Σύγκλειση PFO&ASD
Γεώργιος Δ. Κατσιμαγκλής
Διευθυντής Α΄ Καρδιολογικής Κλινικής & Αιμοδυναμικού Εργαστηρίου NNA
I have no disclosures
Leonardo da Vinci described the patent foramen ovale in the early 1500s:

“I have found a perforating channel from left auricle to right auricle”

In 1875, Karl von Rokitansky provided a superb account of pathological anatomy of the atrial septal defect together with its embryological basis.

He even distinguished between primum and secundum defects.
An atrial septal defect (ASD) is a deficiency of the atrial septum. ASDs account for about 10-15% of all congenital cardiac anomalies.

Research indicates that the incidence of congenital heart disease (CHD) is 0.8% of the US population. Approximately 7% of these individuals, or about 1 in 1500 live births, have an ASD. An estimated 15-30% of healthy adults have an unfused foramen ovale in which the valve functions normally but has failed to fuse.
ΑΝΟΙΚΤΟ ΩΟΕΙΔΕΣ ΤΡΗΜΑ
ΔΟΜΗ-ΦΥΣΙΟΛΟΓΙΑ

Patent Foramen Ovale: STRUCTURE AND PHYSIOLOGY

In Utero
- Right atrium
- Septum (divider)
- PFO tunnel
- Left atrium

After Birth
- Right atrium
- Septum
- PFO tunnel (closed)
- Left atrium

85-90% Population
10-15% Population
Pathophysiology of PFO and Paradoxical Embolism
ΠΑΡΑΔΟΞΗ ΕΜΒΟΛΗ

FIGURE 1. Transesophageal echocardiography demonstrates a 4-cm long thrombus in transit straddling a moderate, 4 mm diameter sized patent fossa ovale (PFO).
ΠΑΡΑΔΟΞΗ ΕΜΒΟΛΗ
Every PFO has to be closed so as to reduce the number of potential handicaps
Closure or Medical Therapy for Cryptogenic Stroke with Patent Foramen Ovale

Anthony J. Furlan, M.D., Mark Reisman, M.D., Joseph Massaro, Ph.D., Laura Mauri, M.D., Harold Adams, M.D., Gregory W. Albers, M.D., Robert Felberg, M.D., Howard Herrmann, M.D., Saibal Kar, M.D., Michael Landzberg, M.D., Albert Raizner, M.D., and Lawrence Wechsler, M.D., for the CLOSURE I Investigators*
## Table 3. Serious Adverse Events.*

<table>
<thead>
<tr>
<th>Event</th>
<th>Closure (N=402)</th>
<th>Medical Therapy (N=458)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major vascular procedural complication — no. (%)†</td>
<td>13 (3.2)</td>
<td>0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Atrial fibrillation — no. (%)</td>
<td>23 (5.7)†</td>
<td>3 (0.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Major bleeding episode — no./total no. (%)‡</td>
<td>10/378 (2.6)</td>
<td>4/374 (1.1)</td>
<td>0.11</td>
</tr>
<tr>
<td>Death other than end point — no. (%)</td>
<td>2 (0.5)¶</td>
<td>4 (0.9)¶</td>
<td>0.51</td>
</tr>
<tr>
<td>Nervous system disorder — no. (%)**</td>
<td>6 (1.5)</td>
<td>16 (3.5)</td>
<td>0.15</td>
</tr>
</tbody>
</table>

- Convulsion: 1, 3
- Hypesthesia: 2, 2
- Migraine: 1, 3
- Headache: 0, 2
- Syncope: 0, 2
- Amyotrophic lateral sclerosis: 0, 1
- Brain abscess: 0, 1
- Facial palsy: 1, 0
- Loss of consciousness: 0, 1
- Paresthesia: 0, 1
- Parkinson’s disease: 1, 0

| Any serious adverse event — no. (%)       | 68 (16.9)       | 76 (16.6)               | 0.90    |

---

*The results shown include all treated patients.

