

Stenting in coarctation of the aorta- Shall all adolescent & adults receive covered stent?

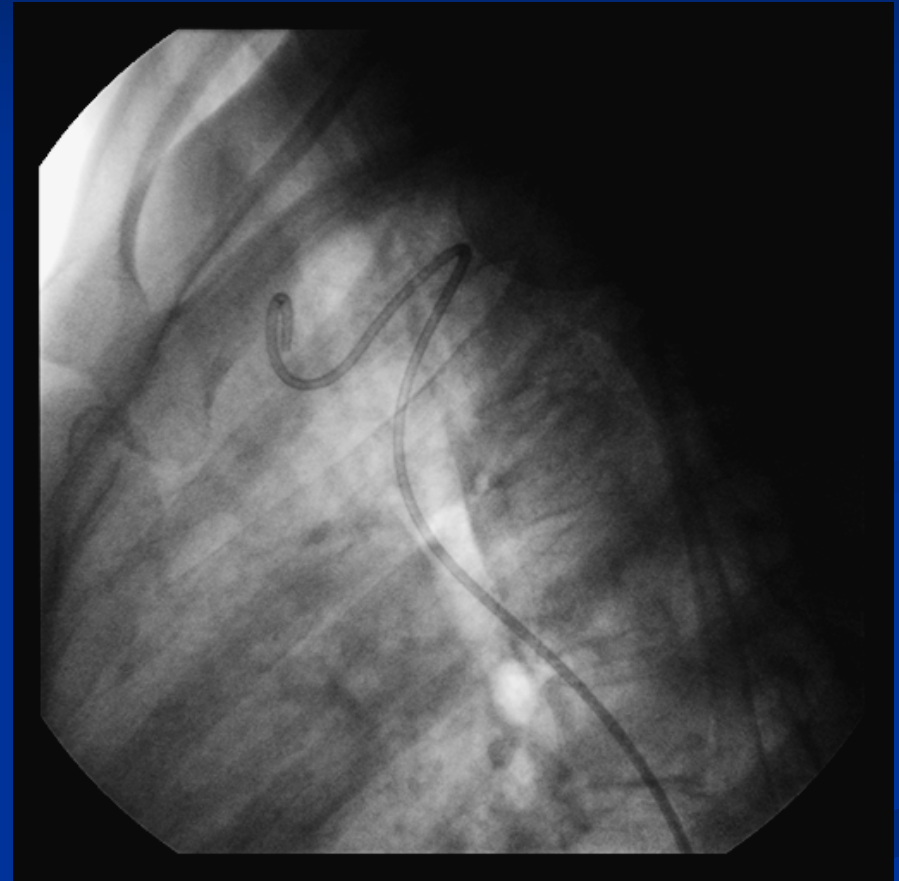
Prof. Masood Sadiq

The Children's Hospital / Institute of Child Health &
Punjab Institute of Cardiology, **Lahore**

PAKISTAN.

Aortic coarctation in adults

- Coarctation anatomy is complex
- Not all native coarctations are localised discrete stenosis
- Many have tortuous aorta
- Unknown incidence of cystic medial necrosis – especially in adults



Coarctation of the aorta in adolescents and adults

Options of treatment

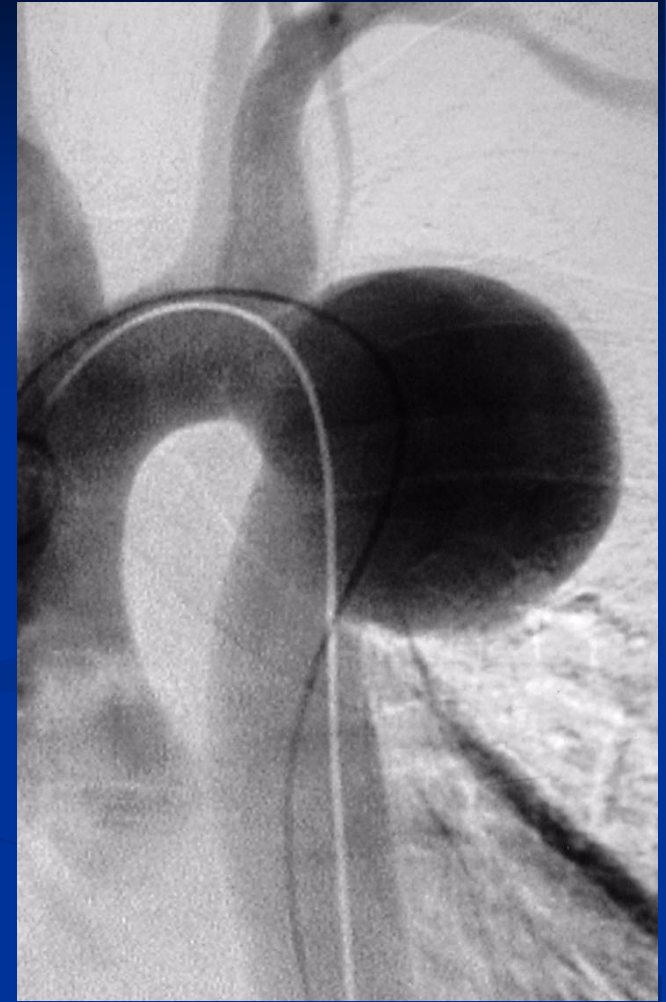
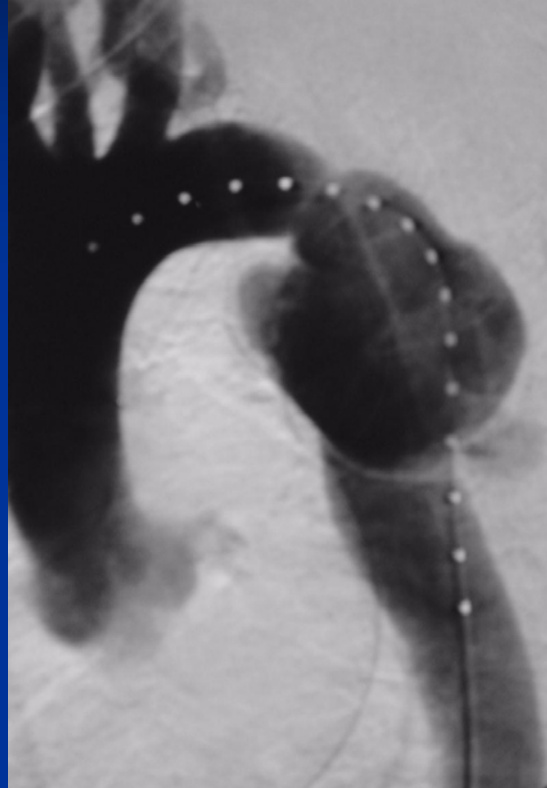
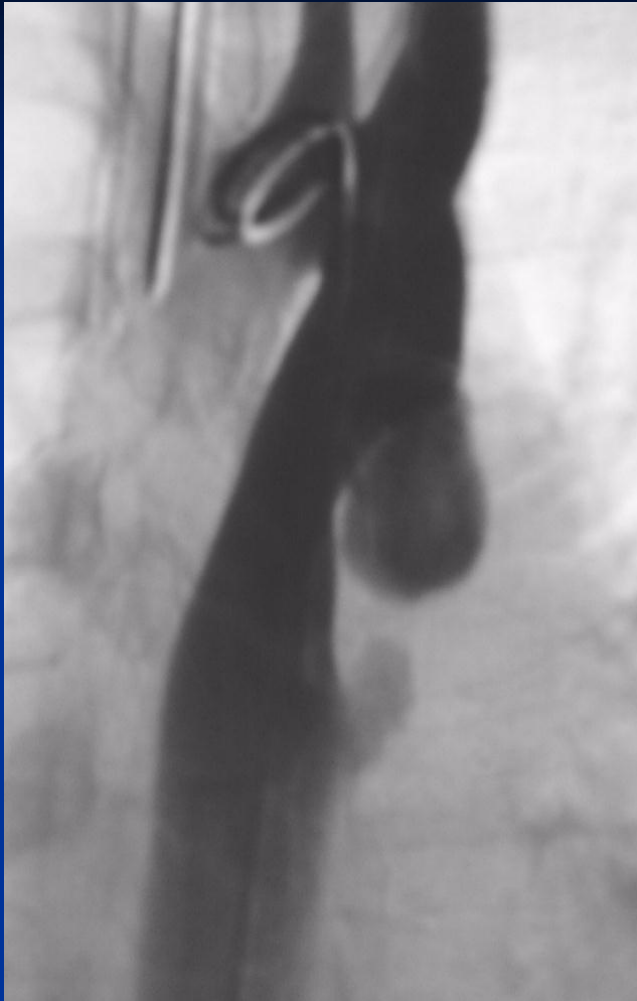
- Surgery
- Balloon Angioplasty
- Stent Implantation

Surgery in adolescents and adults

- Death
- Paraplegia is higher than simple CoA -1%
- Recurrent or residual coarctation – 4-10%
- Late aneurysm – 10-20%

- Young age at operation favourably influenced the outcome

Cohen M et al. Circulation 1989;80:840-5



Aneurysms after surgery for coarctation

Courtesy: Dr Shakil Qureshi-Guys London

Balloon angioplasty in adults

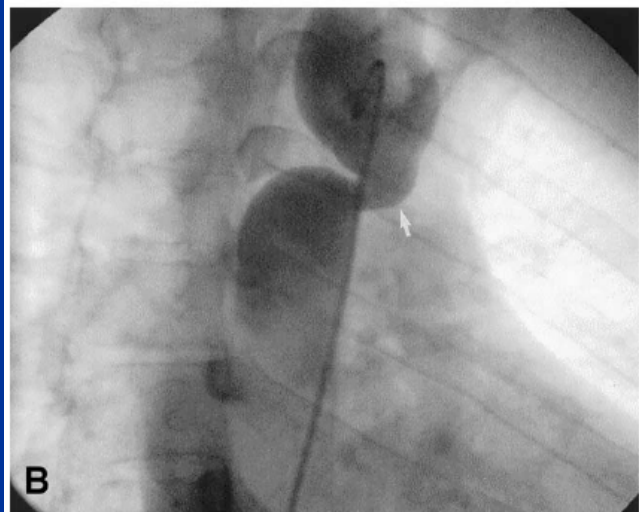
Adolescents and adults are different

- Intrinsic aortic wall abnormalities in adults
- Aneurysm formation - 7-13%
- Persistent residual or recurrent coarctation
- Aortic rupture / dissection
- Persistent Hypertension

Fawzy ME, Sivanandam, Galal O, et al. J Am Coll Cardiol 1997;30:1542-6.

Balloon angioplasty - adults

Fawzy et al. JACC 2004



Some patients not suitable for ballooning

Figure 1. (A) Aortogram in left anterior oblique view showing apparently discrete coarctation (arrow). (B) Aortogram of the same patient in posterior anterior view showing long tortuous coarctation (arrow) not suitable for balloon angioplasty.

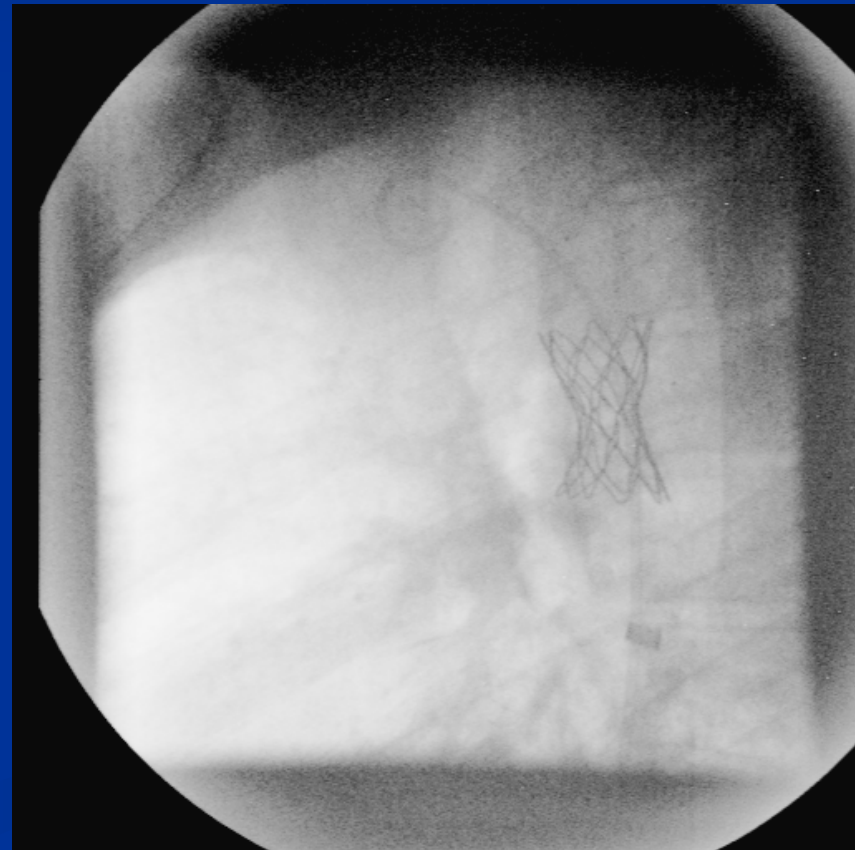
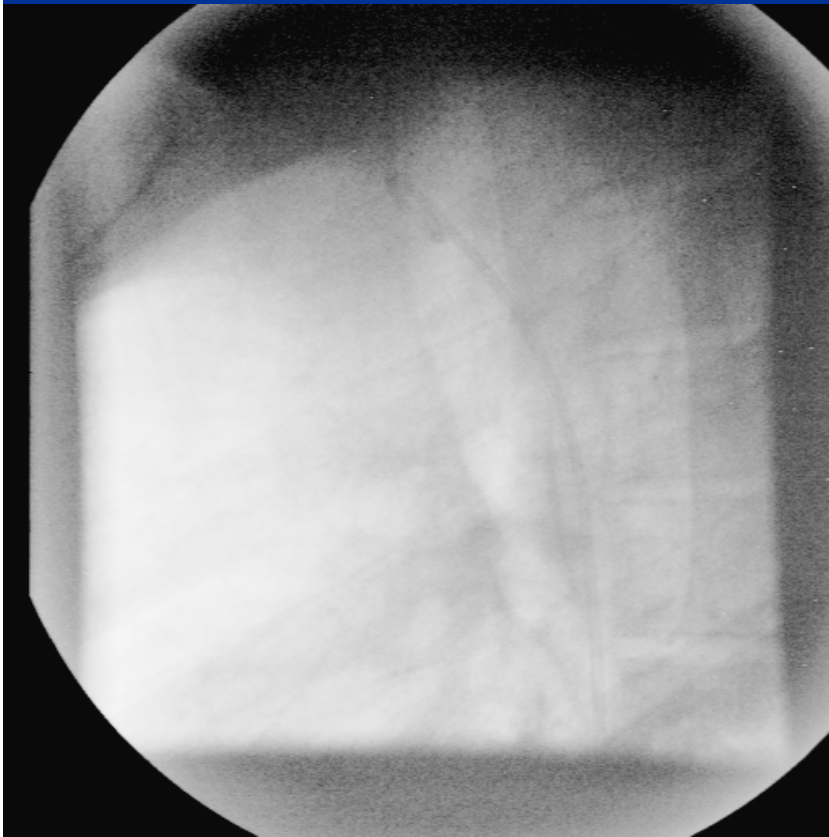
Stents in Coarctation of the aorta

