

# Interventional Cardiology Imaging

An Essential Guide

Amr E. Abbas  
*Editor*

 Springer

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*This book is dedicated to my parents, El-Sayed and Raifa, who I owe everything to and then more, my wife, Mona, who I love dearly and lots, my children, Zane and Layla, who are my life and then some, and my co-authors, who without them, this book would not be possible.*



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## Preface

Ever since the establishment of invasive coronary angiography, the limitations of the technique have not gone unnoticed. As a result, multiple invasive imaging modalities have been developed in an attempt to characterize the true severity of coronary artery disease as well as guide the percutaneous coronary interventions.

Invasive imaging modalities have included ultrasound, optical, and chemographic technologies. Moreover, physiological assessment of the degree of the coronary blood flow has also been performed through fractional and coronary flow assessments.

This book provides an overview of the current available invasive coronary imaging modalities in an attempt to present a concise review of their current technologies, indications, appropriate use, and pitfalls. It is an invaluable tool for interventional cardiologists and cardiologists in training who wish to have a concise and practical review of all these modalities.

Royal Oak, MI, USA    Amr E. Abbas, MD, FACC, FSCAI, FSVM, FASE, RPVI



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# Basic Coronary Artery Anatomy and Histology

# 1

Alfred C. Burris II and Mazen Shoukfeh

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## Abstract

An interest in coronary anatomy dates back to the sixteenth century when Renaissance scholars began anatomic investigation. This was preceded by philosophical and theological teachings of Greek and Arabic scholars such as Aristotle (384–322 BC) and Galen of Pargamum (129–199 AD). Prior to the twentieth century, anatomic analysis of the coronary arteries were based solely on gross anatomic inspection. With the advent of catheter based selective coronary angiography in 1962 by Mason Sones, there has been an increased awareness of variation in the “normal” coronary anatomy. This has been further clarified most recently by computed tomography angiography. A thorough understanding of normal coronary anatomy and variations are imperative in making accurate diagnoses and providing effective management.

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## Keywords

Coronary vascular anatomy • Coronary histology • Anatomic analysis of coronary arteries • Normal coronary anatomy • Myocardial bridging • Right coronary artery • Left main artery • Left anterior descending artery • Left circumflex artery

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## Introduction

An interest in coronary anatomy dates back to the sixteenth century when Renaissance scholars began anatomic investigation. This was preceded by philosophical and theological teachings of Greek and Arabic scholars such as Aristotle (384–322 BC) and Galen of Pargamum (129–199 AD) [1]. Prior to the twentieth century, anatomic analysis of the coronary arteries were based

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solely on gross anatomic inspection. With the advent of catheter based selective coronary angiography in 1962 by Mason Sones, there has been an increased awareness of variation in the “normal” coronary anatomy [2]. This has been further clarified most recently by computed tomography angiography [3–5]. A thorough understanding of normal coronary anatomy and variations are imperative in making accurate diagnoses and providing effective management.

## Normal Coronary Anatomy

Coronary arteries are the only branches of the ascending aorta. Traditionally a coronary artery has been described as any artery or arterial branch that carries blood to the cardiac parenchyma [1]. The cardiac parenchyma is defined as any structure located in the pericardial cavity and includes not only the myocardium but also structures such as the pulmonary trunk, the superior vena cava, and the semilunar valves. Coronary arteries are located on the epicardial surface of the heart. Septal perforators would be the exception and run intramuscularly in the ventricular septum. Coronary arteries are named based on the vessels’ distal vascularization territory but not its origin [1]. This would explain the description of coronaries with anomalous origin: a right coronary artery that arises from the left coronary cusp remains a right coronary artery. The left anterior descending artery (LAD) is defined as the artery that runs within the interventricular septum, the right coronary artery is defined as the artery supplying the major blood supply to the right ventricle, and the circumflex is defined as the third major epicardial artery.

“Normal” coronary anatomy is that which occurs in greater than 99 % of the general population [6], and any variation is considered an anomaly. The true incidence of coronary anomalies has been reported from 0.3 % to 1.6 % by autopsy or cardiac catheterization, respectively and are discussed elsewhere [7]. However, gender differences have not been well described. Newer imaging modalities such as coronary CTA may be a better representation of the population; as it represents a more diverse patient population [3]. Angiographic

studies, both invasive and noninvasive, have shown some common anatomical variation within the “normal” anatomy.

## Origin from the Sinus of Valsalva

The aortic root is the initial part of the ascending aorta that consists of three sinuses of Valsalva: right, left, and posterior. The posterior sinus is also referred to as the non-coronary sinus. Each sinus correlates with a leaflet of a tri-leaflet aortic valve. The right and left sinus of Valsalva lie anteriorly, and are the site or origin for the right and left coronary arteries, and lie adjacent to the pulmonary root (Fig. 1.1). The aortic root begins at the aortic annulus and extends distally to the sinotubular junction; an area of circumferential thickening that divides the aortic root from the ascending aorta.

Coronary ostia typically arise from the middle of the right and left sinus of Valsalva; below the sinotubular junction and above the free margin of the corresponding open aortic valve leaflet [1, 8]. This allows for maximal coronary filling during diastole. A coronary ostium that arises above or below the sinus of Valsalva is termed to be a variant of normal anatomy (Fig. 1.2). If the ostium of a coronary artery takes off >1 cm above the sinotubular junction, it is considered a high take off or ectopic position [9]. This has been described to be associated with decreased diastolic filling and chronic ischemia in the absence of epicardial stenosis [10].

Normally, there are two to three coronary ostia [11]. Two ostia are more common and correspond with the left and right coronary arteries. The third typically comes from a separate ostium for the conus or infundibular branch that is present in 23–51 % of normal hearts [1, 12] and has been referred to as the “third coronary artery”. Less commonly, there is an absence of the left main with separate ostia of the left anterior descending and the left circumflex arteries (Fig. 1.3). The ostial orientation is generally orthogonal to the aortic root or ascending aorta [6]. Although there is some variation, the right coronary artery ostium generally arises in the vertical plane and the left coronary in the horizontal plane (Figs. 1.4, 1.5, and 1.6).