† Major vascular events included hematoma larger than 5 cm in diameter at the access site (in 4 patients), procedure-related transfusion (3), retroperitoneal hemorrhage (3), perforation of the left atrium (1), vascular surgical repair (1), and peripheral-nerve injury (1).

‡ Of these 23 cases of atrial fibrillation, 14 were periprocedural.

¶ Major bleeding status was not ascertained for all treated patients.

‖ The two deaths in the closure group were caused by cardiac arrest on day 232 and by cardiac arrhythmia on day 242.

¶ The four deaths in the medical-therapy group were caused by septic shock on day 269, suicide on day 489, amyotrophic lateral sclerosis on day 557, and metastatic cancer on day 569.

** This category excludes primary-end-point events.
Conclusions

- Superiority of PFO closure with STARFlex® plus medical therapy over medical therapy alone was not demonstrated.
- Significantly higher rate of atrial fibrillation in device arm (5.7%).
Percutaneous Closure of Patent Foramen Ovale in Cryptogenic Embolism

Bernhard Meier, M.D., Bindu Kalesan, Ph.D., Heinrich P. Mattle, M.D., Ahmed A. Khattab, M.D., David Hildick-Smith, M.D., Dariusz Dudek, M.D., Grethe Andersen, M.D., Reda Ibrahim, M.D., Gerhard Schuler, M.D., Antony S. Walton, M.D., Andreas Wahl, M.D., Stephan Windecker, M.D., and Peter Jüni, M.D. for the PC Trial Investigators

PC TRIAL ENDPOINTS

ENDPOINTS AND SAMPLE SIZE

**PRIMARY COMPOSITE ENDPOINT**
- Composite of death from any cause, non-fatal stroke, TIA, and peripheral embolism
- 205 patients per group provide 80% power to detect a reduction in the primary composite endpoint from 3% to 1% at a mean follow-up of 4.5 years and an α-level of 0.0492

**SECONDARY ENDPOINTS**
- Myocardial infarction
- New arrhythmia (atrial fibrillation)
- Re-hospitalization related to PFO or its treatment
- Device – related problems (dislodgement, structural failure, infection, thrombosis)
PC TRIAL RESULTS

- Percutaneous PFO closure with the Amplatzer PFO Occluder for secondary prevention of thromboembolism showed no significant reduction in ischemic and bleeding events compared with medical treatment in this trial.

- However, the observed difference in stroke (80% relative risk reduction, NNT=40) may be clinically relevant if confirmed in further studies.
Closure of Patent Foramen Ovale versus Medical Therapy after Cryptogenic Stroke

John D. Carroll, M.D., Jeffrey L. Saver, M.D., David E. Thaler, M.D., Ph.D., Richard W. Smalling, M.D., Ph.D., Scott Berry, Ph.D., Lee A. MacDonald, M.D., David S. Marks, M.D., and David L. Tirschwell, M.D. for the RESPECT Investigators

RESPECT TRIAL

Enrolled
N=980

Randomization stratified by site and presence/absence of atrial septal aneurysm

Randomized to device group
N = 499

Study device implant attempted
N = 464

Post Implant: clopidogrel 1 month and aspirin 6 months. After 6 months, antplatelet therapy at discretion of site investigator

TEE with bubble study at 6 months

Randomized to medical group
N = 481

Medical treatment specified pre-randomization by site neurologist

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin only</td>
<td>46.5%</td>
</tr>
<tr>
<td>Warfarin only</td>
<td>25.2%</td>
</tr>
<tr>
<td>Clopidogrel only</td>
<td>14.0%</td>
</tr>
<tr>
<td>Aspirin + dipyridamole</td>
<td>8.1%</td>
</tr>
<tr>
<td>Aspirin + clopidogrel</td>
<td>6.2%</td>
</tr>
</tbody>
</table>
Inclusion/Exclusion Criteria

**Inclusion Criteria:**
- Patients (ages 18 to 60) with PFO who have had a cryptogenic stroke within 270 days
  - Stroke defined as acute focal neurological deficit, presumed to be due to focal ischemia, and either symptoms persisting 1) ≥ 24 hours, or 2) < 24 hours with MR or CT confirmed new, neuroanatomically relevant, cerebral infarct
  - PFO defined as TEE visualization of micro-bubbles in the left atrium within 3 cardiac cycles of their appearance in the right atrium at rest and/or during Valsalva release

