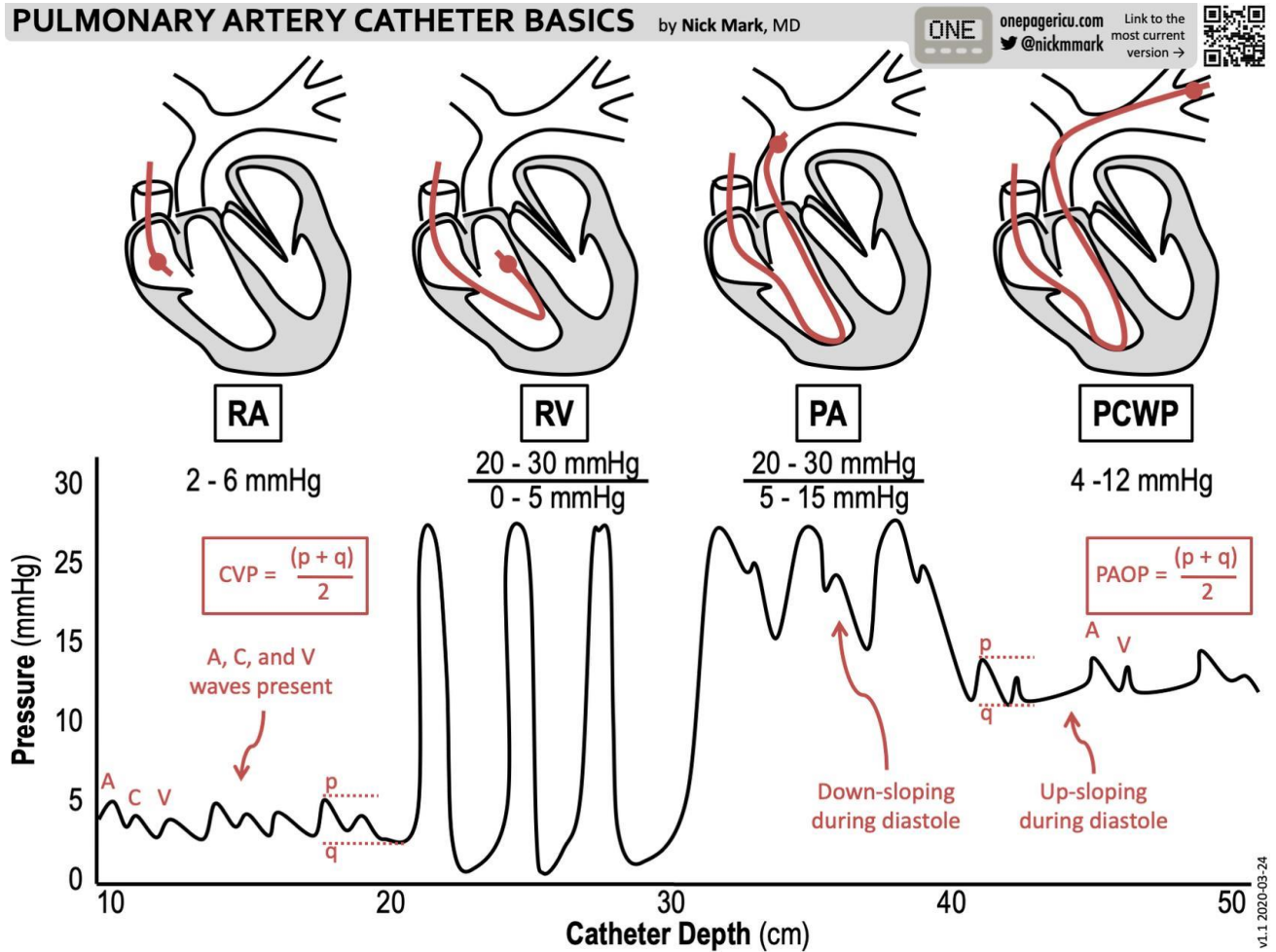
RECHTS HARTKATHETERISATIE, DIAGNOSTIEK EN INTERVENTIE PFO EN ASD SLUITING

PAUL VAN BRONSWIJK

FELLOW CONGENITALE CARDIOLOGIE,

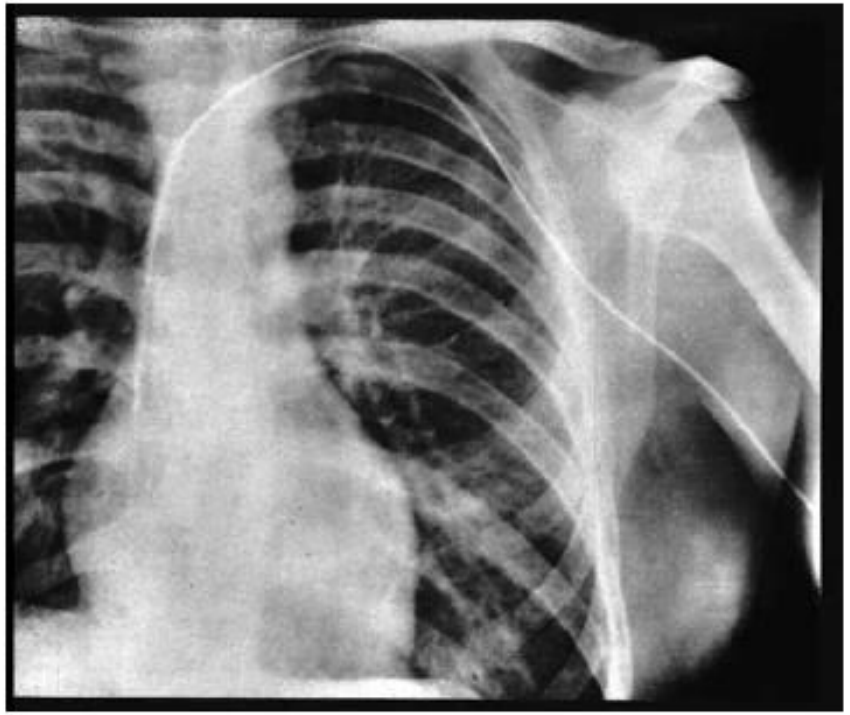
ACAHA ERASMUS MC / RADBOUD UMC



RECHTSCATHETERISATIE

Werner Forssmann 1929, Berlijn

DR. WERNER FORSSMANN performs the first cardiac catheterization – on himself! After first anesthetizing his lower arm, he threaded a catheter to his heart, then walked some distance to the X-ray department to document his daring experiment.

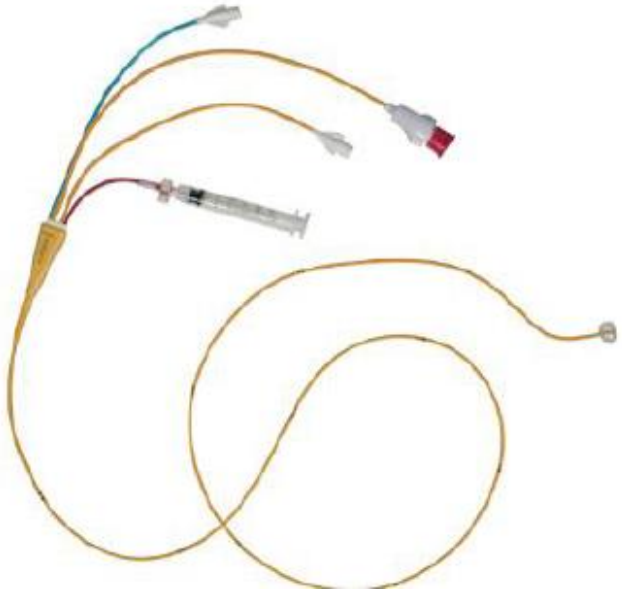


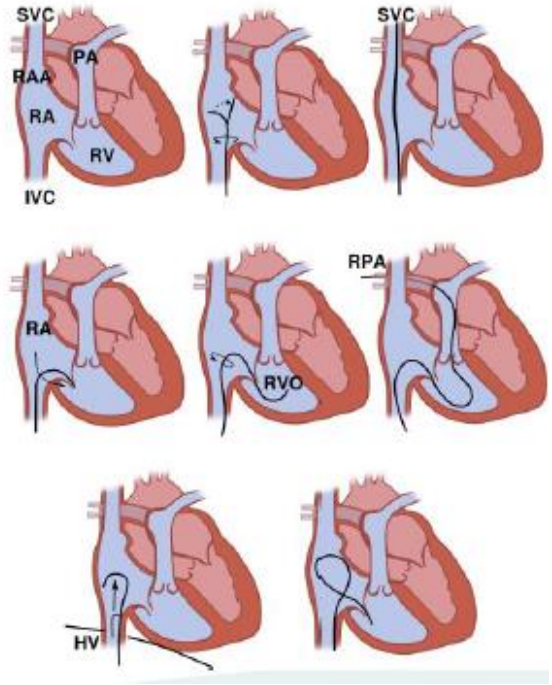
Catheter in het rechter atrium

RECHTSCATHETERISATIE

Swan en Ganz - 1970

William Ganz and H.J.C. Swan





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RECHTSCATHETERISATIE - INDICATIES

- Diagnostiek

- Pulmonale hypertensie
- ‘Onbegrepen’ dyspnoe
- Diastolische dysfunctie
- Kleplijden
- Congenitale hartziekten
- Hartfalen

Therapie

ASD sluiting
PFO sluiting

Ballondilatatie
Percutane klep
Stenting pulmonaaltakken
Vascular plug

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RECHTSCATHETERISATIE

Contra-indicatie:

- Endocarditis

Risico op een complicatie: <1%.

- bloeduitstorting op de plaats waar de katheter werd ingebracht
- afwijkingen van het hartritme (m.n. ventriculaire extrasystolen)
- Zeer zelden ernstige bijverschijnselen (b.v. longbloeding)

RECHTSCATHETERISATIE

- Intracardiale/pulmonale drukmetingen (CVD, RA, RV, AP (L/R), Wedge)
  - Eventueel simultane drukmeting bv. bij pericarditis constrictiva meting in RV/LV
- Cardiac output (m.b.v. thermodilutie of (in)direkte Fick methode), cardiac index
- O_2 saturaties: screening intracardiale shunts
- Berekenen vaatweerstand (PVR, SVR) en drukgradiënten (TGP, DPG)
- Vasoreaktiviteitstest (geïnhaleerde NO of iloprost, i.v. epoprostanol of adenosine)

RECHTSCATH IN DE RICHTLIJNEN
AANBEVELINGEN OM EEN RECHTSDRUK METING TE DOEN

Recommendations	Class[a]	Level[b]
RHC is recommended to confirm the diagnosis of pulmonary arterial hypertension (group 1) and to support treatment decisions	I	C
In patients with PH, it is recommended to perform RHC in expert centres (see section 12) as it is technically demanding and may be associated with serious complications	I	B
RHC should be considered in pulmonary arterial hypertension (group 1) to assess the treatment effect of drugs (Table 16)	IIa	C
RHC is indicated in patients with CTEPH (group 4) to confirm the diagnosis and support treatment decisions	I	C
RHC is recommended in patients with congenital cardiac shunts to support decisions on correction (Table 24)	I	C
RHC is recommended in patients with PH due to left heart disease (group 2) or lung disease (group 3) if organ transplantation is considered	I	C
When measurement of PAWP is unreliable, left heart catheterization should be considered to measure LVEDP	IIa	C
RHC may be considered in patients with suspected PH and left heart disease or lung disease to assist in the differential diagnosis and support treatment decisions	IIb	C
In patients with non-invasive signs of PAP elevation, invasive measurement of PVR is mandatory.	I	C
In patients with LV disease, it is recommended to perform balloon testing and carefully weigh the benefit of eliminating L–R shunt against the potential negative impact of ASD closure on outcome due to an increase in filling pressure (taking closure, fenestrated closure, and no closure into consideration).	I	C

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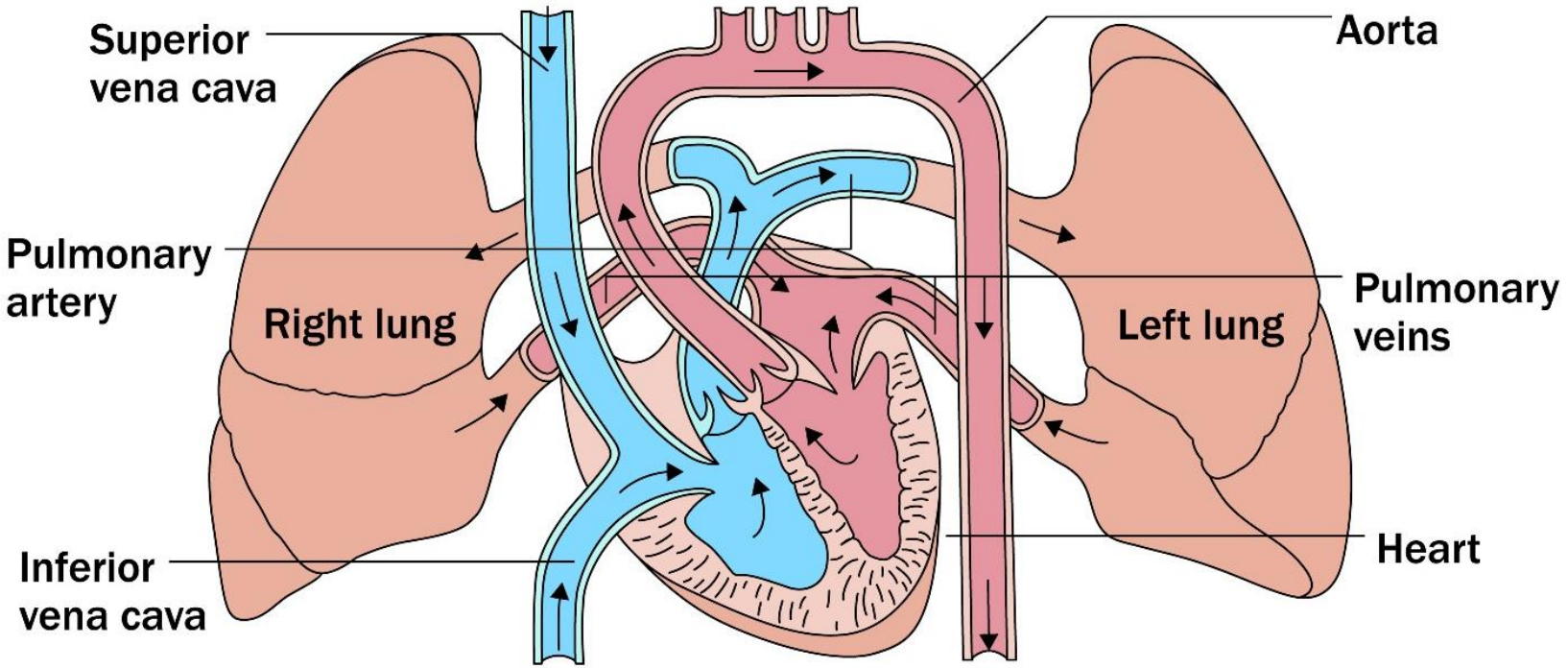
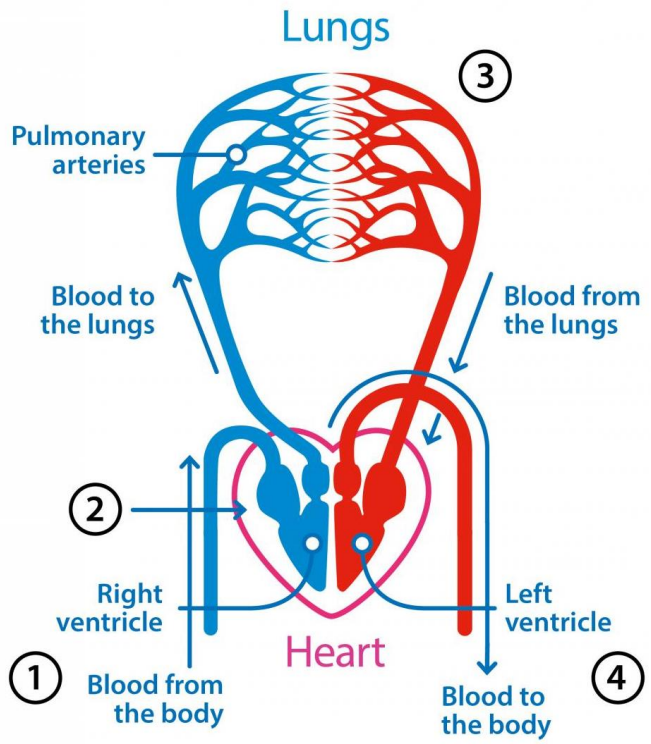
CIRCULATIE

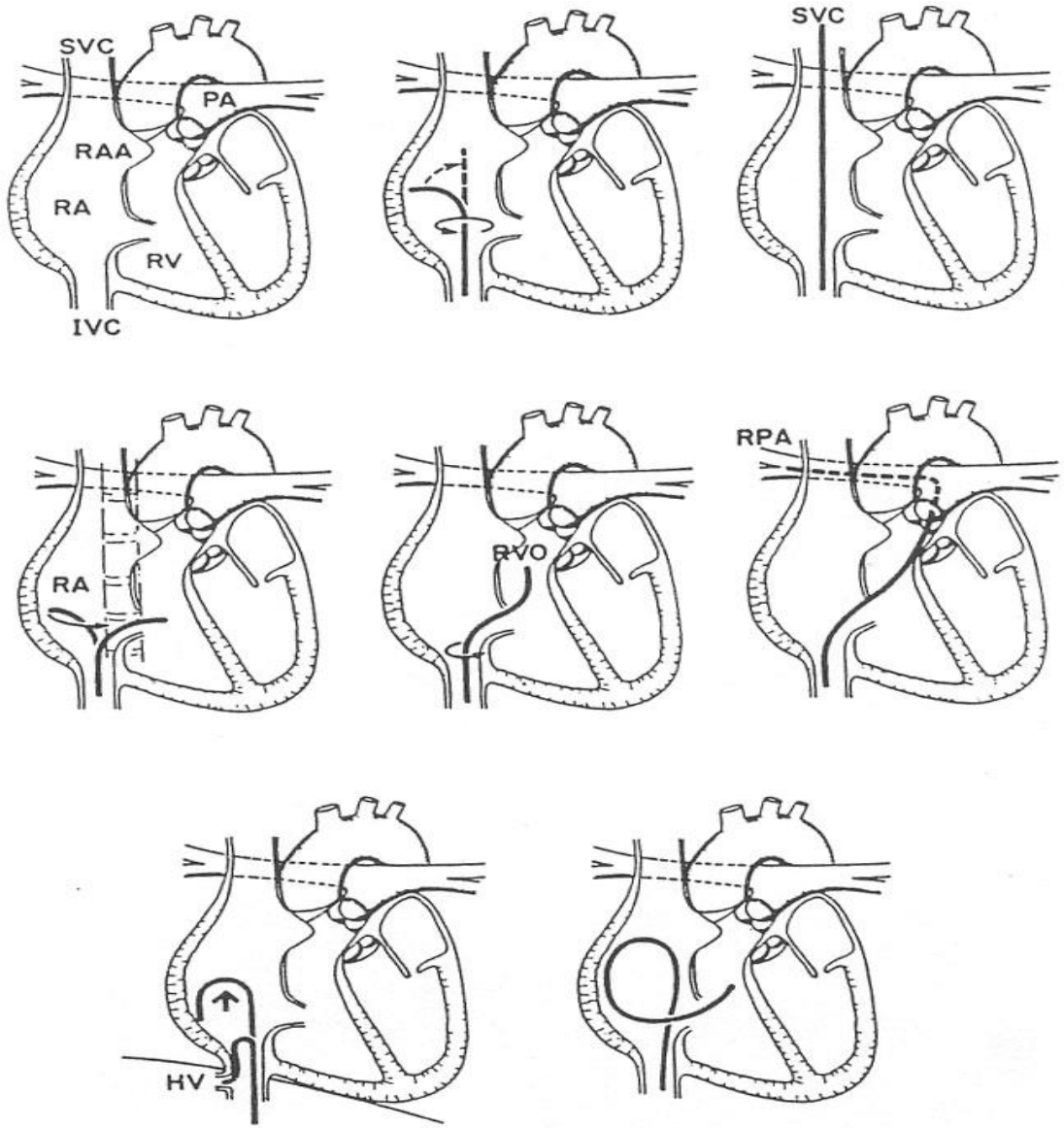

Superior vena cava
Aorta
Pulmonary artery
Right lung
Left lung
Pulmonary veins
Heart
Inferior vena cava


Pulmonary circulation
Lungs
3
Pulmonary arteries
Blood to the lungs
Blood from the lungs
2
Right ventricle
Left ventricle
Heart
1
Blood from the body
Blood to the body
4

HOE RECHTSDRUKMETINGEN

- Elke grote vene
- Druk en saturatie in elk compartiment
- Rust en belasting (diastolische functie)

When measurement of PAWP is unreliable, left heart catheterization should be considered to measure LVEDP	IIa	C



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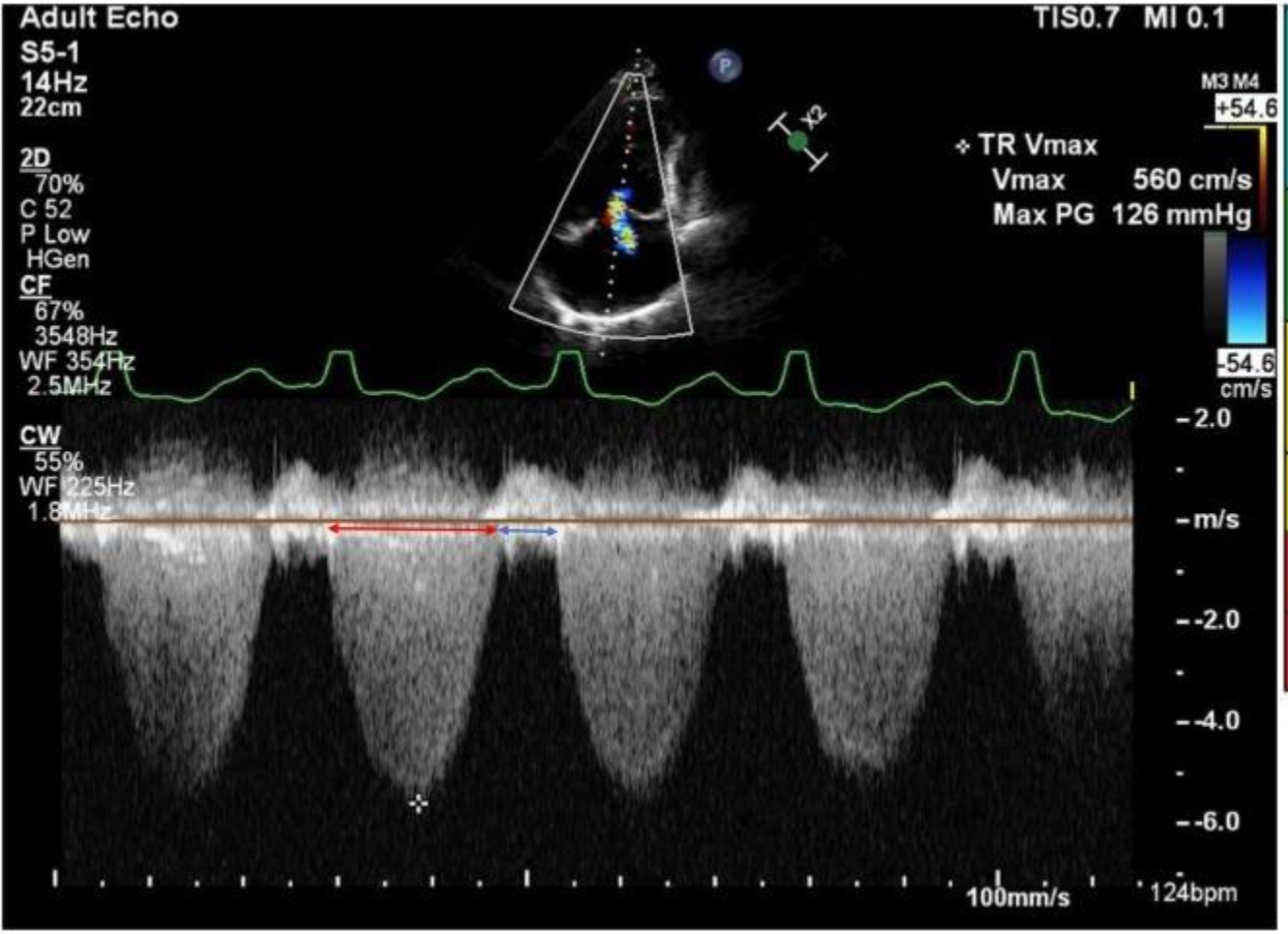
RECHTSDRUKMETINGEN



