Recent Advances in Interventional Tx of CoA

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Cystic medial necrosis in coarctation of the aorta: a potential factor contributing to adverse consequences observed after percutaneous balloon angioplasty of coarctation sites

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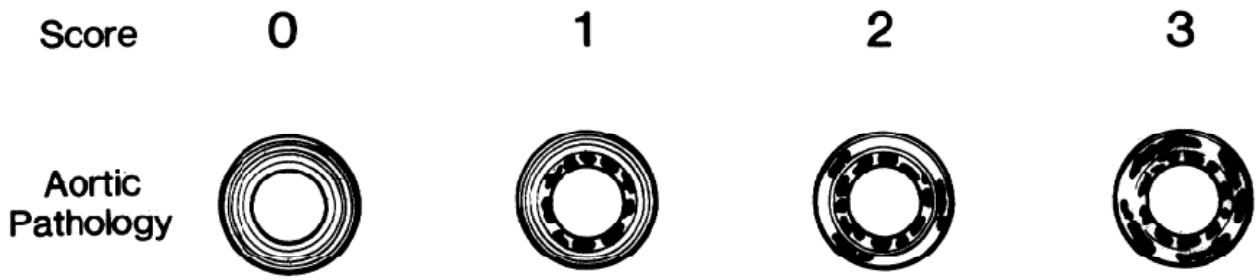
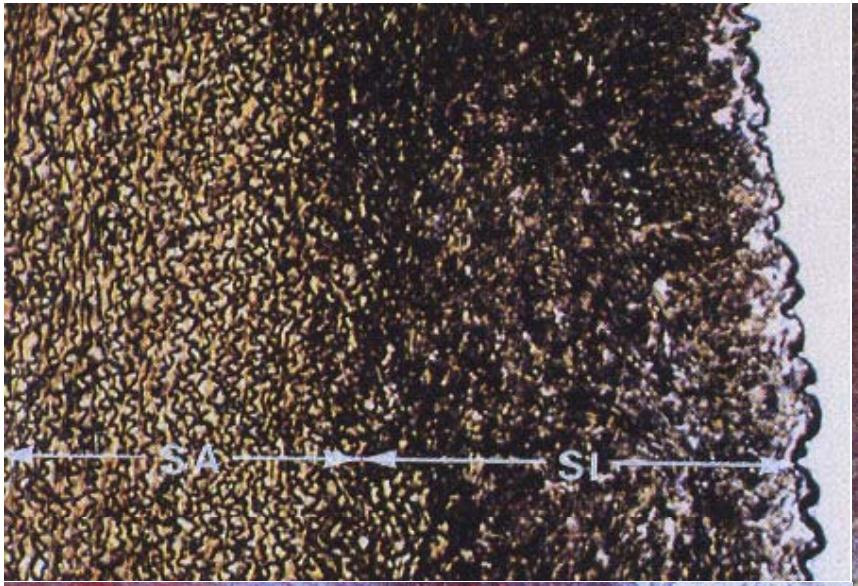
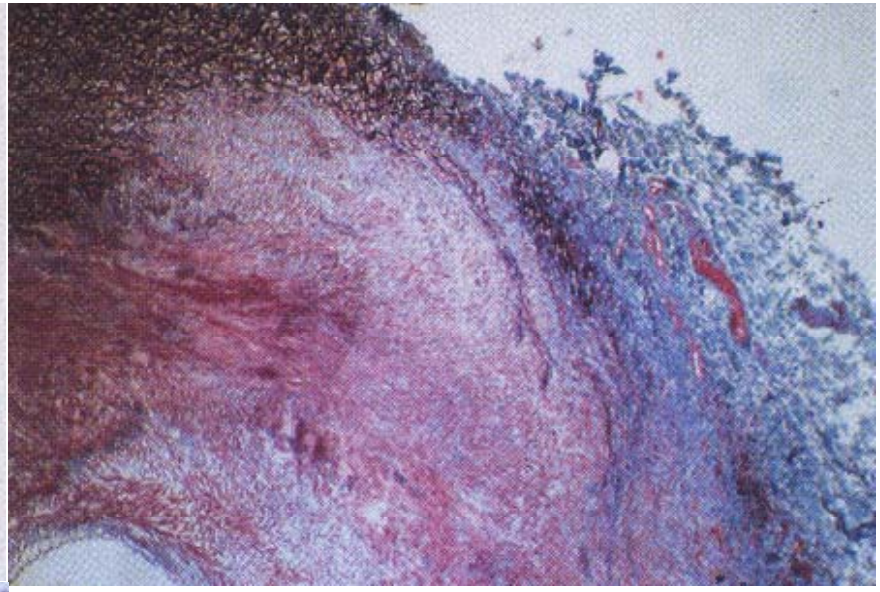
ABSTRACT Percutaneous transluminal angioplasty has been shown to be both feasible and efficacious for the treatment of aortic coarctation. Recent reports, however, have indicated that the development of aortic aneurysms at or near the coarctation segment may complicate attempts to treat this lesion by catheter-based intervention. Accordingly, we examined the light microscopic features of coarctation segments excised at surgery (n = 31) or obtained at autopsy (n = 2) in 33 patients with coarctation of the aorta. Cystic medial necrosis, defined as depletion and disarray of elastic tissue, was observed in each of the 33 specimens. In the majority of coarctation specimens (22 of 33 or 67%) the extent of cystic medial necrosis, graded semiquantitatively on a scale of 0 (normal aorta) to 3+, was severe (3+). The finding that cystic medial necrosis represents a consistent histologic feature of coarctation of the aorta provides a pathologic basis for the formation of aneurysms observed after balloon angioplasty of coarctation sites.

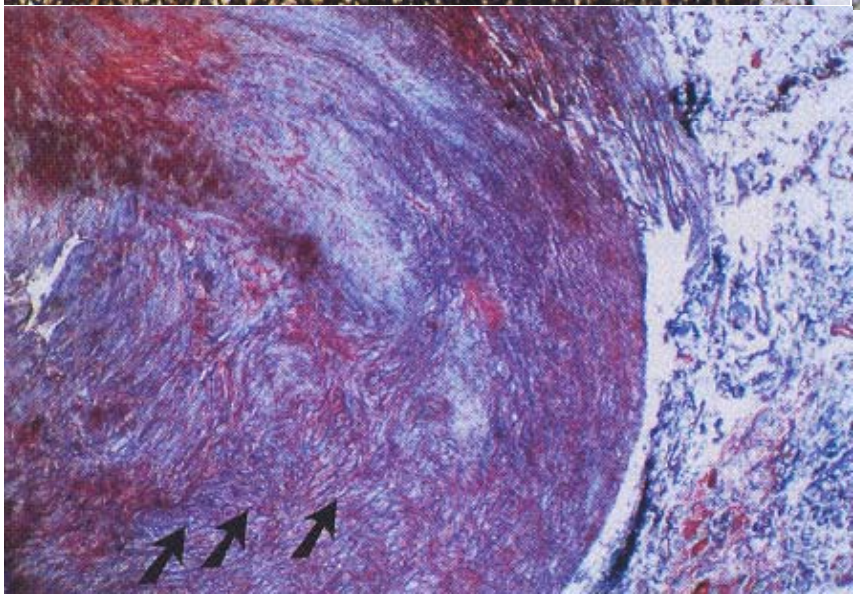
Circulation 75, No. 4, 689–695, 1987.



