ASD closure in the elderly
: Physiology & Strategy

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Pathophysiology of ASD in the elderly

- Cardiac chamber dilation
- ventricular → heart failure/dysfunction
- pulmonary hypertension
- arrhythmia>> heart failure/ stroke

ASD in the elderly

- Pulmonary artery pressure increased continuously with age
- Incidence of arrhythmia increased with age
- Incidence of heart failure increased with age

Yalonetsky S, et al. CHD 2009;4:17-20

Kim NK et al. KCJ 2011;41:633

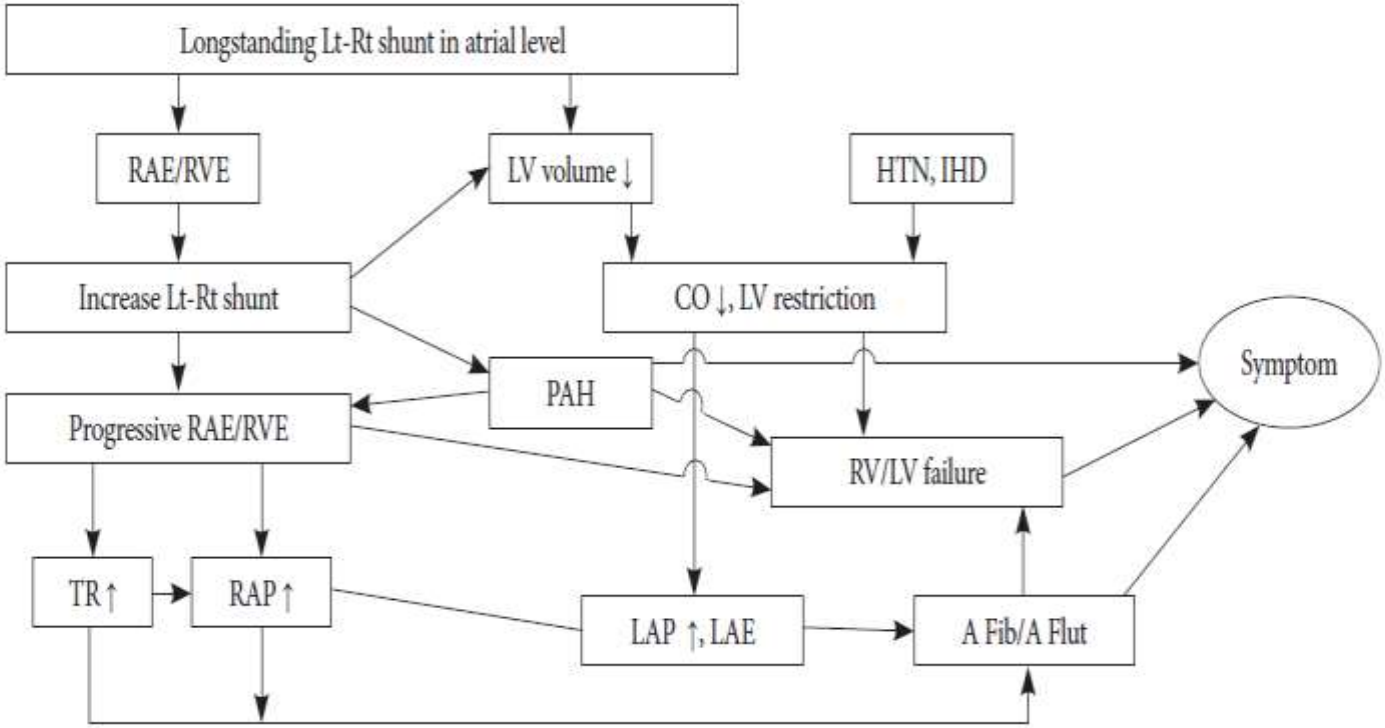


Fig. 2. The pathophysiologic mechanisms in elderly patients with atrial septal defect. Longstanding left to right shunt in the atrial level results in progressive right heart dilatation, significant TR and subsequent increase in RA pressure. Left heart may also be influenced by chronic volume underload, increased atrial pressure as well as co-morbid diseases. Lt: left, Rt: right, RAE: right atrial enlargement, RVE: right ventricular enlargement, LV: left ventricle, HTN: hypertension, IHD: ischemic heart disease, CO: cardiac output, PAH: pulmonary arterial hypertension, TR: tricuspid regurgitation, RAP: right atrial pressure, LAP: left atrial pressure, LAE: left atrial enlargement, A Fib: atrial fi-

Table 1. Summary of Reported Hemodynamics and Diastolic Function Before and After ASD Closure

	Baseline	After ASD Closure
Heart rate and cardiac dimensions/volume		
Heart rate (beats/min)		→
RV diameter/volume	↑(47)	↓ (29,47,48)
LV diameter/volume	↓(12)	↑(29,49-51)
LA dimension/volume		↑(49), →(29), ↓(50)
Diastolic function		
Left atrial pressure (mm Hg)		↑(9,39), →(9)
LV end-diastolic pressure	→(12)	↑(18)
LV tau	→with Qp/Qs<3 (13), ↑with Qp/Qs>3 (13)	→(18)
LV−dp/dt max	→with Qp/Qs<3 (13), ↓with Qp/Qs<3 (13)	→(18)
k	→(13)	
Mitral E/A		→(29), →without (9) and ↑with pathological LA pressure rise during test occlusion (9)
e′ septum	→(28)	→(5,27), ↓(24,28,29)
E/e′		↑(29)
Diastolic P-V relation in one cardiac cycle	Left and upper shift (13)	
ED P-V relation during load-manipulation		Parallel downward shift (unpublished)

↑, greater than control or increased after ASD closure; →, not significantly different from the control or no significant change after ASD closure; ↓, smaller than control or decreased after ASD closure; RV, right ventricle; LV, left ventricle; tau, time constant of ventricular relaxation; Qp/Qs, the ratio of pulmonary to systemic flow; k, stiffness constant; E, peak mitral inflow velocity during early diastole; A, peak mitral inflow velocity during late diastole; e′, peak mitral annular velocity during early diastole; P-V, pressure-volume; ED, end-diastolic.