**Key Exclusion Criteria:**
- Cerebral, cardiovascular, and systemic conditions that suggest other mechanisms for stroke. Examples:
  - Carotid disease, atrial fibrillation, cardiomyopathy, etc
  - Arterial hypercoagulable states
  - Uncontrolled diabetes mellitus or hypertension
  - Other sources of right to left shunt
- Contraindications:
  - To aspirin or clopidogrel
  - Anatomical to device placement
- Any other reason to expect limited life expectancy, inability to attend follow-up visits, or inability to provide informed consent
For carefully selected patients with history of cryptogenic stroke and PFO, the RESPECT Trial provides evidence of benefit in stroke risk reduction from closure with the AMPLATZER PFO Occluder over medical management alone:

- Primary analysis of ITT cohort was not statistically significant but trended towards superiority while secondary analyses suggested superiority.
- Stroke risk reduction was observed across the totality of analyses with rates ranging from 46.6% - 72.7%.

PFO closure with the AMPLATZER PFO Occluder exposes patients to a very low risk of device- or procedure-related complications.

Results of the RESPECT Trial have substantial import for the treatment of patients with a history of cryptogenic stroke and PFO.

Follow-up of patients is on-going and will continue to provide additional longer term information regarding benefits, risks, and differential treatment effects in sub-populations.
Nearly 1/3 of Recurrent Strokes in Extended Follow-up Are of Known Mechanism

- Atherosclerosis = 1
- Small Vessel Disease = 6
- Cardioembolic = 5 (AF = 4, endocarditis = 1)
- Other = 1 (radiation arteriopathy)
- Dissection = 0

Subjects with Recurrent Ischemic Stroke

- Cryptogenic (Possibly Paradoxical Embolism) = 29
- Known Mechanisms = 13
1 out of 3 Recurrent Strokes Had Mechanism That PFO Closure Cannot Prevent

Extended Follow-up in ITT Population

Event-free Probability

- AMPLATZER™ PFO Occluder (N=499, # strokes = 18)
- Medical Management (N=481, # strokes = 24)

HR: n/a (non-proportional hazards)
Log-rank p-value: 0.16

# at Risk (KM Estimates)

<table>
<thead>
<tr>
<th></th>
<th>Events</th>
<th># at Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMPLATZER</td>
<td>18</td>
<td>499 (0%)</td>
</tr>
<tr>
<td>MM</td>
<td>24</td>
<td>481 (0%)</td>
</tr>
</tbody>
</table>

Time to Event (Years)
Significant Reduction in Recurrent Cryptogenic Stroke

54% Relative Risk Reduction in ITT Population

Event-free Probability

- AMPLATZER™ PFO Occluder (N=499; # cryptogenic strokes = 10)
- Medical Management (N=481; # cryptogenic strokes = 19)

Device not in place

HR: 0.460
Log-rank p-value: 0.042

# at Risk (KM Estimates)

<table>
<thead>
<tr>
<th></th>
<th>AMPLATZER</th>
<th>Medical Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Event (Years)</td>
<td>499 (0%)</td>
<td>481 (0%)</td>
</tr>
<tr>
<td>0</td>
<td>499 (0%)</td>
<td>481 (0%)</td>
</tr>
<tr>
<td>1</td>
<td>463 (1.2%)</td>
<td>462 (4.1%)</td>
</tr>
<tr>
<td>2</td>
<td>369 (1.5%)</td>
<td>307 (4.1%)</td>
</tr>
<tr>
<td>3</td>
<td>212 (2.5%)</td>
<td>168 (4.1%)</td>
</tr>
<tr>
<td>4</td>
<td>86 (2.5%)</td>
<td>71 (5.2%)</td>
</tr>
<tr>
<td>5</td>
<td>20 (2.5%)</td>
<td>10 (10.8%)</td>
</tr>
</tbody>
</table>
70% Relative Risk Reduction in Recurrent Cryptogenic Stroke With Device In Place

