2019 euroPCR

Solving the mysteries of cardiac physiology – Back to basics

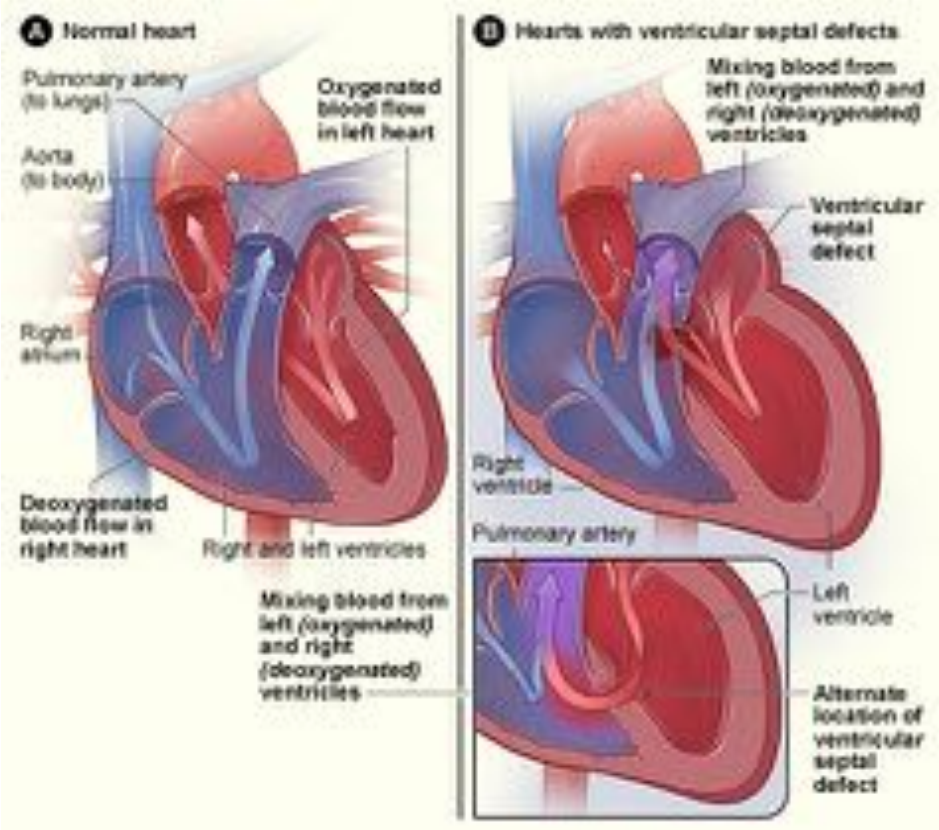
Septal defects

Panagiotis Xaplanteris, MD, PhD
Interventional cardiologist
CHU Saint-Pierre, Brussels, Belgium

Speaker's name : Panagiotis Xaplanteris

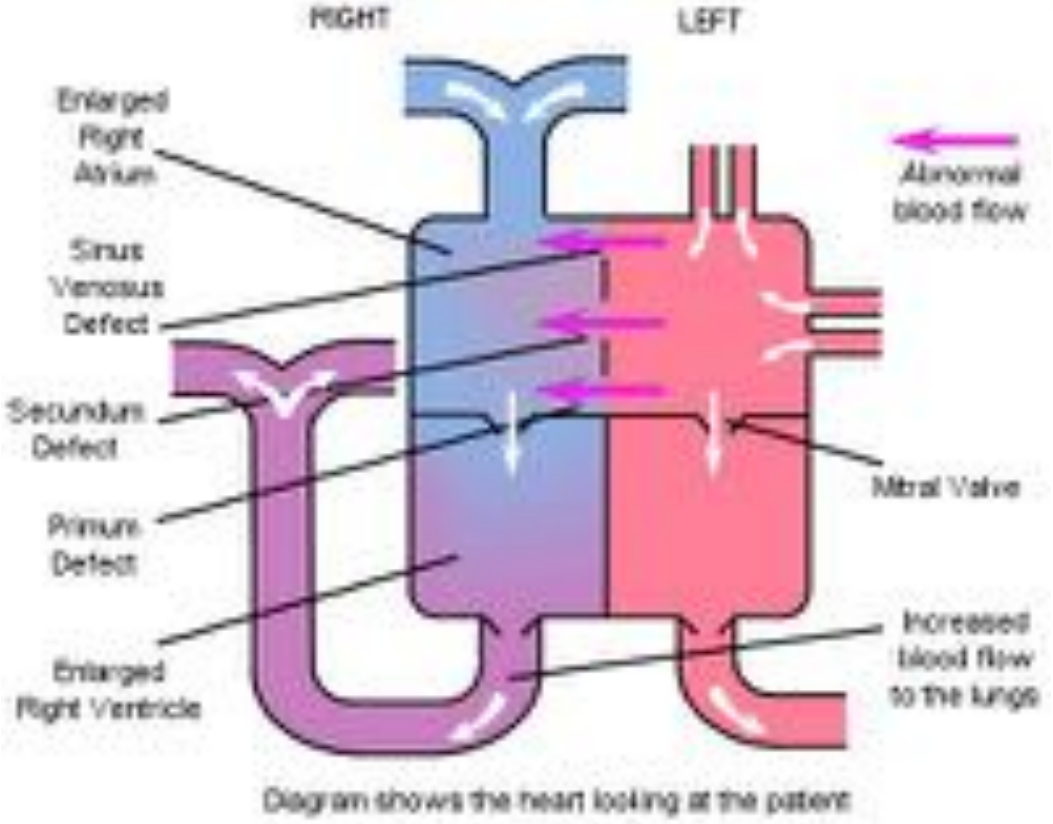
☑ I do not have any potential conflict of interest to declare

