

CARDIOVASCULAR MRI FOR STRUCTURAL AND VALVULAR HEART DISEASE INTERVENTIONS

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INTRODUCTION

- CARDIAC MAGNETIC RESONANCE (CMR) IS A NON INVASIVE IMAGING MODALITY THAT ALLOWS DETAILED VISUALISATION OF CARDIAC ANATOMY AND FUNCTIONAL ASSESSMENT INCLUDING WALL MOTION ANALYSIS ,QUANTIFICATION OF CHAMBER SIZE AND VOLUME ,SYSTOLIC AND DIASTOLIC FUNCTION AND MYOCARDIAL TISSUE CHARACTERISATION , WITHOUT EXPOSURE TO IONIZING RADIATION .

ADVANTAGES OF CMRI

- HIGH TEST REPRODUCIBILITY FOR QUANTIFICATION OF CHAMBER SIZE ,VOLUME , MASS , INFARCTION SIZE .
- ENABLES TISSUE CHARACTERISATION .
- PROVIDES LARGE FIELD VIEW .
- HIGH SPATIAL RESOLUTION AND EXCELLENT TEMPORAL RESOLUTION .
- 3D CARDIOVASCULAR ANATOMY VISUALISATION WITHOUT CONTRAST .
- NO IONIZING RADIATION TO PATIENT .
- PRECISE QUANTIFICATION OF COMPLEX FLOW PATTERNS .

LIMITATION OF CMRI

- LIMITED TO TERTIARY REFFERAL CENTERS.
- CLAUSTROPHOBIA .
- SEVERLY OBESE PATIENT .
- CARDIAC ARRTHYMIAS AND RESPIRATORY MOTION CAN COMPROMISE IMAGE QUALITY .
- MECHANICAL PROSTHESIS, IMPLANTS AND CARDIAC DEVICES CAN CAUSE IMAGING DEFECTS.

CONTRAINDICATIONS OF CMRI

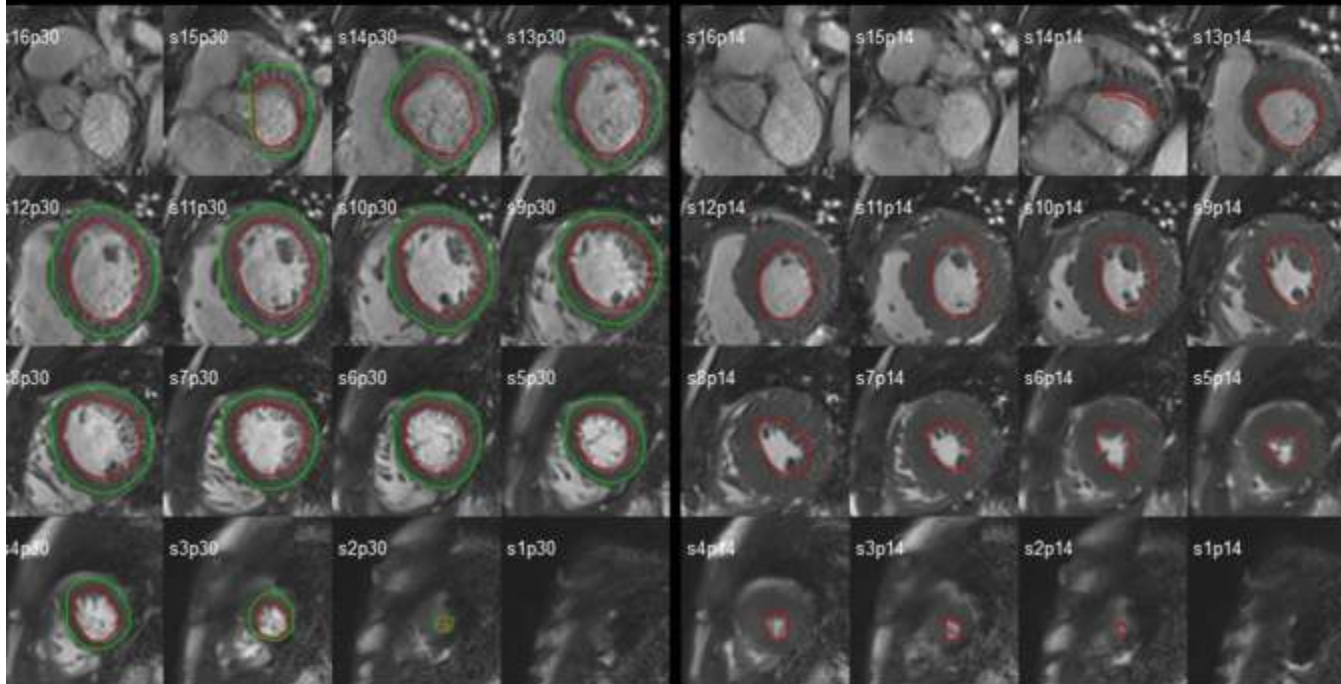
- PACEMAKERS/ICD .
- CEREBRAL ANEURYSM CLIP .
- COCHLEAR IMPLANTS .
- RETAINED METALLIC FOREIGN BODY .
- PULMONARY ARTERY CATHETERS.
- SEVERE RENAL IMPAIRMENT .

OVERVIEW OF CMRI TECHNIQUE

- STRENGTH OF CARDIAC MRI IS TO ASSESS CARDIAC FUNCTION .
- QUANTIFICATION OF RIGHT AND LEFT VENTRICLE MASS, VOLUMES AND SYSTOLIC FUNCTION .
- END DIASTOLIC AND SYSTOLIC FRAMES ARE IDENTIFIED AND USED TO CALCULATE ENDDIASTOLIC , SYSTOLIC VOLUMES AND SYSTOLIC FUNCTIONS.

Diastole

Systole



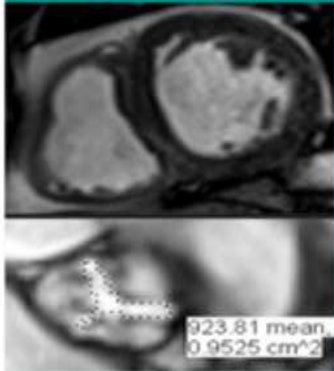
Left Ventricular Volume Results		Normal (reference)	Indexed values (by Body Surface Area)		Normal (reference)
Mass:	341.15 g	85 - 181	Mass index:	141.16 g/m²	46 - 84
ED volume:	381.74 ml	101 - 236	ED volume index:	157.95 ml/m²	52 - 112
ES volume:	167.85 ml	28 - 93	ES volume index:	69.45 ml/m ²	-
Stroke volume:	213.89 ml	66 - 150	Stroke volume index:	88.50 ml/m ²	-
Ejection fraction:	56.03 %	55 - 74			
Cardiac output:	19.72 l/min		Cardiac output index:	8.16 l/(min*m ²)	

TISSUE CHARACTERISATION

- MOST OF CMRI CONTRAST AGENTS ARE GADOLINIUM CHELATES WHICH IN NORMAL CIRCUMSTANCES REMAIN IN BLOOD POOL AS THE MYOCARDIAL EXTRACELLULAR SPACE IS NOT DISRUPTED .
- IN ACUTE OR CHRONIC MYOCARDIAL INFARCTION CELLULAR NECROSIS CAUSE CELL MEMBRANE RUPTURE AND INCREASE IN EXTRACELLULAR SPACE WHERE GADOLINIUM CAN DISTRIBUTE.
- LATE GADOLINIUM ENHANCEMENT (LGE) IMAGING IS USED TO VISUALISE AND QUANTIFY ISCHEMIC MYOCARDIAL INFARCT .

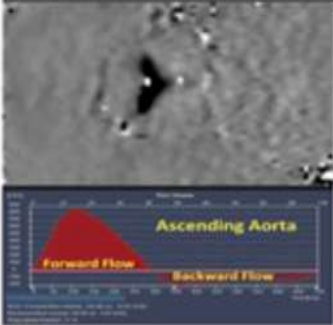
LGE IMAGING

Ventricular Function (Cine Images)




- Assessment of ventricular remodeling (volumes and mass)
- Visualization and interrogation are not limited to a specific imaging plane.
- Evaluation of wall motion abnormalities
- Quantification of valvular stenosis and/or regurgitation (measurement of aortic valve area by 2D planimetry)

Flow and Velocities (Phase Contrast)



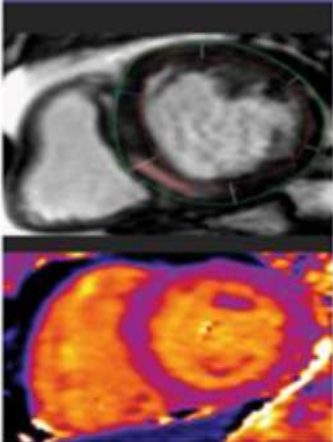
- For stenotic valves, allows for the assessment of peak flow velocities; for regurgitant lesions, it measures regurgitant volume and fraction.
- Quantification of paravalvular leak post-TAVR
- Quantification of shunt magnitude (Qp/Qs)
- Evaluation of hemodynamic significance of congenital abnormalities

3D Anatomical Evaluation (Contrast-Enhanced MRA and 3D SSFP Non-Contrast MRA)



- Three dimensional evaluation of the entire cardiovascular system with multiplanar reconstruction
- In patients being evaluated for TAVR, accurate measurements of the aortic annulus can be obtained (similar and comparable to Cardiac CTA).
- Quantification of aortic coarctation/dilation; pulmonary artery/vein stenosis/dilation
- Evaluation of congenital anatomy pre-post surgical interventions

Myocardial Tissue Characterization (Late Gadolinium Enhancement and T1 Mapping Pre- and Post-Contrast for Calculation of Extracellular Volume Fraction)



- Assessment of myocardial fibrosis is prognostically important for patients with valvular disease. This evaluation can be done with late gadolinium enhancement imaging for the quantification of the different patterns of myocardial fibrosis (sub-endocardial type from prior myocardial infarction or midwall type from long standing pressure overload as in patients with aortic stenosis).
- T1 mapping pre- and post-contrast allows for the calculation of extracellular volume fraction, which has been validated against histology, as a marker of diffuse interstitial myocardial fibrosis.

