Congenital heart diseases -
Sources of emboli:
Echo guided treatment

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Disclosures

• No disclosures
Congenital and structural heart interventions

Shunt Closure
- ASD - closure
- PFO - closure
- VSD - closure
- Ductus – closure

Valve Interventions
- Valvuloplasty
- Intervventional mitral valve procedures
- Paravalvular leak closure
- Percutaneous valve implantation

Others
- LAA - closure
Consider an intraatrial septal defect as source of embolism...

73y old lady, left sided hemiparesis + MI
Questions:

• How does echocardiography diagnose ASDs and PFOs?
• How does echocardiography guide therapy?
• Which defects should be closed?
• Which defects can be closed?
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How does a PFO differ from an ASD?

ASD and PFO are different types of interatrial defects

- The septum primum forms first
- It leaves a window, the ostium secundum
- The septum secundum forms later, and usually covers the ostium secundum
What is a PFO?

- In utero, the foramen ovale allows blood to flow from the right atrium to the left, bypassing the lung.
- Usually it closes after birth.
- But in ~25% of people it stays open.

→ Patent Foramen Ovale
• If the septum secundum fails to cover the ostium secundum, blood can flow in either direction.
• This causes a continuous shunt.

→ Atrial Septum Defect
Types of ASD

- Secundum or fossa ovalis defect – defect of septum primum (~75%)
- Superior sinus venosus defect → usually associated with RULPV anomaly
- Inferior sinus venosus or IVC defect
- Primum ASD or partial AVSD – endocardial cushion defect
- De-roofing of coronary sinus
Diagnosis of atrial septal defects

- TTE Transthoracic Echo
- TCD Transcranial Doppler
- TEE Transesophageal Echo
  - „Gold-standard“
Echo Contrast

Agitated saline with microbubbles which do not survive pulmonary passage

Agitated saline
~60 micron (40-100)

Agitated saline + blood
~52 micron (24-75)
Transthoracic Echo (TTE)

Rest

Valsalva
Transthoracic Echo (TTE)

ASD- SAX and 4 Ch view
So you can diagnose an ASD or PFO by TTE...

... **but you can not exclude it!**

No shunt on TTE does not mean that there is no PFO or a small ASD
Transcranial Doppler

→ significant shunt: > 10 bubbles*

*Consensus Conference of Venice - Jauss, Zanette; Cerebrovasc Dis 2000; 10: 490-6
You can exclude an intraatrial septal defect (ASD or PFO) by transcranial doppler …

... but you can not diagnose it!
Why no diagnosis of PFOs or ASDs by transcranial doppler?

TCD is unable to locate the source of the right-to-left shunt

– PFO/ASD or intrapulmonary shunt?

However, TCD and TTE in combination can detect a PFO accurate and reliable in comparison to TEE *

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Role of Transesophageal Echo (TEE)

• To confirm the diagnosis
• Shunt assessment and exclusion of intrapulmonary shunts
• To assess anatomical characteristics
• To guide PFO closure
Confirmation of the diagnosis in TEE

ASD: 2D TEESAX 32°
ASD: 3DTEE RA/LA
PFO detection with contrast
Role of Transesophageal Echo (TEE)

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• To guide the closure procedure
Right to Left Shunt depends upon

- Size of defect
- Pressure RA - LA
- Femoral or brachial echo contrast injection
- Quality of Valsalva
Different answers after contrast injection + Valsalva manoeuvre
Shunt detection by echo works but quantitative assessment does not!!

No need to count the bubbles!
Intrapulmonary Shunting

- Echo contrast appears late in the LA
  - But this may also happen in intraatrial defects
  - More important is where in the LA the contrast appears

- Intrapulmonary shunting is confirmed by echo contrast injection into the pulmonary
Intrapulmonary Shunting

Contrast via femoral vein

Contrast via A. pulmonalis
Intrapulmonary shunting
Role of Transesophageal Echo (TEE)

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Why is anatomy important?

• For device selection
  – e.g. PFO with long tunnel (Premere, intra-tunnel device)
• To decide which implantation technique
  – e.g. Through the PFO tunnel or transseptal puncture?/ Cribriforme device or 2 devices in multiperforated ASD
• To prevent complications
Anatomy and Morphology

Which information do we need?

• Number of defects
• Size of defect
• Rims
• Relation of device to other cardiac structures during deployment
  – AV- Valves
  – Pulmonary veins
  – Coronary sinus
Multiple defects

P. Ewert

Courtesy to Robert Siegel
Size of defect- PFO

→ The true size of a PFO is not predictable with echo
→ Balloon sizing of the PFO provides additional information about the tunnel length and the stiffness of the tissue
Size of defect- ASD

3D TEE IAS- RA view

Size of defect - ASD

Ballon sizing

Large ASD
2D TEE - Rim assessment

- AV rim (inferior)
- aortic rim (anterior)
- SVC rim (cranial)

LA, RA, RV, LV, Ao, IVC
3D TEE- Rim assessment

Rims named after the adjacent structures

RA aspect

LA aspect
ASD- no anterior rim

28 mm Amplatzer-ASD-Occluder after release
Questions:

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Implantation technique today is straightforward:

- Local anesthesia
- Transvenous 8-11 F sheath
- 10,000 E Heparin
- Multipurpose catheter → left upper pulmonary vein
- Balloon sizing
- Device implantation
- < 30 min door to door
- < 24 hours hospital stay
Intraprocedural guidance of an ASD closure

ASD before closure (view from LA)
Wire through defect

Unfolded balloon in ASD (view from LA)
Intraprocedural guidance of an ASD closure

Delivery sheath in LA

Opening of the LA disc
Intraprocedural guidance of an ASD closure

Assessment before device release

Conventional 2D TEE

3D TEE
Intraprocedural guidance of an ASD closure

LA aspect after release
What has to be judged by TEE?