- Stenting in native coarctation of the aorta
 - Prevents elastic recoil
 - Can address long segment lesions
 - Reduces risks like rupture, dissection, aneurysms
 - Results are comparable with surgery

Much higher patient acceptability

Stenting in aortic coarctation

Adult coarctation treated with bare metal CP stent



Complications of stenting native and recurrent coarctation of the aorta: CCSI data

- **Successful outcome 580/588 (98.6%) procedures**
- **Total complications (major and minor): 84 (69/588 pts)-11.7%**
- **Peripheral vascular complications** in 22 procedures
 - Cerebral vascular accident 6/588

Positive association between CVA and old age

Complications of stenting native and recurrent coarctation

Technical complications

- Stent migration 28 (4.8%)
- Stent fracture 6 (1.0%)
- Balloon rupture 13 (2.2%)
- Overlap of brachiocephalic vessels? 61 pts

Complications of stenting native and recurrent coarctation: CCSI data

Aortic wall complications

■ Aneurysms	5 (<1%)
■ Intimal tears	8 (1.3%)
■ Dissections	9 (1.5%)
■ Aortic rupture	0

Aortic Dissection

- Risk of dissections 1-2%
 - *Age above 20 years*
 - location in abdominal aorta
 - Pre-stenting angioplasty
 - Bare CP stent

Aortic Rupture

A rare (4 reported cases) but catastrophic complication

- *Advanced patient age*
- Presence of calcification
- Vessel tortuosity
- Pre-dilatation without stent placement
- Attempting to dilate more than 3 times the size of coarctation
- Subsequent balloon dilatation to flare the stent to ensure apposition

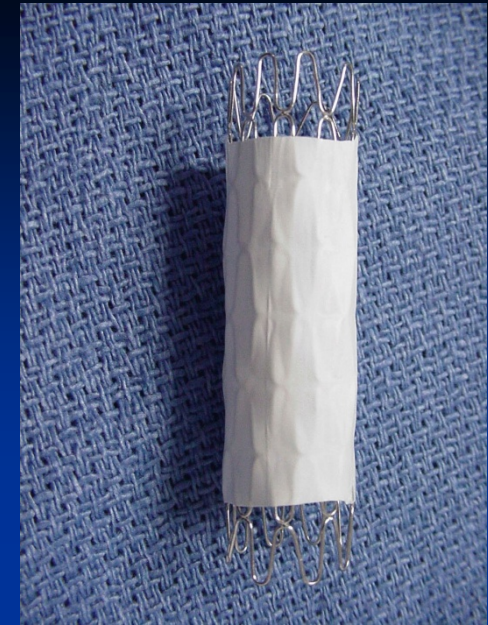
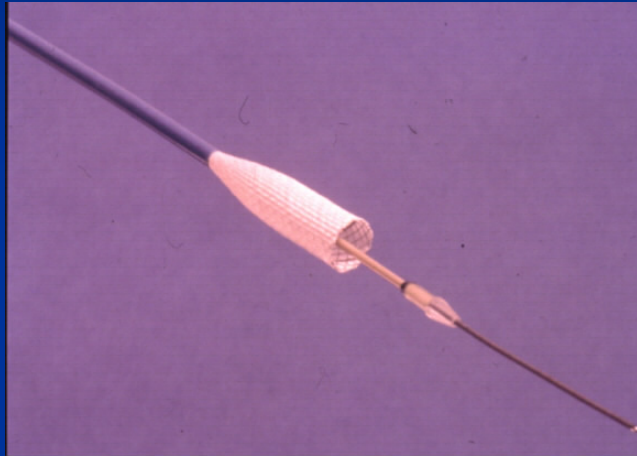
Why covered stent

- Aortic wall dissection
- Aneurysms
- stent fractures
- aortic rupture

Hence the need for covered stent

- Important bail out following any complications

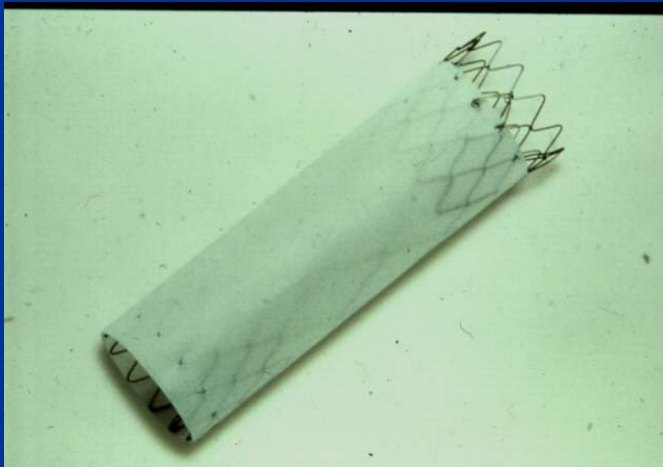
Covered Stents



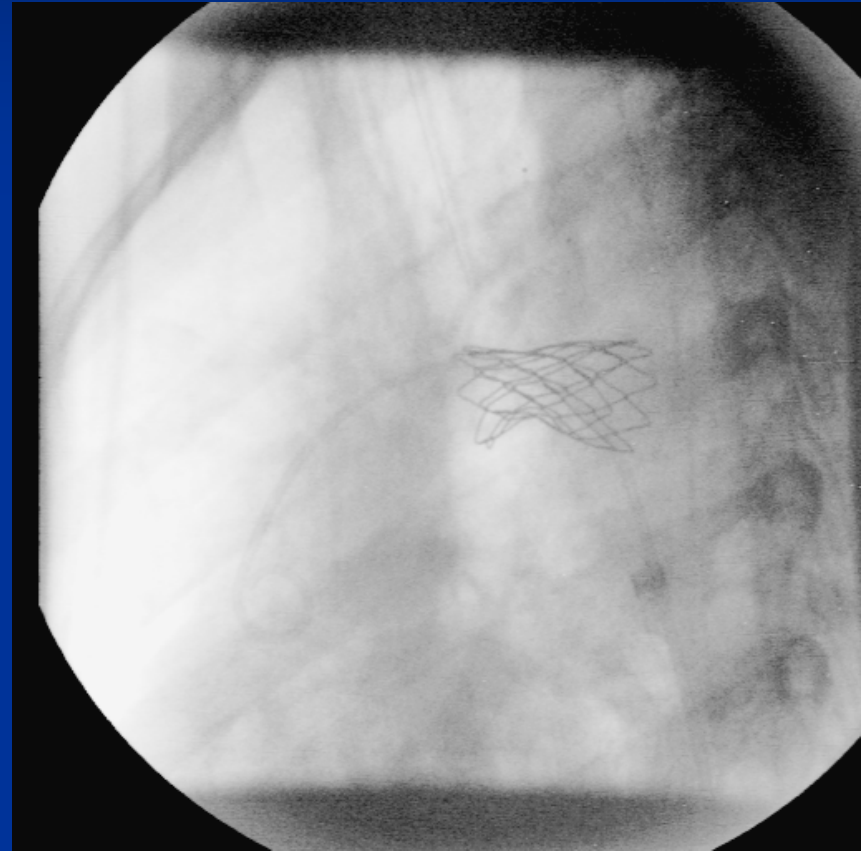
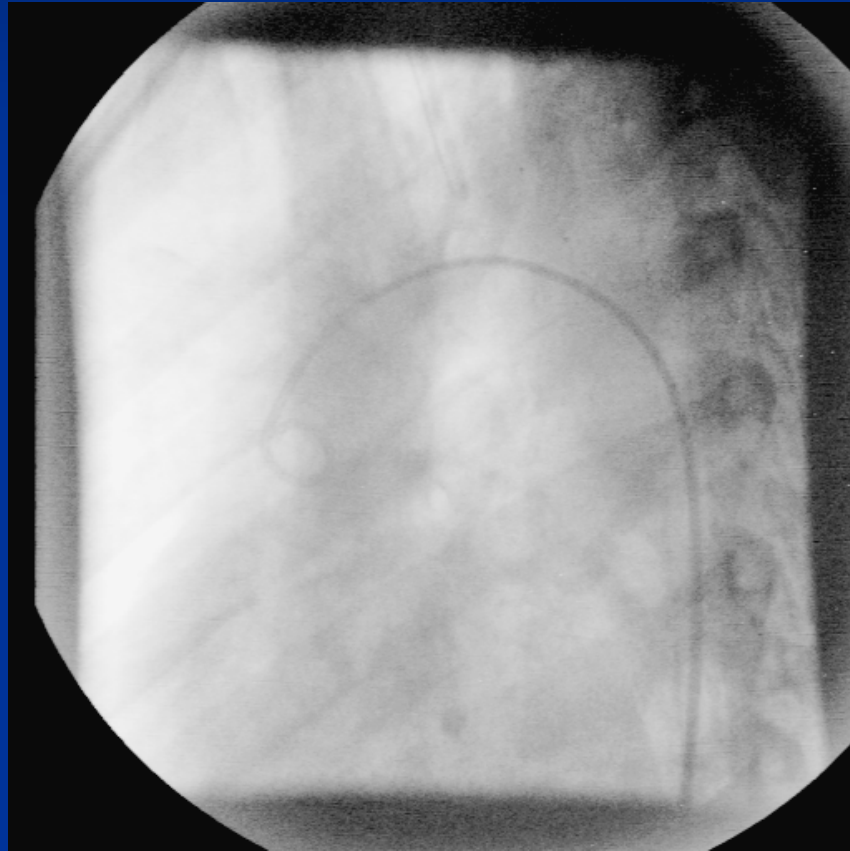
Available stents
Gore & Cook stent
grafts

Jomed

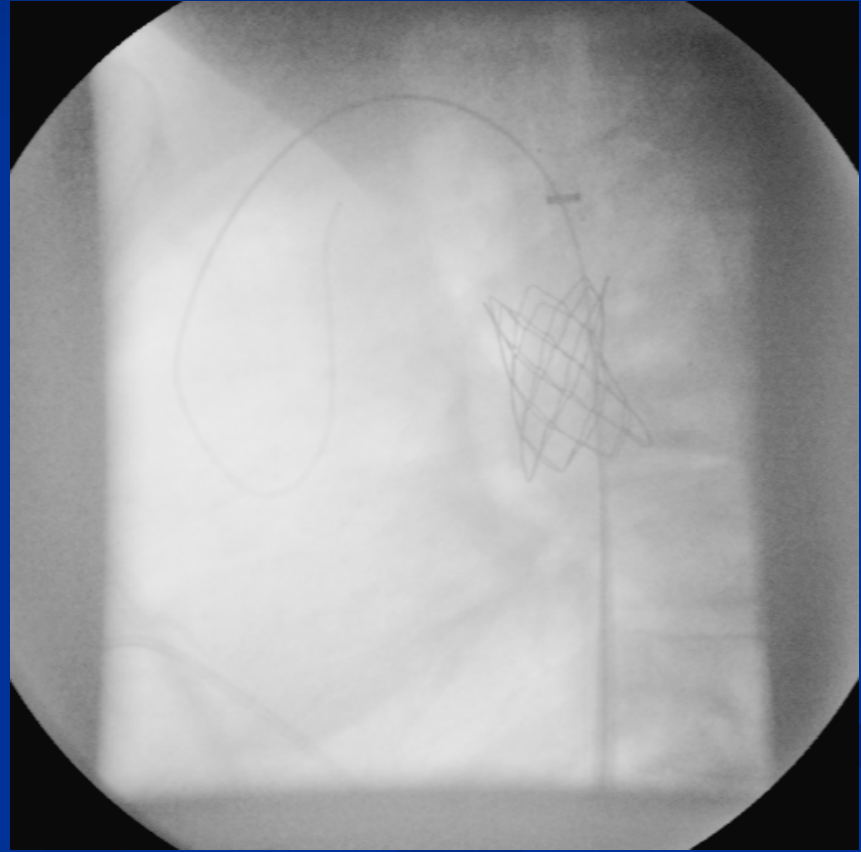
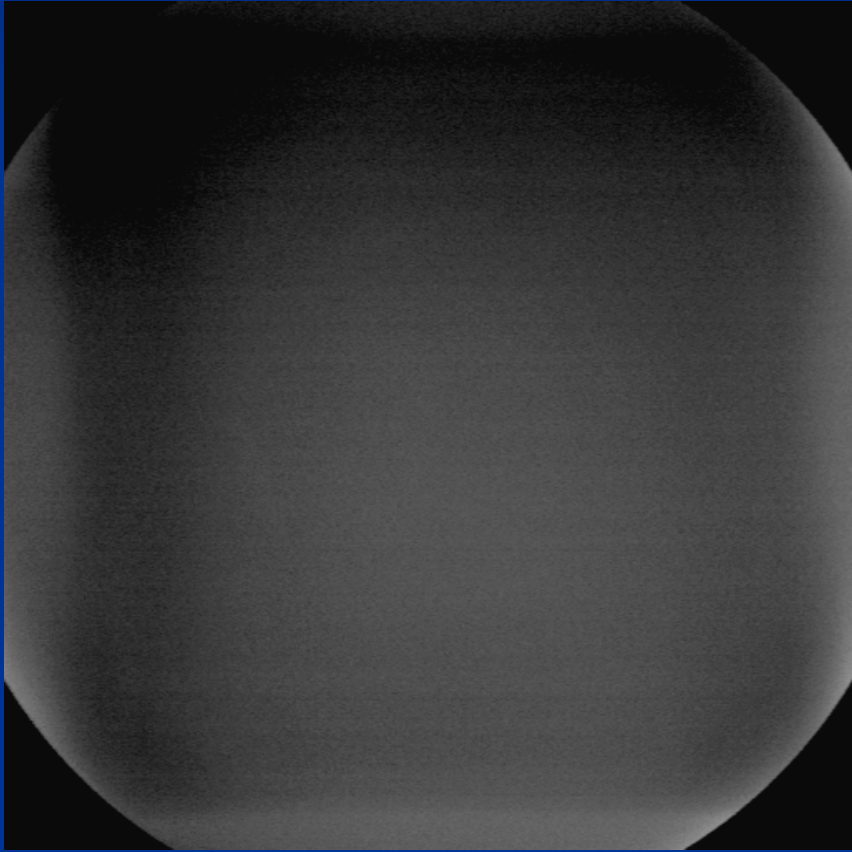
Numed
(covered
Cheatham-
Platinum)
V12 Atrium –
recently
available



