Arrhythmias after ASD closure: device related or genetic?

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What predisposes to arrhythmias in the setting of an ASD?

Intrinsic to the disease process?

An effect of age?

Device related?

Prior history of arrhythmias?

ASD or PFO?

Genetic influences?

Interplay of some or all of the above......
Reported morbidity for device closure is less than surgery.

Potential complications include:
- access difficulties
- device embolization or malposition
- pericardial effusion 2ndry to perf. of the atrium or PV
- thrombus formation

Reported electrocardiographic complications include
- development of atrial tachyarrhythmias
- heart block, both transient & permanent
Genetics & the ASD

2:1 female predominance with almost all secundum defects occurring sporadically, with a multifactorial inheritance pattern.

There are kindred’s suggesting a Mendelian (autosomal dominant) pattern of inheritance associated with GATA4 gene mutation (atrial defect & pulmonary stenosis).

Well described association with the Holt-Oram syndrome.

Some families have associated abnormalities of sinus node function or atrioventricular nodal dysfunction (PR prolongation) associated with a mutation or haploinsufficiency in the NKX2.5 gene.
The Congenital lesion....... 

- Defects of the atrial septum are well known to cause electrophysiological changes, not only secondarily to hemodynamic changes but an inherent part of this congenital heart defect.

- Both apparent & latent abnormalities of AV nodal function are frequent findings in patients with an ASD.

- There is a reported incidence of 15% for 1st degree AVB in preoperative electrocardiograms of children with ASD.
The substrate for arrhythmia development

1 - Conduction from the SA node to AV node, occurs over a fast pathway along the anterior margins of the foramen ovale or ASD

2 - Superior margin of the foramen ovale include Bachmann’s bundle, which are fibers in the roof of the atrium & forms the primary route of interatrial conduction
Direct compression or injury of these pathways may occur after percutaneous or surgical closure of the defect.

Fibrosis or compression of Bachmann's bundle may result in prolongation of interatrial conduction & changes in P-wave morphology.

Resultant conduction delay could provide the substrate for re-entry & subsequent tachyarrhythmias.

The risk of bundle compression in those with large ASDs, & those with deficient anterosuperior rims, may be increased.
ECG changes & arrhythmias following percutaneous ASD & PFO device closure

Johnson Catheter Cardiovasc Interv 2011;78:254

Demographics 1999-2008

<table>
<thead>
<tr>
<th></th>
<th>Total cohort</th>
<th>PFO cohort</th>
<th>ASD cohort</th>
<th>Multiple devices</th>
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<td># of patients</td>
<td>610</td>
<td>384</td>
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<td>age (yr)</td>
<td>50±18.1</td>
<td>54± 14</td>
<td>42± 21</td>
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<td>F/M</td>
<td>307/303</td>
<td>164/220</td>
<td>122/62</td>
<td>21/21</td>
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Pre-procedure ECG & Holters were compared:
<2 months & >2 months after placement

Arrhythmia incidence: 5.2% (32) within 4 months of implant:

29 with atrial tachyarrhythmias (22-fibrillation, 7-flutter)
1 with junctional tachycardia, & 2 with heart block
Other findings

- **Acutely** there were changes in P-wave height & duration consistent with acute off-loading of volume from the RA

- **Intermediate follow-up:** the average P-wave duration was increased & PR interval decreased...which may be related to fibrosis or endothelialization in the region of Bachmann’s bundle

- Development of new-onset 1° AVB after the procedure was associated with an increased risk of ATs in follow up
Incidence of atrial fibrillation following transcatheter closure of atrial septal defects in adults
Spies C  Am J Cardiol 2008;102:902

n=1,062 - 822 had a PFO and 240 had an ASD closure

median follow up ~20 months

- 8% of pts had new-onset AF
- 7% - after PFO & 12% after ASD closure

Annual incidence: 2.5% & 4.1% PFO & ASD, respectively

Generally, new-onset AF pts were older than those without
Device type/size did not influence AF occurrence.
In the AF group with a PFO, residual shunt was more common.
Compared with an age-matched general population, the incidence of AF is increased after ASD & PFO closure.

