MDCT Findings of Aortic Valve Regurgitation

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Learning objective: To show 64-slice MDCT usefulness for the comprehensive evaluation of aortic regurgitation, primarily focused on depiction of various causes of AR.

Etiologies of AR

Primary valve disease
- Rheumatic
- Congenital
  - bicuspid aortic valve
  - Outlet supracristal VSD
  - Discrete subaortic stenosis
- Endocarditis
- Other inflammatory disorders
- Degenerative
- Traumatic leaflet rupture

Secondary AR
- Aortic root dilatation
- Aortic dissection
  - Damage to aortic annulus
  - Prolapsing intimal flap with intact leaflets and annulus

Diagnostic imaging modalities

Chest X ray
- LV enlargement, dilatation of ascending aorta and aortic knob

Echocardiography
- Principal tool for diagnosis and grading of AR severity as well as serial follow-up

Aortic root angiography
- Invasive

MRI
- Preferred imaging modality for valve morphology and function, ventricular function, and additional cardiovascular information

MDCT
- Excellent spatial resolution for valve anatomy
- Retrospective ECG-gated images for valve mobility and LV function

Assessment of AR with 64-slice MDCT

- Leaflet morphology, thickening and calcification
- Valve leaflets in the end-diastolic phase
- Planimetric measurement of the regurgitant orifice area
- Aortic root dimension.
- AR/root involvement and coronary artery ostial involvement in case of type A aortic dissection.
- LV chamber size, wall thickness and LV function.

Manghat NE, et al, BJR 2008;81:275-290

Quantification of AR severity

- Direct planimetric measurement of the aortic valve anatomic regurgitant orifice area on 64-slice MDCT allow highly accurate differentiation between mild and moderate AR (sensitivity, 85%; specificity, 88%) and between moderate and severe AR (sensitivity, 100%; specificity, 95%), as determined with transthoracic echocardiography.

Alkadhi H, et al, Radiology 2007;245:111-21.

Acute aortic dissection with diastolic prolapse of intimal flap into the left ventricle

- Acute AR is a well-recognized complication in patients with Stanford type A aortic dissection (AD), occurring in 41% to 76% of patients.
- The incidence of intimal prolapse into the left ventricular outflow tract was < 2% of the type A AD examined with TEE.
- Coexistence of 3 conditions - Severe AR, circumferential dissection, and complete transaction of the intimal flap .
- The everted circumferential intimal flap creates a conduit between the ascending aorta and the left ventricle, prohibiting proper coaptation of the aortic valve leaflets and resulting in severe AR.
- A prolapsed aortic intimal flap can cause myocardial ischemia and cardiogenic shock by completely obstructing the coronary ostia during diastole.
- Treatment- Aortic valve repair and replacement of the ascending aorta with an interposition graft.

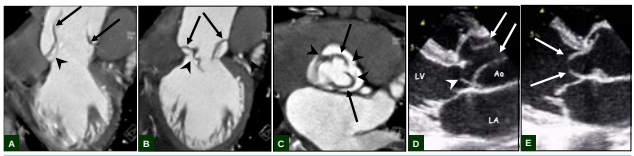


Fig. 11. Type A aortic dissection with AR in a 63-year-old man.
Multiplanar reformatted CT images (A-C) - Intimal flap (arrows) projecting into the aortic root and proximal ascending aorta during systole (A), prolapse of circumferentially dissected intimal flap through the plane of the aortic valve (arrowheads) during diastole, causing severe AR (B, C).
Echocardiographic images (D, E) - Back-and-forth movement of the intimal flap (arrows) in the aortic root and left ventricular outflow tract in the systolic (D) and diastolic phases (E).

Annuloaortic ectasia and Marfan syndrome

- **Annuloaortic ectasia (AAE)**
  - Dilatation of the proximal ascending aorta and aortic annulus
  - AR, thoracic aortic dissection, aneurysm and rupture
- **Marfan syndrome**
  - Autosomal dominant inherited disorder
  - Annuloaortic ectasia in 60%-80% of adults with Marfan SD
  - Aortic dissection, congestive heart failure, and cardiac valve disease are the most common causes of death in more than 90% of those affected by Marfan SD
- **AAE with AR**
  - Systolic tethering of leaflets due to dilatation of Valsalva sinus and diastolic triangular coaptation defect on MDCT
- **ECG-gated MDCT** provide a clear and detailed depiction of the structural features of the aortic root and the coronary arteries →important information for surgical planning and postoperative evaluation.

