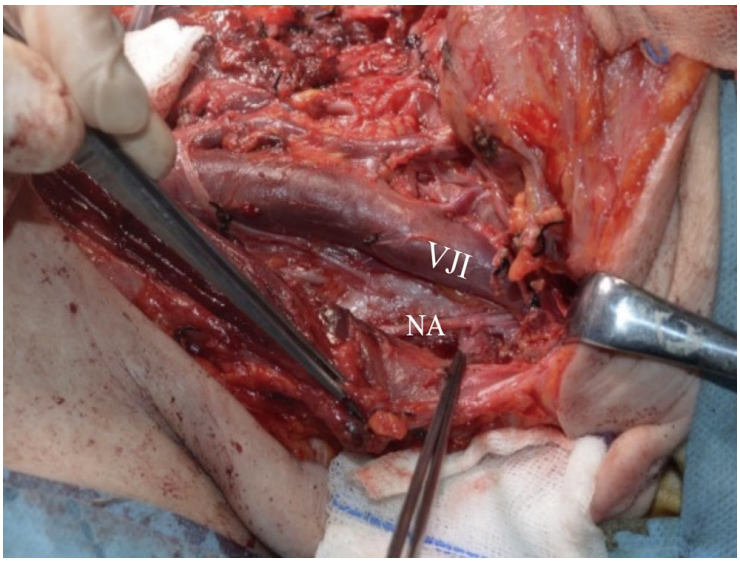

Fig. 2. Accessory nerve (NA) located posterior to the internal jugular vein (IJV).

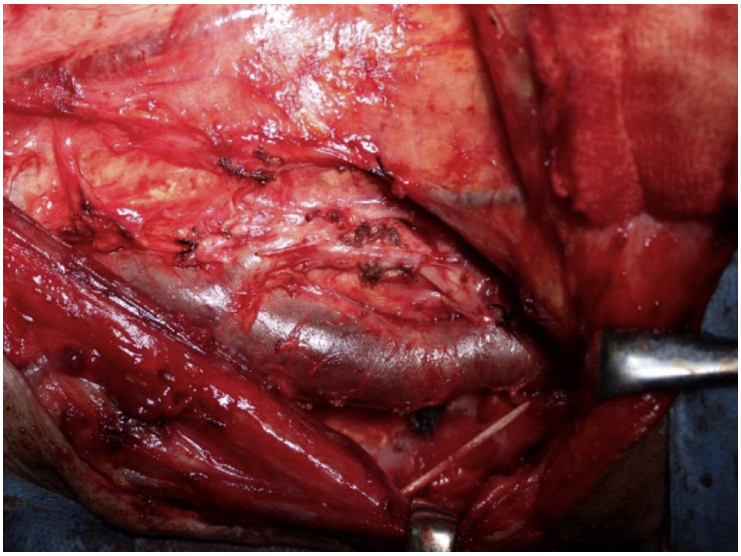

Fig. 3. Accessory nerve located lateral to the internal jugular vein.

DISCUSSION

The internal jugular vein and CCA are the major vascular structures in the head and neck region. These vessels are frequently encountered by head and neck surgeons during prophylactic or therapeutic cervical lymphadenectomy, and by anesthesiologists during procedures such as central venous pressure monitoring, drug administration, and volume resuscitation (Wang *et al.* (2020)). Therefore, understanding the morphological and morphometric characteristics of these major vessels, as well as recognizing their anatomical variations, is crucial to avoid potential complications.

In our study, we examined the morphological and morphometric features of the IJV in 59 neck dissection sides. The average length of the IJV in the neck was previously reported as 15.0 ± 1.1 cm by Tartière *et al.* (2009). In our study, we measured the IJV length from the posterior belly of the digastric muscle to the level of the clavicle. The average length of the right IJV was 12.43 ± 1.30 cm, while the left IJV was 12.27 ± 1.09 cm.