CMR FOR MYOCARDIUM

- PARAMAGNETIC EFFECT OF GADOLINIUM CAUSES SHORTENING OF RELAXATION TIME ,THUS CAUSING AREAS OF GADOLINIUM TO BE BRIGHT ON IMAGES .
- BRIGHT SIGNALS FROM DAMAGED MYOCARDIUM .
- CMR IS USED TO VISUALISE AND QUANTIFY ISCHEMIC MYOCARDIAL INFARCT .
- TRANSMURALITY OF MYOCARDIAL SCAR WAS A KEY PREDICTOR FOR FUNCTIONAL IMPROVEMENT .

CMR FOR NON ISCHEMIC CARDIOMYOPATHY

- LGE IMAGING SHOWN TO BE PROGNOSTICALLY IMPORTANT IN NON ISCHEMIC CARDIOMYOPATHY.
- MYOCARDIAL TISSUE CHARACTERISATION BY CMR CAN ALSO BE OBTAINED BY APPLYING DIFFERENT PULSE SEQUENCES .
- LIKE TISSUE COMPOSITION , MAGNETIC TRANSFER AND SPIN RELAXATION .
- MAPPING IS TO BE DONE FOR MYOCARDIAL FIBROSIS, OEDEMA/INFLAMMATION AND IRON CONTENT .

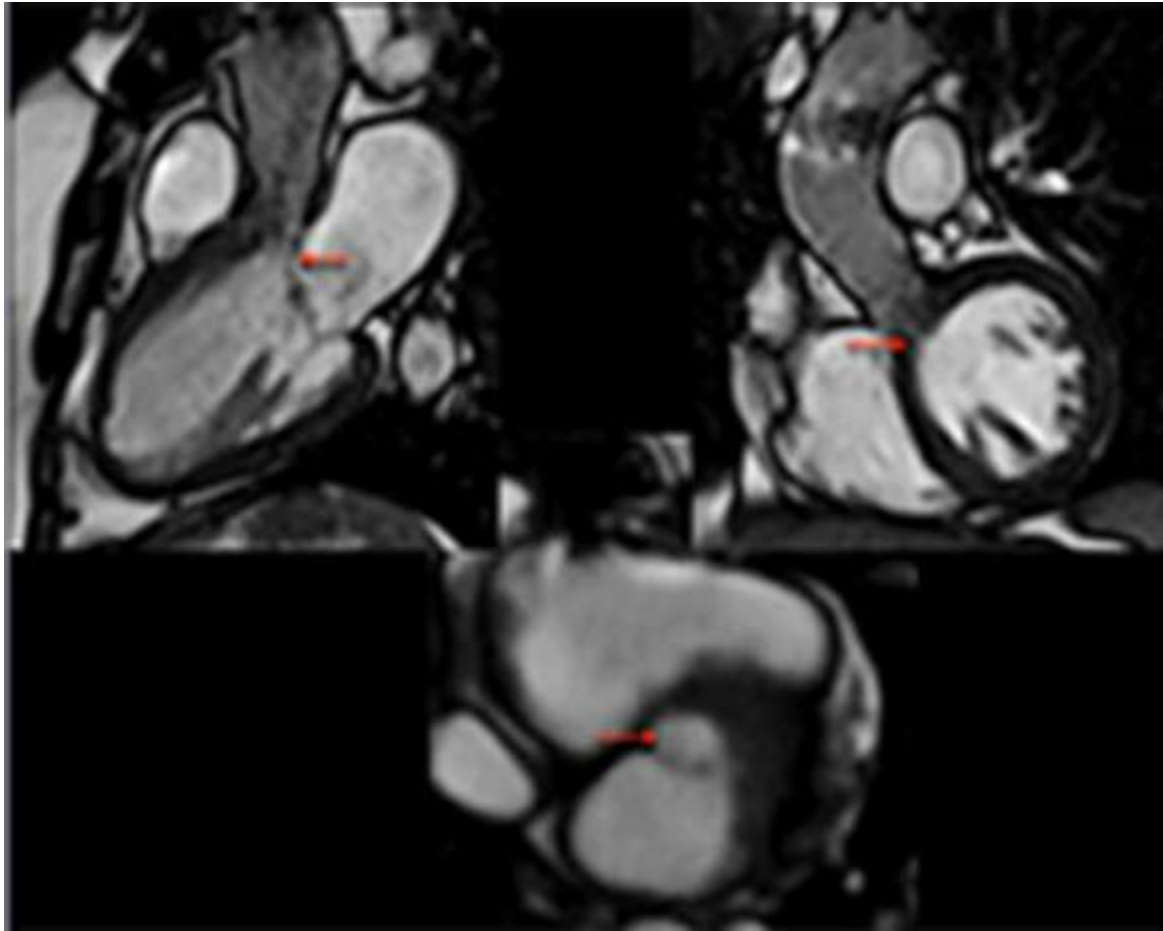
CMR FOR VALVULAR DISEASE

- CMR CAN EVALUATE VALVULAR MORPHOLOGY , MECHANISM OF DYSFUNCTION AND CONSEQUENCES OF THE STENOSIS/REGURGITATION ON THE VENTRICULAR FUNCTION AND REMODELLING .

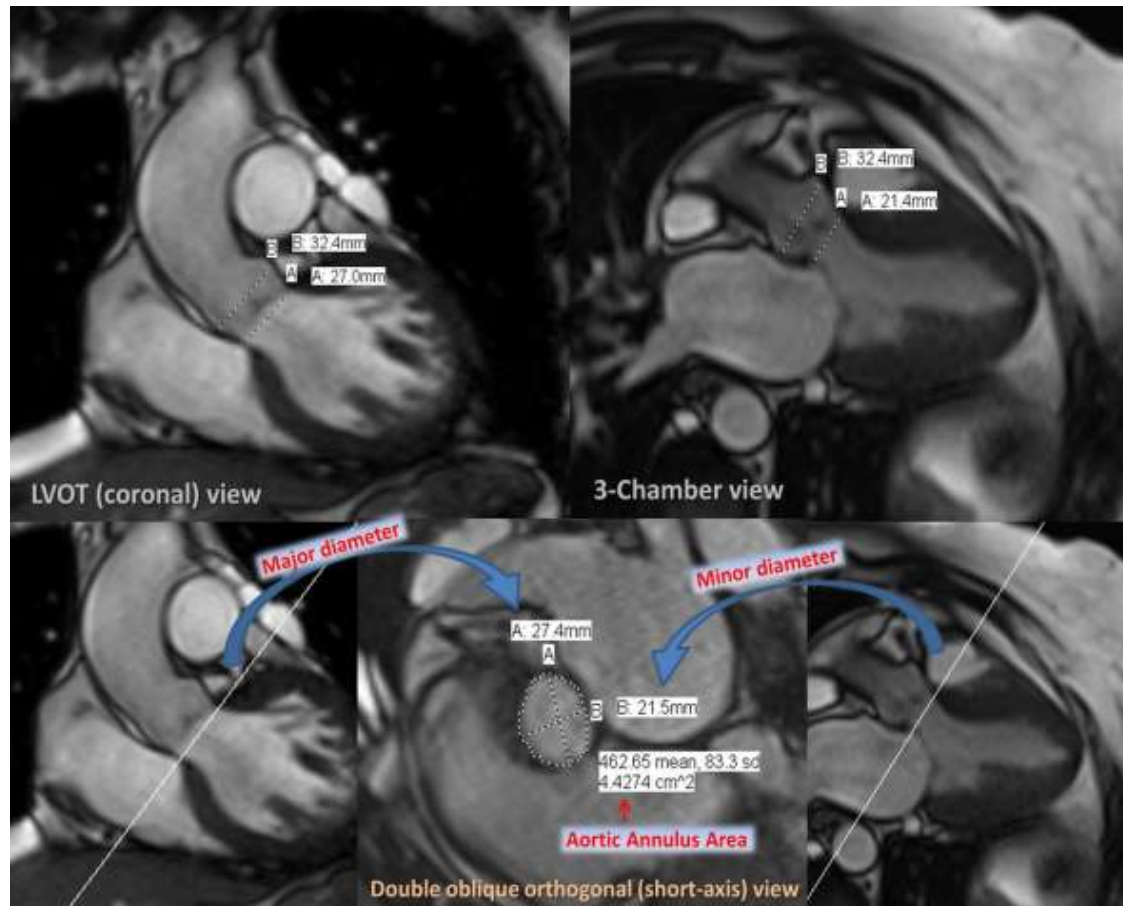
CMRI IN AORTIC STENOSIS

- CALCIFIC AORTIC STENOSIS .
- MYOCYTE HYPERTROPHY AND MYOCARDIAL FIBROSIS.
- SYSTOLIC AND DIASTOLIC DYSFUNCTION .
- CMR IS NEEDED FOR MEASUREMENT OF ANATOMICAL AORTIC VALVE AREA .
- QUANTIFICATION OF LV MASS,VOLUMES AND FUNCTION .