Cystic medial necrosis in CoA







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Circulation 1987;75:689-95

Acute Results of Balloon Angioplasty of Native Coarctation Versus Recurrent Aortic Obstruction Are Equivalent

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Objectives. This study sought to compare the immediate results and risk factors for suboptimal outcomes of percutaneous balloon angioplasty for native versus recurrent aortic obstruction.

Background. Some cardiology centers have been reluctant to adopt balloon angioplasty for treatment of native aortic coarctation, while advocating balloon angioplasty over an operation for treatment of postsurgical or recurrent aortic obstruction.

Methods. Acute results were analyzed from 970 procedures (422 native and 548 recurrent lesions) performed between 1982 and 1995 in 907 patients from 25 centers. An acute suboptimal outcome was defined as one or more of the following: residual systolic pressure gradient ≥20 mm Hg, residual proximal to distal systolic pressure ratio ≥1.33 or a major complication (death, aortic transmural tear, stroke).

Results. Balloon angioplasty significantly (p = 0.0001) increased lesion diameter for both native (mean [±SD] 128 ± 94%) and recurrent aortic obstruction (97 ± 87%), with a significantly greater increase in the native group (p = 0.0001). A reduction in systolic pressure gradients was significant in both groups (p = 0.0001), but slightly higher (p = 0.01) for native (−74 ± 24%) versus recurrent obstruction (−70 ± 31%). Death associated with angioplasty was reported in 0.7% of patients with native and in 0.7% of patients with recurrent lesions (p = 1.00). An acute suboptimal outcome was noted with angioplasty in 19% of native and in 25% of recurrent lesions (p = 0.04). Significant independent risk factors included higher preangioplasty systolic gradient (odds ratio [OR] 1.39/10-mm Hg increment; 95% confidence interval [CI] 1.28 to 1.50, p = 0.0001), earlier study date (OR 0.92/1-year increment, 95% CI 0.87 to 0.96, p = 0.0006), older age (OR 1.13/5-year increment, 95% CI 1.02 to 1.26, p = 0.02) and recurrent obstruction (OR 1.39 vs. native lesions, 95% CI 1.00 to 1.94, p = 0.05).

Conclusions. Acute results and complications of balloon angioplasty of native coarctation appear to be equivalent or slightly superior to those of recurrent aortic obstructions.

(J Am Coll Cardiol 1996;28:1810–7)

Characteristic	Native (n = 422)	Recurrent (n = 548)	p Value
Mean change in aortic diameter			
Proximal	+2 ± 11% (n = 102, p = 0.07)	+2 ± 15% (n = 223, p = 0.13)	0.75
Stenotic lesion	+128 ± 94% (n = 259, p = 0.0001)	+97 ± 87% (n = 343, p = 0.0001)	0.0001
Distal	+3 ± 15% (n = 91, p = 0.04)	+1 ± 7% (n = 123, p = 0.02)	0.23
Mean ratio of stenotic lesion to proximal aortic diameter after angioplasty	0.84 ± 0.18 (n = 98)	0.83 ± 0.22 (n = 205)	0.78
Mean change in ratio of stenotic lesion to proximal aortic diameter	+125 ± 90% (n = 96, p = 0.0001)	+98 ± 90% (n = 218, p = 0.0001)	0.01
Median systolic gradient after angioplasty (mm Hg)	9 (0–65) (n = 412)	9 (0–82) (n = 509)	0.44
Mean ratio of proximal to distal systolic pressure after angioplasty	1.11 ± 0.10 (n = 404)	1.13 ± 0.15 (n = 477)	0.05
Mean change in hemodynamic variables			
Systolic gradient	−74 ± 24% (n = 405, p = 0.0001)	−70 ± 31% (n = 530, p = 0.0001)	0.01
Ratio of proximal to distal systolic pressure	−26 ± 11% (n = 399, p = 0.0001)	−23 ± 14% (n = 498, p = 0.0001)	0.005
Complications			
Any complication	63 (15%)	72 (13%)	0.41
Death	3 (0.7%)	4 (0.7%)	1.00
Transmural aortic tear	0	4 (0.7%)	0.14
Neurologic event	3 (0.7%)	3 (0.6%)	1.00
Reported intimal tear/flap	22 (5.2%)	9 (1.6%)	0.002
Vascular			
Pulse loss	19 (4.5%)	10 (3.7%)	0.50
Thrombolysis required	1 (0.2%)	3 (0.6%)	0.64
Operation required	2 (0.5%)	7 (1.3%)	0.31
Blood products given	13 (4.1%)	52 (15%)	0.0001

JACC 1996;28:1810–7

To stent or Not to stent?

* Balloon angioplasty
  - recoarctation – d/t risk of repeat surgery
  - high incidence of recoarctation femoral a injury in neonates and infants
  - beyond infancy – acceptable
    - aneurysm, dissection – 2–20%
    - restenosis – 5–25%
    - unsuitable for angioplasty
      - tortuous coarctation
      - long tubular coarctation
      - hypoplasia of aortic isthmus
      - mild discrete coarctation

* Stent – advantage over balloon angioplasty
  - radial support of the stent – preventing recoil, residual or recurrent stenosis
  - preventing dissection – appose intimal flaps to the aortic wall
    neointimal formation
  - no over sizing, no over dilation – intimal, medial damage↓

–> less gross and histological trauma to the normal vessel wall

better and longer lasting result

J Interv Cardiol 2001;14:283–298

Stents

Palmaz (Johnson & Johnson) rigid, sharp edge, stainless steel endoprosthesis for adult peripheral vascular ds