Ventricular septal defects



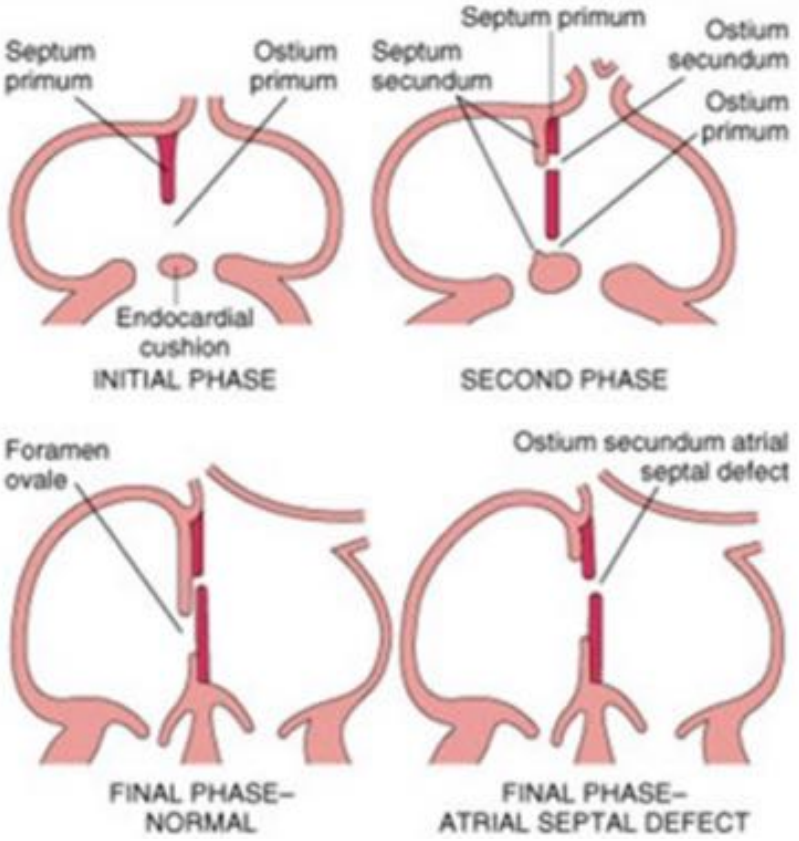
www.nhlbi.nih.gov/health-topics/congenital-heart-defects