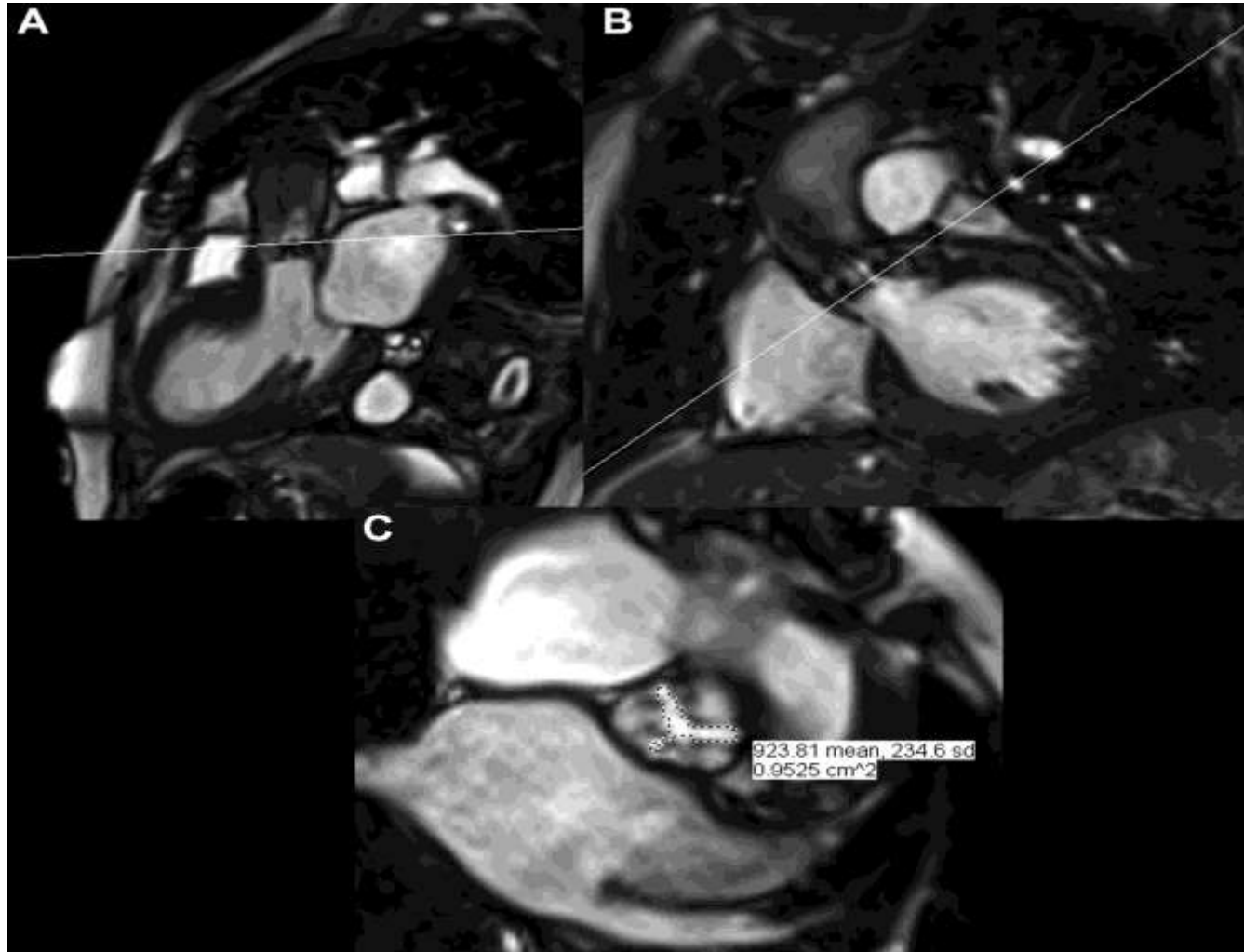
SUBAORTIC MEMBRANE



AORTIC ANNULUS MEASUREMENT



EVALUATION OF AORTIC STENOSIS SEVERITY



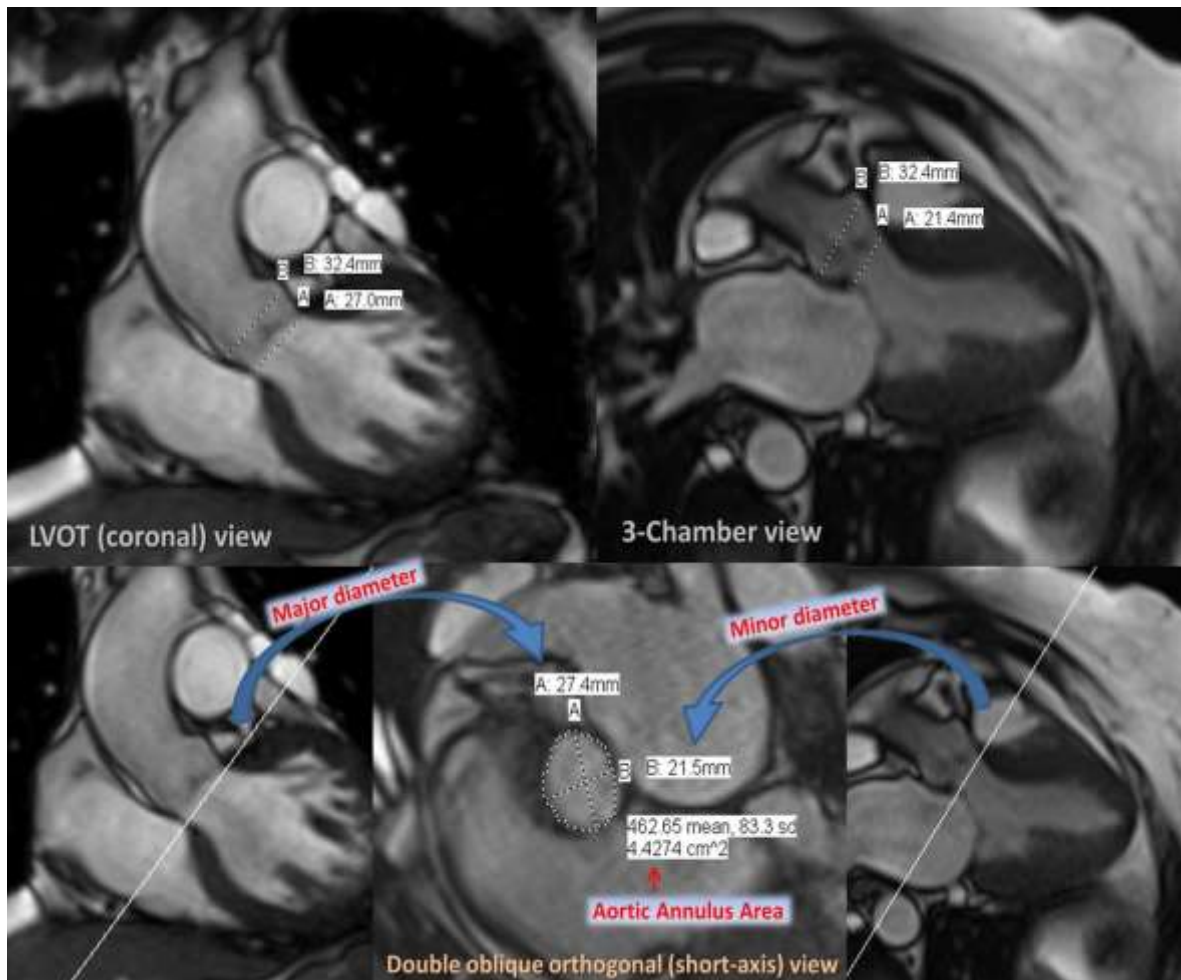
CMR FOR AORTIC STENOSIS

- BICUSPID AORTIC VALVE IS ASSOCIATED WITH THORACIC AORTOPATHY AND COARCTATION .
- QUANTIFICATION OF FLOW DERIVED PARAMETERS LIKE STROKE VOLUME ,PEAK AORTIC VALVE VELOCITY , PEAK GRADIENT , REGURGITANT VOLUME AND FRACTION .
- DIRECT MEASUREMENT OF AVA.