Numbers in parentheses represent reference numbers in the Reference list.

Benefits of ASD closure in the elderly

- Regression of PAP & RV size, less in the elderly
- Prevent RV failure
- Stop the progression of PVOD?
- Preventing development of arrhythmia
- Restore sinus rhythm in patients with paroxysmal AF
- Function status improvement

Humenberger M, et al. Eur Heart J 2011;32:553-6
Spies C. Am J Cardiol 2008;102:902-6

To close or not to close: considerations in the elderly

- general condition (comorbidities)
  heart disease, noncardiac disease
- Benefits vs. Risks
- Indications & contraindication of closure

* pulmonary artery pressure
* heart failure
* arrhythmia

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

Methods of closure

- surgery (closure & Maze procedure)
- catheter closure

Ventricular dysfunction or heart failure in elderly ASD patients

LV dysfunction in ASD patients undergoing catheter closure

- LV diastolic dysfunction 11-27 % in general population (age ≥ 60 yr, hypertension, obesity, CAD) common in elderly ASD Patients, masked
- ASD closure → ↑ LV filling
  → ↑ LV dimension (↑ BNP)
  → lung edema
- How to identify masked LV dysfunction
  →balloon test occlusion→↑LAP 5 mmHg

Muta et al. Acta Paediatr 2002;91:649-52
Ewert P, et al. CCI 2001;52:177-80
Kudo et al, Kyobu Geka 1991;44:387-90
Schubert et al. CCI 2005;64:333-7

Masked LV dysfunction in elderly patients with ASD

- Closure lead to pulmonary edema/ HF

- Balloon test occlusion

  → LA pressure/

  wedge PA pressure↑ ≥ 5 mmHg

- Conditioning treatment

  * diuretics/ afterload reduction/ mirilone

- fenestrated device

Preconditioning of LV

- Medications
  - dopamine 3-5 μg/kg/ min
  - Milrinone 0.5 μg/kg/min
  - furosemide 1-2 mg/kg/day

  } 48-60 hrs

- ↓ LA pressure → close,
  LA pressure → no change → fenestrated device

Schubert S, et al. CCI 2005;64:333

Pulmonary hypertension

:Very common in the elderly patients

Age vs PAP

Eur Heart J 2011;32:553

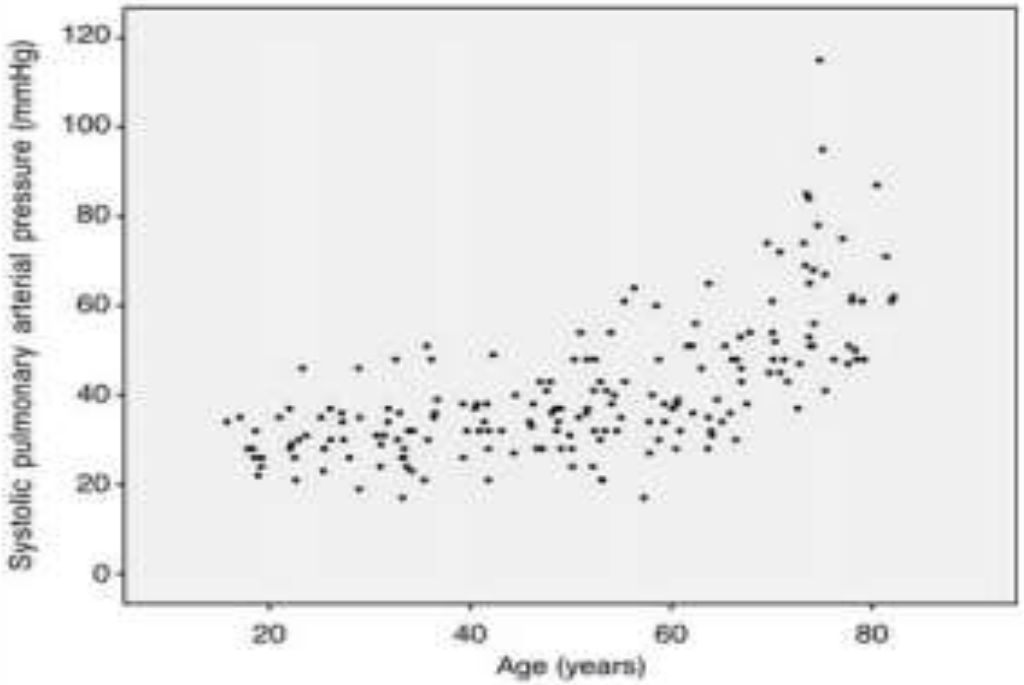


Figure 1 Correlation between systolic pulmonary artery pressure and age ($r = 0.65$, $P < 0.0001$).

