

# Anatomical Variations of the Internal Jugular Vein: Focus Through Three Clinical Observations

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**Abstract:** The authors report three cases of division anomalies (bifurcation and fenestrations) of the internal jugular vein (IJV) revealed intraoperatively during cervical lymph node dissection. Although these terms are commonly interchanged in the literature, they are used interchangeably often granting ambiguity among surgeons. The objective of this work was to report our experience through three clinical observations collected from 2017 to 2022 in order to be able to build the different terminologies and also discuss the clinical implications. Clinical cases: These are three patients aged 55, 59 and 62, male, who all underwent total laryngectomy plus bilateral functional lymph node dissection for squamous cell carcinoma classified as T4aN2bMO, T4aN1MO, T4aN2aMO. During the recesses of the right sides, the dissection carried out along the internal jugular vein found a small duplication in the shape of a "needle point" giving the appearance of a window (fenestration) through which the spinal nerve passed between the branches. In one case, the window was slightly wide in the second patient and in the third patient we found splitting of the vein with a bifurcation type. The postoperative course was simple. Conclusion: Divisions (duplication, bifurcation or fenestration) of IJV are rare and are mainly observed during cervical surgery, diagnostic imaging, and very rarely during cadaver dissection. Understanding its IJV variation abnormalities is important to avoid iatrogenic injury during cervical surgery or during central venous catheterization.

**Keywords:** Anatomical Variations, Internal Jugular Vein, Cervical Surgery

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## 1. Introduction

The internal jugular vein (IJV) is the largest vein in the neck. It drains blood from the skull, brain, face and neck. It runs down the neck along the carotid sheath and unites with the subclavian vein behind the sternal end of the clavicle to form the brachiocephalic vein. It is frequently used for the central venous line and is an important anatomical reference for radiologists and head and neck surgeons [1]. Cervical lymph node dissection or neck dissection is a common practice performed in head and neck cancer surgery. Complications associated with this surgery include

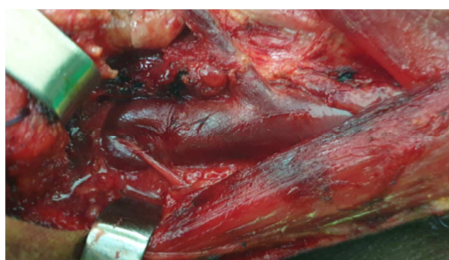
hemorrhage and nerve damage. Successful surgical management of these patients is therefore based on knowledge of the anatomical structures [2]. Identification of the IJV and the omohyoid muscle is critical to any cervical dissection [1]. Divisions (duplication, bifurcation or fenestration) of the IJV are rare and are mainly observed during cervical surgery and diagnostic imaging, and very rarely during cadaver dissection [3]. The preoperative mode of discovery is the most frequent [2, 4]. Understanding its IJV variation abnormalities is important to avoid iatrogenic injury during cervical surgery or during central venous catheterization. Although these terms are commonly interchanged in the literature, they are used interchangeably

often creating ambiguity among surgeons. We report three cases of IJV abnormalities in patients during cervical dissection from 2017 to 2022 in order to be able to edify the different terminologies and also discuss the clinical implications.

## 2. Clinical Cases

### 2.1. Patient 1

NC, 55-year-old male, with a history of alcohol and smoking, admitted to the unit for management of inspiratory dyspnea evolving for 3 months. The data of the clinical examination, the computed tomography and the result of the biopsy concluded to a moderately differentiated squamous cell carcinoma classified T4aN2bMO. We performed a total laryngectomy with functional bilateral jugulo-carotid dissection. During dissection of the right side, the dissection carried out along the internal jugular vein found a small duplication in the shape of a "needle point" giving the appearance of a window (fenestration) through which the spinal nerve passed between the branches (figure 1). No accident or operational incident was noted. The postoperative course was simple.

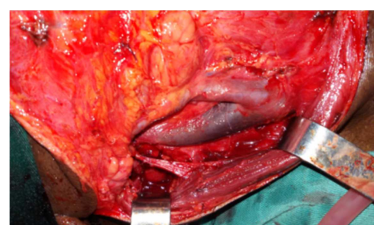


**Figure 1.** Cervical dissection image. Fenestration right internal jugular Vein. The spinal nerve passes through the fenestration.