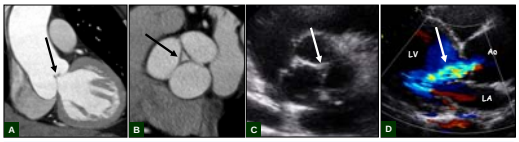


Fig. 1. AAE with AR in a 45-year-old woman.
Multiplanar reformatted CT images (A, B) - Aortic root dilatation with triangular coaptation defect (arrows) on mid-diastole.
Echocardiographic images (C, D) – Incomplete coaptation of aortic valve (C, arrow) and central moderate AR (a jet regurgitating into the left ventricle) (D, arrow)

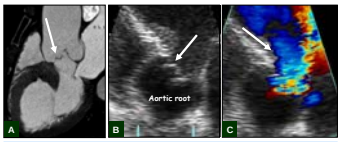


Fig. 2. AAE with AR in a 36-year-old man.
Multiplanar reformatted CT image (A) - Redundant right coronary cusp (arrow) with diastolic prolapse and coaptation defect.
Echocardiographic images (B, C) - Eccentric severe AR due to prolapse of right coronary cusp (B, arrow) and a jet regurgitating in the left ventricle (C, arrow).

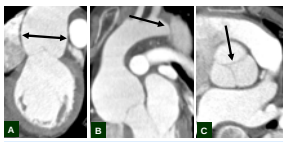


Fig. 3. AR and type B aortic dissection in Marfan SD .
Multiplanar reformatted CT images (A-C)
– Abnormal aortic root (double-ended arrow) with dilatation of Valsalva sinus and indistinct sinotubular junction (A), intimal flap at distal aortic arch (B, arrow), and coaptation defect on mid-diastole (C, arrow).

Aortic valve prolapse associated with outlet-type ventricular septal defect

- Association of outlet-type VSD with aortic valve prolapse, mainly right coronary cusp prolapse, and AR.
- The aortic cusp adjacent to the VSD has a characteristic deformity in which the nadir of the cusp is elongated and there is associated cusp prolapse with resultant insufficiency.
- AVP in juxta-arterial type VSD.
  - Incidence: 36-79%
  - Mechanism: lack of infundibular septal support, intrinsic discontinuity of aortic valve annulus and aortic media, and Venturi effect of the VSD jet.
- Risk factor for an early onset of AVP in outlet VSD - larger shunt and anterior malalignment.
- Predisposition to endocarditis
- Associated VSD may be closed by the prolapsing aortic sinus.

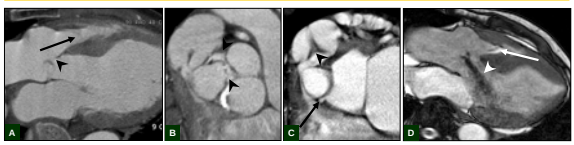
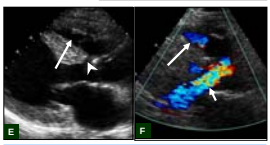


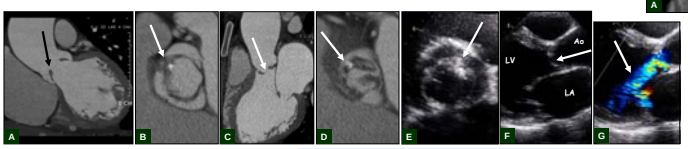
Fig. 12. Aortic valve prolapse associated with outlet VSD in a 71-year-old man.
Multiplanar reformatted CT images (A-C)
– Prolapse of elongated right coronary cusp (A, arrow) into the right ventricle, causing coaptation defect (arrowheads) on mid-diastole (A, B).
– A small perimembranous VSD (arrow) and a incomplete coaptation with thickened cusps of pulmonary valve (arrowhead) on mid-diastole (C).
Cine-MR image (D)
– A signal void (jet, arrowhead) in the left ventricular outflow tract and prolapse of elongated right coronary cusp (arrow) on diastole.



