Stellate Ganglion Encircling Atypical Vertebral Artery

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ABSTRACT

We present the case of an unusual course of the right vertebral artery with intra-foraminal entrance at C4, enveloped by an abnormal stellate ganglion. Case reports and literature mention these abnormalities independently, but it is uncommon to have them presented simultaneously. The close association of the vertebral artery and the stellate ganglion, especially in patients who harbor anomalies, could potentially cause lesions to the ganglion during clinical procedures. The anatomical variations are clinically significant in relation to procedures like endovascular intervention, stellate ganglion blocks, and anterior cervical surgical procedures. Complications of the sympathetic trunk and its ganglion can range from Horner's Syndrome to severe hypertensive reactions. Clinical procedures should require the use of magnetic resonance imaging, computerized tomography, and ultrasound imaging, to reduce the risk of possible complications. Ultrasound techniques reduce the risk of harming the vertebral artery, while remaining vastly more practical and affordable than other techniques. This discovery allows for future breakthroughs in prevention and intervention of cervical vessels of iatrogenic injury during surgical procedures involving cervical vessels.

Keywords: Stellate ganglion; Vertebral artery; Sympathetic trunk; Inferior cervical ganglion

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INTRODUCTION

According to most anatomical texts, the vertebral artery (VA) originates from the superior aspect of the subclavian arteries, traveling cranially through the transverse foramina of C6 until reaching C1 (atlas). When the VAs reaches the level of the atlas, they make a medial turn around the lateral mass to travel slightly posterior along the superior surface of the atlas's posterior arch, and upward through the foramen magnum. Once located in the intracranial space, it joins the contralateral VA at the vertebrobasilar junction to become the basilar artery for perfusion of the brainstem, cerebellum, posterior cranial fossa, and inner ears [1]. In this particular human donor, we found two unusual deviations from the typical course of a right VA, which were an intra-foraminal entry at C4 and encircling by a stellate ganglion. This abnormal stellate ganglion is a direct result of what would be the inferior cervical ganglion joining with the first thoracic ganglion around the first segment of the VA.

Placement of the VA within a particular cervical vertebral transverse foramen is determined in early embryological development. When the post costal anastomosis becomes enlarged, the final position of the VA within the transverse foramen is decided [1]. Normally, the post costal anastomosis between the sixth and first cervical segments allows the vessels to lay within the costotransverse foramina of cervical vertebrae during embryological development. The transverse foramina result from the special formation of the cervical transverse process. When the nerve plexus and the vertebral vessels are caught between a vestigial costal element, they fuse to the true transverse processes and the body of the cervical vertebrae. Then, the costotransverse bar closes the lateral aspect of the transverse foramen, becoming an enclosed structure. This donor’s right intra-foraminal entrance at C4 was determined when post costal anastomosis of the vessel found itself between the fourth and fifth cervical segments, while the left VA found itself between the fifth and sixth [2-6].

The stellate ganglion, while perforated by the VA, still forms part of the sympathetic network formed by the inferior cervical and first thoracic ganglia. It continues to receive input from the paravertebral sympathetic chain, and provides sympathetic efferents to the upper extremities, head, neck, and heart [7]. Interventional procedures for pain management range from local injections to specific neural blockade of the sensory supply to specific body structures. For example, the stellate ganglion block is primarily performed by pain management physicians with the use of ultrasound, fluoroscopic, and CT guided techniques [4]. These procedures have been performed by different medical specialists including the orthopedic surgeons, neurosurgeons and anesthetists. While they are usually effective in the short term, the efficacies of these interventional procedures in the treatment of chronic pain syndromes have been questioned by several recent evidence-based systematic reviews [7]. If you take into account the stellate ganglion enveloping the VA, the anesthetic could cause more complications than if it would have been just the stellate ganglion by itself [8,9].

To our understanding, this rare stellate ganglion enveloping a VA with entry at C4 variant found in our donor has not been described in the scientific literature. The clinical significance of anatomical variation of the VA and stellate ganglion for interventional or surgical procedures is evident [4,10]. The close association of the VA and the stellate ganglion, especially in patients who harbor anomalies, could potentially cause lesions to the ganglion during a surgical procedure. This should encourage an expansion of our clinical knowledge and practices. The anatomical variability of the first two segments of the VA should be documented and well understood.

CASE REPORT

During a routine dissection of a 65-year-old White male human donor at the Gross Anatomy Laboratories, University of Medicine and Health Sciences at Basseterre, St. Kitts, an anatomical variant of the stellate ganglion of the cervical sympathetic trunk and the right VA was exposed.