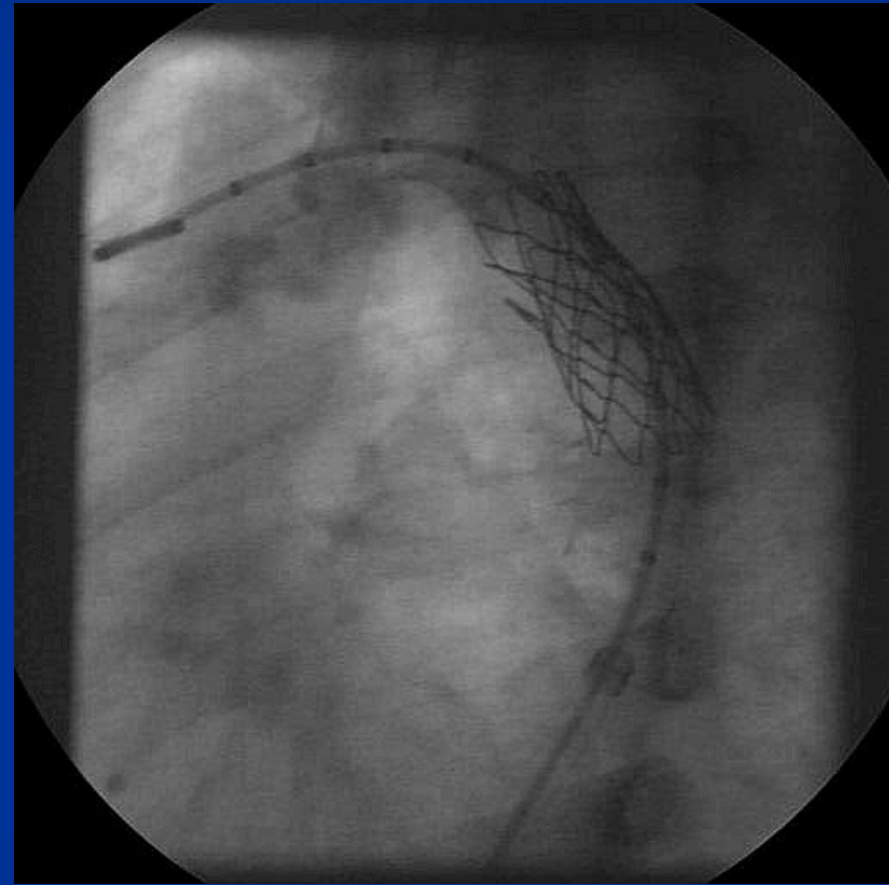
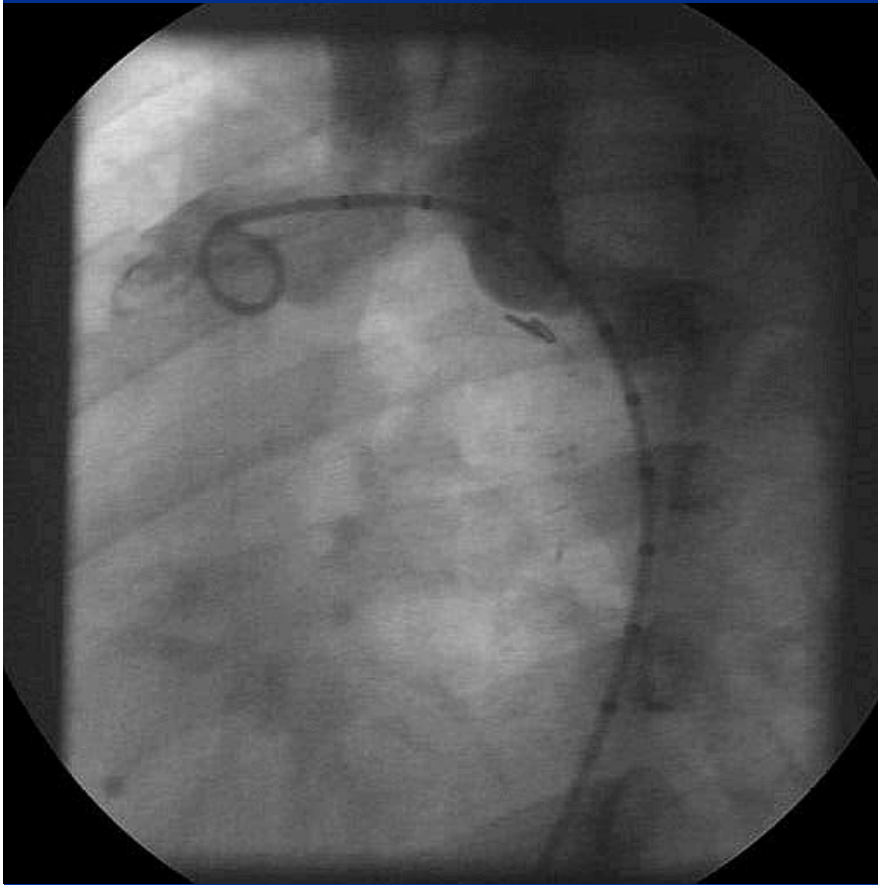
Transverse arch coarctation



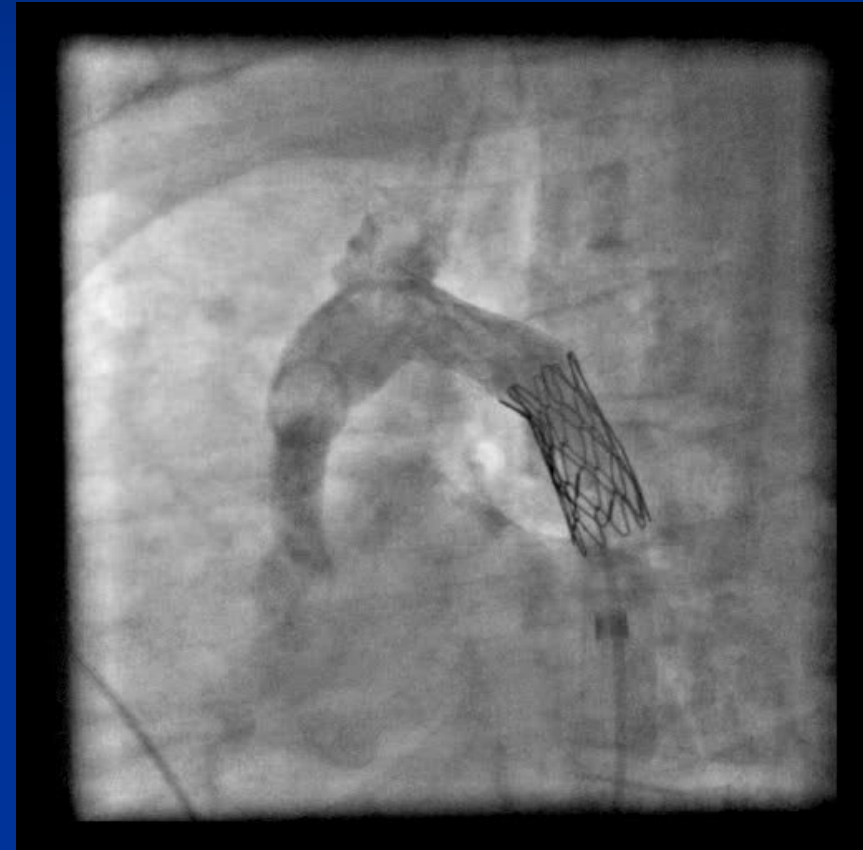
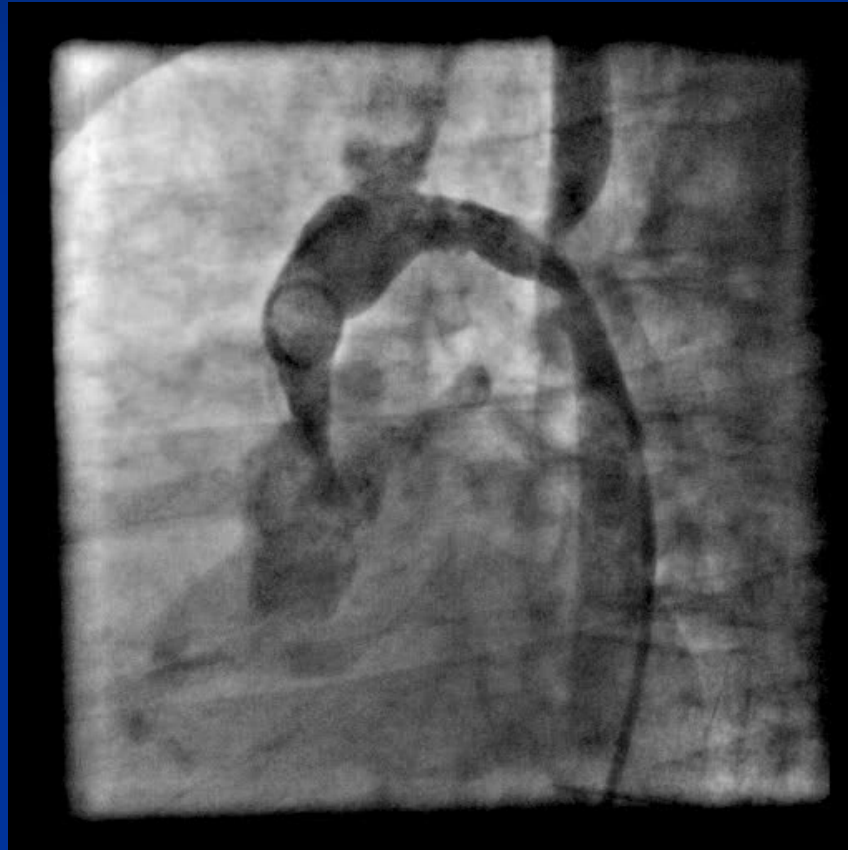
Coarctation with PDA



Complex aortic recoarctation – treated with covered CP stent

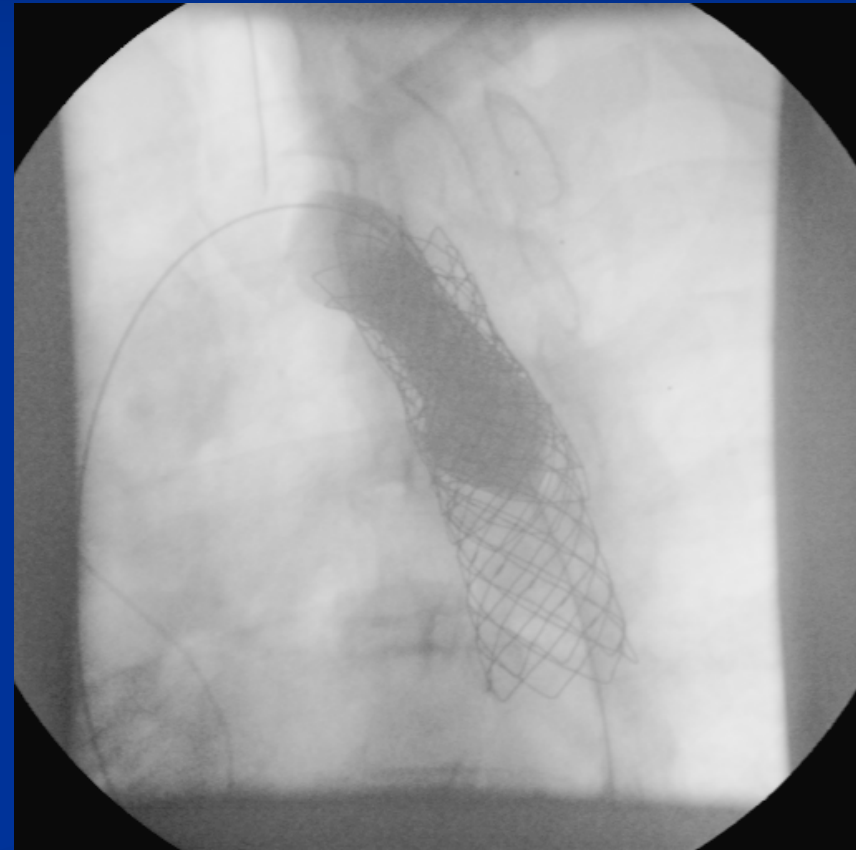
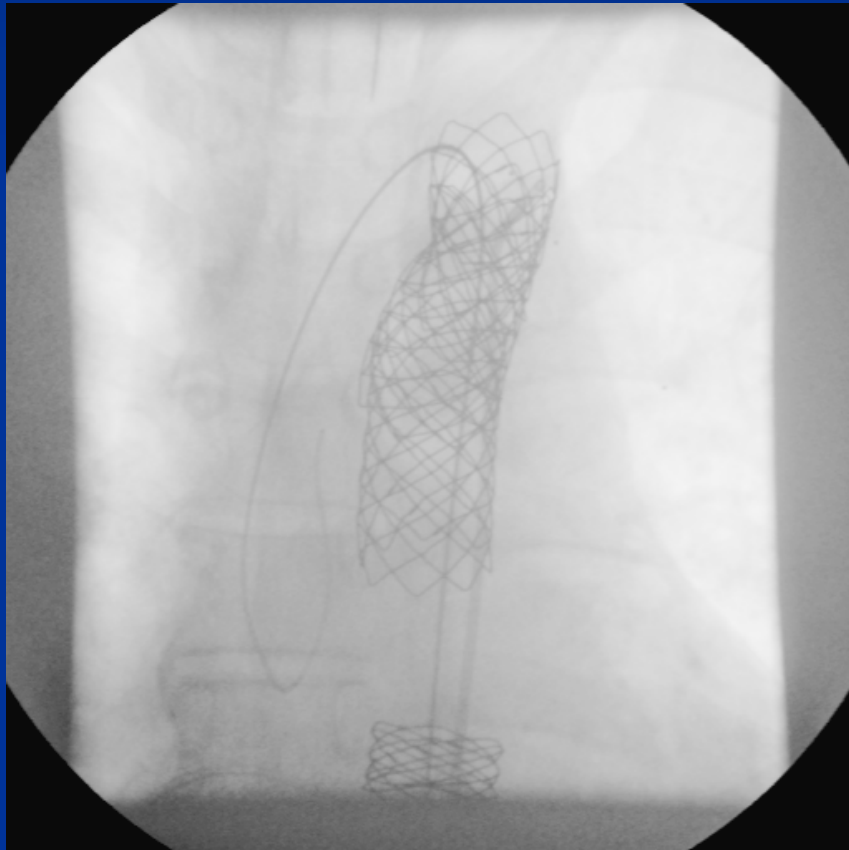


