



Device closure of large hypertensive PDA

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Large and hypertensive PDA

- newborns, young infants
- adolescents & adults
- Down syndrome



Case I

- A 34 year-old woman
- CHD known since early childhood
- exertional dyspnea, chest pain for 3 years
- echo: large PDA with a small muscular VSD
severe PAH
- PE, No cyanosis, A grade II/ VI systolic murmur heard,
O₂ saturation 92% (finger & toe)

Case I hemodynamic data

	pressure (mmHg)	O ₂ Saturation (%)
IVC	<u>80</u>	78
RA	1	72
SVC		68
RV	92/7	71
MPA	97/56 (<u>75</u>)	81
A-Ao	104/60 (80)	89
D-Ao		90
LV	107/7	92

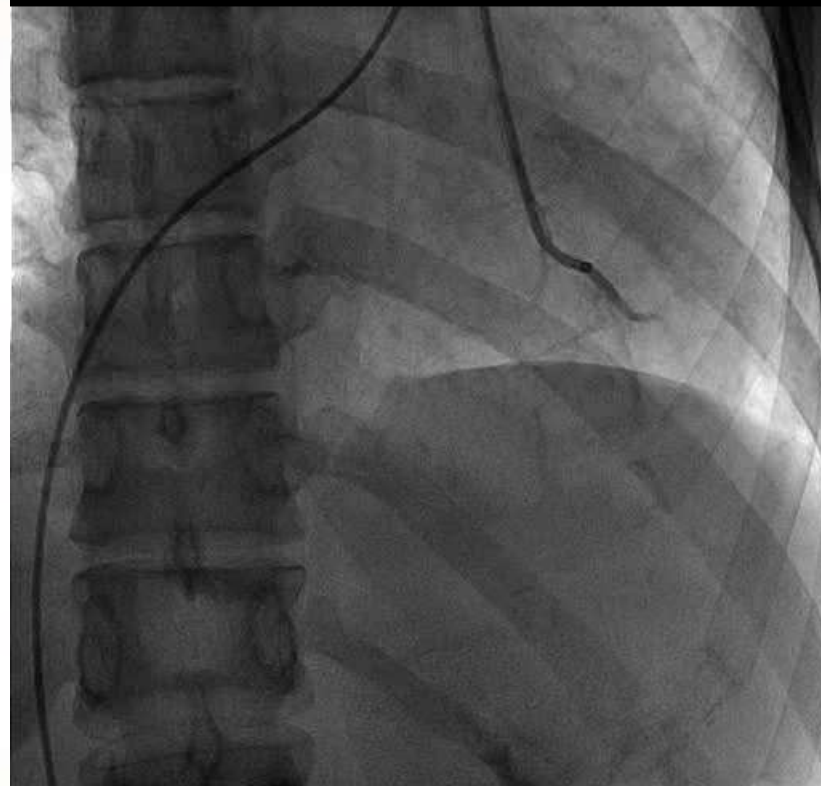
Qp/ Qs = 1.68

PVR 7.95 w.u.

PVRI 11.1 w.u. m²

PA wedge angio

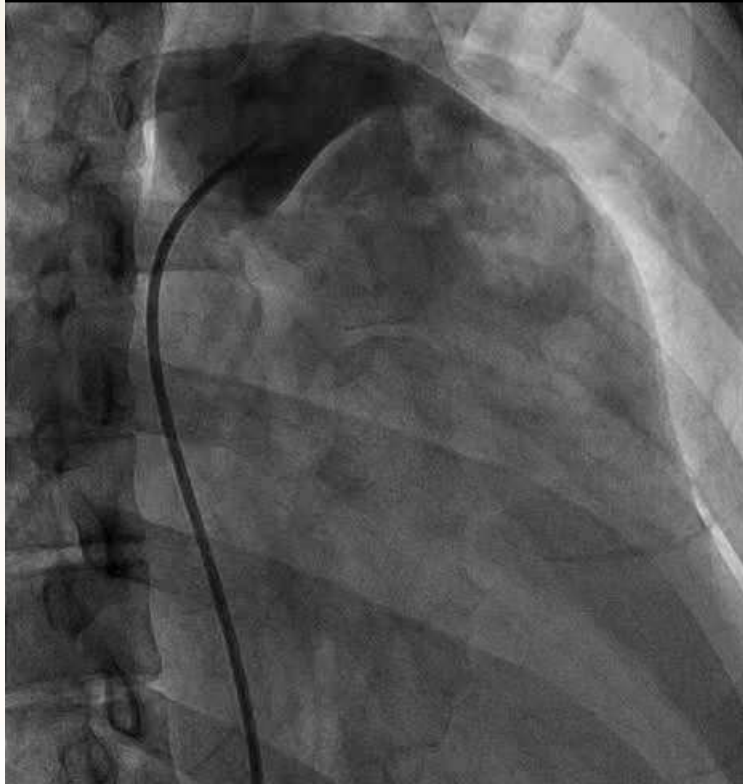
Lossy compression - not intended for diagnosis



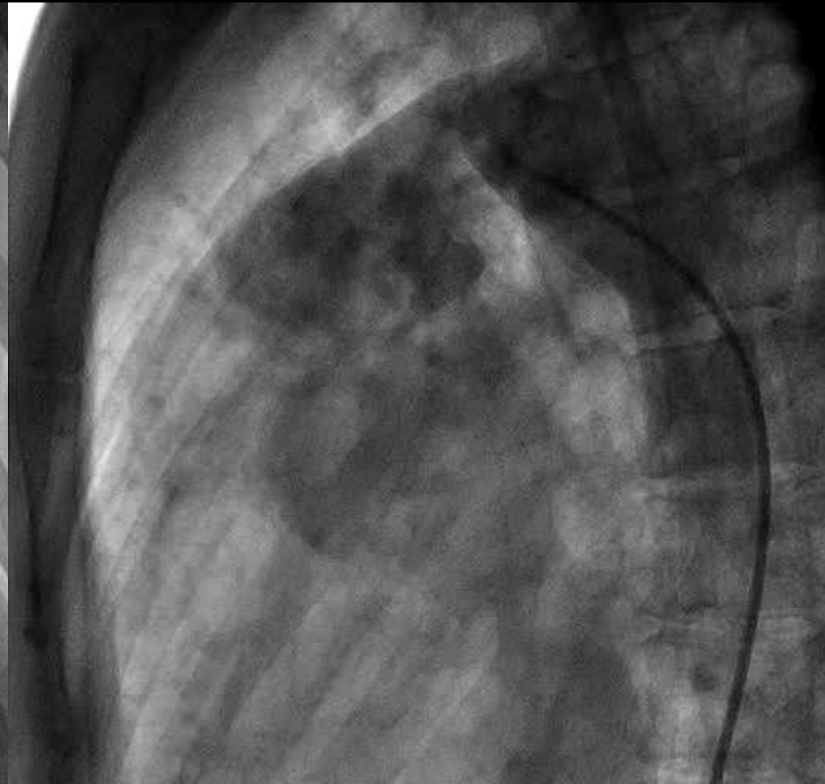


Large hypertensive PDA: to close or not to close ?