Echocardiographic images (E,F)
- Perimembranous VSD (E, arrowhead), prolapsed right coronary sinus with jet regurgitating into the right ventricle indicative of sinus Valsalva rupture (E, arrows), and jet regurgitating into the left ventricle (F, short arrow) during diastole.

Bicuspid Aortic Valve

- **Most common** congenital heart malformation (2% prevalence)
- **Complications** - Aortic stenosis and regurgitation (younger patients), infective endocarditis and aortic dilation and dissection
- Association with other cardiovascular malformation, including coarctation of aorta (50-80%), interruption of aorta (36%), ventricular septal defect (20%)
- **Anatomy** - unequal size, due to fusion of two cusps leading to one larger cusp, the presence of a central raphe and smooth cusp margin
- **Aortic regurgitation**
  - More common in younger patients compared with AS
  - Caused by redundancy and prolapse of the greater cusp or in association with dilatation of the aortic root and/or the sinotubular junction, aortic coarctation and endocarditis
  - Increased risk of endocarditis
  - Candidates for aortic valve repair in case of isolated AR



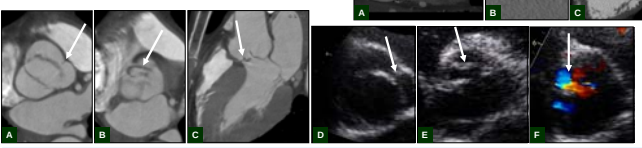


Fig. 4. Bicuspid aortic valve with AR in a 47-year-old man.
Multiplanar reformatted CT images (A-D) - Upcoming of thickened and partially calcified cusps of bicuspid aortic valve (arrows), dilated aortic root, and dilated left ventricle on mid-systole (A, B). Large coaptation defect (arrows) due to prolapsed cusps and dilated aortic root on mid-diastole (C, D).
Echocardiographic images (E-G) – Bicuspid AV with heavy calcification of anterior leaflet (E, arrow) and moderate or severe AR due to incomplete coaptation (F, arrow) and a jet regurgitating into the left ventricle during diastole (G, arrow).

Fig. 5. Bicuspid aortic valve with AR in a 52-year-old man.
Multiplanar reformatted CT images (A-C) - A central raphe (arrow) in the larger, thickened cusp on mid-systole (A), coaptation defect (arrows) due to prolapsed anterior cusp on mid-diastole (B, C).
Echocardiographic images (D-F) - Bicuspid AV with a central raphe in anterior cusp on systole (D, arrow), prolapse of anterior cusp (E, arrow), and jet regurgitating into the left ventricle (F, arrow) during diastole.

Rheumatic aortic valve disease

- The most common aortic lesion is a combination of stenosis and regurgitation.
- A minimal degree of AR occurs frequently in mild rheumatic involvement.
- Valve deformity
  - fusion of the cusps at the commissures
  - rigidity and shortening of the cusps alone
  - combinations of both processes with calcification superimposed
- Regurgitant jet is usually central.
- Concomitant mitral valve involvement is common.

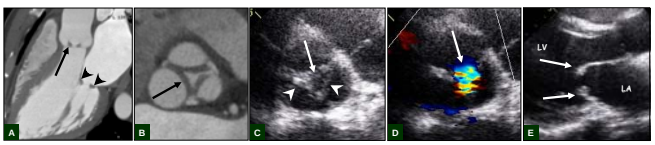


Fig. 6. Rheumatic aortic and mitral valvular diseases in a 38-year-old man.
Multiplanar reformatted CT images (A, B) - Thickened aortic cusps (arrows) with a triangular coaptation defect, thickened mitral leaflets with stenosis of mitral valve orifice (arrowheads), and dilatation of left ventricle and on mid-systole.
Echocardiographic images (C-E) – Fibro-thickened three cusps of aortic valve (C, arrowheads) and incomplete coaptation with AR (C, D, arrows), and the doming motion and hockey stick appearance of mitral leaflets (E, arrows), which is the typical example of rheumatic involvements.

