The Heart

Imaging of the heart will be considered under the following headings:

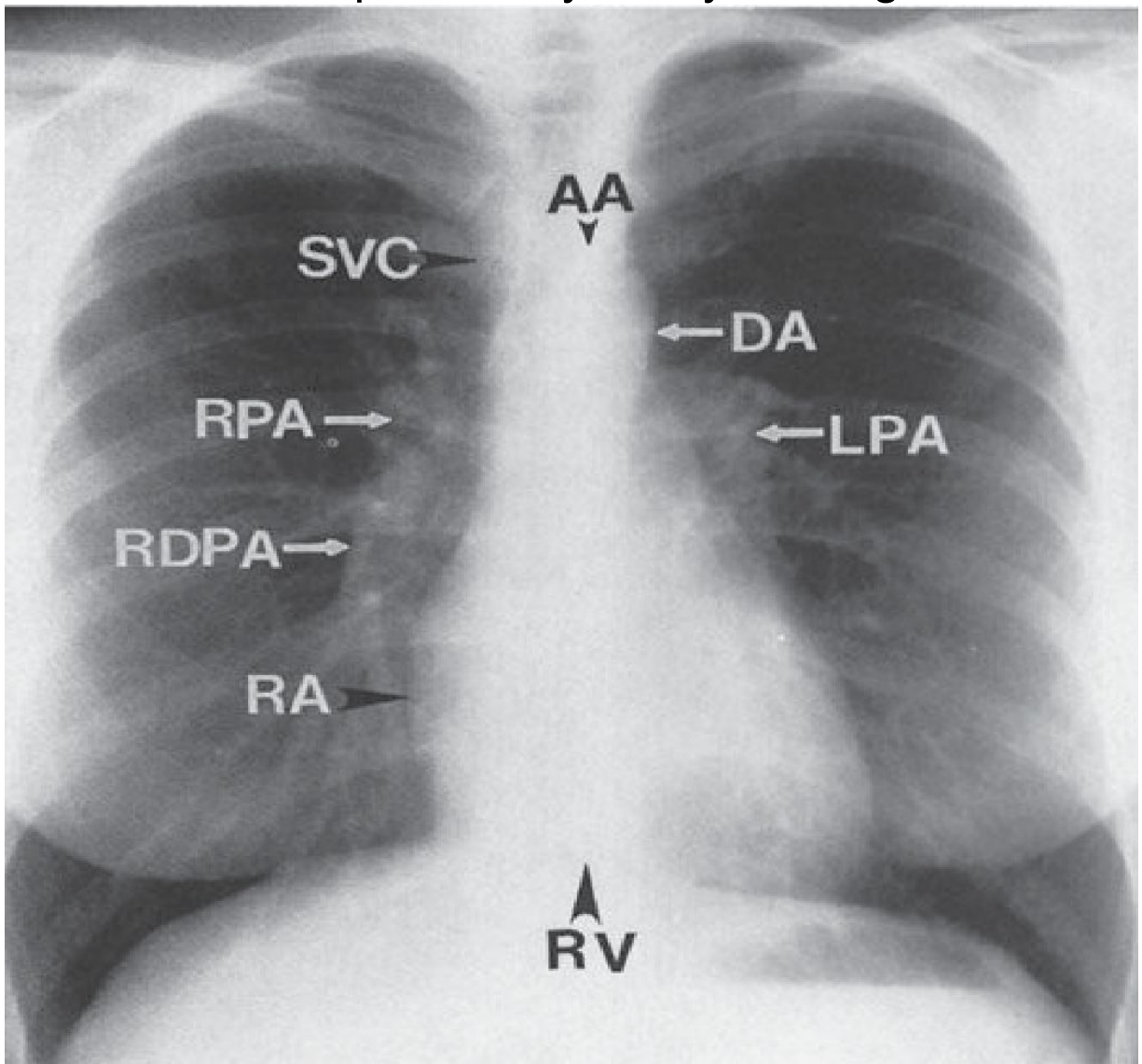
- 1. Simple x-ray
- 2. Screening
- 3. Cardiac catheterization
- 4. Angiocardiography
- 5. Coronary arteriography
- 6. Ultrasound
- 7. Isotope scan
- 8. MRI

Simple x-ray

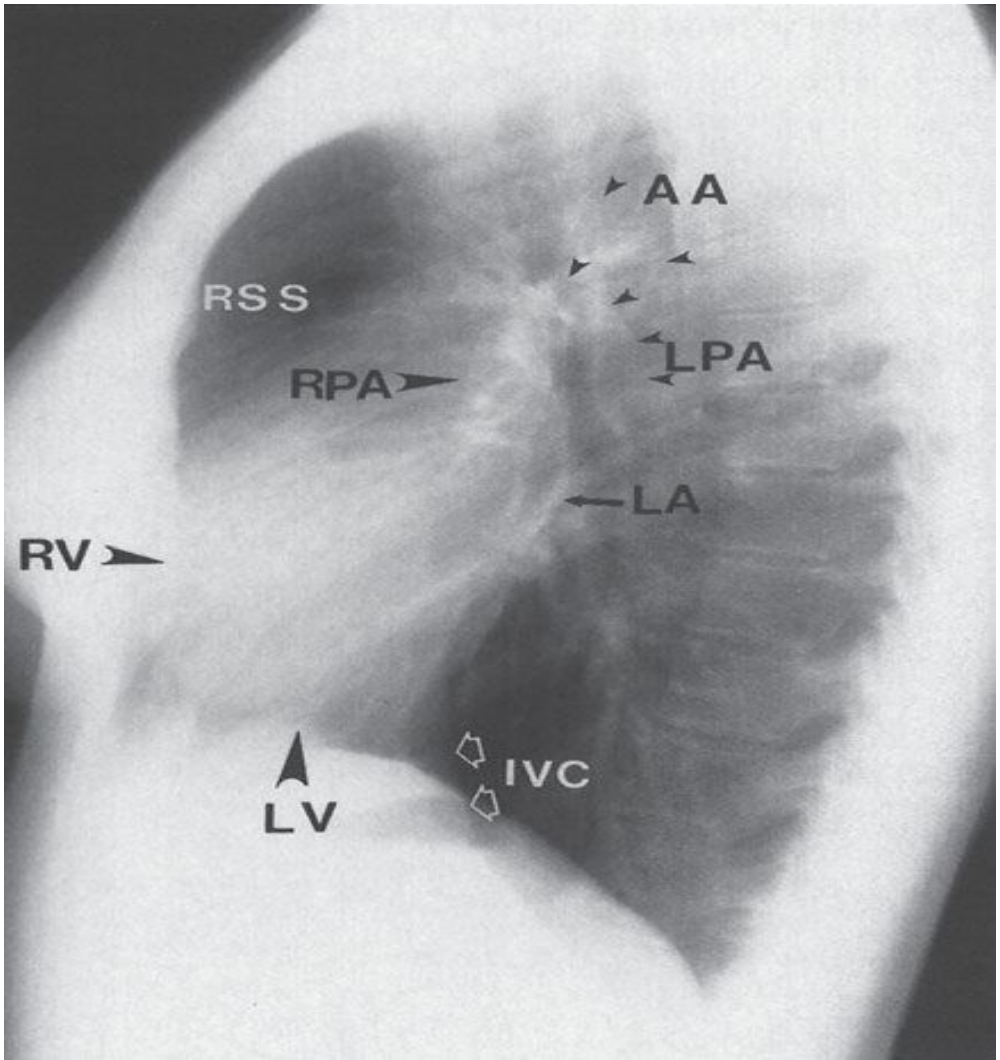
A simple x-ray of the chest is mandatory as the first imaging investigation in cases of heart disease, because it yields vital information concerning of the

- 1. size of the heart
- 2. enlargement of individual chambers
- 3. condition of the lung fields

PA view of normal chest. RA, right atrium; RDPA, right descending pulmonary artery; RPA, right main pulmonary artery; SVC, superior vena cava; AA, aortic arch; DA, proximal descending thoracic aorta; LPA, left pulmonary artery; RV, right ventricle.



Lateral view of normal chest. RV, right ventricle; RSS, retrosternal clear space; AA, ascending aorta; LPA, left pulmonary artery; RPA, right pulmonary artery en face; IVC, inferior vena cava; LA, left atrium; LV, left ventricle.



Screening

Cardiac calcification is seen at screening with an image intensifier than on a simple film.

Calcification is most commonly seen:

- in the mitral or aortic valves
- but may also be seen in atheromatous coronary arteries, in the mitral annulus
- or in a left atrium containing mural thrombus

Echocardiography

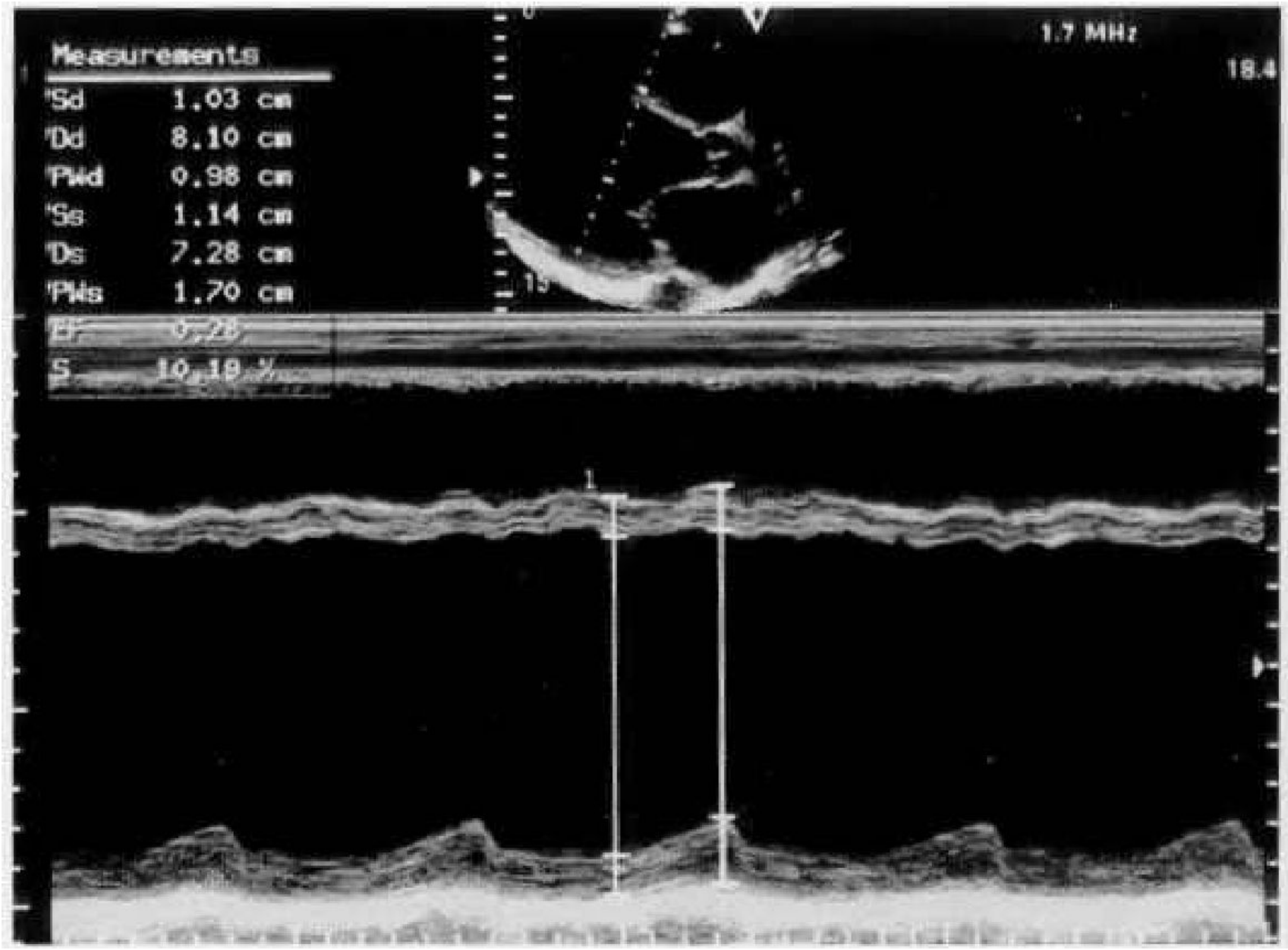
- 1. Echocardiography is a highly versatile technique, which is central in cardiological diagnosis but is operator dependent and requires considerable experience.

- 2. Echocardiography is performed from the transthoracic route using a sector probe.

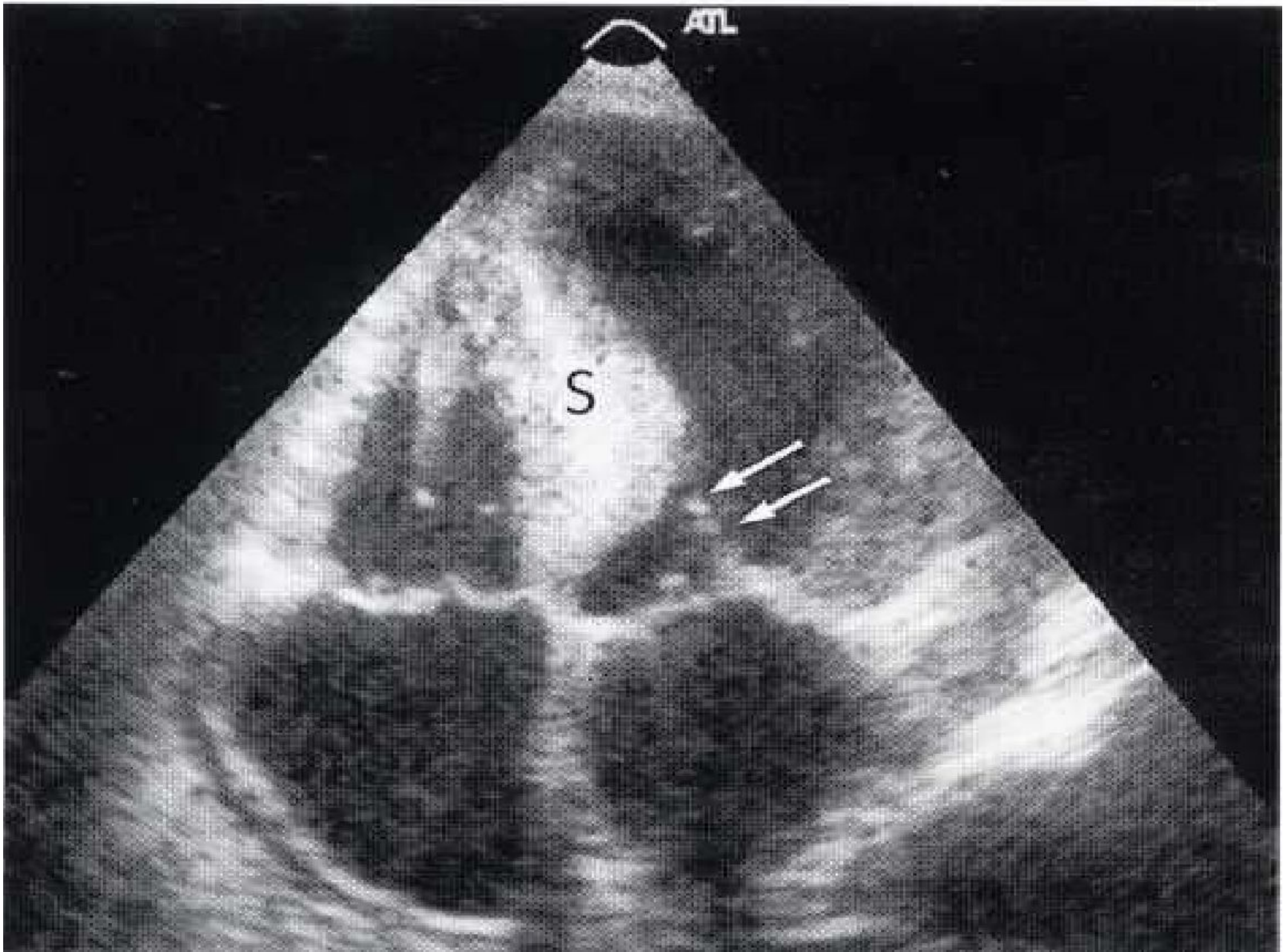
- 3. Patient is positioned in a 45 degree semierect position rotated towards his/her left side to enhance cardiac contact with chest wall.
- 4. Two-dimensional imaging gives direct information about the anatomy and physiology of the heart
- 5. M-mode is a one-dimensional evaluation useful for precise measurement and timing of cardiac events.