JACC 2013;62 D 34-41

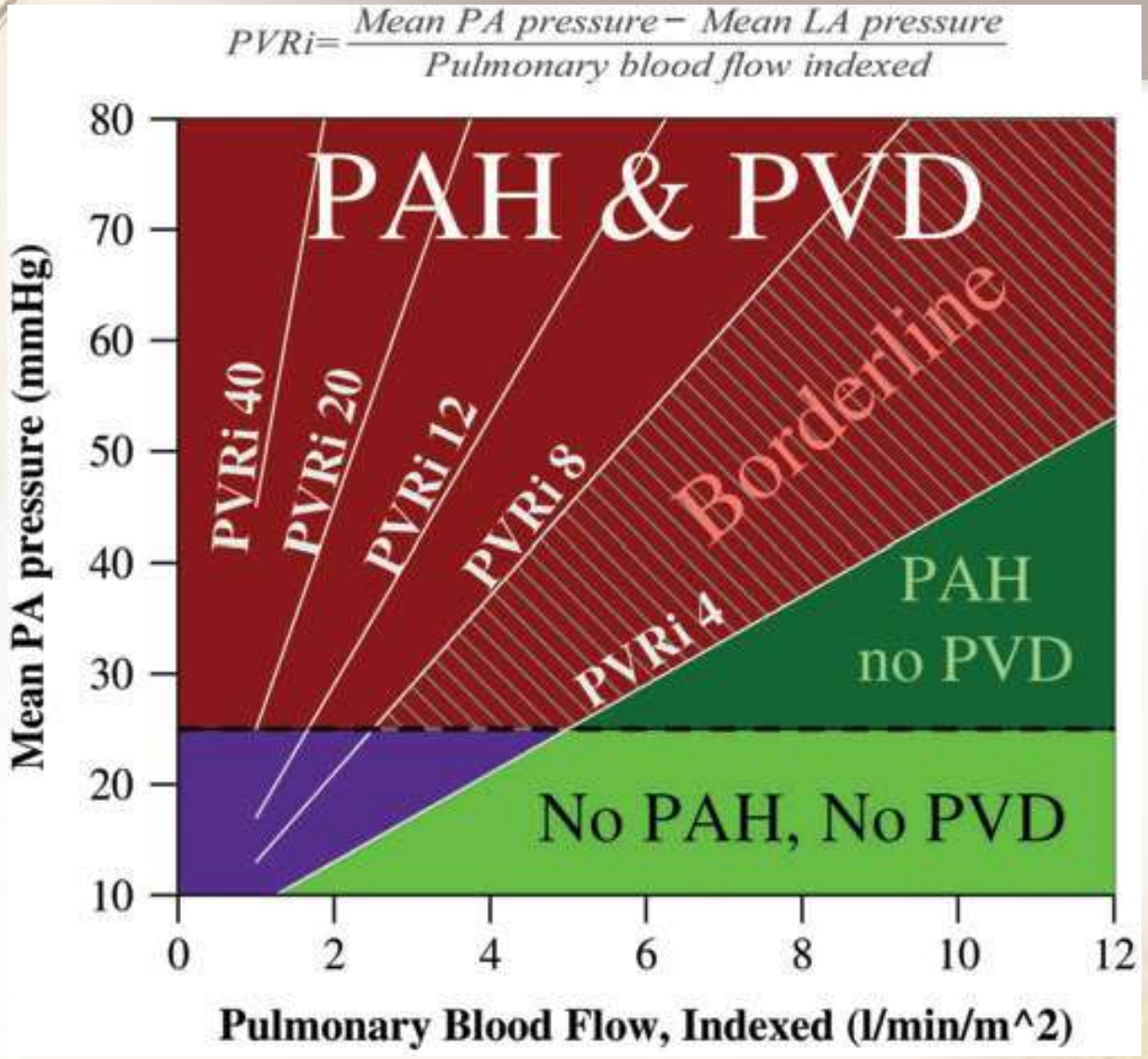
Table 4 Criteria for Closing Cardiac Shunts in PAH Patients Associated With Congenital Heart Defects*

PVRi, Wood units/m^2	PVR, Wood units	Correctable†
<4	<2.3	Yes
>8	>4.6	No
4-8	2.3-4.6	Individual patient evaluation in tertiary centers

*Criteria: the long-term impact of defect closure in the presence of pulmonary arterial hypertension (PAH) with increased PVR is largely unknown. There are a lack of data in this controversial area, and caution must be exercised. †Correctable with surgery or intravascular nonsurgical procedure.

PVR = pulmonary vascular resistance; PVRi = pulmonary vascular resistance index.

Gray zone of PVRi



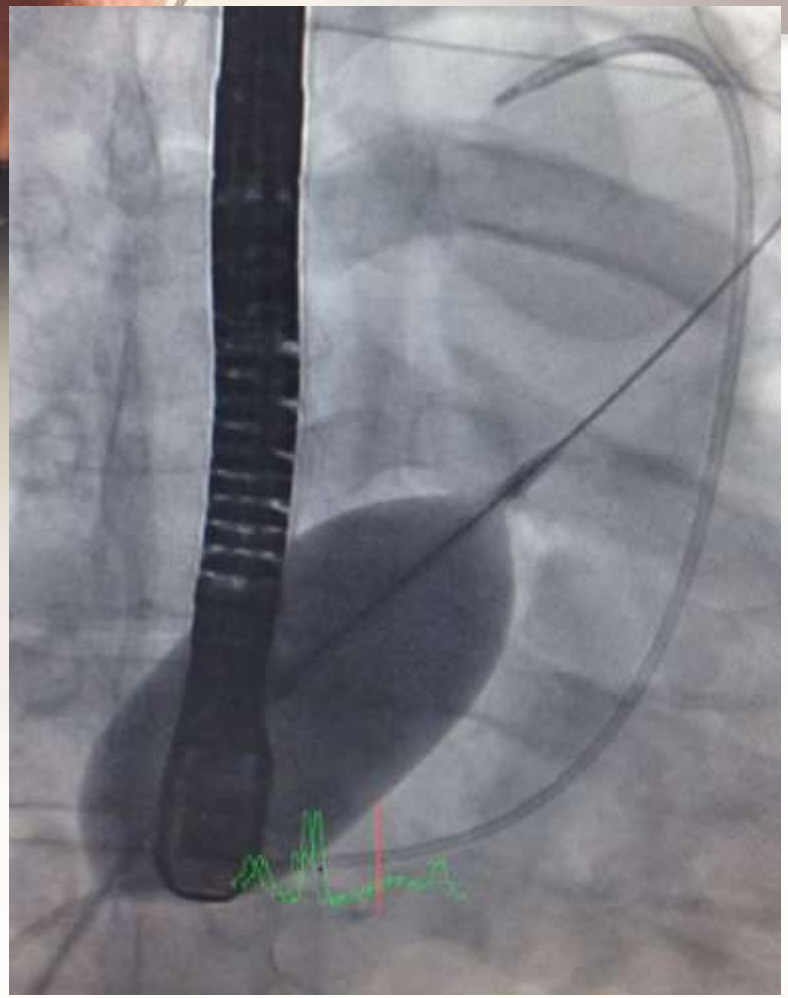
Evaluation of "operability"