After the first section of the right subclavian artery was defined, the variant right VA became apparent. It was noticed that the cervical sympathetic trunk enveloped the VA. It was noted that the donor displayed an aberrant dorsal scapular artery in the third section of the subclavian artery. Comparing the right and left sympathetic trunks revealed a normal left sympathetic trunk with a C5 intra-foraminal entrance of the left VA. Figure 1 shows an anterolateral view of the right side of the neck. This figure demonstrates that the VA is entering the transverse foramina at C4 and the loop created by the stellate ganglion around the VA. Also note the cardiac branch leaving the stellate ganglion. Figure 1 also includes a higher magnification view of the stellate ganglion and its looping around the VA as the cardiac branch is leaving. Figure 2 is a lateral view of the right side of the neck. This figure shows the relationship of the various anatomical structures one would find on a deep dissection of the right side of the neck. The right sympathetic trunk's loop was noted as being medial to the anterior scalene, lateral to the vagus nerve, and anterior to the transverse process of C7. After defining the loop around the VA, we found the inferior cervical sympathetic ganglion was fused to the first thoracic paravertebral ganglion, forming the stellate ganglion**.** We followed the sympathetic trunk into the thoracic cavity and did not find a visible thoracic paravertebral ganglion until the T3 vertebral level on the right side. We also did not see a middle cervical sympathetic ganglion at the C6 vertebral level on the right side.

Figure 1: Illustrates the regional right neck anatomy of the anterior cervical vertebrae. *va* vertebral artery, *lsg* loop of the stellate ganglion, *sg* Stellate Ganglion, *st* sympathetic trunk, *cb* Cardiac Branch, *ac* ascending cervical, *ants* anterior scalene muscle, *bct* brachiocephalic trunk, *c5* Right C5 Root, *c6* Right C6 Root, *c7* Right C7 Root, *cc* common carotid, *cs* Carotid Sinus, *cnx* vagus nerve, *in* Internal Carotid artery, *it* internal thoracic artery, *ii* suprascapular artery, *sub* subclavian artery, *tc* transverse cervical artery, *th* inferior thyroid artery. The upper left corner includes a macro showcasing the loop of the *sg* enveloping the *va*.

Disclaimer: Appearance of the common carotid artery has been altered due to the embalming process.

Figure 2: Illustrates the regional right neck anatomy of the anterior cervical vertebrae. *va* vertebral artery, *lsg* loop of the stellate ganglion, *sg* Stellate Ganglion, *st* sympathetic trunk, *ac* ascending cervical artery, *ants* anterior scalene muscle, *bct* brachiocephalic trunk, *c5* Right C5 Root, *c6* Right C6 Root, *c7* Right C7 Root, *cc* common carotid artery, *cs* Carotid Sinus, *cst* continuation of the sympathetic trunk, *cnx* vagus nerve, *ds* dorsal scapular artery, *ic* Internal Carotid artery, *it* internal thoracic artery, *sub* subclavian artery, *tc* transverse cervical artery, *th* inferior thyroid artery.

Disclaimer: Appearance of the common carotid artery has been altered due to the embalming process.

DISCUSSION

VAs are usually asymmetric, and in some individuals occasionally travel different routes than what is classically described. In a recent study, 920 VAs were evaluated to find that 7% deviated from the classical entry into the transverse foramina at C6, and 1.8% displayed intra-foraminal entrance at C4 [7]. A separate study observed that 6% of individuals had intra-foraminal entrance of the cervical vertebrae at C7, while in another 6% had the intra-foraminal entrance at C5, or C4 [11]. Abnormalities such as these, when closely associated to the stellate ganglion, not only increase the risk of vascular pathologies, Horner's syndrome, severe hypertensive reactions, among others, but also seriously threaten the lives of patients [3,4]. An example of one such complication resulted in death when an anesthesiologist mistakenly punctured the VA during a stellate ganglion block, inducing a cardiac arrest [8]. Another potential complication in clinical intervention of the anterior cervical vertebrae would be the unintentional disruption of the sympathetic innervation to the head, upper limb, and thoracic area in people whose stellate ganglion is in such close proximity to the VA [3]. In a successful stellate ganglion block, symptoms representative of Horner's syndrome will develop five minutes after the introduction of the stellate ganglion block, before receding after a duration of two hours [4]. These symptoms include an increase in the blood flow by 50%, a 1-3ºC increase in temperature, ptosis, miosis, enophthalmos, anhidrosis and conjunctiva and/or nasal congestion ipsilateral to the blocked site [4].