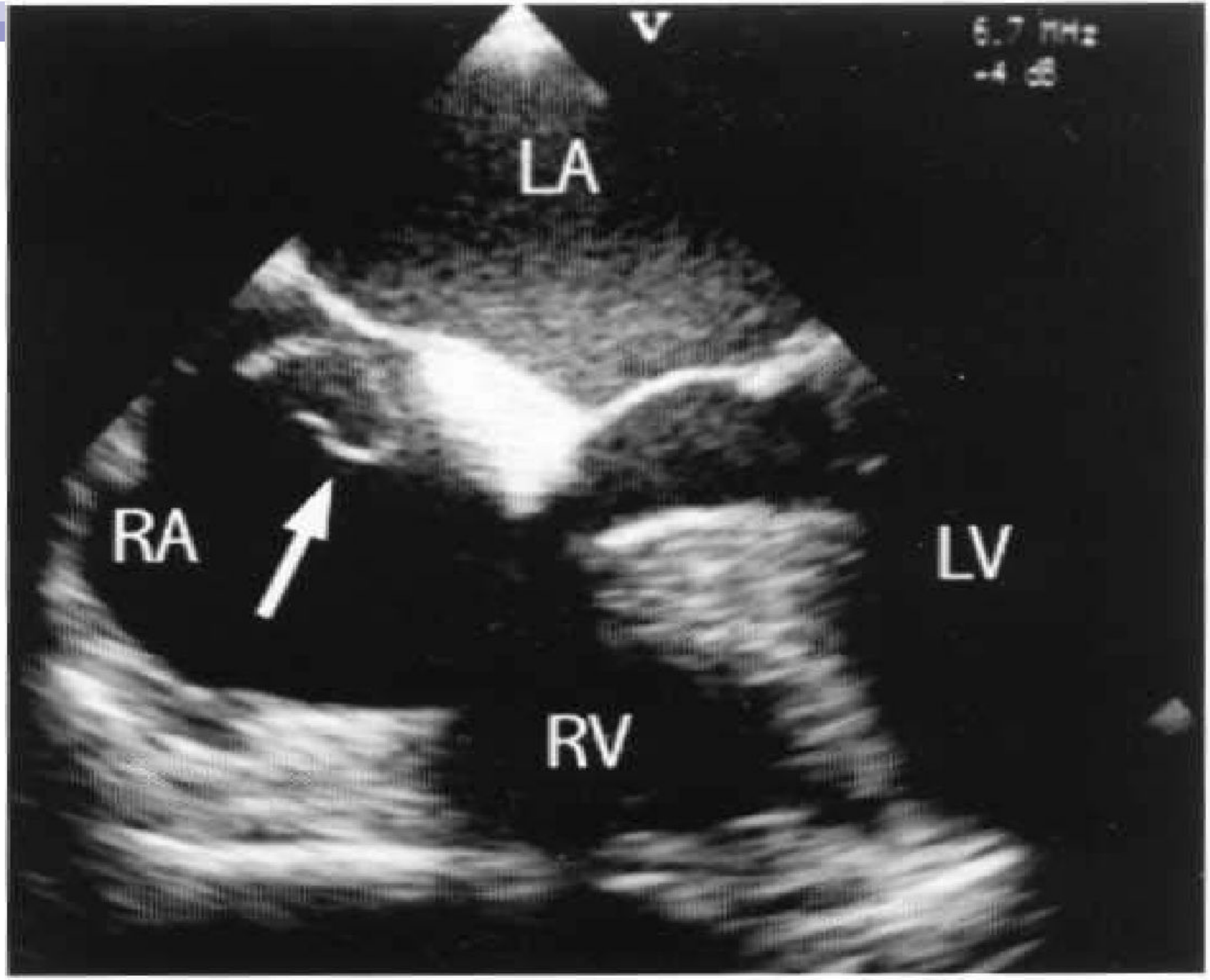
Echocardiography

an aneurysm of the apex of the left ventricle


Measurements
'Sd 1.03 cm
'Dd 8.10 cm
'PWd 0.98 cm
'Ss 1.14 cm
'Ds 7.28 cm
'PWs 1.70 cm
S 10.19 %
1.7 MHz
18.4
15
1

Apical four-chamber transthoracic echocardiogram in a patient with hypertrophic cardiomyopathy.



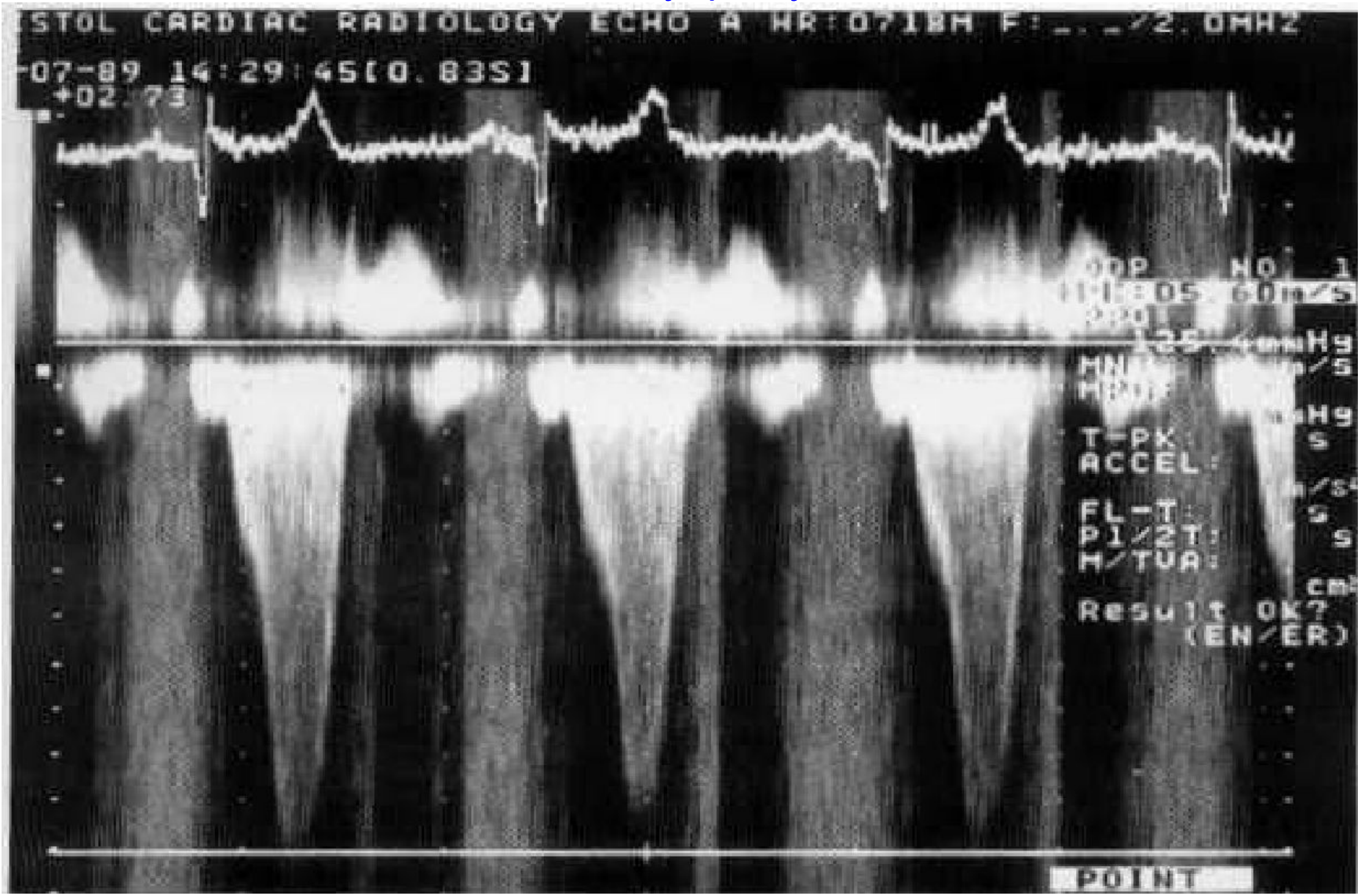

LA
RA
LV
RV

Doppler examination

Doppler evaluation allows the study

- 1. of different flow velocities within the cardiac chambers and in the outflow tracts
- 2. calculation of the cardiac output, ejection fraction

Apical continuous-wave Doppler trace in a patient with dynamic left ventricular outflow tract obstruction due to hypertrophic cardiomyopathy.



Cardiac catheterization

- This procedure requires the introduction of a catheter into the heart and manipulation of its tip under screen control so as to enter different chambers of the heart or to pass through abnormal defects of communications.

Right heart catheterization

- This can be performed percutaneously or after surgical exposure of a vein in the arm or groin, and passage of a catheter from there to the right. The tip is manipulated into the right ventricle or beyond into the pulmonary artery or lung fields. If there is an atrial septal defect, ventricular septal defect, or patent ductus present, the catheter may be passed to the left atrium, left ventricle or aorta through the defect.

- The site of the catheter tip can be confirmed by taking pressure recordings during the investigation and also by taking blood samples which are examined for oxygen saturation. The pressure recordings and oxygen saturation levels are of vital importance in the diagnosis of the different forms of congenital heart disease.

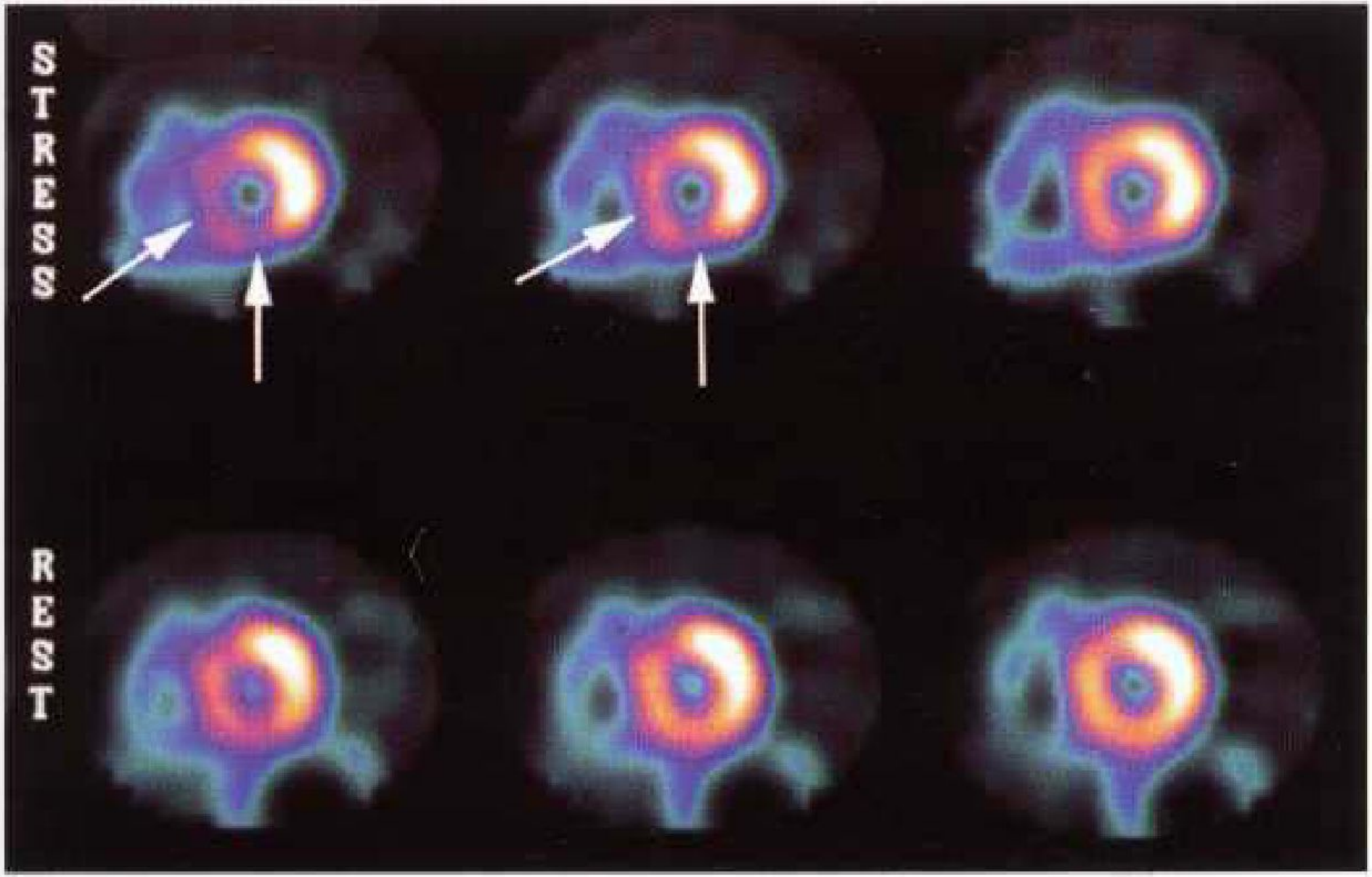
Left heart catheterization

- The usual technique of left heart catheterization is for the radiologist to introduce a catheter percutaneously into the femoral artery and to pass it under screen control into the aortic arch and through the aortic valves into the left ventricle. Pressures are obtained from inside the ventricle recorded, as is a withdrawal pressure trace into the aorta.

Isotope scanning

- Technetium-99m pyrophosphate accumulates in damaged myocardium whereas thallium-201 produces a deficient uptake in territories supplied by occluded or narrowed arteries. Thallium is most commonly used as a screening technique in patients with suspected coronary artery disease.

demonstrates a partially reversible perfusion defect in th interventricular septum and posterior wall of the left ventricle