Peak tricuspid regurgitation velocity (m/s)	Presence of other echo 'PH signs'*	Echocardiographic probability of pulmonary hypertension
≤2.8 or not measurable	No	Low
≤2.8 or not measurable	Yes	Intermediate
2.9–3.4	No	
2.9–3.4	Yes	High
>3.4	Not required	

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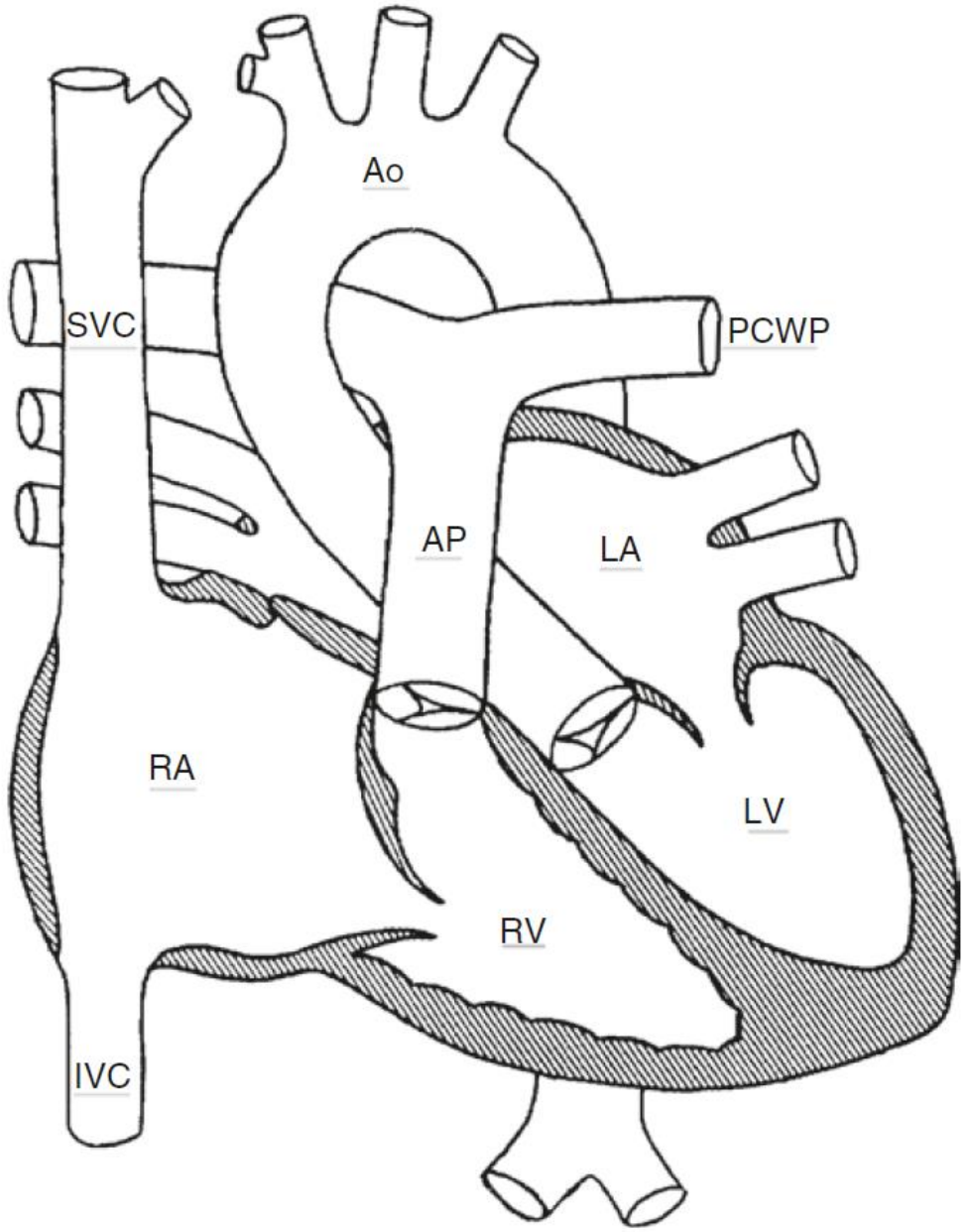
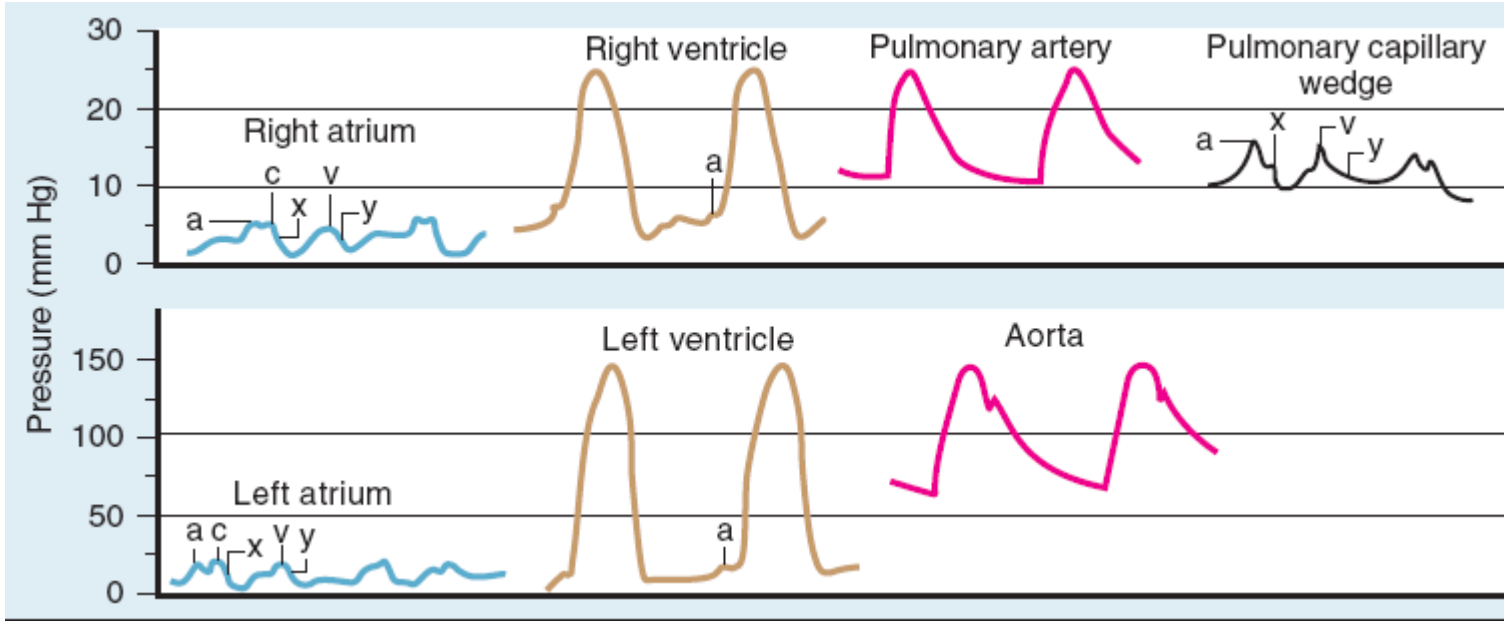
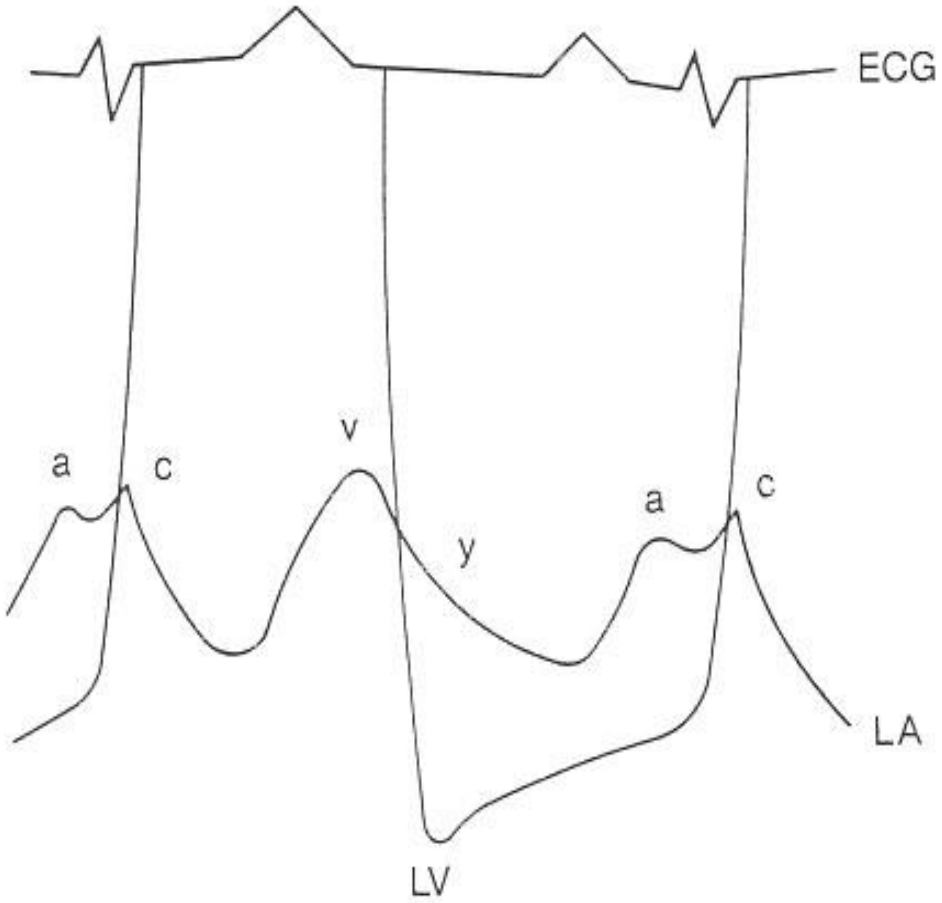
RECHTSDRUK METINGEN

In patients with non-invasive signs of PAP elevation, invasive measurement of PVR is mandatory.	I	C
In patients with LV disease, it is recommended to perform balloon testing and carefully weigh the benefit of eliminating L–R shunt against the potential negative impact of ASD closure on outcome due to an increase in filling pressure (taking closure, fenestrated closure, and no closure into consideration).	I	C



DRUK REGISTRATIE
WAT ZIEN WE





WAT METEN WE

- Druk, saturatie, flow (cardiac output)
- LVEDP : diastolische functie
  - Geen goede afkapwaardes

- Drukverschil tussen AP en LA — Pulmonale weerstand
- Drukverschil tussen Aorta en Vena cava — Systemische weerstand

- Wet van Ohm: V=IxR
  - R=weerstand
  - V=druk
  - I=flow (cardiac output) ; NB : bij shunts de juiste flow kiezen!!

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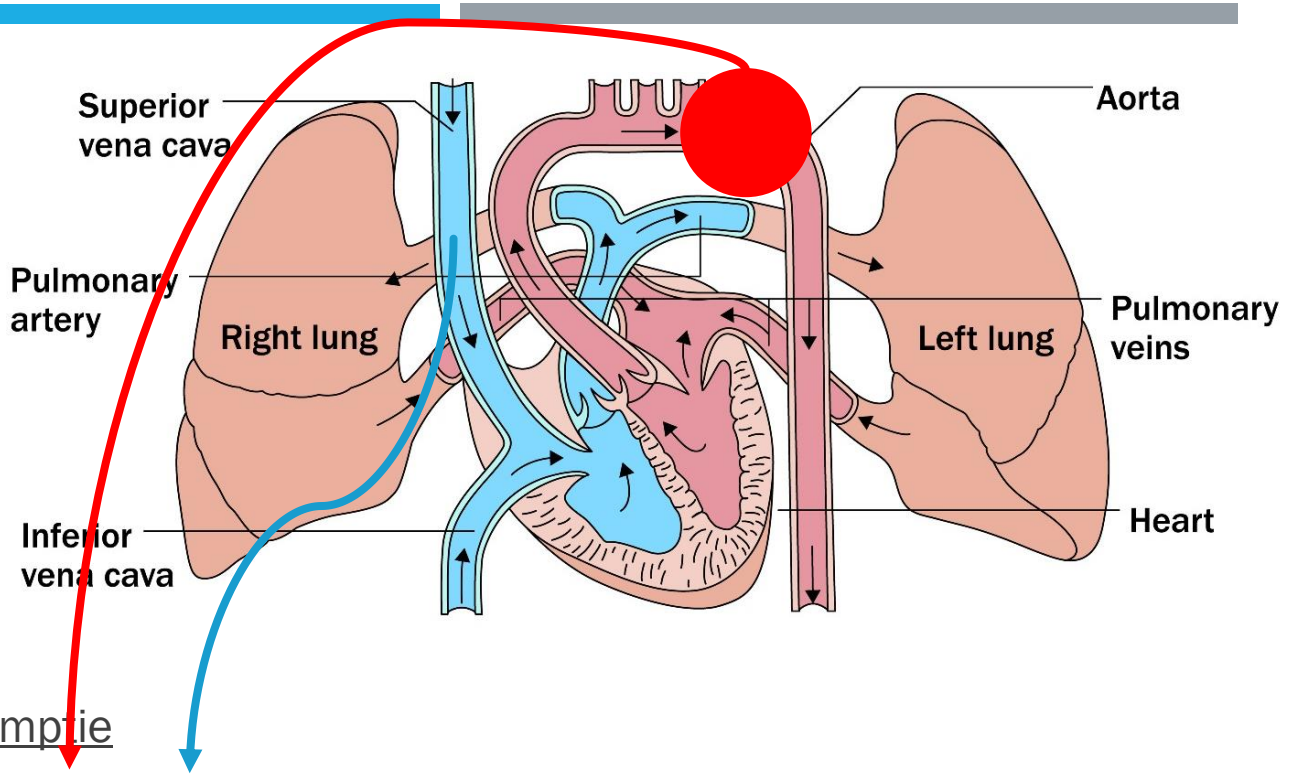
CARDIAC OUTPUT BEREKENEN FICK EQUATION



- Cardiac Output :

$$\frac{O_2 \text{ consumptie}}{1.36 * Hb\ (g/dl) * (SaO_2\text{-}SvO_2)}$$

- O2-consumptie : 157,3*BSA+10*Geslacht (0=man, 1=vrouw)-10,5*LN(leeftijd)+4,8

  Ingewikkelde formule, maar voor grootste deel bepaald door BSA

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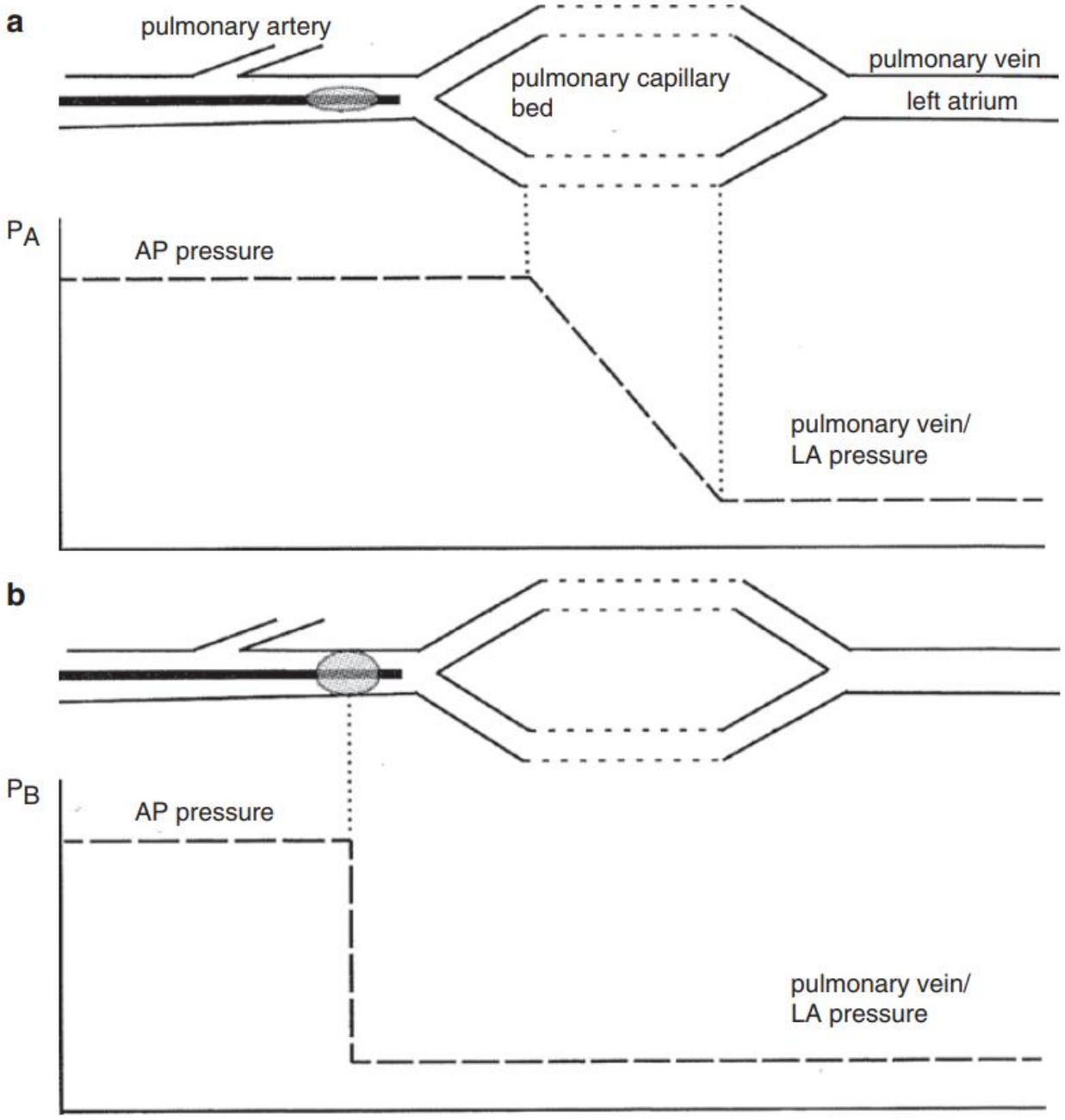
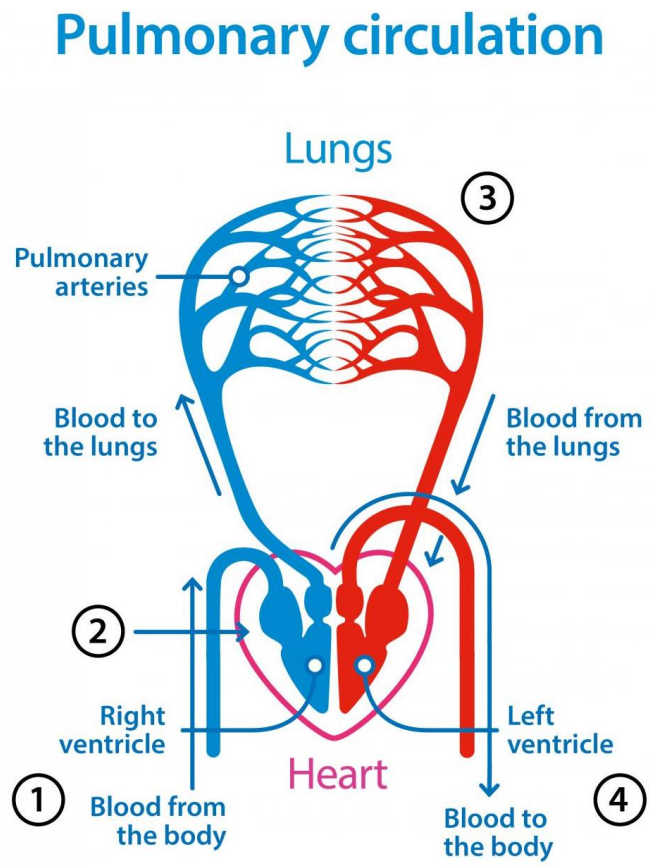
WEDGE METING



PULMONALE VAATWEERSTAND

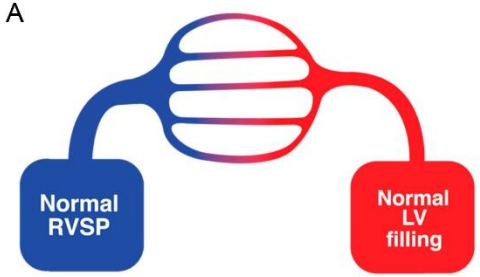
- Wet van Ohm: V=I*R
- Ofwel R=V/I
- Dus wordt formule voor longvaatweerstand dus
- Drukverschil tussen arterieel (arteria pulmonalis) en veneus (linker atrium)
  - Mean pressure AP – mean pressure LA (=LVEDP/PCW)

    Cardiac Output [dyne-sec-cm^{-5}]
    - of Wood's resistance unit (WU) = dynes/80