Event-free Probability

AMPLATZER™ PFO Occluder Implanted
(N=464; # cryptogenic strokes = 7)

Not Implanted
(N=516; # cryptogenic strokes = 22)

HR: 0.302
Log-rank p-value: 0.004

# at Risk (KM Estimates)
AMPLATZER 464 (0%)
Not Implanted 516 (0%)

Time to Event (Years)

0 1 2 3 4 5 6 7 8 9 10
Greater Benefit in Substantial Shunt or ASA Subgroup

75% Relative Risk Reduction in Recurrent Cryptogenic Stroke in ITT Population

Event-free Probability

- **AMPLATZER™ PFO Occluder**
  - $N=319$, # cryptogenic strokes = 4

- **Medical Management**
  - $N=301$, # cryptogenic strokes = 13

- HR: 0.245
- Log-rank p-value: 0.007

# at Risk (KM Estimates)

<table>
<thead>
<tr>
<th></th>
<th>AMPLATZER</th>
<th>Medical Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>319</td>
<td>301</td>
</tr>
<tr>
<td>0.6%</td>
<td>299</td>
<td></td>
</tr>
<tr>
<td>1.0%</td>
<td>229</td>
<td></td>
</tr>
<tr>
<td>1.5%</td>
<td>134</td>
<td></td>
</tr>
<tr>
<td>1.5%</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>1.5%</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>3.6%</td>
<td>243</td>
<td></td>
</tr>
<tr>
<td>4.8%</td>
<td>186</td>
<td></td>
</tr>
<tr>
<td>4.8%</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>6.6%</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>6.6%</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>
RESPECT Final Results

Freedom from Recurrent Ischemic Stroke
(Intention to Treat – Patients censored at age 60 years)

- AMPLATZER PFO Occluder (# strokes = 12)
- Medical Management (# strokes = 25)

Risk Reduction: 58%
HR: 0.42 (95% CI: 0.21, 0.83)
Log-rank 2-sided p-value = 0.010

# at Risk (KM Estimates)
AMPLATZER
- 475 (0%) 443 (1.3%) 418 (1.8%) 383 (1.8%) 345 (2.0%) 285 (2.6%) 203 (3.0%) 150 (3.0%) 97 (3.0%) 55 (3.0%) 29 (3.0%)

MM
- 463 (0%) 402 (1.8%) 363 (3.4%) 321 (3.9%) 289 (4.9%) 220 (5.2%) 159 (5.2%) 109 (6.7%) 76 (7.7%) 44 (7.7%) 22 (13.2%)

Time from Randomization (Years)
Conclusions

• In the RESPECT trial, PFO closure with the AMPLATZER™ PFO Occluder was more beneficial than medical management alone.

• Collaboration between a cardiologist and neurologist is important for proper patient selection.

• For patients with cryptogenic stroke and PFO, closure with the AMPLATZER™ PFO Occluder is an appropriate treatment option that reduces the risk of recurrent stroke.
The AMPLATZER™ PFO Occluder is indicated for percutaneous transcatheter closure of a patent foramen ovale (PFO) to reduce the risk of recurrent ischemic stroke in patients, predominantly between the ages of 18 and 60 years, who have had a cryptogenic stroke due to a presumed paradoxical embolism, as determined by a neurologist and cardiologist following an evaluation to exclude known causes of ischemic stroke.
## Patent Foramen Ovale Recommendations

<table>
<thead>
<tr>
<th>2014 Recommendation</th>
<th>Revisions (2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td>For patients with an ischemic stroke or TIA and a PFO who are not on anticoagulation therapy, antiplatelet therapy is recommended. (Class I, LOE B)</td>
<td>Class changed from IIa to I</td>
</tr>
<tr>
<td>For patients with an ischemic stroke or TIA and both a PFO and a venous source of embolism, anticoagulation is indicated, depending on stroke characteristics. (Class I, LOE A). When anticoagulation is contraindicated, an inferior vena cava filter is reasonable (Class IIa, LOE C).</td>
<td>New Recommendations</td>
</tr>
<tr>
<td>For patients with a cryptogenic ischemic stroke or TIA and a PFO without evidence for DVT, available data does not support a benefit for PFO closure. (Class III, LOE A)</td>
<td>Revised Recommendation</td>
</tr>
<tr>
<td>In the setting of PFO and DVT, PFO closure by a transcatheter device might be considered, depending on the risk of recurrent DVT. (Class IIb, LOE C)</td>
<td>New Recommendation</td>
</tr>
</tbody>
</table>
RoPE Score