308, 188, 128 : 8-series

3.4mm ø, 30, 12, 18mm long, 8~12mm expansion, up to 18mm

shortens too much, limited length and diameter

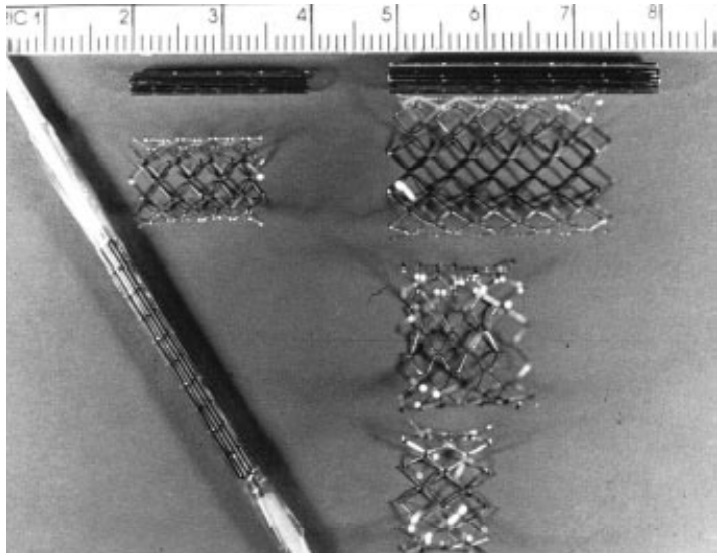
-> do not reach the size of adult aorta

(male 26.1±4.3mm female 21.1±3.2mm)

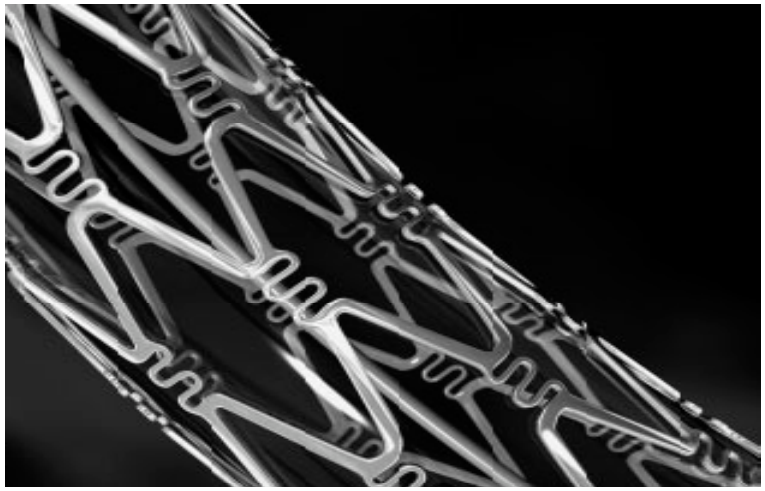
Palmaz XL (Johnson & Johnson) 3110, 4010, 5010 : 10-series

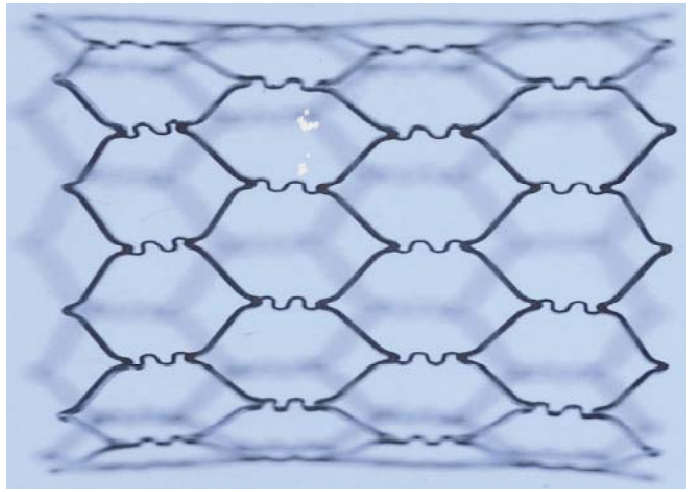
4.6mm ø, max 25-28mm, less sharp than P-8

significant shortening by 50%



Genesis (Cordis) sigma hinge interposition,
superior crimpability, flexibility
excellent in curve lesion - arch
max 18-20mm expandable
reduces shortening 10-12%
comparable radial strength to Palmaz

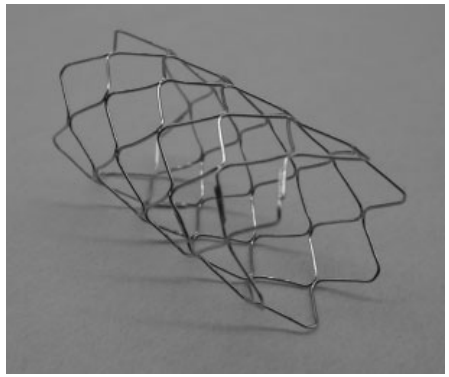


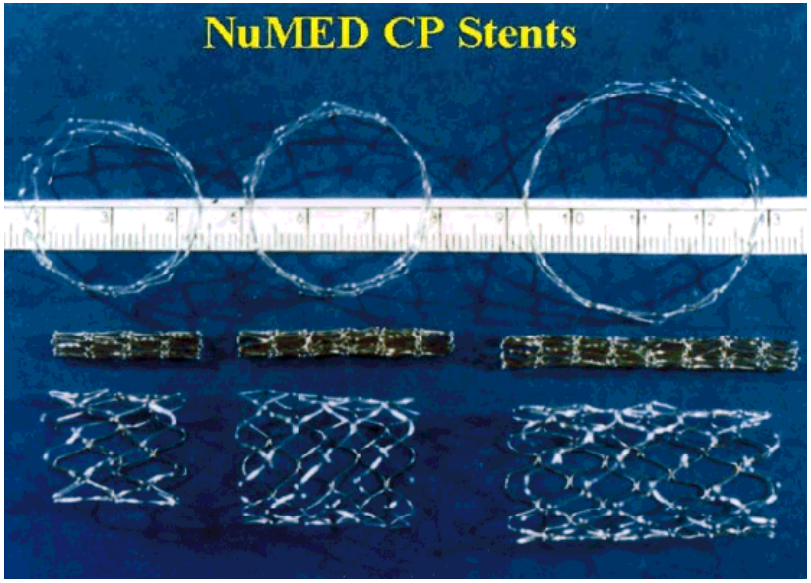


Catheter Cardiovasc Interv 2003;59:406-14

CP stent (NuMed)

Heat tempered platinum-iridium wire,
arranged in a “zig” pattern,
laser welded at each joint and
over brazed with 24K gold,
atraumatic rounded leading and trailing edge
variable length (up to 50mm)
larger expandable diameter (25-30mm)
shortening < 20%