Atrial septal defects

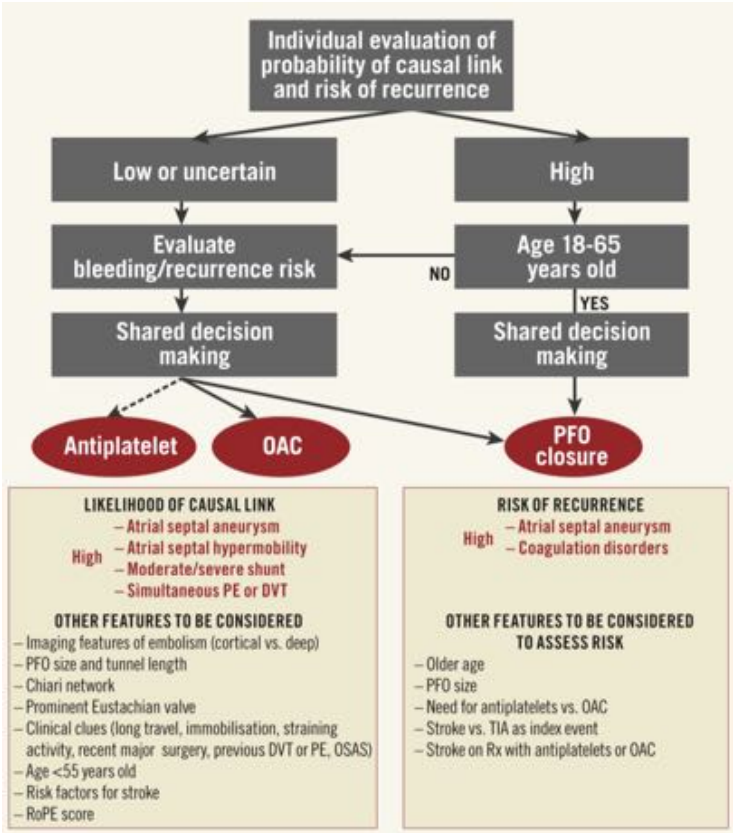


dhg.org.uk/information/atrialseptaldefect.aspx

Patent foramen ovale

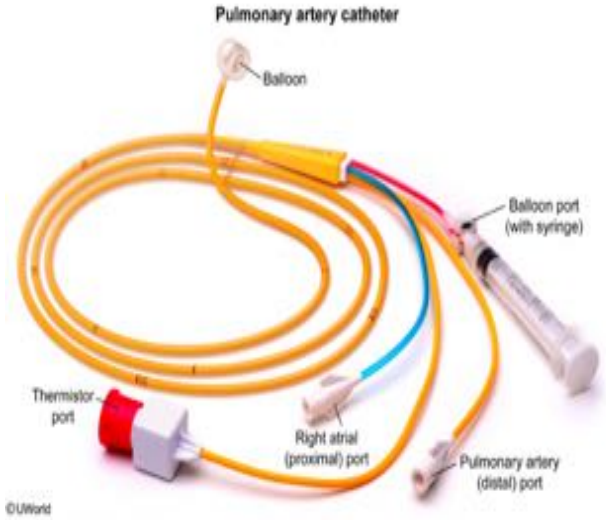


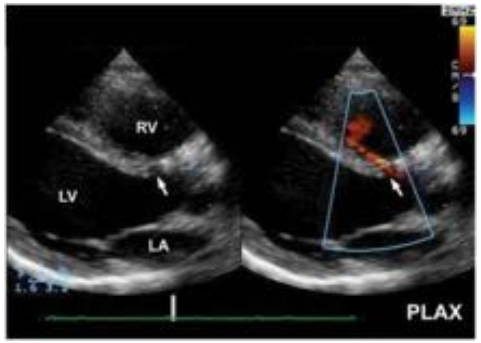
Patent foramen ovale



European position paper on the management of patients with PFO; EHJ 2018

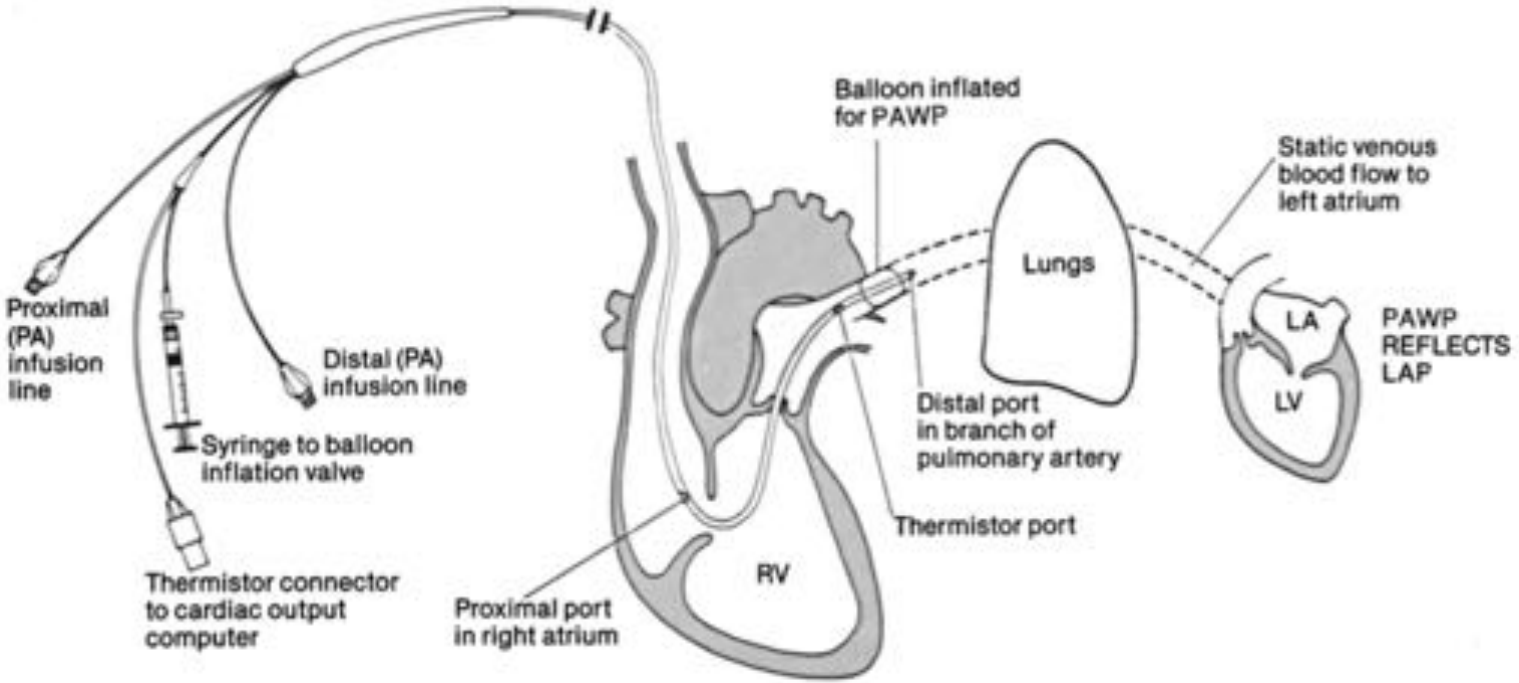
Shunt quantification





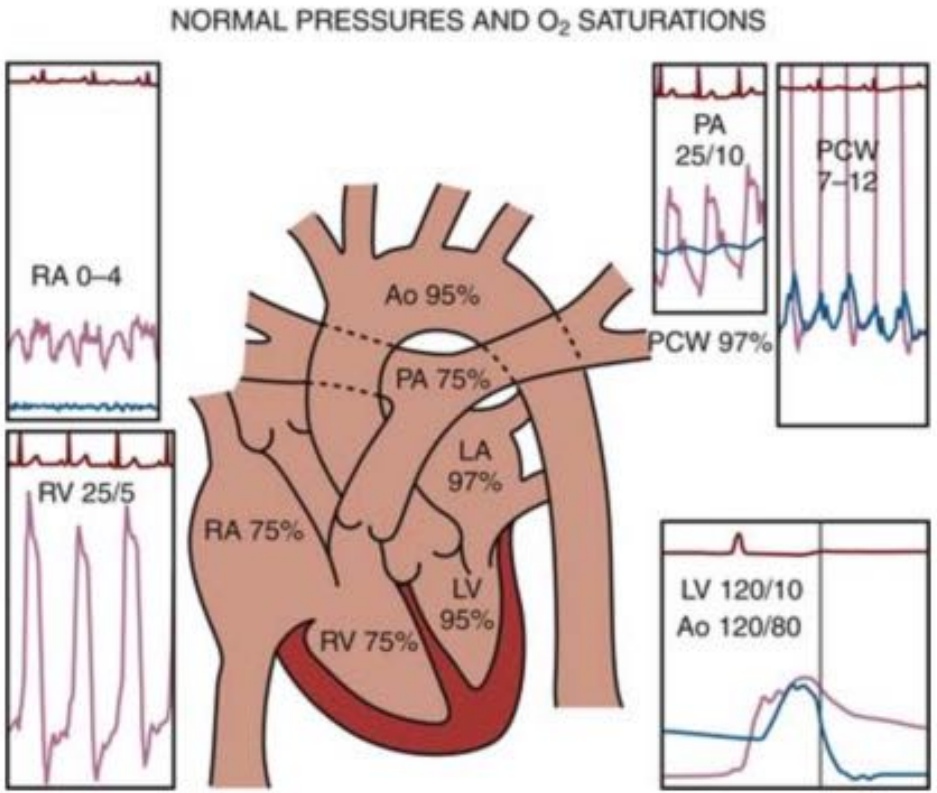
- Septal defects result in L to R shunts
- Right heart: increases in **P** and **O_2** saturation
- Atrial and ventricular dilatation
- Long-standing large defects may result in shunt reversal (R to L; Eisenmenger's physiology -> cyanosis)
- Imaging vs cardiac catheterization

Cardiac catheterization



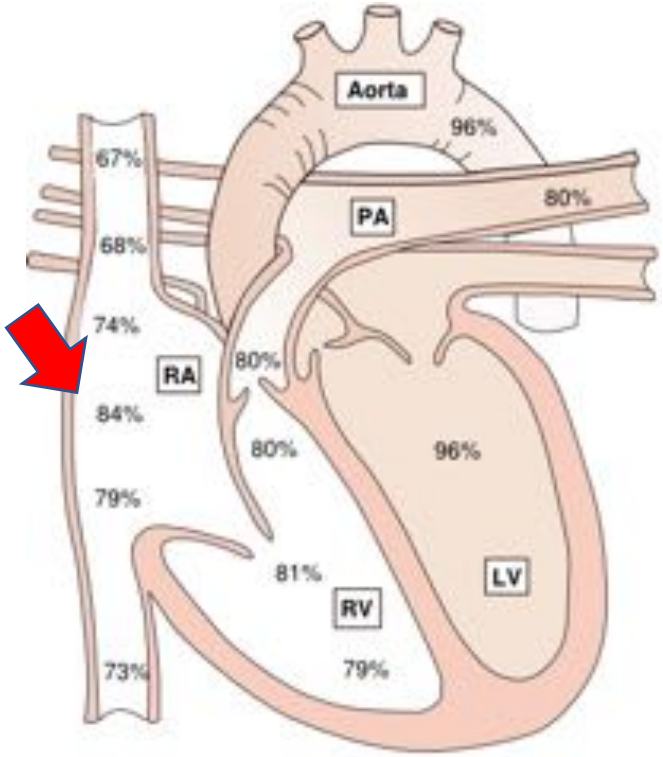
L D. Kersten, Comprehensive Respiratory Nursing: A Decision Making Approach, Saunders 1989

