Journal of Veterinary Cardiology (2017) ■, ■–■

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Journal of Veterinary Cardiology
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Comparative anatomy and angiography of the cardiac coronary venous system in four species: human, ovine, porcine, and canine☆,☆☆

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Received 7 March 2017; received in revised form 28 September 2017; accepted 18 October 2017

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https://doi.org/10.1016/j.jvc.2017.10.004
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Please cite this article in press as: Genain M-A, et al., Comparative anatomy and angiography of the cardiac coronary venous system in four species: human, ovine, porcine, and canine, Journal of Veterinary Cardiology (2017), https://doi.org/10.1016/j.jvc.2017.10.004

KEYWORDS
Heart;
Veins;
Translational;
Animal model

Abstract *Introduction:* The coronary arterial system has been the subject of greater investigation than its venous system due to the importance of human coronary artery disease. With the advent of new percutaneous treatments, the anatomy of the coronary venous system has increasing relevancy. We compared the organization of the coronary venous circulation in three species commonly used in research and compared these to normal humans using both macroscopic anatomic and angiographic studies.
Animals: The anatomy of five explanted hearts from healthy dogs, pigs, and sheep were studied macroscopically, and 10 explanted hearts per animal species and 10 clinically normal human were examined by angiography.
Methods: Animal hearts were injected with latex and dissected macroscopically. The coronary venous system of humans was evaluated from clinical angiographic studies. In the animal hearts, a retrograde angiographic study was performed via a Foley catheter in the coronary sinus.
Results: The general organization of the coronary venous circulation was similar among humans, dogs, sheep, and pigs. Despite overall similarities to humans, animal hearts demonstrated the absence of the oblique vein of the left atrium and differences in position and organization of venous valves; venous diameters; number of tributary veins; and presence of an anastomosis between the left and right (human anterior and posterior) venous tree. The left azygos of the pig and sheep joined the coronary sinus.
Conclusions: Anatomical differences must be considered when planning biomedical and veterinary studies incorporating cardiac veins. This study provides baseline data regarding structure and organization of the cardiac venous system.
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Abbreviations

AIV	anterior interventricular vein
CS	coronary sinus
GCV	great cardiac vein
LMV	left marginal vein
LPV	left posterior vein
MB	myocardial bridges
OV	oblique vein of the left atrium (Marshall)
PIV	posterior interventricular vein

Introduction

Studies of cardiac vascularization have focused largely on the arterial system and comparative studies venous studies are lacking [1,2] as coronary artery pathology is responsible for the majority of cardiovascular-related mortality and morbidity in humans, especially in developed countries [3—6]. However, with the advent of new treatment options for various cardiovascular diseases, such as biventricular pacing, ablation procedures, and implantation of medical devices (as with percutaneous mitral annuloplasty), the coronary sinus (CS) is increasingly used to access the coronary venous system [5,7—13]. Knowledge of coronary venous anatomy has therefore become important, and pre-clinical research focusing on the CS has increased dramatically [5,14—22]. Choosing the appropriate animal model in translational, pre-clinical studies is essential to the success of subsequent human studies [23,24]. In addition, laboratory animal experience might provide a baseline for therapies in veterinary medicine. A few studies published studies have presented anatomical details of mammalian coronary veins [25], though most describe the systems of the mouse and guinea pig [26—29].

The cardiac veins can be grouped into three categories according to the regions drained: the CS and its tributaries, the anterior cardiac veins, and the thebesian veins. The normal organization of the CS and its tributaries has been described in humans both anatomically and through imaging studies. The CS ostium is located in the right atrium and constitutes the terminal portion of the coronary venous system. The CS is typically connected to the great cardiac vein (GCV), then to the anterior interventricular vein (AIV), followed by the posterior interventricular vein (PIV) which begins close to the apex of the heart and goes into the posterior interventricular groove and enters the CS close to the CS ostium [30]. The normal

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