Case Report
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The Brachiocephalic Trunk Variant Origin and High-Riding Course: Two Cadaveric Cases

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Abstract

Objective. The current report describes two rare cadaveric findings of a left sided brachiocephalic trunk (BCT) in relation to the trachea, and its high-riding course above the suprasternal notch (SN). **Cases Descriptions.** In two elderly body donors dissected after death, a left-sided BCT was identified with a high-riding course (0.5 and 0.8 cm above the SN). The BCT originated from the aortic arch, in common with the left common carotid artery, more distally than the typical left-side location and crossed in front of the trachea. In the 1st case, the ascending and descending aortae, and the left subclavian artery had aneurysmal dilatation. In both cases, the trachea was displaced to the right side and had a stenosis due to the chronic compression. **Conclusion.** A high-riding BCT is of paramount clinical importance, as it may complicate tracheotomy, thyroid surgery and mediastinoscopy, leading to fatal complications. BCT injury leads to a massive bleeding during neck dissection (level VI), when the vessel crosses the anterior tracheal wall.

Key Words: High-Riding Brachiocephalic Trunk ▪ Innominate Artery ▪ Variant ▪ Compression ▪ Trachea.

Introduction

The typical aortic arch (AA) three-branch pattern, with a 77% prevalence (1) consists of the brachiocephalic trunk (BCT), alternatively called the innominate artery (1st branch), that further divides into the right common carotid artery (RCCA) and the right subclavian artery (RSA). The 2nd and 3rd branches are the left common carotid artery (LCCA) and the left subclavian artery (LSA). AA variant branching patterns (23% prevalence) have been associated with dysphagia, vascular diseases, and aortic dissection (1). The increase in cardiovascular interventions requires a deep and detailed understanding of AA anatomy (2). The importance of the evolution of computed tomography (CT) scans in AA variant detection was highlighted in a recent meta-analysis (1). Among the atypical AA variants, the brachiocephalico-carotid trunk (BCCT), is the most common variant (36% prevalence) (1) and is composed of the fused vessels BCT and LCCA. This arterial complex in humans was falsely characterized as "bovine AA". The true "bovine AA" is identified only in animals with deep chests, and corresponds to a single great vessel originating from the AA, giving rise to both the RSA and LSA and a common trunk of the RCCA and LCCA (the so-called bicarotid trunk) (3). A correlation was identified between BCCT occurrence and thoracic aortic disease onset (4). In addition, the aneurysmal presence, and the high risk of rupture with concomitant death is highlighted (5). Therefore, this variant was characterized as a "true silent killer” (5). Typical and variant BCT locations: Typically the BCT is located across the anterior tracheal wall, between the 6th and 13th rings (the 5th and 6th tracheal rings are the most common locations) (6). A high BCT location has been identified between the 1st and 5th tracheal rings (6-8) and is of clinical importance, as it may complicate tracheotomy (6, 8), thyroid surgery (9) and mediastinoscopy (7), leading to death. During neck dissection, massive bleeding may occur after BCT injury (10).

The current report describes two rare cadaveric findings of an ectopic BCT (left-sided BCT) related to the trachea and its high-riding course. The possible clinical impact is highlighted on the basis of clinical studies. Coexisting variants are also described.

Case Presentations

Case 1. An 80-year-old donated male cadaver was identified as having a left-sided BCT (28mm diameter) originating in common with the LCCA. The BCT had a typical elongation of 6.25cm and a high-riding course, reaching up to the right side of the 5th tracheal ring (uppermost border point). The BCT crossed in front of the trachea, and posterior to the right sternoclavicular joint, dividing into the RSA and RCCA. The RCCA had an atypical course, anterolateral to the trachea. The ascending aorta had an aneurysmal dilatation (18 cm perimeter and 3cm diameter) and a bicuspid aortic valve. The LSA, and the remaining part of the descending aorta, from the isthmus downwards, also presented aneurysmal dilatation. The trachea was displaced to the right, and had a stenosis due to its chronic compression by the abnormal vessel (Figure 1). A pacemaker was implanted into the left cephalic vein (drained in common with the axillary vein to the subclavian vein) to help heartbeat control. Coexisting variants: a common origin of the BCT with the LCCA, and the bilateral common origin of the internal thoracic artery from the thyrocervical trunk.

Case 2. A 77-year-old donated female cadaver had a left-sided BCT originating from a common trunk with the LCCA, the so-called BCCT. The BCT had an aberrant high-riding route up to 1.5cm beneath the lower border of the thyroid isthmus. The RCCA and RSA originated after characteristic coiling (angulation of the BCT, where the superior border compresses the trachea). The LCCA route was tortuous just after its point of origin (Figure 2). The right recurrent laryngeal nerve originated at the point of the BCT division into the RSA. *Coexisting variants:* a common trunk of the BCT with the LCCA (BCCT).

Both cadavers derived from the body donation programme of both Universities after written informed consent (donation before death).