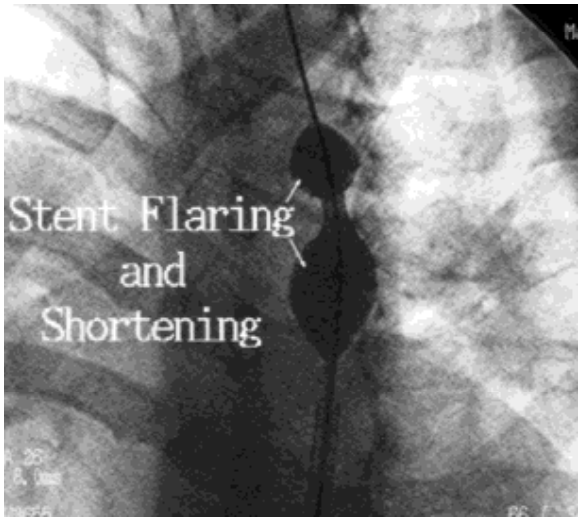


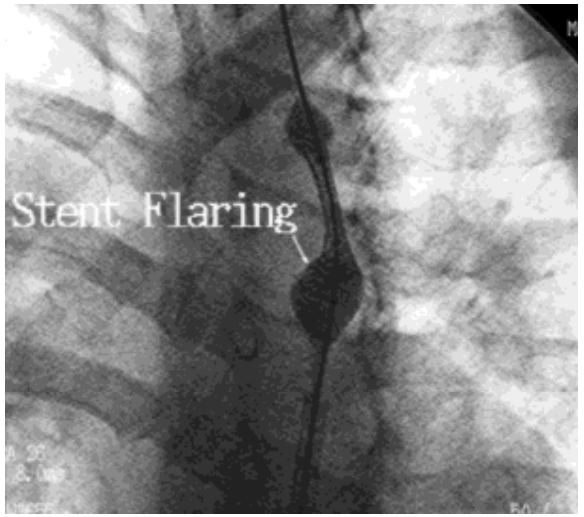


Catheter Cardiovasc Interv 2001;54:112-25

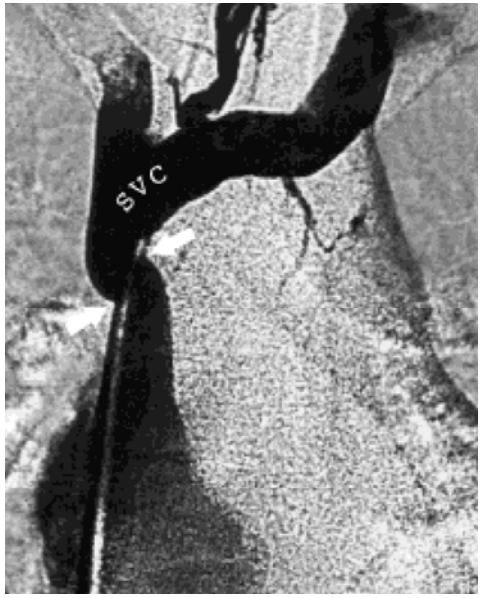
Balloons

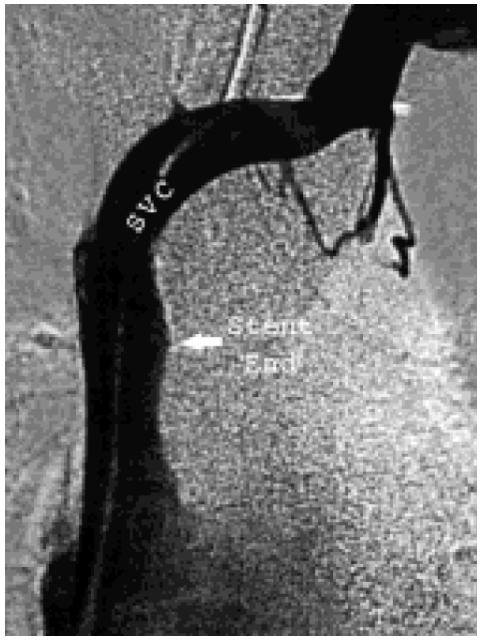
Single balloon - both ends protrude radially (flare)
->injury to the vessel -> aneurysm or dissection

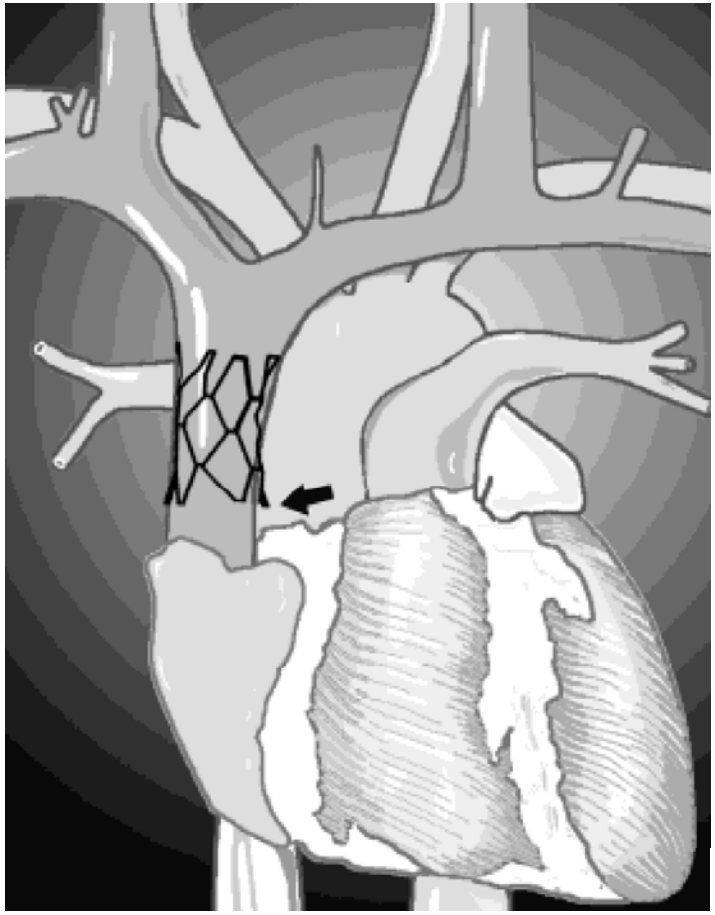




Catheter Cardiovasc Interv 2000;49:163-6







P308 mounted 16mm 3cm Z-Med balloon

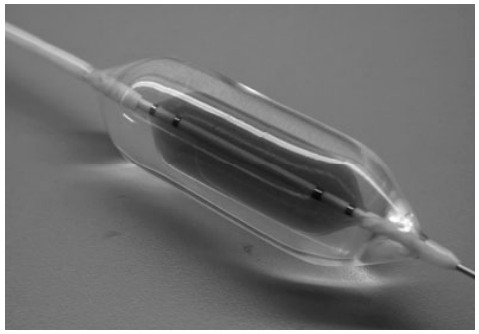
Catheter Cardiovasc Interv 2000;49:160-2