Device position?
- Septum secundum embraced by both discs
  - Stable?

Residual shunt/additional defects?

Complications?
- Pericardial effusion
- Obstruction of pulmonary vein/coronary sinus
- Disturbance of AV-valve function
- Thrombi
Questions:

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Reasons for Closing PFOs

- Cyanosis due to right to left shunt (Platypnea-orthodoxia, Ebstein, RV infarct, tricuspid stenosis, post-LVAD)
- Decompression syndrome (divers, flight personnel)
- Paradoxical embolism (cerebral, retinal, peripheral, coronary)
- Migraine
- High-Altitude Pulmonary Edema
- Obstructive Sleep Apnea
- Pulmonary embolism
- Hypercoagulopathy
Indication for PFO Closure

- Stroke: 42%
- TIA: 52%
- Peripheral Embolism: 4%
- Migraine: 0.6%
- Diver: 1%
- Other: 1%
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Patient Evaluation

• Exclusion of other sources of the embolic event
  – ECG, Holter, TTE, TEE
  – Duplex
  – CT/MRI
  – MR-Angio
  – Assessment of thrombophilic disorders…
Is there any evidence for closing PFOs because of paradoxical embolism?
Common sense...

No PFO/ASD

No Paradoxicical Embolism
Annual Stroke Rate Non randomized trials

- PFO Closure (Catheter or surgery)
- Medical Therapy

Dearani 1999 (Surgery)
Devuyst 1996 (Surgery)
Cujec (surgery)
Palacios 2002
US Multicenter Registry 2002
Meier 2000
Lock 1999
Onorato et al
Braun et al
Du et al
Martin et al
Beitzke et al
Wahl et al
Butera et al
Sievert et al
Ende et al
Hung et al
PICCS 2002
Mas 2001 (PFO+ASA)
Mas 2001 (PFO only)
Nedeltchev et al
Homma et al
Mas et al
Mas et al
De Castro et al
Cujec et al
Bogousslavsky et al

0% 2% 4% 6% 8% 10% 12%
Randomized Trials?

- CLOSURE I
  - CardioSeal STARflex
  - Initially 1600 patients planned, halved in 2007 (800 patients)

- RESPECT
  - Amplatzer
  - 500 patients
  - PC Trial
  - Amplatzer
  - 500 patients
CLOSURE I Conclusions

CLOSURE I is the first completed, prospective, randomized, independently adjudicated PFO device closure study.

Superiority of PFO closure with STARFlex® plus medical therapy over medical therapy alone was not demonstrated:
- no significant benefit related to degree of initial shunt
- no significant benefit with atrial septal aneurysm
- insignificant trend (1.8%) favoring device driven by TIA
- 2 year stroke rate essentially identical in both arms (3%)

Major vascular (procedural) complications in 3% of device arm

Significantly higher rate of atrial fibrillation in device arm (5.7%)
- 60% periprocedural
What are the problems with CLOSURE I?

- Patients with deep vein thrombosis and hypercoagulopathy were excluded
- Some centers had limited experience with the procedure
- Patient numbers are too small
- Patients with a clear paradoxical embolism may have had PFO closure outside of the trials
- Follow-up is too short (2y)
- Technology outdated (CardioSEAL- STARflex device most commonly associated with thrombi*)

Taeffe et al., 2008
Most patients do accept the procedural risk

1. Because they just don't want to take the risk of a recurrent stroke – even if it is low

2. Because they do not want to take medication for the next 40-50 years
Indication to close an ASD

In the textbooks & guidelines

– Symptoms

– or RV / RA enlarged

– or QP:QS > 1.5

– or paradoxical embolism
Amplatzer ASD Occluder

- Suitable for $\geq 95\%$ of the defects
- Self-expandable, double disc device
- Nitinol wire mesh
- Two discs linked together by a short connecting waist
- Discs and waist filled with polyester patches
Questions:

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Which defects can be closed?

- Almost all PFOs and secundum defects
- Technical success rate > 90% for ASDs, >95% for PFOs
- Maximum diameter 40mm for ASDs
- Should have a rim on 3 sides
  - Multiple defects
    - Not a problem
  - Septum aneurysm
    - Not a problem
- Age
  - Not a problem
... and surgery?

Will stay for ASDs

- > 40 mm
- Non secundum defects
- No septal rim on ≥ 2 sides
Take-Home Message

- TCD and TTE for primary diagnosis of interatrial septal defects
- TEE (or ICE) to confirm the diagnosis, to exclude intrapulmonary shunts, to assess anatomical characteristics and to guide PFO and ASD closure procedures
- PFO closure should be considered after embolic events due to paradoxical embolism
- Catheter closure of ASDs replaced surgery
- Most ASDs and PFOs can be closed by catheter techniques
Thank you!