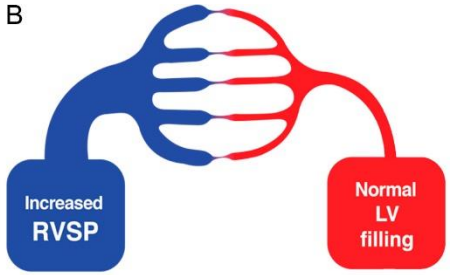


DEFINITIE PULMONALE HYPERTENSIE

A



B



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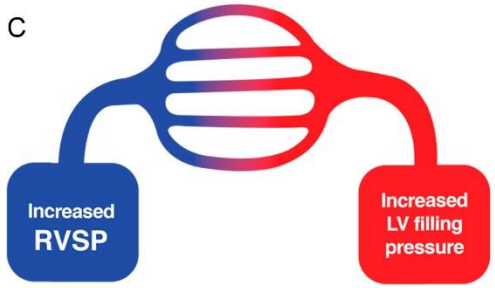
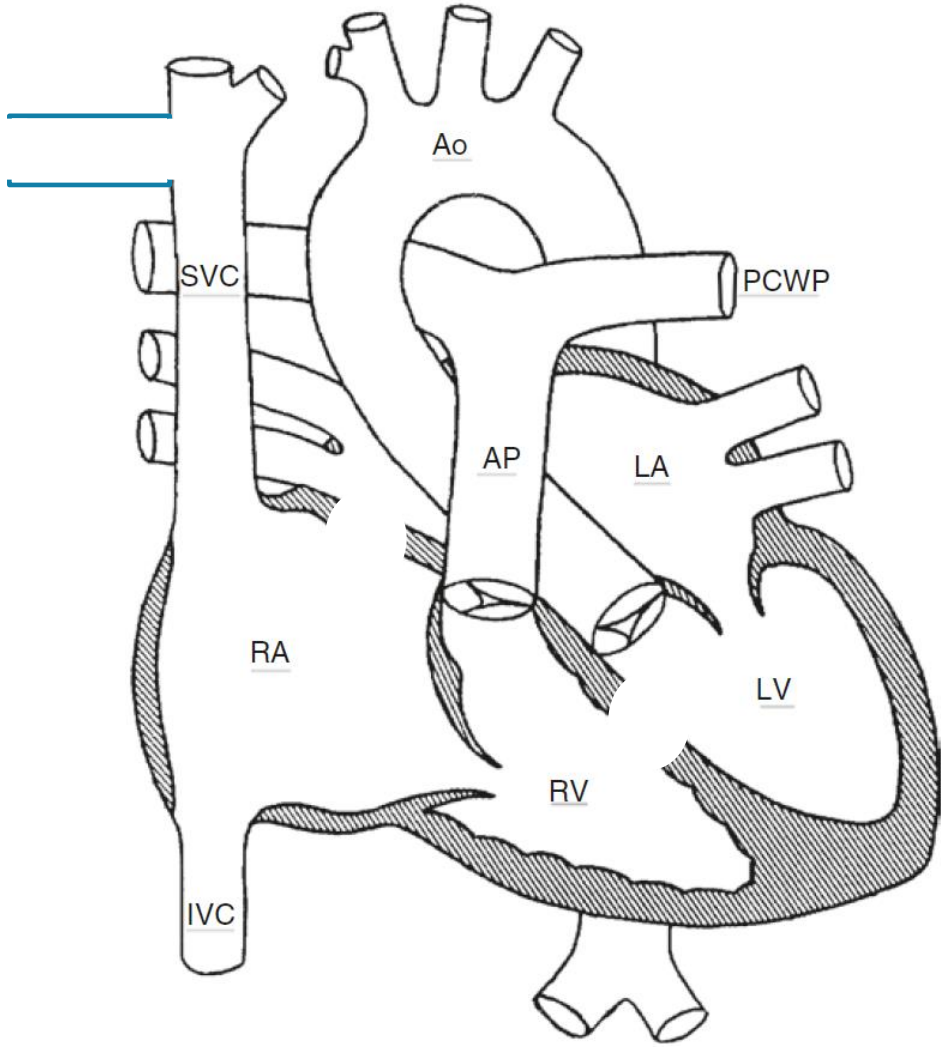


Definition	Characteristics[a]	Clinical group(s)[b]
PH	PAPm ≥25 mmHg	All
Pre-capillary PH	PAPm ≥25 mmHg PAWP ≤15 mmHg In Radboudumc < 5mm Hg	1. Pulmonary arterial hypertension 3. PH due to lung diseases 4. Chronic thromboembolic PH 5. PH with unclear and/or multifactorial mechanisms
Post-capillary PH	PAPm ≥25 mmHg PAWP >15 mmHg	2. PH due to left heart disease 5. PH with unclear and/or multifactorial mechanisms
Isolated post-capillary PH (Ipc-PH)	DPG <7 mmHg and/or PVR ≤3 WU[c]	
Combined post-capillary and pre-capillary PH (Cpc-PH)	DPG ≥7 mmHg and/or PVR >3 WU[c]	

SHUNTS

- Verschil in flow over
  - Pulmonale vaatbed
  - Systemische vaatbed
- Pulmonale flow versus Systemische flow



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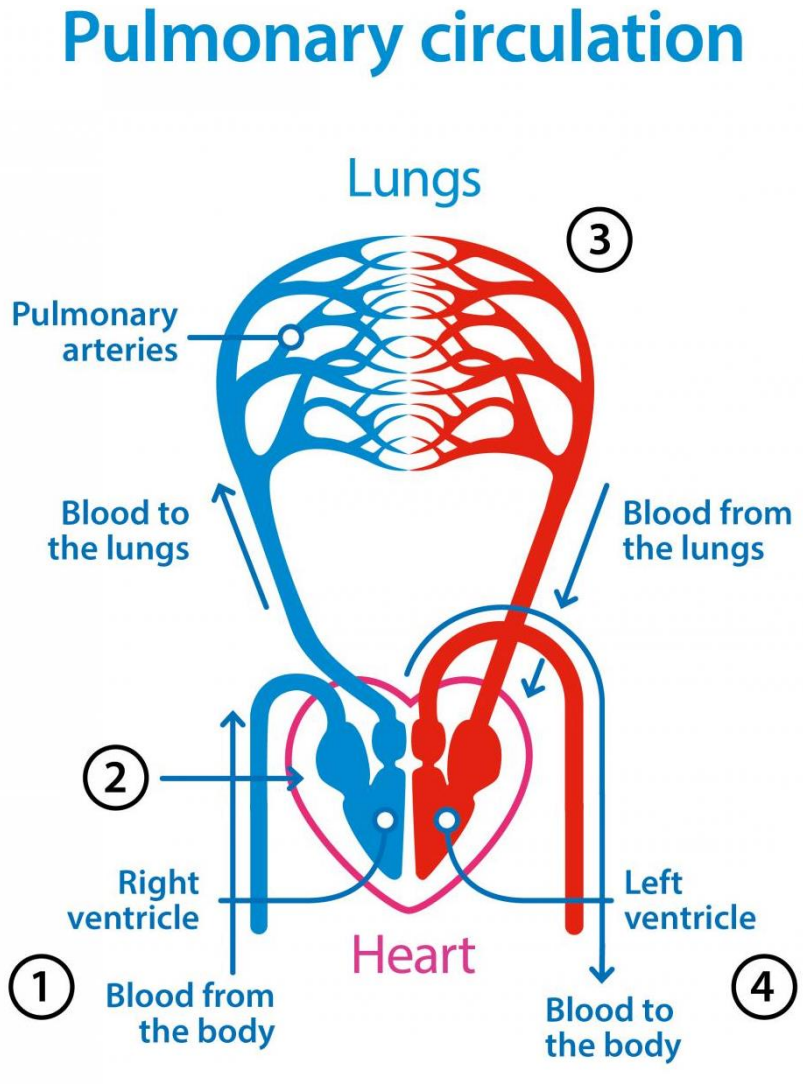
SIMPELE SHUNT BEREKENING

- Flow pulmonaal
- Flow systeem

$$Qp/Qs = \frac{[\text{Sat Aorta} - \text{Sat Mixed Venous}]}{[\text{Sat Pulmonary vein} - \text{Sat AP}]}$$



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SHUNT BEREKENING

- Q_p

$$\frac{O_2 \text{ consumptie (mL/min)}}{[PV\ O_2] - [PA\ O_2]}$$

- Q_s

$$\frac{O_2 \text{ consumptie (mL/min)}}{[Sa\ O_2] - [MV\ O_2]}$$

$$Q_p / Q_s$$

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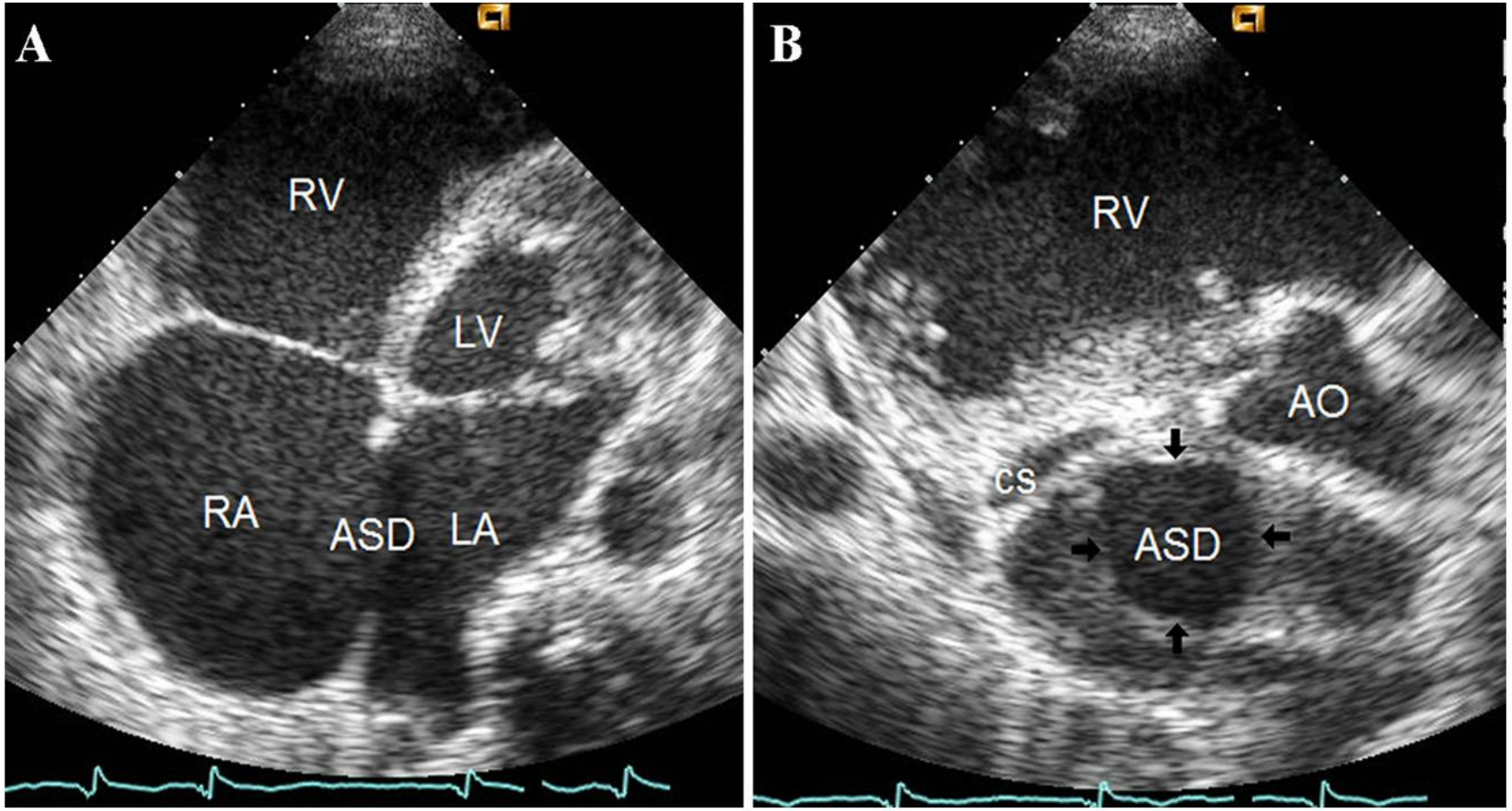
WELKE SHUNTS

- Atriumseptumdefect
- Ventrikelseptumdefect
- Ductus arteriosus



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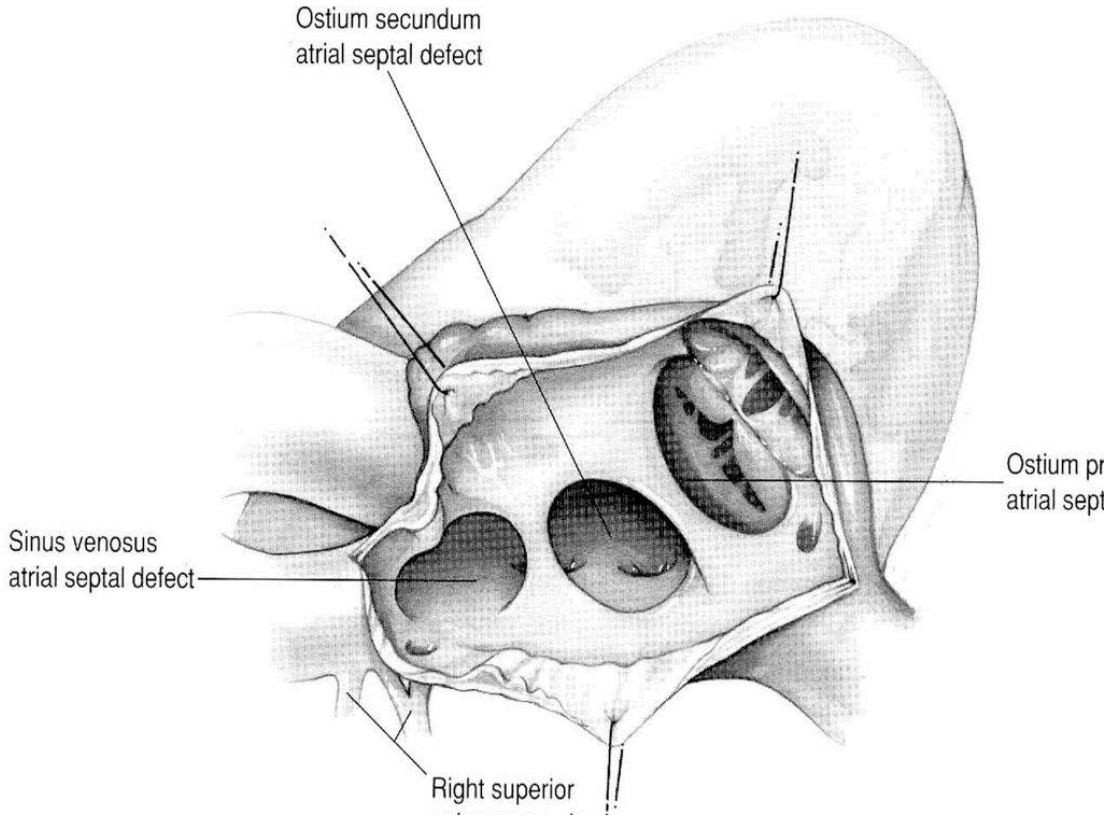
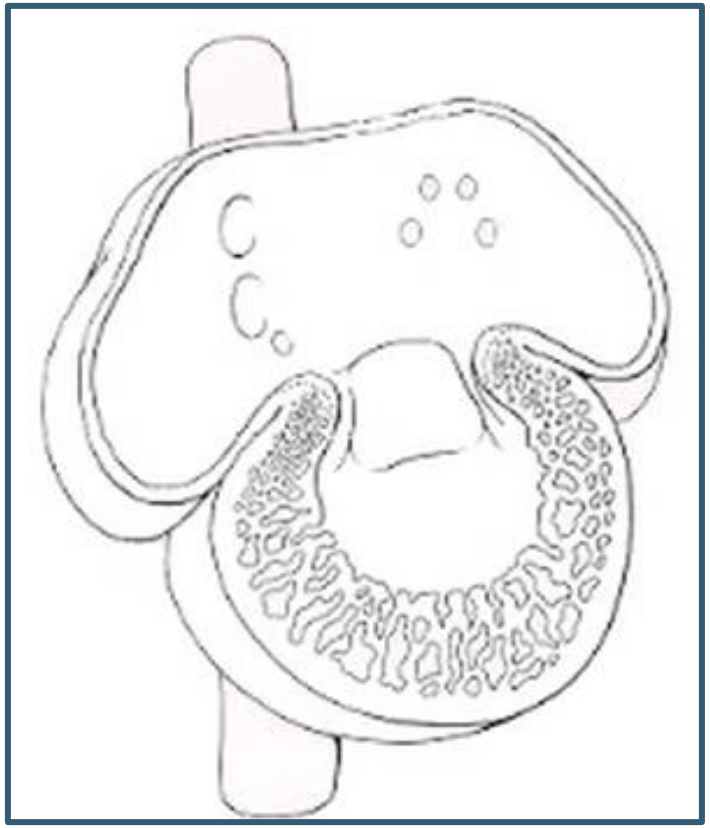
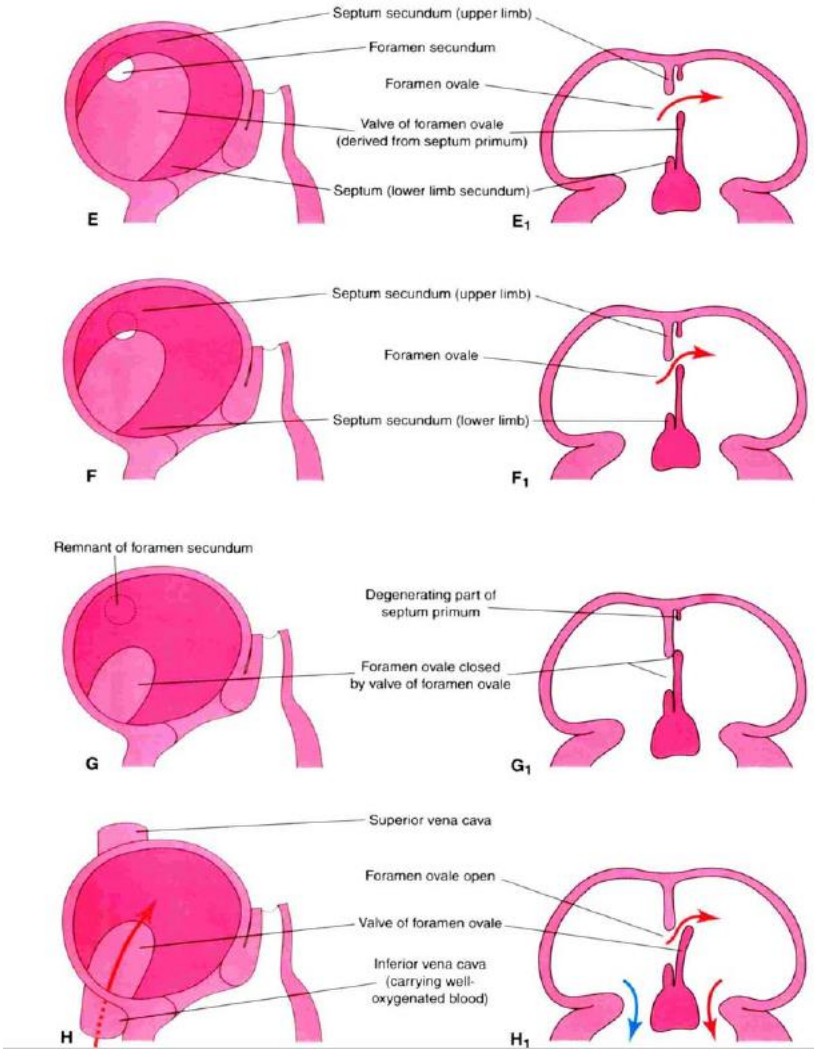
ASD AND PFO CLOSURE

- Imaging information pre procedure
  - ASD
  - PFO
- Imaging per procedure
  - TEE and ICE and X-ray
- What would you do?



Atrial development





Atrial Partitioning II

- Septum secundum grows down, overlapping foramen secundum
- Foramen ovale: between septum primum & septum secundum
- Remaining portion of septum primum forms valve of foramen ovale

From Moore & Persaud 1998

Table 3 Indications for intervention in atrial septal defect

Indications	Class[a]	Level[b]
Patients with significant shunt (signs of RV volume overload) and PVR <5 WU should undergo ASD closure regardless of symptoms	I	B[26]
Device closure is the method of choice for secundum ASD closure when applicable	I	C
All ASDs regardless of size in patients with suspicion of paradoxical embolism (exclusion of other causes) should be considered for intervention	IIa	C
Patients with PVR ≥5 WU but <2/3 SVR or PAP <2/3 systemic pressure (baseline or when challenged with vasodilators, preferably nitric oxide, or after targeted PAH therapy) and evidence of net L–R shunt (Qp:Qs >1.5) may be considered for intervention	IIb	C
ASD closure must be avoided in patients with Eisenmenger physiology	III	C

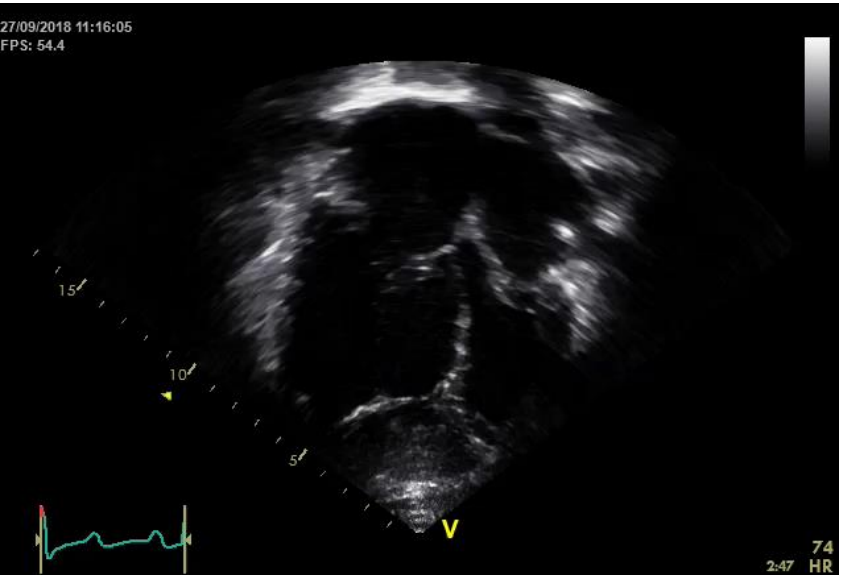
		Therapeutic
I	B-NR[SR]	4. In adults with isolated secundum ASD causing impaired functional capacity, right atrial and/or RV enlargement, and net left-to-right shunt sufficiently large to cause physiological sequelae (e.g., pulmonary–systemic blood flow ratio [Qp:Qs] ≥1.5:1) without cyanosis at rest or during exercise, transcatheter or surgical closure to reduce RV volume and improve exercise tolerance is recommended, provided that systolic PA pressure is less than 50% of systolic systemic pressure and pulmonary vascular resistance is less than one third of the systemic vascular resistance (S4.1.1-7–S4.1.1-12).
I	B-NR	5. Adults with primum ASD, sinus venosus defect or coronary sinus defect causing impaired functional capacity, right atrial and/or RV enlargement and net left-to-right shunt sufficiently large to cause physiological sequelae (e.g., Qp:Qs ≥1.5:1) without cyanosis at rest or during exercise, should be surgically repaired unless precluded by comorbidities, provided that systolic PA pressure is less than 50% of systemic pressure and pulmonary vascular resistance is less than one third of the systemic vascular resistance (S4.1.1-13, S4.1.1-14).
IIa	C-LD[SR]	6. In asymptomatic adults with isolated secundum ASD, right atrial and RV enlargement, and net left-to-right shunt sufficiently large to cause physiological sequelae (e.g., Qp:Qs 1.5:1 or greater), without cyanosis at rest or during exercise, transcatheter or surgical closure is reasonable to reduce RV volume and/or improve functional capacity, provided that systolic PA pressure is less than 50% of systemic pressure and pulmonary vascular resistance is less than one third systemic resistance (S4.1.1-7–S4.1.1-10, S4.1.1-12).
IIa	C-LD	7. Surgical closure of a secundum ASD in adults is reasonable when a concomitant surgical procedure is being performed and there is a net left-to-right shunt sufficiently large to cause physiological sequelae (e.g., Qp:Qs 1.5:1 or greater) and right atrial and RV enlargement without cyanosis at rest or during exercise (S4.1.1-15–S4.1.1-18).
IIb	B-NR	8. Percutaneous or surgical closure may be considered for adults with ASD when net left-to-right shunt (Qp:Qs) is 1.5:1 or greater, PA systolic pressure is 50% or more of systemic arterial systolic pressure, and/or pulmonary vascular resistance is greater than one third of the systemic resistance (S4.1.1-19, S4.1.1-20).
III: Harm	C-LD	9. ASD closure should not be performed in adults with PA systolic pressure greater than two thirds systemic, pulmonary vascular resistance greater than two thirds systemic, and/or a net right-to-left shunt (S4.1.1-21, S4.1.1-22).