Complex coarctation with transverse arch hypoplasia

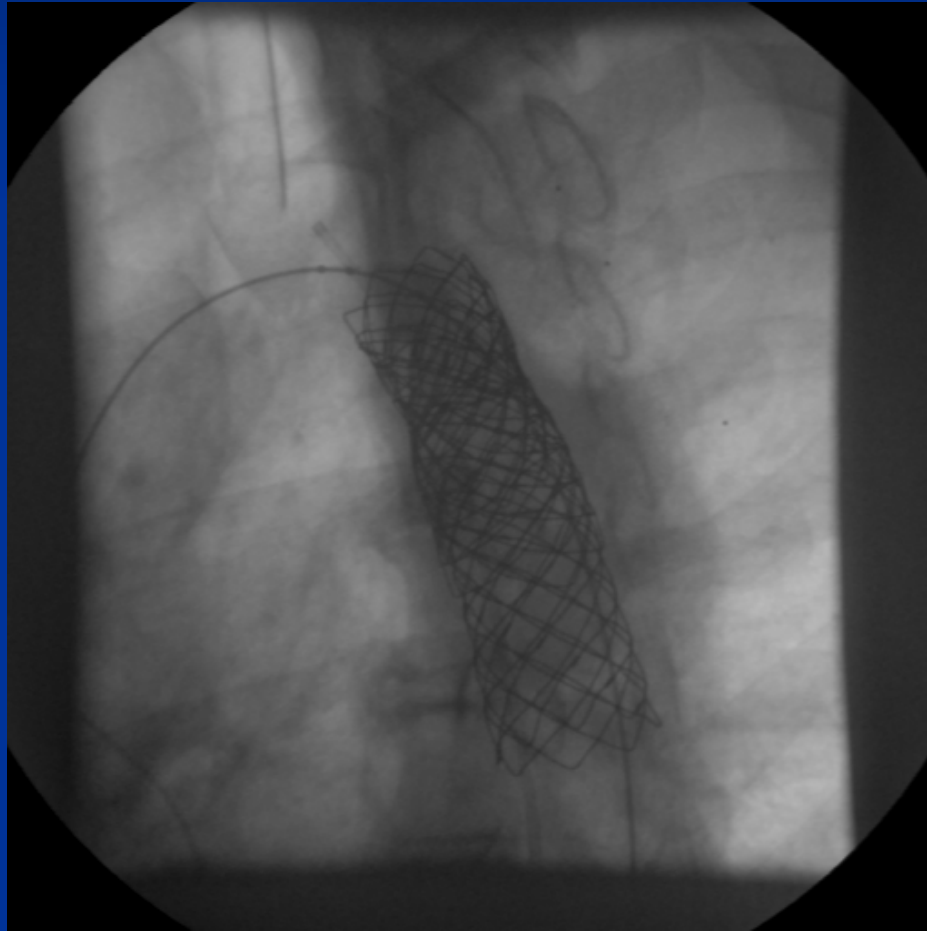


Treated with a bare and covered CP stent

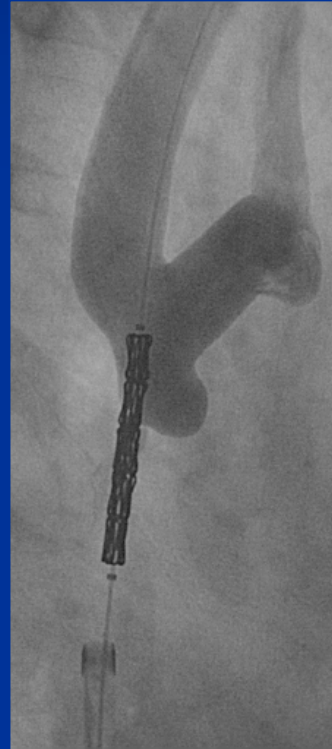
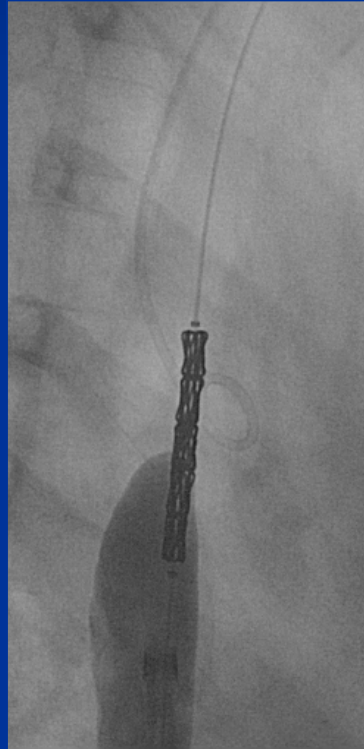
Large dissection post bare stent placement & treated with covered stents



Large dissection post bare stent placement & treated with covered stents



Interruption of aorta – covered CP stent



Our Experience

- October 1999- September 2008
- Ongoing study on stenting in native coarctation of the aorta
- Single tertiary referral center-Punjab Institute of Cardiology, Lahore. Pakistan
- Native coarctation of the aorta
- Age above 12 years (Weight > 35Kg)

Patient Selection – Covered Stents

- Critical long segment (tubular) coarctation
- Critical transverse arch coarctation
- Turner Syndrome
- Associated PDA (2 pts)
- Aortic dissection following previous attempted stenting
- Complex coarctation
- Old Age->50 years

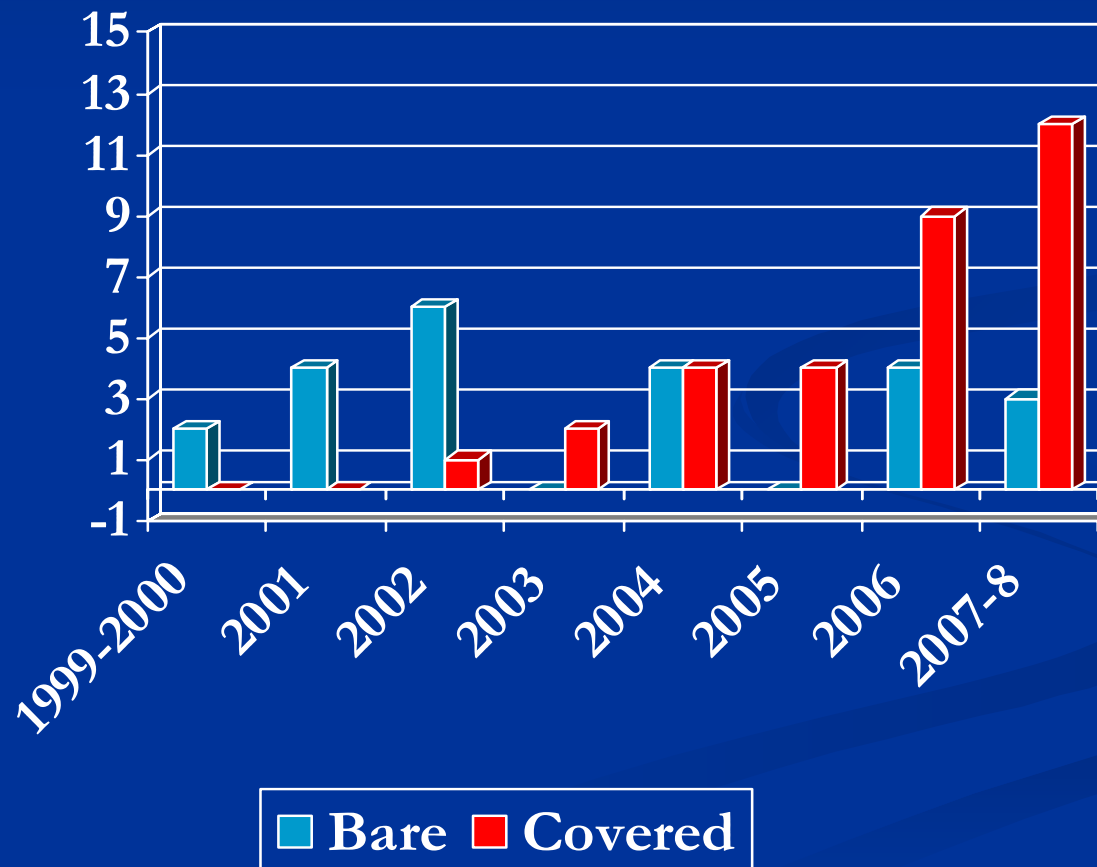
Results

■ Patient Population

- Total stent implantation = 56 procedures in 54pts
- Total number of stents = 59
- Covered Stents = 32/56 (57%)

- Male: Female (1:5)
- Age: 12 to 56 Years (median = 24 Years)
- Sheath size: 11-16 F

Annual trends



Outcome

- Adequate implantation in 31/32 (97%)
- Failure to cross- 1 pt with interrupted arch
- 31 procedures – 34 stents
- PDA closed in both pts with associated duct
- No paradoxical hypertension or post coarctectomy syndrome

Complications

- Death: 1 pt
- Left SCA sacrificed (transverse arch coarctation)- 4 pts
- No rupture or aneurysm
- No thromboembolism or other major vascular complications
 - Local haematoma (2 pt)
 - Transient left arm paresis (1 pt)

Follow - up

4.6 yrs (0.2-6.5) years

- Re-dilatation (1pt)
- No Recoarctation (clinical, echo)
- Spiral CT (23 pts- 74%):
 - No aneurysm
 - No dissection
- Hypertension:
 - Antihypertensive treatment (29/31 pts- 93%)

Spiral CT at 24 months



Use of covered stent

- 7 studies with 96 pts
- Effective in near atretic and complex aortic coarctation, associated PDA or aneurysm and as rescue

Follow-up complications

- Aneurysm formation - 2 pts
- Stent fractures - 3 pts (initial series)
- Re-dilation - 9 pts
- No other major complications

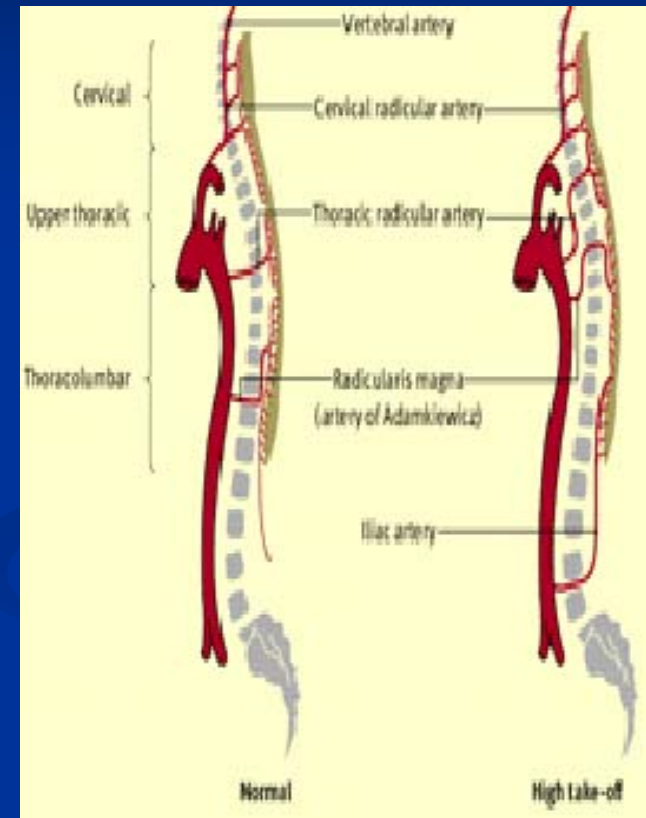
Tzifa A et al. J Am Coll Cardiol 2006;47:1457-63

Butera G et al. Am Heart J 2007;154:795-800

Point of concern

Spinal artery occlusion

- Spinal artery originates below the level of ninth thoracic vertebra in over 90% of the patients
- So unlikely complication after implantation in thoracic aorta



Wada T, Yao H, Miyamoto T et al. *Ann Thorac Surg* 2001;72:80-84.

Occlusion of significant aortic side branches

Left subclavian artery occlusion

- Stent-graft-induced occlusion of the ostial left subclavian artery is well tolerated without chronic functional deficit
- In the absence of stenotic vertebral and or carotid arteries and with a documented intact vertebrobasilar system

Rehders TC, Petzsch M, Ince H et al. J Endovasc Ther 2004;11:659-66.

Aortic Rupture

- Reported with a covered stent as well
- Second balloon dilatation within the stent was required as distal stent remained under deployed

Collins N, Mahadevan V, Horlick E. Cath Cardiovasc Interv 2006;68:653-55.

- CP covered stent has rounded edges (theoretically)
- The covering PTFE shortens variably being less than the length of the stent
- An induced wall tear within the stent margins may not be covered by the membrane

Re-dilation

Can they be re-expanded a great deal ? so should be avoided in growing children?? Intimal proliferation?

- 7 pts with restenosis after covered stent
 - Native coarctation- 4 pts
 - Post-surgical recoarctation- 3 pts
- Mean age 14.2 ± 3.0 years
- Procedure done at a mean of 20 (12-24) months
- Stent diameter increased of 20-50% predilation value
- At median follow up of 12 months stable with no immediate or late complications

Butera G, Gaio G, Carminati M. Cath and Cardiovasc Int 2008;72:273-7

Covered stents in aortic coarctation in adults

- **Surgery**-the gold standard but technically demanding, a high risk of paraplegia, re-coarctation & aneurysms
- **Balloon angioplasty** in only selected pts- discrete coarctation , significant risk of re-coarctation & risk of aneurysms, dissection and rupture
- **Stenting** with bare stents prevents recoil but risk of aneurysms, dissection and rarely rupture stays

Covered stents in aortic coarctation

- **Covered stents** may be used as first line treatment in adults and all pts (adolescents and adults) with complex CoA
 - Long segment /tortuous native coarctation
 - Atretic or near atretic coarctation
 - Transverse arch coarctation
 - Coarctation with PDA
- Covered CP stents may be used as the therapy of choice in patients with complications after CoA repair:
 - Aneurysm, dissection or rupture
- In adults, may be considered as **primary treatment of choice for aortic coarctation**

Covered stents in aortic coarctation

- September 2001 - February 2005
- Covered Cheatham-Platinum CP stents implanted in 30 patients in 3 centers
- Mean age 28 ± 17.5 years, range 8-65 yrs
- 4 patients were children below 14 years old of age (8, 12, 13 and 13 yrs old)
- Mean weight 62 ± 13 kg, range 28-86 kg

Covered stents in aortic coarctation

- Systolic gradient across coarctation decreased from mean 36 ± 20 mmHg before, to a mean of 4 ± 4 mmHg after the procedure
- Diameter of the coarctation site increased from 6.4 ± 3.8 mm to 17.1 ± 3.1 mm
- The only complication encountered was fracture of the covered stent welds during the procedure in 2 patients, necessitating the use of a second covered stent in one.

Covered stents in aortic coarctation

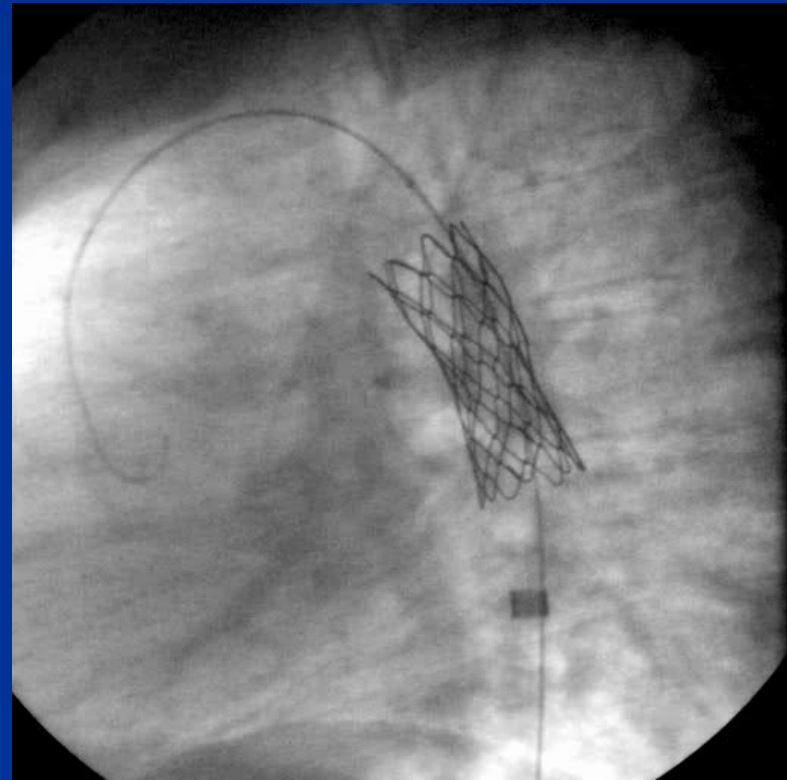
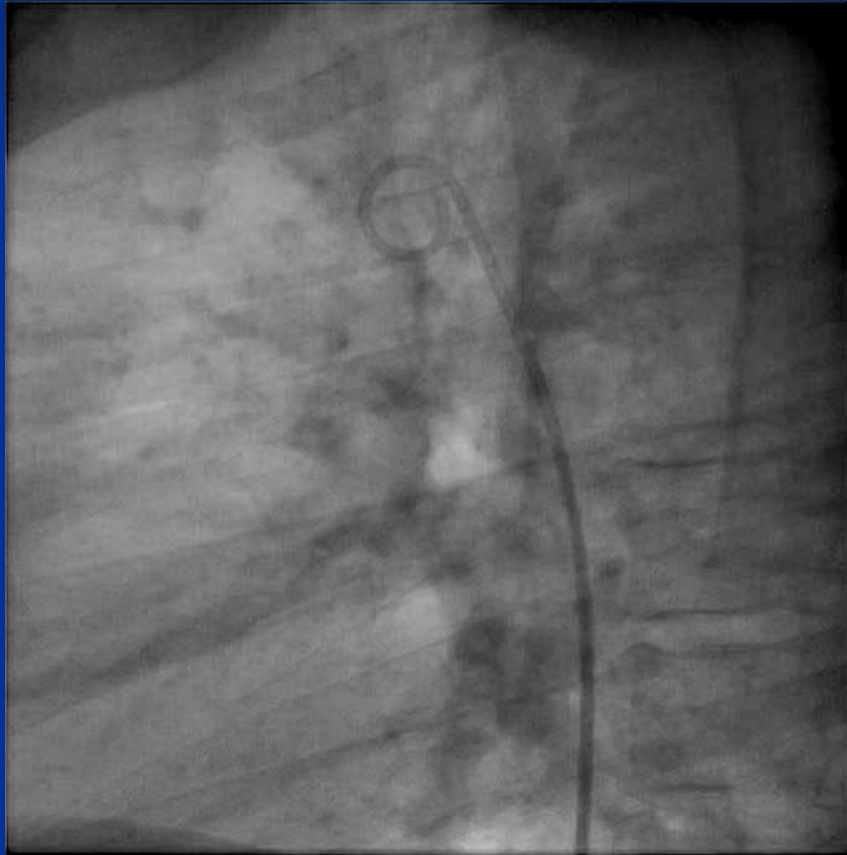
- Follow up period was up to 40 months (median 12)
- All stents were patent
- No fractures
- Good position on CT or MRI performed 3-6 months after the procedure
- 21/30 patients were on antihypertensive medication prior to the procedure
- In 9/21 (43%) of the patients the medication was either decreased or discontinued altogether