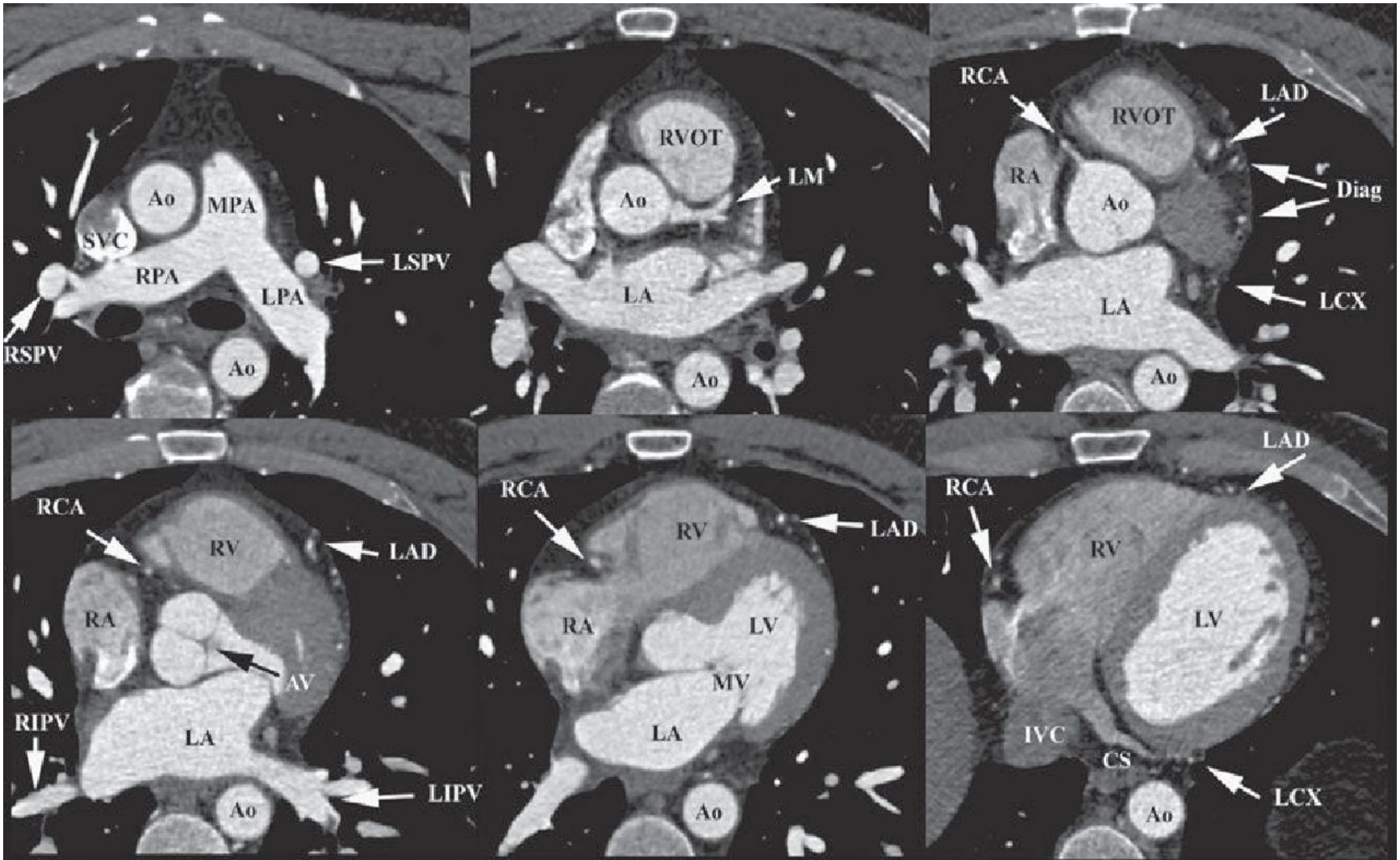


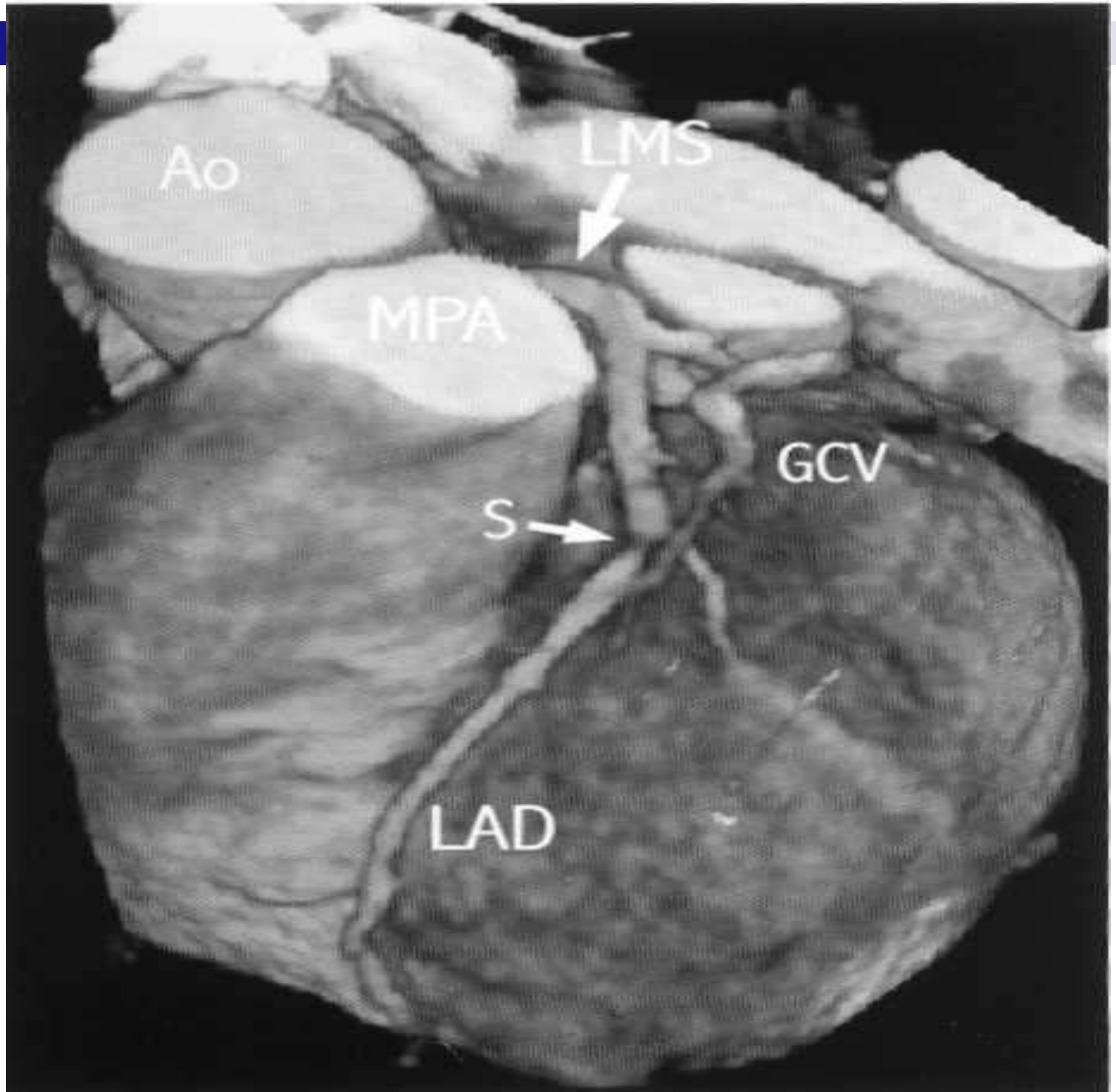
CT scan

CT evaluation of the heart is useful for detecting:

- 1. the atherosclerotic disease of the coronary vessels
- 2. myocardial calcifications and aneurysmal
- 3. dilatations and dissection of aorta
- 4. CT is the investigation of choice for the evaluation: of cardiac tumors like myxoma, for pericardial diseases like effusion and pericardial tumors and dissection of aorta

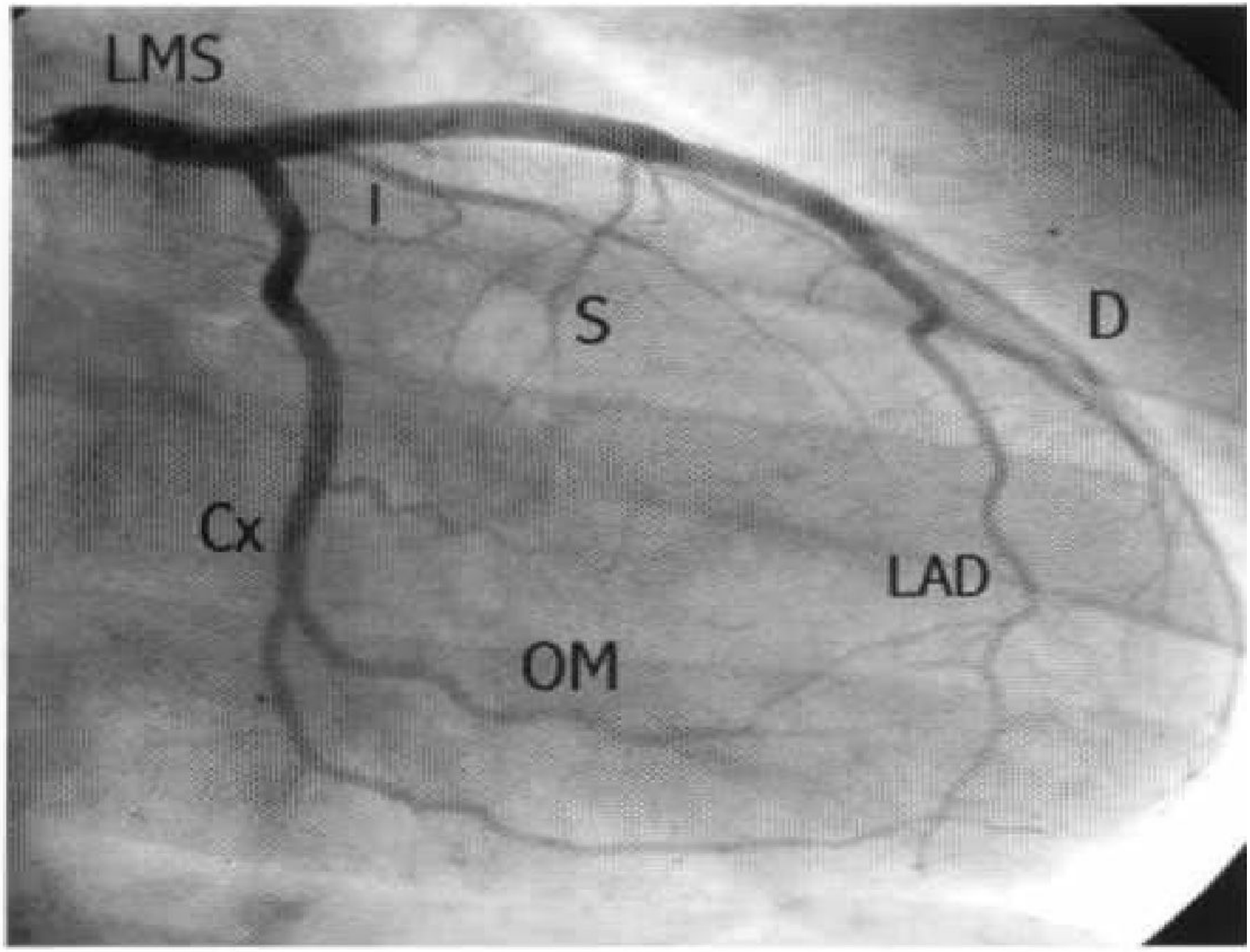
Axial composite image




Ao
LMS
MPA
GCV
S
LAD

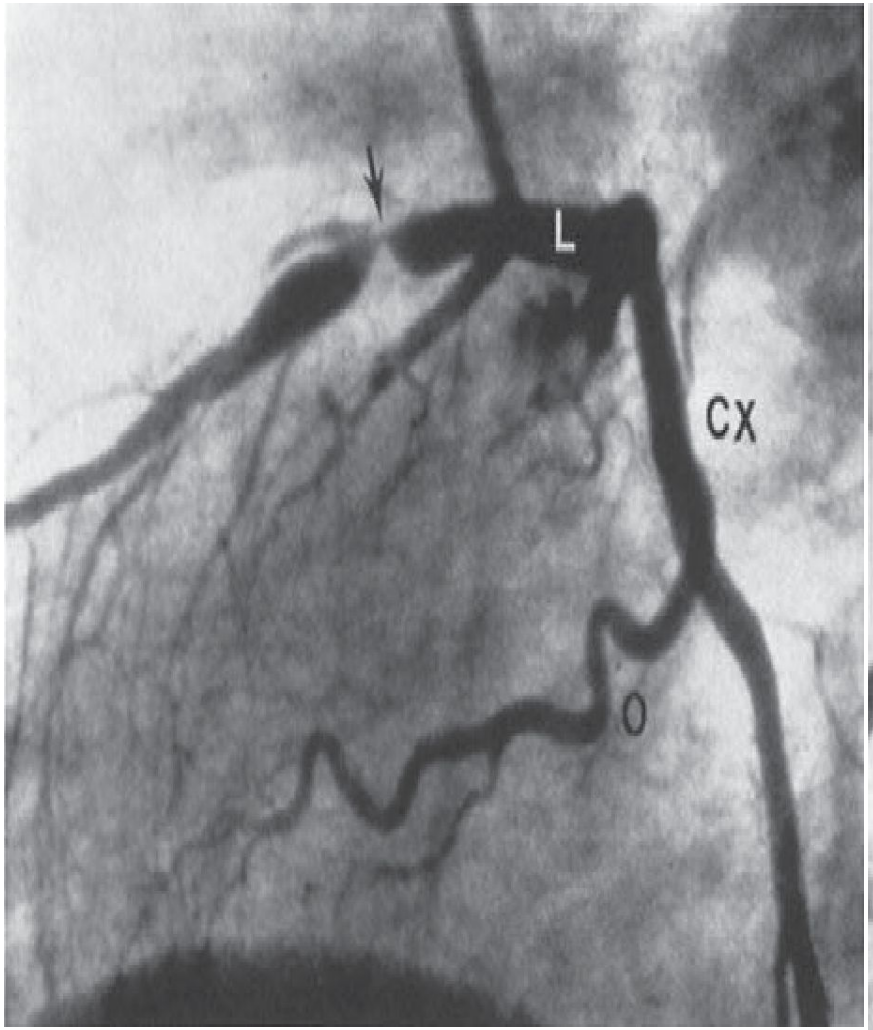
Arteriography

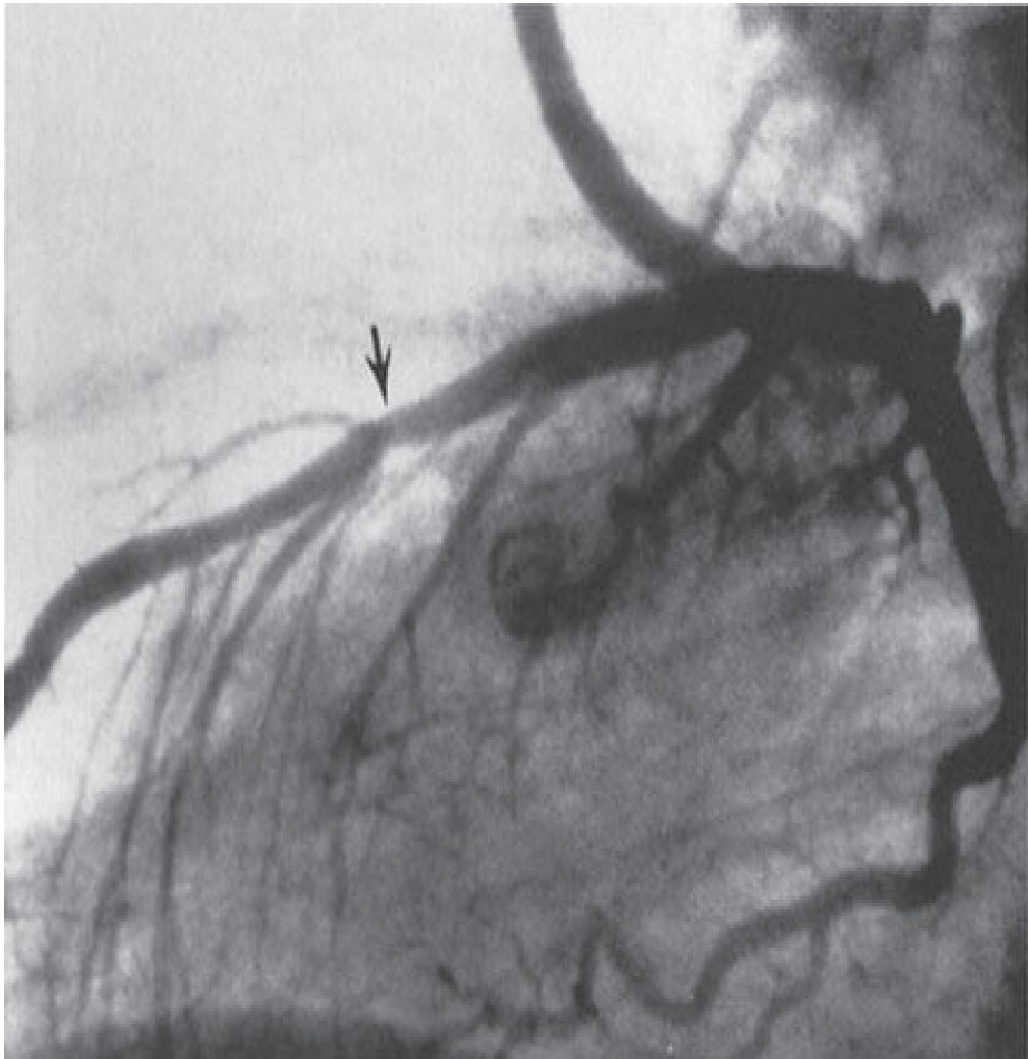
- Vascular access is usually obtained using a percutaneous approach via the femoral artery. Any major vessel or blood supply to an organ can be studied by selective arterial cannulation with contrast injection. Radial, brachial, axillary or popliteal arteries can also be punctured percutaneously, if femoral artery access is unsuitable. Anatomical detail is excellent; hemorrhage and arterial thrombus are recognized rare local complications.



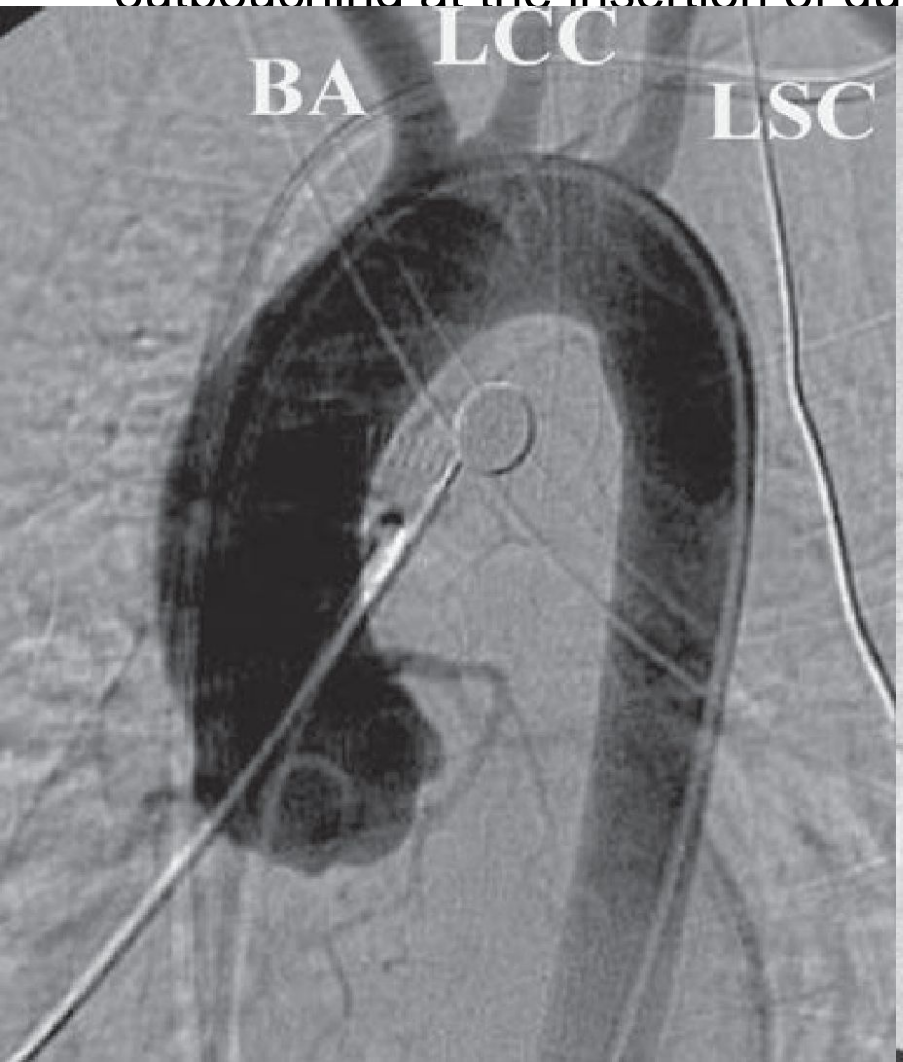
A

(B) Coronary arteriogram, same projection and patient as in (A), obtained
1 day later. The stenosis in the left anterior descending coronary artery (arrow) has been reduced after percutaneous
balloon angioplasty.