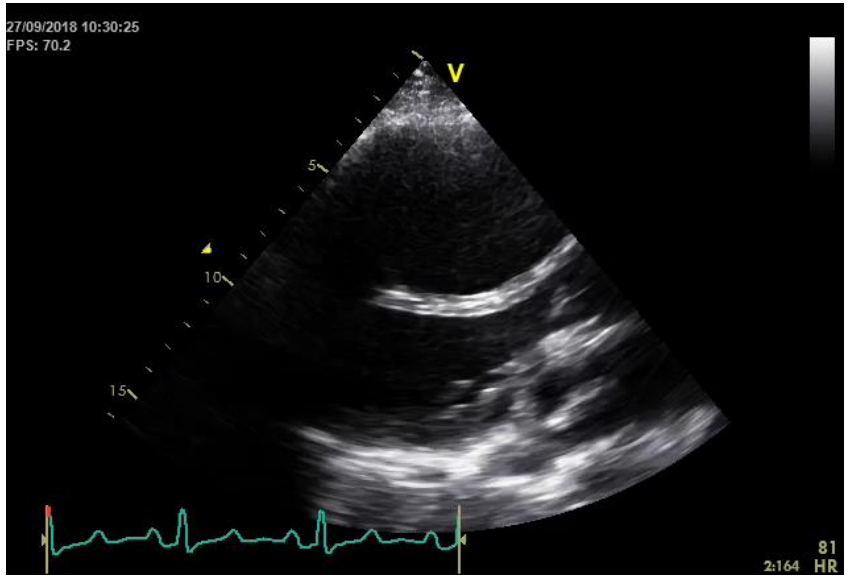
ASD PRE INTERVENTION WORK-UP

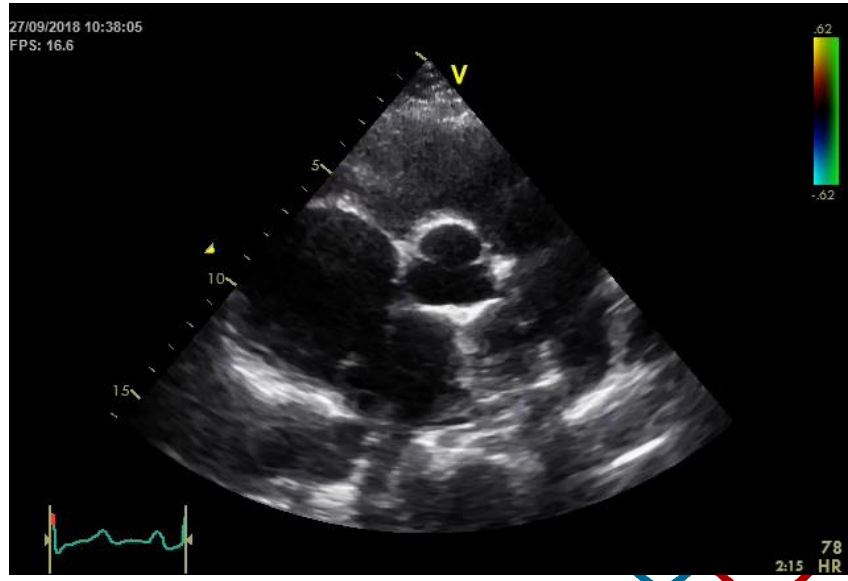
- Important
  - Concomitant cardiac abnormalities (valves)
  - Coronary artery disease (elderly)
  - Pulmonary hypertension
    - Pulmonary vascular resistance > 2/3 Systemic vascular resistance
    - Left – Right shunt
  - Pulmonary venous drainage
  - Atrial fibrillation
    - Decide on peri-procedural PVI
    - After device more difficult to perform

ASD IMAGING

- Volume overload of the right heart
  - Dilatation of Right Atrium Right Ventricle and Pulmonary artery







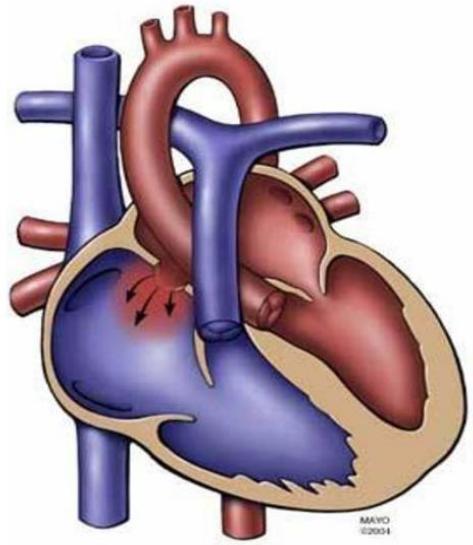
ASD IMAGING

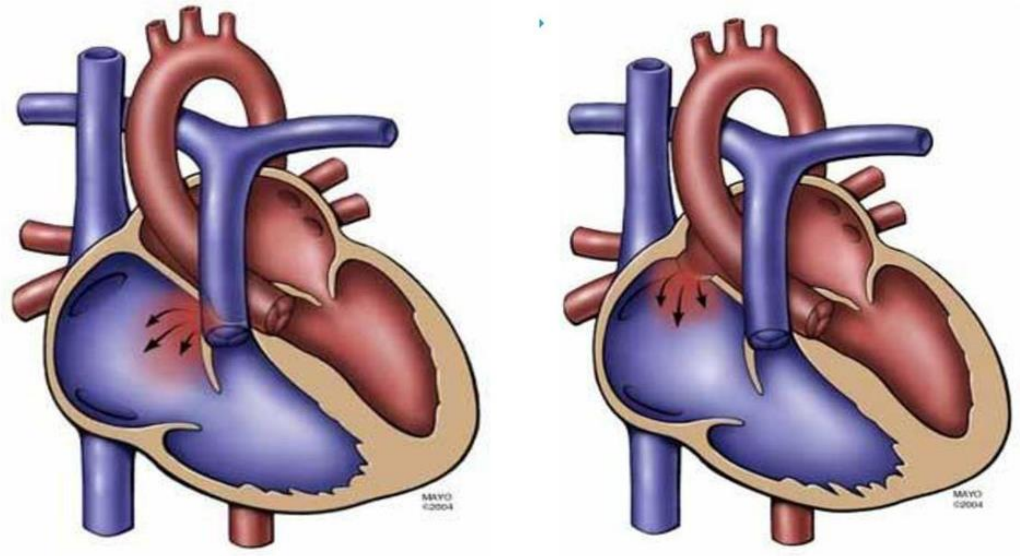
- Volume overload of the right heart
  - Dilatation of Right Atrium Right Ventricle and Pulmonary artery

- Find the shunt, Find the overload

  - Partial Anomalous Pulmonary Venous Return
  - Severe tricuspid regurgitation/pulmonary regurgitation
  - ASD
  - Type of ASD
  - Morphology of the ASD

- Type of ASD
  - Only secundum defect suitable for percutaneous closure
- Relationship with surrounding structures
  - Distance toward posterior wall of atrium
  - Distance toward AV-valves
- Rim information
  - Absence > 90 degree : closure ??
- Size of defect
  - >40mm contra-indicated
  - >30mm relative contra-indication
- Septum stability
  - Floppy?
- Intra cardiac thrombus





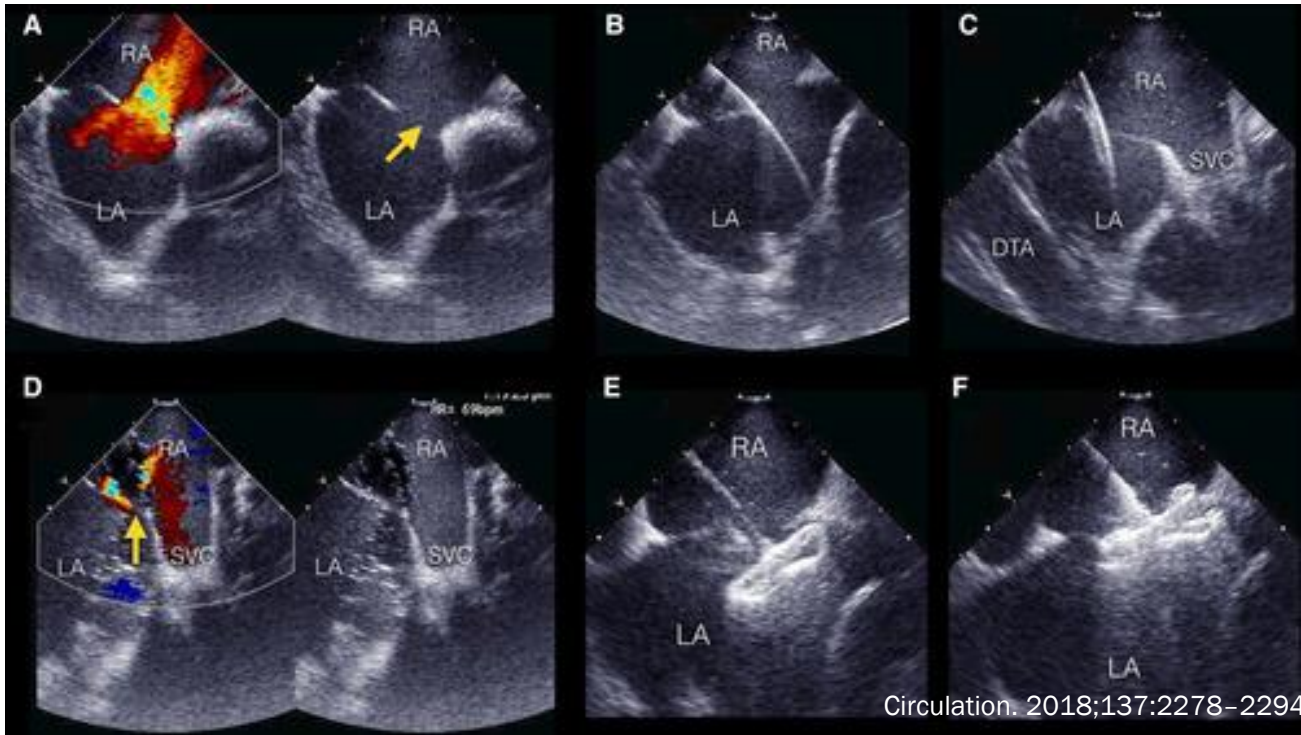
PFO

- 1/3 of population has PFO

- Diagnosis with right to left shunt proof with physiologic contrast
  - Trans cranial doppler
  - Trans thoracic echocardiogram
  - Trans esophageal echocardiogram
- Relationship with
  - Stroke
    - Secondary additional prevention
  - Decompression sickness
  - Platypneau deoxy syndrome

PERI-PROCEDURAL IMAGING

- TEE
  - General anesthesia
  - More degrees of freedom
  - Complete echocardiogram
  - Imaging dependent on operator
- X-ray
  - Radiation
  - Wire position
  - Indirect information



Circulation. 2018;137:2278–2294


AcuNav
8F-110

Table 2 Advantages and disadvantages of TTE, TEE, and ICE in percutaneous transcatheter guidance of PFO and ASD

Modality	Advantages	Disadvantages
TTE	Readily available Low cost Unlimited multiple planes to evaluate IAS Noninvasive Does not require any additional sedation Excellent image quality in pediatric patients	Image quality in larger patients could be suboptimal Requires technologist or echocardiographer to perform study during closure Lower rim of IAS not well seen after device placement owing to shadowing in virtually all views
TEE	Improved image quality over TTE 3D technique adds incremental value over 2D technique in evaluating ASD size, shape, location Provides en face imaging that might be more intuitively understood to nonimagers	Requires additional sedation or anesthesia to perform Risks include aspiration and esophageal trauma Could require endotracheal intubation if prolonged procedure performed Requires additional echocardiographic operator to perform Patient discomfort
ICE	Comparable image quality to TEE Can be performed with patient under conscious sedation Reduces procedure and fluoroscopy times Superior to TEE for evaluating inferior aspects of IAS Interventionalist autonomy (can perform without additional support)	Invasive Risks of 8F–10F venous access and catheter, including vascular risk and arrhythmia Role of 3D technique to be defined Cost of single-use ICE catheters Limited far field views with some systems Need for additional training of ICE operator Operator might have two tasks (imaging and procedure)

Silvestry et al. J Am Soc Echocardiogr 2015;28:910-5

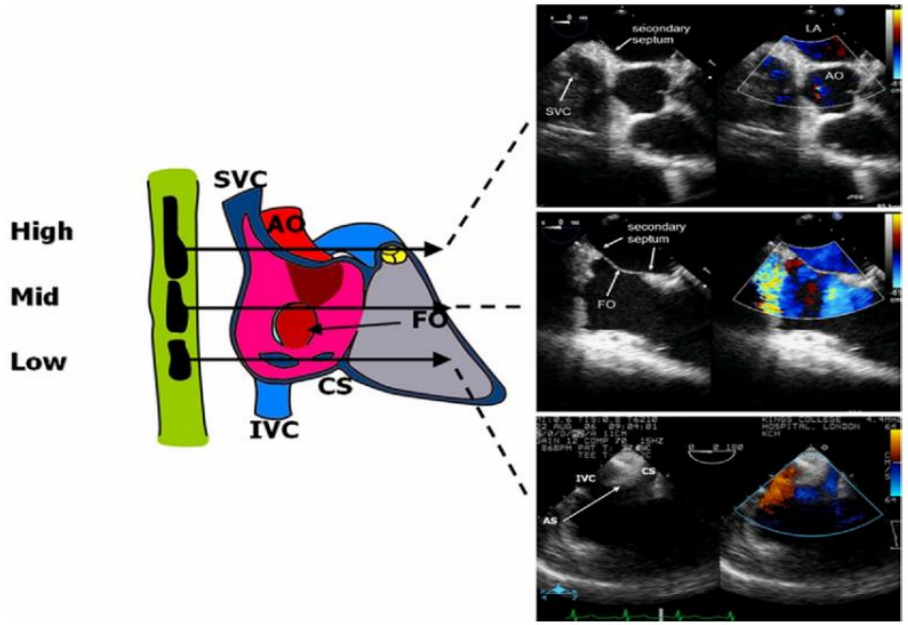


Figure 7. Illustration of the 3 Levels Within the Esophagus and the Corresponding TEE Images, at 0°

Illustration of the 3 levels (high, mid, low) within the esophagus and the corresponding transesophageal echocardiographic images, at 0°. AS = atrial septum; LA = left atrium; other abbreviations as in Figures 1 and 3.

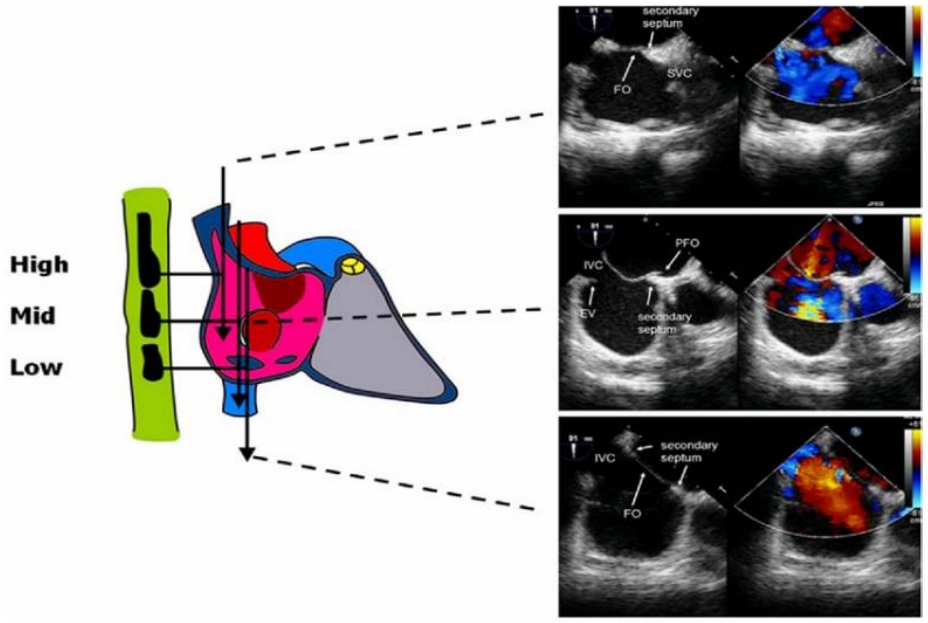
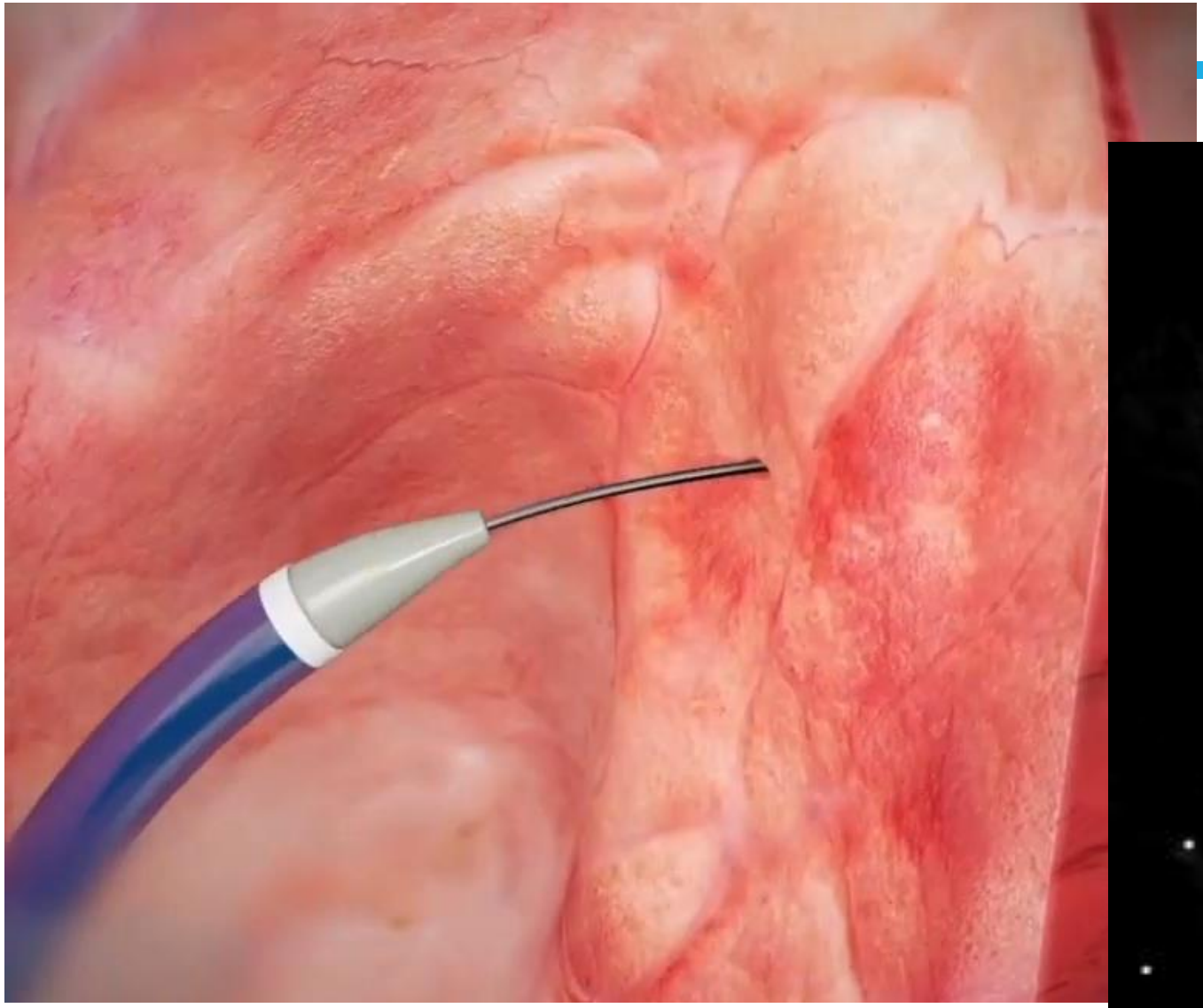
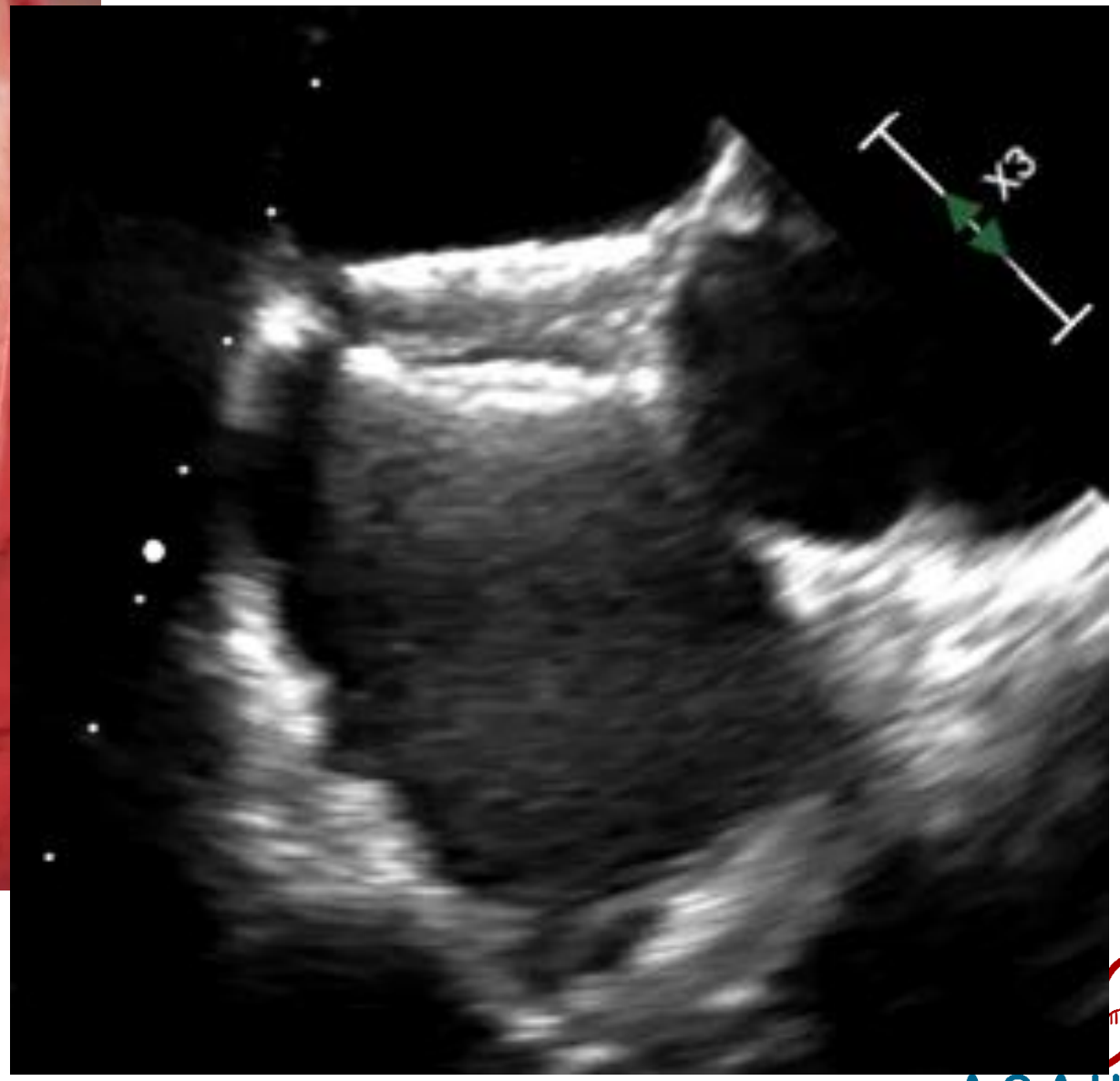