Identifying a PFO-related Cryptogenic Stroke: The RoPE Score

Add points for each risk factor and for age
- A patient less than 30 years with no risk factors has a score of 10
- A patient ≥ 70 years with all 5 risk factors has a score of 0

Maximum Score = 10

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>(0 to 5 points)</th>
<th>RoPE Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>No history of hypertension</td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>No history of diabetes</td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>No history of stroke or TIA</td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>Non-smoker</td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>Peripheral infarct on CT or MRI</td>
<td>(1)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age at time of index event</th>
<th>(0 to 5 points)</th>
<th>RoPE Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥70 years</td>
<td>(0)</td>
<td></td>
</tr>
<tr>
<td>60 – 69 years</td>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>50 – 59 years</td>
<td>(2)</td>
<td></td>
</tr>
<tr>
<td>40 – 49 years</td>
<td>(3)</td>
<td></td>
</tr>
<tr>
<td>30 – 39 years</td>
<td>(4)</td>
<td></td>
</tr>
<tr>
<td>18 – 29 years</td>
<td>(5)</td>
<td></td>
</tr>
</tbody>
</table>

Total Score =

Kent DM et al, Neurology 2013; 81:619-625
RoPE Score

Increasing RoPE score = Increasing PFO attributable fraction = Decreasing risk of recurrent TIA/Stroke
Management of PFO & Stroke

Italian way

Italian Scientific Societies Position Paper: Management of PFO and CS

Cryptogenic Stroke/TIA (symptomatic/asymptomatic) & PFO with R-L Shunt

First cryptogenic event without anatomical/clinical risk factors
(or Low RoPE score)

Medical therapy

Cryptogenic event in medical treatment-naïve patients with ≥ 1 risk factor
(or High RoPE score)

Cath PFO closure as an alternative to medical therapy

Any cryptogenic event (first or recurrent) on AP and/or OA therapy

Cath PFO closure

Anatomical risk factors
- Atrial septal aneurysm
- Large PFO (>4 mm)
- Basal R-L shunt
- Eustachian valve >10 mm
- Chiari network
- Long PFO tunnel

Clinical risk factors
- Multiple ischemic lesions on CT/MR
- Recurrent clinical events
- History of DVT/PE and/or Thrombophilia
- Valsalva-associated embolic event
- Ischemic event on arousal (OSAS)
- Long travel/immobilization associated event
- Simultaneous systemic/pulmonary embolism

EXTENSIVE PATIENT EVALUATION NEEDED AND MULTIPLE CONSIDERATIONS IN MAKING DECISIONS

CLINICIAN’S DECISION TO CONSIDER PFO CLOSURE FOR AN INDIVIDUAL PATIENT

- Clinical Clues
- Patient Characteristics
  - Age – Risk Factors
- Patient Preferences
- Neuroimaging Data
- PFO and Septum Characteristics
- VTE Assessment
Migraine Intervention With STARFlex Technology (MIST) Trial: A Prospective, Multicenter, Double-Blind, Sham-Controlled Trial to Evaluate the Effectiveness of Patent Foramen Ovale Closure With STARFlex Septal Repair Implant to Resolve Refractory Migraine Headache

Andrew Dowson, Michael J. Mullen, Richard Peatfield, Keith Muir, Arif Anis Khan, Christopher Wells, Susan L. Lipscombe, Trevor Rees, Joseph V. De Giovanni, W. Lindsay Morrison, David Hildick-Smith, Giles Elrington, W. Stewart Hillis, Iqbal S. Malik and Anthony Rickards

*Circulation* 2008;117:1397-1404; originally published online March 3, 2008; doi: 10.1161/CIRCULATIONAHA.107.727271

*Circulation* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Copyright © 2008 American Heart Association, Inc. All rights reserved.