Normal aortogram of transverse arch in patient suspected of having traumatic aortic injury.
(**B**)Aortogram in a patient with acute traumatic aortic injury. The site of injury is the focal
outpouching at the insertion of ductus arteriosus (arrow).



Intravenous digital subtraction angiography

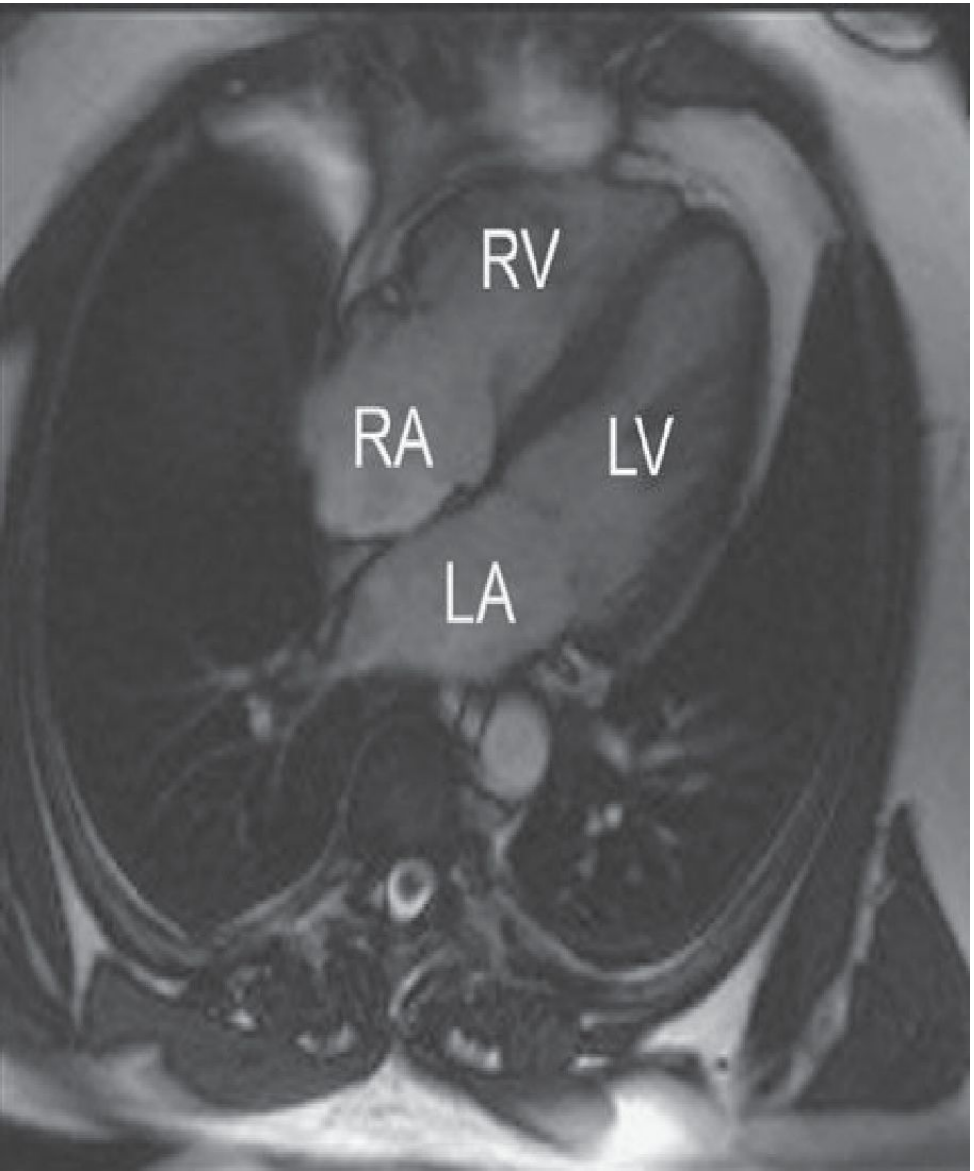
- This technique is utilized to visualize the arterial system by injection of a bolus of contrast into the superior vena cava. After passage through the heart and lungs, the dilute contrast may be imaged in the arterial circulation by computer subtraction. Resolution is not as detailed as conventional arteriography, but can be an effective investigation in many clinical situations.

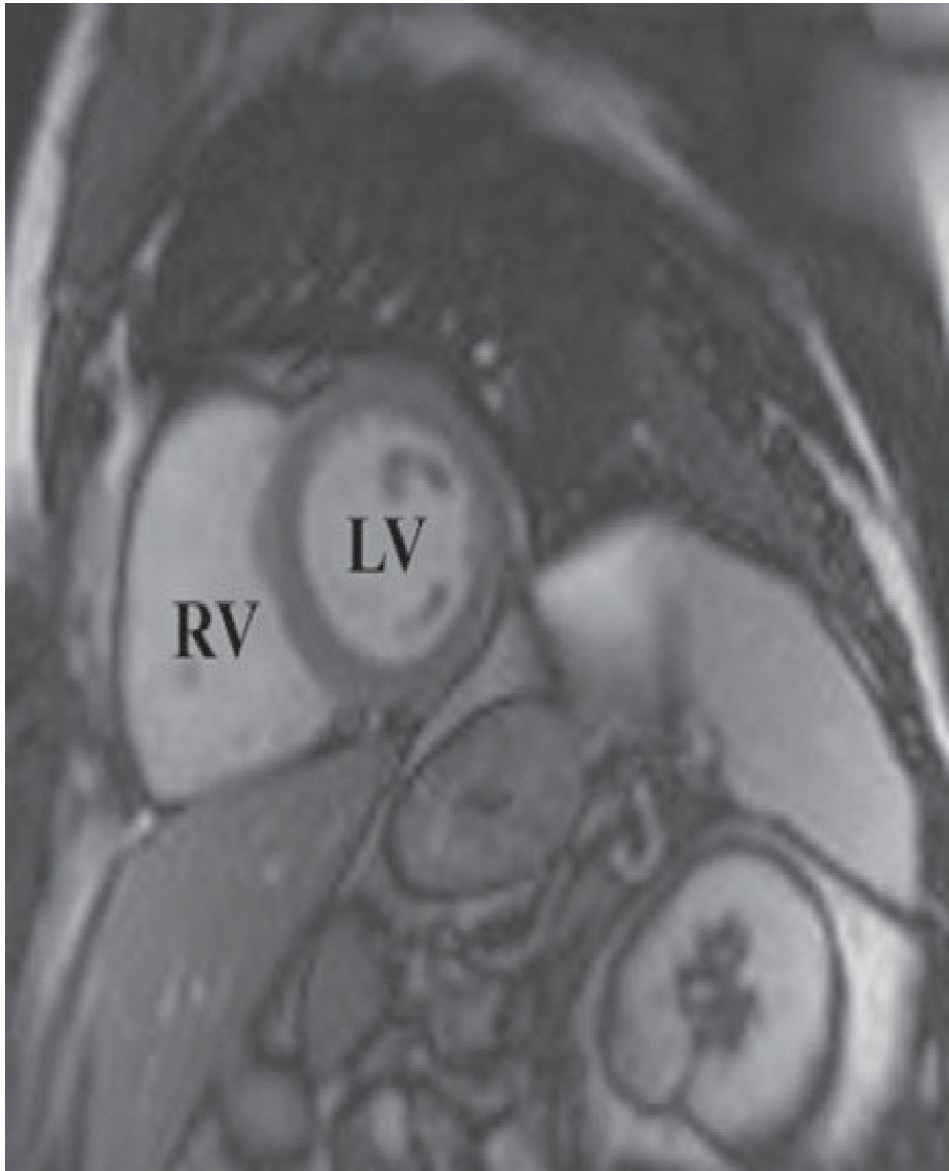
MRI

- MRI is fast gaining popularity as the investigation of choice in most cardiac pathologies. Assessment of the flow velocities in different cardiac chambers and outflow tracts helps in estimating the ejection fraction, cardiac output.

- Perfusion scanning gives the estimation of the surviving and infracted myocardium following myocardial infarction.
- Cardiac tumors and pericardial diseases are also better evaluated with MRI.
- MRI is the investigation of choice in the evaluation of congenital heart diseases, can help in quantifying shunt.

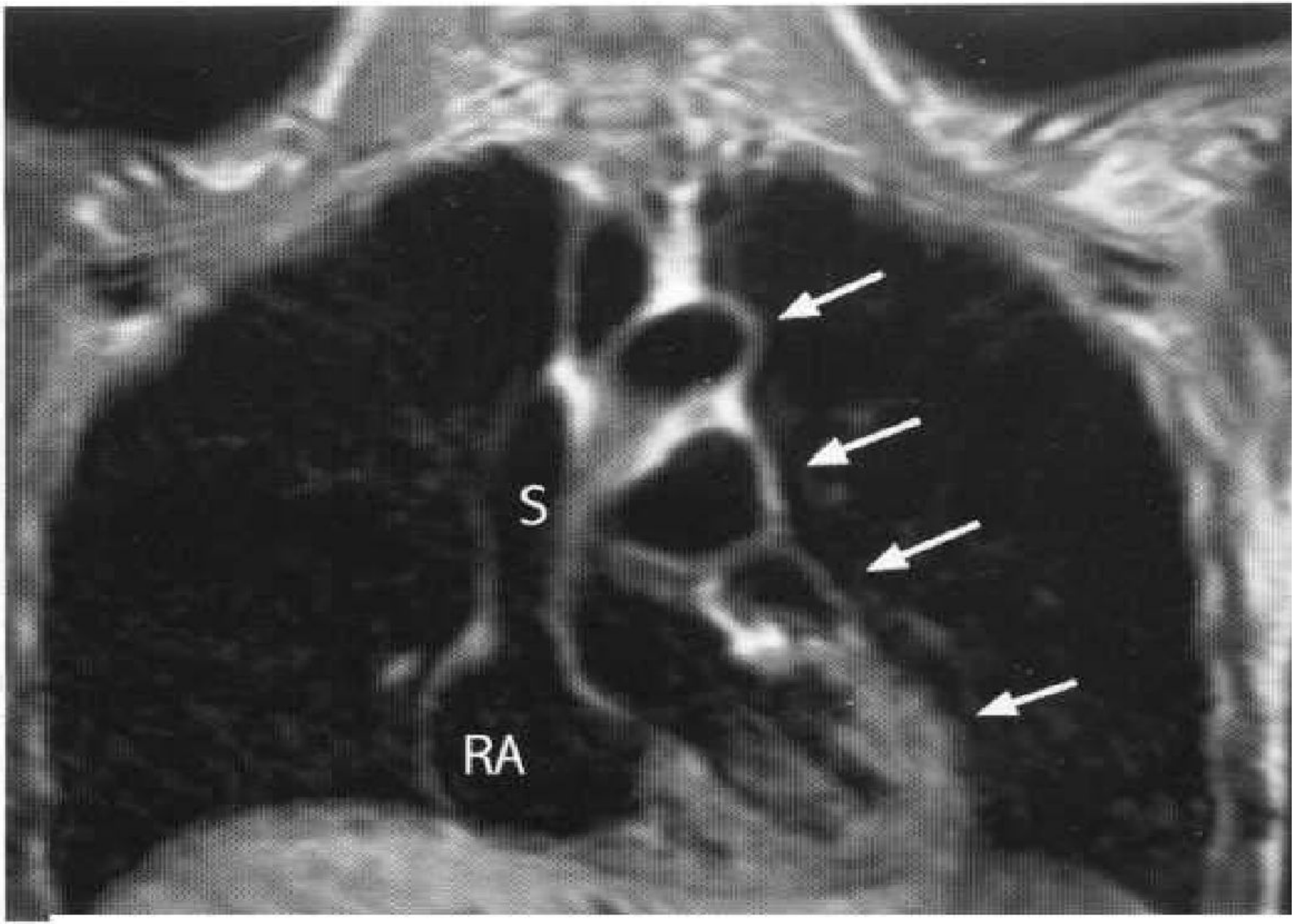
MRI image





MRI image

MRI image



Cardiac pulsation

- Normally, pulsation on the left border is much more prominent than on the right side. During systole the left border is seen to contract forcibly and during diastole it moves outwards from 2mm. After left ventricular contraction the shadow of the pulmonary conus and the aortic knob bulge forcibly outwards.
- On the right side the lower border formed by right auricle shows a faint contraction of not more than 1 mm. Pulsation is greater in children than in adults and increases after exercise.

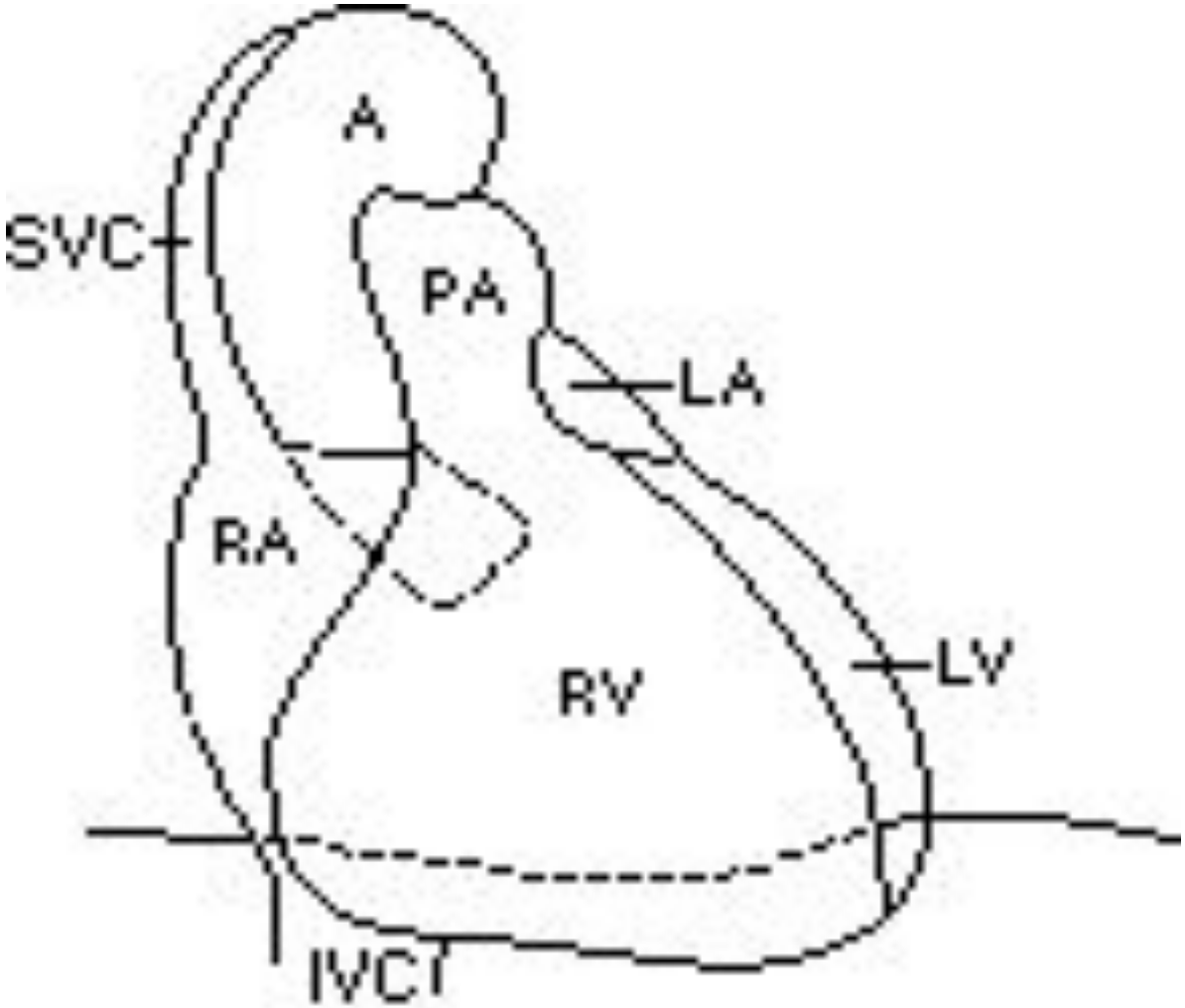
Posterioanterior Projection

the upper right border is formed by:

- 1. the SVC
- 2. the lower cardiac border is formed by the RA

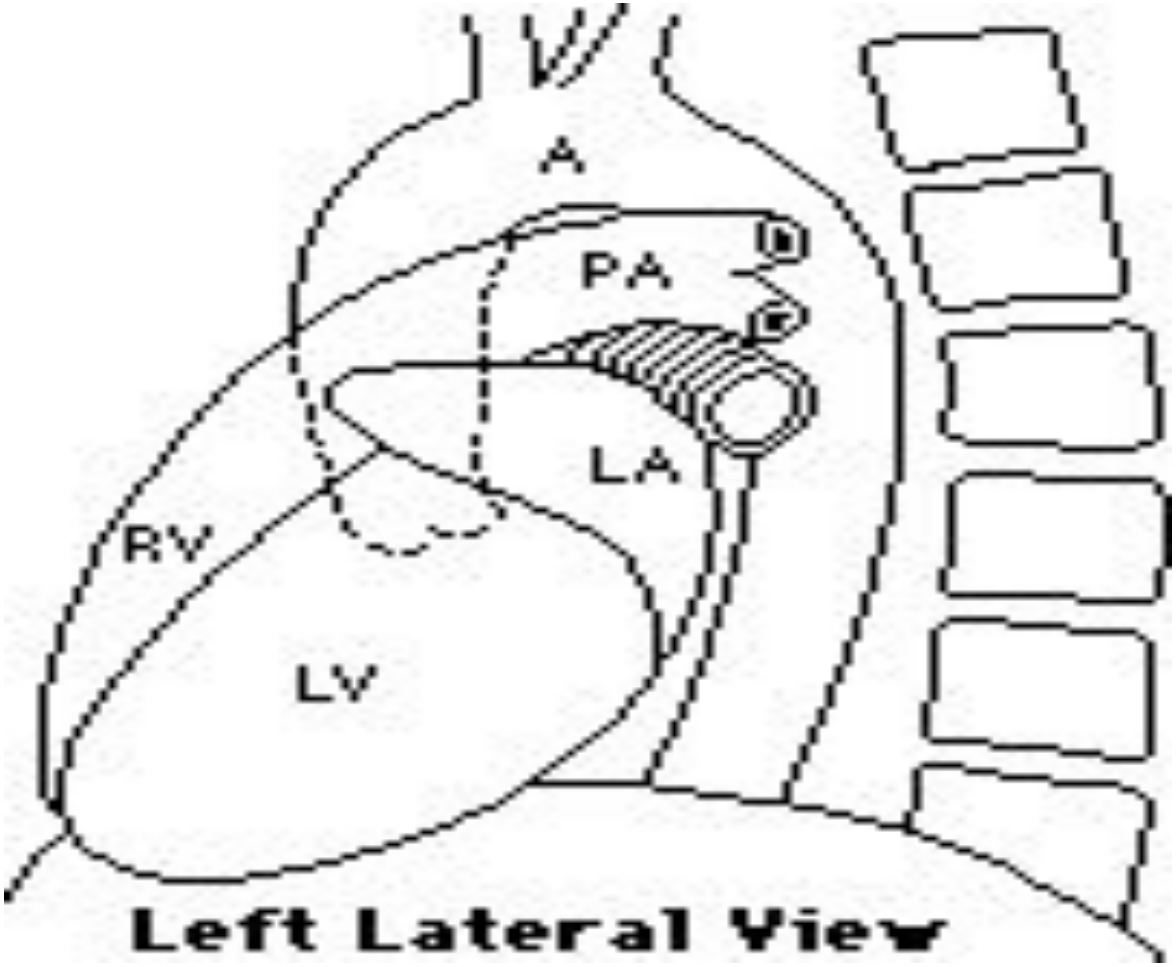
the left border has three well-defined segments:

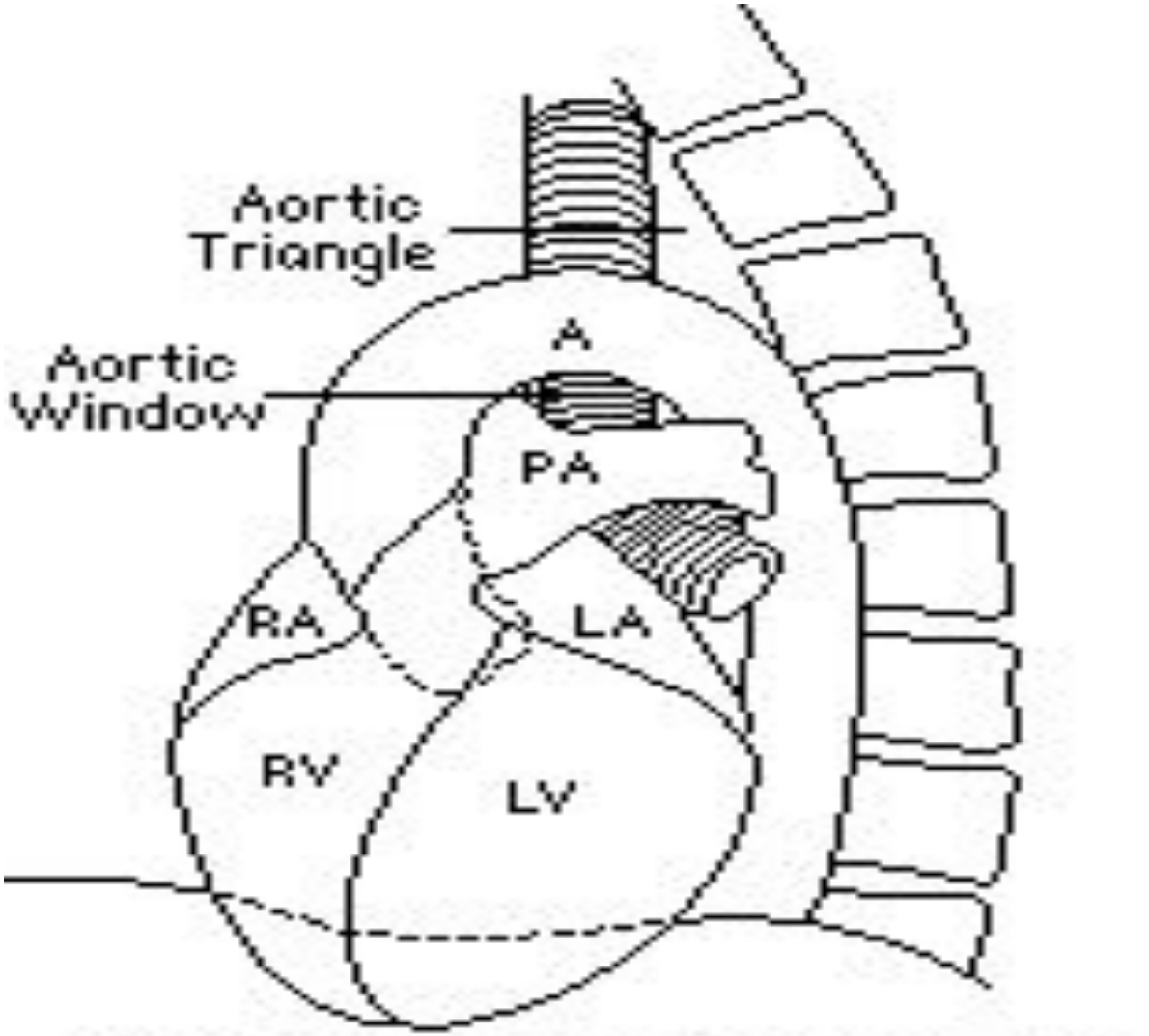
- 1. the uppermost is formed by the aortic arch
- 2. the main pulmonary artery lies immediately below the aortic knob
- 3. LV and the apex (the LA appendage lies between the pulmonary artery segment and the LV and is usually not seen as a separate bulge)



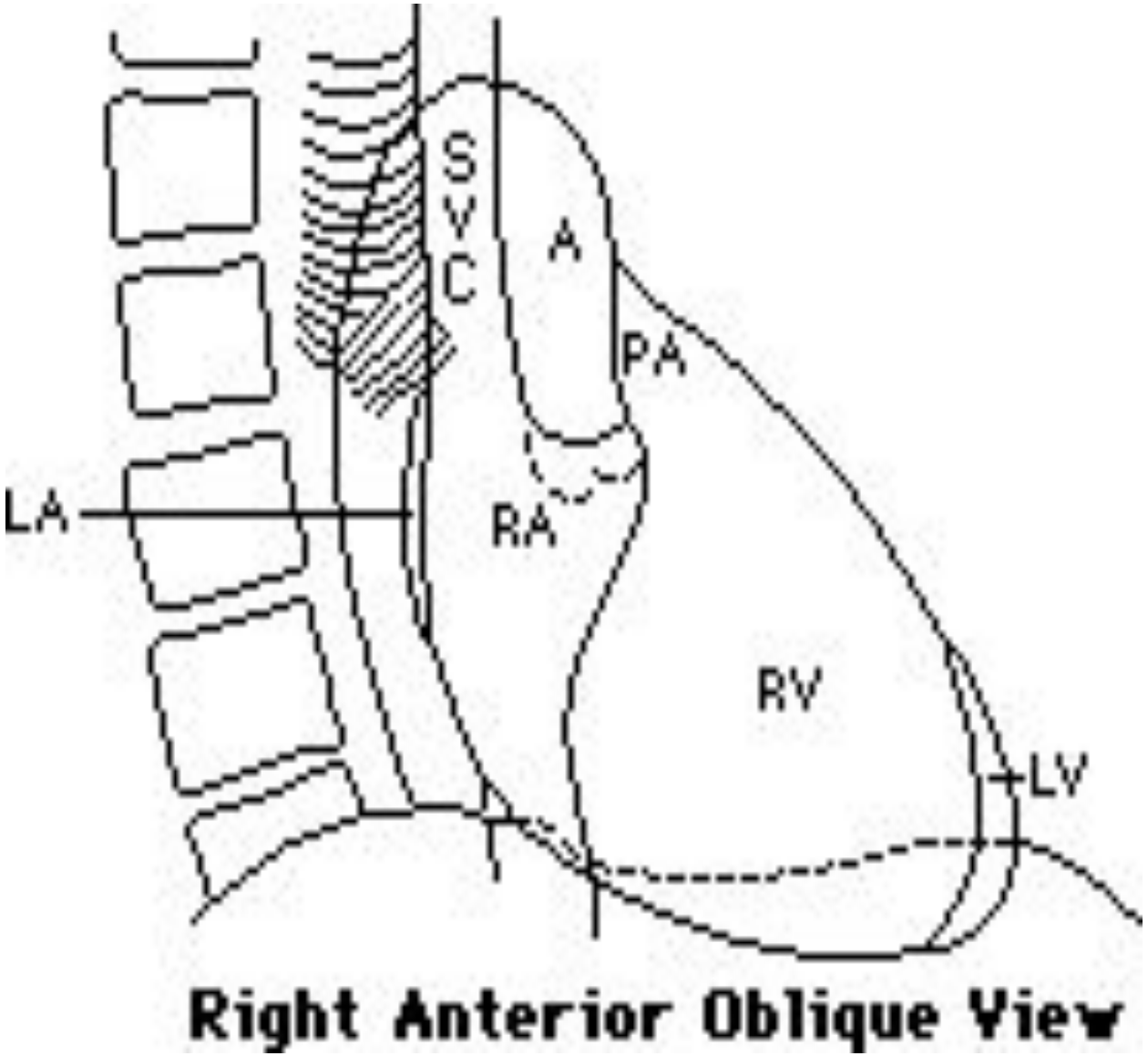
Posteroanterior View

Lateral Projection

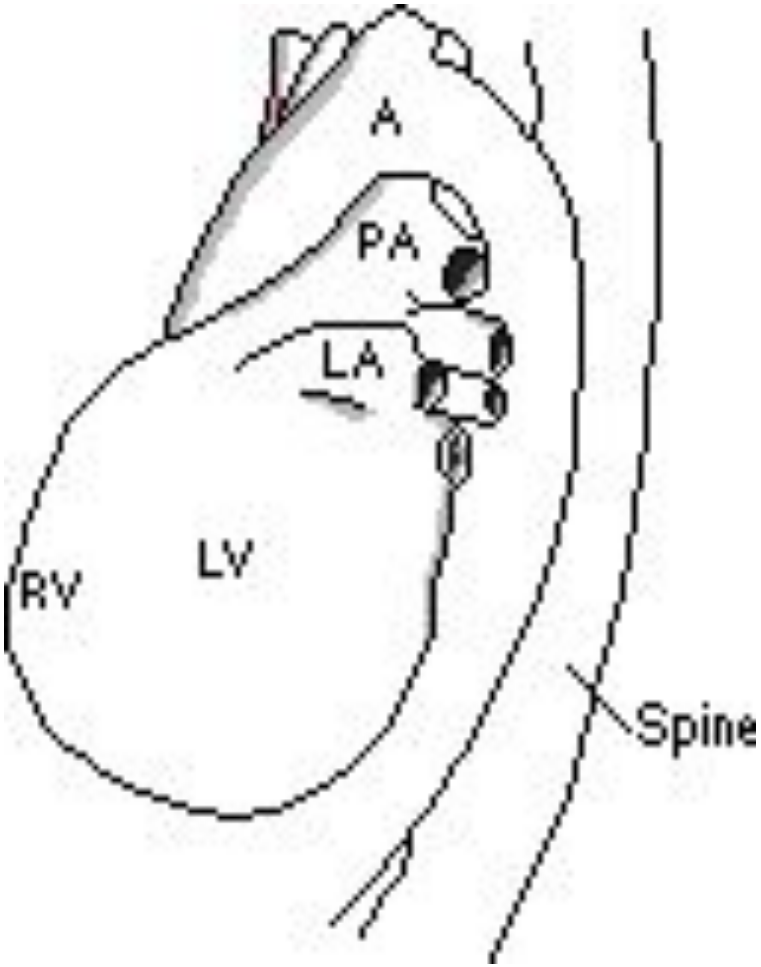


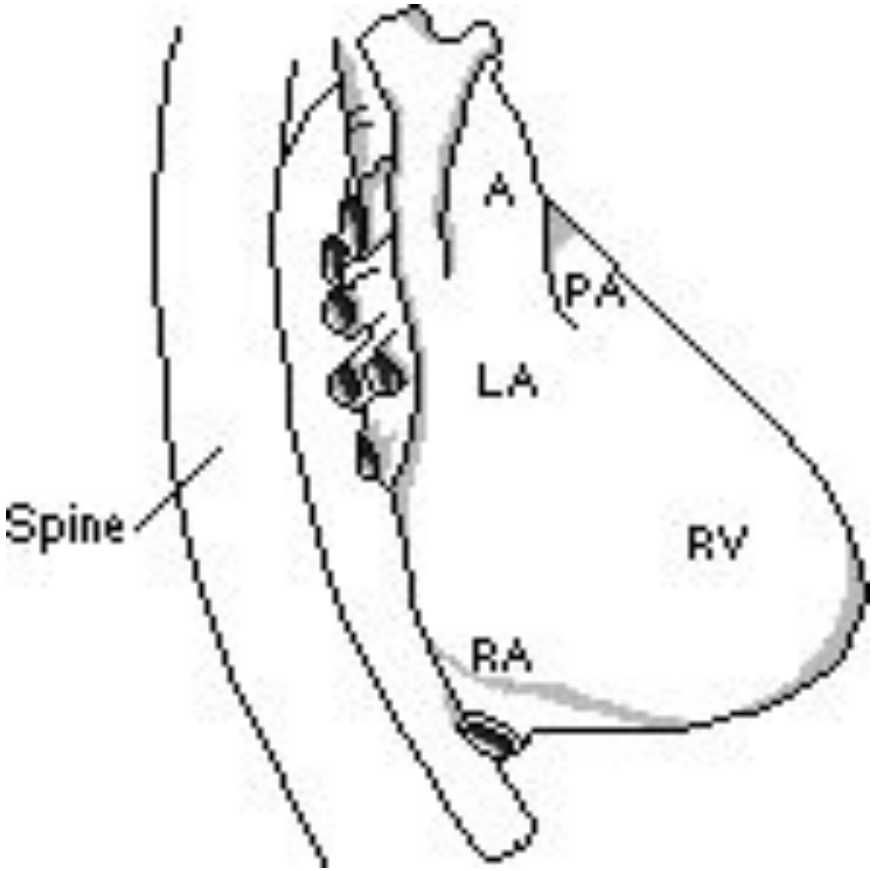


Left Anterior Oblique View



Right Anterior Oblique View





Cardiac Size — normal is 1/2 or less of the thoracic width on a PA film.

Technical Factors

- • The heart appears larger on AP than PA views.
- • Film during expiration — simulates pulmonary edema and the heart appears larger.
- • One should check side markers for dextrocardia.
- • One should check the clavicles for angulation.
- • Over penetrated films may miss heart failure.