New-onset AF soon after ASD closure appears to be due to occluder placement rather than coincidentally occurring as a consequence of the structural heart disease.

This is supported by the close timely proximity of AF & occluder placement in patients with PFO.
Two studies by Silversides from Toronto addressed whether device closure worsened or improved arrhythmia risk

n=132 consecutive pts, ~44 (16) years; 74% female

- Looked for sustained or symptomatic atrial arrhythmias:
  - early follow up (6 weeks; n = 115)
  - intermediate follow up (17 (11) months; n = 121).

- 15% of the pts (20) had AT before implant (14 paroxysmal, 6 persistent)

- Patients without a Hx of arrhythmia had a low incidence of AT early
  (6%) & in intermediate follow up (1%/year)

- Those with persistent AT before closure remained in AF or flutter

*Heart 2004;90:1194-1198.*
Those in SR but with Hx of AT, ~2/3 remained arrhythmia-free in follow up, incidence of paroxysmal 17% & persistent 11%/yr

A history of AT before closure (RR 35.0, 95% CI 7.2 to 169.0) & age >55 years at the time of closure (RR 5.6, 95% CI 1.2 to 25.0) predicted AT after closure

Device closure of an ASD before the onset of atrial arrhythmias may protect against the subsequent development of arrhythmia, in particular in pts <55 years of age
The purpose of the 2\textsuperscript{nd} study was to prospectively determine the incidence of AT in adults with an ASD & identify predictors of AT after closure

Am J Cardiol 2008;101:683

n=200 adult pts undergoing closure of a secundum ASD

arrhythmic events were: sustained or symptomatic AT requiring treatment

- 20\% of pts (mean age 50 (17) yrs; 26\% men) had a history of AT

- early follow-up the prevalence of AT was 17\%

- late follow-up (mean 1.9(0.9) yrs, n=171), AT was detected in 16\% after device closure

![Prevalence of Arrhythmias](image)
Closure resulted in alleviation of symptoms (p <0.001), but symptoms alone did not identify patients at risk of recurrent AT.

After closure, the likelihood of remaining arrhythmia free was highest in pts without a history of AT (p<0.001) & those <40 years at closure (p<0.04).

Transcatheter ASD closure in pts without a history of arrhythmias & those <40 years of age conferred the highest likelihood of a pt remaining arrhythmia free in follow-up.

Am J Cardiol 2008;101:683
KM estimates of survival free from ATs in pts in SR at baseline

Pts without ATs (continuous line) before ASD closure had improved arrhythmia-free survival vs. patients with a history of ATs

An arrhythmia-specific treatment strategy should be considered for patients with documented established AT before ASD closure, in addition to shunt relief

Am J Cardiol 2008;101:683
Speculation as to possible mechanisms of AF

Generally, the type & size of occluder does not seem to impact the occurrence after defect closure.

1 - the device via a foreign body reaction may lead to an inflammatory response in the atrial myocardium

2 - the occluder may function as an electrical barrier leading to new macro-reentry circuit (similar to the reentry of scar-related VT)

3 - atrial septal aneurysms, commonly found in pts with underlying PFO may predispose AF via P-wave dispersion

4 - underlying structural heart disease in patients with ASD & the possibility of occult pre-existing AF before defect closure
What about AV Block in Children?

Incidence:

Suda (JACC 2001) reported an incidence of 6.2% of new onset AVB among 162 implants...... half being 2\textsuperscript{nd} or 3\textsuperscript{rd} degree

3 occurred during the procedure & 7 during the first week after the implant

All pts recovered to normal AV conduction in the 1\textsuperscript{st} month except 1 after 6 months & 2 who had persistent 1\textsuperscript{st} degree AVB

Steroids were used in 1 case with CAVB which recovered 2 weeks later
The most concerning complication is complete AV Block?

CAVB has been described sporadically in several studies & case reports, in most of which the AV block was transient & recovered in a short period of time.
What about complete AV Block?