Lossy compression - not intended for diagnosis

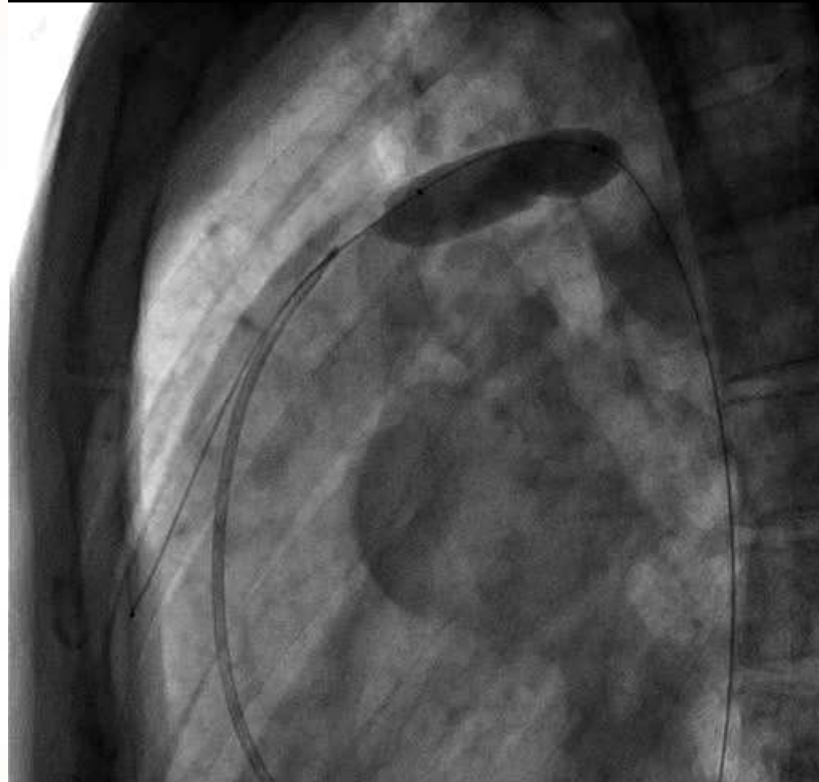


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Balloon test occlusion

Lossy compression - not intended for diagnosis





Case I Test occlusion

before

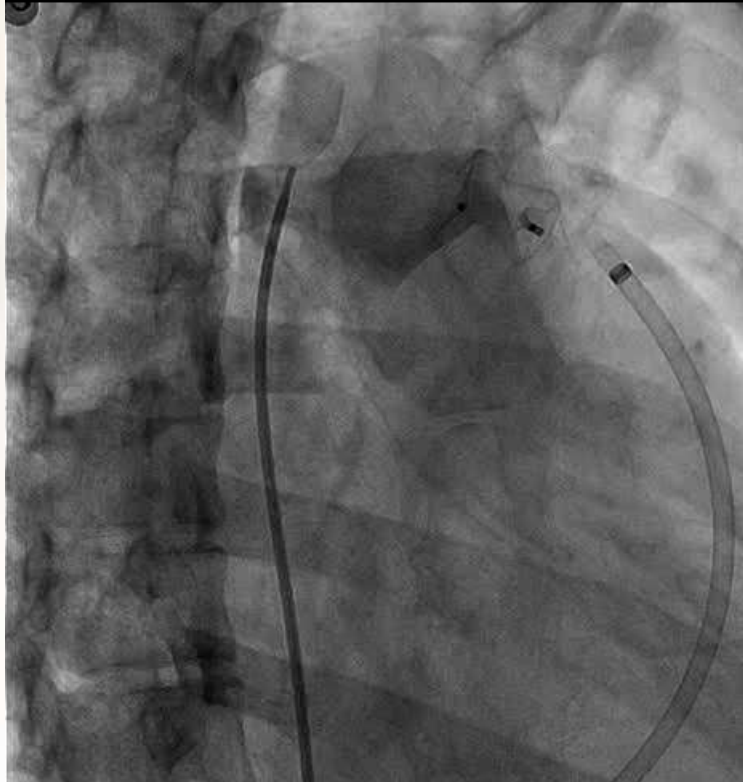
after

PAP	97/56	$\overline{75}$	100/	55	$\overline{78}$
Ao	104/60	$\overline{85}$	127/65		$\overline{88}$



PAH PDA s/p device closure

Lossy compression - not intended for diagnosis



Lossy compression - not intended for diagnosis



Case I recath 16 months after

	pressure (mmHg)	O ₂ Saturation (%)
IVC		81
RA	$\bar{2}$	74
SVC		68
RV	50/6	74
MPA	52/20 ($\bar{38}$)	74
Ao	105/64 ($\bar{83}$)	92
LV	113/7	91

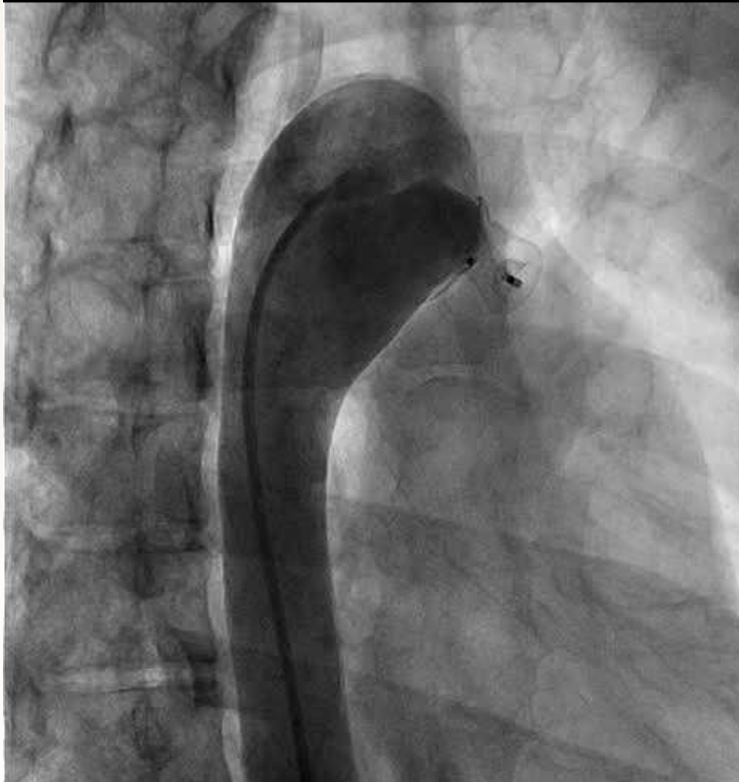
PVR 6.37 w.u

PVRI 9.12 w.u.