Figure 8. Illustration of the 3 Levels Within the Esophagus and the Corresponding TEE Images, at 90°

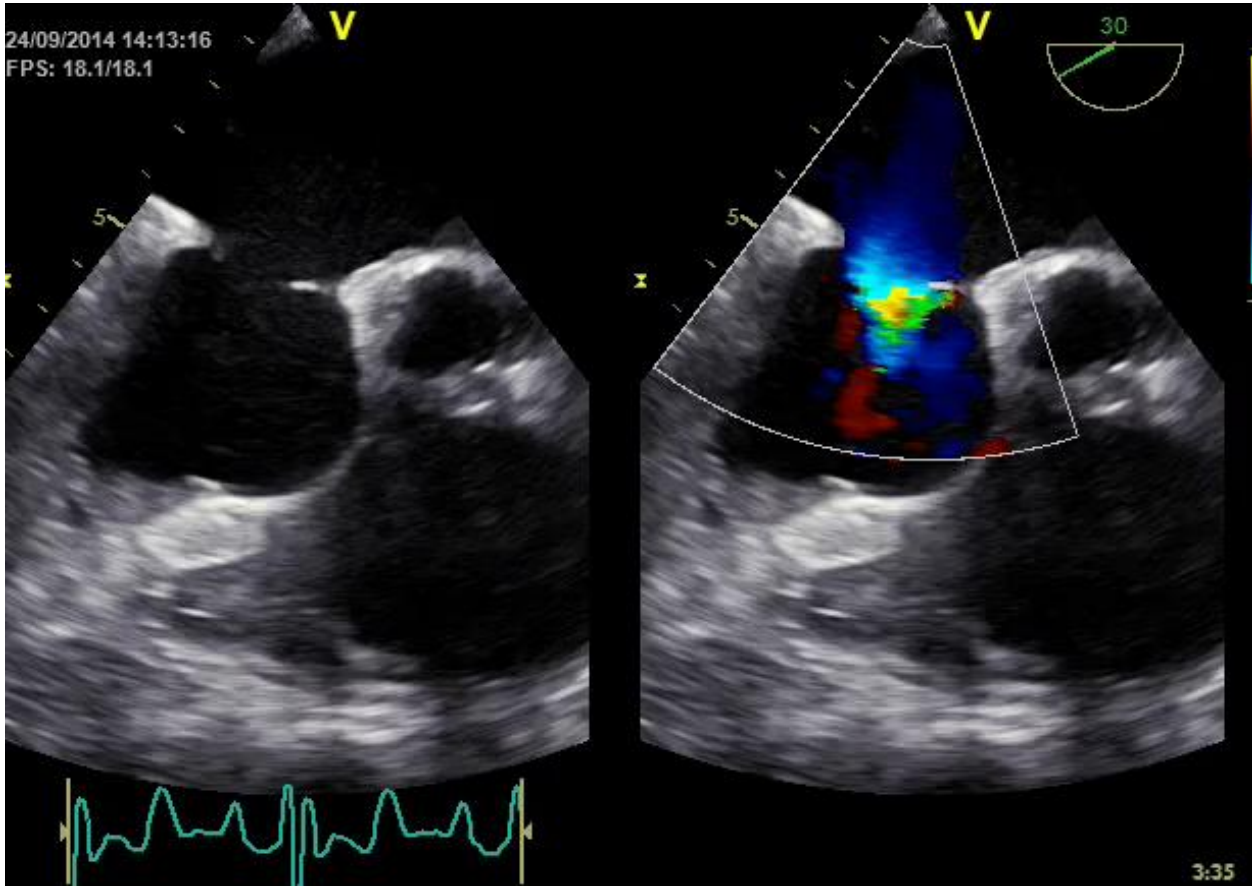
Illustration of the 3 levels (high, mid, low) within the esophagus and the corresponding transesophageal echocardiographic images, at 90°. EV = Eustachian valve remnant; other abbreviations as in Figures 1, 2, 3, and 7.

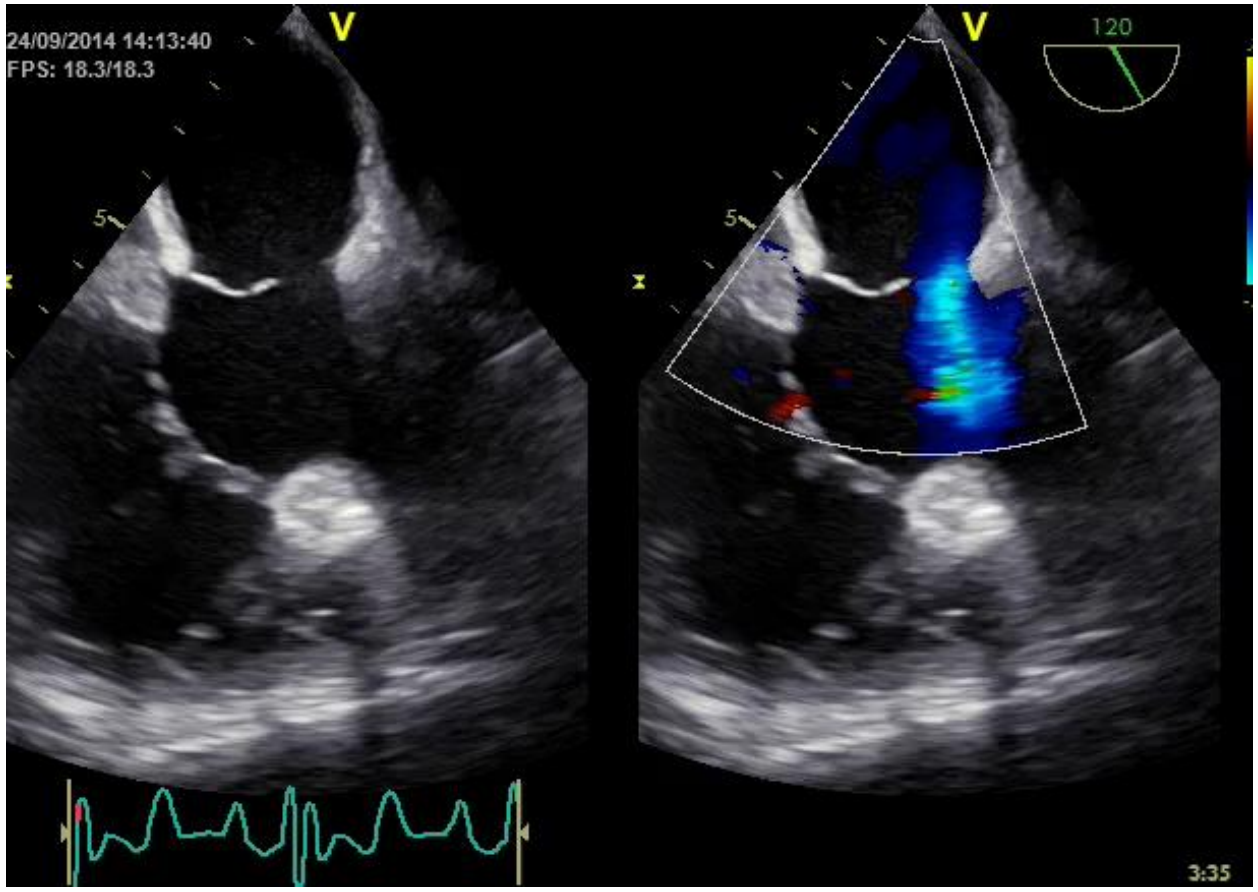
Rana et al. JACC Cardiovascular





ACAHA
Academisch Centrum Aangeboren Hartafwijkingen



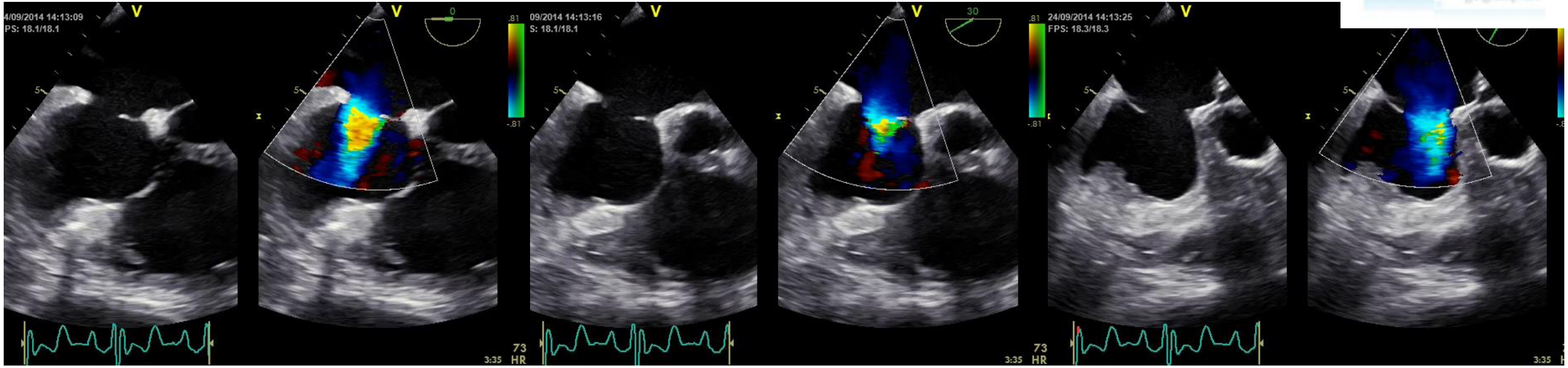


posterior and aorta (superior) rim diameter

anteroposterior diameter

IVC en SVC rim

cranio-caudal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24/09/2014 14:13:25
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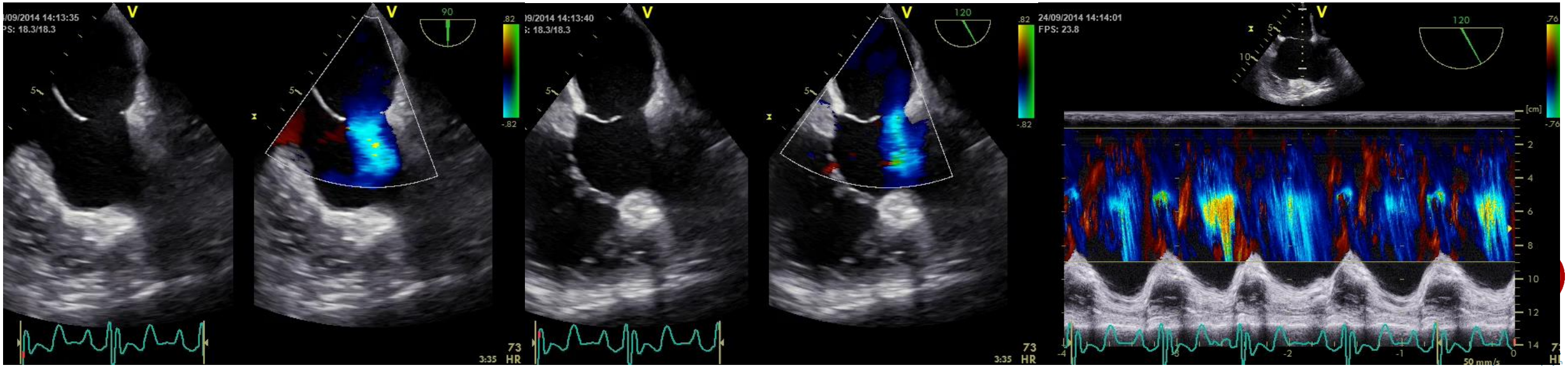
73
HR
3:35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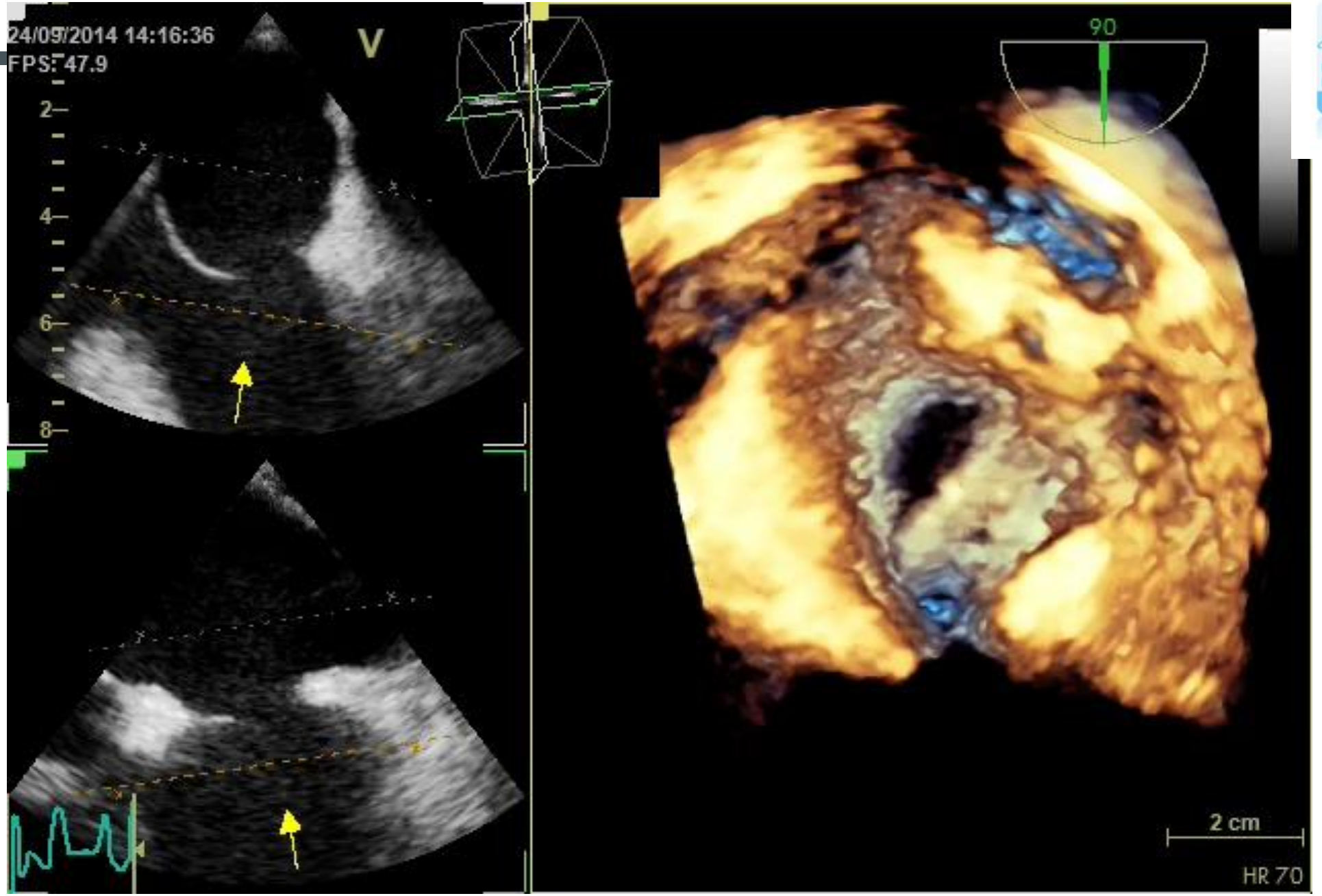
73
HR
3:35
[cm]
50 mm/s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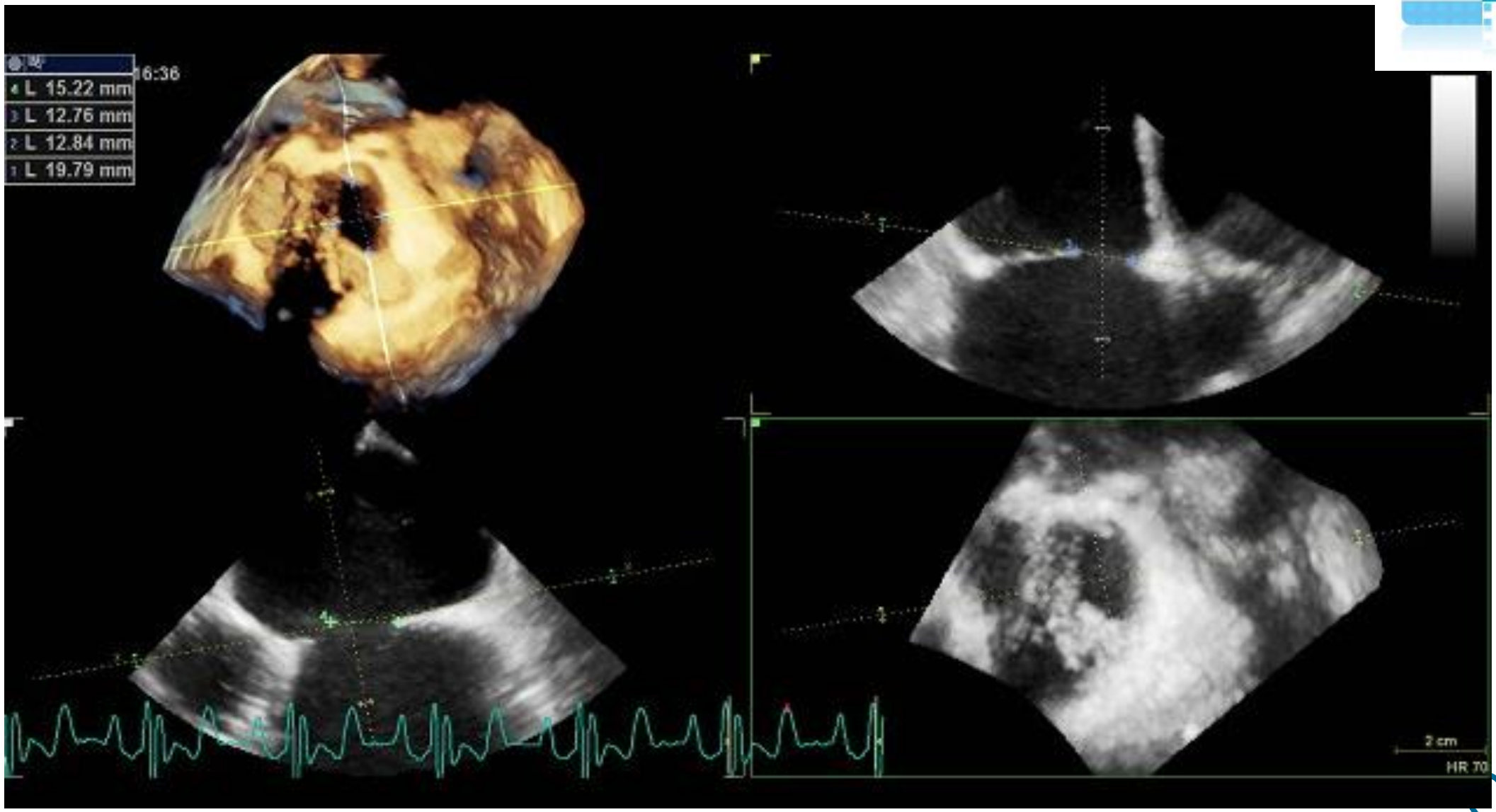
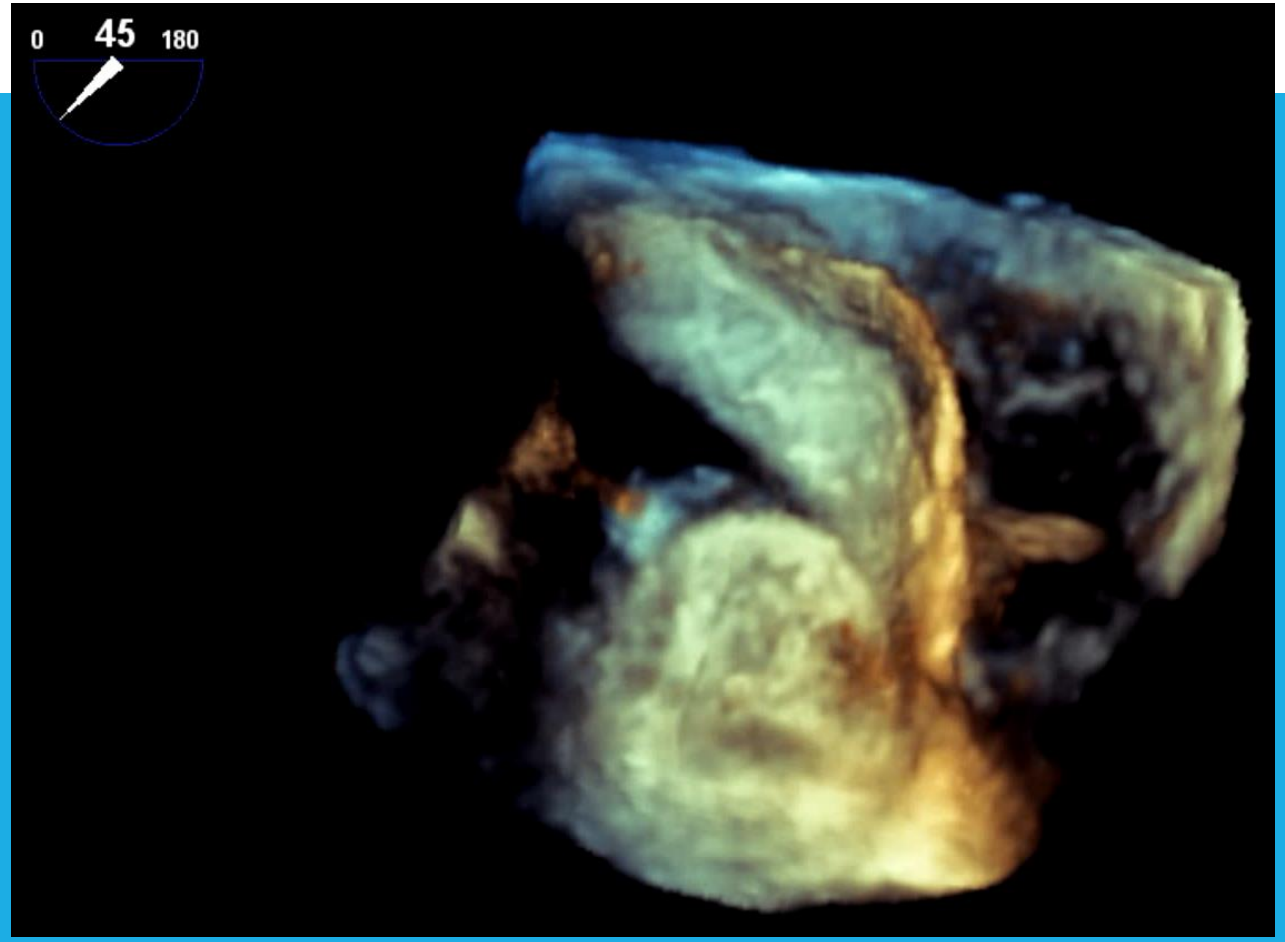
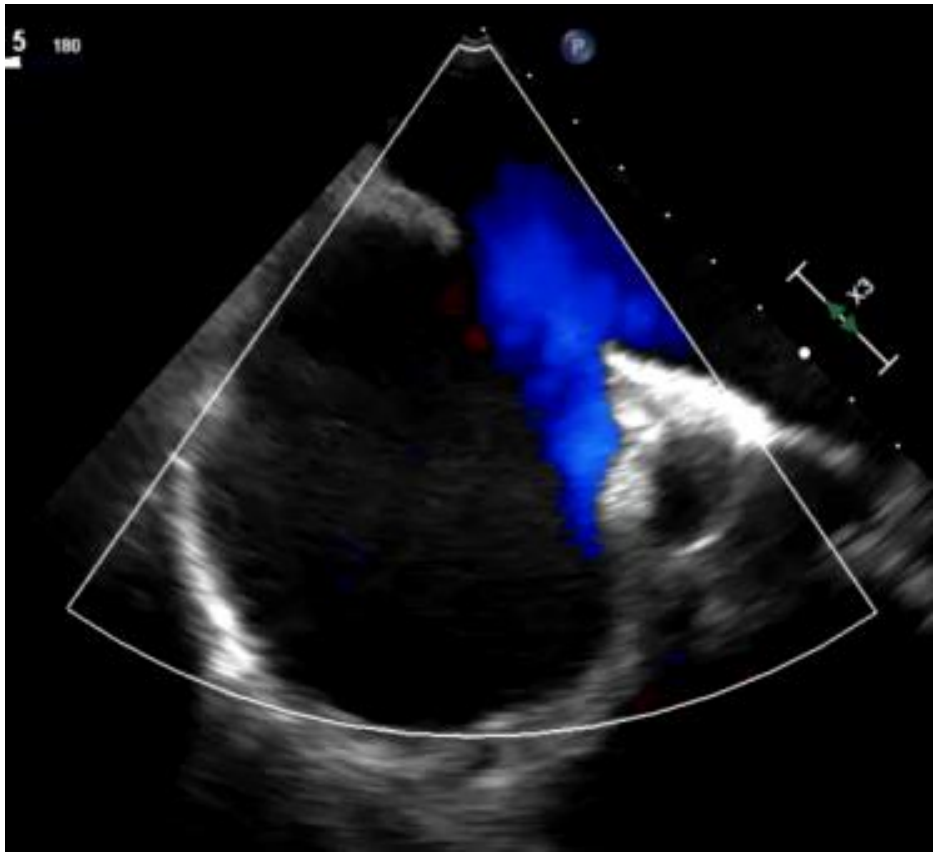
V
2
4
6
8
90
2 cm
HR 70