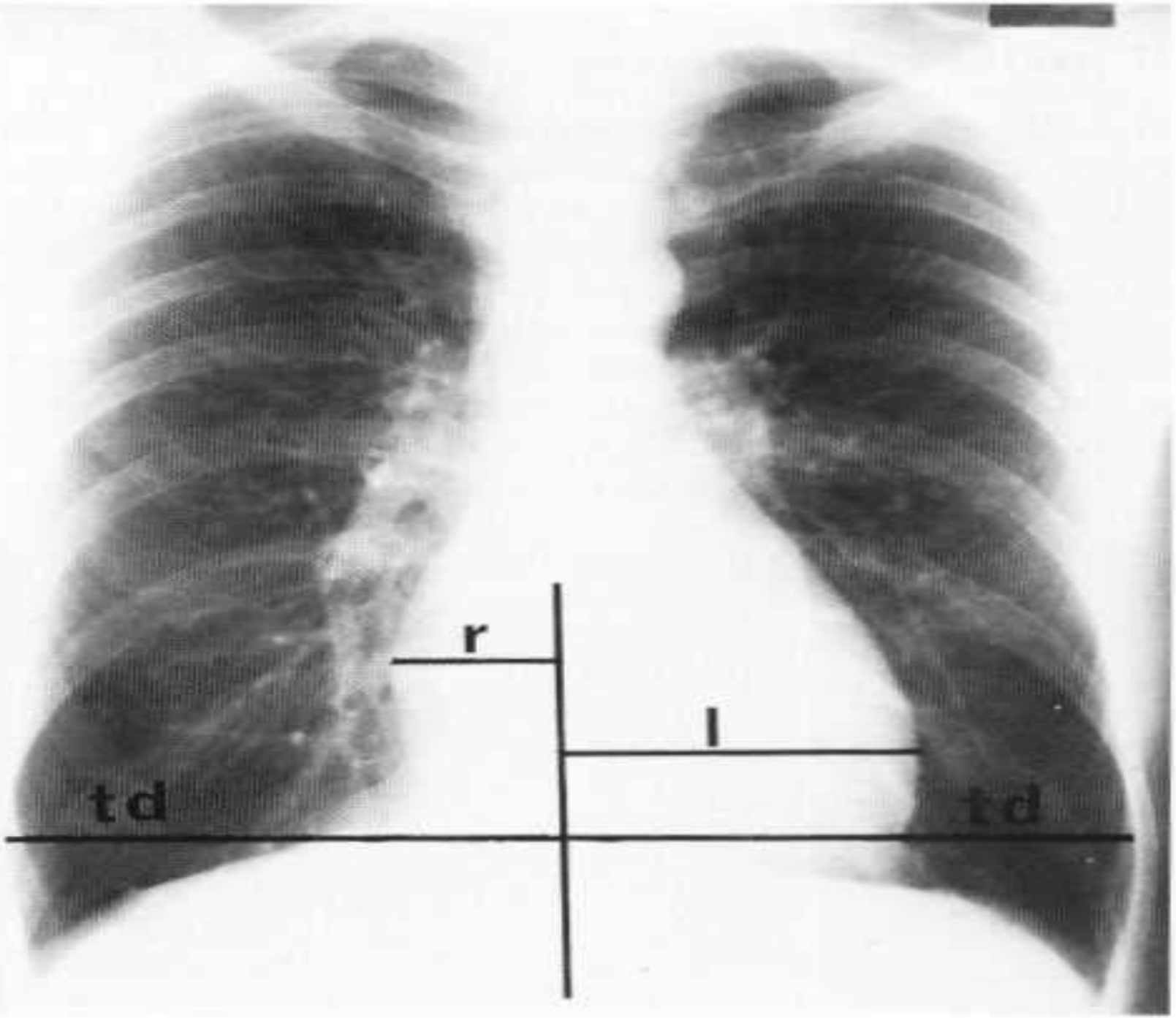
Cardiothoracic ratio (CT)

- It is a simple method of estimating cardiac enlargement.
- Estimation of CT ratio should always be done in erect PA view.

Normal:

- for adults 50%
- for neonates 60%

Cardiomegaly is diagnosed on frontal chest PA radiographs when the CT ratio exceeds 50%.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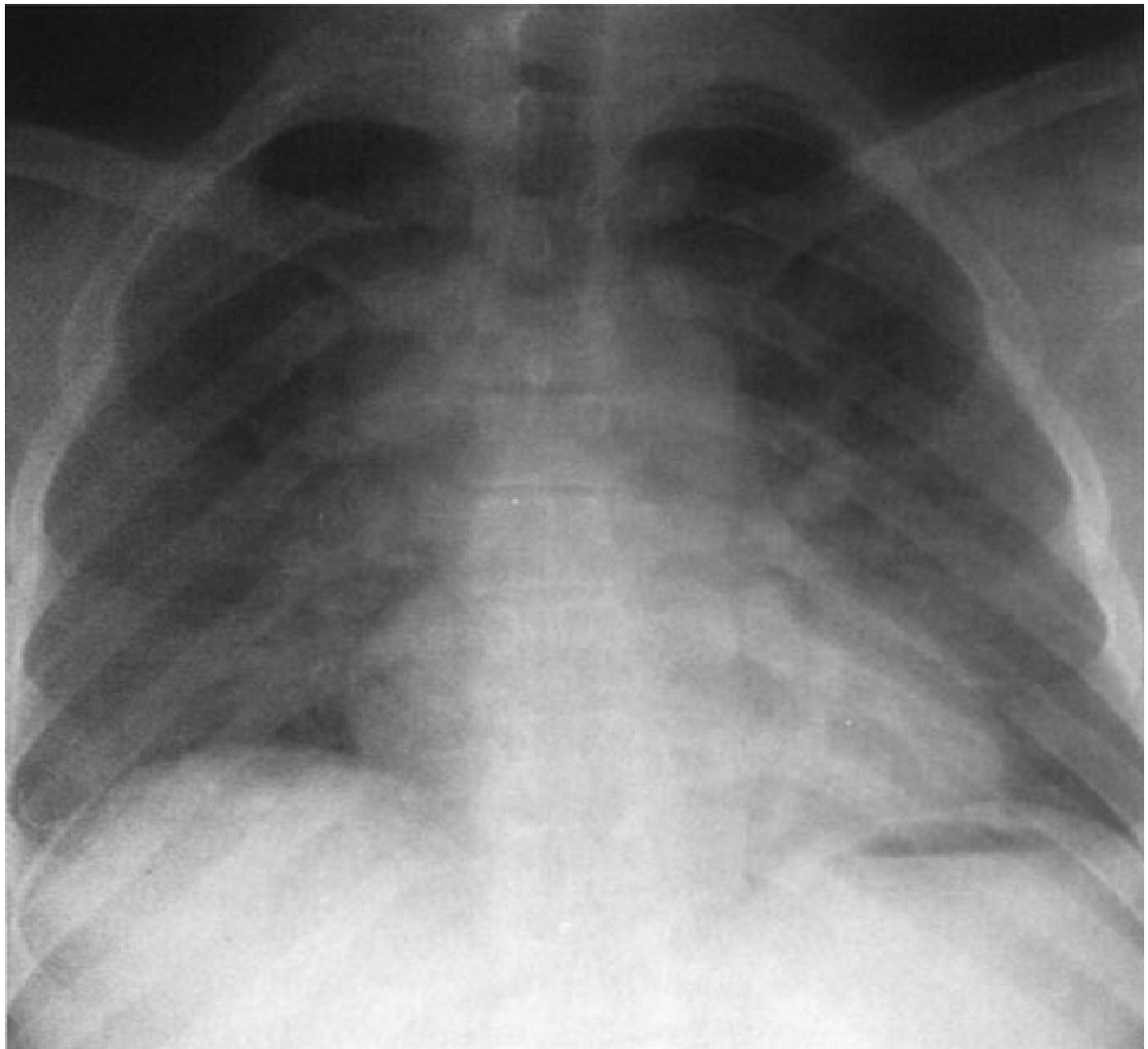
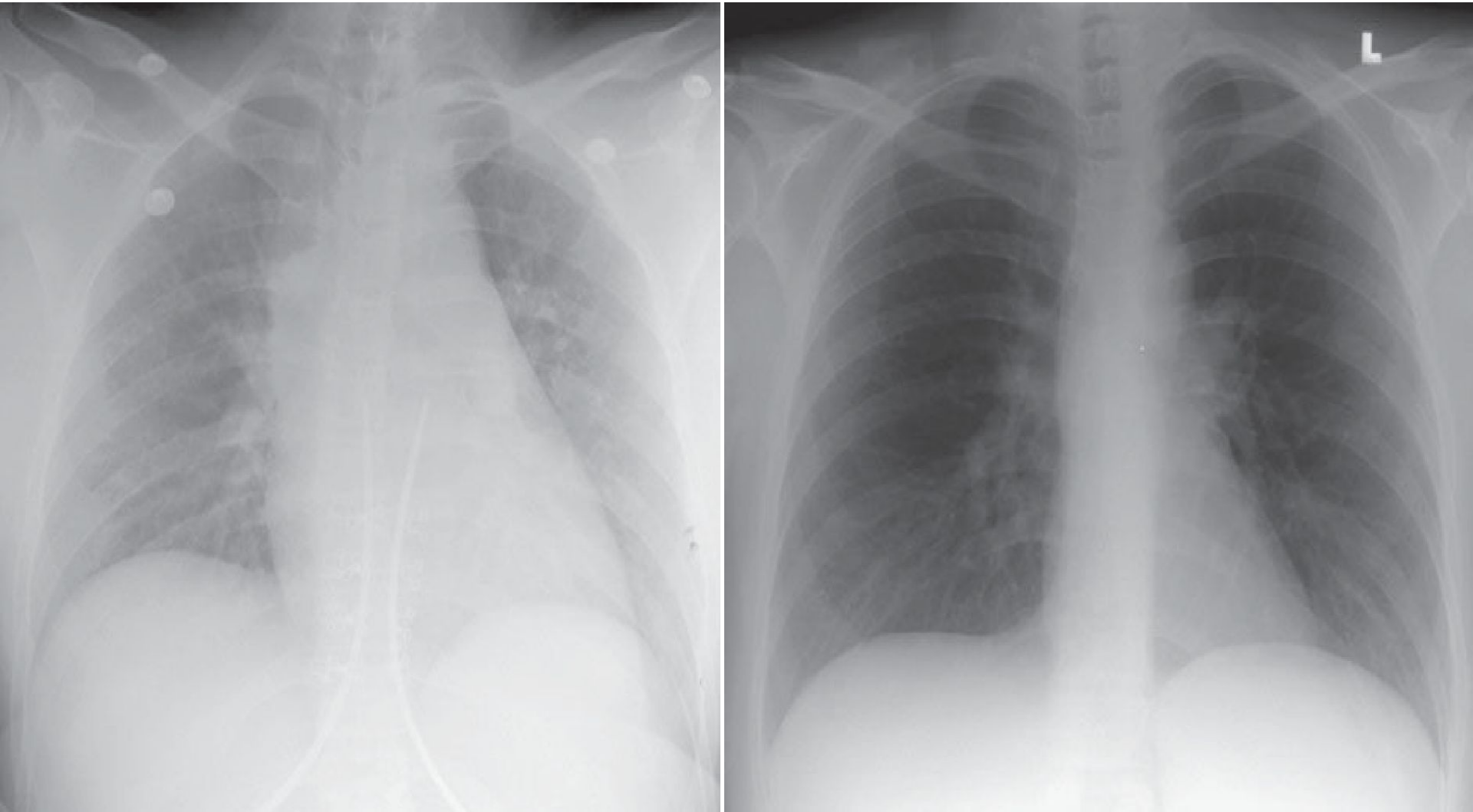
The causes for increased CT ratio due to nonstandard radiographic techniques include:

- poor inspiration
- supine position
- prone position
- AP radiographs, or with a short focus film distance

Expiratory phase on a PA radiograph. Note the low lung volumes, apparent enlargement of the cardiac silhouette, and crowding of bronchovascular structures at the bases. Findings may be misinterpreted as heart failure if analysis of depth of inspiration is not performed.



AP (**A**) and PA (**B**) radiographs of the chest in same patient on same day. Note that the cardiac silhouette appears
larger on the AP radiograph and may be mistaken for disease if patient position is not considered in the interpretation.



Common causes of cardiomegaly

- Valvular heart diseases like mitral stenosis, mitral regurgitation, aortic regurgitation
- Pericardial diseases like pericardial effusion
- Myocardial diseases like ventricular aneurisms
- Congenital cardiac diseases like atria septal defect, ventricle septal defect

Causes of small heart

- constrictive pericarditis
- Addison’s disease
- Pulmonary emphysema

Enlargement of the heart

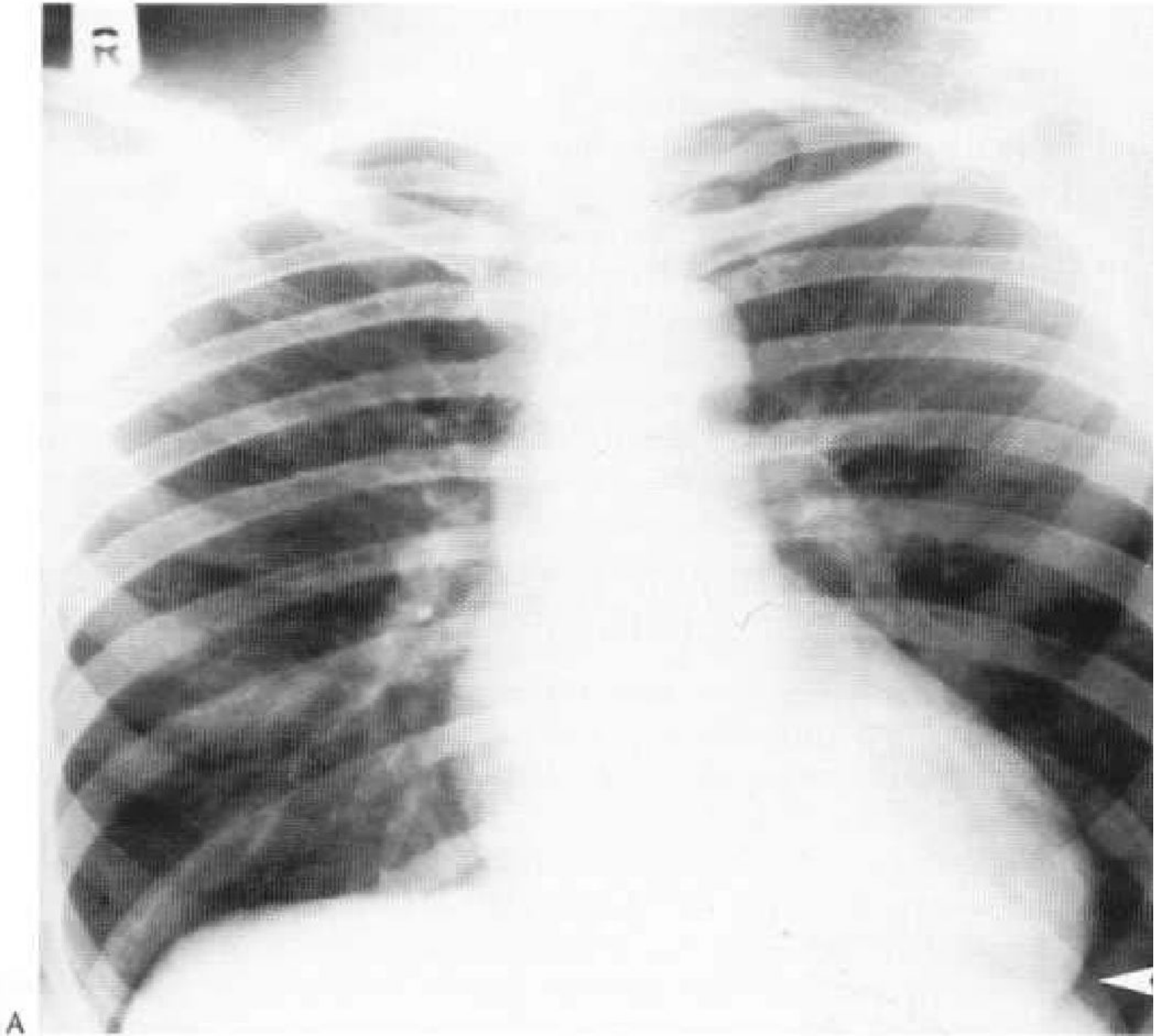
- It may be general, involving all chambers or eccentric involving one or two chambers unequally.

The common causes of the left ventricular enlargement are:

- hypertension
- aortic regurgitation
- aortic stenosis
- coronary arteriosclerosis
- acute/chronic nephritis
- cardiac aneurism
- coarctation of aorta

- The left ventricle enlarges to the left and posteriorly and only slightly to the right and anterioly. Left side of the heart becomes more globular.

Left ventricular enlargement



Lateral view shows the left ventricle extending behind the line of the barium-filledoesophagus (arrow).

The common causes of right ventricle enlargement are:

- mitral stenosis
- congestive failure
- chronic pulmonary diseases
- tricuspid regurgitation
- Fallot's tetralogy

- Right ventricle when enlarges, it does so by a broadening of its triangular shape. It enlarges chiefly to the left and anterioly.