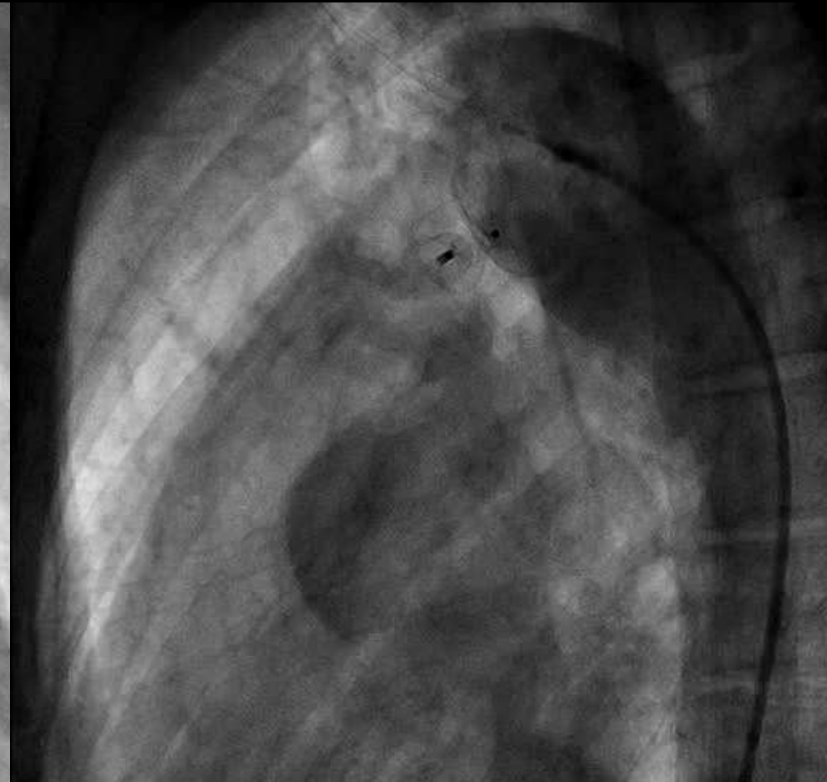


Recath hypertensive PDA

Lossy compression - not intended for diagnosis




Lossy compression - not intended for diagnosis





Follow-up (case I)

- symptoms improved
 - Sildenafil 20 mg tid (irregularly)
 - Echo: TR \bar{V}_{max} 38 mmHg, most recent
- 

Case II

A case of Down syndrome, 7 yr, F

	pressure (mmHg)	O2 Saturation (%)
IVC		50
RA	$\overline{10}$	55
SVC		61
RV	107/15	58
MPA	101/69	78
LPA		75
LV	150/16	89
A-Ao	146/86	90
D-Ao	142/78	87