Native aortic coarctation

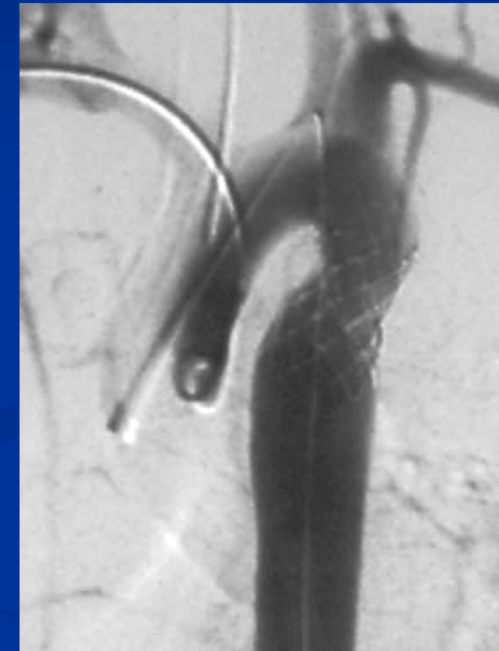
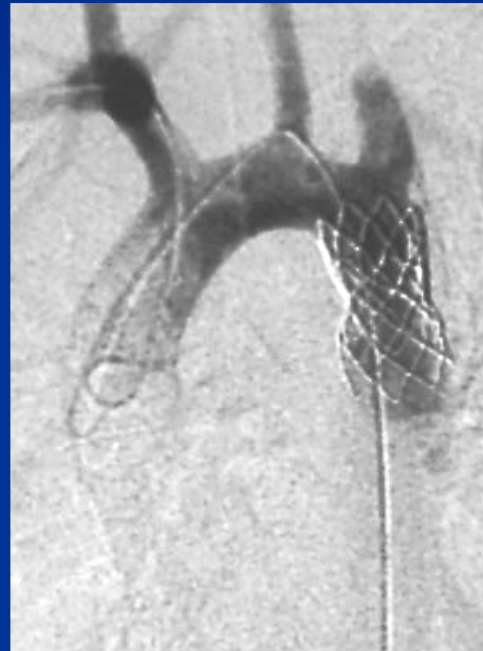
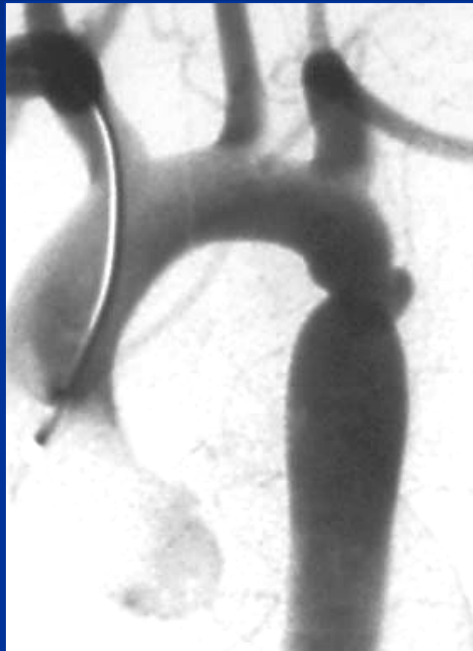


12 yrs old, primary stent implantation

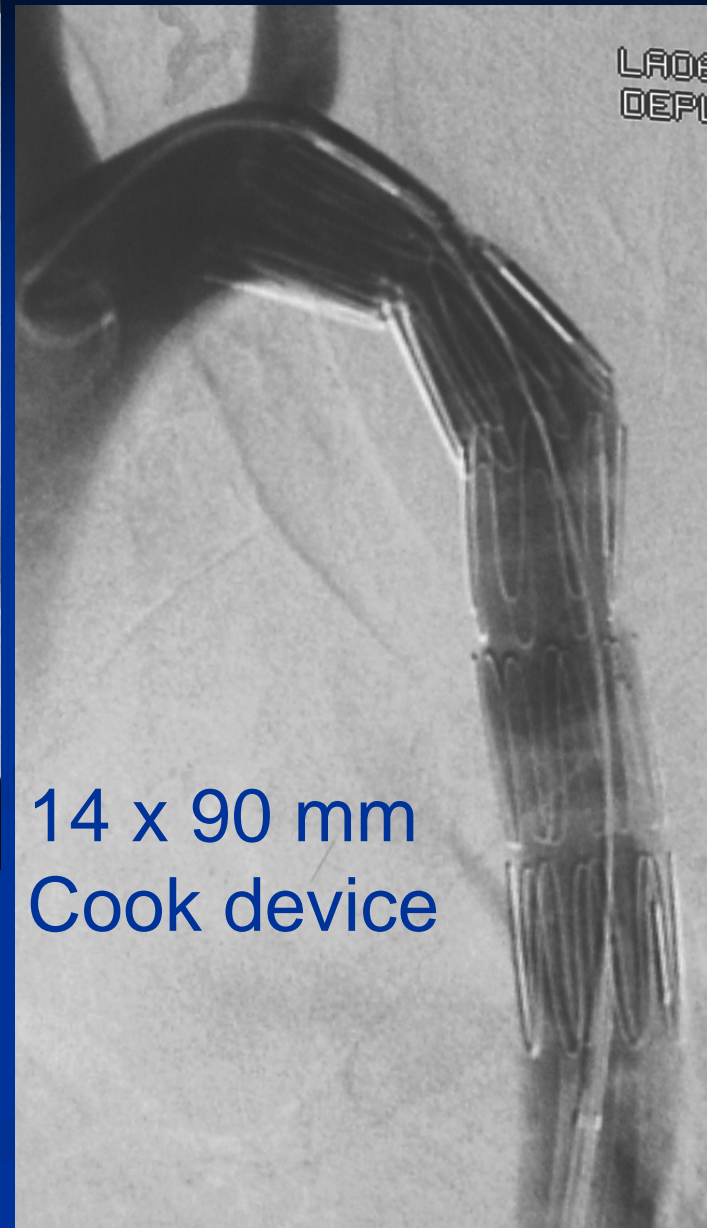
Covered stents



Covered stent – treatment of aortic aneurysm



12 yrs old, 55 kg, developed aneurysm after balloon angioplasty.
Covered stent implantation 1 mth later



14 x 90 mm
Cook device

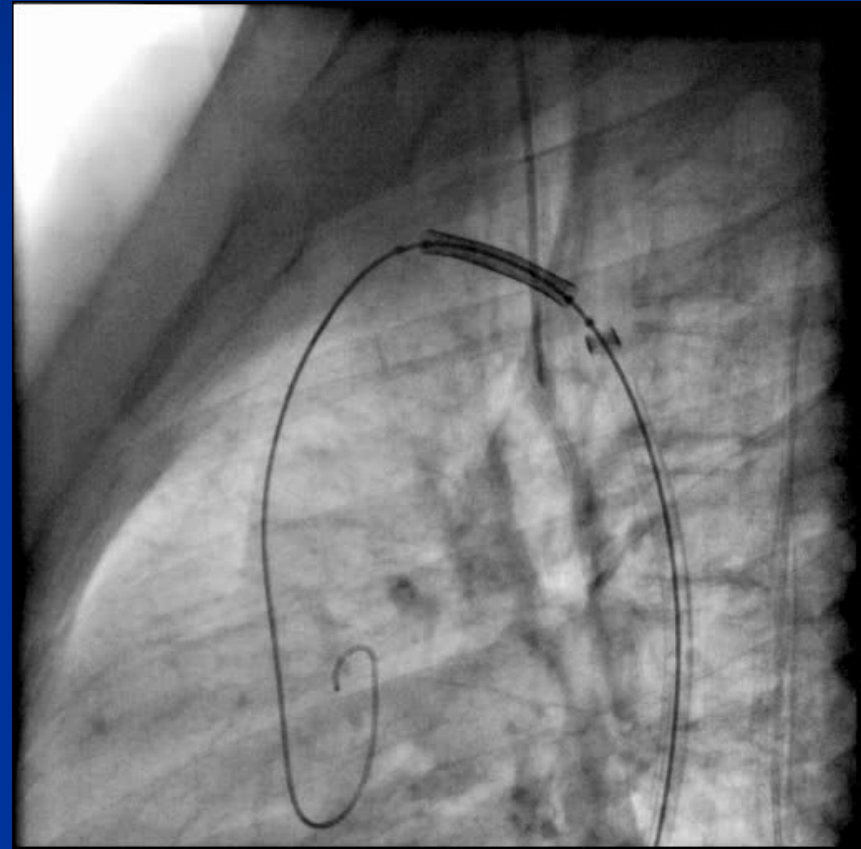
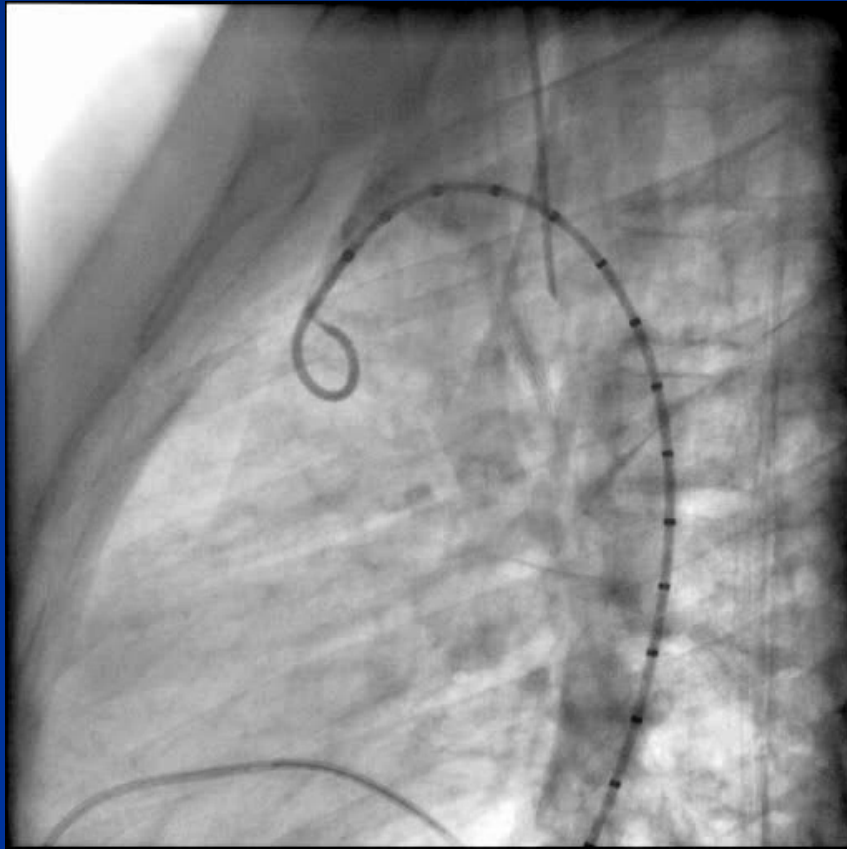
21 yr old female
CoA repairs age 6 weeks &
2 yrs

What about these native coarctations

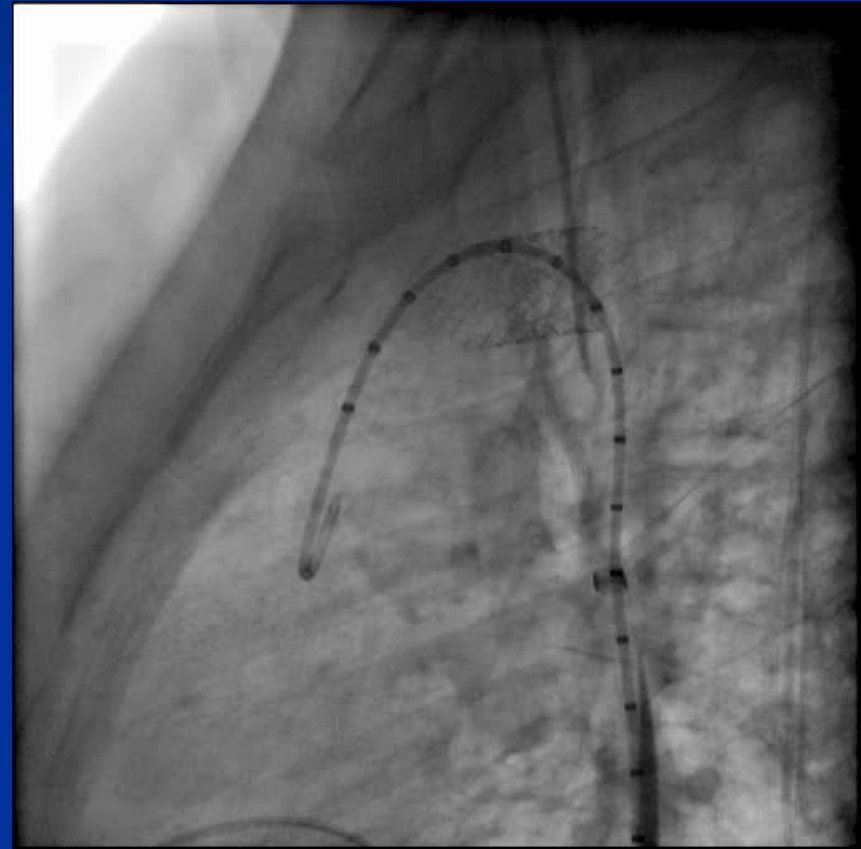
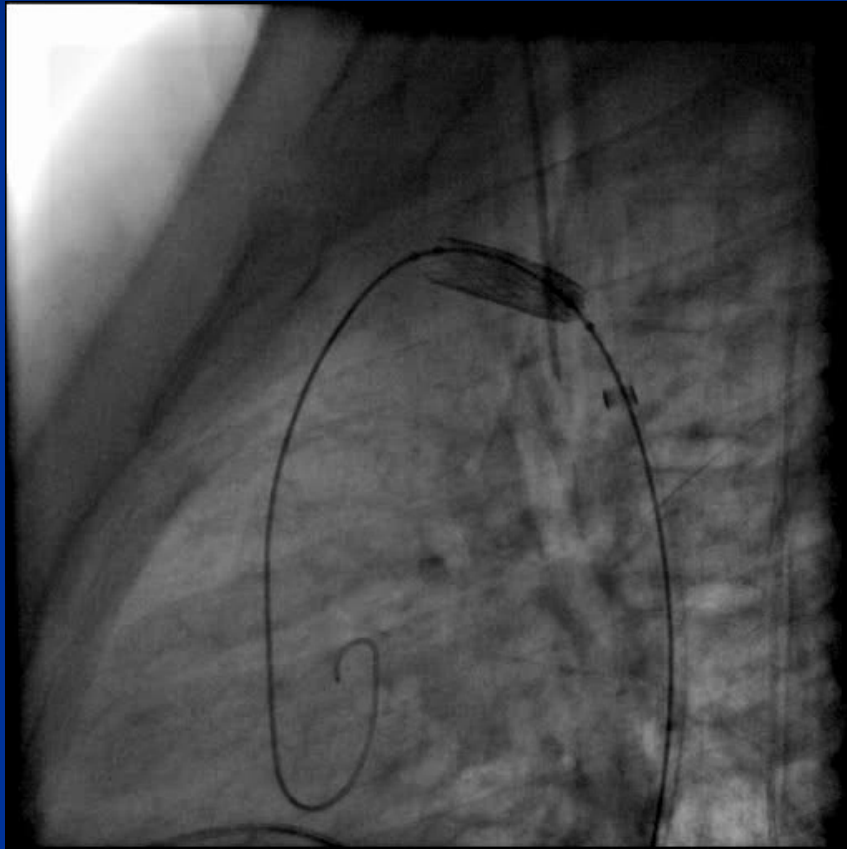
- Suitable for balloon dilation?