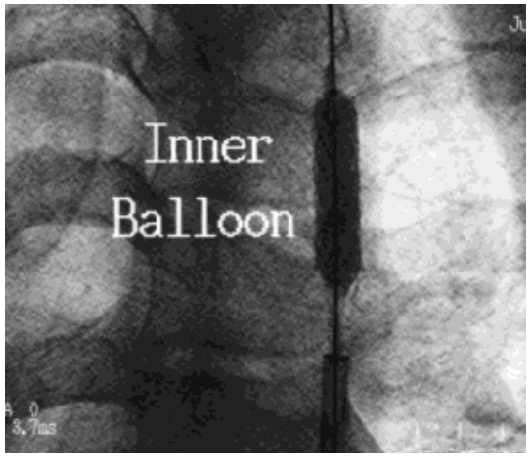
BIB balloon (NuMED) 1997 opens stent uniformly

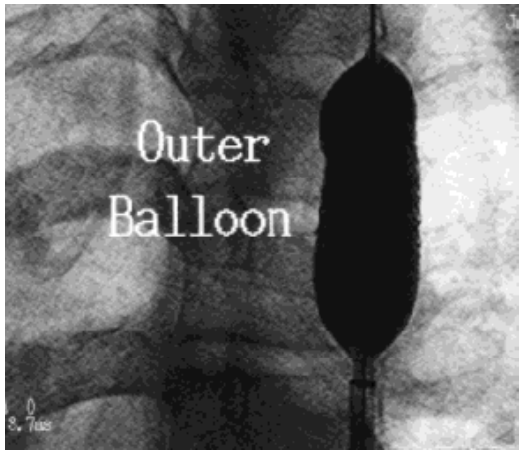
Inner balloon - thin compliant Tyshak,
half diameter, shorter than stent, 1cm shorter than outer balloon

Outer balloon - noncompliant Z-Med, same size with stent
ex P-308 -> inner 8mm * 2.5cm
outer 16mm * 3.5cm

-> no flaring, repositionable, minimizing shortening, rupture, trauma
minimizing stent migration
require large sheath (femoral artery injury risk↑)







Catheter Cardiovasc Interv 2000;49:163-6

Coarctation of the Aorta: Stenting in Children and Adults

Alex B. Golden,* MD, and William E. Hellenbrand, MD

Coarctation of the aorta may present in infants, children, or adults, and it requires treatment to prevent serious morbidity and mortality. Recent advances in equipment and a growing collective experience have made placement of balloon-expandable stents a safe and effective alternative to surgery or angioplasty in a growing range of patients. This review seeks to provide a working aid for stenting of coarctation of the aorta, based on the techniques and technical considerations in practice at our institution. Between 1989 and 2005, the Congenital Cardiovascular Interventional Study Consortium (CCISC), a consortium of 17 centers, of which our institution is the largest contributor, performed 588 stent placements for coarctation of the aorta. Of the 588 procedures, 580 (98.6%) were successful, as defined by reduction of the gradient to less than 20 mm Hg or increase of the ratio of the diameter of the coarctation area (CoA) to the diameter of the descending aorta (DAo) to at least 0.8. There were a total of 84 complications occurring in 69/588 (11.7%) cases. The most common significant complications were femoral access vessel related 15/588 (2.6%), aneurysm formation 13/588 (2.2%), aortic dissection 9/588 (1.5%), and cerebrovascular accident 6/588 (1.0%). There were two procedure-related deaths (0.3%) recorded in the 16-year period. Many of these significant complications occurred in the same patients. Balloon-expandable stents should be considered a safe and very effective treatment modality in a significant subset of patients with coarctation of the aorta.

Catheter Cardiovasc Interv 2007;69:289–99

General anesthesia used in: $n = 366$ pts	259 (70.8)[a]
Median of sheath size in Fr	11 [6–16][b]
Balloon type: $n = 423$ pts[c]	
Z-med	118 (27.9)
Cordis	71 (16.8)
Balloon in balloon	188 (44.4)
XXL	19 (4.5)
Other	27 (6.4)
Prestent angioplasty: $n = 449$ pts	79 (17.6)
Balloon dimension: $n = 565$ pts Mean ± S.D.	15.2 ± 3.6 mm
Median balloon:Coarctation ratio	2 [1.1–18]
Initial stent type: $n = 511$ pts	
P 8 series/P10 series	170/154
LD	14
EV3	16
Genesis	104
Cheatham-Platinum series	33
Covered stent	14
Others	6
Number of stents used per procedure: $n = 565$	
1 stent	517
2 stents	40
3 stents	5
4–5 stents	3

Complications 84 Cx in 69/588(11.7%)

Aortic wall complications (3.9%)

- intimal tear - 8/588 (1.3%)
- dissection, rupture - 9/588(1.5%)
  - 3covered stent, 3surgery, 3observation -> 2 death
- aneurysm - 13/588 (2.2%)
- risk factor - prestent angioplasty, abdominal aorta, age>40yrs, long segment

Technical complications (10.4%)

- stent migration - 25/588 (4.8%)
  - stent larger than prox Ao > 2mm
  - undersized balloon
  - oversized balloon
  - balloon rupture
  - large balloon >15mm
- fracture - 6 (4CP, 2Genesis) - 5 2nd stent
- balloon rupture - 13/588 (2.2%)
  - P8-series 9/13 (69%)

Peripheral vascular complication

- CVA 6/588 (1.0%) - old age↑
- peripheral emboli 1 (renal artery thrombosis)
- femoral vessel injury 15/588 (2.6%) - less than 6years
- overlap of vessels - 61 cases (17.8%)
  - mean 3.1yr f/u - no CVA or embolic event

Intermediate Follow-Up Following Intravascular Stenting for Treatment of Coarctation of the Aorta