- PVR & PVRi
- Vasodilator test
- Balloon occlusion test
- Wedge angiogram
- Treat-and-repair

Pulmonary arteriolar wedge angiography

Pruning of distal vasculature and decreased background haze

Cardiac catheterization



stretching diameter of the ASD： 34.6 mm

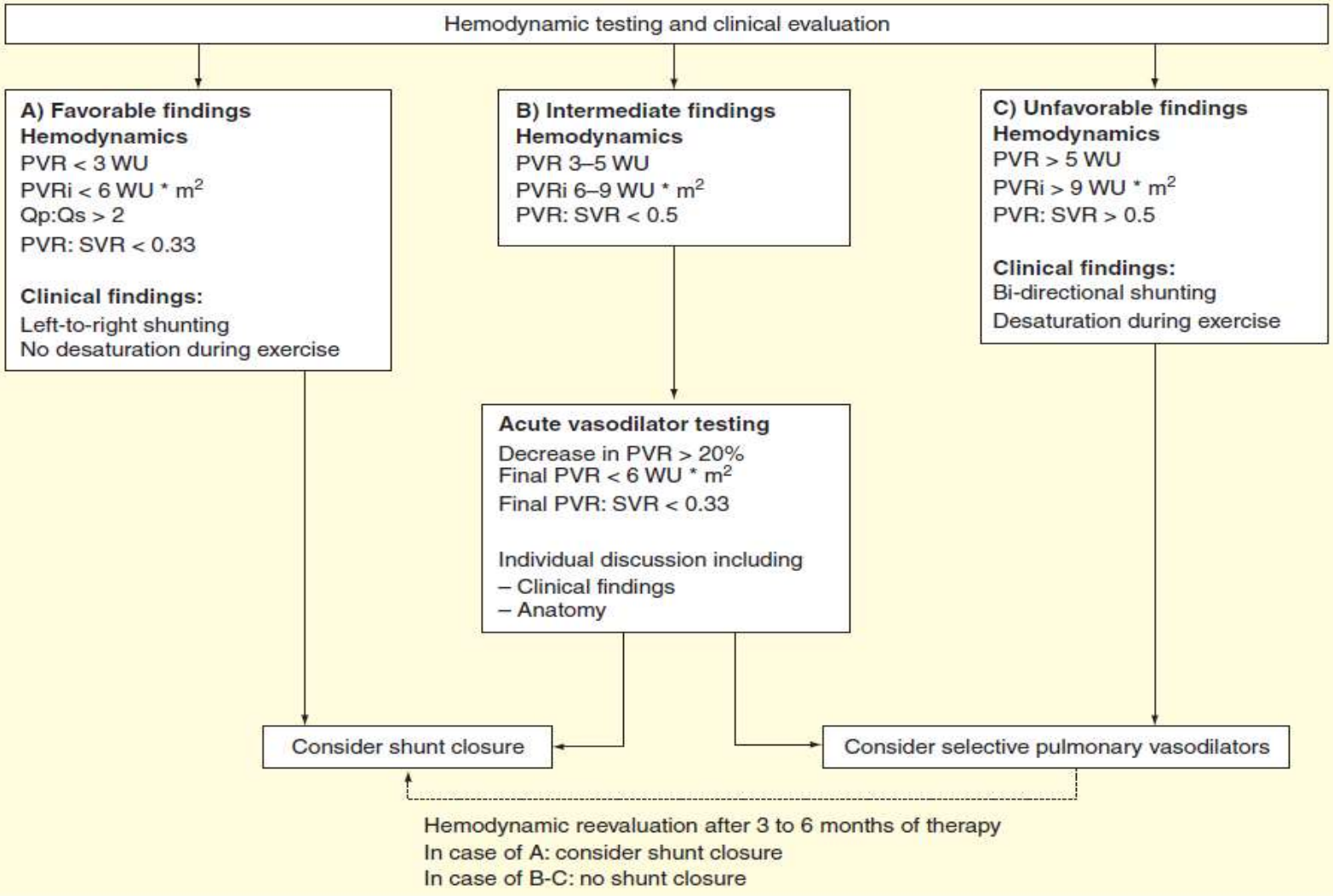


Figure 1. Suggested treatment algorithm for patients with ASD and PAH.
PVR: Pulmonary vascular resistance; PVRi: Pulmonary vascular resistance index; SVR: Systemic vascular resistance; WU: Wood units.