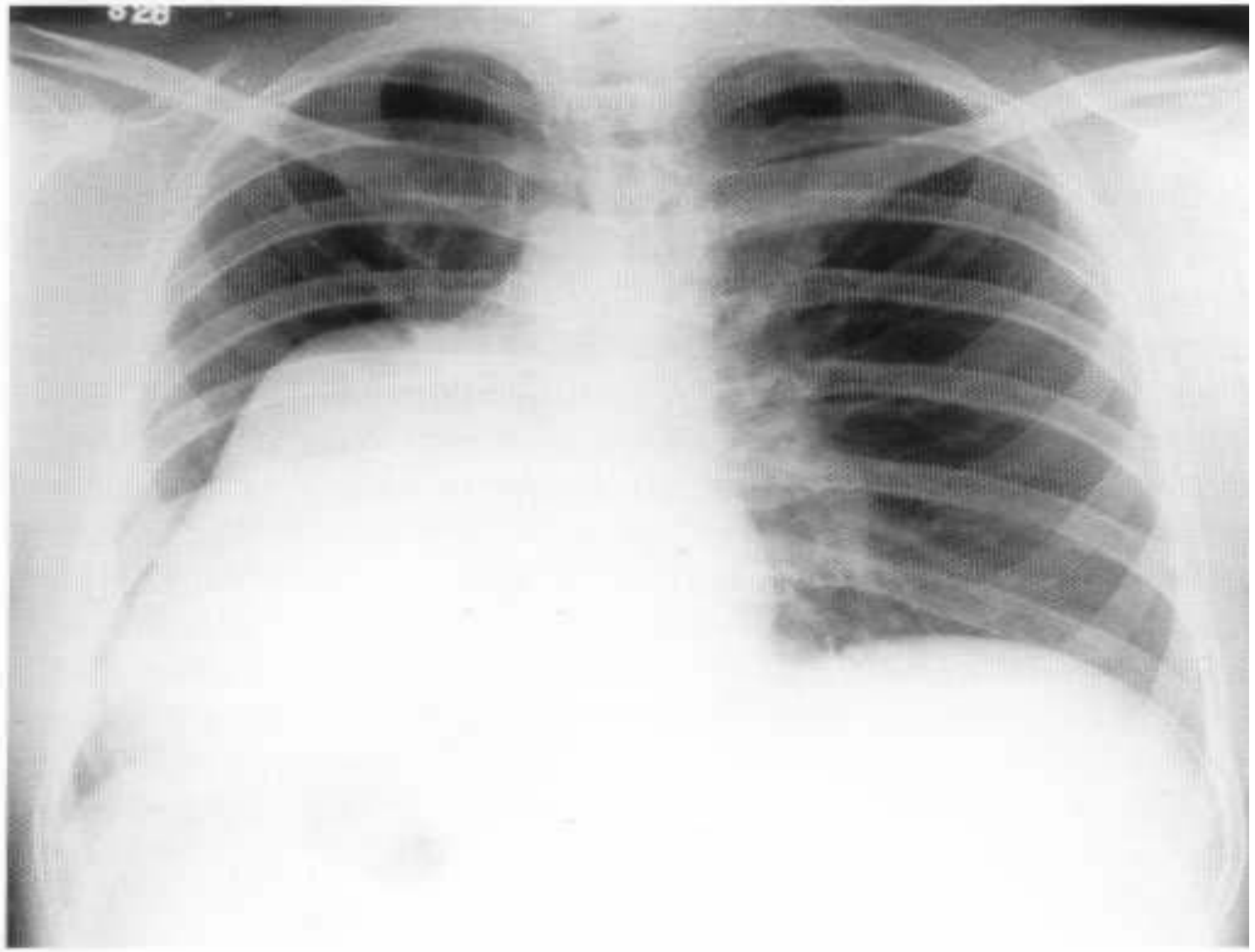
Direct signs of right ventricular enlargement are:

- upward and outward displacement of the ventricular border
- elevation of the apex
- an upper longer arc above the apex and a lower shorter arc turning medially below the apex

Indirect signs are:

- prominent right atrial border
- dilated pulmonary trunk
- signs of pulmonary hypertension

Gross right ventricular enlargement



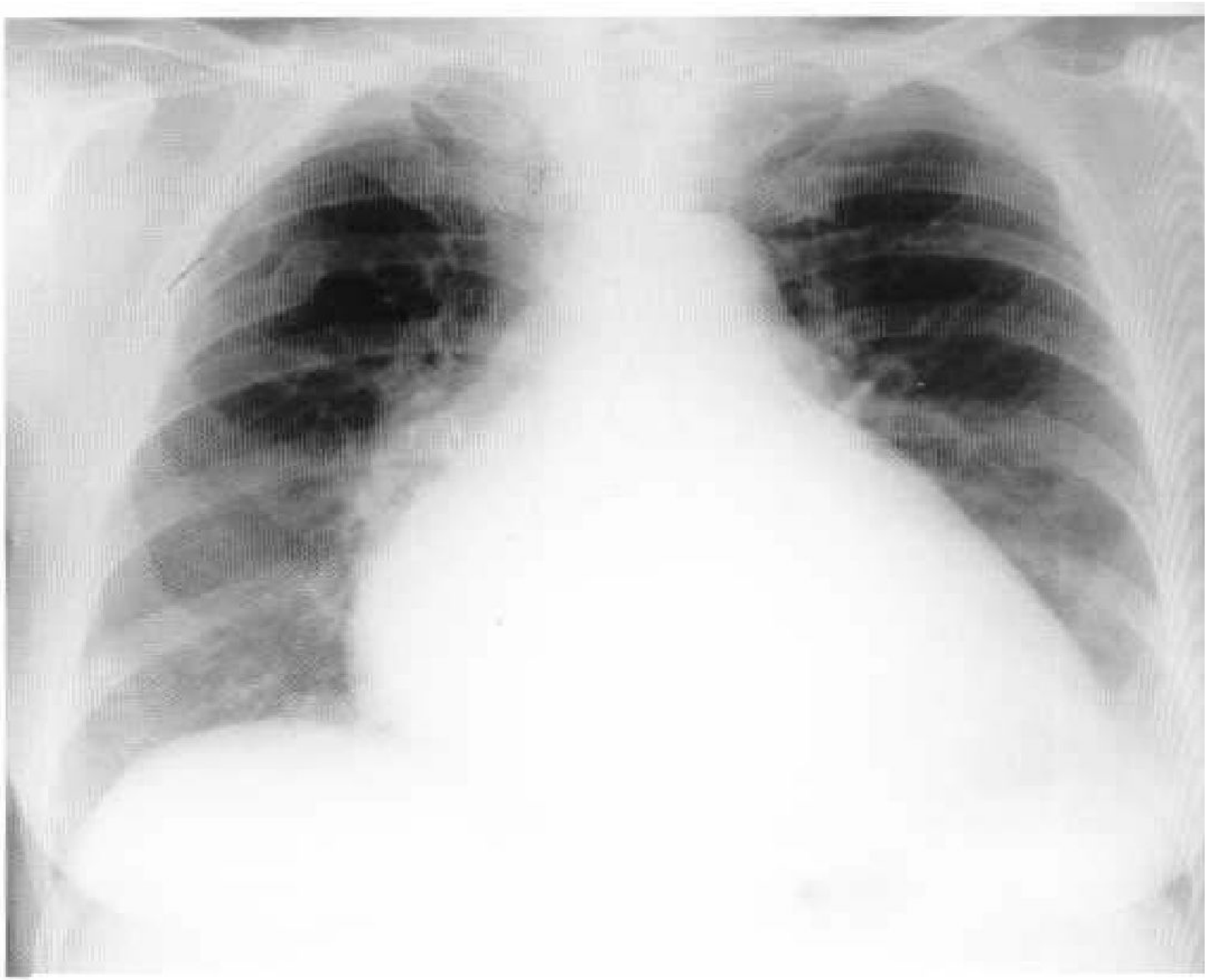
A

The common causes of left atrial enlargement are:

- ischemic heart disease
- mitral stenosis
- mitral regurgitation
- aortic obstruction and regurgitation
- systemic hypertension
- left heart tumor

- On the anterior view the right atrium forms less than the lower half to the right mediastinal border in adults.

left atrial enlargement

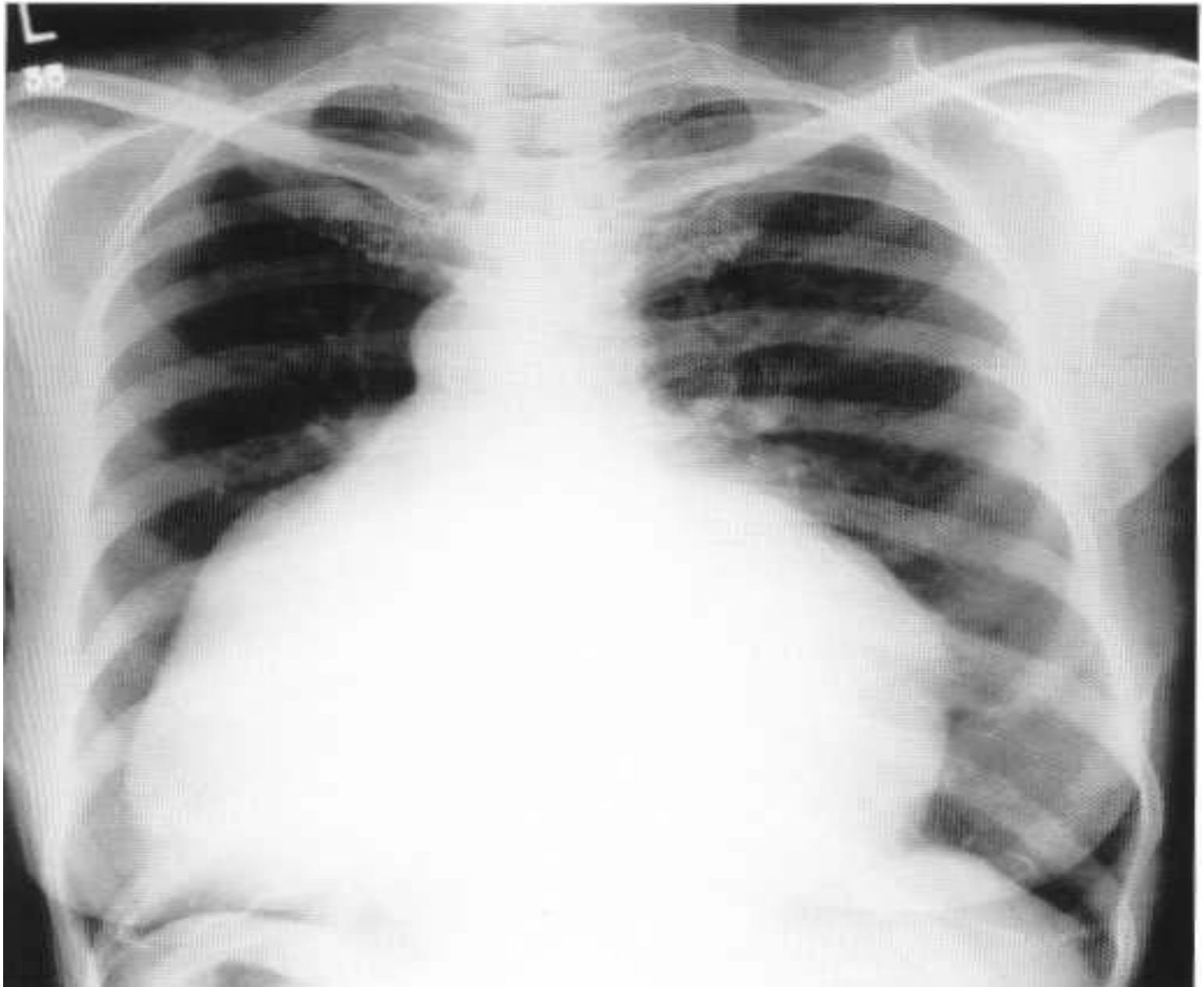


A

The causes of the right atrium enlargement are:

- Shunts into right atrium (left ventricular – right atrial shunt, ruptured aortic sinus into right atrium)
- Pulmonary obstruction and regurgitation
- Pulmonary arterial hypertension
- tricuspid obstruction and regurgitation
- Right – sided cardiomyopathy
- right atrial tumors

Right atrium enlargement



Essential hypertension

It is a common cause of cardiac enlargement.

- In most cases there is unfolding and pseudoenlargement of aorta.
- The ascending part appears wider and longer.
- The aortic knuckle becomes higher.

- Left heart enlargement is common in prolonged hypertension.
- The apex lies below the dome of the diaphragm. Similar findings may be seen in aortic regurgitation except vigorous pulsation of the left ventricle.
- When failure does occur the heart enlarges to the left and right in the transverse diameter greater than the long diameter.

- The pulmonary artery and the conus are somewhat dilated.
- The enlargement hazy outline of the hilar shadows may precede clinical evidence of failure and is a useful sign.

Chronic nephritis

- The heart is enlarged in 80% cases. Marked rounding of the left ventricle is a conspicuous
- Feature in chronic nephritis than in essential hypertension. Pulmonary edema occurs.

Pericardial effusion

- A pericardial effusion is a collection of fluid in the pericardial sac, the fluid being either serous, blood or lymphatic in origin.

Radiological features

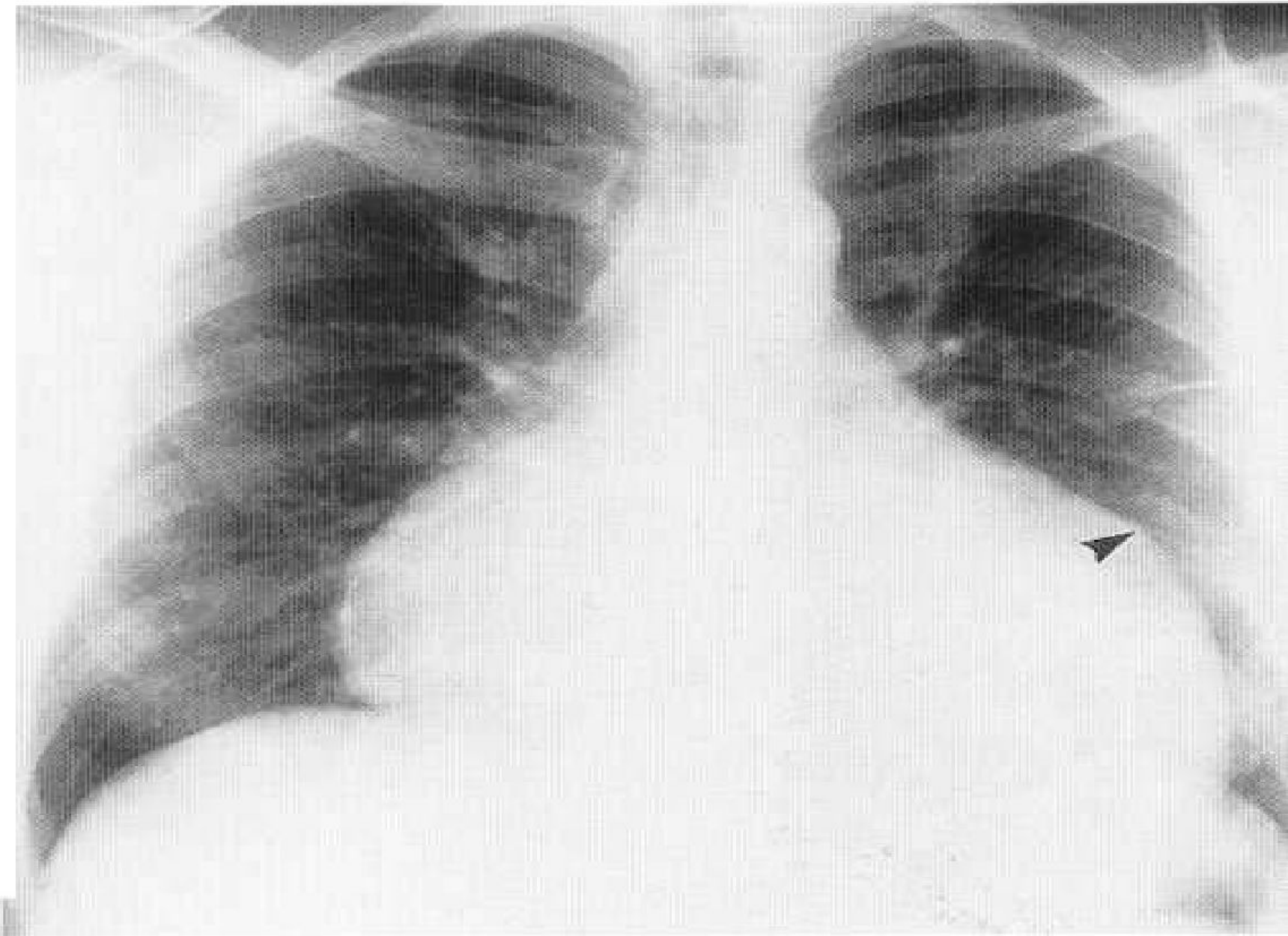
- Chest film: illustrates a symmetrically enlarges and globular cardiac shadow only when there is a significant effusion (>250 ml). Pericardial effusion should be suspected if there has been a rapid serial increase in the cardiac shadow, with normal pulmonary vasculature.
- Echocardiography: the investigation of choice. Effusions are visible as echo-free areas surrounding the heart.

- CT: may also identify the aetiology, e.g. mediastinal malignancy.
- MRI: accurate for diagnosis and also images the chest and mediastinum.