$Q_p / Q_s \doteq 2.61$ PVR 10.1 w.u

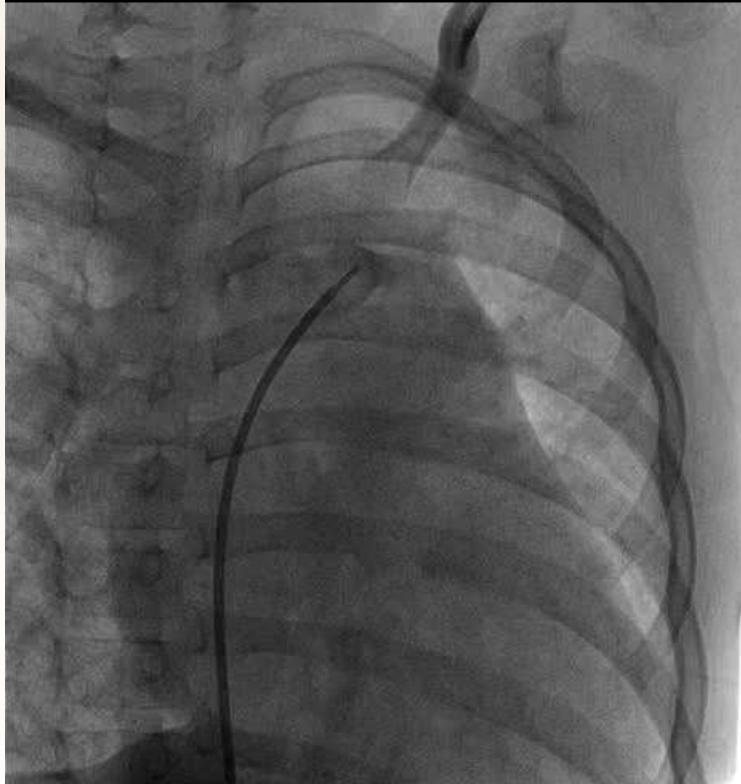
PVRI 6.94 w.u m^2

To close ? or not to close

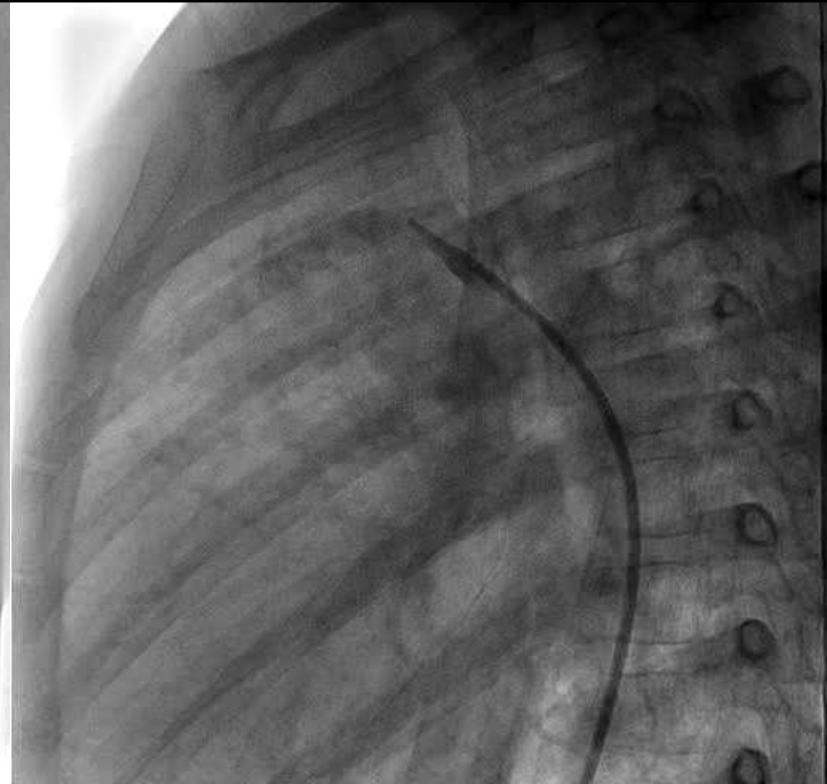


PDA PAH Down syndrome

Lossy compression - not intended for diagnosis



Lossy compression - not intended for diagnosis



Balloon test occlusion

Lossy compression - not intended for diagnosis





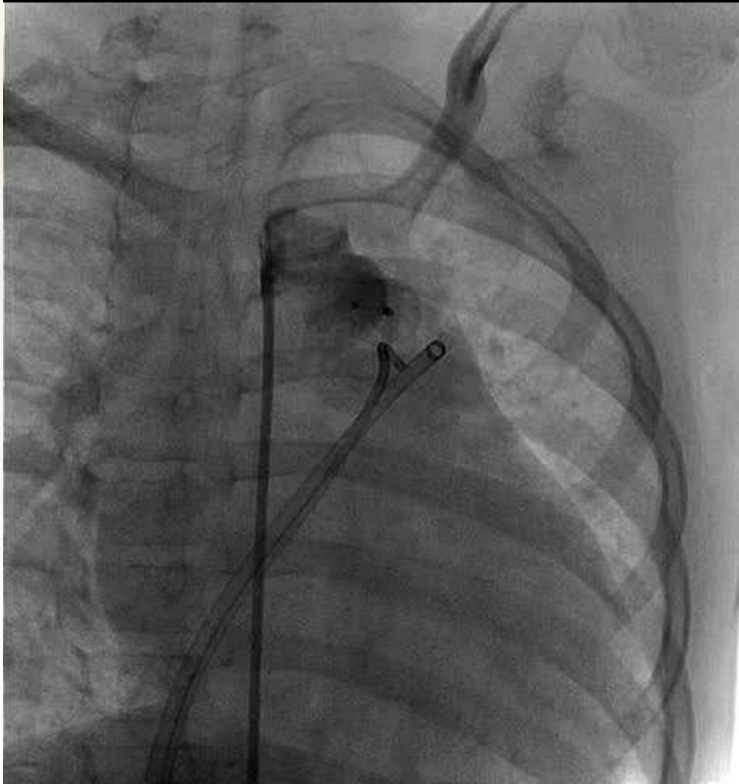
Case II Test occlusion

MPA	46/14	$\overline{29}$
Ao	160/100	$\overline{120}$

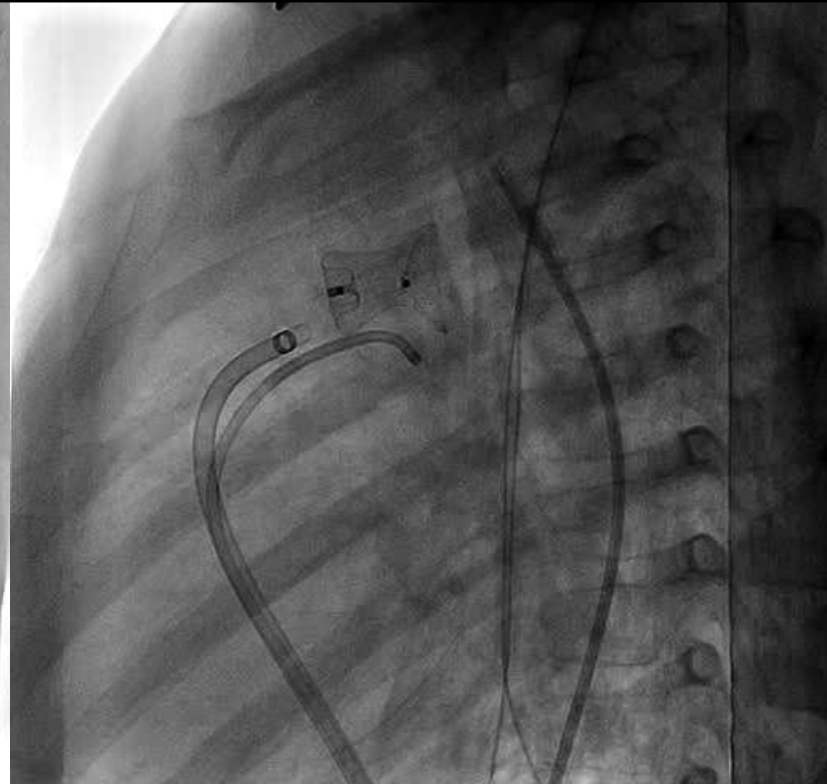


PDA PAH Down syndrome s/p occlusion

Lossy compression - not intended for diagnosis



Lossy compression - not intended for diagnosis






Follow-up (case II)

- Duct diameter 9.2 mm, device ADO 14-16
- improved, less dyspnea
- pro BNP 236 → 129 (normal < 125 pg/ ml)
- Echo: F/u 6 months small residual PDA
TR ΔP 33 mmHg
- No medication



Case III 6.5- yr-old boy

History:

1. PDA found since early childhood, parents refused surgery
 2. cath at NTUH
- 

Case III hemodynamic

	pressure (mmHg)	O ₂ Saturation (%)
SVC		71
RA		64
IVC		69
RV	95/3	61
PA	95/58 (72)	73
Ao	115/62 (88)	95

PVR around 10.5 WU
→ operation ligation , 9mm PDA


Case III recath 2 months after PDA ligation due to residual shunt

	pressure (mmHg)	O ₂ Saturation (%)
IVC		75
SVC		77
RA	$\overline{1}$	71
RV	68/3	70
MPA	65/37 ($\overline{51}$)	70
Ao	126/85 ($\overline{103}$)	95

* coil closure of residual PDA




Case 3 F/U

- Increase in PAsP during F/U.
 - Recath 2 years later showed PAP increased to 102/64 mmHg
 - Sildenafil was used since 6 years ago, but the PAP remains high.
- 




Large PDA with pulmonary hypertension, to close or not to close

- pulmonary hypertension, reversible or irreversible, borderline case?
 - surgery vs. transcatheter treatment
- 



**Is there a clear cutoff point of PVR
valve for “reversibility”
in current practice?**

- **Traditionally, 6-8 wood units m^2**
 - **Assess vasoactivity of pulmonary vascular bed “vasodilation therapy”**
 - **Test occlusion**
- 



Definition of responder to vasodilator or occlusion test balloon

- **Methods of testing vasoreactivity**
 - 100 % O_2
 - balloon occlusion
 - adenosine, NO
- **Parameters used to predict vasoreactivity**
 - PAP ↓ 20 %
 - Q_p/Q_s ↑ 20 %
 - pulmonary wedge angio > 5 monopodial arteries & uniform capillary blush