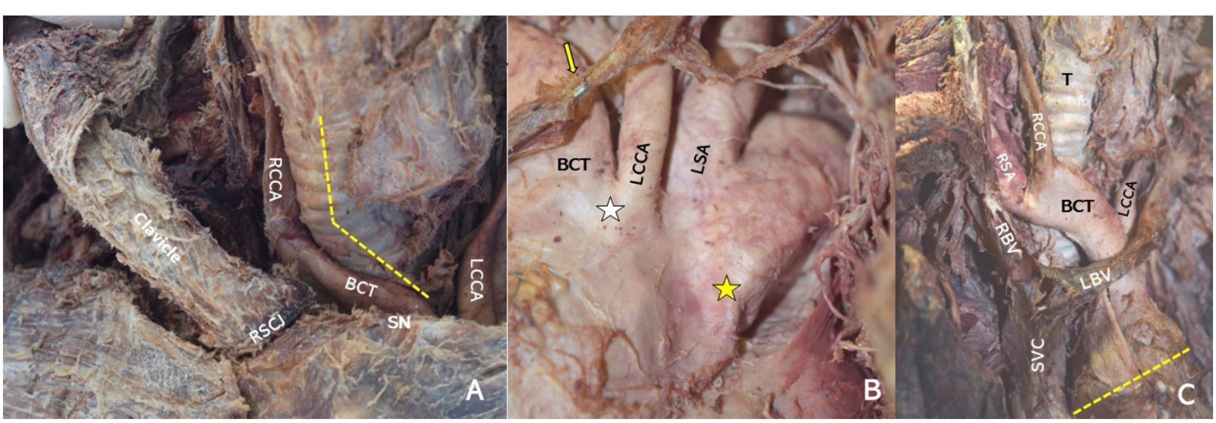

Figure 1. **A.** Trachea (T) compression, brachiocephalic trunk-BCT bifurcation into the right common carotid and right subclavian artery (RCCA and RSA) posterior to the right sternoclavicular joint (RSCJ). SN- sternal notch, dotted yellow line- T inclination after compression. **B.** White asterisk- the BCT-LCCA common origin, yellow asterisk aneurysm dilation, yellow arrow- catheter of the pacemaker into the vein, LCCA-left common carotid artery, LSA-left subclavian artery. **C.** The BCT on the left of the T, yellow dotted line-the aneurysm diameter, RBV-right brachiocephalic vein, LBV-left brachiocephalic vein, and SVC-superior vena cava.

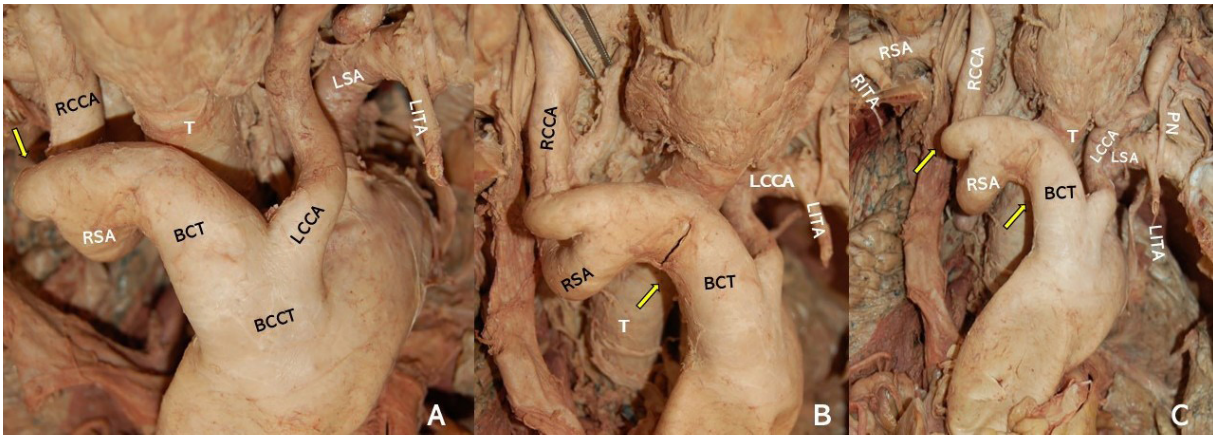

Figure 2. **A**. The brachiocephalico-carotid trunk (BCCT) after the brachiocephalic trunk (BCT) fusion with the left common carotid artery (LCCA). Trachea (T) compression by the elongated BCT, yellow arrow-kinking vessel. **B**. yellow arrow curvature of the elongated BCT and division into the right common carotid and right subclavian artery (RCCA and RSA), LITA-left internal thoracic artery. **C**. Yellow arrows indicate the vessels' tortuosity, RITA-right internal thoracic artery, LSA-left subclavian artery.