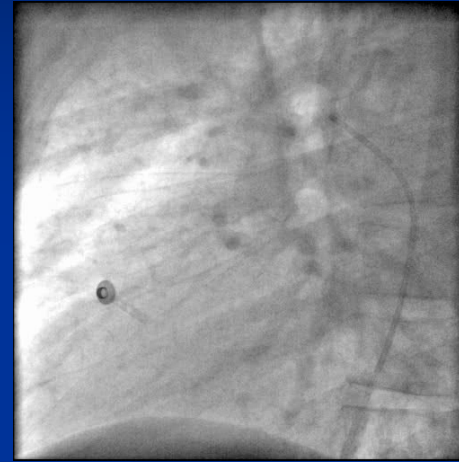
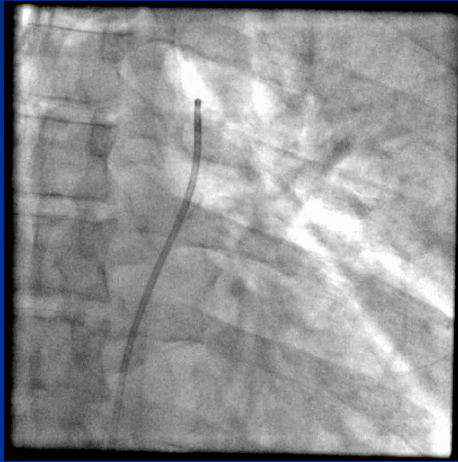
Covered stents with transverse arch hypoplasia - treated with bare stent



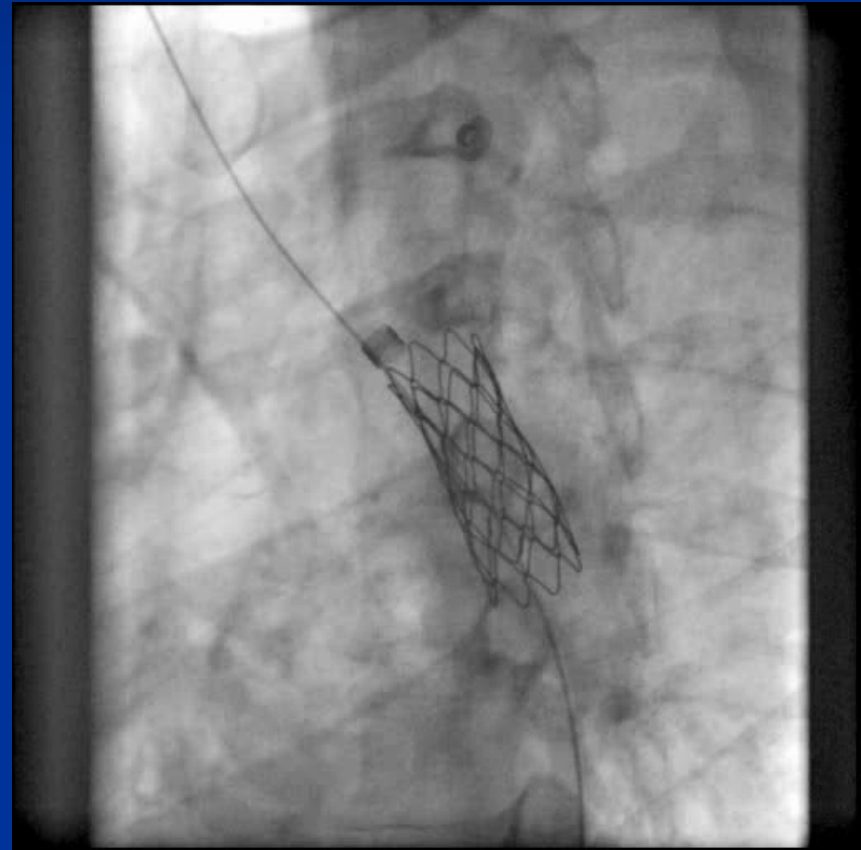
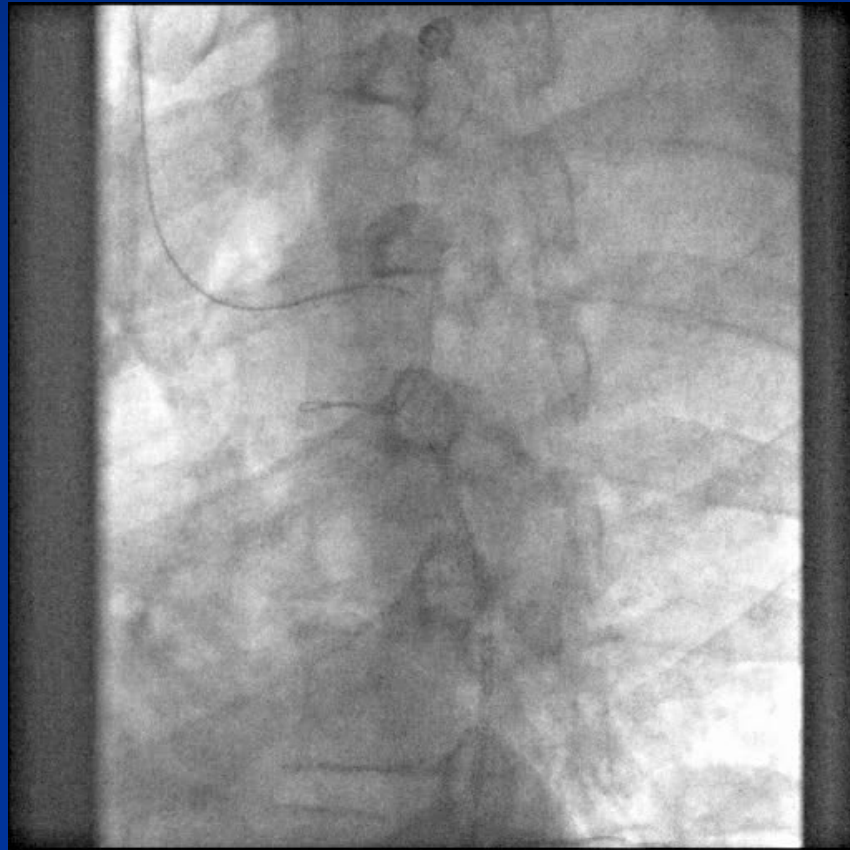
Covered stents with transverse arch hypoplasia - treated with bare stent



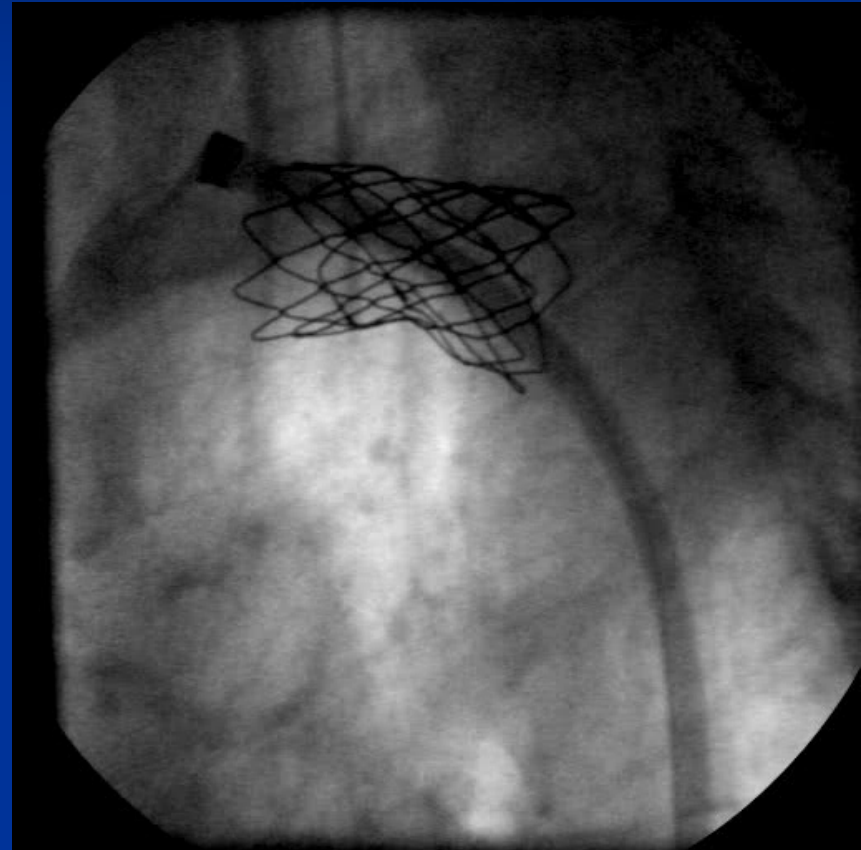
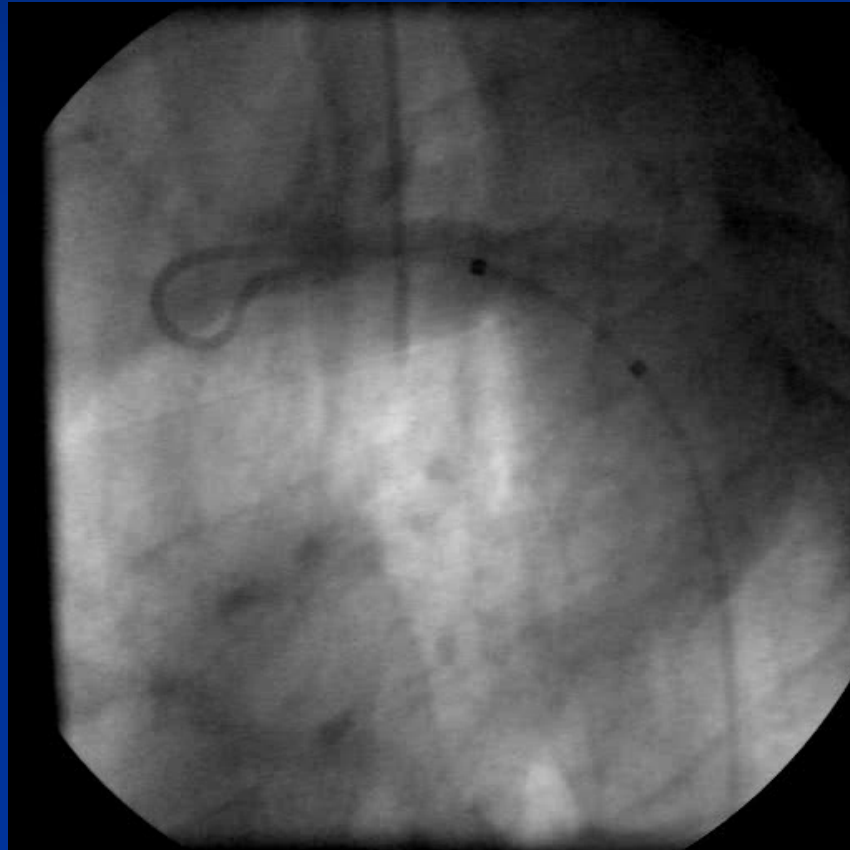
Near interruption of aorta



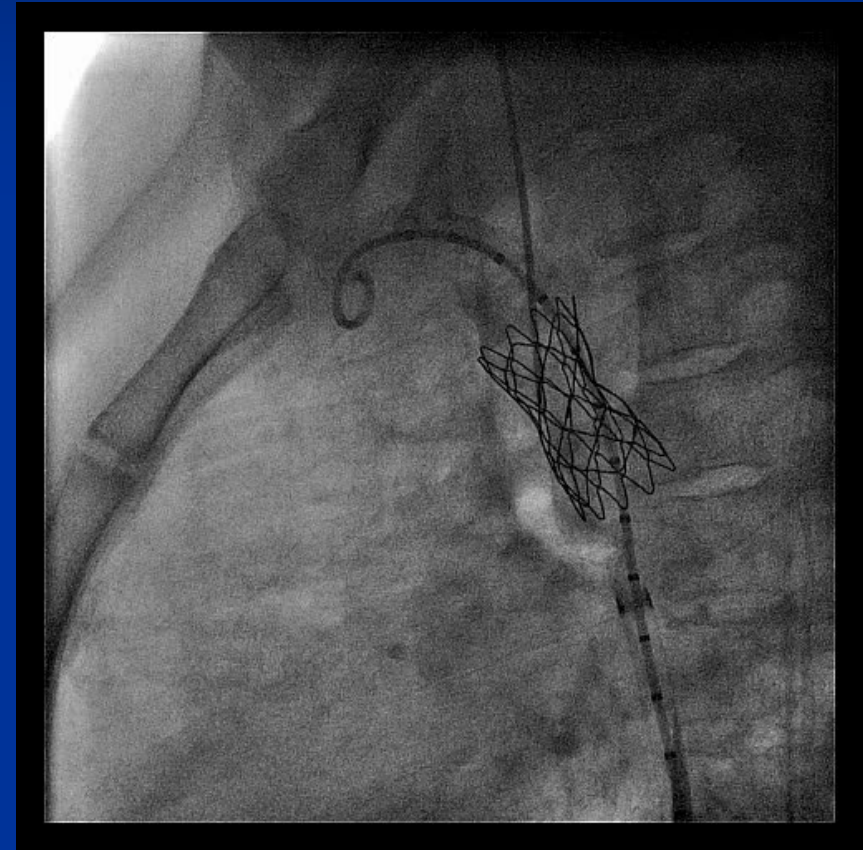
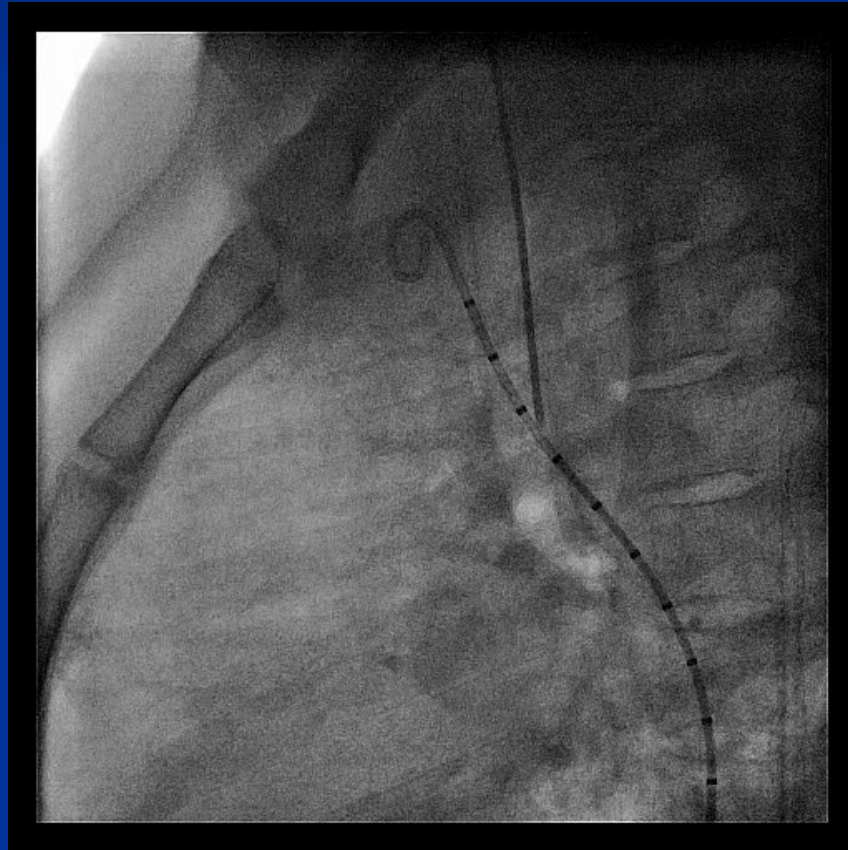
Near interruption of aorta