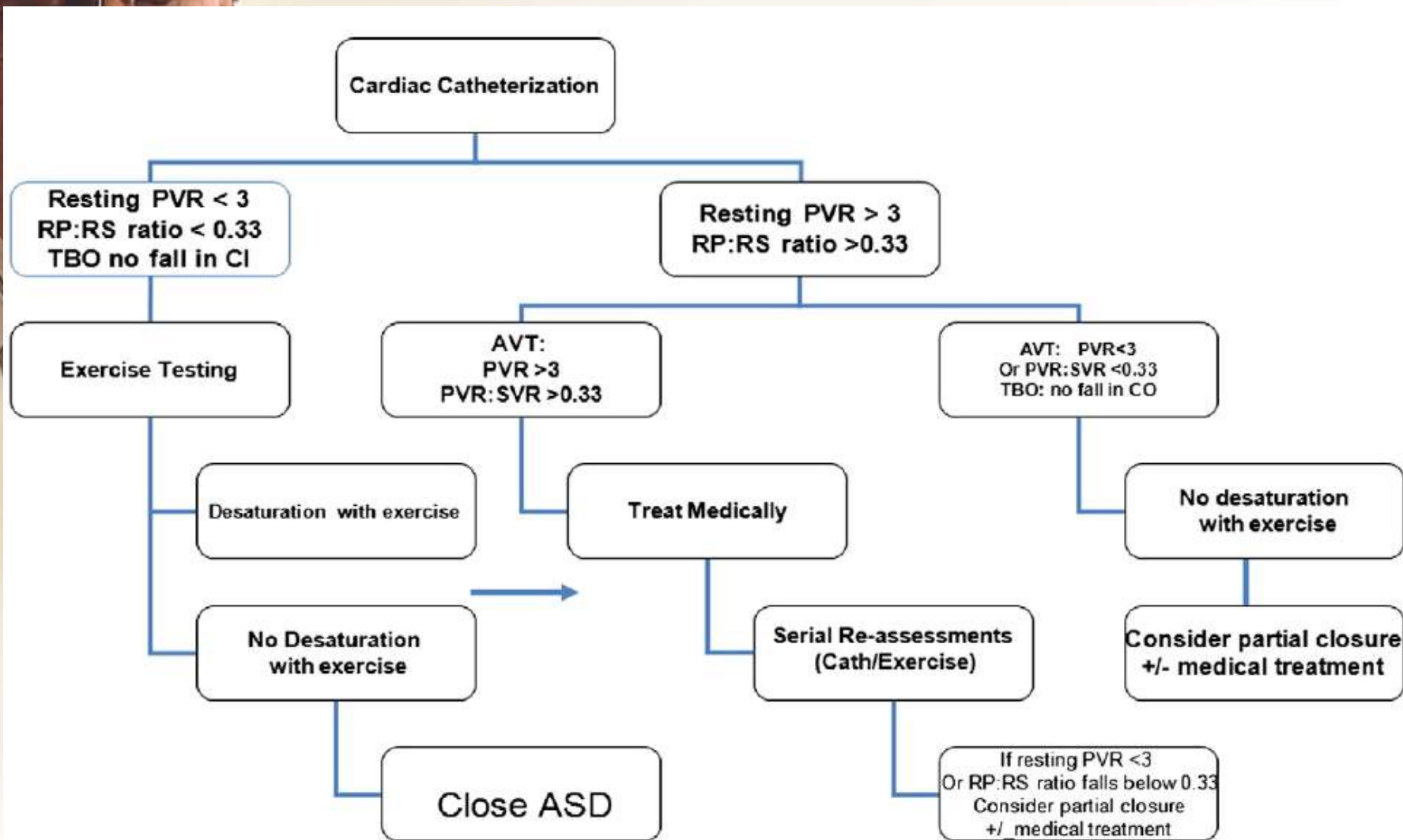


Fig. 1. CHD/PH (ASD) Clinical management algorithm: Individualized case approach.



Closure of a Large Patent *Ductus Arteriosus* in Children and Adults with Pulmonary Hypertension

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Introduction: Surgical closure of a patent *ductus arteriosus* (PDA) in cases with pulmonary hypertension, a short and wide PDA, and/or calcification of the wall of the vessel can be a hazardous procedure. The use of extracorporeal circulation provides the necessary safety for effective closure.

Methods: Four patients (one male), aged 7, 22, 54 and 60 years old, underwent PDA closure. All had pulmonary hypertension (pulmonary artery pressure, PAP 55-85 mmHg, PAP-to-systemic pressure ratio 0.6-0.8) and a wide, short PDA (diameter 9-12 mm) with a calcified wall in 2 cases. The surgical technique involved transpulmonary PDA closure with a synthetic patch under extracorporeal circulation and mild hypothermia (n=2); or double ligation and purse-string suture of the PDA with extracorporeal circulation and normothermia on a beating heart (n=1), or with heart-lung machine on standby (n=1).

Results: Mortality was nil. The postoperative course was mild in all cases. Follow up 3 to 8 years post surgery showed effective PDA closure, PAP within normal (n=3) or at upper normal limits (n=1), and no other sequelae.

Conclusion: The use of extracorporeal circulation allows safe and uncomplicated surgical closure of a PDA in “difficult” cases.



F/U hypertensive PDA after closure

G. Kalavrouziotis et al

Table 1. Patients' preoperative and postoperative data.

No.	Sex	Age (years)	PAP before (mmHg)	Pp/Ps	PDA diameter (mm)	Qp/Qs	NYHA class before	Follow up (years)	PAP after (mmHg)	NYHA class after
1	♀	22	70	0.6	9	2.1	II	8	30	I
2	♀	54	75	0.7	10	1.8	II-III	7	35	I
3	♀	60	85	0.8	12	1.5	III	5	40	II
4	♂	7	55	0.7	10	2.8	III	3	30	I

NYHA – New York Heart Association; PAP – pulmonary artery systolic pressure; PDA – patent ductus arteriosus; Pp/Ps – pulmonary-to-systemic pressure ratio; Qp/Qs – pulmonary-to-systemic flow ratio.





CONGENITAL HEART DISEASE

Transcatheter closure of patent ductus arteriosus with severe pulmonary arterial hypertension in adults


C Yan, S Zhao, S Jiang, Z Xu, L Huang, H Zheng, J Ling, C Wang, W Wu, H Hu, G Zhang, Z Ye, H Wang

Heart 2007;**93**:514–518. doi: 10.1136/hrt.2006.091215





1. Success n= 20
2. 9 failed (increase in PA n= 5)
3. PASP 104.9 ± 27.4 mmHg
→ trial occlusion → closure
→ 56.3 ± 18.3 mmHg
4. Occluder diameter 15.6 ± 3.2 mm



Man-li Yu · Xin-miao Huang · Jia-feng Wang
Yong-wen Qin · Xian-xian Zhao · Xing Zheng

Safety and efficacy of transcatheter closure of large patent ductus arteriosus in adults with a self-expandable occluder

Abstract Most occurrences of large patent ductus arteriosus (PDAs) of ≥ 10 mm have been surgically closed, and transcatheter closure of these large PDAs was only reported in a few case reports. The present study reviewed our experience in transcatheter closure of such large PDAs with a Chinese self-expandable occluder, which is similar to but much cheaper than the Amplatzer occluder. From July 2000 to January 2008, 23 patients underwent transcatheter closure of large PDA ≥ 10 mm with this kind of occluder. The mean (SD) age of the patients was 38.0 (15.6) years (range 18–75 years). Radiographs of the chest, electrocardiograms, and echocardiograms were used for follow-up evaluation of the treatment within 1 day, 1 month, 6 months, and then every year after successful closure. The mean (SD) angiographic PDA diameter was 12.8 (2.6) mm (range 10–18 mm) and the mean occluder diameter was 18.0 (2.9) mm (range 16–22 mm). The occluders were delivered successfully and closed the PDA completely in 19 out of the 23 patients. Pulmonary arterial pressures decreased significantly after occlusion in patients with successful treatment: 67.3 (24.7) mmHg (range 29–122 mmHg) before occlusion and 42.3 (22.0) mmHg (range 19–98 mmHg) immediately after the procedure. Radiographs of the chest and echocardiograms showed that the diameters of the left atrium, left ventricle, and the main pulmonary artery decreased, and the ejection fraction (EF) increased at a mean (SD) follow-up of 36.3 (18.7) months (range 6–72 months). No severe complication occurred. The immediate and long-term outcomes suggested that transcatheter closure of PDAs with the native PDA occluder is a safe and effective treatment for adults with large PDA ≥ 10 mm.