16:36
L 15.22 mm
L 12.76 mm
L 12.84 mm
L 19.79 mm
2 cm
HR 70

TOE 3D DEFINITE

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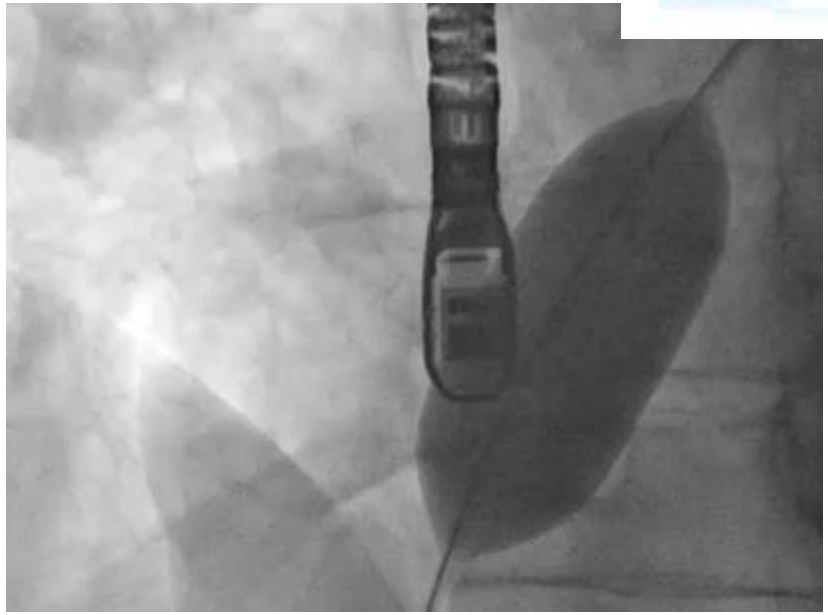

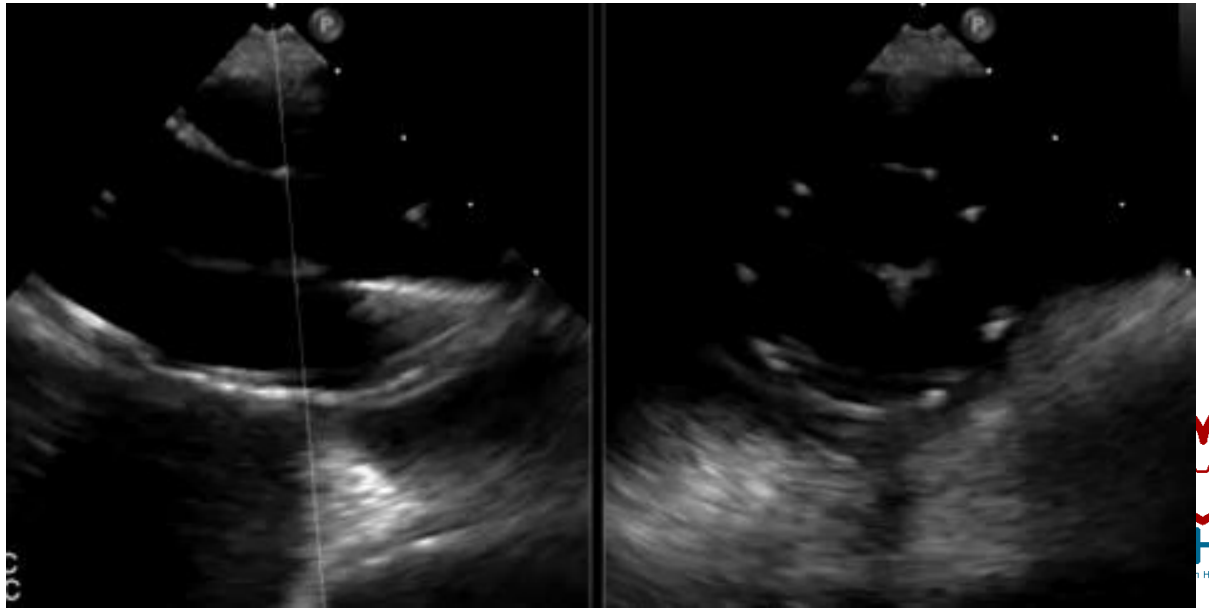

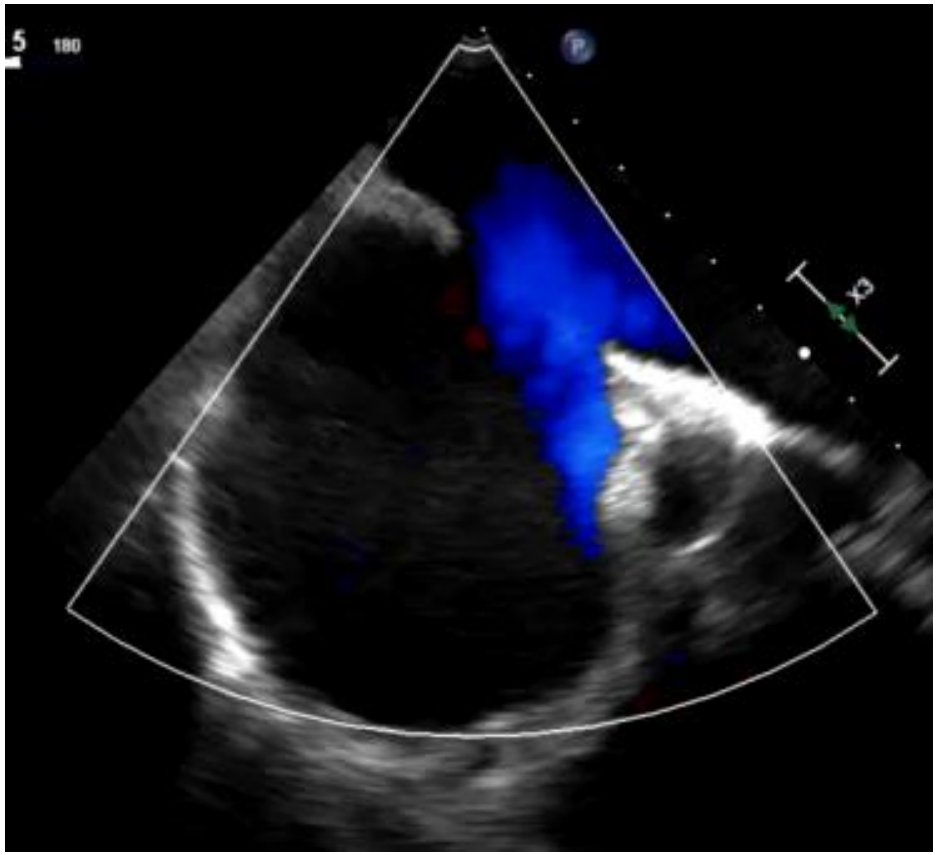
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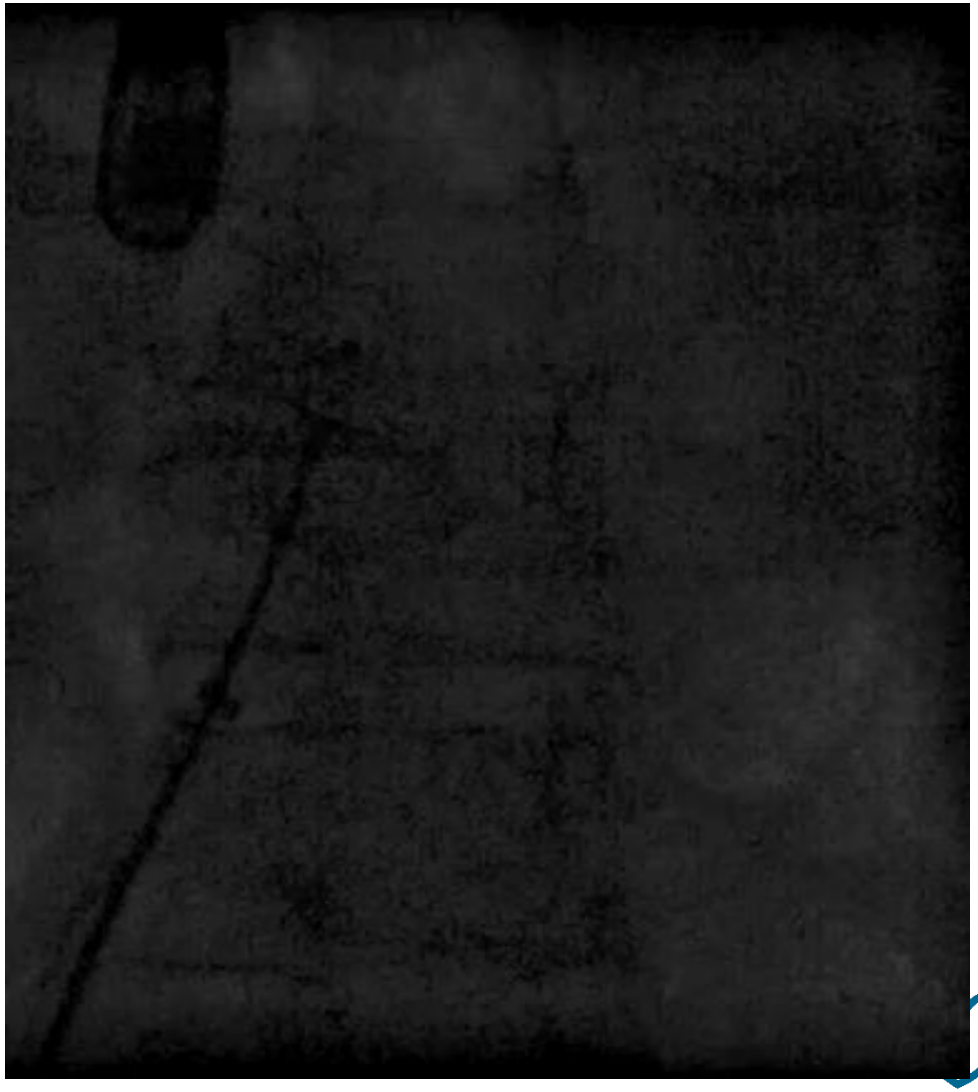

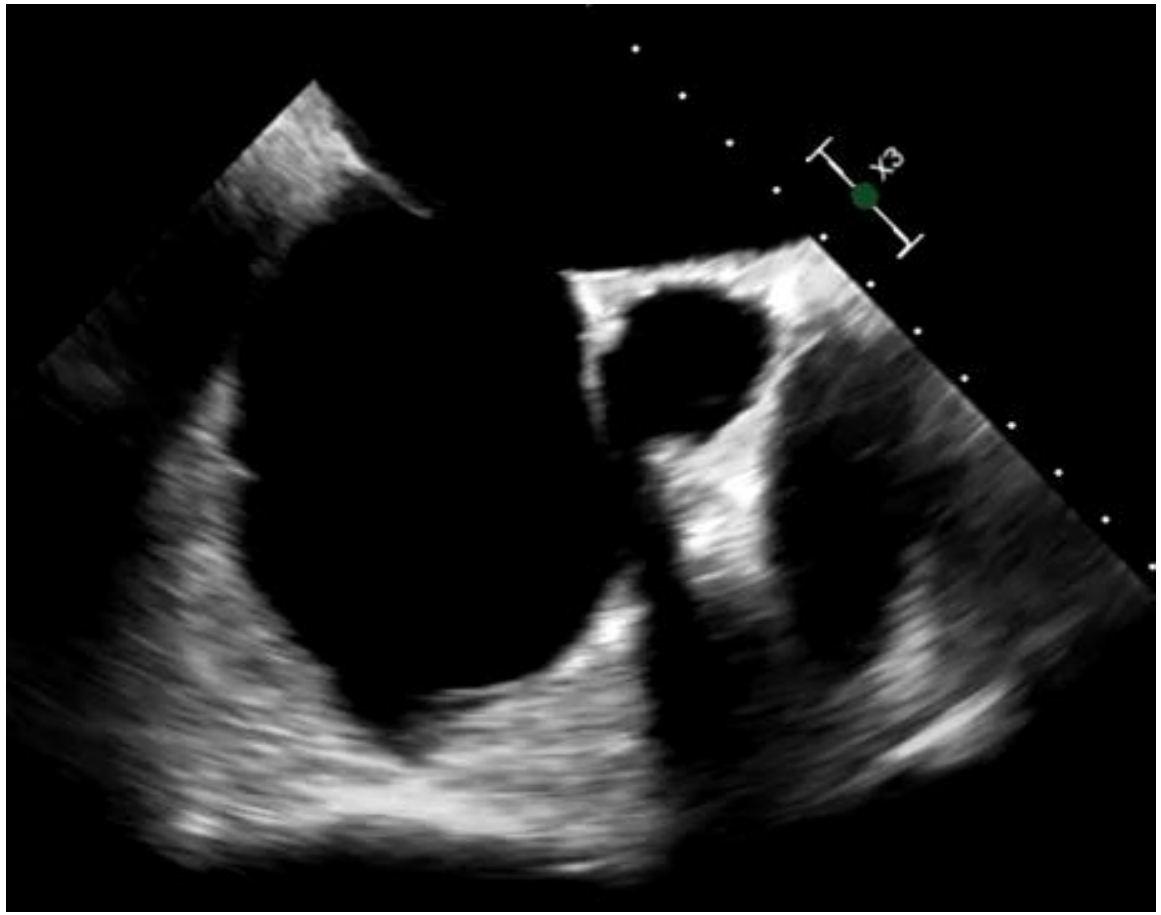
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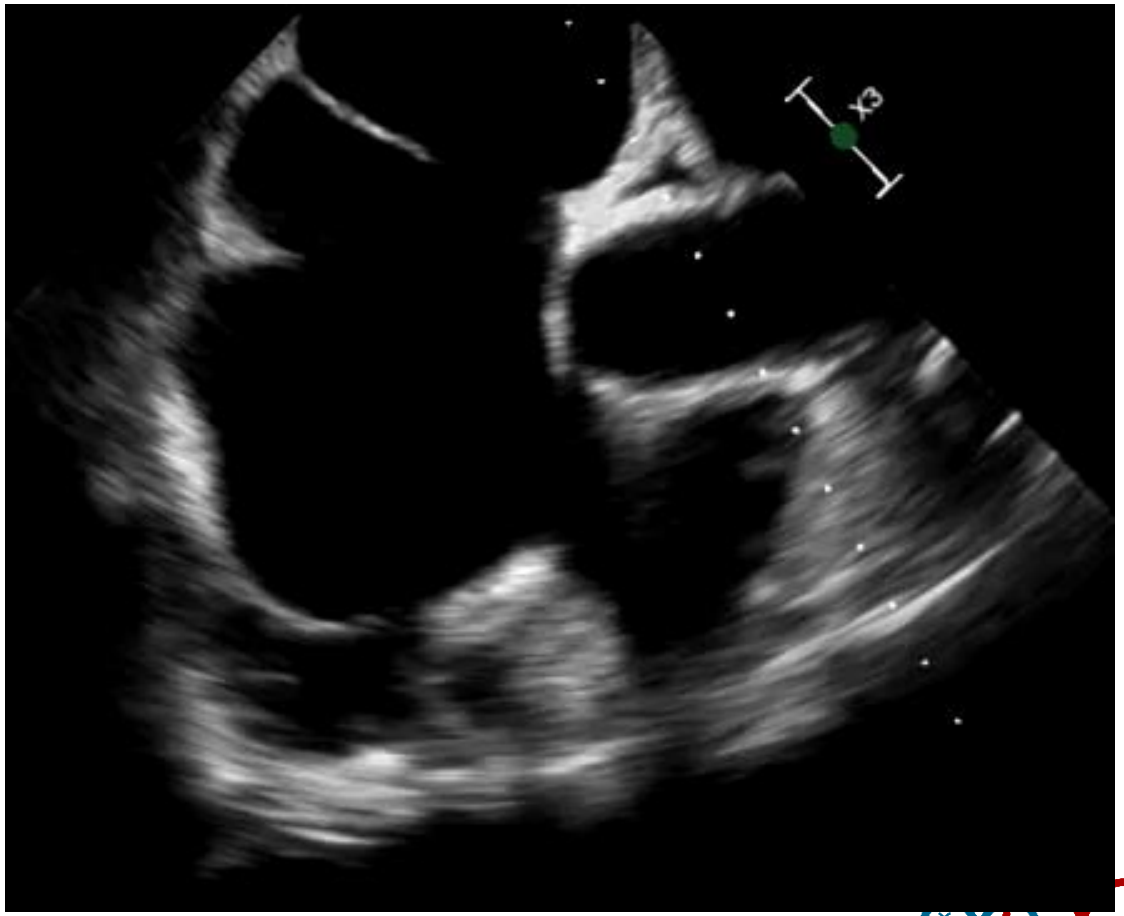
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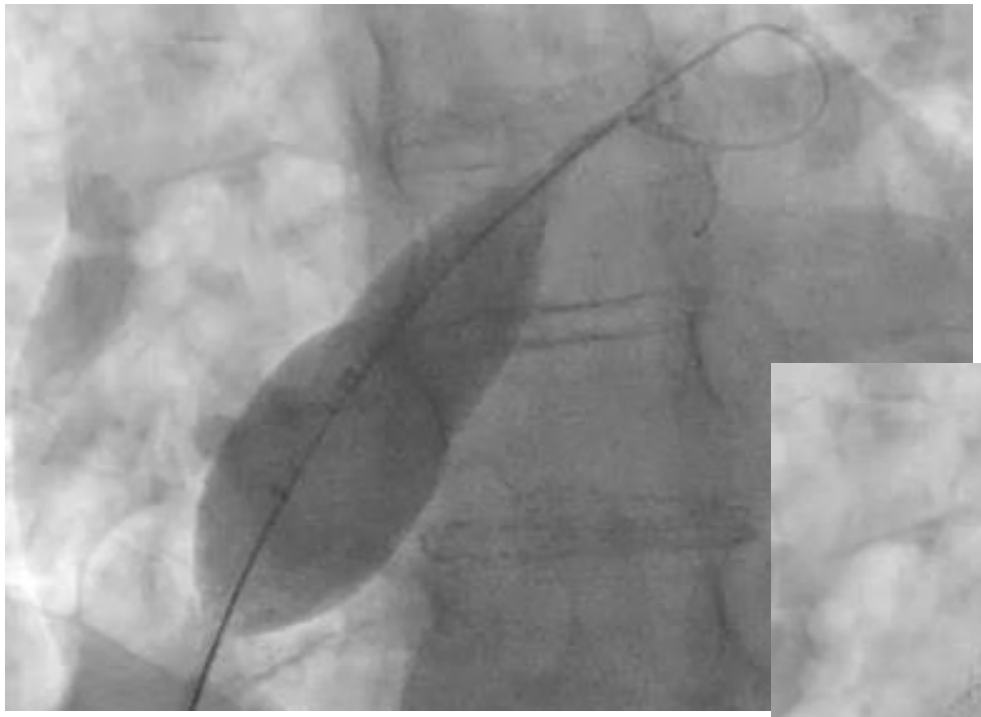