The sympathetic chain has received inappropriate attention especially in the field of pain medicine. We can see an example of this when the sympathetic blockade that has little evidence to support it is placed among the first lines of treatment [5]. The theory of "sympathetic efferent hyperactivity," has never been substantiated and blockade of the chain is perhaps based on a false premise [5]. Flinch even goes as far as to imply that the stellate ganglion blocks have been performed blindly at times where they just palpate the anterior tubercle of the transverse process of C6 and infiltrate a large volume (as much as 20 mL) of local anesthetic. These methods could lead to complications like apnea, unconsciousness and seizures. However, occasionally an unusual complication, 'locked-in' syndrome, has also been reported by Chaturvedi 2010. In this syndrome the patients remain conscious despite their inability to move, breathe or speak. Further potential clinical correlations can be drawn from a study conducted by Dr. Henry G. Schwartz. In the study, he found that the joining between nerve roots in cervical ganglia could lead to persistent sensations of pain despite physicians performing nerve blocks [9]. It is our inference that a similar situation could occur as a result of the anastomosis of the stellate ganglia in the donor. It is possible that, despite a successful stellate ganglion block, our donor may have still been capable of pain sensation in his superior thoracic region, anterior neck triangle, and his right head. Anesthesiologists should be aware of potential complications arising from variations to the formation of the stellate ganglia, such as we have observed in this donor body.

Abnormal neurovasculature is discovered prior to clinical intervention with the use of imaging techniques, such as magnetic resonance imaging (MRI), computerized tomography (CT), and ultrasound. Although these imaging techniques can all be used for non-invasive procedures, the use of MRI and CT are still more expensive, time-consuming, and impractical for most physicians [6]. Fortunately, development of new ultrasound techniques reduces the risk of puncturing the VA, while remaining vastly more practical and affordable than other techniques [6]. Given the bedside availability of ultrasound, its relatively affordable nature, and the ability to track subfascial drug deposition with real-time imaging, places ultrasound imaging above other imaging modalities. The recent ultrasound techniques for procedures involving VA abnormalities reduce the risk of puncturing the first segment of the VA and should be a part of every physician's arsenal [6].

CONCLUSION

Our donor's anatomy is somewhat unique, given that he had two VA that varied from the classical descriptions in conjunction with the variation of the sympathetic trunk involving the right stellate ganglion. We concur that the anomalies witnessed in our donor should be understood to prevent future complications in procedures such as: cervical surgery, stellate ganglion block, and VA surgery among others [11]. With imaging guidance, the needle is accurately introduced near the stellate ganglion. As a result, a safer and smaller amount of local anesthetic can be used, reducing the risk of adverse effects. The present case demonstrates that despite having positive aspirations, intra-arterial injection can occur during stellate ganglion block and can result in complications such as locked-in syndrome with severe hemodynamic depression that can be life threatening [2]. Understanding the VA's possible anatomical variations is thus clinically relevant to promote the safety of future patients who undergo endovascular intervention or surgical procedures. One way to reduce the risk of harming these structures is using imaging techniques to evaluate patients prior to procedures involving the VA and anterior cervical vertebrae [10]. Furthermore, pioneering cost effective and ubiquitous techniques to identify these rare anomalies prior to complications must continue to be developed. Future studies should focus on the effects and clinical consequences of the abnormal fusing of the sympathetic trunk around the VA.

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CONFLICT OF INTEREST

The authors of this study have no conflicts of interest to declare.

ETHICAL STANDARD

All experiments and endeavors related to this investigation were conducted in accordance with the laws of the island of Saint Kitts and Nevis, WI.

CONTRIBUTIONS

Torres

- Protocol/project development for manuscript
- Data collection and management for manuscript
- Data analysis for manuscript
- Manuscript writing/editing

- Participation in dissection
- Participation in taking images

Lara

- Data analysis for introduction and discussion sections of manuscript
- Writing/editing introduction and discussion sections of manuscript
- Data collection and management for introduction and discussion sections of manuscript
- Editing images for paper
- Participation in dissection
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- Writing introduction section of manuscript
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- Data collection for discussion section of manuscript

Guttmann

- Identification of anomaly
- Manage manuscript editing
- Manage dissection presentation
- Manage submission of paper

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