1. n= 19 (38-75 yrs)

2. Q_p/Q_s 2.3 ± 1.1

3. mean vascular resistance

9.3 ± 5.4 wu \rightarrow 6.7 ± 4.5 wu after O_2

4. mean functional class

$2.4 \pm 0.9 \rightarrow 1.7 \pm 0.5$

5. mean PAP

$93.8 \pm 35 \rightarrow 61 \pm 30.9$ mmHg

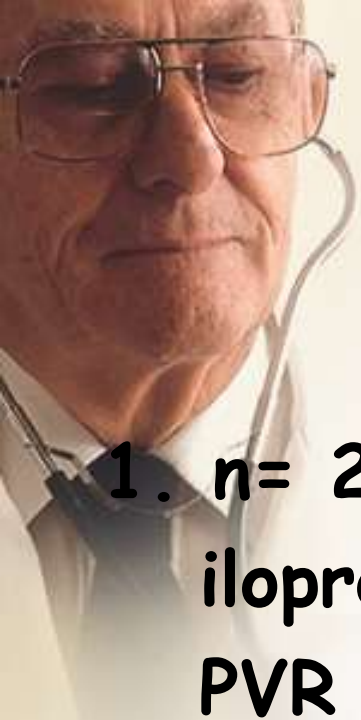


Follow-up of hypertensive PDA after closure

1. PASP 42.5 ± 13.3 mmHg
(from 63.5 ± 16.2 mmHg)
2. Further ↓ of PASP to 30.1 ± 7.7 mmHg
3. Sildenafil n=5


Zabal et al. Heart 2010;96:625-9





1. n= 29, PASP 68-149 mmHg adults
iloprost inhalation,
PVR $6.9 \pm 2 \rightarrow 5.1 \pm 1.6$ wood unit, closure
2. n= 9, received advanced PAH therapy
after closure
3. tadalafil, bosentan, Sildenafil

Zhang et al. Chin Med J 2012;125:3844-50



Treatment of Severe Pulmonary Hypertension in the Setting of the Large Patent Ductus Arteriosus

AUTHORS: Mary C. Niu, MD,^a George B. Mallory, MD,^b Henri Justino, MD,^a Fadel E. Ruiz, MD,^b and Christopher J. Petit, MD^a

abstract

● N=7, Median PVRI 11.7 u m2, closure in 6



Niu et al. Pediatrics

TABLE 3 Follow-up Data

Patient No.	Age at Last Follow-up	Time Since PDA Closure	Interval Events and Findings	PH Medications at Follow-up	Clinical Status
1	36 mo	35 mo	Successfully weaned from PPV and decannulated Weaned off sildenafil once RV pressures normalized by echocardiography	None	Doing well; no O ₂ requirement
2	38 mo	25 mo	Subsequently underwent elective tracheostomy to continue PPV; weaned from ventilator support	Sildenafil	Doing well; no O ₂ requirement
3	6.5 y	32 mo	Successfully weaned from PPV and decannulated; successful complete CAVC repair 1 y s/p PDA occlusion	Sildenafil, aspirin	Doing well; new-onset autoimmune disease; no O ₂ requirement
4	8.6 y	46 mo	Repeat catheterization 8.5 mo after PDA occlusion secondary to exertional chest pain -PA pressures near systemic at baseline; PVR: 14 U · m ² -Suprasystemic PA pressures and ST segment depression in inferior leads with isoproterenol challenge -No pulmonary vasoreactivity with vasodilatory testing 6-min-walk test: 562 yards; Sao ₂ 91%–94%.	Sildenafil Bosentan Treprostinil (inhaled) Aspirin Budesonide (inhaled)	Mild exercise intolerance; exertional chest pain; no O ₂ requirement
5	5.1 y	19 mo	Near normalization of RV and LV systolic function by echocardiography; improvement in LV ejection fraction from 25% to 57%; sildenafil discontinued	Enalapril Carvedilol Amiodorone	Doing well with minimal exercise restriction; no O ₂ requirement
6	18.7 y	N/A	6-min-walk test: 642 yards; Sao ₂ 94%–98%. Persistent systemic RV pressures estimated by echocardiography	Tadalafil Ambrisentan Warfarin	No exercise intolerance; nonadherent to inhaled treprostinil; transitioned to adult care; no O ₂ requirement
7	1.6 y	0.3 y	Remains on sildenafil; off O ₂ therapy	Sildenafil	Doing well

CAVC, complete atrioventricular canal; LV, left ventricular; N/A, not applicable; PPV, positive pressure ventilation; Sao₂, arterial oxygen saturation; s/p, status post.



Percutaneous closure of hypertensive ductus arteriosus

Carlos Zabal, José Antonio García-Montes, Alfonso Buendía-Hernández, Juan Calderón-Colmenero, Emilia Patiño-Bahena, Antonio Juanico-Enriquez, Fause Attie





ABSTRACT

Background The Amplatzer duct occluder (ADO) has been used with success to close large patent ductus arteriosus (PDA), but some problems exist especially with hypertensive PDAs, such as incomplete closure, haemolysis, left pulmonary artery stenosis, obstruction of the descending aorta and progressive pulmonary vascular disease.

Methods and results We analysed a group of 168 patients with isolated PDA and pulmonary artery systolic pressure (PSAP) ≥ 50 mm Hg. Mean age was 10.3 ± 14.3 years (median 3.9), PDA diameter was 6.4 ± 2.9 mm (median 5.9), PASP was 63.5 ± 16.2 mm Hg (median 60), Qp/Qs was 2.7 ± 1.2 (median 2.5), total pulmonary resistance index (PRI) was 3.69 ± 2.15 (median 3.35) and vascular PRI was 2.73 ± 1.72 (median 2.37). We used ADOs in 145 (86.3%) cases, Amplatzer muscular ventricular septal defect occluders (AMVSDO) in 18 (10.7%), Amplatzer septal occluders (ASO) in three (1.8%) and the Gianturco-Grifka device in two (1.2%) cases. Device diameter was $106.3\% \pm 51\%$ higher than PDA diameter. PASP decreased after occlusion to 42.5 ± 13.3 mm Hg ($p < 0.00001$). Immediately after closure, no or trivial shunt was present in 123 (74.5%) cases. Immediate complications were device embolisation in five (3%) cases and descending aortic obstruction in one case. The overall success rate was 98.2%. Follow-up in 145 (86.3%) cases for 37.1 ± 24 months (median 34.1) showed further decrease of the PASP to 30.1 ± 7.7 mm Hg ($p < 0.0001$).

Conclusions Percutaneous treatment of hypertensive PDA is safe and effective. ADO works well for most cases, but sometimes other devices (MVSDO or ASO) have to be used. When cases are selected adequately, pulmonary pressures decrease immediately and continue to fall with time.



