Original article

Right ventricular morphology on catheter angiography: Variations and its implications for the diagnosis of arrhythmogenic right ventricular cardiomyopathy

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Background: **Catheter angiography is one modality used to diagnose right ventricular (RV) structural abnormalities in suspected arrythmogenic right ventricular dysplasia or cardiomyopathy (ARVC) patients. The appearance of the normal RV on angiography is poorly defined. This study aimed to assess RV morphology in a control group to define the range of normal appearances.**

Methods: **RV angiography was performed in 46 subjects (mean age 59 years; 70% male) undergoing coronary angiography for suspected coronary artery disease. Qualitative assessment for RV dilatation, regional wall motion abnormalities (RWMAs), pattern of trabeculae, and presence of micro-aneurysms was performed. Right ventricular outflow tract (RVOT) diameter was measured.**

Results: **Regional or global RV dilatation was considered to be present in 17 patients, RWMA in 13, an abnormal trabecular pattern in 10, and microaneurysms noted in two. The RVOT diameter ranged from 1.78 to 3.51 cm in right anterior oblique view and 2.33 to 4.38 cm in left anterior oblique view.**

Conclusion: **The apparent prevalence of abnormal RV morphology in individuals who have no known RV pathology implies that detection of such is not necessarily of diagnostic significance in suspected ARVC. Significant inter-observer variation limits the usefulness of qualitative assessment; quantitative assessment is preferred therefore.**

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Keywords. Right ventricle; Angiography; Arrhythmogenic right ventricular dysplasia; Cardiomyopathy

Introduction

Arrhythmogenic right ventricular dysplasia or cardiomyopathy (ARVC) is a recognised cause of sudden cardiac death. It is characterised prototypically by fibro-fatty degeneration of right ventricular myocardium. Definitive diagnosis requires histological confirmation of fibro-fatty infiltration at post mortem or surgery, but is not practical in the clinical setting. Myocardial biopsy is relatively insensitive because of the patchy distribution of the abnormal histology, and difficult to interpret with precision.

In 1994 a task force defined a set of major and minor criteria to diagnose ARVD [1]. Modification of the task force criteria has been proposed in 2010 by Marcus et al. [2]. Right ventricular structural abnormalities are part of the diagnostic criteria and right ventricular angiography is used in some centres to aid in the diagnosis. Because of the semi-lunar shape and complex geometry of right ventricle, it is difficult to distinguish between normal and abnormal right ventricular morphology, especially if there are only small changes. Contrast right ventricular angiography provides a great deal of information about the internal structure of the RV, as well as defining abnormalities of regional and global contractile function. However, RV angiography is not normally performed when there is no right heart pathology, and thus the appearances of the normal RV are infrequently seen even by experienced angiographers. And only a limited number of studies have been performed to define normal angiographic right ventricular morphology to compare with the abnormalities found in ARVD. More studies are needed to add to the present knowledge base.

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This study aimed to assess right ventricular morphology on catheter angiography in a group of individuals thought to have normal right ventricles, in order to define the range of normal appearance and acceptable deviations from normal range.

Anatomy of the right ventricle

The right ventricle (RV) is an anterior, nearly midline structure. The shape of the RV is complex; it has the appearance of an asymmetric truncated pyramid. The posterior and the left lateral borders of the RV are formed by the interventricular septum and are concave towards the centre of the ventricular chamber, giving the appearance of draping around the left ventricle. The anterior border is the free wall and is mildly convex. The septal surface of the RV is divided into basal portion; the muscular coarse trabecular portion and the conal (infundibular) septum [3].

Topographically the RV is divided into an inlet portion at the base which includes the tricuspid valve, a body that extends to the apex, and an outflow tract or infundibulum that is directed superiorly and to the left to terminate at the pulmonary valve. The free wall is much thinner (3–5 mm average) than that of the left ventricle (the ratio is usually 1:3), reflecting the lower pressures required in the normal pulmonary circulation.

