Original Article

Anatomical Study of Coexisting Arterial Variations and Asymmetry in the Vasculature and their Clinical Implications

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Abstract

Background: Arterial variations arise due to developmental alterations in embryonic vasculature and may involve differences in origin, course, or branching pattern. Although often incidental, they gain clinical importance in surgical procedures, radiological interpretations, and interventional techniques where unrecognized variants may cause iatrogenic complications. Cadaveric studies remain vital for documenting such variations and highlighting their implications. **Material and Methods:** This cadaveric descriptive observational study was conducted on four well-preserved adult human cadavers during routine academic dissections at Shri Atal Bihari Vajpayee Medical College, Bengaluru. Systematic dissections of the neck, thorax, abdomen, pelvis, and lower limbs were performed using standard techniques. Arteries were traced from their origins to terminal branches, with variations documented by photography and measurements. All observations were independently verified. **Results:** Multiple arterial variations and asymmetry were noted. In the head and neck, a rare faciolingual thyroid trunk arose from the right external carotid artery. The left vertebral artery originated from the aortic arch in three cadavers. Accessory renal arteries were observed in all specimens, with additional anomalies including double left renal arteries, a right accessory renal artery arising with the inferior mesenteric artery, and anomalous testicular and phrenic vessels. A trifurcation of the right internal iliac artery and distinct femoral artery branching variations were also documented. **Conclusion:** The coexistence of multiple arterial anomalies underscores the embryological complexity of vascular development and highlights the need for heightened anatomical awareness. Preoperative vascular mapping using CT or MR angiography is essential to avoid intraoperative complications, and these findings enrich anatomical literature while improving surgical safety.

Keywords: Arterial variation; asymmetry; external carotid artery; vertebral artery; accessory renal artery; internal iliac artery; clinical anatomy.

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Introduction

Arterial variations are common anatomical deviations that result from persistence or regression of embryonic vascular channels. These anomalies may involve differences in the origin, branching pattern, or course of arteries, and are often observed in the head and neck, thorax, abdomen, and limbs. While many of these remain clinically silent, their recognition is essential as they may significantly influence surgical procedures, radiological interpretations, transplantation, and trauma care.[1,2]

The reported prevalence of vascular variations is high across different regions of the body. For instance, variations in the aortic arch occur in 13–35% of the population, the most common being the "bovine arch" pattern.[3] Similarly, renal artery variations such as accessory renal arteries or early divisions are found in approximately 30–40% of individuals, with considerable implications in renal transplantation and urological surgeries.[4] Variations in the external carotid artery branching have also been described, with separate origins or formation of trunks in up to 20% of cases.[5] The Circle of Willis shows variability in configuration, influencing collateral circulation and outcomes in neurosurgical procedures and stroke management.[6]

Embryologically, these arterial anomalies arise due to disturbances in vasculogenesis and angiogenesis, influenced by genetic and molecular signaling pathways during development.[7] Clinically, they are significant in procedures such as catheterization, endovascular interventions, organ transplantation, and head-and-neck surgeries, where unrecognized variants may lead to hemorrhage, ischemia, or iatrogenic injury.

Thus, cadaveric studies remain a cornerstone for identifying and documenting such variations. The present study highlights coexisting multiple arterial variations and right-sided asymmetry in the vasculature, with emphasis on their developmental basis and clinical implications.

Aims and Objectives

This study aims to observe and document multiple arterial variations and asymmetry encountered in a cadaver, with emphasis on their clinical relevance. The objectives are to

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identify vascular
anomalies across different regions, assess their potential impact on surgical, radiological, and interventional procedures, and compare the findings with existing literature to enhance anatomical understanding and clinical preparedness.

Materials and Methods

Study Design: This was a cadaveric observational descriptive study conducted in the Departments of Anatomy and Forensic Medicine at Shri Atal Bihari Vajpayee Medical College, Bengaluru, during routine academic dissections 6 years. The specimen included 4 adult human cadavers.

Inclusion and Exclusion Criteria

The study included an adult human cadaver and suitable for routine anatomical dissection, with well-preserved vascular structures that allowed proper identification and documentation of arterial branching patterns. Cadavers showing evidence of prior major vascular or surgical interventions, gross post-mortem vascular disruption, or pathological changes that could obscure arterial anatomy were excluded from the study.

Data Collection Procedure: The cadaver was first confirmed against the departmental register and examined to ensure suitability for study, excluding any with prior vascular surgery or gross post-mortem disruption.[8] A systematic regional dissection of the right side (neck, thorax, abdomen, pelvis, and lower limb) was carried out using standard gross-anatomy dissection techniques, where arteries were exposed from their origins and traced to their terminal branches.[9] Fine dissection was performed with microsurgical instruments to avoid vessel damage, and in small or intracranial vessels, methods such as latex injection and careful microdissection were used to enhance visualization.