Treat-and-repair

Kijima Y, Akagi t, el.al Circ J 2015

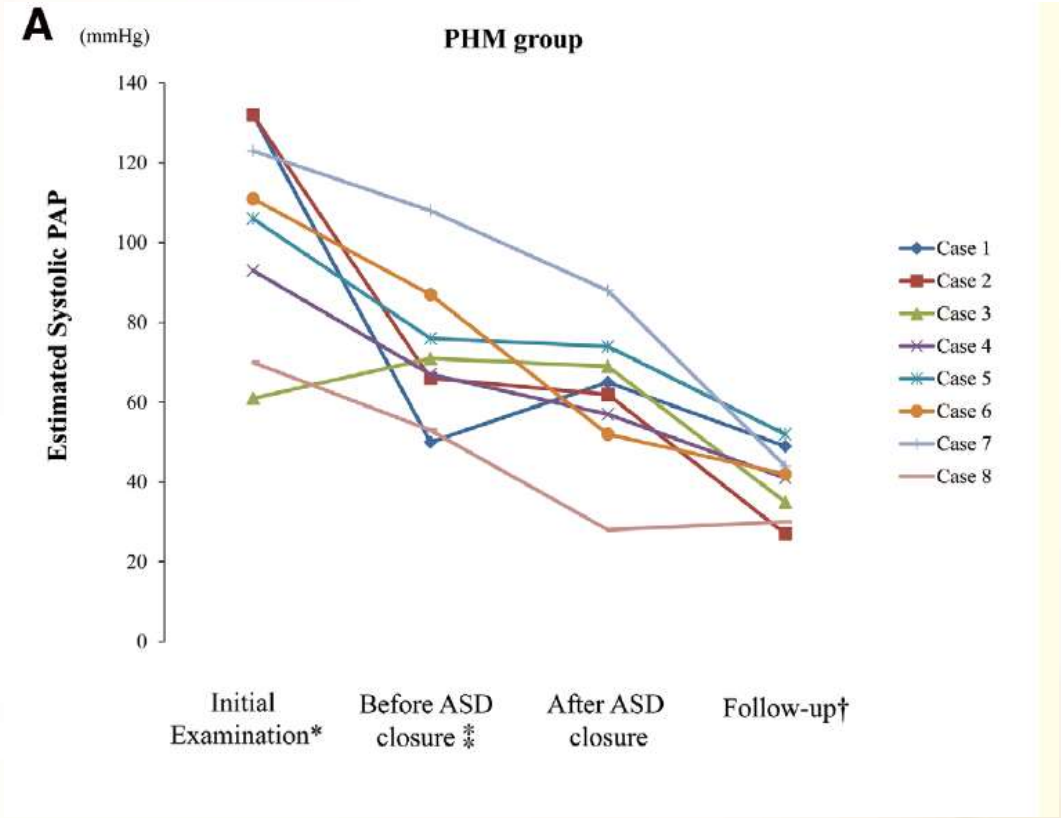
Table 2. Measurement of Hemodynamics by Catheterization Study

	PHM group (n=8)		P value*	Non-PHM group (n=14)
	Initial evaluation	After medical therapy		
sPAP, mmHg	99±30**	60±11†	0.01	58±17
dPAP, mmHg	39±17**	29±8†	0.35	21±5
Mean PAP, mmHg	62±21**	41±10†	<0.01	35±8
PVR, Wood units	9.6±3.8**	4.0±0.8†	<0.01	4.1±1.1
Qp/Qs	1.39±0.41**	2.12±0.60†	0.01	2.32±0.51

Values are mean±SD. *Comparison between the initial evaluation and after medical therapy in the PHM group. **P<0.01 compared with the non-PHM group; †P=0.79 for systolic PAP; P=0.01 for diastolic PAP; P=0.13 for mean PAP; P=0.75 for PVR and P=0.42 for Qp/Qs compared with the non-PHM group. Qp/Qs was derived from 7 patients with available results. PAP, pulmonary arterial pressure; PVR, pulmonary vascular resistance. Other abbreviations as in Table 1.

Treat-and-repair

Kijima Y CirC J 2015



RV dimension & PAP decreased after closure Eur Heart J 2011;32:553

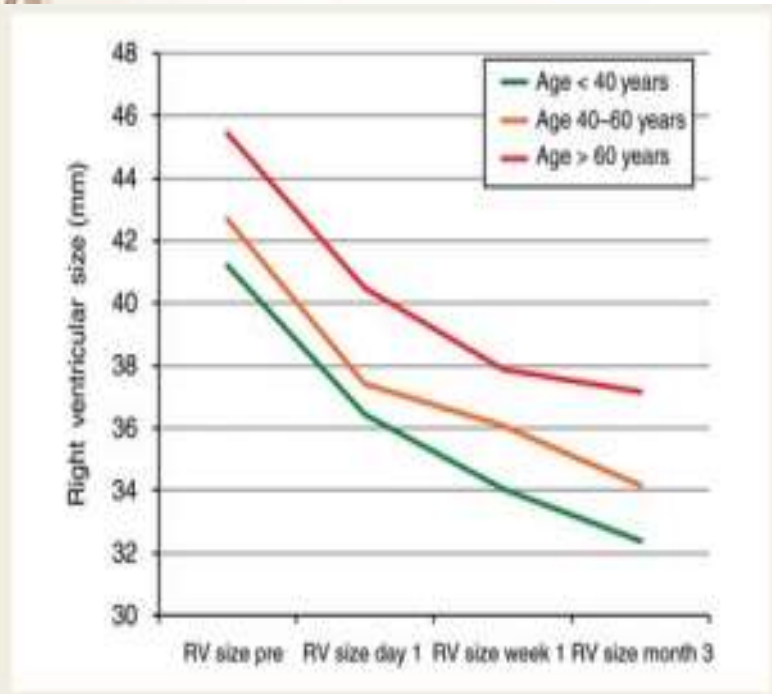


Figure 2 Right ventricular (RV) size before, 1 day, 1 week, and 3 months after atrial septal defect closure for patients younger than 40 years (green line), patients aged 40–60 years (orange line), and patients older than 60 years (red line).