The inlet and the outlet components of the ventricle are separated in the roof of the ventricle by the prominent supraventricular crest (crista supraventricularis). The apical region is coarsely trabeculated. The inlet component is also trabeculated, but the outlet component has predominantly smooth walls. The trabeculated appearance is caused by a myriad of irregular muscular ridges and protrusions, which are collectively known as trabeculae carneae and are lined by endocardium. One protrusion of the right ventricle, the septomarginal trabeculae or septal band is particularly prominent. Towards the apex it supports the anterior papillary muscle and crosses the free wall of the ventricle as the moderator band. Developmental variation of the moderator band may contain an accessory pathway involved in atrio-ventricular re-entrant tachycardia (Mahaim tachycardia) [4]. The pulmonary valve surmounts the infundibulum and is situated at some distance from the other three cardiac valves.

Method

Forty-six subjects were enrolled over a period of one year at Auckland City Hospital. The subjects were selected from patients referred for elective diagnostic coronary angiography, either because of suspected coronary artery disease, or to define coronary anatomy prior to surgery of some sort. In addition to their elective coronary angiography they also underwent right ventricular angiography in two orthogonal planes. The study received Ethics Committee approval, and informed consent was obtained from every subject.

All subjects were over 18 years of age. Those with known or suspected right ventricular abnormalities were excluded. Exclusion criteria consisted of known contrast allergy, any disease likely to cause abnormalities of the RV, including cardiomyopathy, chronic lung disease, previous RV infarction, or RV abnormality documented on previous echocardiography. Because of additional contrast load, patients with a creatinine clearance (by Cockcroft–Gault formula) of less that 40 ml/min (or less than 50 ml/min in case of diabetes) were excluded from the study.

A 5F angled pigtail catheter was positioned in the body of the RV. Exact placement was determined by the need to opacify the RV adequately, and to obtain a stable catheter position without provoking ectopic electrical activity. Angiography was performed on a 23 cm field at 15 frames per second. The exact angles were along the long axis of the RV body as determined by the catheter position on inspiration for the LAO view: the RV view was orthogonal to this. Typical angles were 35° RAO, 55° LAO. Contrast volume was determined by the operator after a small hand injection to assess the size of the RV. A typical volume was 45 ml at 12 ml/s, with an injection rise time of up to 1 s to try and avoid precipitating ventricular ectopic beats. Right atrial and ventricular pressures were recorded before contrast injection in most patients.

Patients were observed for four hours after the angiography in case of complications. Clinical follow-up was determined by the findings of the coronary angiography.

Patient demographic data were collected and recorded in a dedicated database. The angiograms were analysed independently by a cardiac radiologist and an electrophysiologist with two and three decades experience in cardiac angiography respectively. Discrepancies were resolved by joint consensus and recorded as the final analysis. Subjective assessment was made of RV size, regional (apical, antero-lateral, basal, outflow tract) wall motion abnormalities, the presence of a trabecular pattern considered to be abnormal, and the presence of any microaneurysms. The diameter of the RVOT was measured in both views. Adequacy of filling of the right ventricle with contrast and number of ventricular ectopics were recorded.

Results

Forty-six subjects (mean age 59 years, 70% male) were recruited. Baseline demographic, clinical and angiographic data are shown in Table 1.

Sixteen subjects had a history of myocardial infarction (MI). Of these, 12 had suffered a non ST elevation MI (NSTEMI), one an anterior ST elevation MI (STEMI), two an inferior STEMI, and one both an inferior and an anterior STEMI. Right ventricular infarction was not documented in any of these patients.

All patients underwent coronary angiography. Coronary arteries were normal or had only mild disease in 20 subjects. The distribution of single, two and three vessel disease is shown in Table 1. One patient with 3 vessel disease also had an 80% left main stem (LMS) lesion. One patient had an isolated intermediate artery lesion which had been stented in the past, with the present angiogram showed a widely patent stent. One patient with 2 vessel disease had 50% LMS disease with moderate to severe circumflex disease. Two patients with previous coronary