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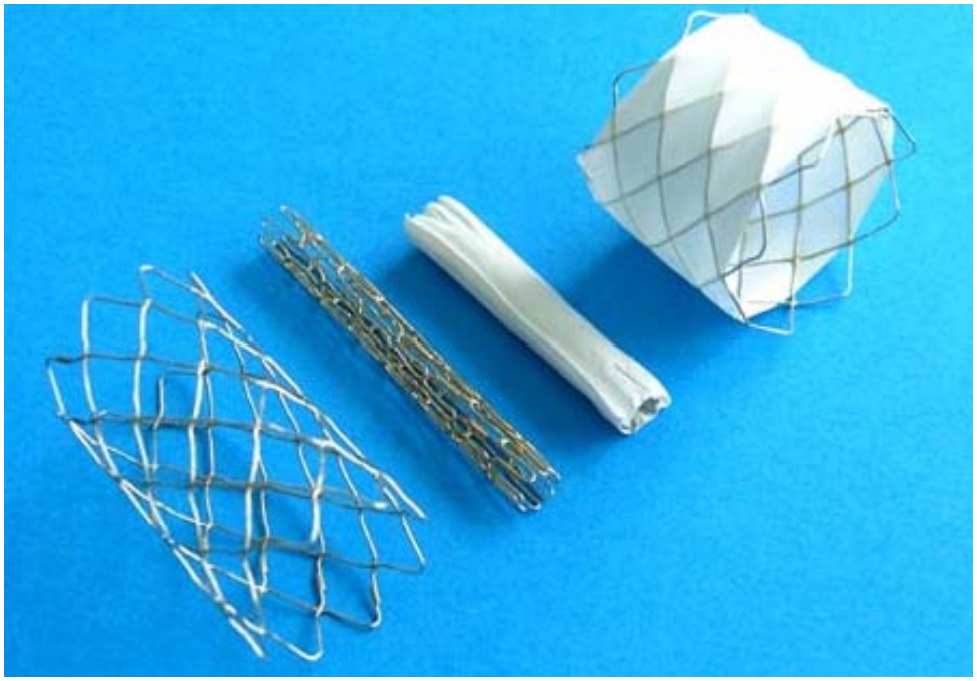
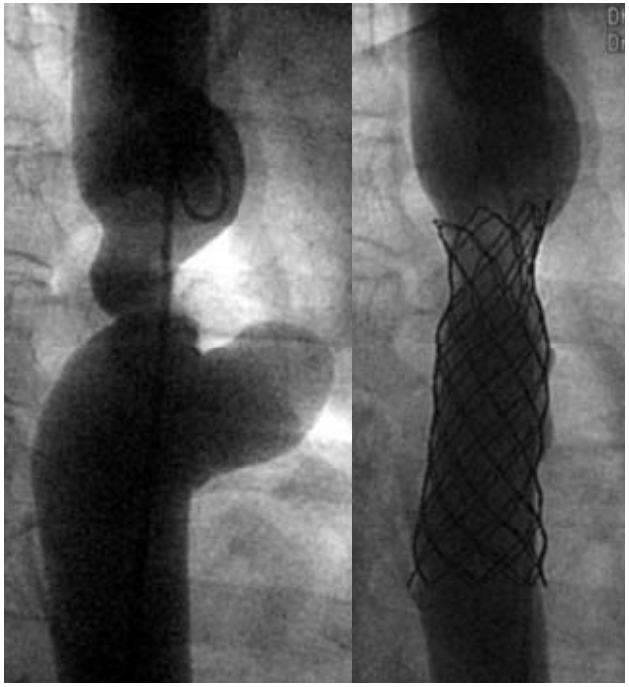
Background: We report a multiinstitutional study on intermediate-term outcome of intravascular stenting for treatment of coarctation of the aorta using integrated arch imaging (IAI) techniques. Methods and Results: Medical records of 578 patients from 17 institutions were reviewed. A total of 588 procedures were performed between May 1989 and Aug 2005. About 27% (160/588) procedures were followed up by further IAI of their aorta (MRI/CT/repeat cardiac catheterization) after initial stent procedures. Abnormal imaging studies included: the presence of dissection or aneurysm formation, stent fracture, or the presence of reobstruction within the stent (instent restenosis or significant intimal build-up within the stent). Forty-one abnormal imaging studies were reported in the intermediate follow-up at median 12 months (0.5–92 months). Smaller postintervention of the aorta (CoA) diameter and an increased persistent systolic pressure gradient were associated with encountering abnormal follow-up imaging studies. Aortic wall abnormalities included dissections (n = 5) and aneurysm (n = 13). The risk of encountering aortic wall abnormalities increased with larger percent increase in CoA diameter poststent implant, increasing balloon/coarc ratio, and performing prestent angioplasty. Stent restenosis was observed in 5/6 parts encountering stent fracture and neointimal buildup (n = 16). Small CoA diameter poststent implant and increased poststent residual pressure gradient increased the likelihood of encountering instent restenosis at intermediate follow-up.

Catheter Cardiovasc Interv 2007;70:569–77

Covered CP-Stent PTFE membrane (NuMED)

Subatretic native aortic coarctation
severe aortic coarctation or recoarctation, esp in adults
native aortic coarctation or recoarctation with aneurysm
aortic coarctation and PDA
collateral vessels creating R-L shunt in UVH
bailout in cases of complications in the catheterization laboratory





Covered Cheatham-Platinum Stents for Aortic Coarctation

Early and Intermediate-Term Results

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London, United Kingdom; Berlin, Germany; and Warsaw, Poland

OBJECTIVES This study sought to evaluate the use of covered Cheatham-platinum (CP) stents in the treatment of aortic coarctation (CoA).

BACKGROUND Aortic aneurysms and stent fractures have been encountered after surgical and transcatheter treatment for CoA. Covered stents have previously been used in the treatment of abdominal and thoracic aneurysms in adults. We implanted covered CP stents as a rescue treatment in patients with CoA aneurysms or previous stent-related complications and in patients at risk of developing complications because of complex CoA anatomy or advanced age.

METHODS Thirty-three covered CP stents were implanted in 30 patients; 16 patients had had previous procedures. The remaining patients had complex or near-atretic CoA.

RESULTS The mean patient age and weight were 28 (±17.5) years (range 8 to 65 years), and 62 (±13) kg (range 28 to 86 kg), respectively. The systolic gradient across the CoA decreased from a mean (±SD) of 36 ± 20 mm Hg before to a mean of 4 ± 4 mm Hg after the procedure ($p < 0.0001$), and the diameter of the CoA increased from 6.4 ± 3.8 mm to 17.1 ± 3.1 mm ($p < 0.0001$). The follow-up period was up to 40 months (mean, 11 months). All stents were patent and in good position on computed tomography or magnetic resonance imaging performed three to six months later. In 43% of the patients antihypertensive medication was either decreased or stopped.

CONCLUSIONS Covered CP stents may be used as the therapy of choice in patients with complications after CoA repairs, whereas they provide a safe alternative to conventional stenting in patients with severe and complex CoA lesions or advanced age.

J Am Coll Cardiol 2006;47:1457–63

Covered stents in patients with complex aortic coarctations

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Background There are limited data in the literature about the use of covered stent in patients with aortic coarctation.

Methods Between January 2004 and September 2006, we implanted covered Cheatham-Platinum stents in 33 patients with complex aortic coarctation (23 men, median age 13 years, range 6-66 years). Twenty subjects had native aortic coarctation, whereas 13 had recoarctation. All procedures were performed under general anesthesia and orotracheal intubation.

Results The stents used ranged from 22 to 45 mm in length. The mean fluoroscopy and procedure times were 14 ± 6 and 74 ± 15 minutes, respectively. After implantation, the gradient across the stenosis decreased significantly (pre stent: median value 39 mm Hg [range 20-75 mm Hg] vs post stent: median value 0 mm Hg [range 0-12 mm Hg] [$P < .0001$]). Vessel diameter increased from a median value of 5 mm (range 0-11) to a median value of 15 mm (range 10-25) ($P < .0001$). The stents were placed in the correct position in all subjects. No complications occurred, and on angiographic control, the stenoses had been relieved and the aneurysms completely excluded. During a median follow-up of 12 months (1-40 months), the results were stable without complications. One patient developed intrastent restenosis due to a significant endothelial proliferation that was successfully treated by high-pressure balloon angioplasty.