Transcatheter closure of large patent ductus arteriosus with severe pulmonary arterial hypertension: Short and intermediate term results


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- Results** : Of 76 patients, nine were found to have PDA with Eisenmenger's syndrome. Of remaining 67, two were thought to have irreversible PHT based on hemodynamic data obtained after balloon occlusion of the duct. Sixty five patients, who eventually underwent TCC of PDA, had a median age of 9.1 years (range 1 month to 40 years). The weight ranged between 2.5 to 62 kg (median 14 kg). The PDA size was 9.1 ± 4.6 mm. The mean systolic pulmonary artery pressure was 66.9 ± 15.3 mm Hg. Duct occluder was used in 63 and muscular ventricular septal defect closure device in 2. The follow up was available in 56 (86%) with a mean follow up period of 65 ± 34 months. All the patients had complete closure of the PDA at 6 months follow up. Mild obstruction of left pulmonary artery ($n=3$) and aortic isthmus flow ($n=6$) was noted at the time of discharge. During the follow up, partial or complete resolution of PHT was observed in all the patients in whom Doppler-derived right ventricular systolic pressure was recorded (available in 40 of 56 patients).
- Conclusions** : TCC of large PDA with severe PHT and significant left to right shunt was found to be effective and safe in the short and intermediate term.



Devices used for large ductus closure

- ADO_I
 - ADO_{II} (premature, neonates, infants)
 - muscular VSD occluder
 - ASD occluder (not an ideal device)
 - Grifka bag
 - coils (Gianturco, pfm)
- 




Size selection for using ADOI or muscular VSD device

- ADOI: for infants add 2 mm, children add 2-3 mm, adult add 4-6 mm or more
- mVSD device : adolescents, adults, 4-6 mm



Possible complications

- Embolization
 - Pulmonary hypertension crisis ?
 - LPA stenosis, acquired CoA (infants)
 - others
- 



**Will pulmonary artery pressure
universally decrease in patients with
PAH after shunt closure?**

PVRI > 6 W.U.m²

D'Alto M.

Int J Cardiol 2013;168:3797-3801



Long term follow-up in PDA & PAH patients after closure

- in infants & young children (< 2 yrs):
excellent results with rare exceptions
- adolescents & adults:
advanced therapy may be required in
a certain percentage of patients



Conclusions

- large & hypertensive PDA can be closed using transcatheter techniques in majority of patients
- test occlusion or vasoactivity evaluation of pulmonary vascular bed should be performed in patients with severe PAH (PAP > 90% systemic)
- Long term results are generally good.
Some may need advanced vasodilator therapy