Our study is the first to examine morphometric features of the IJV using both CT and during neck dissection. Previous studies have relied solely on imaging techniques such as CT or ultrasonography (USg) (Denys & Uretsky, 1991; Armstrong *et al.*, 1993; Sulek *et al.*, 1996; Gordon *et al.*, 1998; Lin *et al.*, 1998; Forauer & Glockner, 2000; Teichgräber *et al.*, 2003; Lim *et al.*, 2006). To date, no consensus exists regarding USg measurement of the IJV's relationship with the CCA. Denys & Uretsky (1991) described positioning the transducer in the groove between the sternal and clavicular heads of the Sternocleidomastoideus muscle (SCM), parallel to and above the clavicle. In contrast, Troianos *et al.* (1996) placed the probe at the apex of the angle formed by the division of the SCM directing it in the same plane as a cannulation needle to visualize both the IJV and CCA. Ultrasonography has limitations as it is a radiologist-dependent technique (Denys & Uretsky, 1991; Lim *et al.*, 2006). The pressure applied by the probe can alter the anatomical appearance of the IJV, and variations in neck position and probe angle may affect the IJV-CCA relationship (Sulek *et al.*, 1996). In contrast, CT imaging does not have the

same drawbacks and provides a more consistent representation of anatomy. Differences in imaging techniques, positioning, and neck rotation may explain the significant discrepancies in evaluating the correlation between the IJV and CCA.

Studies using USg have reported varied results regarding the position of the IJV relative to the CCA (Denys & Uretsky, 1991; Troianos *et al*., 1996; Forauer & Glockner, 2000; Turba *et al*., 2005; Lim *et al*., 2006). As noted by Gordon *et al*. (1998), the lack of standardized guidelines and USg terminology may partially explain these discrepancies. In a study of 200 patients using ultrasonography, 92 % of IJVs were found anterior to the CCA (Denys & Uretsky, 1991), while in another study, 99 % of IJVs were located lateral to the CCA (Turba *et al*., 2005). Qin *et al*. (2010), reported that the IJV was predominantly lateral in their USg study, with no IJV observed in posterior or anterior positions. This lateral position is considered the safest anatomical reference for IJV function.

In a study similar to ours, Lim *et al*. (2006), used neck CT to evaluate the position of the IJV. This approach avoided the complications associated with USg, such as probe pressure and neck position. Lim *et al*. (2006), reported that 85.2 % of IJVs were lateral, 12.5 % anterior, and 2.2 % posterior or medial. In our study, CT images revealed that the IJV was lateral or anterior in 93.3 % of cases, and no IJV was found in a medial position. However, 6.7 % of cases had posteriorly located IJV. Maecken & Grau (2007) reviewed studies that reported the IJV in a medial position in 0 % to 5.5 % of cases. Medial and posterior positions are considered anatomical variations and may increase the risk of complications during neck dissection or IJV puncture. Therefore, it is important to identify these positions in advance during surgeries in this region.

Our study found that both the upper and lower diameters of the IJV on the right side of the neck were larger than those on the left side, which is consistent with other studies (Labato *et al*., 1999; Lim *et al*., 2006; Yoon *et al*., 2013). This asymmetry was also observed in males. Asoushidou *et al*. (2008), investigated IJV diameter abnormalities in 93 cadavers and found that all hypoplastic IJV (defined as having diameters less than 5 mm) were on the left side. In our study, no IJV diameter was less than 5 mm on either side.

Lim *et al*. (2006), reported that the distance between the IJV and CCA was 1 mm or less in 70 % of cases. In our study, this distance was 1 mm or less in 25.4 % of cases, while only 5 % of cases had a distance of 4 mm. This proximity increases the risk of complications during neck dissection or central venous catheter insertion.

The IJV receives branches from several veins, including the inferior petrosal sinus, common facial, lingual, pharyngeal, superior thyroid, middle thyroid, and occipital veins (Deepak *et al*., 2015). During neck dissection, some of these branches may need to be ligated, leading to venous stasis and edema. In our study, the most common type of IJV had five branches (61 %), while the least common type had six branches (10 %). The number of branches entering the IJV was evaluated during neck dissection, and since the IJV above the posterior belly of the digastric muscle and below the clavicle was not part of the dissection area, branches from these regions were not included in the study.