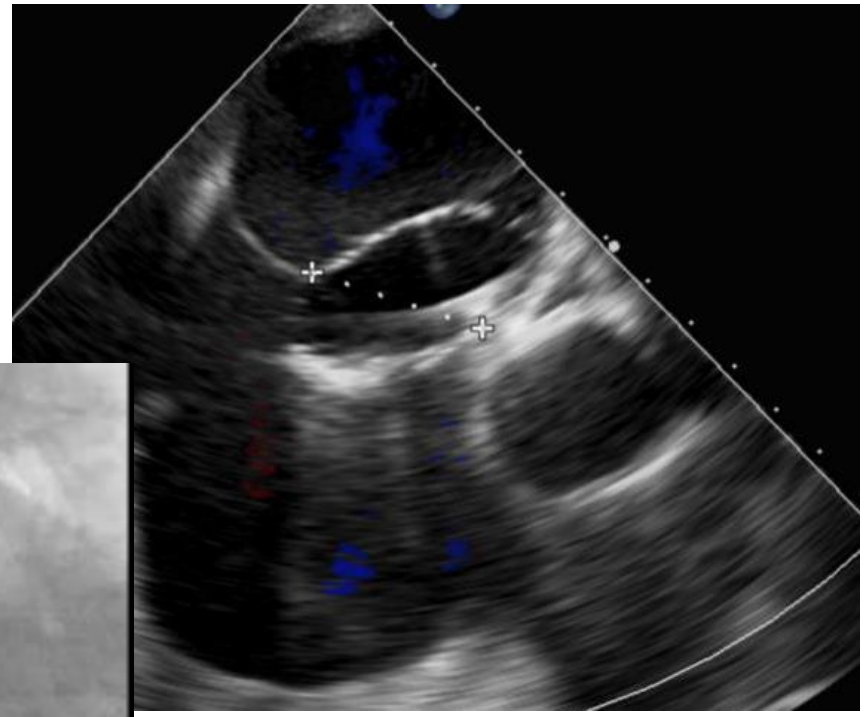

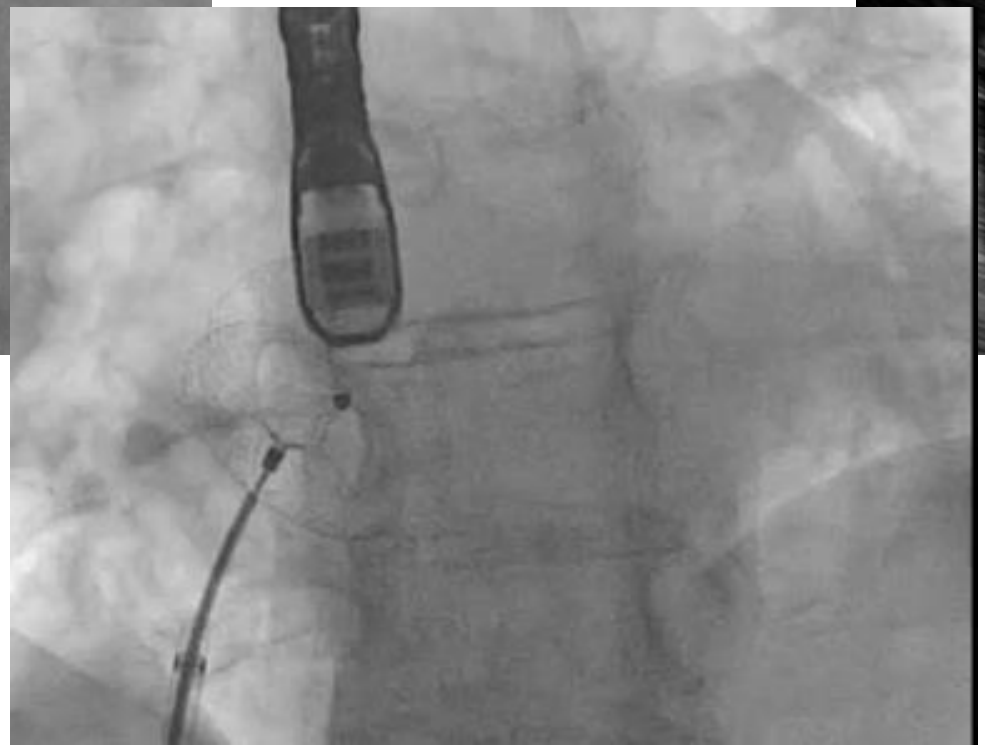

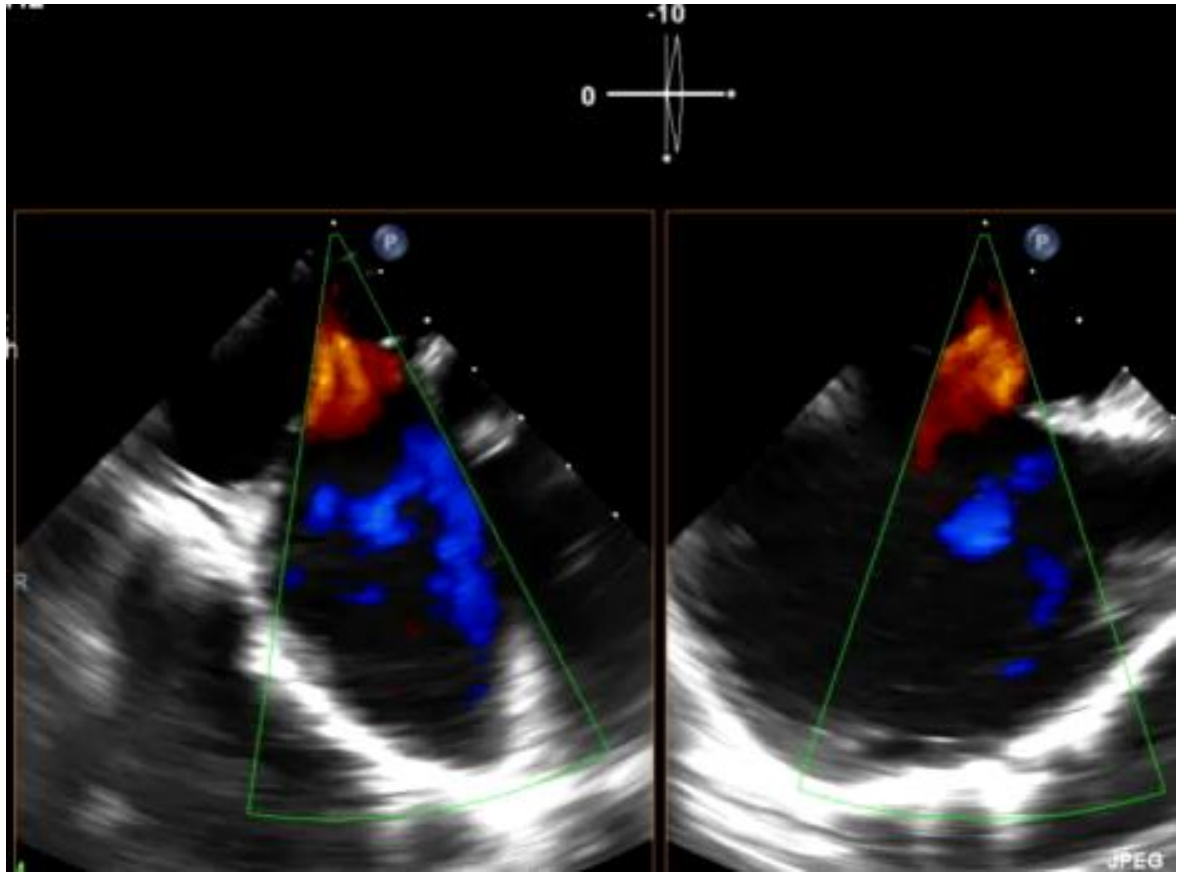
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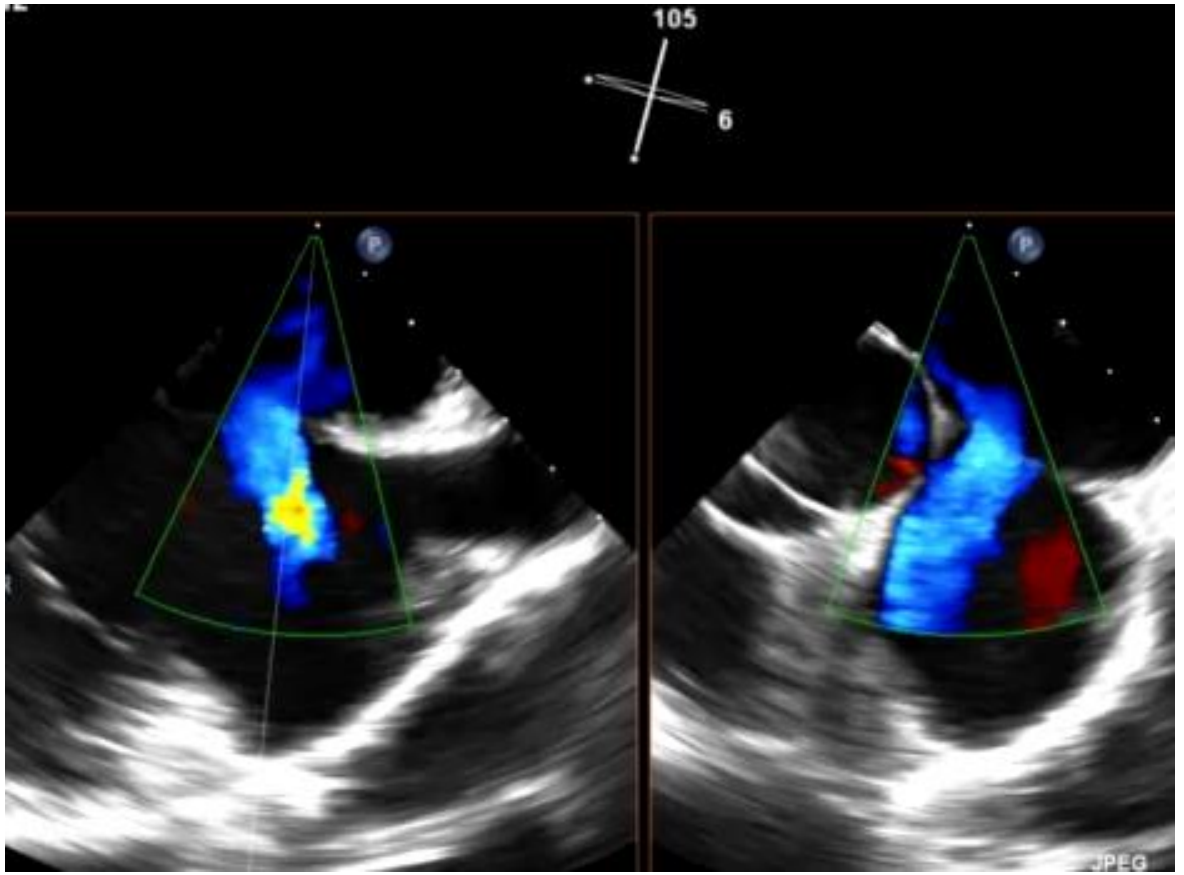
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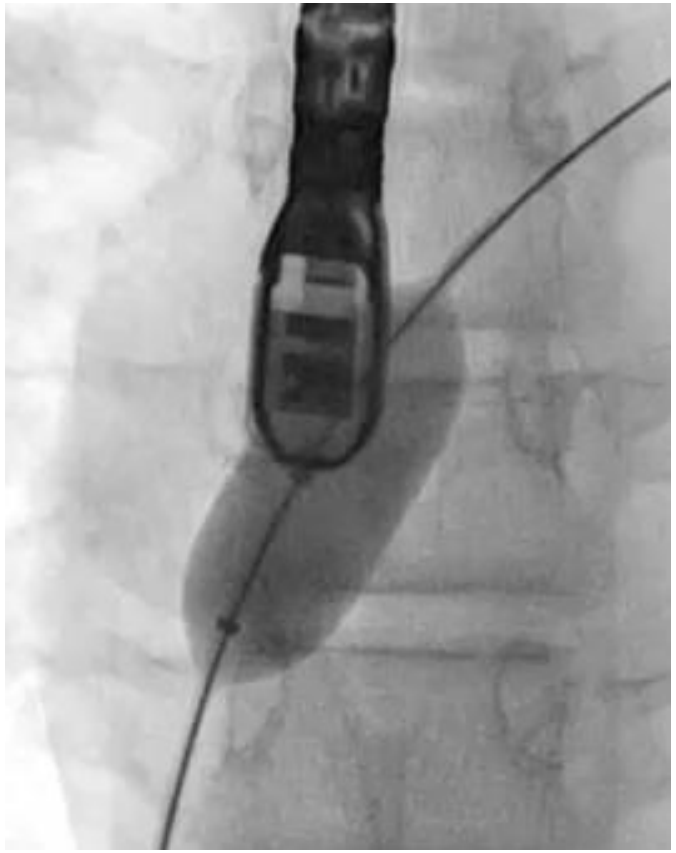

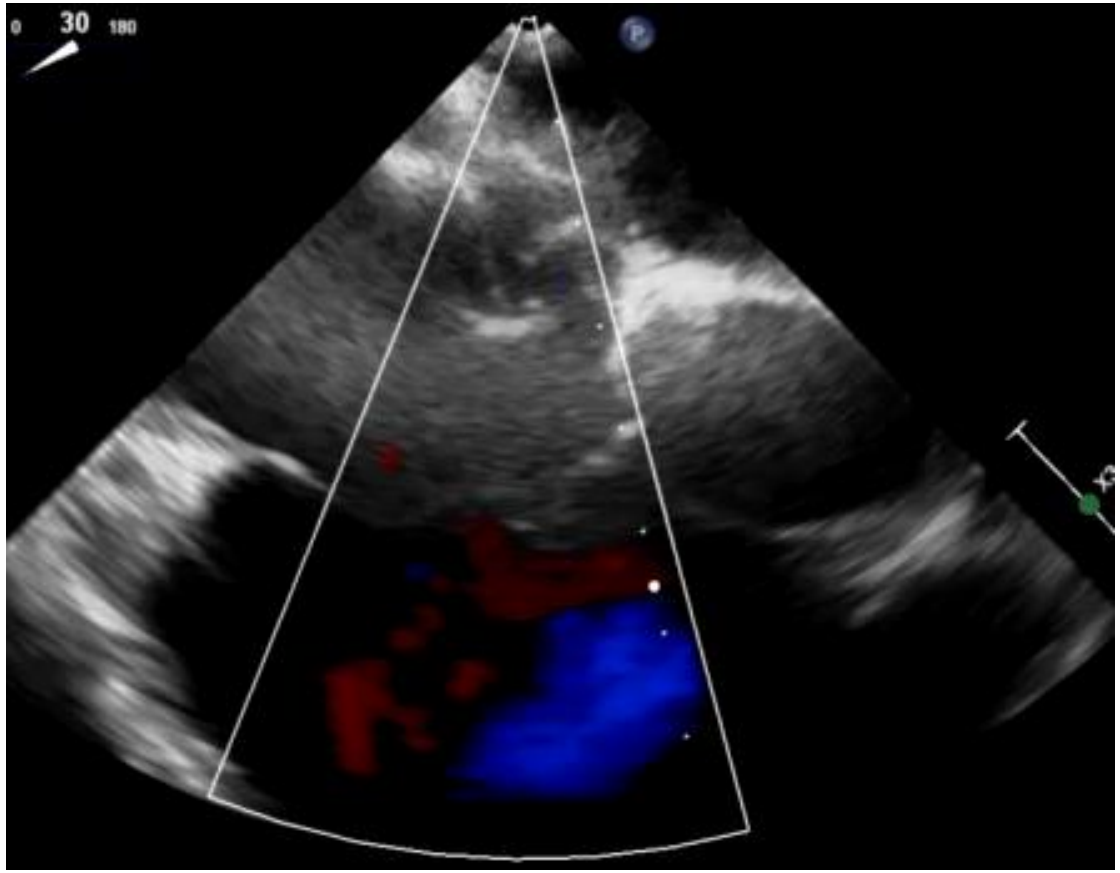
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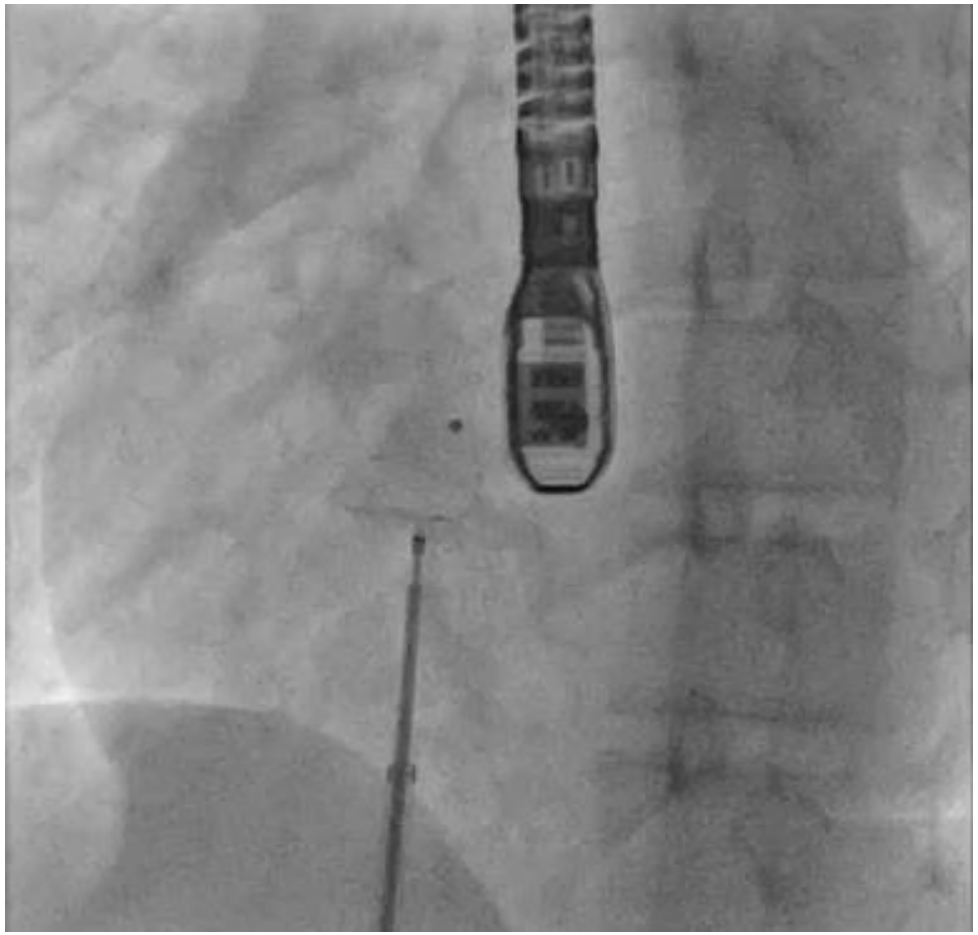