Oximetry run

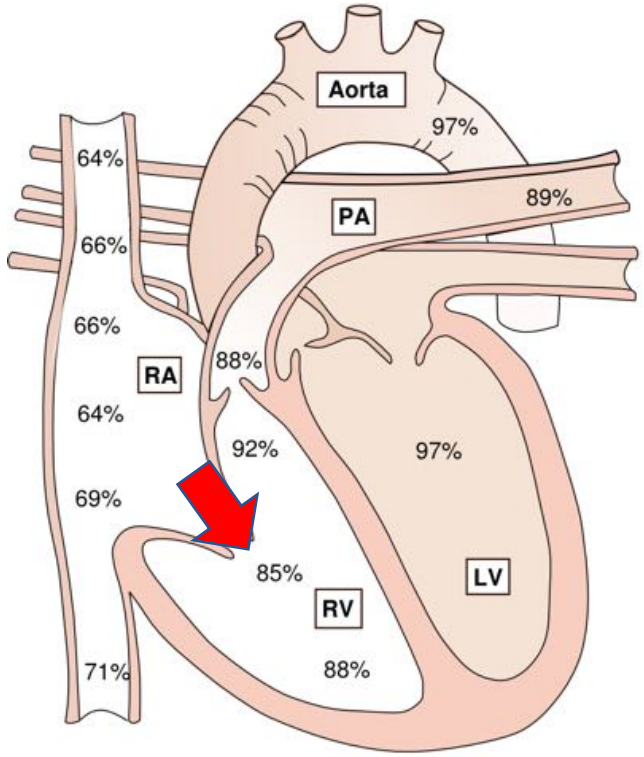


- A step up in O_2 saturation of **5-7%** is considered significant
- The L to R shunt should be localized
- A full oximetry run can include up to 9 blood samples (IVC, SVC, low/mid/high RA, RV, PA, PCW, LV)
- Advantages / disadvantages

Oximetry run for shunt detection

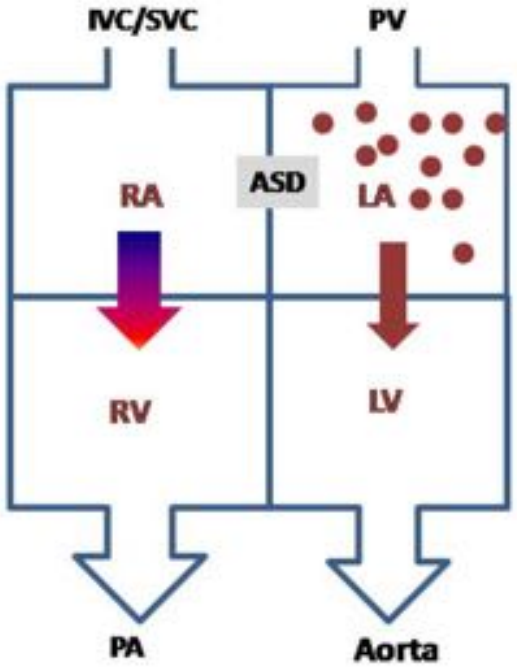


‘step up’ detected in the RA -> ASD



‘step up’ detected in the RV -> VSD

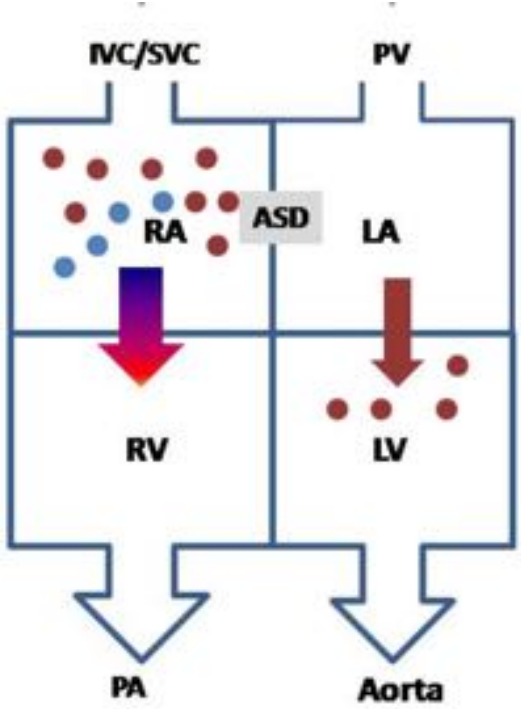
Qp:Qs calculation



$$\text{Qp:Qs} = \frac{Pulmonary\ flow}{Aortic\ flow}$$

$$\text{Qp:Qs} = \frac{Shunt\ flow + aortic\ flow}{aortic\ flow}$$

Qp:Qs calculation



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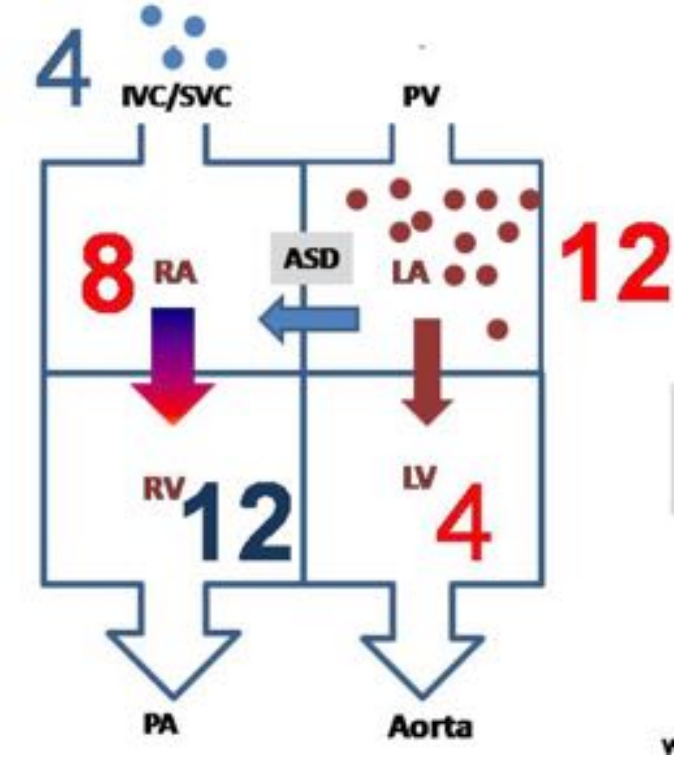
Qp:Qs calculation



$$\text{Qp:Qs} = \frac{Pulmonary\ flow}{Aortic\ flow}$$

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L->R shunt Qp:Qs >1

R->L shunt Qp:Qs <1

Qp:Qs calculation

$$\textbf{Qp:Qs} = (SaO_2 - SvO_2) / (PvO_2 - PaO_2)$$

SaO_2 Systemic arterial O_2 saturation

SvO_2 Mixed venous O_2 saturation

PvO_2 Pulmonary vein O_2 saturation

PaO_2 Pulmonary artery O_2 saturation

SvO_2 = (3 x SVC sat + 1 x IVC sat) / 4

PvO_2 ~ Wedge saturation

Qp:Qs calculation

O2 saturations:

IVC	82%
SVC	70%
RA	85%
PA	88%
RV	84.5%
Wedge	98.5%
LV	97.5%
LA	97%

$SaO_2 = 97.5$

$SvO_2 = (3xSVC + 1xSVC) / 4 = 73$

$PvO_2 = 97.5$ **(~ Wedge)**

$PaO_2 = 88$

$Qp:Qs = (SaO_2 – SvO_2) / (PvO_2 – PaO_2)$

$= (97.5 – 73) / (97.5 – 88)$

$=$ **2.57**

Indications for ASD closure

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

2010 ESC guidelines for the management of grown-up congenital heart disease

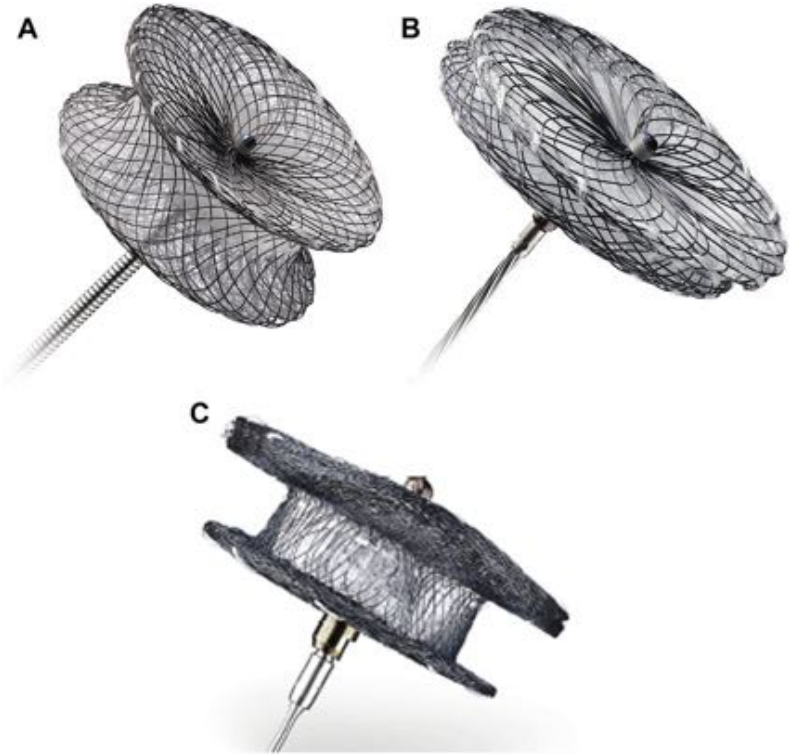
Indications for VSD closure

Indications	Class[a]	Level[b]
Patients with symptoms that can be attributed to L–R shunting through the (residual) VSD and who have no severe pulmonary vascular disease (see below) should undergo surgical VSD closure	I	C
Asymptomatic patients with evidence of LV volume overload attributable to the VSD should undergo surgical VSD closure	I	C
Patients with a history of IE should be considered for surgical VSD closure	IIa	C
Patients with VSD-associated prolapse of an aortic valve cusp causing progressive AR should be considered for surgery	IIa	C

Indications	Class[a]	Level[b]
Patients with VSD and PAH should be considered for surgery when there is still net L–R shunt (Qp:Qs >1.5) present and PAP or PVR are <2/3 of systemic values (baseline or when challenged with vasodilators, preferably nitric oxide, or after targeted PAH therapy)	IIa	C
Surgery must be avoided in Eisenmenger VSD and when exercise-induced desaturation is present	III	C
If the VSD is small, not subarterial, does not lead to LV volume overload or pulmonary hypertension, and if there is no history of IE, surgery should be avoided	III	C