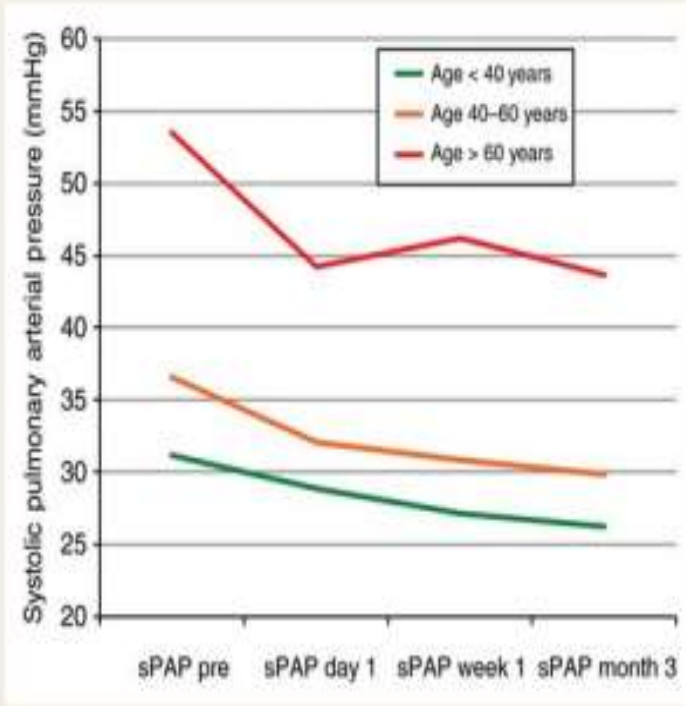
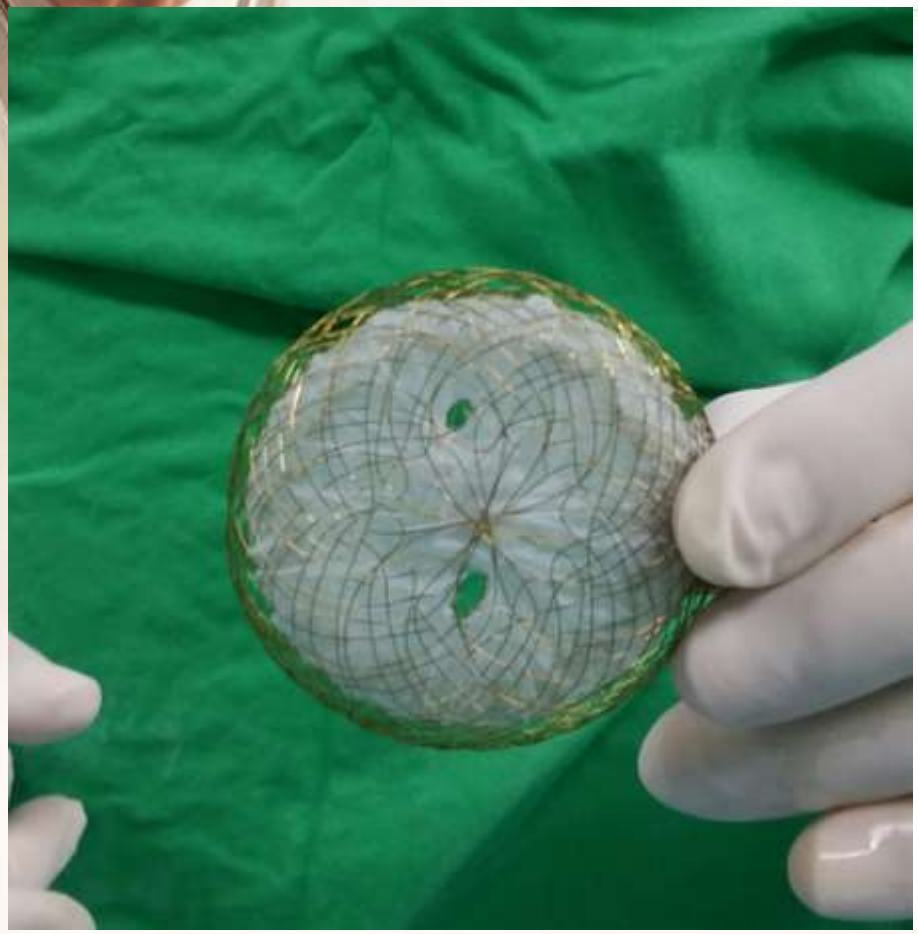
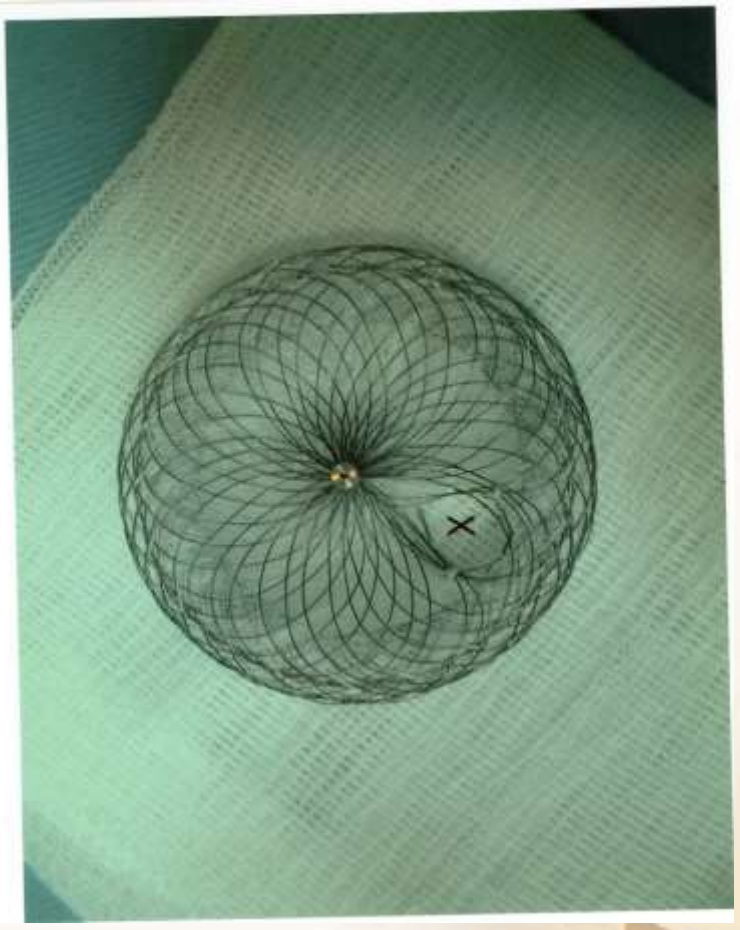