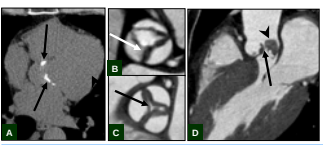


Fig. 7. Rheumatic aortic stenosis and regurgitation in a 66-year-old man.
Unenhanced CT (A) - Aortic valve calcification (arrows).
Multiplanar reformatted CT images (B-D)
– Thickened and calcified aortic cusps with commissural fusion of left and non-coronary cusps (arrow) and stenosis of aortic valve orifice on mid-systole (B).
- Incomplete coaptation (arrows) with thickened aortic cusps, especially polypoid left cusp (arrowhead) on mid-diastole (C, D).

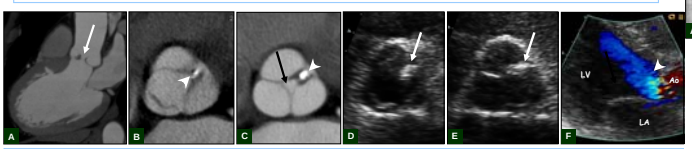


Fig. 8. Rheumatic AR in a 70-year-old man.
Multiplanar reformatted CT images (A-C) - Fusion of thickened and calcified right and left coronary cusps at the commissure (arrowheads) with asymmetric systolic opening and incomplete diastolic coaptation (arrows) of aortic valve.
Echocardiographic images (D-E) - Calcified right and left coronary cusps (arrows) at the commissure during systole (D) and diastole (E), and a jet regurgitating into the left ventricle (moderate AR, arrowhead) during diastole (F).

Sinus of Valsalva aneurysm (SVA)

- Congenital or acquired, with aortic valve endocarditis being the most common cause.
- Symptoms by compression or direct rupture into an adjacent chamber.
- Most right coronary sinus aneurysm rupture into the right ventricle.
- Non-coronary sinus aneurysm ruptures occasionally into the right atrium.
- Ventricular septal defect is the most common associated abnormality (12-53%)
- **Aortic regurgitation** is the second most common associated lesion.
  - Aortic valve replacement in > ⅓ the patients with AR.
  - More common in patients with ruptured SVAs.
- Once rupture has occurred, mean survival is 1 to 2 years (due to congestive heart failure).
- When an unruptured aneurysm is detected, operation has value in preventing further complications.

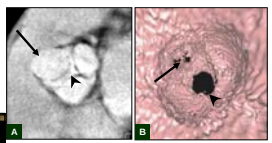


Fig. 13. Sinus Valsalva aneurysm rupture in a 42-year-old man.
MPR image of aortic valve (A) – Isolated aneurysm of right coronary sinus of Valsalva (arrow) and coaptation defect (arrowhead) of aortic valve on mid-diastole.
Virtual endoscopic image (B) – Rupture of right coronary sinus of Valsalva aneurysm (arrow) and coaptation defect of aortic valve on mid-diastole (arrowhead).

Degenerative aortic valve disease

- Progressive dystrophic calcification of the valve cusps → immobilized cusps.
- Result from years of normal mechanical stress on the valve.
- No commissural fusion.
- Calcific aortic stenosis is commonly accompanied by calcifications of the mitral annulus and coronary arteries but rarely by aortic regurgitation.
- Regurgitant jet is usually not discrete jet.

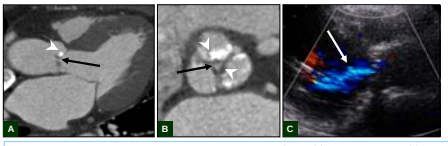


Fig. 14. Degenerative severe aortic stenosis accompanied by mild AR in a 72-year-old man.
Multiplanar reformatted CT images (A, B) – Thickened, calcified cusps of aortic valve (arrowheads) and incomplete coaptation (arrows) on mid-diastole (A, B).
Echocardiographic image (C) – A central jet regurgitating into the left ventricle during diastole (mild AR, arrow).

Infective endocarditis

- Endovascular microbial infection of intracardiac structures facing the blood.
- 60-80% of patients with endocarditis have an predisposing cardiac lesions
  - degenerative or congenital heart disease, mitral valve prolapse, or rheumatic heart disease.
- Mitral valve is most commonly affected, followed by the aortic valve.
- Local complications occur in the valve itself or in the perivalvular region
  - Vegetation, perforation, aneurysm of Valsalva sinuses, annular abscess, tunnel, fistula, chordal rupture.
- Healed endocarditis – indentation of the free margin and/or perforation of the body of the cusps with thick edges, cusp aneurysms, ruptured chordae tendineae, and healed fistulae.