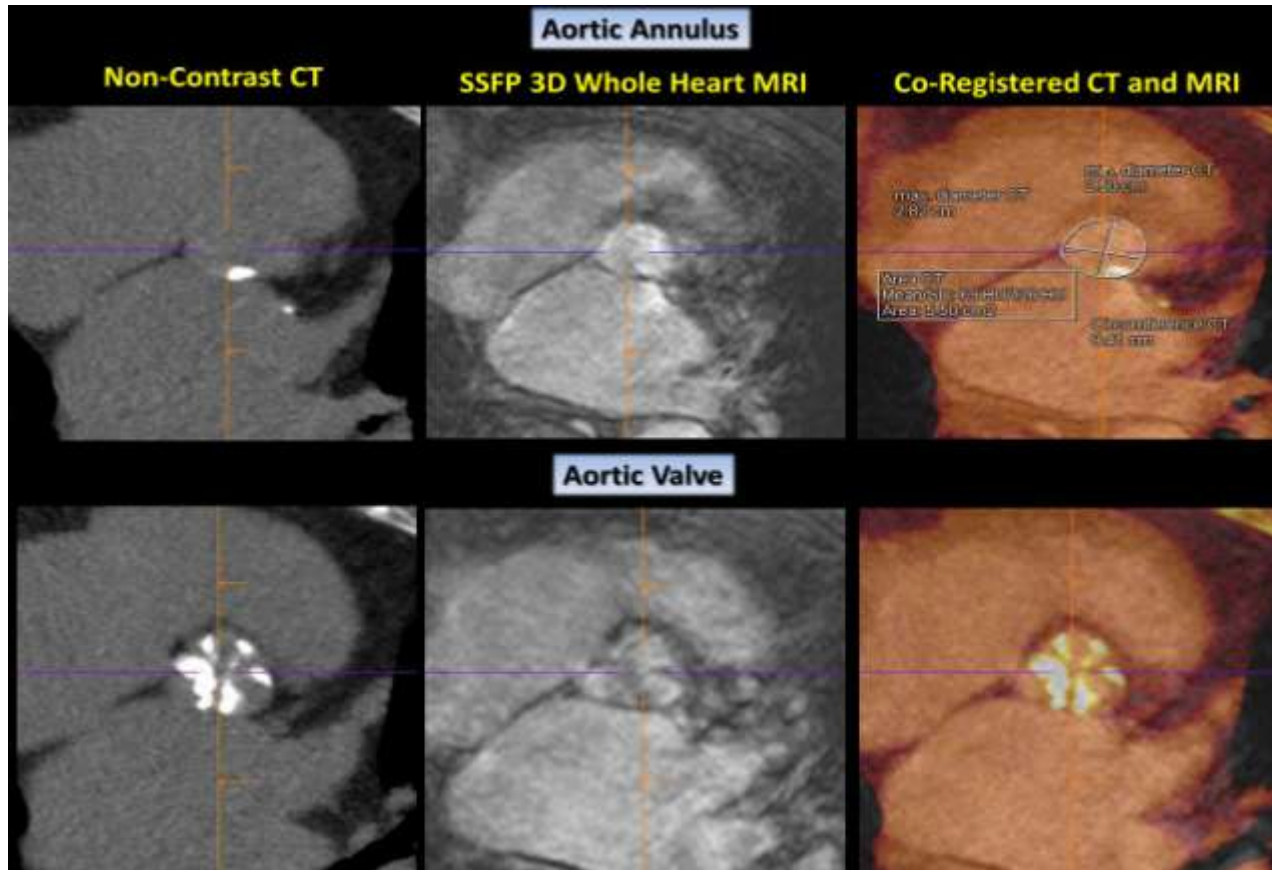
ASSESSMENT FOR TRANSCATHETER AORTIC VALVE REPLACEMENT

- ACCURATE 3D IMAGING OF AORTIC ANNULUS IS KEY TO DETERMINING THE APPROPRIATE BIOPROSTHETIC VALVE SIZING TO AVOID POTENTIAL COMPLICATIONS LIKE AORTIC ANNULUS RUPTURE AND PARAVALVULAR LEAK
- ADVANTAGE OF CMRI IN CHARACTERISATION OF PVL .
- UNDERESTIMATION OF PVL WHILE COMPARING WITH TEE AND CT .
- CMRI IS USEFUL FOR CALCIFICATION OF AORTIC ANNULUS.

CMRI FOR AORTIC ANNULUS MEASUREMENTS .



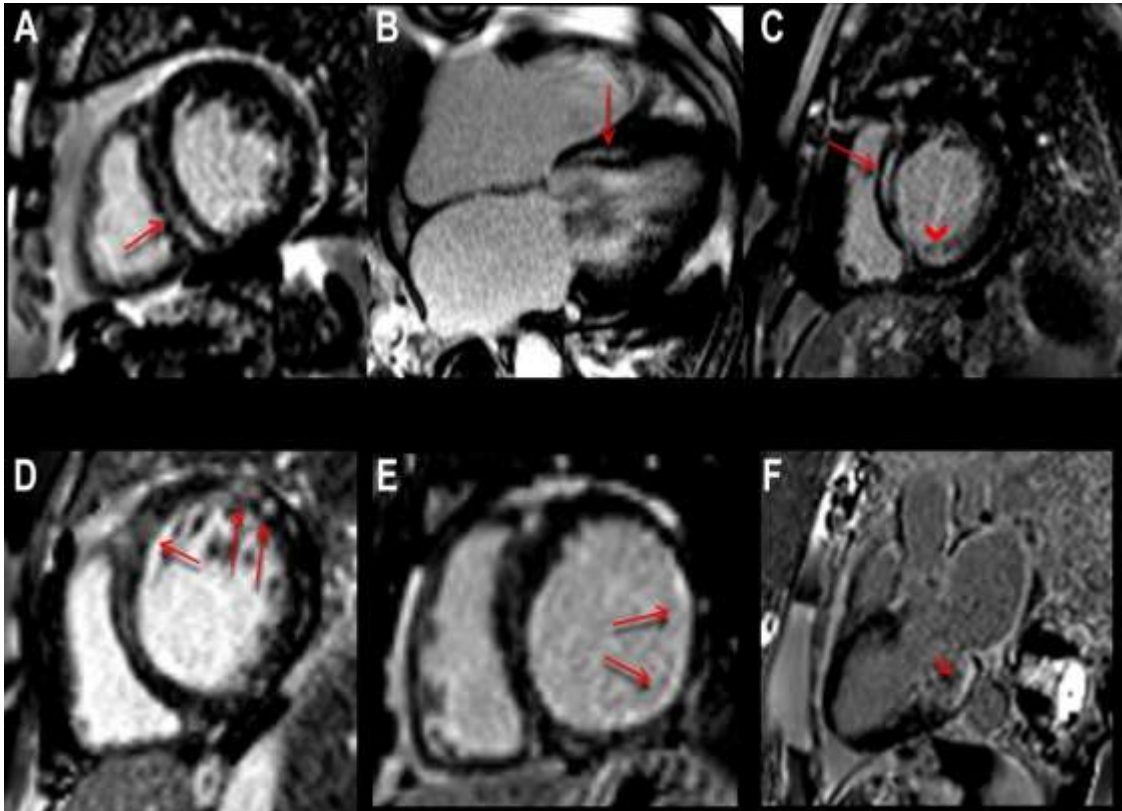
CT AND MRI IMAGES OF AORTIC VALVE



QUANTIFICATION OF MYOCARDIAL FIBROSIS

- LGE IMAGING IS GOLD STANDARD FOR NONINVASIVE QUANTIFICATION OF FOCAL MYOCARDIAL FIBROSIS.
- SEVERAL LGE PATTERNS OF MF HAVE BEEN DESCRIBED IN PATIENTS WITH AS.
- FOCAL,DIFFUSE,SUBENDOCARDIAL .
- PROGNOSTIC SIGNIFICANCE OF MF IN PATIENTS WITH AS IS YET TO BE DETERMINED .

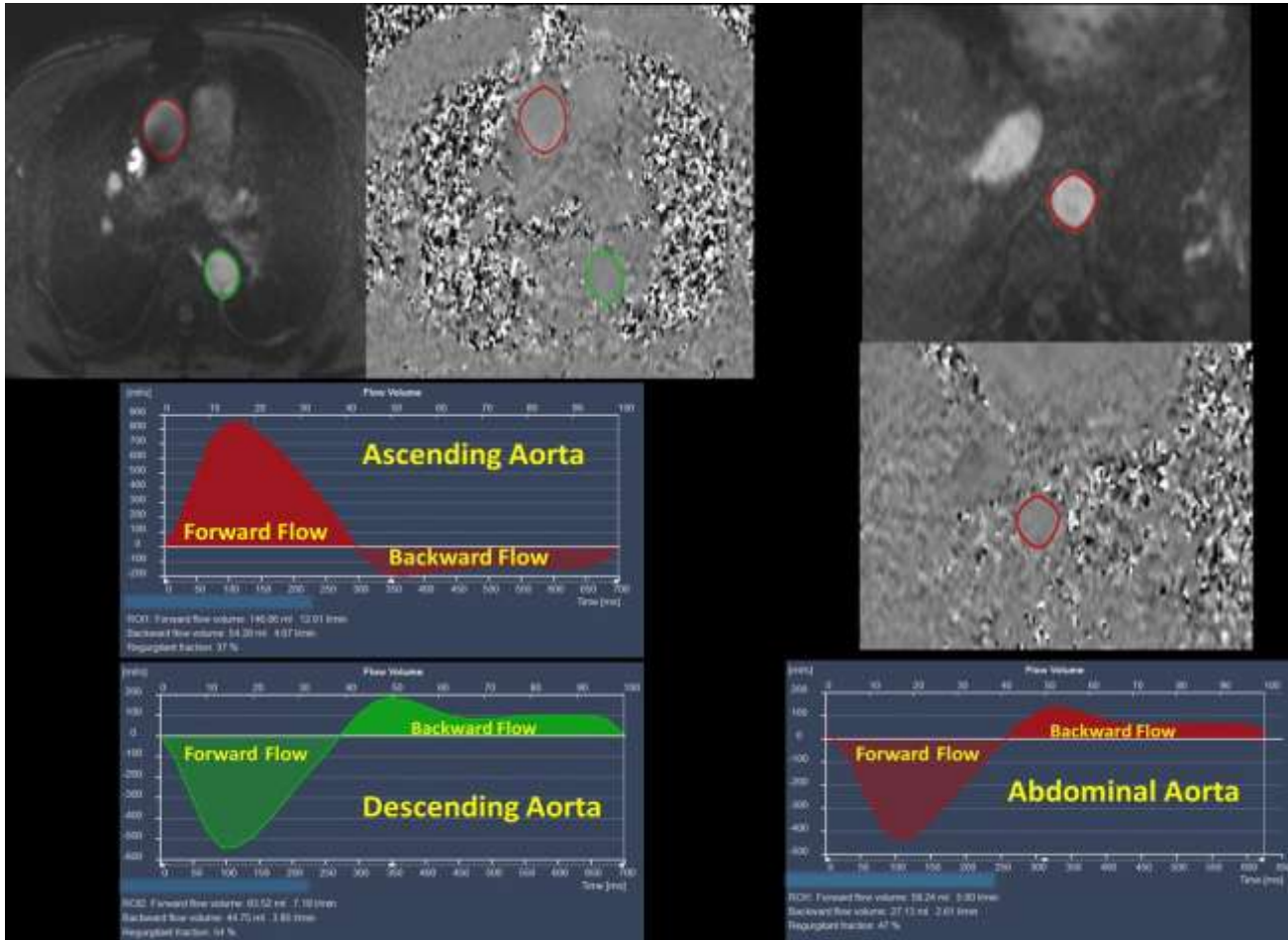
MYOCARDIAL FIBROSIS



AORTIC REGURGITATION

- AR LEADS TO LV VOLUME OVERLOAD WITH ECCENTRIC REMODELLING CAUSES BOTH INCREASE IN VOLUME AND MASS .
- CMRI HELP IN KNOWING THE CAUSE OF AR WHICH CAN BE AORTIC ROOT OR ANNULUS DILATATION, LEAFLET PATHOLOGY .
- REGURGITATION VOLUME AND REGURGITATION FRACTION IS CALCULATED THROUGH CMRI.
- FORWARD FLOW AND BACKWARD FLOW CALCULATED IN ABDOMINAL ,ASCENDING AND DESCENDING THORAIC AORTA .