All observed arterial variations were photographed using standardized gross-anatomy photography protocols with scale markers, ensuring clarity and reproducibility.

To minimize observer bias, two anatomists independently verified each variation. All photographic records, measurements, and notes were anonymized and securely archived in accordance with institutional guidelines for cadaveric research. Finally, the findings were compared with previously published literature to categorize the variants and highlight their clinical significance.[9]

Results

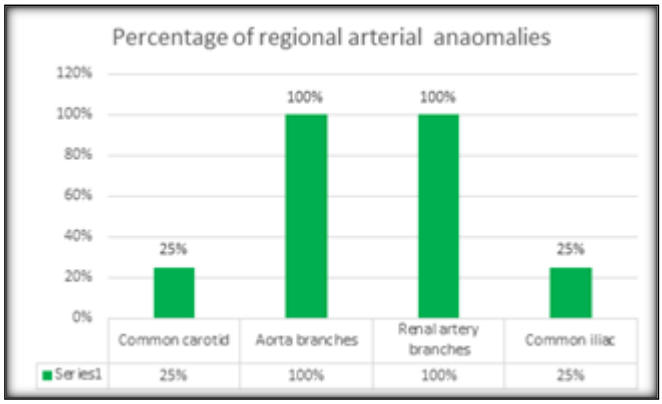
In the present cadaveric study, multiple arterial variations and right-sided asymmetry were observed across different regions:

1. Head and Neck Region: A rare faciolingualthyroid trunk was identified arising from the right external carotid artery.
2. Cerebral Circulation: A variation in the Circle of Willis configuration was noted.
3. Thoracic Region: An anomalous branching pattern of the arch of aorta was observed.
4. Abdominal Region: An accessory renal artery was present on the right side.
5. Pelvic Region: The right internal iliac artery showed a trifurcation instead of the usual branching pattern.
6. Lower Limb: A distinct variation in the right femoral artery branching was documented.

Collectively, these findings highlight the coexistence of multiple arterial anomalies in a 4 cadaver, demonstrating significant arterial asymmetry. Such variations, although rare, emphasize the importance of careful anatomical knowledge in clinical and surgical practice.

Table 1: Show Variation in Common Carotid, Aortic, Renal and Internal Iliac Arteries in Cadaveric Study

Variations	Common Carotid 25%	Aorta Branches 100%	Renal Artery Branches 100%	Common Iliac 25%
Cadaver 1	Faciolingualthyroid trunk of right external carotid artery	Left vertebral artery arises from arch of aorta	Accessory renal artery on right side	Trifurcation of right internal iliac artery
Cadaver 2	No anomaly	Abberant left vertebral artery from arch of aorta	Accessory renal artery on right side	No anomaly
Cadaver 3	No anomaly	Left vertebral artery arises from arch of aorta	Although single right renal artery originated from abdominal aorta,double left renal arteries were found to originate from the abdominal aorta	No anomaly
Cadaver 4	No anomaly	Left vertebral artery arises from arch of aorta	On the right side, one accessory renal artery originated as a common trunk with the inferior mesenteric artery. Additional variations included a left inferior phrenic artery originating from the celiac trunk, bilateral testicular veins emptying into renal veins, and the left testicular artery arising from the left renal artery	No anomaly



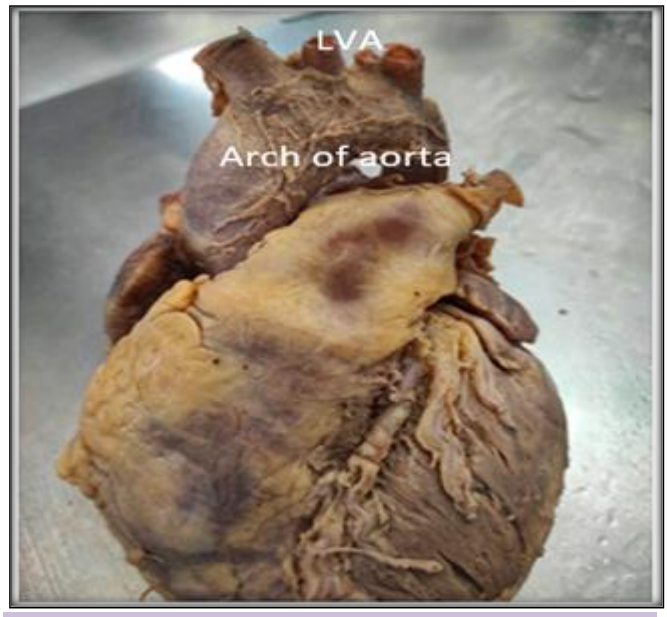


Figure 1: Shows Aberrant Origin of Left Ventricular Artery from Arch of Aorta

Figure 2: Shows Accessory Renal Artery Arising from Abdominal Aorta

Figure 3: **Shows Faciolinguathyroid Trunk Arising from External Carotid Artery**.