Discussion

The AA branching pattern configuration is related to the different developmental grades of the various branches' "migration" and "merging" (11). In BCCTs, the LCCA origin migrates to the right and merges with the BCT (under variable forms, a BCT-LCCA common trunk, or common origin, or LCCA as a BCT branch). In the BCCT pattern, the aortic sac fails to give off the right and left horns, and consequently, the LCCA origin migrates to the right and merges with the BCT trunk (12). The exact BCCT embryological path development remains unclear.

AA variants may increase the blood pressure across the abnormal vessel, which in turn increases stress in the branching vessels and descending thoracic aorta, leading to development of aneurysms (13). Aneurysms usually develop in areas of arterial bifurcations, bends and junctions which are the most common sites for atheromatous plaque formations and, consequently, atherosclerotic lesions usually predispose to aneurysms (5, 13).

The high-riding BCT and clinical landmarks: In high-riding BCTs, although the tracheal rings are used to evaluate the BCT's position, these features are quite difficult to identify precisely, preoperatively (10). The SN was proposed as an alternative and easily identified clinical landmark by Cai et al. (10). The authors (10) also identified high-riding BCTs, 2 cm above the SN, in 2.2% of patients and recorded an intraoperative risk, 51-times higher compared to the relative risk in patients with BCTs 2 cm lower. In a high-riding BCT, measures should be taken to prevent intraoperative injury. In lower anterior neck surgery, especially mediastinoscopy, caution should be taken in maximal neck extension, as this maneuver tends to elevate the BCT, especially in young patients. Thus, even with a typical anatomy, this vessel is at risk for injury during mediastinoscopy. It should be routine to palpate below the SN to ascertain the BCT level, before obtaining access to the pretracheal fascia (7). Anterior neck surgery should be modified in patients with a high-riding BCT and coexisting tortuous common carotid arteries that protrude or are positioned higher than normal (8, 14). Urgent cases of surgical intervention should be evaluated by Doppler ultrasonography to prevent an unexpected fatal complication (15).

The BCCT variant: The BCCT has been observed with a prevalence ranging from 14.4% (2) to 36% (1) in the general population. The highest BCCT prevalence was identified in African and the lowest in Asian populations (1, 2). A higher regional shear stress in the BCCT variant (tendency for thrombus formation) and flow alterations, associated with endothelial injury and vascular stiffness were reported by Shalhub et al. (16). A significantly higher proportion of cerebrovascular events during carotid angioplasty and stenting were reported in cases of BCCT variants (17). These cases were also reported as the greatest predictors of difficult access in older patients (17). During thyroid and neck dissection surgeries, the BCT may be dissected out first and protected. In tracheotomy, it may be necessary to avoid low levels of exposure. Causes of BCT ectopia may be kinking, coiling and tortuosity, and these entities are more prevalent in elderly women with hypertension (18). The co-occurrence of common carotid artery tortuosity with the BCT's common origin with the LCCA may suggest congenital etiological factors, since AA maldevelopment may result in carotid artery anomalies (18). Magnetic resonance imaging and angiography (MRI and MRA) remain the gold standard for identifying the BCT's origin, course and branching pattern, showing more details of the carotid arteries. Since most BCT variant cases are clinically silent, a high index of suspicion makes the preoperative diagnosis of utmost importance to avoid complications (15, 19). BCCTs may cause vascular insufficiencies and become major risk factors for neurological symptoms. Syperek et al. (20) identified a BCCT in 25.7% of stroke patients. Aneurysmatic BCCTs had a higher intimal and adventitial thickness compared to the typical anatomy aneurysmatic AAs (20). The BCCT's higher shear stress might be caused by the altered branching angle of the supra-aortic vessels (16). There is a possibility that in cardioembolic stroke patients, the altered hemodynamics cause the redirection of the embolus towards the carotid arteries, leading to cerebral infarctions (20).

Limitations of Report

No clinical details were known from the subjects' medical record. No morphometric measurements were taken to justify the altered geometry of the variant vessels.

Conclusions

In two elderly body donors an ectopic (left-sided) BCT with a high-riding course was identified, coexisting with aneurysms, and trachea compression. Coiling and tortuosity of the branching vessels was identified. In a unique case, the BCT coexisted with a fused LCCA, a BCCT. Further evidence-based information, based on larger clinical studies, is needed to identify potential risk factors and surgical complications.

What Is Already Known on This Topic:

Typically the BCT is located across the anterior tracheal wall, between the 6th and 13th tracheal rings, with the most common locations at the 5th and 6th tracheal rings. The BCT can migrate left of the trachea and follow a high-level course. A high-riding BCT is of paramount clinical importance, as it may complicate tracheotomy, thyroid surgery and mediastinoscopy, leading to death. BCT injury leads to massive bleeding during neck dissection, when the vessel crosses the anterior tracheal wall.

What This Study Adds:

The current cadaveric report describes a rare ectopic BCT with a high-riding course, compressing on the trachea, coexisting with aneurysms. Coiling and tortuosity of the branching vessels were identified. The elongated BCT may be a BCCT, after the fusion of the LCCA with the BCT.

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Conflict of Interest: The authors declare that they have no conflict of interest.

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