CMRI IN CHRONIC AR



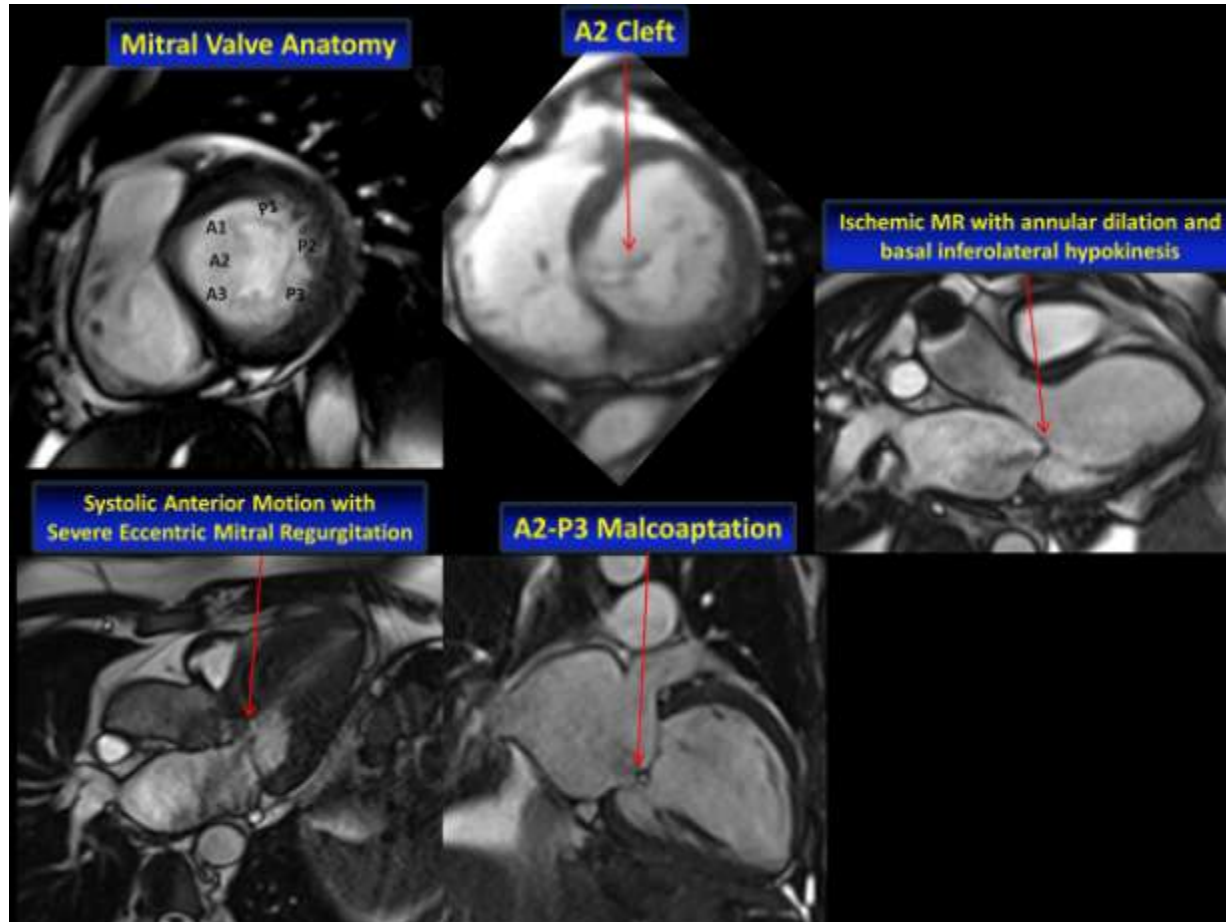
MITRAL STENOSIS

- WITH SPATIAL RESOLUTION ,PLANNIMETRY OF VALVE AREA CAN BE MEASURED AT LEAFLET TIPS .
- ANATOMIC VALVE AREA IS CALCULATED .
- VELOCITY,PRESSURE HALF TIME AND DELINEATION OF MITRAL VALVE OPENING AREA .
- UNDERESTIMATION OF PEAK VELOCITY CAN OCCUR .

MITRAL REGURGITATION

- CMRI CAN PROVIDE EXCELLENT QUANTIFICATION OF MITRAL REGURGITANT VOLUME , FRACTION AND RESULTANT VENTRICULAR REMODELLING .
- PULMONARY HYPERTENSION CAN ALSO BE INFERRED AS DILATATION OF RIGHT VENTRICLE , INCREASED RIGHT RV WALL THICKNESS , D SHAPED SEPTUM AND PA DILATATION .
- CMRI HAS THE POTENTIAL TO VISUALIZE ALL PARTS OF VALVE LIKE LEAFLETS, CHORDAE TENDINAE AND PAPILLARY MUSCLES .

CMRI IN MR



TRANSCATHETER MVR

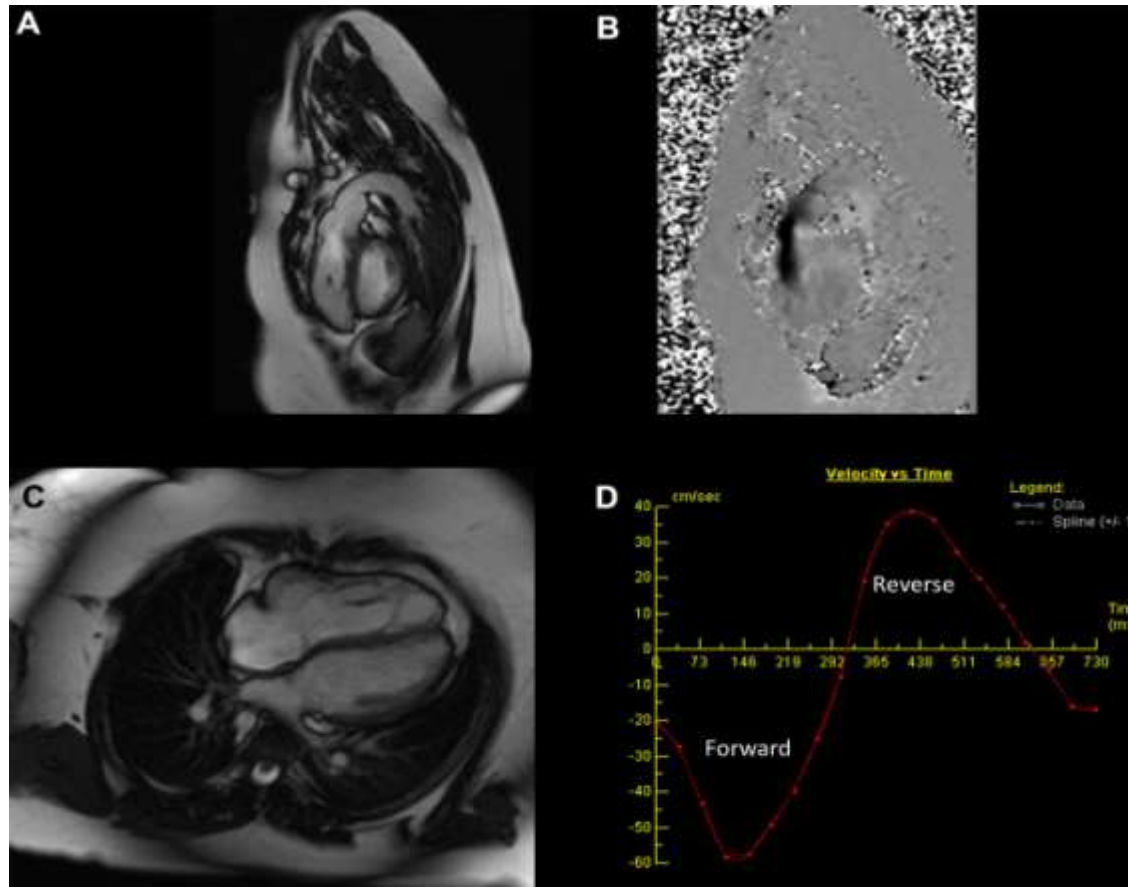
- PRE PROCEDURAL ASSESSMENT OF MITRAL ANNULAR PLANE .
- CMRI CAN BE HELPFUL IN ASSESSMENT AND QUANTIFICATION OF PARA VALULAR LEAK.