Print ISSN: 0009-7322. Online ISSN: 1524-4539
PFO & MIGRAINE

Percutaneous Closure of Patent Foramen Ovale in Migraine with Aura

PRIMA


On Behalf of the PRIMA Investigators
Conclusions

- Interventional studies in migraine/aura patients are difficult to do
- 40% of patients in PRIMA had a R to L shunt
- PFO closure is safe in these patients
- PFO closure did not reduce total migraine days significantly compared to medical therapy
Results of the PREMIUM trial: Patent Foramen Ovale closure with the AMPLATZER™ PFO occluder for the prevention of migraine

Jonathan Tobis, Andrew Charles, Stephen Silberstein, Sherman Sorensen, Brijeshwar Maini, John Gurley, Phillip Horwitz

On behalf of the PREMIUM Investigators
Premium Trial-Conclusions

- PFO closure with the AMPLATZER™ PFO occluder in migraine patients is safe and well tolerated
- The PREMIUM study did not meet its primary endpoint of 50% reduction in attack frequency
- The PREMIUM study did meet its secondary endpoint in reduction in migraine days
- There is a small but significant subset of patients (particularly those with frequent aura) for whom PFO closure appears to be highly effective
ΑΛΛΕΣ « ΕΝΔΕΙΞΕΙΣ»

- Decompression Sickness – Deep sea divers
- Platypnea-Orthodeoxia
- Systemic Embolization
The difficult procedure in interventional cardiology is the one that is not indicated

There are times that closing a PFO is the better approach

MARK REISMAN, MD
UNIVERSITY OF WASHINGTON
ΣΥΣΚΕΥΕΣ ΣΥΓΚΛΕΙΣΗΣ

Amplatzer PFO

NMT Starflex

Helix
AMPLICATER® PFO Occluder

Device Selection

**LEGEND:**

- Device Size (RA Disc = B)
- RA Disc (B)
- LA Disc (C)
- Length of Waist = (D)
HELIX
ΤΥΠΟΙ ΜΕΣΟΚΟΛΠΙΚΗΣ ΕΠΙΚΟΙΝΩΝΙΑΣ

- **Secundum ASD** (80% of ASDs; located in the region of the fossa ovalis and its surrounding)
- **Primum ASD** [15%, synonyms: partial atrioventricular septal defect (AVSD), partial atrioventricular (AV) canal; located near the crux, AV valves are typically malformed resulting in various degrees of regurgitation; see Section 4.3]
- **Superior sinus venosus defect** [5%, located near the superior vena cava (SVC) entry, associated with partial or complete connection of right pulmonary veins to SVC/right atrium (RA)]
- **Inferior sinus venosus defect** [<1%, located near the inferior vena cava (IVC) entry]
- **Unroofed coronary sinus** [<1%, separation from the left atrium (LA) can be partially or completely missing].
Three types of ASDs

- Ostium Secundum
- Ostium Primum
- Sinus Venosus
ASD SECUNDUM
ASD. Secundum, Multiple
Table 3  Indications for intervention in atrial septal defect