2010 ESC guidelines for the management of grown-up congenital heart disease

Percutaneous closure of septal defects



Not all defects amenable to closure

Size

Number of defects

Concomitant cardiac pathologies

Rims

Adjacent anatomical structures

VSD closure

Clinical history

62 y.o. male referred for dyspnea

2014: inferior STEMI -> pPCI @ RCA

Subsequent papillary muscle rupture and VSD -> surgical MVR and patch

Residual VSD and Qp:Qs = 2.0

Mean pressure gradient across the MV prosthesis = 10 mm Hg

Decision for percutaneous VSD closure

VSD closure

Equipment

Right jugular vein : 7F sheath

Right femoral artery: 6F sheath

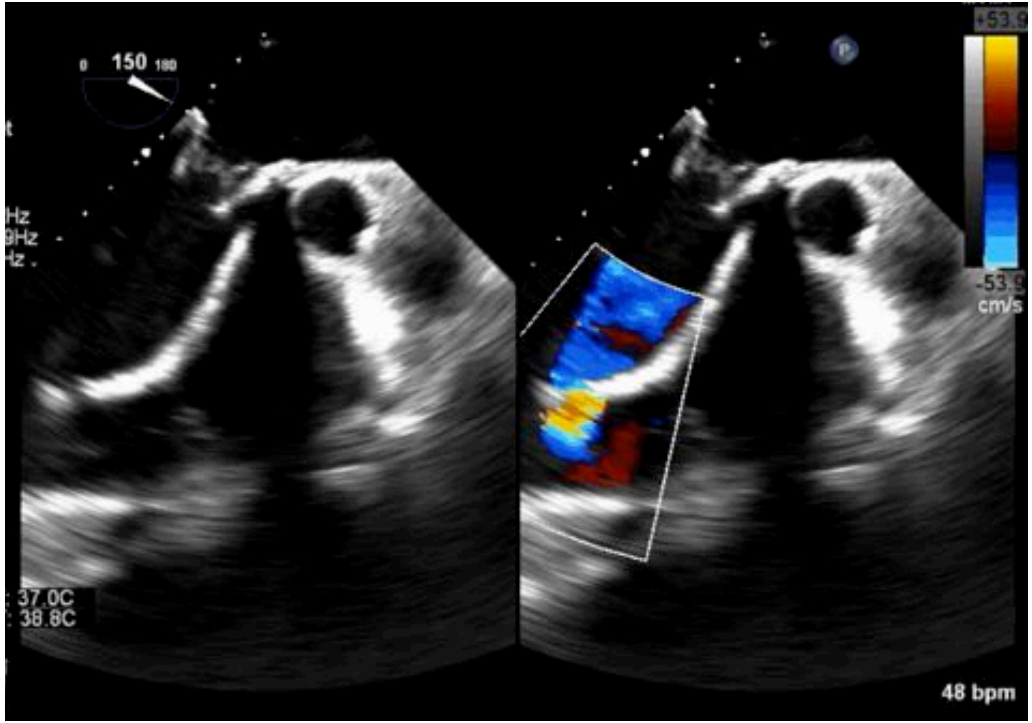
Hydrophilic guidewire 0.035’’ 300cm

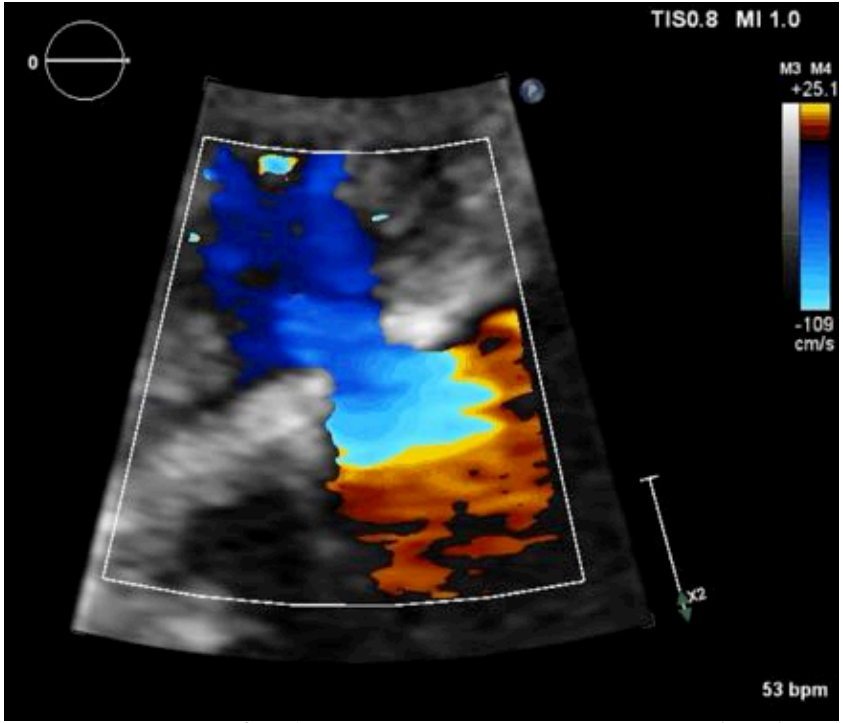
Endovascular snare system EN Snare 18-30 mm