PULMONARY VALVE STENOSIS/REGURGITATION

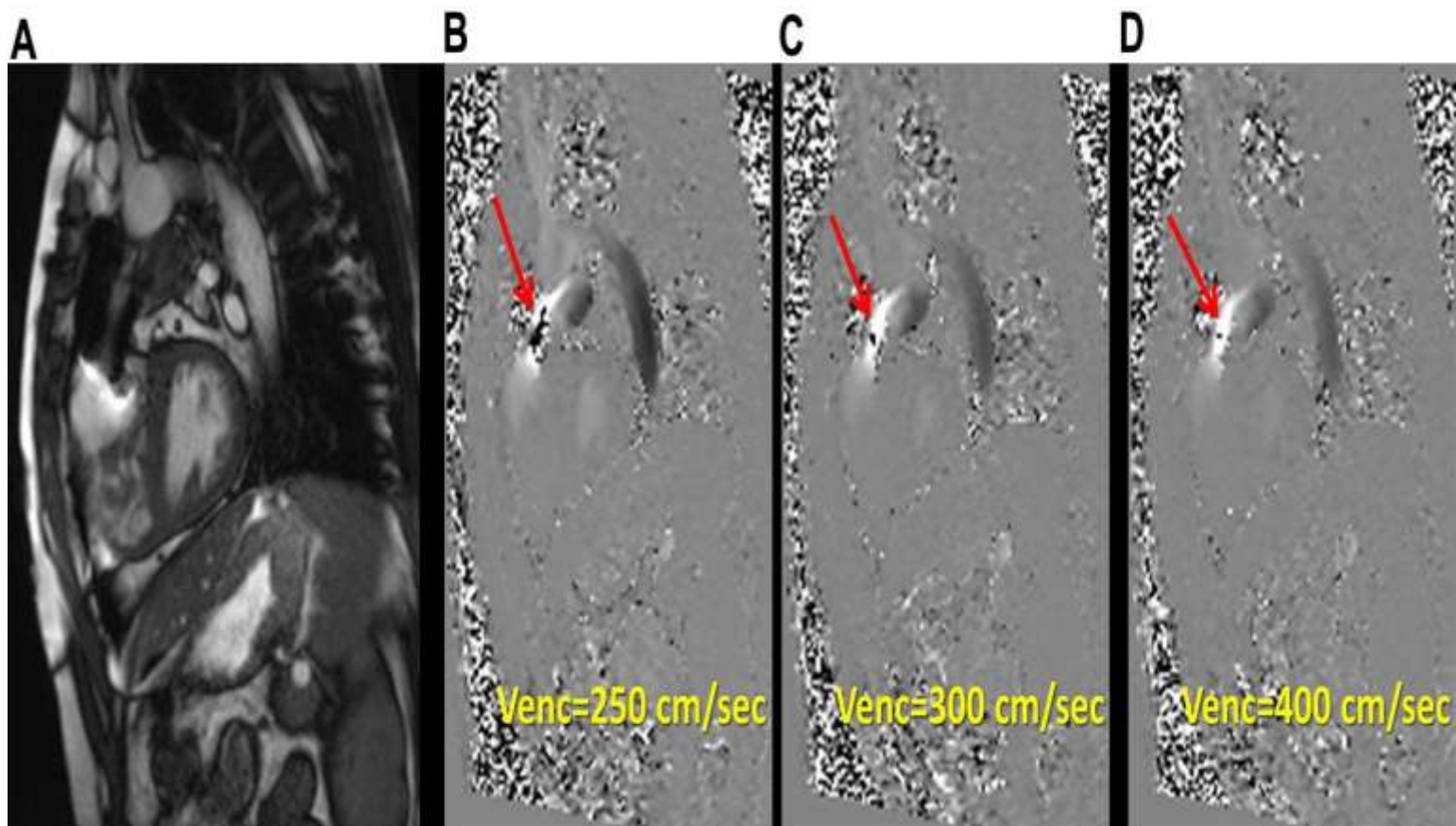
- PHASE CONTRAST VELOCITY MAPPING IS USEFUL FOR ESTIMATION OF SEVERITY OF RVOT OBSTRUCTION OR PULMONARY REGURGITATION
- CMRI DERIVED PARAMETERS OF RV SIZE AND FUNCTION ARE IMPORTANT FOR DETERMINING TIMING OF REINTERVENTION.
- CMRI ALSO ALLOWS 3D MULTIPLANAR RECONSTRUCTION AND PROVIDE ACCURATE INFORMATION OF RVOT,PULMONARY ARTERIES RV-PA CONDUITS AND PROSTHETIC VALVES .

CMRI IMAGING OF PATIENT WITH TOF

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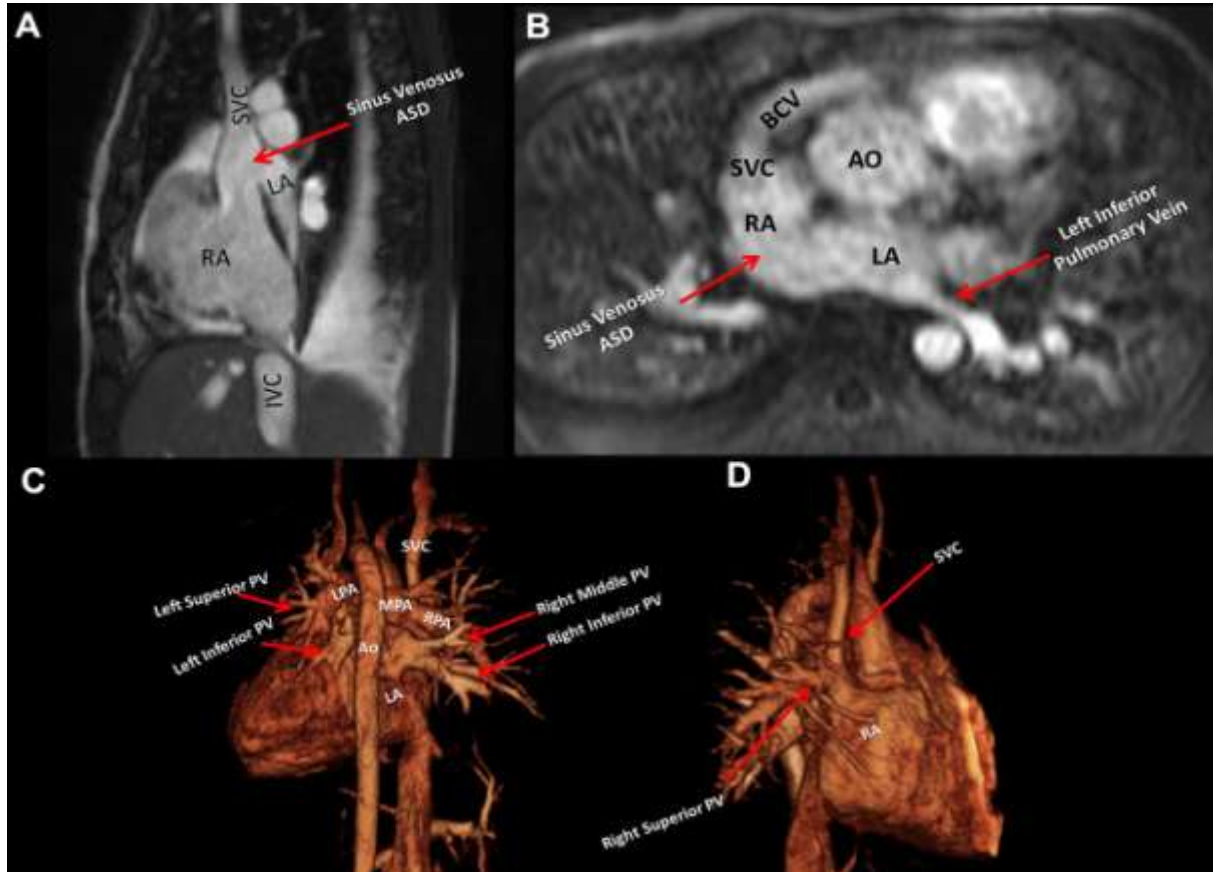
CMR EVALUATION OF RV-PA CONDUIT STENOSIS



CMR FOR ATRIAL SEPTAL DEFECT

- QP/QS CALCULATION BY CMRI IS VERY ACCURATE AND SHOULD BE CONSIDERED IN FIRST LINE OF SHUNT QUANTIFICATION .
- CMR IS STRONGLY CONSIDERED IN CASES WHERE CALCULATION OF INTRACARDIAC SHUNT IS EQUIVOCAL BY ECHO AND INVASIVE HAEMODYNAMICS AND IN CASES WHERE RV DILATATION HAS BEEN SUSPECTED ON TTE WITHOUT ANATOMIC DEFECT .
- IT ALSO HELPS TO KNOW ABNORMAL PULMONARY VENOUS DRAINAGE.