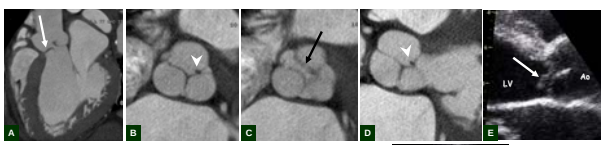


Fig. 9. AR in a 49-year-old woman with infective endocarditis.
Multiplanar reformatted CT images (A-D) – Prolapse of right coronary cusp (arrows) with a small vegetation (arrowheads) on mid-diastole, causing lack of coaptation of aortic valve.
Echocardiographic images (E-G) – Prolapse of the right coronary cusp (arrow) into the left ventricular outflow tract and jet regurgitating into the left ventricle (arrowhead) during diastole (E,F), and a 9-mm highly mobile vegetation at the right coronary cusp of aortic valve (G, arrow).

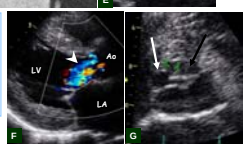
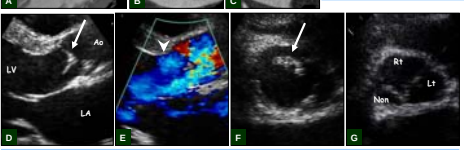


Fig. 10. Infective endocarditis with severe AR in a 35-year-old man who underwent aortic valve-sparing aortic annuloplasty.
Multiplanar reformatted CT images (A-C) – Prolapse of right coronary cusp (arrows) with a tubular vegetation (arrowheads) on mid-diastole, resulting in large coaptation defect of aortic valve.

Interesting Case



Echocardiographic images (D-G) - Prolapse of the right coronary cusp (arrow) into the left ventricular outflow tract and a jet regurgitating into the left ventricle (arrowhead) during diastole (D, E), a 11-mm oscillating mass (vegetation, arrow) at the right coronary cusp of aortic valve (F, arrow), and lack of coaptation of aortic valve due to prolapsed right coronary cusp (G).

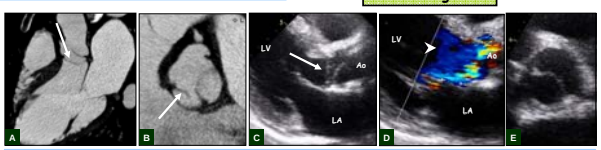


Fig. 15. Severe AR in a 37-year-old man who had bicuspid AV and underwent aortic valve-sparing aortic annuloplasty.
Multiplanar reformatted CT images (A, B) - Prolapse of anterior coronary cusp (arrows) into the left ventricular outflow tract (LVOT) with a large coaptation defect of AV on mid-diastole.
Echocardiographic images (C-E) - Prolapse of anterior coronary cusp (arrow) into the LVOT and jet regurgitating into the LV (arrowhead) during diastole (C, D). Lack of coaptation of aortic valve due to prolapsed anterior coronary cusp (E).

Clinical Implications and Conclusion

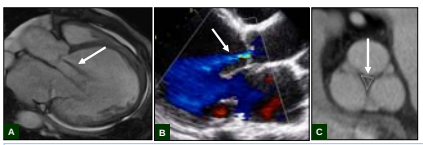


Fig. 16. Dilated cardiomyopathy with mild AR in a 66-year-old woman.
Cine-MR (A) and echocardiographic images (B) – A jet regurgitating into the LV (arrows).
MDCT image (C)- incomplete coaptation of AV (arrow) and regurgitant orifice area 21 mm²

- **CT imaging** has developed rapidly into an alternative imaging tool in patients who require exact assessment of the opening or regurgitant orifice of the aortic valve and in whom other more commonly used methods fail to provide all relevant information.
- Although functional imaging of the aortic valve, including true flow data and calculation of a pressure gradient along the aortic valve cannot be achieved using CT, as with echocardiography and magnetic resonance imaging (Fig. 16 A, B), **MDCT is able to assess aortic valve morphology and regurgitant severity** (Fig. 16 C) **and thus its further expanding role in cardiac imaging.**