Right ventricular wall at 3.0T: Spectrum of normal appearance on spin-echo T1W and Proton Density Weighted images both without and with fat-saturation.

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Learning objectives

The purpose of this poster is to describe the technique employed in 3.0T MR imaging of the right ventricular wall in the assessment of arrhythmogenic right ventricular dysplasia.

We will illustrate the spectrum of normal appearances on spin-echo T1W and Proton Density weighted images both with and without fat-saturation.

We aim to highlight potential artefacts at 3.0T which may impair image quality
Background

Arrhythmogenic right ventricular dysplasia (ARVD) is a genetic cardiomyopathy characterised by ventricular arrhythmias and structural abnormalities of the right ventricle [1]. The pathogenesis involves fibrofatty replacement of the myocardium which progresses from the epicardium to the pericardium to eventually become transmural[2]. These changes lead to thinning and aneurysmal dilatation of the cardiac wall. This is evident in the triangle of dysplasia that affects the infundibulum and the apical and inferior walls [3,4]. At a cellular level it is due to genetic defects in the cardiac desmosomes.

Clinical manifestations include ventricular arrhythmias with left bundle branch block and repolarisation and depolarisation abnormalities seen on ECG [5].

As right ventricular dysplasia represents an important cause of sudden cardiac death and ventricular arrhythmias in young people (and in particular in young athletes), accurate diagnosis is crucial [6]. The diagnosis of ARVD is based on the International Task Force Criteria [1]. There are six categories of diagnostic criteria. These include global and/or regional dysfunction and structural changes, tissue characterisation of the cardiac wall, repolarisation abnormalities, conduction abnormalities, arrhythmias and a positive family history [7]. Diagnostic criteria are then subdivided into major and minor criteria. A positive diagnosis is one that has fulfilled two major criteria or one major and two minor criteria or four minor criteria.

Imaging findings in contrast enhanced MRI in a patient with ARVD may include delayed enhancement, fatty infiltration, areas of regional wall motion abnormality, aneurysmal dilation of the right ventricle and systolic impairment [8,9].
Fig. 0: Causes of sudden cardiac deaths in young athletes in the United States

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Imaging findings OR Procedure details

All scanning was done using a 3T Achieva System (Philips Medical Systems, Netherlands) in the Centre for Advanced Medical Imaging (CAMI), St. James’s Hospital / Trinity College University of Dublin.

All images were acquired using a 6-channel cardiac phased array coil with a SENSE parallel imaging factor of 1.3".

Imaging was performed with T1 and PD sequences.

For the T1-weighted images a black blood turbo spin echo (TSE) sequence was employed with a turbo factor of 11.
TR/TE equalled 1000/5.4ms while allowing 12 secs per breath hold. Spatial resolution was 0.7 x 0.7 x 4 mm, 14 slices, with a 2mm gap between slices.
Black blood inversion delay equalled 421 ms, 15mm thick with an acquisition time of 2mins 48s (in reality this was slightly longer given the time between breath-holds, etc.). This was used without (above) and with fat suppression, using the SPAIR fat suppression technique.

For the proton density weighted images a black blood turbo spin echo (TSE) sequence with a turbo factor of 11 was used.
TR/TE equalled 2000/11ms allowing 14 secs per breath hold.
Spatial resolution was 0.8 x 0.8 x 4 mm, 14 slices with a 2mm gap between slices.
Black blood inversion delay equalled 698 ms, 15mm thick with an acquisition time of 3mins 16s (again in reality this was slightly longer given the time between breath-holds, etc.). This was used without (above) and with fat suppression, using the SPAIR fat suppression technique.

20cc of contrast was administered at 2cc per second. First pass imaging was performed and delayed images at 15 minutes were also obtained.

In general cardiac MRI is ECG gated. This is to overcome motion artefact. The heart chambers, major vessels and valves can be examined in any plane and provides detail of the appearance of soft tissue. The normal myocardium is of intermediate signal intensity. The pericardium is seen as a dark line approximately 2mm thick.

The right ventricular cavity can be seen to extend from the fat of the atroioventricular ring to the fat of the intventricular groove. The presence of the moderator band is a useful way of differentiating the right from left ventricle particularly in congenital conditions.
Fat saturation techniques are employed in cardiac MRI as otherwise it may be difficult to differentiate the normal epicardial fat from fatty infiltration of the myocardium.

Figure 1 highlights an excellent appearance of the right ventricle on MRI. Note the clear interface between the signal suppressed black blood in the right ventricular cavity, the right ventricular wall and epicardial fat. Figures 2-6 demonstrate the appearances on T1 and proton density sequences both with and without fat saturation.

In our institution the appearance of the right ventricle and therefore its diagnostic accuracy is graded. This grading system is set out in figure 9. All the images of the right ventricle in figure 7 were deemed to be of excellent diagnostic quality. Images of poor and adequate quality are included in figure 8 for comparison. Note the loss of a clear interface between the right ventricular cavity and epicardial fat.

Figures 10-13 provide images of the appearance of the right ventricular wall on suboptimal studies. The clear demarcation between the right ventricular wall and the epicardial fat is lost. This limits the sensitivity of these studies for detection of intramyocardial fat and thus potential diagnoses such as arrhythmogenic right ventricular dysplasia may be overlooked.
**Fig. 0:** Normal appearance of the RV wall. Clear interface between the RV cavity, RV wall and epicardial fat.

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**Fig. 0:** RV wall on T1 weighted imaging without fat sat.

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**Fig. 0:** Normal RV wall on T1W image with fat sat.

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**Fig. 0:** Normal RV wall on proton density imaging without fat sat.

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**Fig. 0:** Normal RV wall with fat sat.

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Fig. 0: This image compares the appearance of the RV wall on T1 and PD weighted images both with and without fat saturation.

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**Fig. 0:** Image illustrating the excellent appearance of the RV wall. All images have been graded as being of excellent diagnostic value.

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**Fig. 0:** Comparison of the excellent appearance of the RV wall on the upper two images with those that have been graded as being of poor diagnostic quality. Note on the upper images the clear interface between the RV cavity, RV wall and epicardial fat. There is loss of this clear interface on the lower images.

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Image Evaluation

- 1 = non diagnostic
- 2 = poor quality (minimum diagnostic value)
- 3 = satisfactory
- 4 = good
- 5 = excellent

**Fig. 0:** Illustration of the grading system used in our institution to score the appearance of the RV wall on MRI in terms of diagnostic value.

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**Fig. 0:** T1 fat saturated image

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Fig. 0: T1 without fat saturation

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Fig. 0: T1 with fat saturation

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Fig. 0: T1 fat saturated

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Conclusion

Arrhythmogenic right ventricular dysplasia is an important cause of sudden cardiac death. MRI has a role in the diagnosis of this condition. MRI and in particular 3T MRI provide excellent images of the right ventricle as illustrated by the examples provided.

Knowledge of the appearances of the normal right ventricle on MRI is vital so that deviations from normal can be appreciated and pathological conditions can be diagnosed.

Equally an awareness of the imaging artefacts which can occur during scanning is important as these can possibly mimic pathological conditions such as arrhythmogenic right ventricular dysplasia.
References