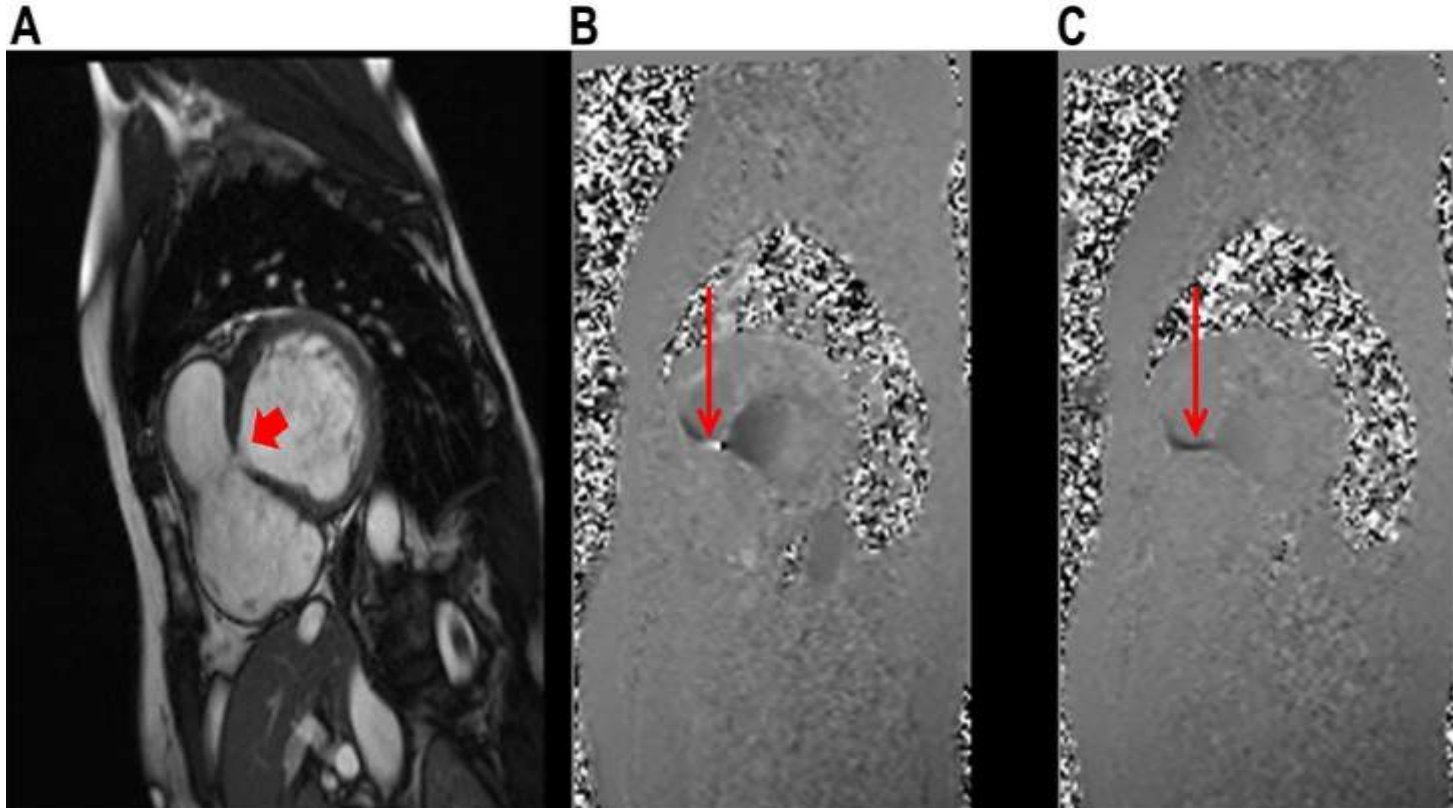
CMR EVALUATION OF SINUS VENOSUS ASD



CMR FOR VSD

- MOST COMMON CHD AT BIRTH .
- COMMON LOCATION IS PERIMEMBRANOUS SEPTUM .
- PROXIMITY TO AORTIC VALVE CAN CAUSE AR AND DEVELOPMENT OF AV BLOCK AFTER PERCUTANEOUS CLOSURE .
- IN POSTINFARCT VSD CMRI IS USEFUL FOR APPROPRIATE DEVICE SIZING , VSD ANATOMY , LOCATION , INFARCT EXTENT AND HAEMODYNAMIC CONSEQUENCES.

CMRI FOR SMALL RESTRICTIVE VSD



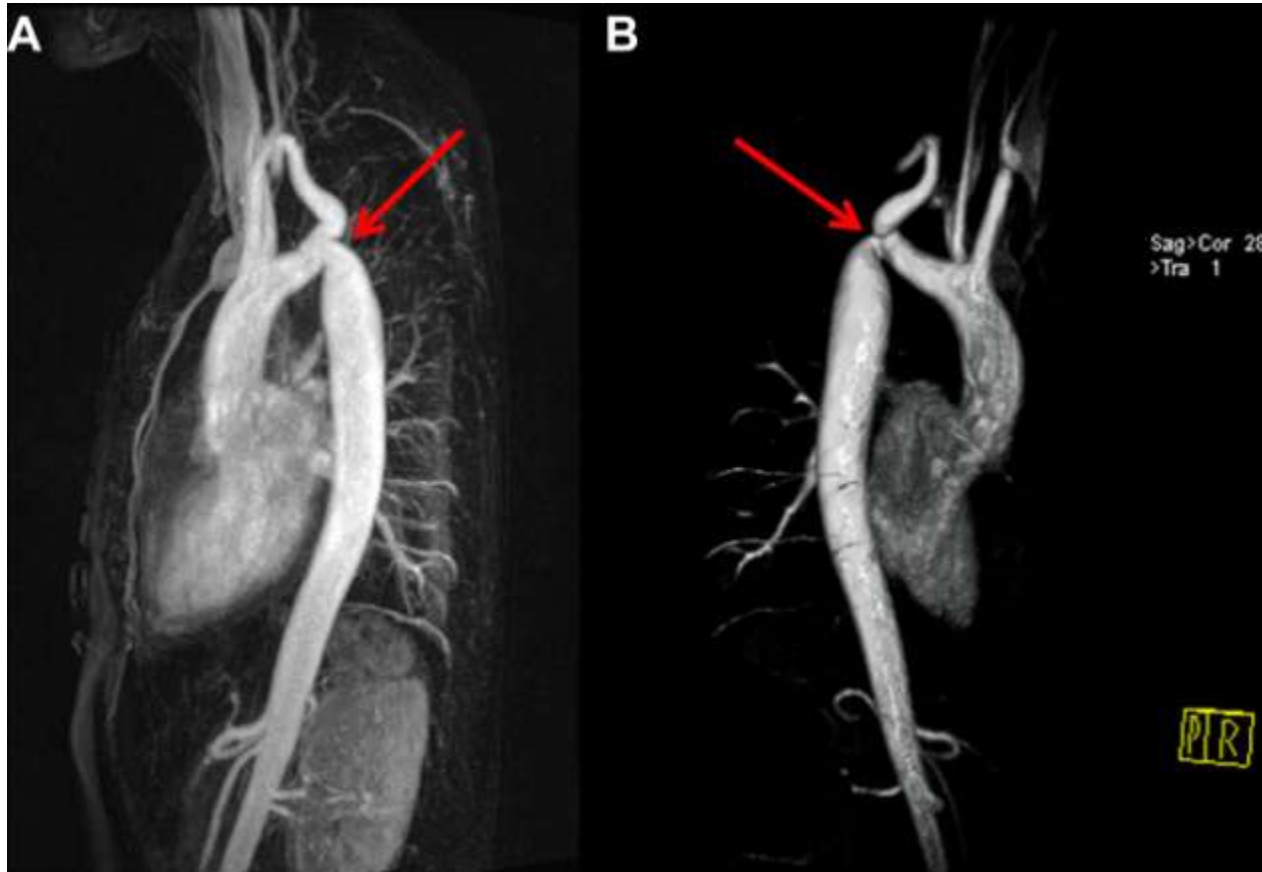
CMRI IN PDA

- CMRI ALLOWS THE ASSESSMENT OF PDA ANATOMY ,EVALUATION OF ASSOCIATED ABNORMALITIES IN AORTIC ARCH AND QUATIFICATION OF DUCTAL SHUNT VOLUME .
- DIRECT QUANTIFICATION IS DIFFICULT DUE TO VARIATION IN PDA ANATOMY,MORPHOLOGY AND POSITION .

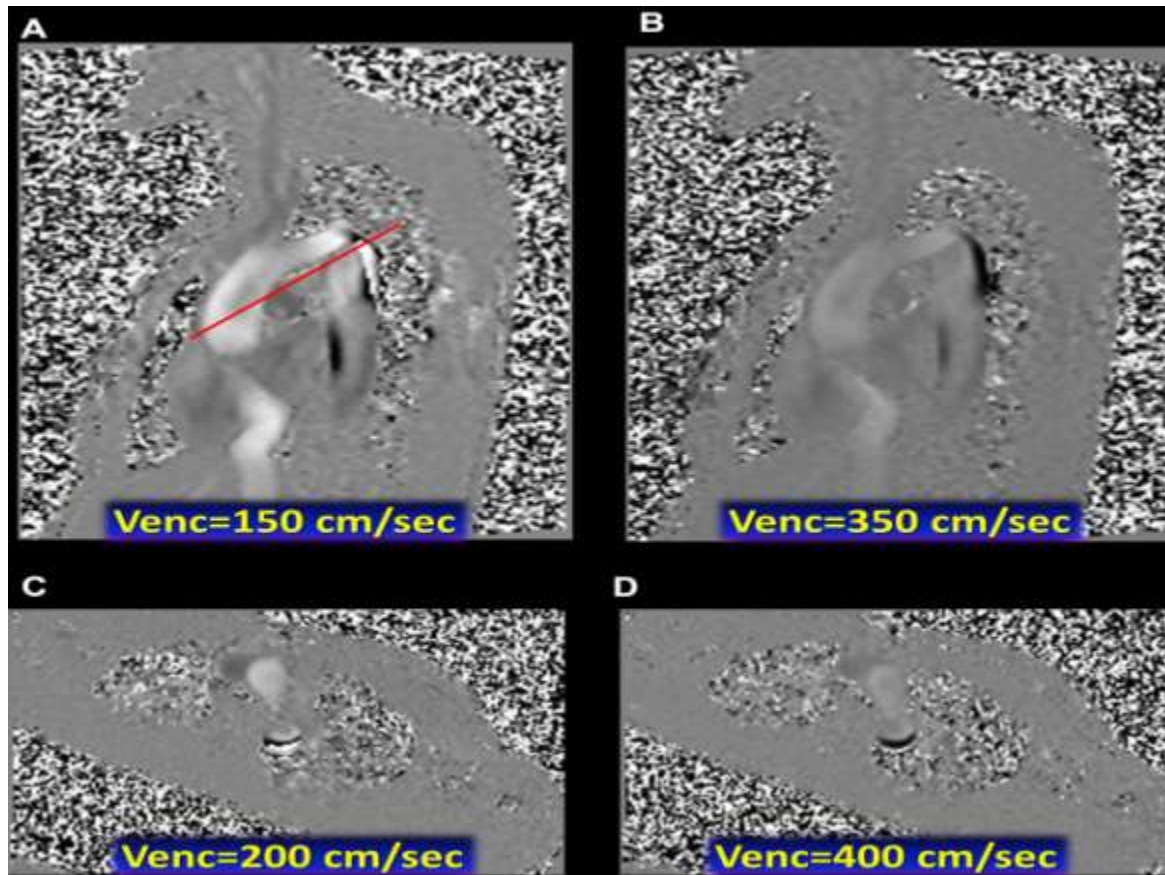
CMR FOR AORTIC COARCTATION INTERVENTIONS

- CMR IS THE FIRST IMAGING MODALITY FOR EVALUATION OF THE PATIENTS WITH AORTIC COARCTATION .
- BOTH ANATOMIC AND FUNCTIONAL HAEMODYNAMIC INFORMATION .
- CAN ALSO ASSESS COLLATERAL VESSELS , LV HYPERTROPHY AND BICUSPID AORTIC VALVE .
- PHASE CONTRAST MAGING IS USEFUL IN EVALUATING THE MAGNITUDE OF COLLATERAL FLOW .