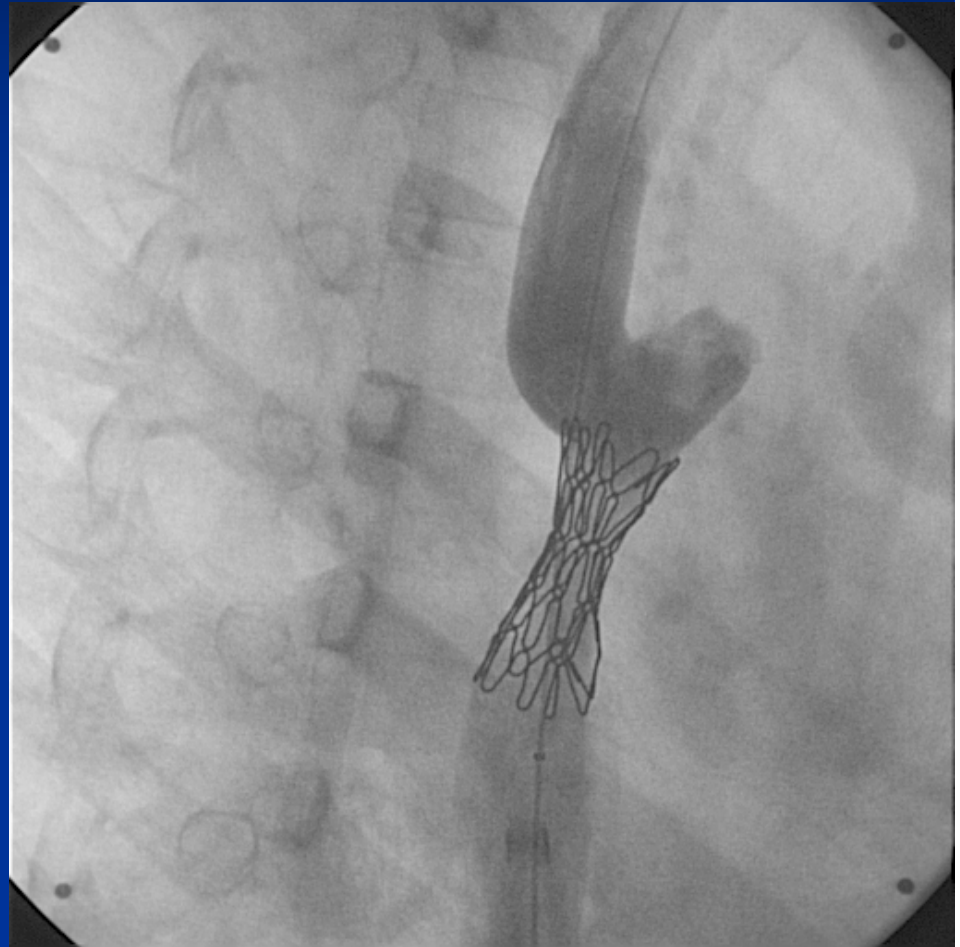
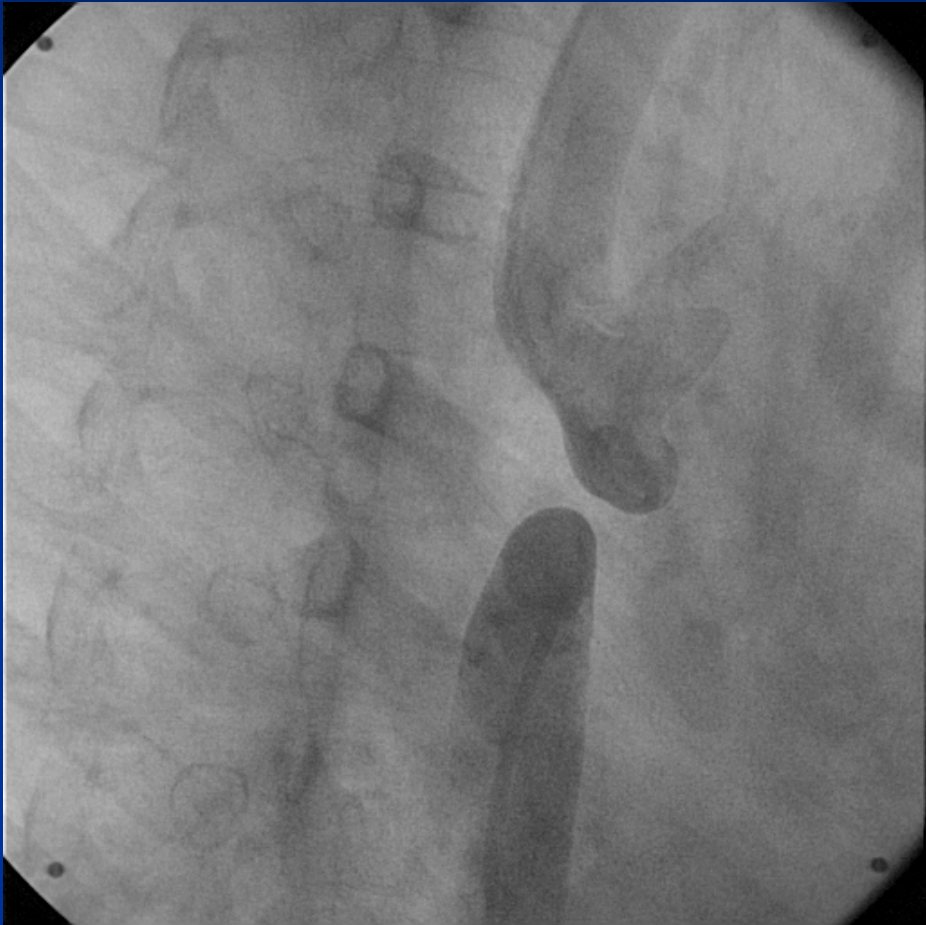
Aortic coarctation



Aortic coarctation



Aortic atresia



Courtesy P Ewert

Catheter treatment of aortic coarctation

- Balloon dilation offers a reasonable alternative to surgery in all but newborns where all forms of treatment have problems
- Stent implantation is limited to older children and adults but is a better alternative because it is more controllable.
- A small incidence of aneurysm formation is inevitable in all forms of treatment.
- Most complications can be treated with covered stents
- Covered stents may become treatment of choice in adolescents and adults

Stent Migration

- The learning curve
- Use of a single balloon as apposed to BiB balloon
- Migration is related to higher risk of aortic wall damage and hence aneurysm formation and dissection.

Intrastent proliferation

- Usually mild
- More with Palmaz stent
- Since vascular lumen is large a mild proliferation does not result in flow obstruction and local gradient generation

Stent Fracture

- Localised fracture between 2 rows may be benign
- Circumferencial tear may result in distal embolisation of the fragments and unpredictable consequences
- Refinements in the welding process using gold has been employed

Complications of stenting native and recurrent coarctation of the aorta: A 17-institution study

Aneurysms

- In native 5
- In recurrent coarctation 0
- All aneurysms localized to the mid-portion of the stent, were small (< 5 mm), and being followed conservatively
- Follow-up at a mean of 17.8 months showed no progression

Aneurysms

- 0-7% in pts treated with bare stents
- Form in the vessel wall crossed by the stent or edges of the stent
- Palmz stents have sharp edges and theoretically has a higher chance of dissection or aneurysm formation but well reported with CP stents as well although they have rounded edges
- Covered stents may be an answer
- Late aneurysm formation- tears or shrinkage in PTFE membrane!

Pedra C, Fontes VF, Esteves CA et al. Cathet Cardiovasc Interv 2005;64:495-506

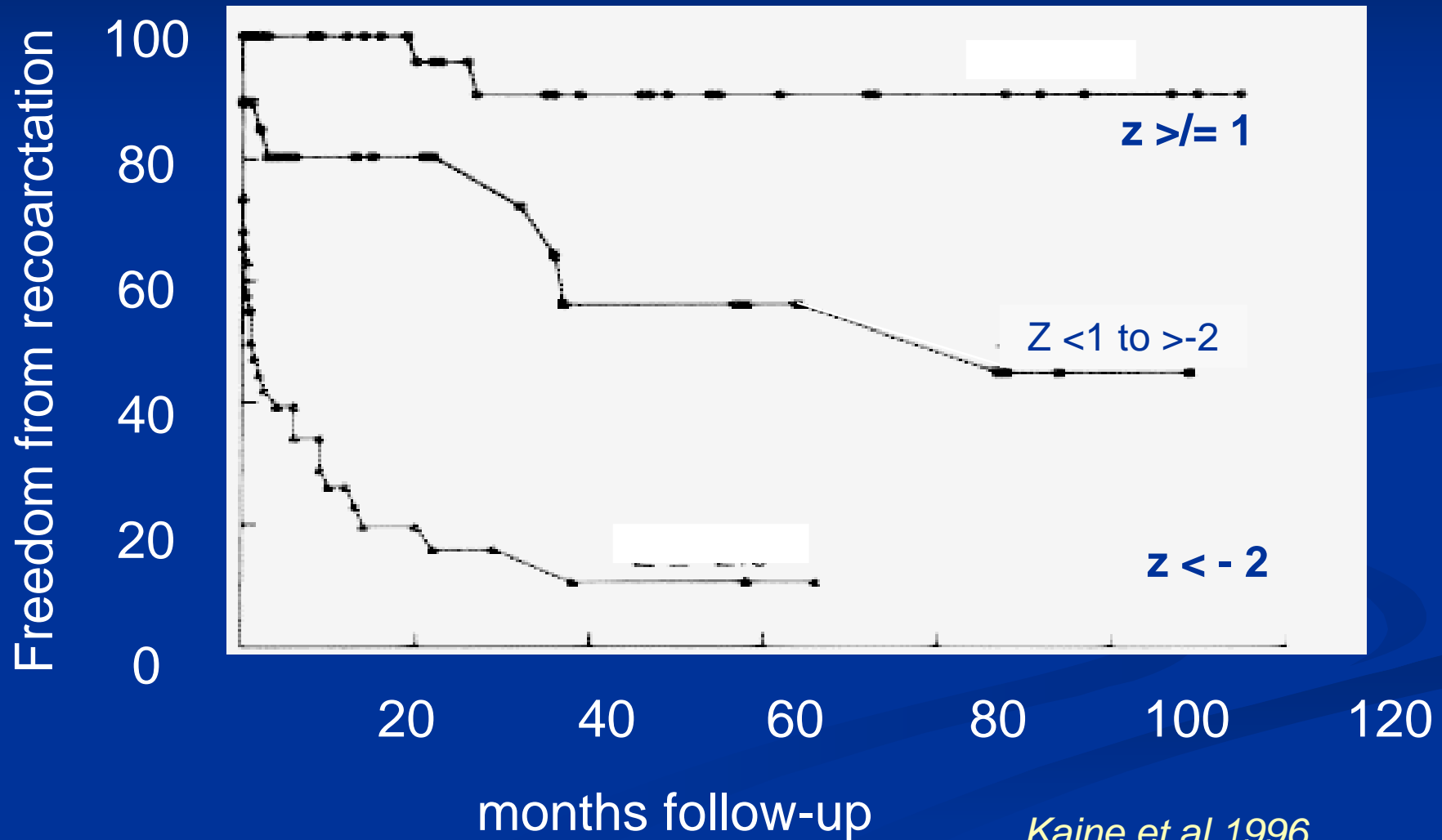
Results

<u>Parameter</u>	<u>Pre</u>	<u>Post</u>	<u>p-value</u>
Peak Systolic Gradient	50mmHg (40-71)	02mmHg (0-07)	<0.001
Mean diameter	04 ₊ 3.5mm	19 ₊ 4.2mm	<0.001

Stents in Coarctation of the aorta

- **Coarctation of the aorta**
 - Not uncommonly missed in early life
 - Diagnosed in adult life:
 - Hypertension
 - Stroke
 - Heart Murmur
- **Management in adolescents and adults**
 - Special challenge
 - Co-existent conditions

Age: aortic isthmus diameter & recoarctation after balloon dilation



Morbidity and Mortality After Endovascular Therapy for Coarctation in the Adult

Author	Year	n	Morbidity	Mortality	Reinterventions	
Stenting						
Suarez de Lezo	2005	73	7%	2 late aneurysms, 1 residual stenosis, 2 stent migrations	1% ^a	?
Johnston	2004	32	6%	1 dissection, 1 stent migration	0	10 repeat angioplasties
Tyagi	2003	21	5%	1 stent embolized	0	0
Harrison	2001	27	19%	3 aneurysms and 1 requiring surgery, 1 stroke, 1 failure	0	1 angioplasty, 3 aneurysms
Hamdan	2001	34	18%	1 retroperitoneal hematoma, 1 embolized balloon, 1 stent migration, 1 failed intervention requiring surgery	3% ^b	4 patients, 2 referred to surgery
Cheatham	2001	46	20%	2 aneurysms, 2 stents embolized, 1 stent dislodged, 1 hemothorax, 1 stent fracture, 2 failures	0	5 additional stents, 4 angioplasties
Ledesma	2001	54	9%	2 aneurysms	0	4 patients, 2 referred to surgery
Marshall	2000	33	9%	1 acute MI, 1 cardiac arrest, 1 femoral thrombosis (7 blood transfusions)	0	1 stent migration, 8 angioplasties
Thanopoulos	2000	17	0	none reported	0	0
Ebeid	1997	9	0	none reported	0	1 repeat angioplasty