### 2.2. Patient 2

Mr G, aged 59, male, smoker, non-alcoholic, admitted to the unit for laryngeal dyspnea. Clinical examination, medical

imaging and the result of the pathology concluded that squamous cell carcinoma of the larynx classified T4aN1MO. The patient underwent a total laryngectomy with functional bilateral jugulo-carotid lymph node dissection. We proceeded to right then left lymph node dissection. The anatomical variation of the fenestrated internal jugular vein was observed intraoperatively during lymph node dissection on the right side (figure 2). The postoperative course was simple.



**Figure 2.** Intraoperative image. Fenestration right internal Jugular vein. The spinal nerve passes outside the fenestration.

### 2.3. Patient 3

62-year-old male patient, 15 pack-years smoker/year, non-drinker admitted to the department for squamous cell carcinoma of the larynx with group II lymph node invasion on the right. The patient was classified as T4aN2aMO. Total laryngectomy with bilateral lymph node dissection of groups II–IV was performed. During lymphadenectomy on the right side, a bifurcation-type partial splitting was found intraoperatively (figure 3). The postoperative course was simple.



**Figure 3.** Intraoperative image. Bifurcation of the internal jugular vein right. The spinal nerve passes outside the bifurcation.

**Table 1.** Clinical data of the three patients.

Patients	Age/Sex	History	Side of lesion	Stage TNM	Type of anomaly	Mode of discovery	Side affected
1	55 M	Alcohol/Tobacco	Larynx	T4aN2bMO	Fenestration	Intraoperative	Right
2	59 M	Tobacco	Larynx	T4aN1MO	Fenestration	Intraoperative	Right
3	62 M	Tobacco	Larynx	T4aN2aMO	Bifurcation	Intraoperative	Right

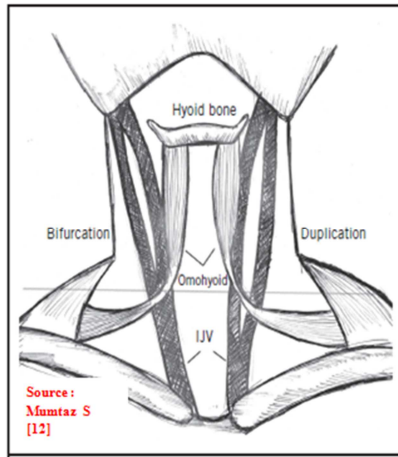
## 3. Discussion

Abnormalities of anatomic variations of the internal jugular vein (IJV) are rare. Different variations of the internal jugular are reported in the literature [5-8]. But duplication anomalies such as duplications, bifurcations and fenestrations seem to predominate, but the terms are most often used interchangeably, often creating ambiguities of definition among surgeons.

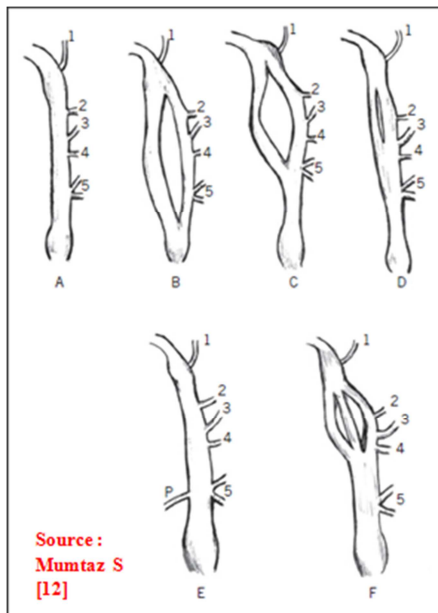
In the literature [4, 6, 9, 11], several denominations are

used to describe its doubling anomalies. Thus the term duplication or complete duplication would relate to the variations where the internal jugular vein descends from the base of the skull in a single vein divides into two branches, remains separate throughout their course and drains separately into the subclavian vein. Incomplete duplication or fenestration would relate to cases where the IJV descends from the base of the skull in a single vein then branches into two branches for some distance and joins before draining into the subclavian vein. But this definition does not clearly take into account notions such as bifurcation and trifurcation.

Recently in 2019 another denomination was proposed by Mumtaz and Singh M [12] in the royal college of surgeons, they suggest using the level where the omohyoid muscle crosses the internal jugular vein as a standard to separate the two terms. If the internal jugular vein divides at or above the omohyoid muscle, the terminology “bifurcation” should be used. If the split occurs below the lower border of the omohyoid muscle, the term “duplication” should be used (Figures 4 and 5). Fenestration is when the window between the middle and side branches is very narrow giving the appearance of a “needle cat” [12].