What to do?

Chessa (JACC 2002) reported 1/417 pts where the device was retrieved during cardiac catheterization & normal AV conduction recovered 3 hr later.

Wang (AHJ 2004) described a case immediately after deployment with an adequate junctional escape rhythm, the device was left in place & resolved 3 days later with 1:1 AV conduction & 1st degree AV block.

Dalvi (CCI 2008) reported a case that developed 2nd degree AVB 24 hr after implant, treated with oral steroids & non steroidal anti-inflammatory agents & regained 1:1 AV conduction within 48 hr.
What about complete AV Block?

What to do?

Hill (JICE 2000) implanted a permanent pacemaker for CAVB in a pt who had sinus node dysfunction before the procedure & developed complete AV dissociation after the implant.

Another case was described by Nehgme (Pediatr Cardiol 2009) in a pt with 2 defects, the rhythm progressing from 1\textsuperscript{st} degree AVB @ 24 hr to 2\textsuperscript{nd} degree AVB (Mobitz type II). Treated with steroids with initial improvement to Wenckebach but subsequently deteriorated over 4 years to CAVB & eventually required an epicardial dual chamber pacemaker.
What about complete AV Block?

Possible mechanisms...risk factors

The proximity of the AV node situated at the base of the triangle of Koch to the rims of the ASD places it at a greater risk for injury both at surgery and with transcatheter device closure.

Adequacy of the inferior rim (<5mm) ..... although it has been reported that pts with deficient posteroinferior rim have been closed successfully (AGA devices) with no reported heart block.
What about complete AV Block?

Possible mechanisms...risk factors

Suda (JACC 2004) suggested that device size >19 mm & device/height ratio (>0.18 mm/cm) and a large shunt Qp:Qs >2.8 were risk factors for AVB block

While anatomical relationship of the distance between the RA disc & the TV in the apical 4-chamber view was not a risk factor

- It can occur in uncomplicated procedures
- It can occur early & late after the implant
- Anti-inflammatory agents may or may not improve the rhythm
- Timing of removal is critical to avoid permanent damage to the AV node
Recommendations:

- Careful selection of appropriate candidates for device closure with sufficient posteroinferior rims.

- High risk pts include those with large defects especially cases of deficient rims & pts with history of pre-procedural electrophysiological changes: should have electrocardiogram & 24 hr ambulatory ECG monitoring prior to & after device closure.

- The importance of echocardiographic guidance during the procedure assess the device position in relation to the tricuspid valve septal leaflet.
- Choose appropriate size device, the same or no larger than 2 mm than the balloon stop flow diameter.

- Any degree of persistent AV block during implantation, retrieve the device consider smaller implant.

- If 1\textsuperscript{st} degree AVB occurs after the procedure, observe closely, to detect later progression to higher degrees of block.

- If there is progression to 2\textsuperscript{nd} of 3\textsuperscript{rd} degree AVB consider, high dose steroids & non-steroidal anti-inflammatory agents.

- In cases of persistence of high degree AV block with hemodynamic instability, it is prudent to proceed to removal of the device.
Summary

- There is a low risk of developing arrhythmias after percutaneous device closure (~5 to 7%, & CAVB ~0.3 to 0.5%)

- The majority of atrial arrhythmias occur in the 1st month following device placement.

- It is critical for the interventionalist to be prepared for potential arrhythmias, both atrial tachyarrhythmias and heart block.

- Pts with clinically significant 2nd degree AVB in whom device closure should be advised of the potential risk for developing worsening block after closure.

- Changes in atrial conduction (P-wave duration) after device closure occur, lengthening of the PR interval should be considered a risk factor for developing subsequent atrial tachyarrhythmias.

- Pts with clinically significant AT prior to closure should have EP evaluation and possible ablation.
Cám o'n
Percutaneous ASD and PFO closure was first described in humans in the 1970s.

With new devices & techniques, percutaneous closure has become the standard of care for most defects modified by patient size, defect morphology & age.
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