Causes

- Infective
  - viral
  - bacterial
  - tuberculosis
- Uraemia
- Posmyocardial infarction
- Myxoedema
- Malignancy
  - bronchial and mediastinal tumors with pericardial invasion
- Collagen vascular diseases
  - systemic lupus erythematosus
  - rheumatoid arthritis

Pericardial effusion



Cardiac failure

- Cardiac failure is said to be present when tissue demands cannot be adequately supplied by the heart. It is usually due to low output from ischaemic heart disease but, paradoxically, may rarely result from high output as a consequence of excessive tissue needs in conditions such as thyrotoxicosis or Paget”s disease.

Radiological features

On a chest x-ray the following may be seen:

- cardiac enlargement
- upper-lobe vascular prominence: from raised pulmonary venous pressure
- pleural effusions: seen as blunting at the costophrenic angels, but as the effusions become larger, there is a homogeneous basal opacity with a concave upper border

- interstitial pulmonary oedema: initially, prominence of the upper-lobe and narrowing of the lower-lobe vessels. As venous pressure rises, interstitial oedema develops and fluid accumulates in the interlobular areas with peripheral septal lines (Kerley “B” lines)

- alveolar pulmonary oedema: with further increases in venous pressure, fluid transgresses into the alveolar spaces (alveolar shadowing) with haziness and blurring in the perihilar regions; in severe cases, pulmonary oedema develops throughout both lung fields. The outer thirds of the lungs may be spared, the bilateral central oedema being described as “bat’s wing”

Valvular diseases of heart
Mitral stenosis

- Mitral stenosis presenting in infancy or early childhood is due to congenital lesion. It takes years to develop mitral stenosis after rheumatic fever. Mitral stenosis produces a pressure load on the left atrium and ultimately on the right ventricle.

In posterioanterior view

- An enlarged left auricle is seen as dense pear-shaped opacity lying transversely inside the cardiac shadow.
- Double heart shadow in many cases can be seen to the right of the spine. Left border of the heart becomes straight and is known as mitralization.
- Small aortic knuckle is caused partly by a true hypoplasia of aorta and partly by right ventricular rotation.

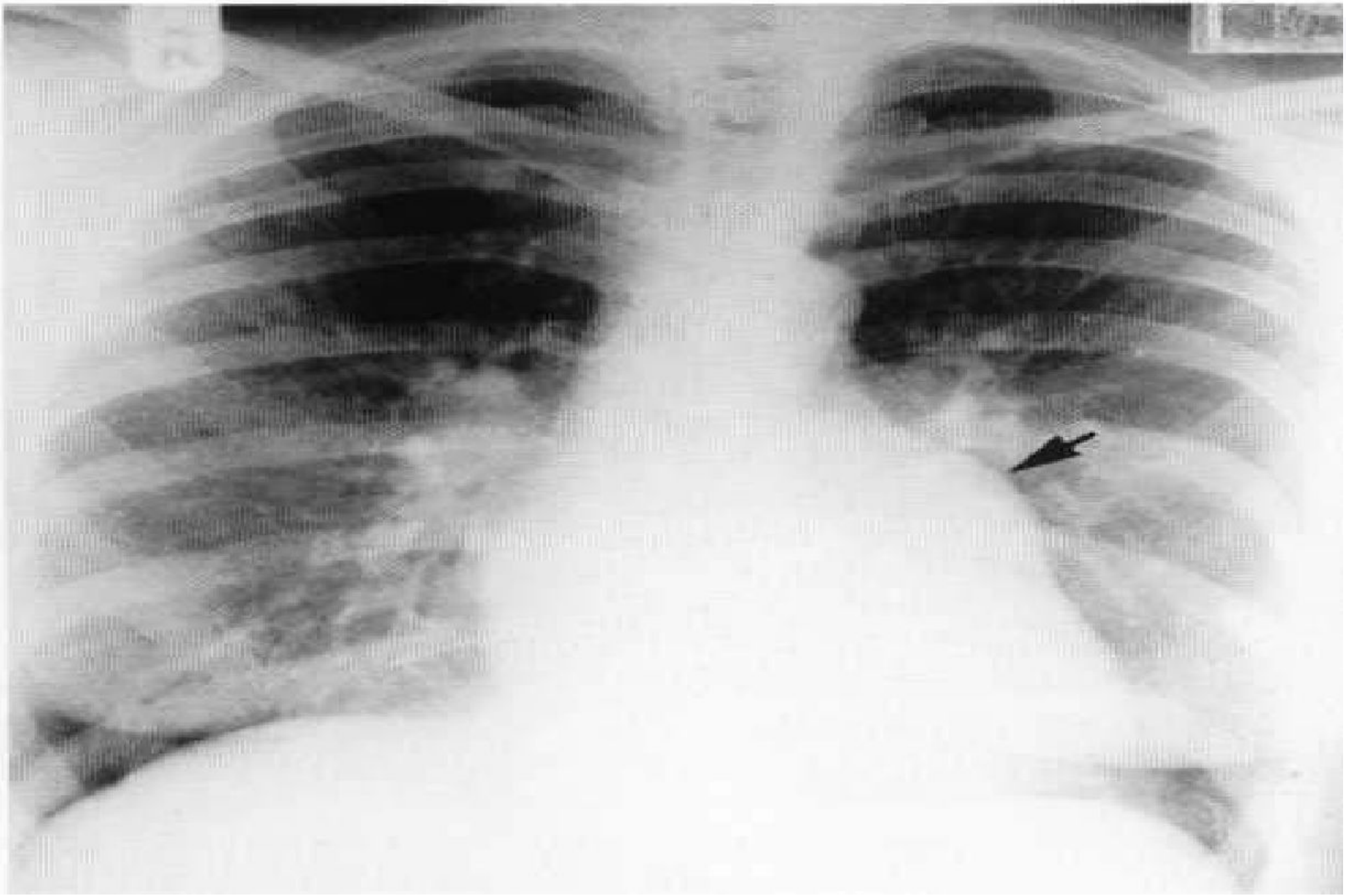
In right oblique view

- The enlargement left auricle bulges backwards and obliterates the translucent retrocardiac space.

- On barium swallow a bolus passes normally down to a point just below the left main bronchus when it seems to halt abruptly. Barium bolus then fills slowly the lower third of the oesophagus which is curved sharply backwards. This sign is more obvious in expiration than in inspiration.

- Elevation of left main bronchus due to enlarged left atrium may be seen.

- Horizontally Kerley “B” lines are more often noted. These lines are usually persistent. Other more fluid signs such as mottling, hilar edema and pleural effusion may develop which disappear on treatment.



Rheumatic mitral stenosis. This frontal film shows marked enlargement of the left atrial appendage (arrow).

Mitral regurgitation

- Mitral incompetence may result from functional or anatomical disturbance of the cusps. Familial cases have been reported. The characteristic signs are mid-systolic click and a late systolic murmur. There is a volume and pressure load on the left ventricle and left atrium and in severe regurgitation a pressure load on the right ventricle.

- In mild regurgitation heart size may remain normal.
- In late cases, moderate cardiac enlargement suggests left ventricular rather than right ventricular enlargement. Left atrial dilatation is usually obvious. Gross enlargement of left atrium is noted in chronic rheumatic regurgitation with stenosis. Mitral valve calcification is common.

Aortic valve stenosis

In ninety percent it is congenital in origin.

- Heart is never more than slightly enlarged unless there is regurgitation.
- Left border is often more rounded or longer than normal with a low apex, a shape characteristic of left ventricular enlargement.
- Poststenotic dilatation of aorta is seen as a localized bulge to the right above the right atrium.
- Calcification of the valves is almost invariable in males over the age of 40 years.

Aortic regurgitation

- Congenital regurgitation is usually due to bicuspid valve whose cusps elongates or lack support. Aortic regurgitation with rheumatic heart disease is often associated with stenosis. In acute regurgitation following bacterial endocarditis heart may take many months to enlarge.

- * The ventricle enlarges mainly downwards and many cause no increase in transverse diameter.
- * A prominent appendix is particularly suggestive of rheumatic valve disease.
- * Dilatation of ascending aorta is more diffuse.
- * Calcification of the valve is less common and less extensive with pure regurgitation than in stenosis.
- * A few plaques are occasionally seen but obvious calcification always means a mitral lesion.

Coarctation of aorta

- It is a congenital narrowing of the aortic lumen in the region of isthmus. If a coarctation presents after the first year of life, it is usually symptom-free and symptom is discovered due to hypertension, murmur or an abdominal chest radiograph. It causes a systolic overload on the left ventricle with hypertension in the upper part of the body.

X-ray shows:

- * enlargement of heart in the early weeks after birth and become very large if heart failure is there
- * descending aorta may lie far off to the left off to the left of the spine
- * rib notching is an important finding
- * plethora with or without edema suggest a shunt in addition to coarctation
- * in adults aortic knuckle becomes prominent

Pulmonary stenosis

Pulmonary valve stenosis is always congenital.

- The heart is usually normal in size with severe stenosis but may be slightly enlarged in childhood as a result of marked hypertrophy of the right ventricle with elevated apex.
- Gross enlargement is seen only with congestive cardiac failure.
- Right atrium appears prominent.
- Poststenotic dilatation of pulmonary trunk and or the left branch occurs in 90% cases.
- Pulmonary oligaemia is noted.

Pulmonary regurgitation

It may be:

- congenital
- acquired
- functional

- Isolated pulmonary regurgitation is a benign lesion unless associated with pulmonary hypertension. The heart and pulmonary trunk show little or no enlargement.
- Elderly patients on chronicity may develop congestive failure. When the pulmonary trunk is large with normal size heart, idiopathic dilatation is due to pulmonary regurgitation.

Venous hypertension

- When there is an increase in resistance to flow beyond the pulmonary capillaries, pressure rise in the pulmonary veins with the production of postcapillary or pulmonary venous hypertension. i.e. 15 mmhg or more.
- Earliest change is dilatation of upper zone vessels. More often both veins and arteries are widened, all vessels above the hilum are little wider than those at lower levels. Vessels may measure more than 3mm in diameter.

- When the capillary pressure exceeds the normal plasma osmotic pressure to 25 mmHg fluid including fibrin and red cells escape in the interstitial tissue. Lymph flow is increased and all lymphatic dilate.
- Kerley “B” lines are dense, short, straight horizontal lines most commonly seen in the bases. They result from thickening of the interlobar septa. Unlike vessels these do not branch. After treatment these lines disappear but may occasionally persist due to fibrous replacement of edema fluid and deposition of hemosiderin. Thus they become thinner and sharp.

- Deep septal lines are caused by edema of deep tissue probably around the lymphatics. One of these lines is Kerley "A" line. This is a straight or slightly angled line up to 4 cm in length, dense and fairly uniform in thickness. It runs towards the hilum.
- Edema if the perivascular loose connective tissue blurs the edges of the segmental vessels.

- In hilar edema, fluid collects in the loose connective tissue. The outline of the vessels becomes distinct.
- The lung field may show a generalized loss of translucency with or without fine generalized mottling.
- Pleural effusion is commonly found. Small effusion may be noted without septal lines and is the only sign of edema. Larger effusions are usually seen a higher venous pressure and are common in left ventricle failure than in mitral valve disease.

- When the pulmonary venous pressure reaches 30 mmHg, edema fluid may be no longer contained within the interstitial tissues but escape into alveoli. X-ray shows ill-defined semi-confluent lying in any part of the lung. The commonest appearance is the “bat’s wing” shadow in which the edema apparently has a peripheral distribution. It may be unilateral.

- Pulmonary hemosiderosis is due to focal deposition of hemosiderin. The lung show diffuse mottling in all zones which may be fine of course.
- Pulmonary ossific nodules are also formed following organization of intraalveolar edema. The nodules are dense and irregularly round or oval and rarely a small central medullary space may be visible. These vary from 1 to 10 mm most commonly seen in lower zones. These increase slowly in number.

Fallot's tetralogy

- Consists of:
- ventricular septal defect
- right ventricular outflow tract obstruction
- pulmonary stenosis
- right ventricular hypertrophy

Plain radiograph features:

- the heart is usually is not enlarged at birth but may enlarge later due to biventricular heart failure
- the pulmonary vasculature shows pulmonary oligemia
- the classic "cour en sabot" silhouette is due to combination of a deeply concave pulmonary bay and elevation from the diaphragm of slightly angular cardiac apex due to right ventricular hypertrophy
- the ascending aorta is typically enlarged and prominent on plain radiograph

Ventricular septal defect

is abnormal opening between the two ventricles.

- Types:
- membranous
- muscular

Chest radiograph:

- left atrium is enlarged
- associated hypertrophy of right ventricle and left ventricle
- increased pulmonary vascular markings (plethora)

Atrial septal defect

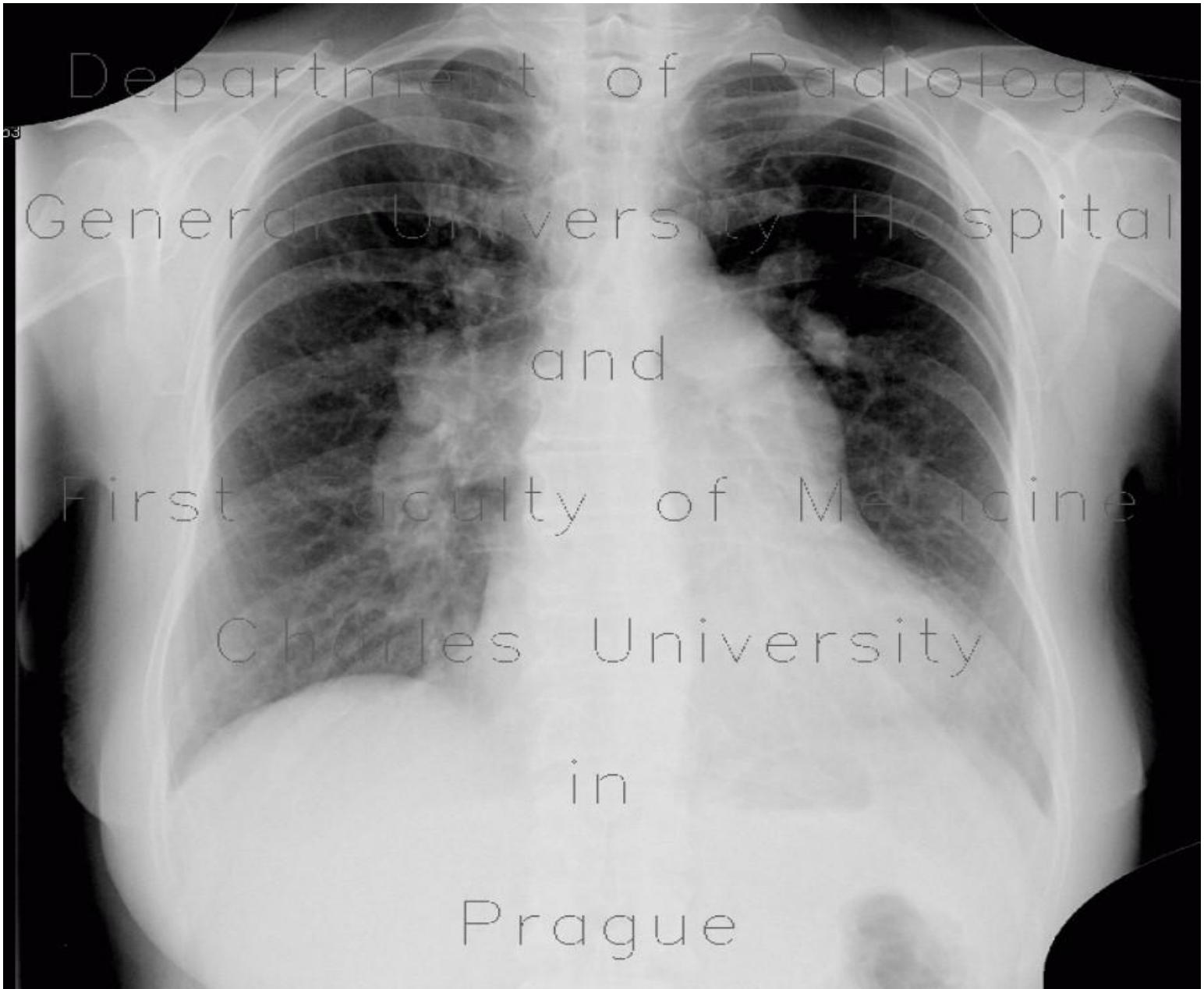
Atrial septal defect is the abnormal communication between the right and the left atria.

- Types:
- osteum secondum
- osteum primum

Chest radiograph:

- enlargement of right atrium and right ventricle
- pulmonary vascular prominence in lung field (plethora)

Atrial septal defect



Cardiac tumors

- metastasis from bronchogenic carcinoma, mediastinal tumors, melanoma, and lymphoma are the most common malignant lesions of the heart

- left atrial myxoma is the most common primary tumor of the

Myxoma:

- most common location is left atrium arising from the interatrial septum
- in echocardiography, a polypoidal and mobile mass with heterogeneous echotexture is seen
- on Ct scan, a heterogeneous mass lesion noted in the left atrium showing inhomogeneous enhancement