Figure 3 Systolic pulmonary artery pressure (sPAP) before, 1 day, 1 week, and 3 months after atrial septal defect closure for patients younger than 40 years (green line), patients aged 40–60 years (orange line), and patients older than 60 years (red line).

Fenestrated device





Fenestrated devices for ASD closure in the elderlies with CHF/ pulmonary hypertension (I)

- n=22 out of 84 patients aged > 60
- Ages 60-86
- PAH with a mean PAP> 35 mmHg (n=18) or heart failure with or without PAH (n=4)
- preconditioning with diurectics or ACEi
- Balloon test occlusion in PVR > 5 WU

Fenestrated devices for ASD closure in the elderlies with CHF/ pulmonary hypertension

- Embolization in 1 with AF due to elevated CVP & possibly LAP
- Procedural success n=21
- Sildenafil used in 9 (reimbursed last year)

Follow-up

- Mortality n=2, 6 m, 25 m
- 2 lost to F/U
- Majorities had improvement in symptoms
- Recath in 1 decrease in PAP, but PVR slightly increased.

Fenestrated device

- Ventricular dysfunction
- Borderline pulmonary hypertension
- Geriatrics

Strategy of transcatheter closure of ASD in the elderly (I)

- closure (surgery/ transcatheter)
  if PAH (−)
  LV function (−)
  arrhythmia (−)

Arrhythmias in elderly ASD patients

- Atrial fibrillation (paroxysmal/ persistent)
- Atrial Flutter
- Supraventricular tachycardia

Arrhythmias in elderly ASD patients

- PV isolation for paroxysmal AF
- Permanent AF rarely can be converted to sinus rhythm
- Ablation PSVT
- Closure after optimal treatment

Atrial fibrillation in elderly ASD patients

- permanent
  * surgical closure with concomitten Maze
  * catheter closure with medications
- paroxysmal
  * PV isolation

KCJ 2013;43:110

Atrial arrhythmia in elderly ASD patients

- quite common, 26-53 %
- Atrial fibrillation
- Atrial flutter

Woo SB et al. CCJ 2013;43:110
Taniguchi M. CCI 2009;73:682
Nakagawa K. CCI 2012;80:84

Reduced arrhythmia after closure

Table 4: The percentage of patients with AF before and after closure in the elderly patients in different age groups

Atrial fibrillation in the elderly patients

Age	Number	Before closure (%)	After closure (%)	Risk reduction (%)
50-60	35	37	14	23
61-70	32	50	34	16
71-81	12	67	42	25
Total	79	47	27	20