VSD occluder Occlutech mVSD 12-19mm

VSD closure

Transesophageal echo

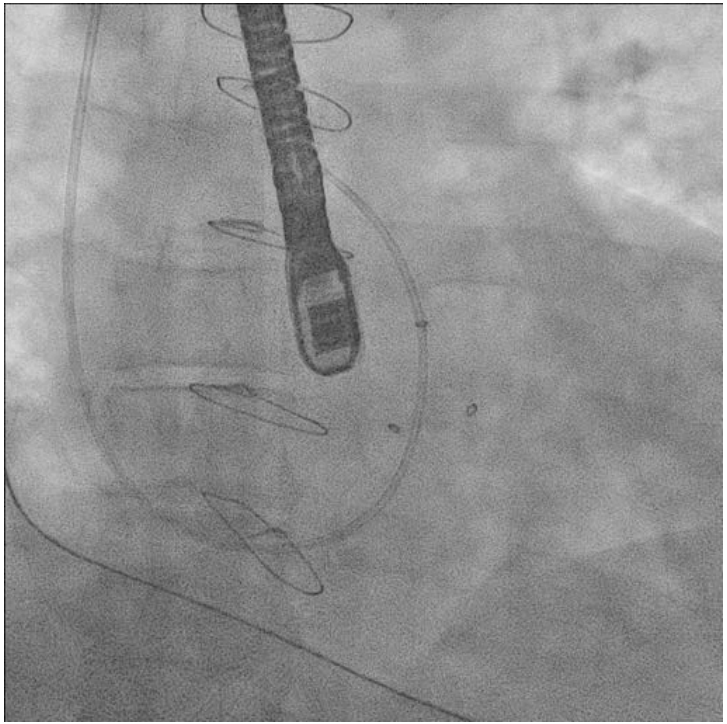


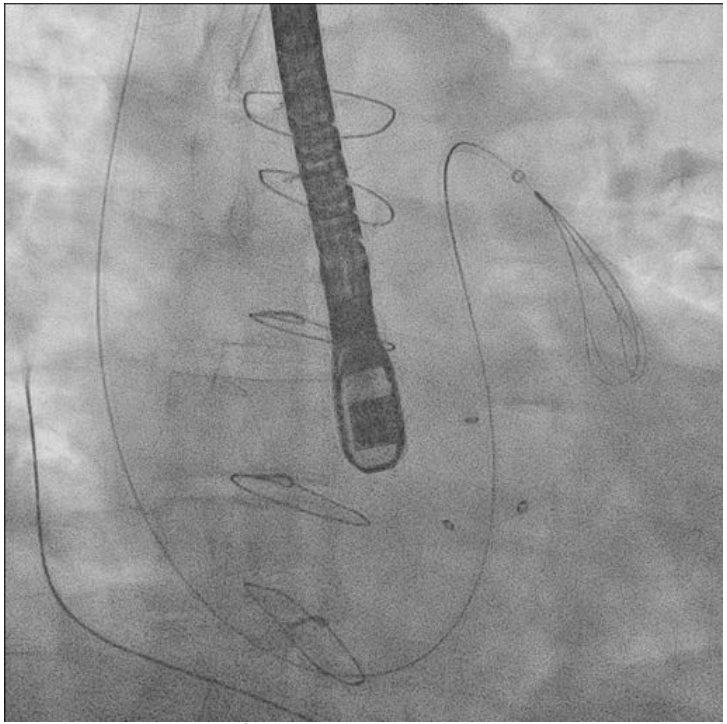


Images courtesy of Dr de Hemptinne, CHU Saint-Pierre, Brussels, Belgium

VSD closure

Snare system





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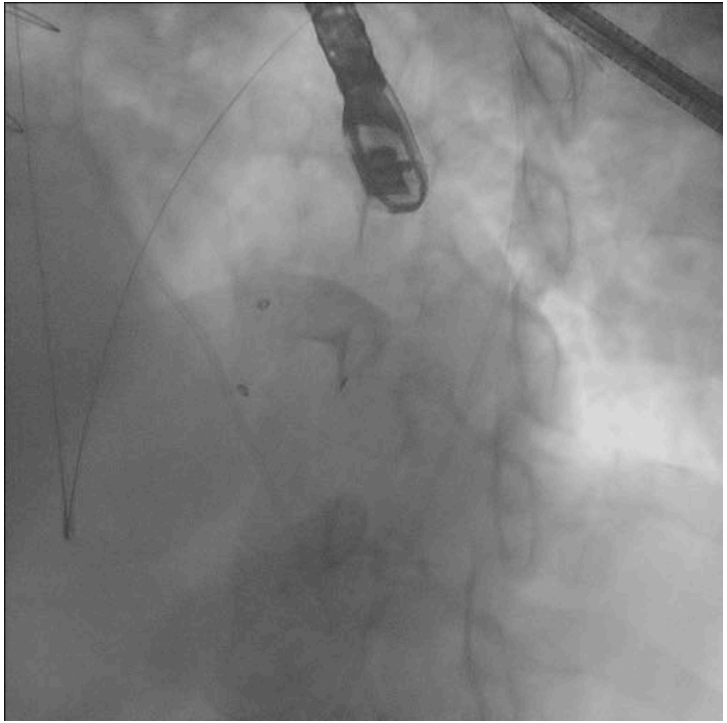
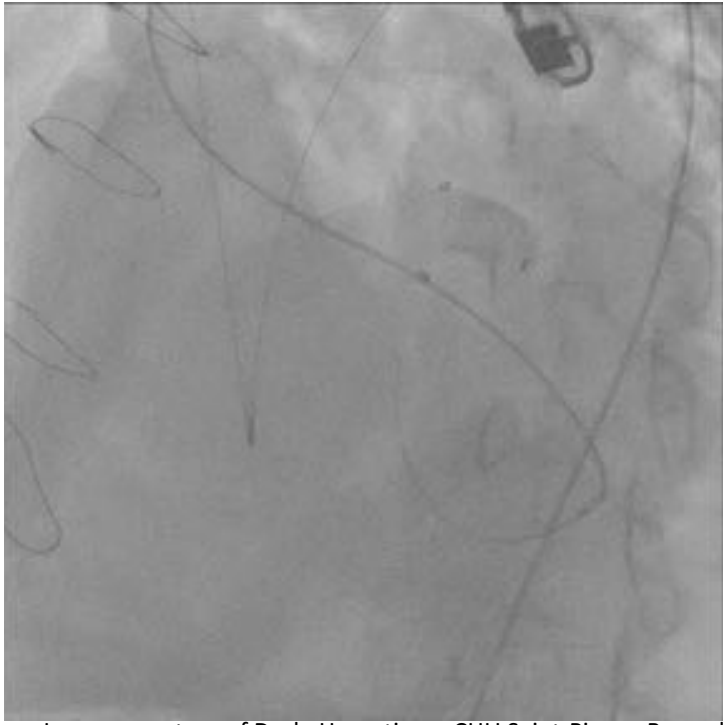
VSD closure

VSD crossing





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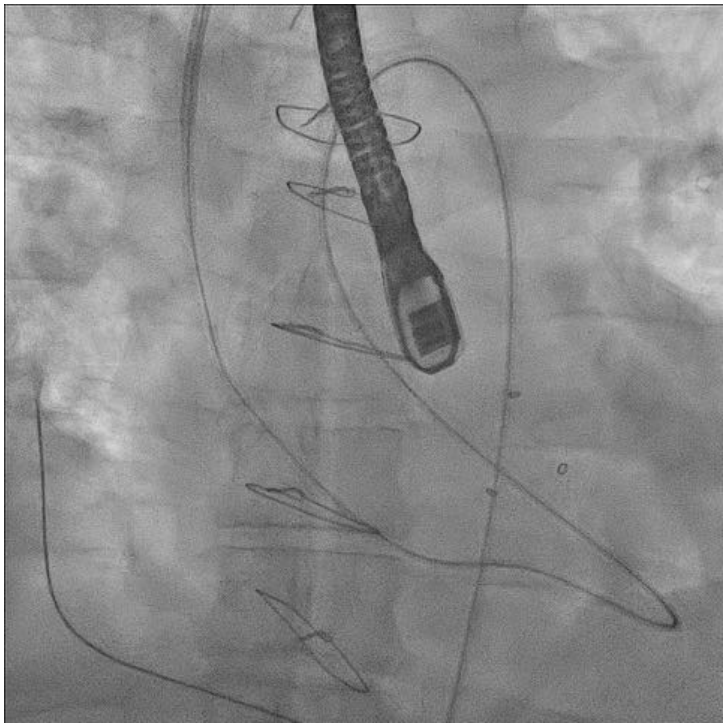
VSD closure