<table>
<thead>
<tr>
<th>Indications</th>
<th>Class</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with significant shunt (signs of RV volume overload) and PVR &lt; 5 WU should undergo ASD closure regardless of symptoms</td>
<td>I</td>
<td>B&lt;sup&gt;24&lt;/sup&gt;</td>
</tr>
<tr>
<td>Device closure is the method of choice for secundum ASD closure when applicable</td>
<td>I</td>
<td>C</td>
</tr>
<tr>
<td>All ASDs regardless of size in patients with suspicion of paradoxical embolism (exclusion of other causes) should be considered for intervention</td>
<td>IIa</td>
<td>C</td>
</tr>
<tr>
<td>Patients with PVR ≥ 5 WU but &lt; 2/3 SVR or PAP &lt; 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 &gt; 1.5) may be considered for intervention</td>
<td>IIb</td>
<td>C</td>
</tr>
<tr>
<td>ASD closure must be avoided in patients with Eisenmenger physiology</td>
<td>III</td>
<td>C</td>
</tr>
</tbody>
</table>
• Right atrial and right ventricular enlargement by echocardiography with or without symptoms.
• ASD minimum diameter should be > 5 mm and < 40 mm on echocardiography.
• Adequate rims of tissue (> 5 mm) from the defect to surrounding structures such as the coronary sinus, SVC, IVC, and AV valves, as well as the pulmonary veins.
• Presence of an ASD with documented or verified paradoxical embolization and/or documented orthodeoxia-platypnea.
• Net left-to-right shunting, pulmonary artery pressures less than two-thirds systemic levels, pulmonary vascular resistance less than two-thirds systemic vascular resistance, when either is responsive to pulmonary vasodilators, or test occlusion of the defect is successful.
Aortic rim absence or severe deficiency confirmed in multiple TEE views. Absence of rims documented in multiple views of 30°, 40°, 50°+. 
IVC rim absence or severe deficiency.
Pulmonary vascular resistance > 15 Woods units is an absolute contraindication.
Patients with PVR between 10 and 15 should have aggressive antipulmonary hypertensive treatment for 6 months and evaluation before exploring ASD closure.
Coronary sinus rim absence with evidence of coronary sinus impingement by the device in the catheterization laboratory.
Mitral valve impingement by the device with evidence of new-onset or increasing mitral insufficiency. Try a smaller device, if feasible.
Development of AV block after device deployment
If 5 mm is considered to be an adequate rim size, then aortic rim deficiency will be common because more than 40% of patients with ASD have an aortic rim that is < 5 mm.

Therefore, aortic rim deficiency is not a generalized contraindication to device closure. The aortic rim, however, is the most important rim when it comes to device-related complications such as erosion.
ΔΙΑΓΝΩΣΤΙΚΟΣ ΑΛΓΟΡΙΘΜΟΣ

- The initial workup at a minimum should include:
  - A through clinical assessment
  - ECG
  - CXR
  - TTE/Doppler evaluation
  - TEE to prove the existence of ASD, better define location, shape and size, assess pulmonary venous connections, and evaluate cardiac valves (if not provided by TTE). TEE is essential for determination of suitability for device closure
  - Resting oxygen saturations
The diagnostic workup may require:

- Right heart Cath (PAP and PVR determination, to assess pulmonary vascular reactivity or to delineate APVC)
- Coronary angio (in high risk pts or in pts >40 y if surgical repair is planned)
- MRI to prove existence of ASD or to assess pulmonary venous connections if doubt remains after other imaging modalities. Also can calculate Qp:Qs
- Oxygen saturation with exercise if there is any suggestion of PHTN. Do not exercise if there is severe PHTN or resting oxygen Sat is <85%
- Open lung Bx should be considered when the reversibility of PHTN is uncertain from hemodynamic data
Figure 2: AMPLATZER septal occluder device (AGA Medical Corporation, now St. Jude Medical).
Occlutech Flex II ASD Device
• Femoral venous access
• TTE/ICE imaging for PFO
• TEE, 3DTEE or ICE imaging for ASD
• IV heparin to ACT > 250 sec
• Catheter access across defect
• Balloon sizing of defect
• Exchange for delivery sheath
• Device deployment and release
• Confirmatory imaging- PAKMAN Sign
• Total time: ~30 minutes for PFO, ~60 minutes for ASD
Atrial septal defect closure using an expanding device

1. Atrial septum
2. RA → LA
3. Secundum ASD
4. Device passed up inferior vena cava, into the right atrium and into septal defect

© The Royal Children's Hospital, Melbourne, Australia
Balloon diameter $d = 33\text{mm}$

ASD amplatz occluder (36mm)
Stroke
Cardiac tamponade from cardiac perforation
Device-associated thrombus
Device embolization
Device erosion
Incomplete defect closure
ΣΑΣ ΕΥΧΑΡΙΣΤΩ