Complications of stenting in CoA

- Most common complications
 - Traumatic aneurysm formation
 - Aortic dissection
- No pt had paralysis
- Restenosis was 0-25% (mean 11%)
- Repeat intervention was 0-31% (mean 14)
 - Repeat angioplasty
 - Additional stenting
 - Referral for surgery
- Cure of hypertension was 18-88% (mean 61%)

Carr JA. J Am Coll Cardiol. 2006 Mar 21;47(6):1101-7

Stents in coarctation of aorta

Disadvantages

- May alter vessel wall compliance, pressure wave propagation and blood pressure
- In young patients will require additional dilations to keep pace with growth, so confined to adults

Procedure details

- General Anaesthesia
- Cut down and femoral arteriotomy (3pts)
- 14F Or 12 F Sheath, 16 F (3 pts)

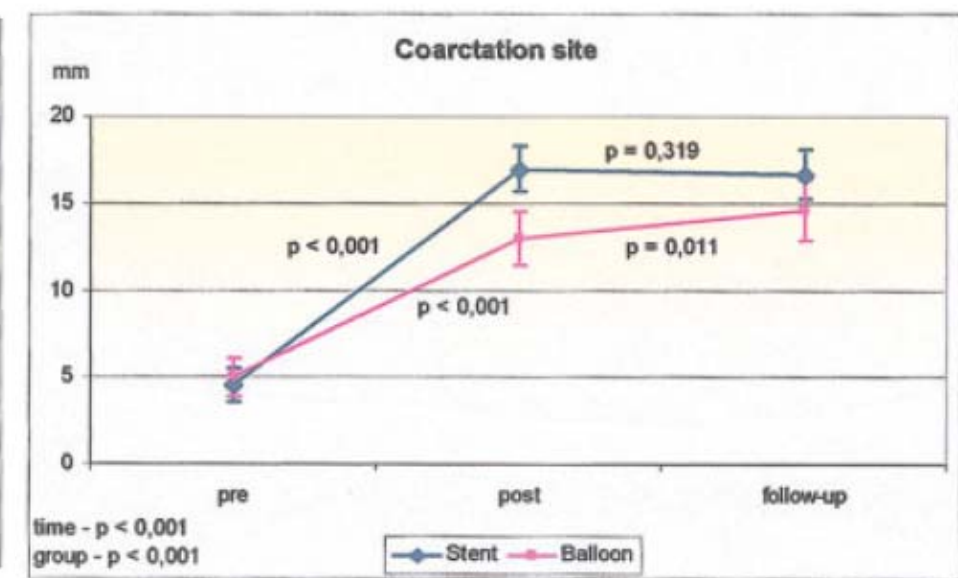
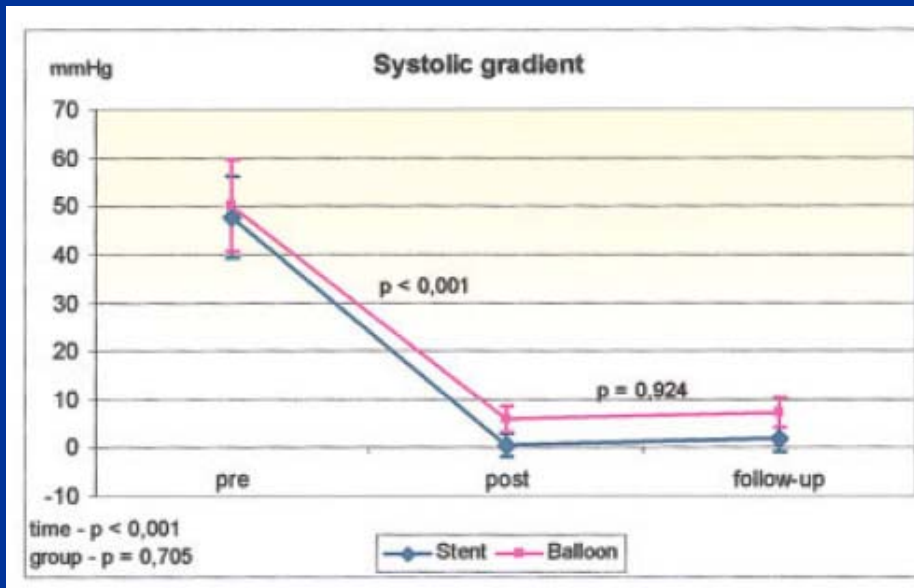
- Balloon expandable CP Stent -6 Or 8 Zig/row
- BIB Balloon (NuMed)

CONCLUSIONS

- **Covered stent** is an important addition to the armamentarium of the interventional cardiologist AND an important bail out
- Covered stent decreases potential of complications in complex coarctations, special situations and old age
- Can be used to seal the associated duct without additional device

Balloon dilation or stenting adults with native aortic coarctation

- 21 patient who received stents compared with 15 who had balloon dilation
- All adolescents or adults
- Greater gradient reduction after stents



Morphology: aortic coarctation anatomy



Anatomy unsuitable for BD

Native aortic coarctation



Anatomy ? suitable
for BD

Comparison of angioplasty and surgery

- 16 reports of stenting and/ or angioplasty reported in the last 10 years (1995-2005)
- Compared them with 6 series of surgical repair in the adults
- Primary stenting had lowest risk of complications
- Need for reintervention was highest with stenting

Carr JA. J Am Coll Cardiol. 2006 Mar 21;47(6):1101-7

Coarctation of aorta - stent implantation

Primary stenting

- 9 studies with 320 pts (175 native aortic coarctation in children and adults)
- Gradient reduction from mean 41 mmHg to 4 mmHg
- Effective in severe, complex aortic coarctation

Follow-up complications

- Aneurysm formation in 3-4%
- Stent malposition in 4%
- Vascular complication including stroke 3%
- Death and need for emergent surgery have occurred but rare

Stents in Coarctation of the aorta

Factors affecting such decision

- Age
- Morphology of the coarctation of aorta
- Any previous intervention
- Local institutional results
- Expertise

Aortic Rupture

A rare but catastrophic complication

- 4 reported cases in the literature
- Two of them fatal (50% mortality)
- Youngest was infant and eldest was 65
- Native coarctation (1 pt) Recoarctation (3 pts)
- Dilatation following previous end to end anastomosis may be a particular risk factor – lack of compliance in a circumferential scar
- Re-dilatation is a particular risk factor

Covered stents in aortic coarctation

Available stents:

- Numed (covered Cheatham-Platinum)
- Jomed
- Stent grafts
- V12 Atrium – recently available

Current indications

- Covered Cheatham-Platinum (CP) stents currently used
 - as a rescue treatment in patients with aneurysms or previous stent related complications
 - in patients in whom increased risk of developing complications due to complex anatomy (e.g. near interruption or arch tortuosity) or advanced age
 - ? Use in all adults with coarctation of aorta

Covered Stents

Stent implantation – technical tips

- Amplatz super-stiff exchange guide wire (usually 0.035”), positioned in ascending aorta
- Rapid RV pacing is used
- BIB balloon used for mounting stents
- In adolescents and adults, per close suture used for haemostasis

Covered Stents

Stent implantation – technical tips



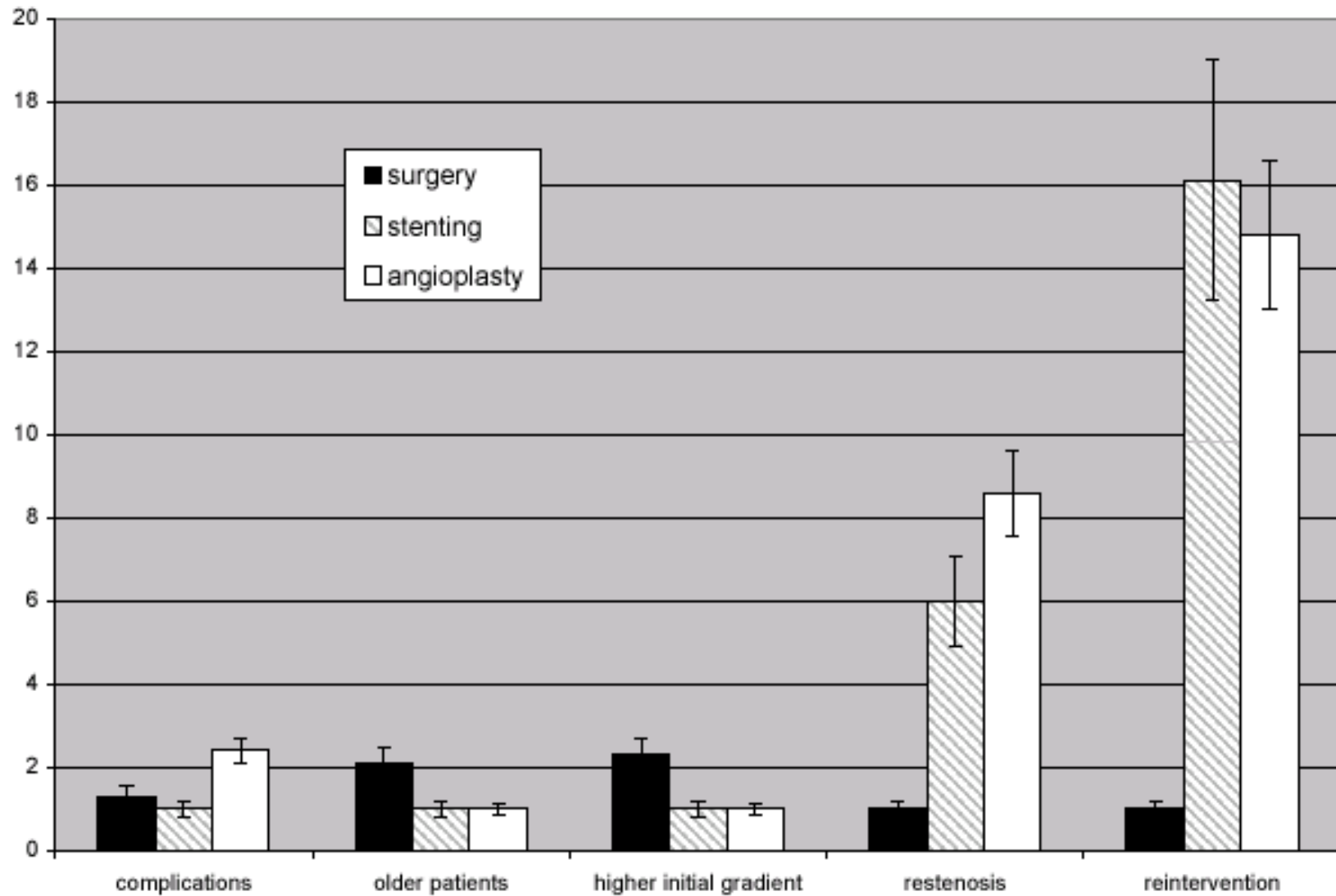
- Balloons longer than stents allow more precise placement and repositioning if necessary before fully inflating the balloon
- Or use the BIB balloon
- If lesion is tough and there is a residual waist on the stent, then high pressure balloons such as Opta, Power flex, Z-med or Mullins balloons are used

Covered Stents

Stent implantation – technical tips

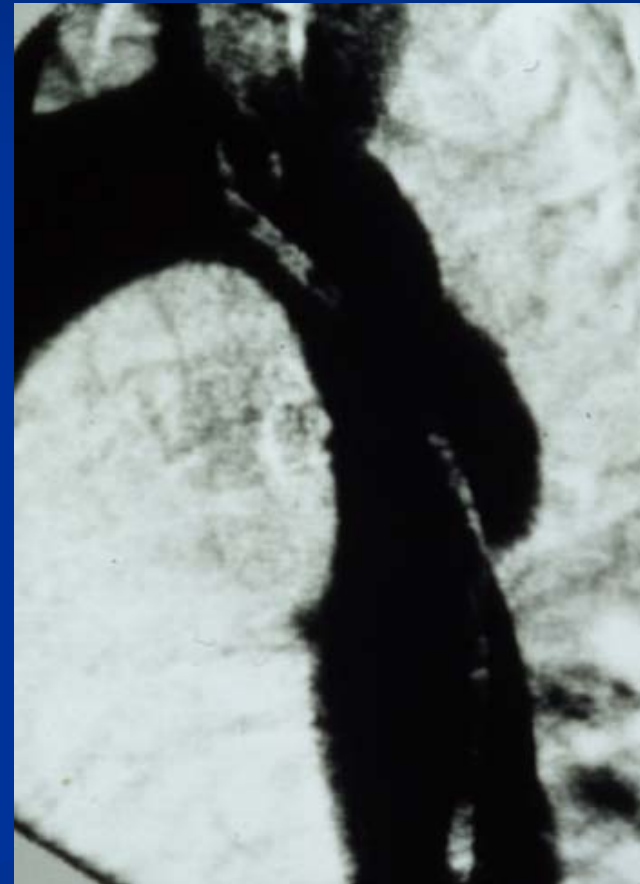
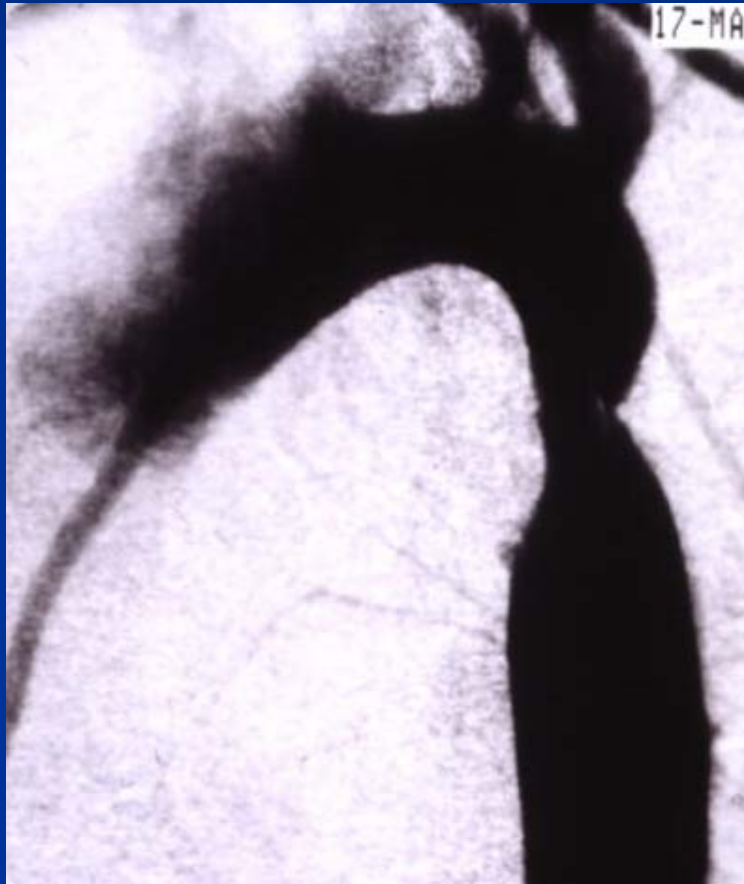
- For covered stents, dilate to 70 – 100% at first procedure
- No attempt made to match stent to dilated aorta
- Aspirin for 6 months

Odds Ratios With 95% Confidence Intervals





Previous intervention: balloon dilation for aortic coarctation



Complications of stenting native and recurrent coarctation: A 17-institution study (CCISC data)

- 588 procedures
- Median age 15 years (range 1 month-64.9 years)
- Median weight 55 kg (range 1.8 to 145 kg)
- Stenting
 - Native coarctation 44%
 - Recurrent surgical coarctation 49%
 - Recurrent coarctation after balloon 3%
 - After previous stent placement 4%

Golden A, Hellenbrand WE. Cath and Cardiovasc Intv 2007;69:289-99