(LVA-Left vertebral artery,CIA-common iliac artery,EIA-external iliac artery,ILA-internal iliac artery,AD-Anterior division,PD-posterior division,ILA-iliolumbar artery,LSA-lumbosacral artery,IVA-inferior vesical artery,OA-obturator artery.)

Discussion

Our cadaveric investigation revealed a remarkable constellation of arterial variations and pronounced right-sided asymmetry, spanning multiple anatomical regions—including the head and neck, cerebral, thoracic, abdominal, pelvic, and lower limb territories. These findings expand the body of knowledge regarding anatomical diversity and underscore several critical clinical implications.

Head and Neck Region: A rare faciolingual thyroid trunk emanating from the right external carotid artery was observed—representing a previously undocumented variant that does not neatly fit existing classification systems such as those by Vázquez T et al. and others.[10] Though variants like thyrolingual or thyrolinguofacial trunks have been documented, the specific branching pattern encountered here appears to be uniquely rare.[11,12] Clinically, such anomalies hold significance during head and neck surgeries, thyroid operations, and vascular interventions; unknown variants increase the risk of inadvertent injury or surgical complications.[11,12]

Cerebral Circulation and Aortic Arch: The anomalous origin of the left vertebral artery from the aortic arch is a well-established variation with recognized surgical and radiological importance. Such variations may influence catheterization, arch interventions, or posterior circulation surgeries.

Abdominal Region – Renal Vasculature: Accessory renal arteries were found on the right side across multiple cadavers. Literature indicates that such arteries occur in approximately 25–30% of kidneys, depending on population and methodology.[13,14] A study in South Indian cadavers reported an incidence of 27.7%, with a left-sided predominance and aortic origins to hilar or polar regions.[13] Another larger study reported anatomical variations in 62.65% of cadavers, with accessory renal arteries being the most common (28.92%), and significantly more prevalent on the right side (34.93%), consistent with our findings.[14] Clinically, these variations are critical for planning renal surgeries, donor nephrectomy, minimally invasive vascular procedures, and angiography, as overlooked accessory vessels can lead to

hemorrhage or ischemia.[13,14]

Pelvic Region – Internal Iliac Artery: The trifurcation of the right internal iliac artery (as opposed to the usual branching pattern) presents another uncommon variant. While literature on precise prevalence is limited, awareness of such variants is vital in pelvic surgeries, embolization procedures, and gynecological interventions.[10]

Thoracic Region and Vasculature Embryology

Variations in the aortic arch (such as the aberrant vertebral artery origin) reflect altered embryologic remodeling of aortic arches. Surgical and radiologic procedures involving the arch and supra-aortic vessels must account for such deviations to minimize procedural risk.[12]

Lower Limb Region

Although detailed prevalence data on femoral artery branching variations are scarce, it is well established that such anomalies can significantly affect catheterization, bypass grafting, and endovascular procedures. Preoperative imaging becomes vital to identify these anatomical idiosyncrasies.[15]

Clinical Significance and Recommendations

1. Preoperative Imaging

High prevalence of renal and other vascular variations justifies preoperative CT or MR angiography in surgical and interventional settings.[13,14]

2. Surgical Awareness and Education

Cadaveric studies, including rare findings such as the faciolingualthyroid trunk, emphasize the need for surgical training beyond textbook anatomy.[10-12]

3. Classification and Nomenclature Updates

Discovery of previously unclassified arterial variants suggests the need to expand current classification systems.[10,11]

4. Surgical and Diagnostic Implications

- Head and Neck: Risk of hemorrhage during thyroidectomy or carotid interventions.[10-12]
- Renal: Risk during transplantation, nephrectomy, and angiography.[13,14]
- Pelvis/Lower Limb: Importance during pelvic and vascular surgeries.[15]

Conclusion

The present cadaveric study demonstrated the coexistence of multiple arterial variations and significant asymmetry across diverse regions of the body, including the external carotid artery, vertebral artery origin, renal vasculature, internal iliac artery, and femoral artery. The identification of a rare faciolingualthyroid trunk, anomalous left vertebral artery arising from the aortic arch, frequent accessory renal arteries, and variant pelvic branching patterns highlights the complex spectrum of vascular diversity in humans. These findings not only reinforce the embryological basis of arterial variation but also underscore their critical clinical implications for surgical planning, endovascular interventions, radiological interpretation, and organ transplantation. Preoperative imaging and heightened anatomical awareness are essential to minimize iatrogenic complications, and the documentation of such rare patterns enriches the anatomical literature while contributing to safer clinical practice.

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Conflicts of interest

There are no conflicts of interest.

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