Conclusions Covered Cheatham-Platinum stents are promising tools for the treatment of complex aortic coarctation.

Am Heart J 2007;154:795–800

Aortic Rupture following a Covered Stent for Coarctation: Delayed Recognition

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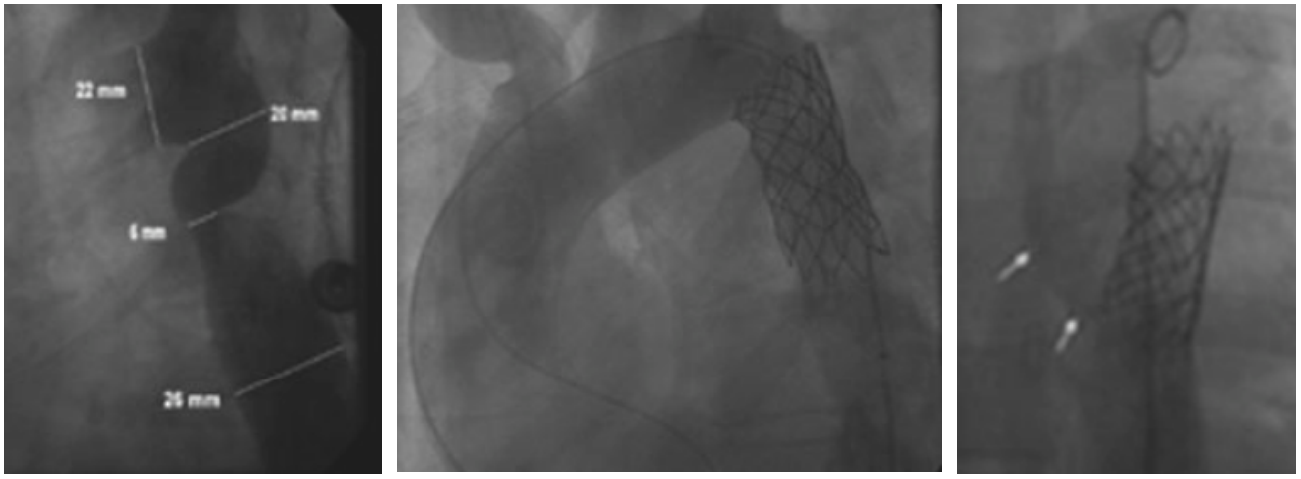
Primary stenting for aortic coarctation is frequently used in adult patients. Aortic rupture remains an infrequent complication. A number of strategies, including the use of covered stents, have been proposed to reduce the risk of this catastrophic complication. We describe a 51-year-old female who underwent stenting of aortic coarctation using a covered stent, which was complicated by aortic rupture. Treatment consisted of placement of an additional covered stent to seal the site of aortic disruption. The prevention and management of aortic rupture complicating aortic coarctation stenting are discussed.