**Figure 4.** Schematic representation of the relationship between variations of the internal jugular vein (IJV) and muscle omohyoid. The recommended definition of bifurcation (above the level of the omohyoid) and duplication (below omohyoid) are displayed (the red line indicates the level where the omohyoid muscle crosses the IJV).



**Figure 5.** Anatomical variations of the internal jugular vein. A) Normal. B) Duplicate. C) Fork. D) Windows. E) Posterior tributary. F) Trifurcation.

1. inferior petrosal sinus
2. Pharyngeal vein;
3. common facial vein;
4. lingual vein;
5. Inferior and middle thyroid veins;
- p. posterior tributary.

The etiology of its variations remains poorly understood. Several etiopathogenic hypotheses have been suggested [2, 4, 13, 14]. But the most shared hypothesis seems to be vascular. From the embryological point of view, the anterior cardinal vein, also called the precardinal vein, drains the cephalic regions of the embryo. The right anterior cardinal, common cardinal, and posterior cardinal veins undergo a major evolutionary process to become the superior vena cava and its tributaries. The distal segments of the bilateral anterior cardinal veins become the bilateral internal jugular veins, which drain the head and neck. An anastomosis develops from the left anterior cardinal vein to the right anterior cardinal vein to form the left brachiocephalic vein. Therefore, blood from the left internal jugular vein passes through the left brachiocephalic vein, draining directly into the superior vena cava. The final architecture of this vascular system is determined by a combination of factors including genetics, hemodynamics, growth factors, neural factors and mechanical constraints are therefore numerous, thus the risks of abnormal development, regression or failure. anastomosis can generate anatomical variations [10, 13, 15]. In addition to this vascular hypothesis, three other hypotheses are incriminated:

- a) A neural hypothesis suggests that branching of the internal jugular vein results from growth obstruction by the spinal accessory nerve during development.
- b) A bony hypothesis suggests that the junction is due to a conflict of development of the internal jugular vein at the level of the jugular foramen.
- c) A muscular hypothesis, based on an observed duplication of the internal jugular vein around the edge of the homohyoid [4, 9].

We agree with the literature on the incidence of this anomaly, it is estimated at about 4 per 1000 unilateral cervical dissections [9, 16-18]. In our series, it was 3 cases for 1260 dissections, i.e. a prevalence of 0.23%.

Clinically, the internal jugular vein is the largest caliber blood vessel that runs along the neck. It serves as a major surgical landmark for adjacent structures during neck dissection. It also serves as a common site for taking a central venous line, but in case of fenestration or duplication the insertion of the catheter could cause vascular lesions causing cervical hemorrhage or hematoma. The IJV is also an essential radiological landmark, its variation could be misinterpreted as thrombosis or lymphadenopathy. In neck dissections, such variations could increase operative difficulties with the risk of bleeding or the impossibility of complete lymph node dissection, especially if the patient has undergone radiotherapy, thus increasing morbidity. Hence the importance of knowing its different anatomical variations [10, 18]. Several authors have described its anomalies of anatomical variations either during cadaver dissections [10, 15, 19] or by medical imaging such as CT angiography and magnetic resonance imaging (MRI) [11, 20]. In our three cases, the findings were intraoperative. Most splits and fenestrations occur in the upper third of the IJV and are associated with the spinal accessory nerve, which passes either between the two divisions of the vein or through the

fenestration [1, 4]. In our series, the spinal nerve passed through the fenestration in one case.

In the literature [21-23], the spinal accessory nerve crossed the IJV anteriorly in 80% of cases, posteriorly in 19% of cases and in 1% of cases it passed through the bifurcated IJV. The morbidity associated with injury to any of these structures is significant. Spinal nerve injury can lead to painful shoulder syndrome (pain in affected shoulder, difficulty shrugging, limitation of active range of motion). This syndrome is an important determinant of postoperative quality of life [23-25]. Knowledge of the existence of these anatomical variants in the relationship between the spinal nerve and the IJV coupled with intraoperative vigilance remains the best way to avoid complications.

## 4. Conclusion

Conclusion: Divisions (duplication, bifurcation or fenestration) of IJV are rare and are mainly observed during cervical surgery, diagnostic imaging, and very rarely during cadaver dissection. Understanding its IJV variation abnormalities is important to avoid iatrogenic injury during cervical surgery or during central venous catheterization. Although these terms are commonly interchanged in the literature, they are used interchangeably often creating ambiguity among surgeons.

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