Wire snaring and device deployment



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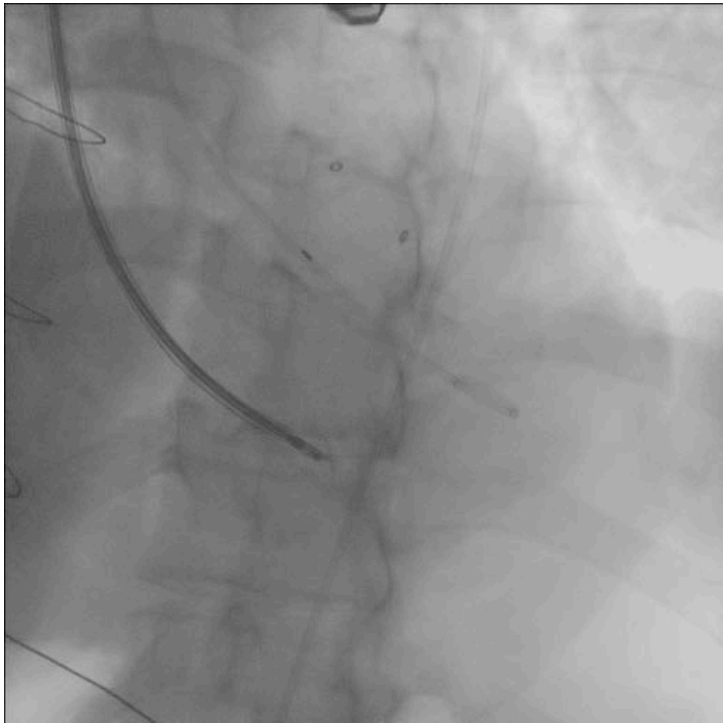
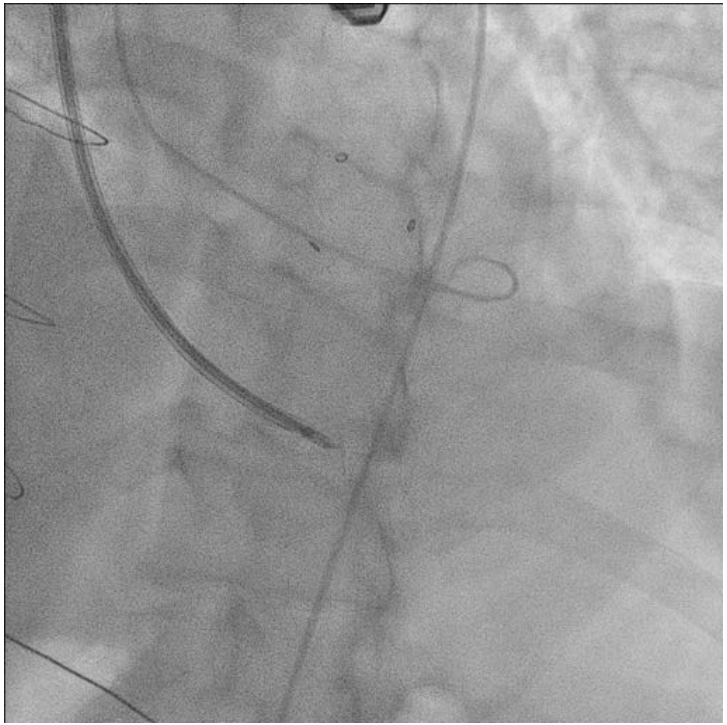
VSD closure

Device deployment and release





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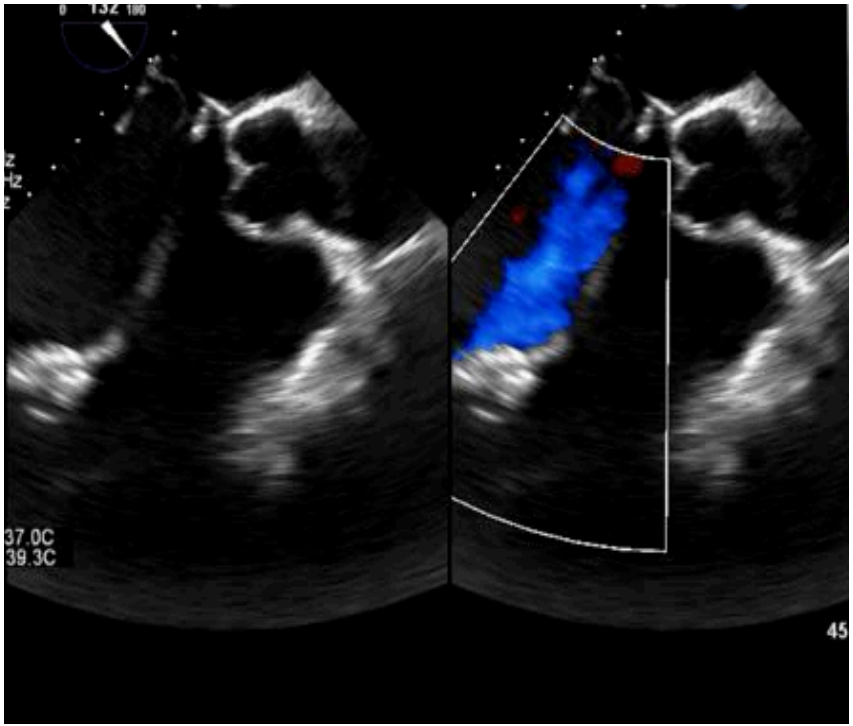
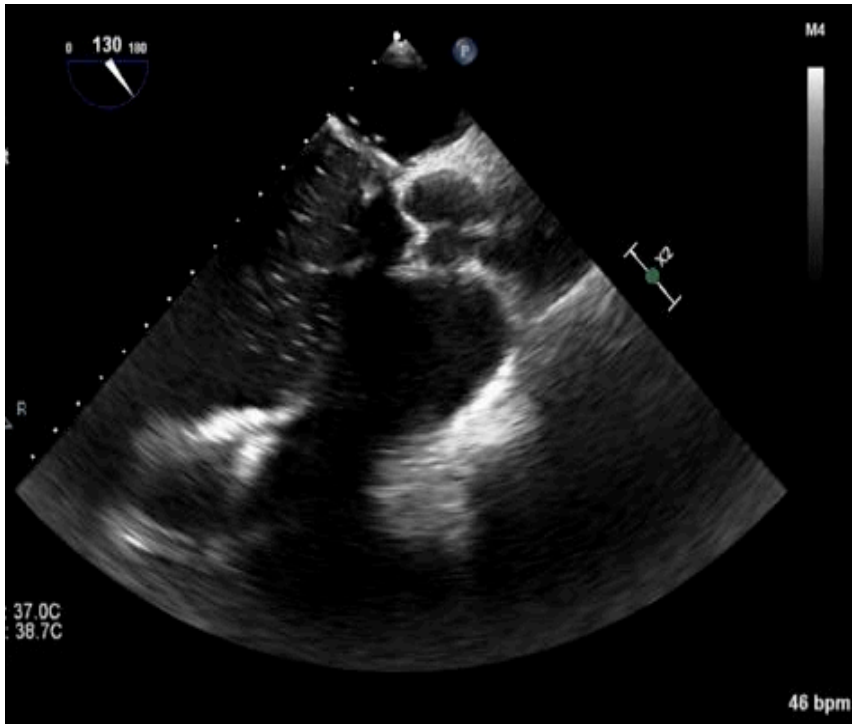
VSD closure

Final result





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Conclusions

Septal defects include PFOs, ASDs and VSDs

PFOs are the most common defect (present in ~25% of adults)

Main indications for closure

- PFO: cryptogenic stroke
- ASD, VSD: large L->R shunt

Cardiac catheterisation for pressures, Qp:Qs

Closure contraindicated in Eisenmenger's cases

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Backup slides

Oximetry disadvantages

- Lacks sensitivity – small shunts can not be detected
- Steady state for blood sampling
- Mixed venous saturation is an approximation; influenced by CO
- Dependance on Hb concentration
- Valvular regurgitation (MR, TR) blurs results

Finetuning oximetry

- Blood sampling should be rapid
- Consider multiple samples and calculate average saturations
- If cardiac output at rest is low, make the patient exercise
- If supplemental O_2 is administered, the dissolved O_2 should also be considered