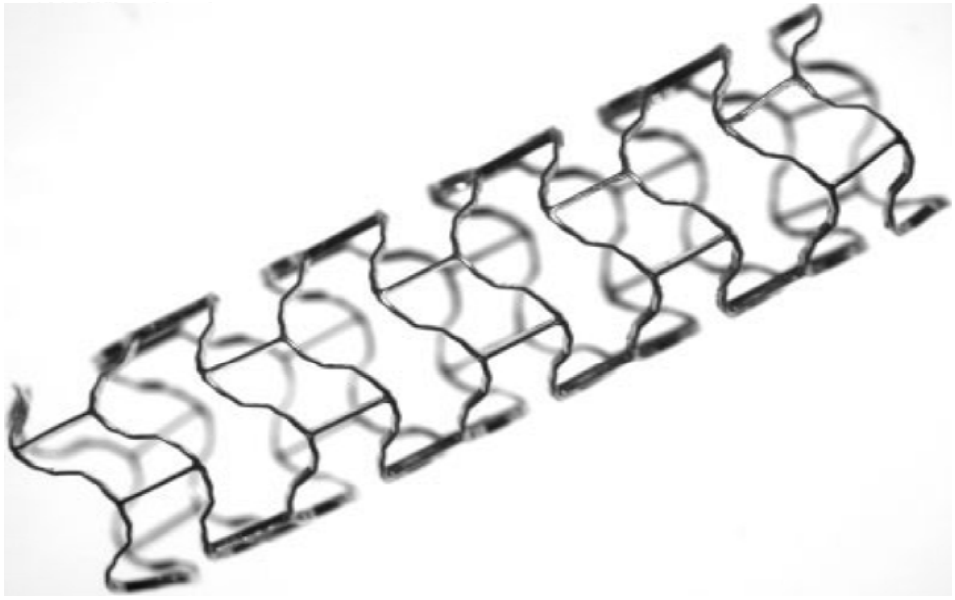


Catheter Cardiovasc Interv 68:2006

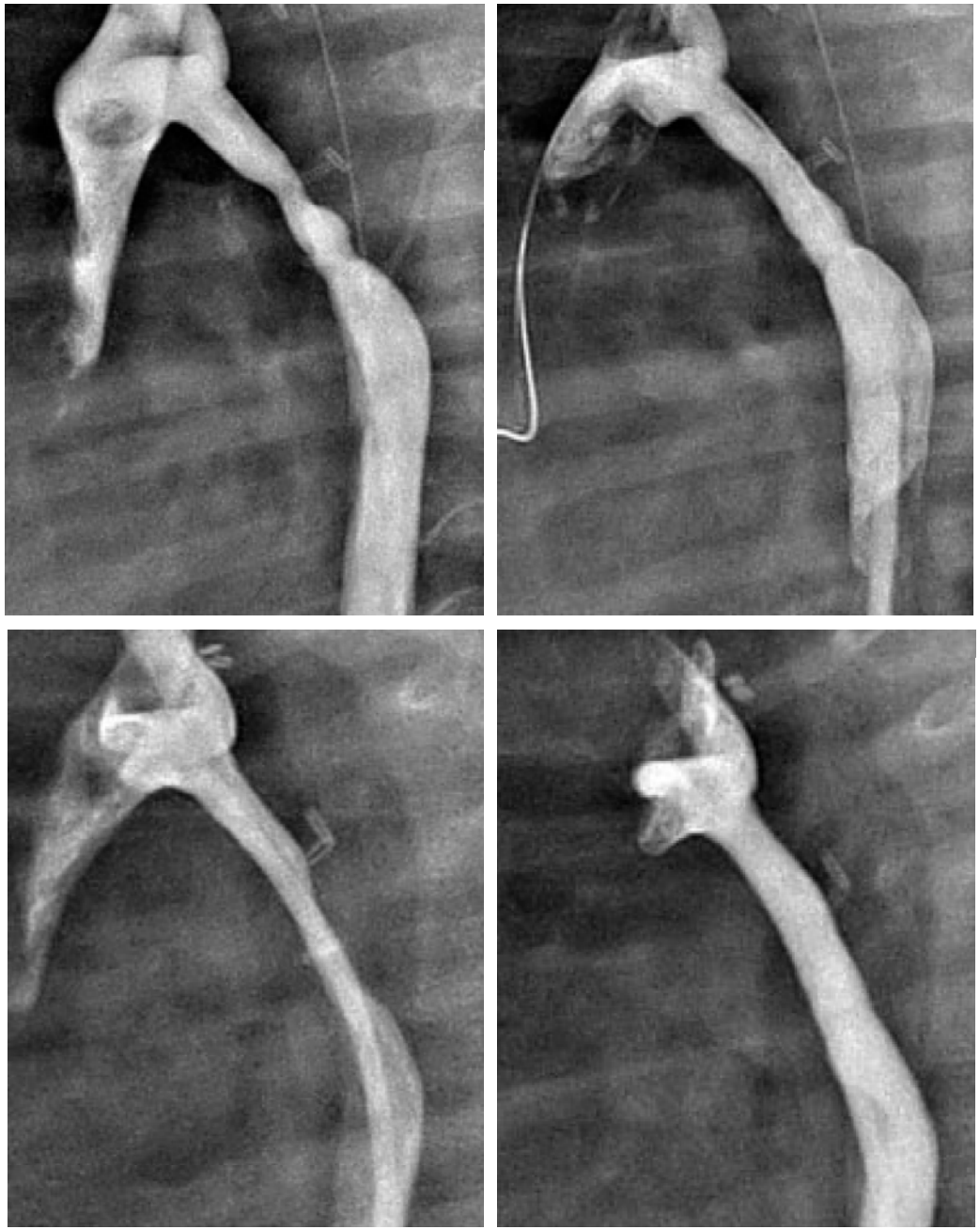
Bioabsorbable Metal Stents for Percutaneous Treatment of Critical Recoarctation of the Aorta in a Newborn

Dietmar Schranz,* MD, Peter Zartner, MD, Ina Michel-Behnke, MD, and Hakan Akintürk, MD

In neonates and infants with critical aortic coarctation, balloon angioplasty is considered for rescue therapy of heart failure. The use of conventional stents is limited because of further vessel growth, the need of redilation, and later surgical removal. However, a novel bioabsorbable magnesium stent (AMS) might overcome such restrictions of vessel stenting in newborns. Presented is the first use of an AMS for acute treatment of a newborn with severely impaired heart function due to a long segment recoarctation after a complex surgical repair. We hypothesize that bioabsorbable stents will dramatically change the treatment of coarctation and recoarctation in newborns.



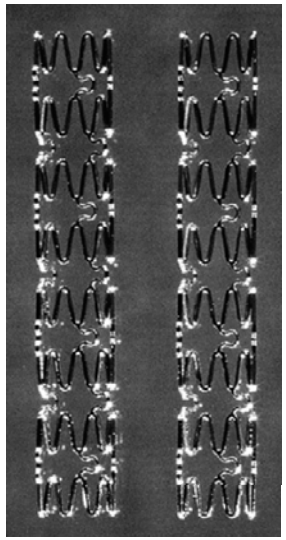
Catheter Cardiovasc Interv 2006;67:671–3



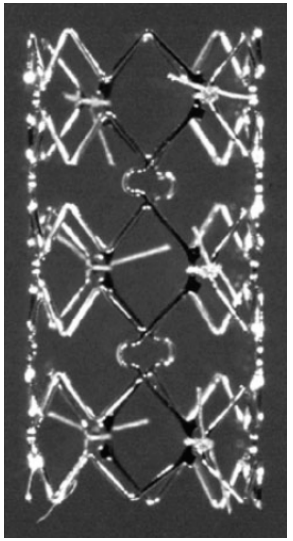
Catheter Cardiovasc Interv 2006;67:671-3

Early and Mid-Term Results With the Growth Stent—A Possible Concept for Transcatheter Treatment of Aortic Coarctation From Infancy to Adulthood by Stent Implantation?

Peter Ewert,* MD, PhD, Bjoern Peters, MD, Nicole Nagdyman, MD, Oliver Miera, MD, Titus Kühne, MD, PhD, and Felix Berger MD, PhD



Aims: Evaluation of the Growth Stent—a stent consisting of two stent halves connected by reabsorbable sutures—for the treatment of aortic coarctation in infants. Methods and Results: Surveillance study of 13 Growth Stents implanted in 12 patients aged 1–15 months (median 5 months). Body weight ranged from 3.4–12.8 kg (median 5.4 kg). Eight patients suffered from aortic (re-)coarctation, four of them from stenosis of the aortic anastomosis after a Norwood I procedure. The follow-up period was 24 months (11–51 months). Pressure gradients immediately after stent implantation decreased from 30 mm Hg (range 20–50 mm Hg) to 8 mm Hg (range 0–15 mm Hg). Five patients had one (3 pts) or two (2 pts) balloon dilations 3–28 months (median 12 months) after Growth Stent implantation. The median pressure gradient decreased from 25 mm Hg (range 15–30 mm Hg) to 15 mm Hg (range 5–25 mm Hg). Six patients received a large stent after 19–34 months. Median body weight was 11.8 kg (9.4–15 kg). Conclusions: The Growth Stent is suitable for the acute treatment of aortic coarctation in infants and can be overstented later on—if necessary—with a larger stent without causing restriction.



Catheter Cardiovasc Interv 2008;71:120–6

Summary(1)

1. Careful sizing is crucial
2. Choice of balloon used to deploy the stent should not be more than the diameter of the isthmus or the aorta at the level of the diaphragm
3. Covered stent will be more safe
4. If the covered stent is not available, stent should not expanded to more than three times the diameter of the coarcted segment and do not exceed the diameter of isthmus or aorta at the level of diaphragm
5. Avoid prestent angioplasty

Summary(2)

(1) Neonate, infancy native CoA - Surgery

(2) Recurrent CoA - BAP for most in infants and children < 1yr

(3) 1year ~ time when the child reaches 30-35 kg (9-11 years)

- insufficient data for native lesions

balloon angioplasty is the treatment of choice recurrent CoA

(4) more than 35 kg who have not yet reached adult size

- stent placement for native and recurrent lesions

(5) adult-sized adolescents and adult patients - stent placement

(6) advanced age, young adults with vasculitis or vasculopathy, Turner synd - high risk of life-threatening complications

(7) Complete resolution is favorable

(8) Serial, long term f/u is needed

(9) Anticipate the development of more intelligent stent and balloon catheter

Thank you for your attention!