Back to basics: do interventional cardiologists have to relearn anatomy?

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Interventional cardiology, which involves minimally invasive procedures to diagnose and treat cardiovascular diseases, has seen significant advancements over the past few decades, driven by technological innovations and improved understanding of cardiovascular diseases [1]. Procedures such as coronary interventions, transcatheter valve repairs and replacements, heart structural defect repairs, and various electrophysiological procedures necessitate a deep understanding of the heart's anatomy. Profound knowledge of cardiac anatomy is paramount for interventional cardiologists because misinterpretation of cardiac morphology can lead to procedural failures and adverse patient outcomes [2, 3]. Therefore, a thorough grasp of cardiac anatomy is essential. However, the growing complexity of procedures and reliance on advanced imaging technologies have raised concerns about whether interventional cardiologists are maintaining their foundational knowledge of cardiac anatomy.

Many clinicians argue that anatomy is a closed, non-developing field, and that learning it once is sufficient for an entire medical career. However, this perception is incorrect. Cardiac anatomy is far from being a dead science; it is a vibrant and continually developing field, enriched by technological advances, new research, and clinical innovations. As our tools for studying the heart improve, so too does our understanding of its complexities. This ongoing evolution not only enhances our knowledge but also translates into better diagnostic and therapeutic capabilities, ultimately improving patient care. Furthermore, a significant decline in the recognition of anatomical structures is observed among physicians over time [4].

Although recent achievements in cardiac imaging have revolutionised the way interventional cardiologists approach heart diseases, enhancing precision in procedures and patient outcomes, the foundation should still be a thorough knowledge of the heart's structure. Proficient knowledge of anatomy, taking into account the latest research in this field, can provide many advantages to the operator. First, understanding detailed anatomical entities that are important for interventional cardiologists helps them grasp the essence of the phenomena they observe in their clinical practice. An example would be the structure of the heart's vascular bed at the submacroscopic level, which is not typically taught during undergraduate anatomy courses or postgraduate clinical training. This was perfectly illustrated in the pages of Advances in Interventional Cardiology, where seemingly minor discrepancies in nomenclature (Thebesian veins vs. vessels of Wearn) change the meaning of the observed pathology [5–7]. Nonetheless, the structure and function of the smallest arteries and veins, as well as their mutual connections, cannot be overestimated and should be well known to all cardiologists.

Knowledge of cardiac anatomy increases the precision of procedures. Knowledge of the exact location and structure of coronary arteries, heart chambers, and valves allows cardiologists to navigate catheters and guidewires accurately. This precision is crucial in avoiding complications such as vessel perforation. Human hearts exhibit considerable anatomical variability. Anomalies in coronary artery origins and their courses, variations in chamber size and shape, differences in valve morphology, as well as proximity to other heart structures along the course of the coronary arteries can impact procedural approaches and outcomes. Interestingly, recent studies have shown that even structures as well-established in

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consciousness as the tricuspid valve are misunderstood. The right atrioventricular valve in the human heart, commonly referred to as the "tricuspid valve," is often a more complex and heterogeneous structure than anticipated and has 4 functional leaflets in more than 40% of cases, which drastically changes the view of its function and the invasive repair methods used [8]. There are dozens of examples of such new discoveries and refinements of existing knowledge in the field of cardiac morphology [9–13]. Interventional cardiologists must recognise and adapt to anatomical variations to ensure successful interventions. Furthermore, complications during interventional procedures can arise from anatomical misunderstandings, and comprehensive anatomical knowledge mitigates such risks. Finally, thorough knowledge of anatomy significantly enhances imaging interpretation, especially with advanced imaging techniques such as cardiac computed tomography or magnetic resonance imaging (MRI), which are now integral to interventional cardiology. Three-dimensional (3D) imaging and visualisations are revolutionising invasive cardiology. These technologies provide detailed, real-time views of cardiac structures, allowing for precise procedural planning; however, they are of no use without a thorough knowledge of heart anatomy.

Additionally, the importance of attitudinally correct cardiac nomenclature cannot be overstated, because it ensures clear communication, improves education and research, and enhances patient safety [14]. The principle of anatomical description is to account for structures as they lie within the body as viewed in the so-called anatomical position [15]. However, few clinicians know that this rule has not been applied to the heart for decades, because cardiac components have usually been described with the heart removed from the body and positioned on its apex. Currently, we see large discrepancies between the latest studies determining the correct location of heart structures and the traditional and historical habits of clinicians describing heart structures incorrectly. An example is the naming of the walls of the left ventricle. Using historic nomenclature, the rightfully inferior (or diaphragmatic) wall of the left ventricle is often referred to as the "posterior" wall. However, the anterior wall of the left ventricle is, in fact, the superior one. The interatrial septum is located in the anterior position when the heart is described properly [16]. Following the rules, the left anterior descending artery, which runs in the superior interventricular sulcus and is not really "anterior", should therefore be named as a superior branch of the left coronary artery. The same applies to the so-called posterior descending artery; this name should be revisited because the artery is located inferiorly, not posteriorly, as its name indicates. It is also questionable whether arteries that run in the interventricular sulcus should be described as descending, because they course horizontally toward the heart apex [14, 17]. Nevertheless, accurate and consistent cardiac nomenclature is vital for effective communication among healthcare professionals. Consistent use of accurate, attitudinally correct terminology reduces ambiguity and enhances clarity in clinical communication, ensuring that all members of the healthcare team understand the exact anatomical references. As new imaging and diagnostic technologies emerge, integrating them with existing nomenclature requires continuous updates and revisions. Ensuring that technological advancements are aligned with accurate anatomical terms is essential for their effective use. Moreover, standardised nomenclature aids in the education and training of medical students and residents. It provides a clear and uniform framework for learning and understanding cardiac anatomy. Finally, clear and precise communication of anatomical details is essential for patient safety. Misunderstandings or miscommunications due to ambiguous terminology can lead to errors in diagnosis and treatment.

Constantly revisiting anatomical knowledge is not redundant but necessary in the context of evolving morphological and technological landscapes. Continuous anatomical education, simulation-based training, and adherence to accurate anatomical nomenclature are essential for interventional cardiologists. By doing so, we can optimise procedural outcomes, minimise complications, and provide personalised, effective care to patients. Finally, a robust anatomical foundation, complemented by advanced imaging technologies, will continue to drive the success and evolution of interventional cardiology.

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