In neck dissections, recognizing the position of the accessory nerve (AN) in relation to the IJV is crucial. The accessory nerve typically courses in front of the IJV at the level of the posterior belly of the digastric muscle in 75-90 % of cases, with 10-25 % of cases showing a posterior course (Lévy *et al*., 2001). In our study, the AN was found anterior to the IJV in 56 % of cases, posterior in 39 %, and lateral in 5 %. No cases showed a medial position of the AN. The higher frequency of posterior AN positioning in our study, compared to other reports, may be due to the nature of our study, which was conducted during neck dissection rather than on cadavers. It is essential to be aware of the AN's position, especially when it is located posteriorly or medially, as these positions pose a higher risk of injury during dissection.

Our study had several limitations. The sample size, particularly for females, was small. Additionally, IJV diameters and other measurements were taken with patients in the supine position. Finally, our study population consisted mainly of middle-aged and older adults, rather than younger individuals.

CONCLUSION

Ultrasonography-based anatomical studies to date have reported significant variability in their findings. Our study is the first to comprehensively examine the anatomical variations and morphological features of the internal jugular vein using both CT imaging and direct measurements during neck dissection. This research provides objective clarification of the relative positions of the IJV to the common carotid artery and accessory nerve, offering measurable guidelines for surgical and clinical practice. The notable anatomical variations between the IJV and CCA present significant risks during neck dissection and jugular vein catheterization. We recommend further studies with broader age groups and larger sample sizes, particularly including younger individuals, to better understand these anatomical relationships.

GÜVEN, E. M.; ÇOLAK, T. & ELDEN, H. Investigación de la morfometría y anatomía topográfica de la vena yugular interna en pacientes sometidos a disección cervical. *Int. J. Morphol., 43(3)*:753-758, 2025.

RESUMEN: Este estudio investigó la anatomía morfológica y topográfica de la vena yugular interna (VYI) y sus relaciones con otras estructuras vasculares y neurales en pacientes sometidos a disección cervical funcional. Se incluyeron 32 pacientes (27 hombres, 5 mujeres; edad media: 63,03 años). La tomografía computarizada (TC) preoperatoria midió los diámetros transversales de la VYI a nivel del hueso hioides y el cartílago cricoides, junto con mediciones morfométricas como la posición de la VYI con respecto a la arteria carótida común (ACC) y la distancia entre la VYI y la ACC. También se registraron la longitud de la vena yugular interna (VYI) y el número de ramas que drenaban en ella. Durante la disección, se observó la relación anatómica de la VYI con el nervio accesorio (NA). Los hallazgos mostraron que el 67,7 % de las posiciones de la VYI fueron laterales al ACC, mientras que el 25,5 % fueron anteriores y el 6,8 % posteriores. El tipo de rama de la VYI más común fue el de cinco ramas (61 %). Los diámetros de la VYI derecha fueron mayores que los de la izquierda, sin que se observaran diferencias significativas entre los lados del cuello y el sexo. Se encontró una correlación positiva entre los diámetros superior e inferior de la VYI. La distancia entre la VYI y el ACC varió, con algunas medidas a 1 mm y otras a 4 mm. La mayoría de las posiciones del NA fueron anteriores (55,9 %). Nuestro estudio, que incluyó mediciones obtenidas tanto mediante TC como durante la disección del cuello, aclara objetivamente las posiciones relativas de la VYI con respecto al ACC, proporcionando pautas mensurables para la práctica quirúrgica. Las variaciones anatómicas significativas entre la vena yugular interna, la arteria carótida interna y el NA aún presentan riesgos significativos durante las cirugías de disección cervical y cateterización de la vena yugular.

PALABRAS CLAVE: Nervio accesorio; Arterias carótidas; Venas yugulares; Tomografía computarizada multicorte; Disección cervical.

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