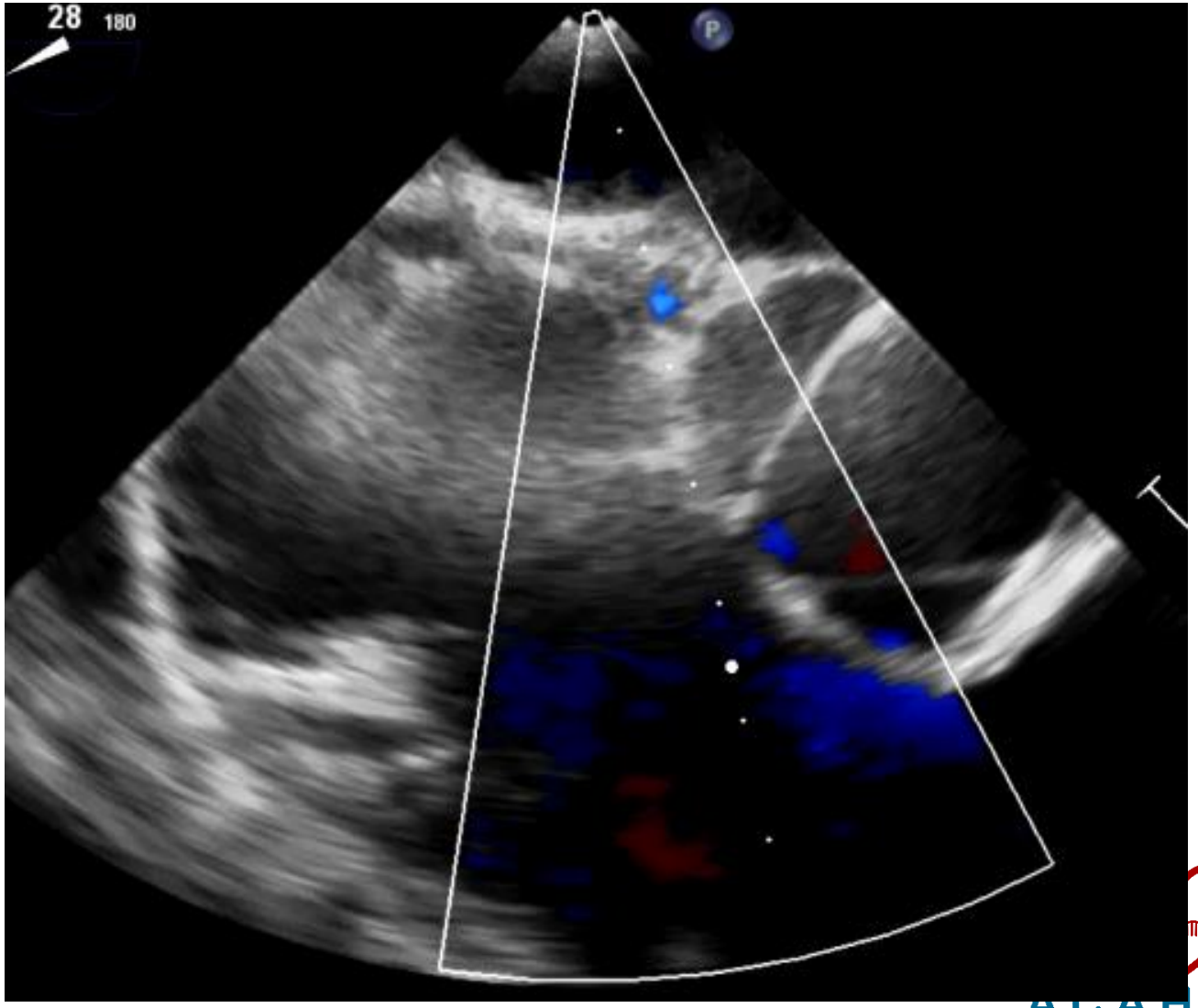
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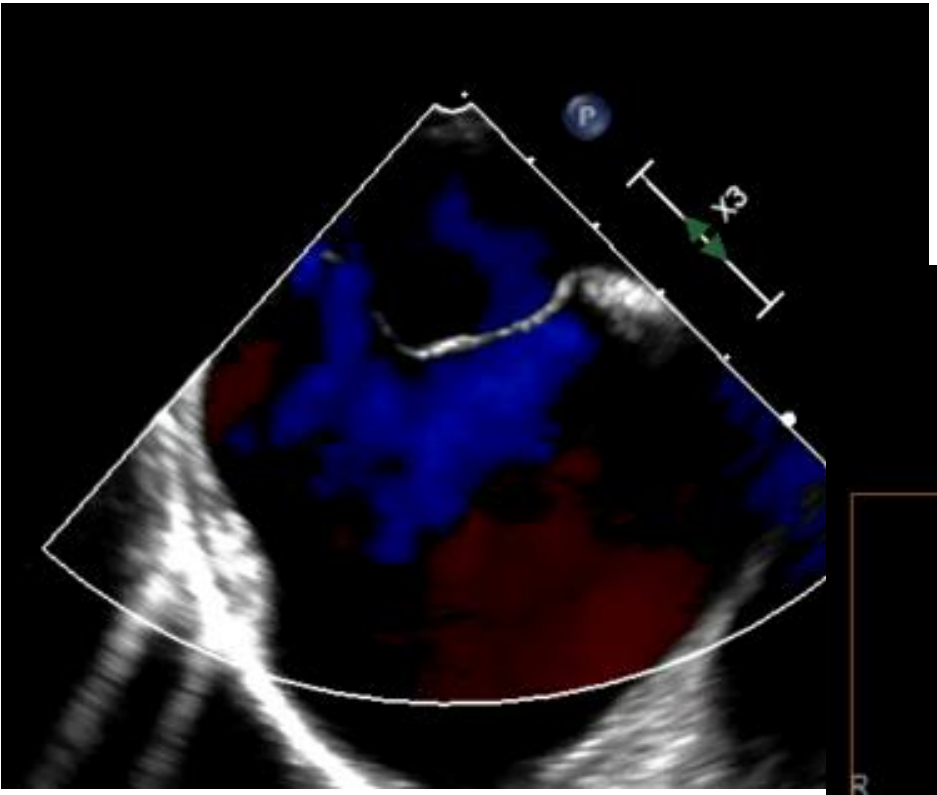
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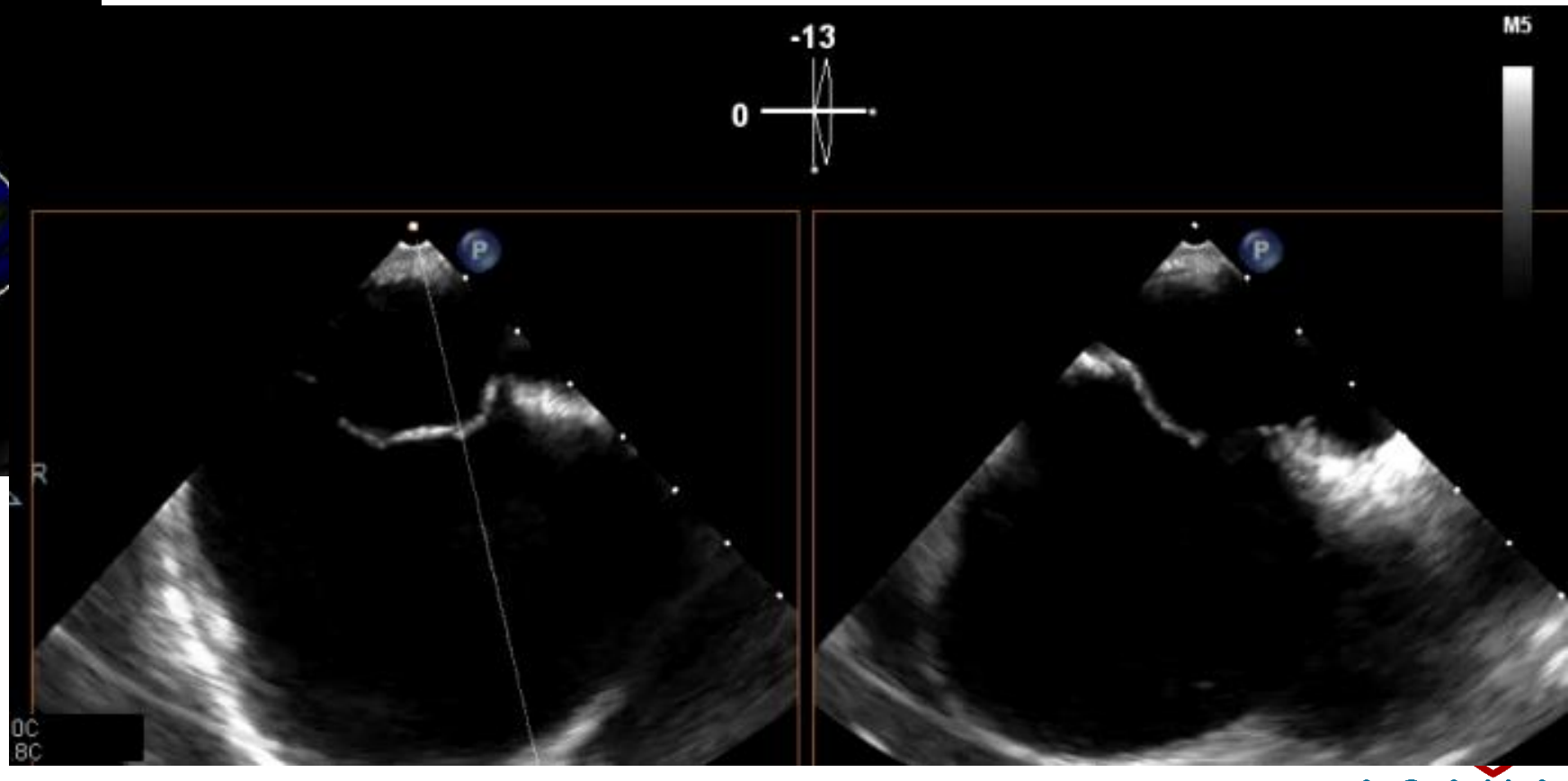
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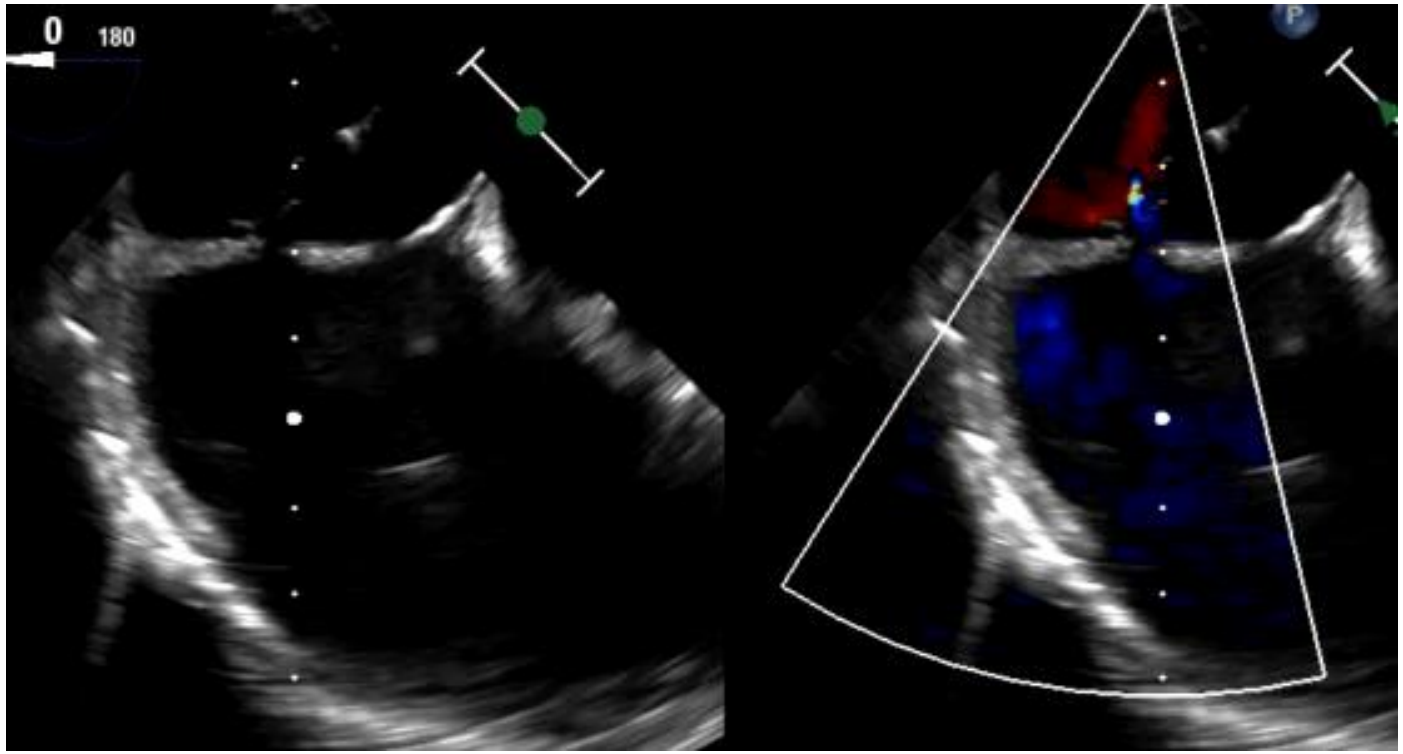
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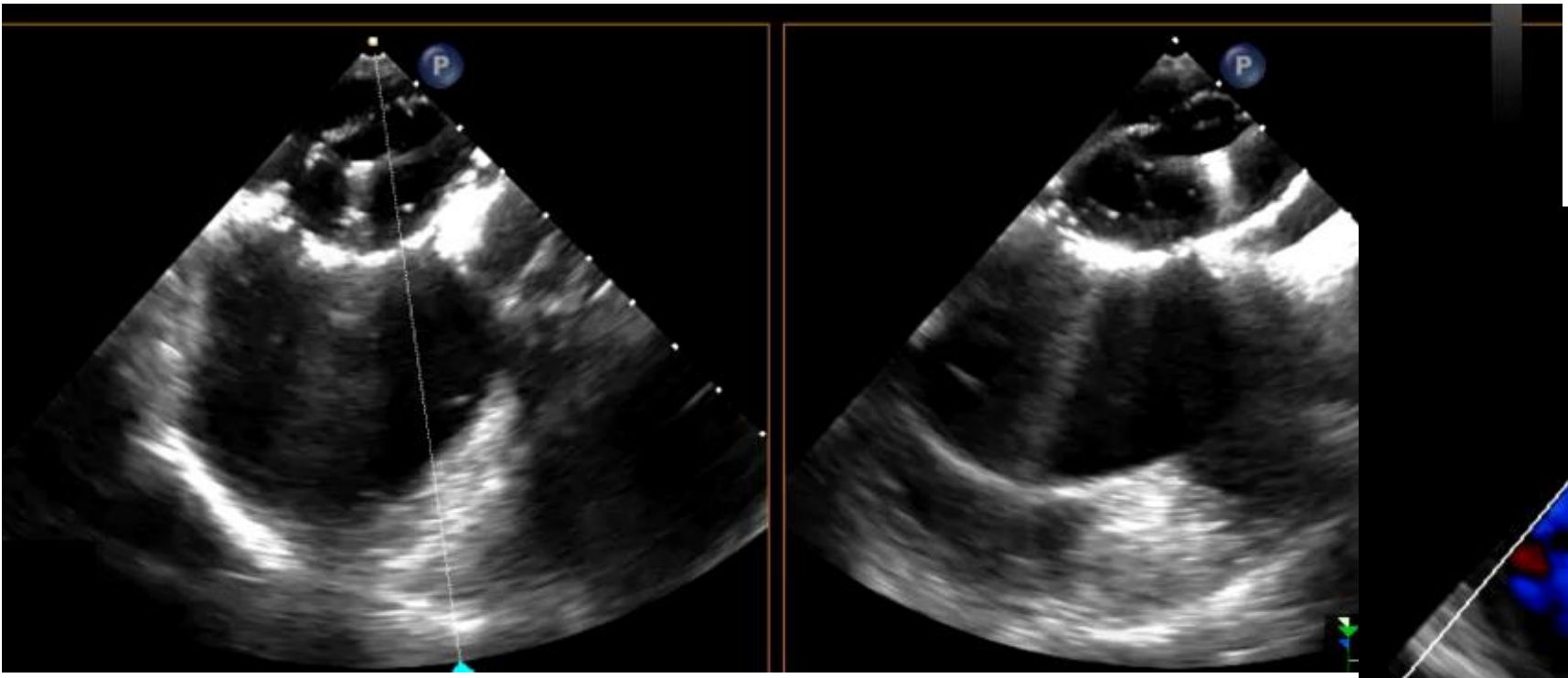

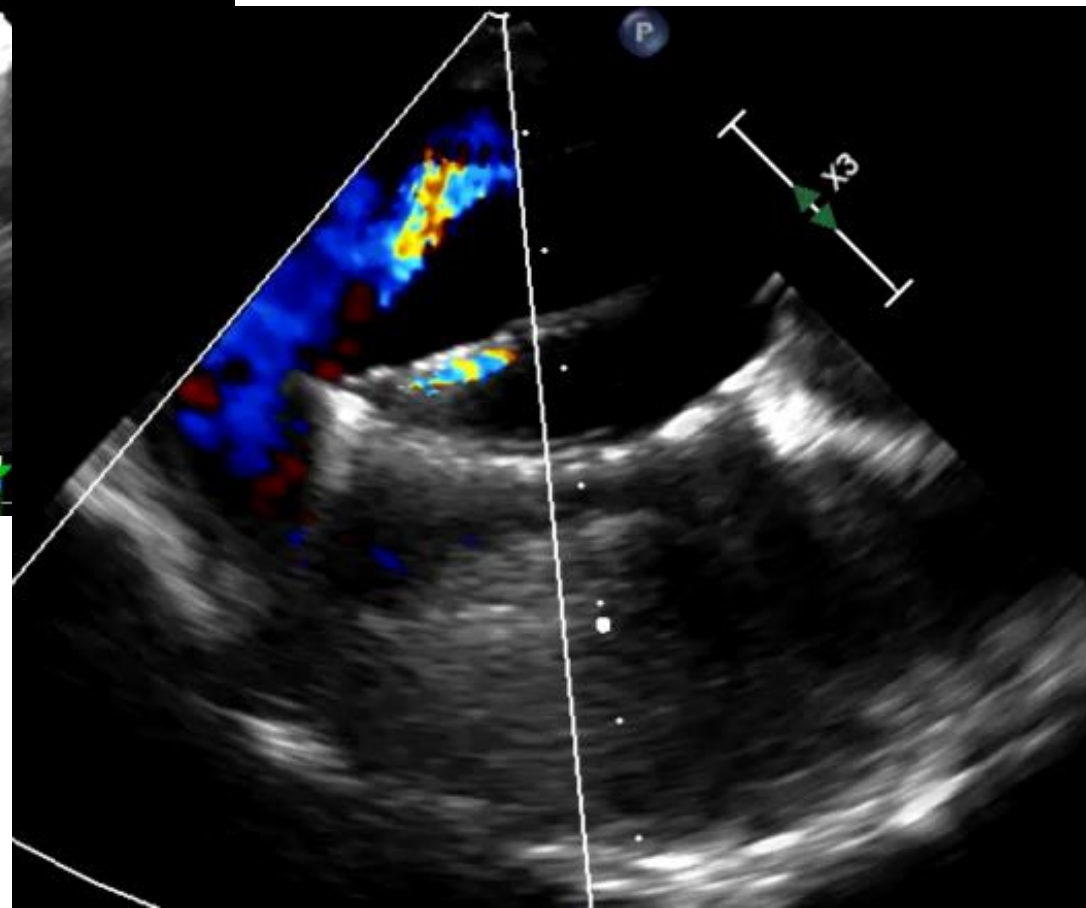
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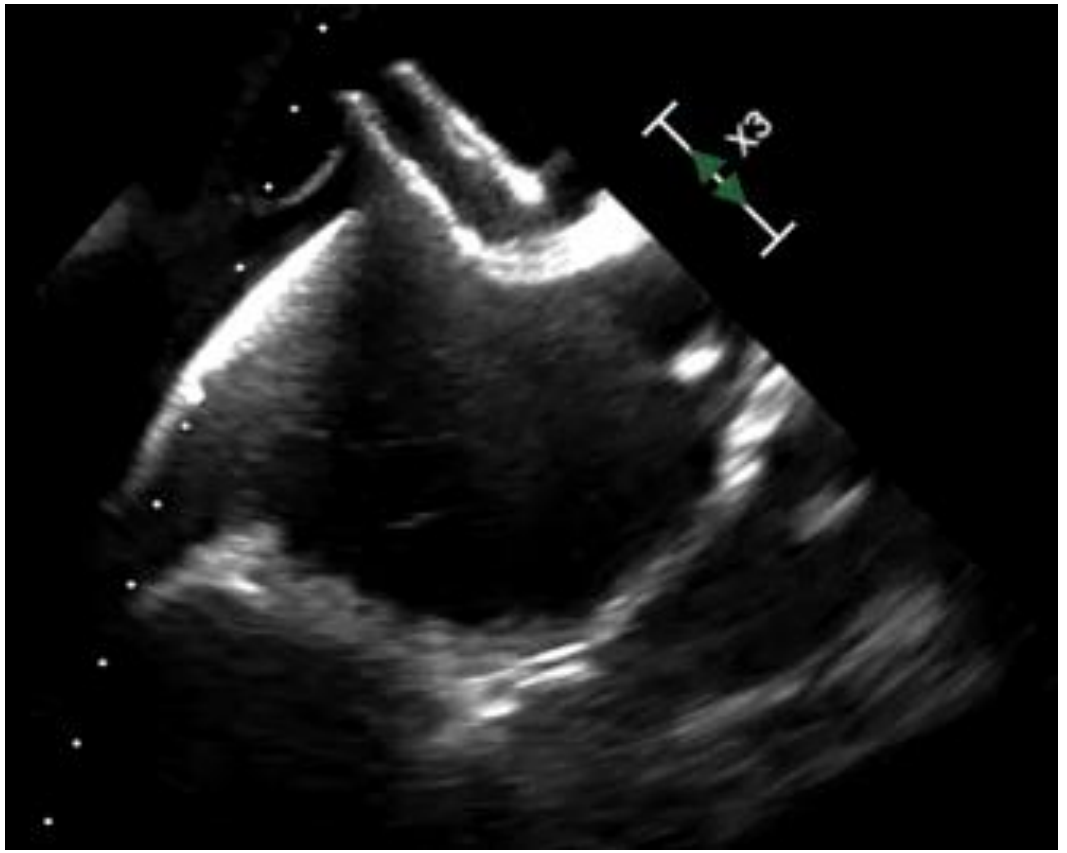
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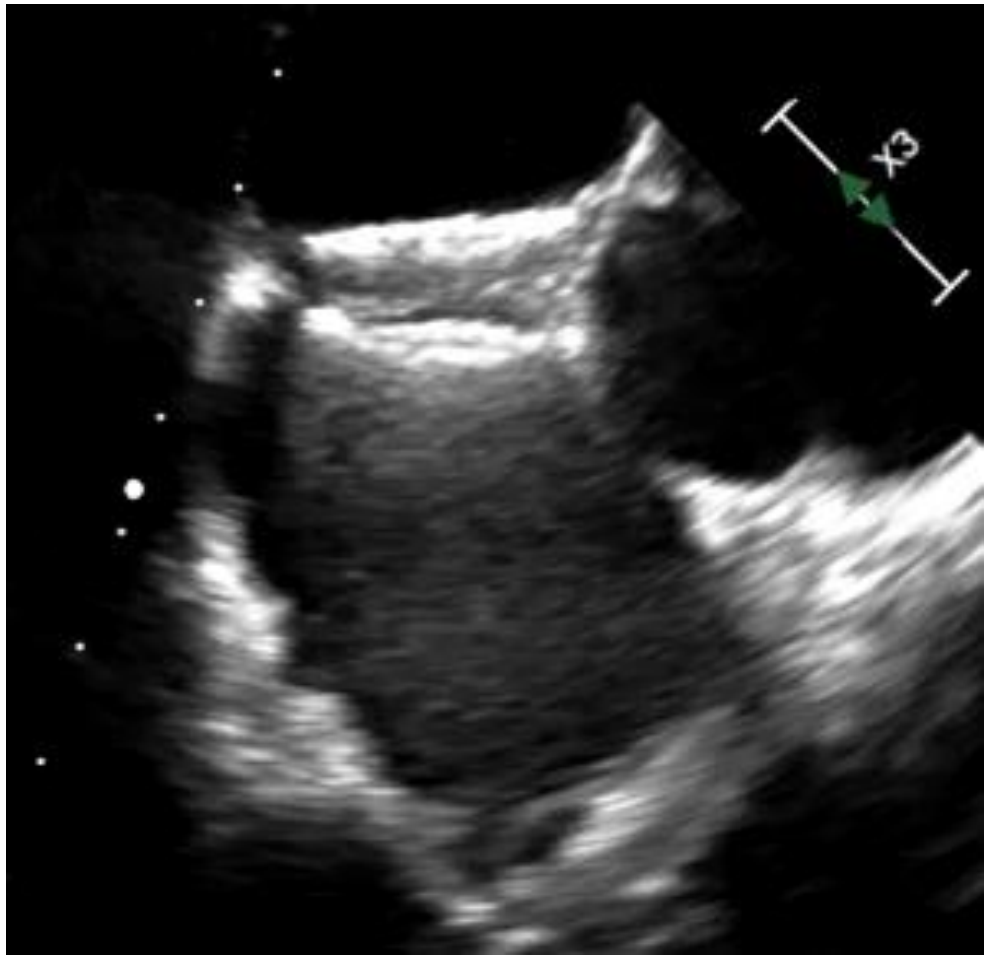
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