CMR IN COA



CMR OF COA PATIENT USING PHASE CONTRAST IMAGING .



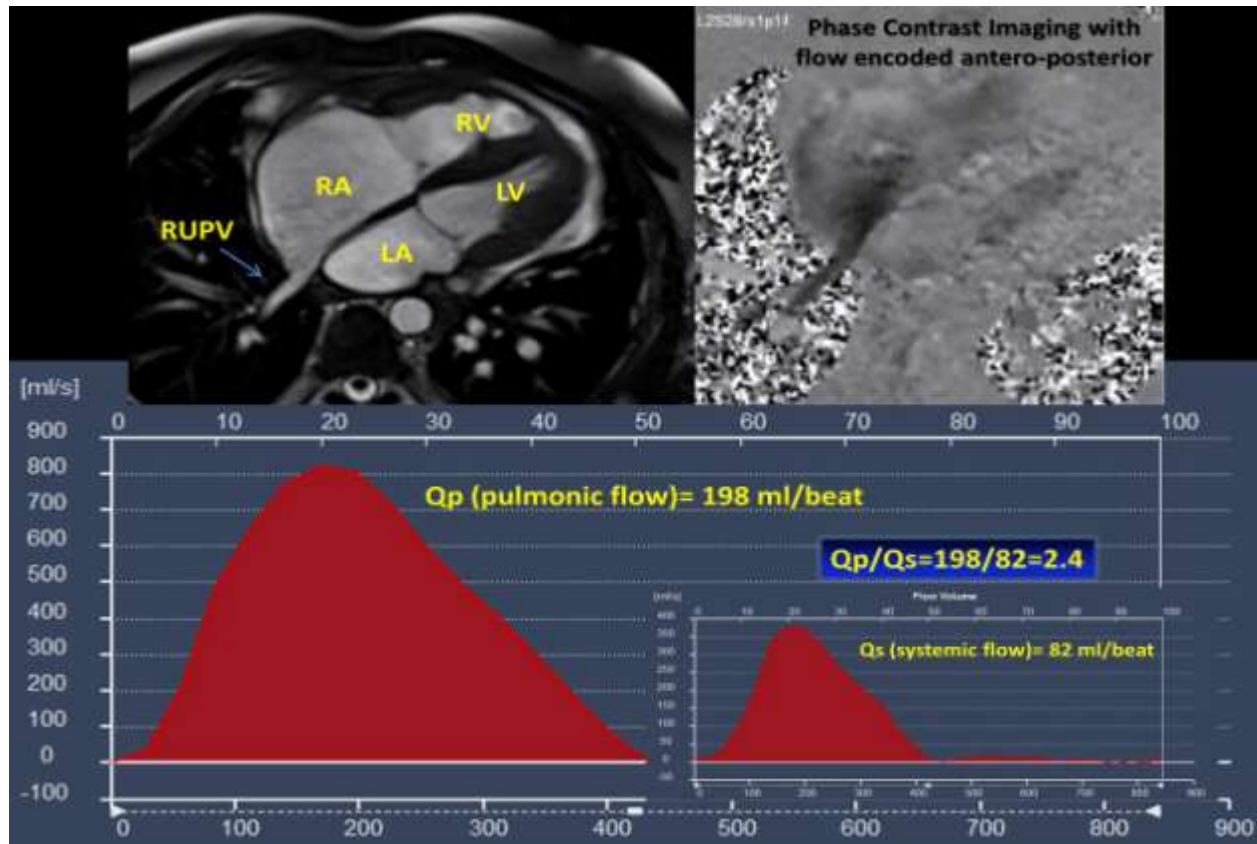
POST COA REPAIR

- CMR IS RECOMMENDED FOR ALL PATIENTS AFTER COA REPAIR (SURGERY OR STENTING).
- TO ASSESS POTENTIAL COMPLICATIONS LIKE STENT MIGRATION , PSEUDOANEURYSM, ENDOLEAK OR RECOARCTATION .

CMR FOR ANOMALOUS PULMONARY VEIN DRAINAGE.

- PAPV OFTEN REPRESENTS DIAGNOSTIC CHALLENGE .
- USUALLY SUSPECTED IN ECHO WITH RIGHT SIDED CHAMBER DILATATION .
- CMR IS MOST COMPREHENSIVE IN ASSESSING ANATOMY AND PATHOPHYSIOLOGY OF PULMONARY VEINS AT THE SAME TIME.

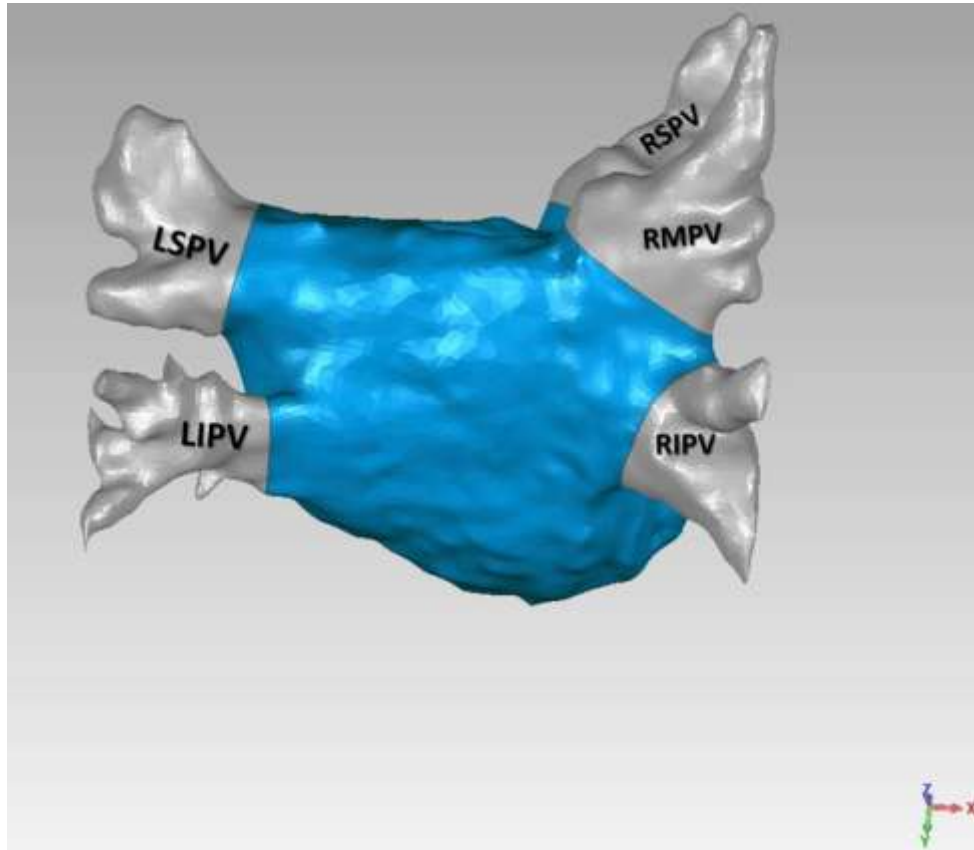
PHASE CONTRAST IMAGING IN PATIENTS WITH ANOMALOUS RIGHT UPPER PULMONARY VEIN



CMR FOR PULMONARY VEIN STENOSIS

- IS A POTENTIAL COMPLICATION AFTER PV ABLATION .
- MAY PRESENT WITH HAEMOPTYSIS,FEVER,PLEURITIC CHEST PAIN , DRY COUGH OR DYSPNOEA.
- ONSET IS 3 TO 6 MONTHS AFTER PROCEDURE
- CMR IS USED TO CONFIRM THE DIAGNOSIS.

CMR IMAGING OF PULMONARY VEIN .



SUMMARY

- TRANSCATHETER INTERVENTIONS FOR STRUCTURAL AND VALVULAR HEART DISEASE ARE AN EXCITING AND EVOLVING FIELD IN INTERVENTIONAL CARDIOLOGY .
- MULTIMODILARY IMAGING HAS CENTRAL ROLE FOR PREPROCEDURAL PLANNING ,INTRAPROCEDURAL GUIDANCE AND POST OPERATIVE SURVEILLANCE.
- NON INVASIVENESS OF CMR AND ITS ABILITY FOR A COMPREHENSIVE ,ACCURATE AND REPRODUCIBLE ASSESSMENT OF CARDIAC MORPHOLOGY AND FUNCTION ESTABILISHES CMR AS ONE OF THE KEY IMAGING MODALITIES IN THIS CONTEXT , ALONG WITH ECHO (TTE,TEE),CT SCAN.

THANK YOU.