C. Nyboe *et al.* / European Journal of Cardio-Thoracic Surgery

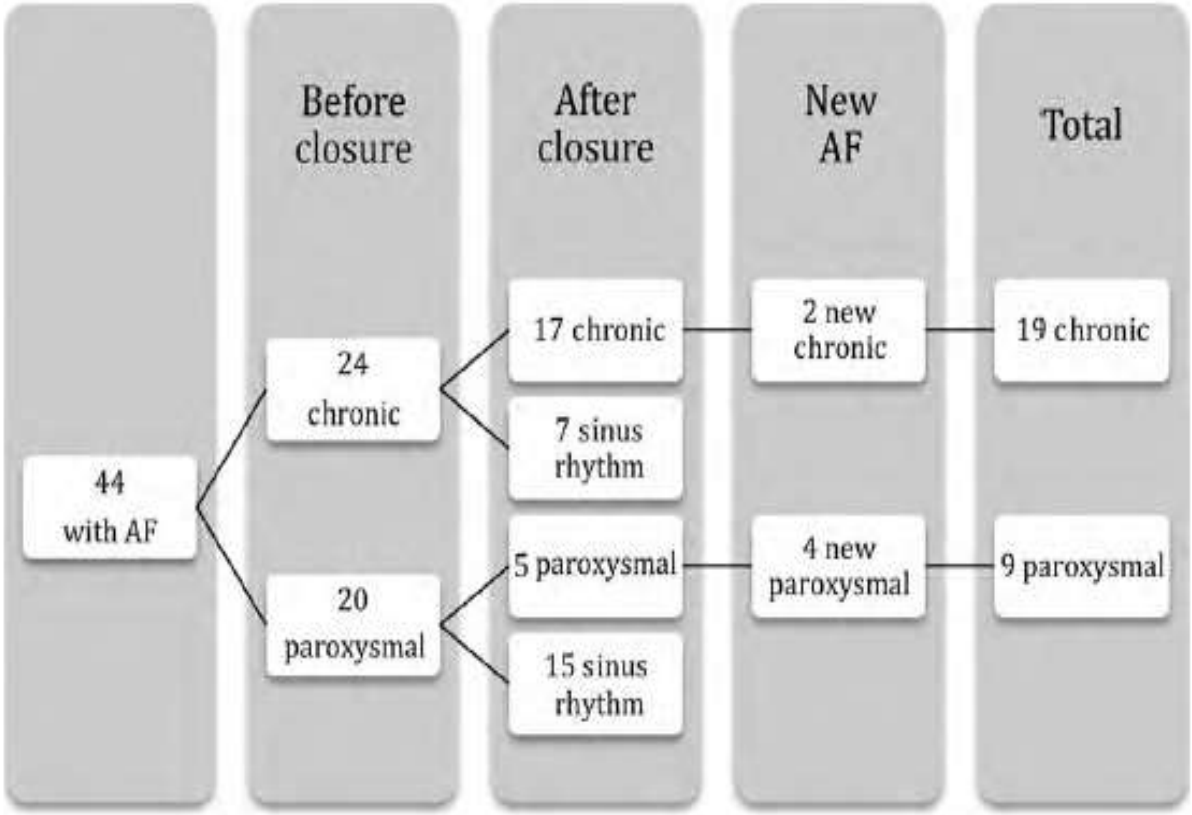


Figure 1: Total number of patients with AF before and after closure.

ASD-with AF management strategy

- Paroxysmal AF → PV isolation → catheter closure

- Permanent AF → catheter closure

Transcatheter Closure of Atrial Septal Defect in a Geriatric Population

Koji Nakagawa,[1] MD, Teiji Akagi,[2*] MD, PhD, FSCAI, Manabu Taniguchi,[2] MD, PhD, Yasufumi Kijima,[1] MD, Keiji Goto,[3] MD, PhD, Kengo F. Kusano,[1] MD, PhD, Hiroshi Itoh,[1] MD, PhD, and Shunji Sano,[4] MD, PhD

PVR < 8 WU

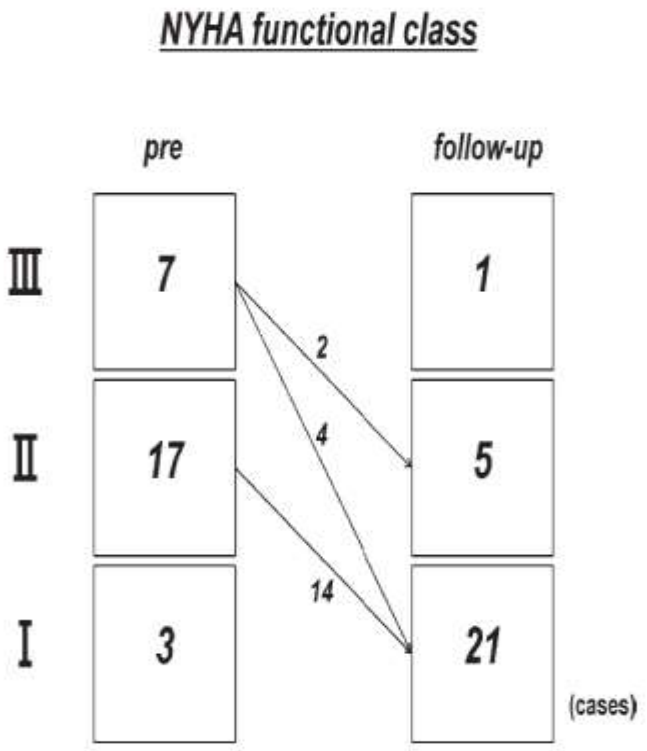


Fig. 1. NYHA functional class before the procedure and at follow-up.

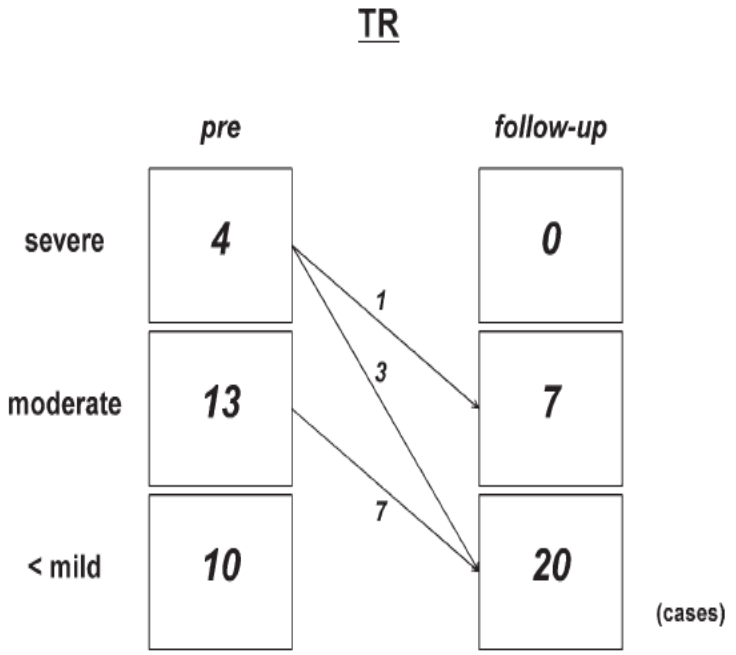


Fig. 2. Degrees of TR before the procedure and at follow-up.

Conclusions

- Cardiac co-morbilities
  (PAH, AF/ Atrial flutter, CAD) are quite common
  in elderly ASD patients (PVR < 5 w.u.)

- severe PAH, Vasodilator test

- LV dysfunction can be masked in 2-4 %
  → Unmasking LV dysfunction by balloon test occlusion

- Preconditioning

- A fenestrated device may be an ideal solution