See you all in Taipei



PICS-AICS AP

Pediatric and Adult Interventional Cardiac Symposium, Asia-Pacific

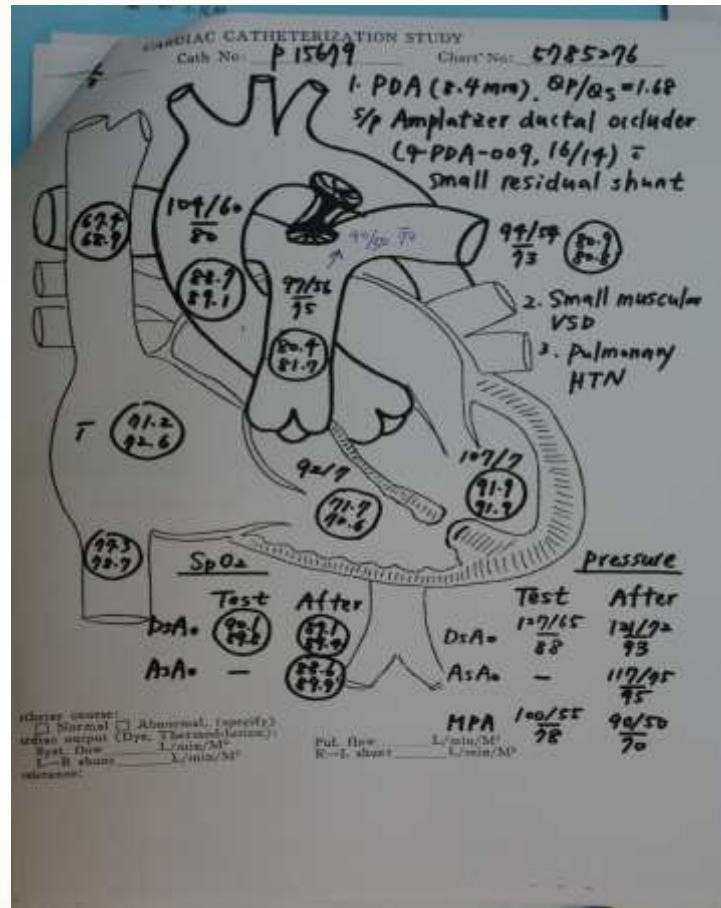
TAIPEI

April 1-4, 2015

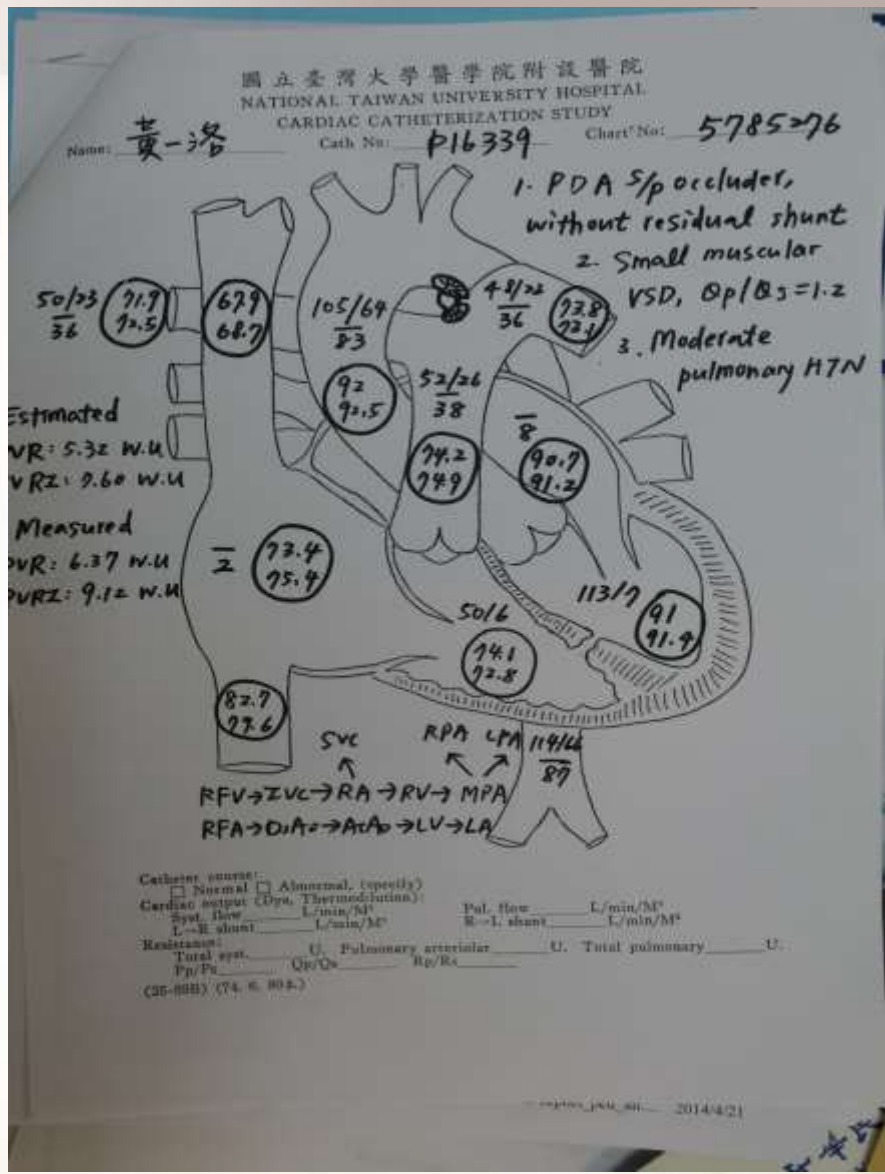




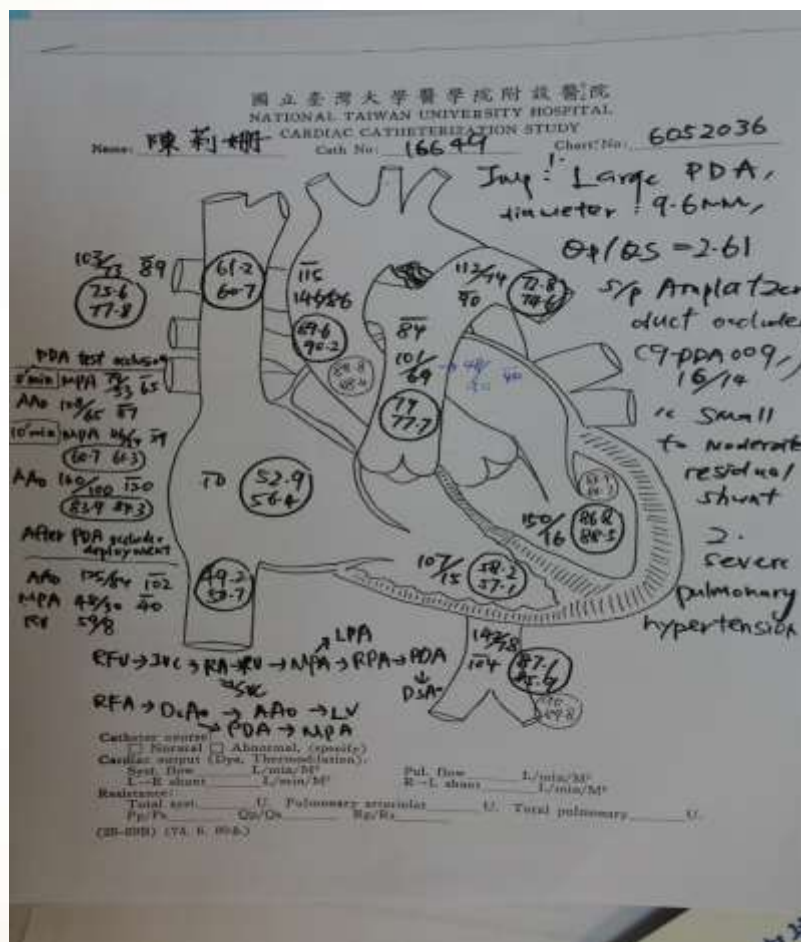
Case I 34-year-old F



Re-cath 16 months later

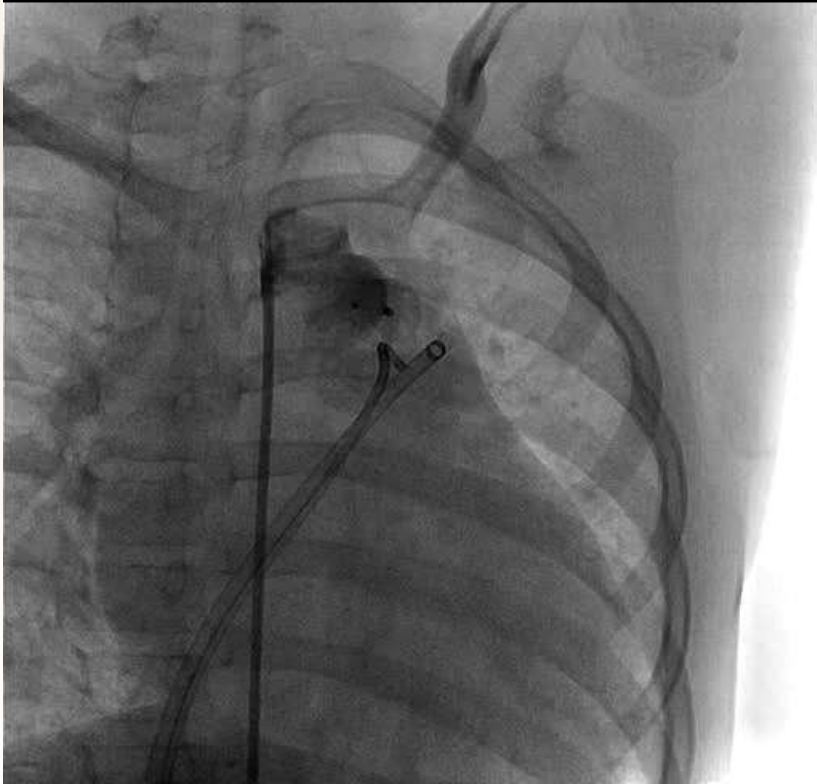


7-year-old F down syndrome





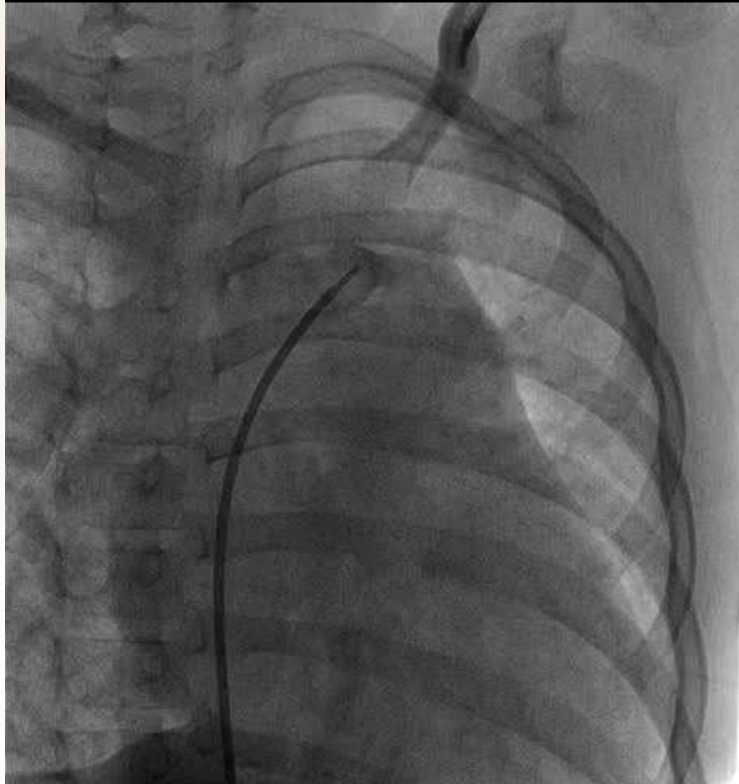
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PDA PAH Down syndrome

Lossy compression - not intended for diagnosis



Lossy compression - not intended for diagnosis

