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AD-COR Program inovativ de formare in domeniul cardiologiei pediatrice
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MODUL TEORETIC

Hybrid Approach in Congenital Heart Diseases

Imputernicit: Prof. Dr. Tammam Youssef

Activitate prestata de I.R.C.C.S. POLICLINICO SAN DONATO – MILANO, ITALIA in baza contractului nr. 18/22144/29.07.2015

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Beneficiar: Universitatea de Medicină și Farmacie „Carol Davila” București

Hybrid Approach in Congenital Heart Diseases

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Background

- Current trends in treatment of congenital heart malformations aim to adopt minimally invasive strategies to:

- avoid palliative interventions vs primary repair
- reduce overall complexity of therapy
- improve final result and long-term outcome
- reduce patient/family as well as social burden of any treatment
- increase cost-effectiveness and quality of care

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- In general, a hybrid can be defined as:

- an offspring of two animals or plants of different breeds, varieties, species, or genera, especially as produced through human manipulation for specific genetic characteristics

- a person or group of persons produced by the interaction or crossbreeding of two unlike cultures, traditions, etc

- anything derived from heterogeneous sources, or composed of elements of different or incongruous kinds

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- In ancient Greek mythology, the Minotauros, a monster with a human body and a bull's head, was the most famous of these hybrid creatures

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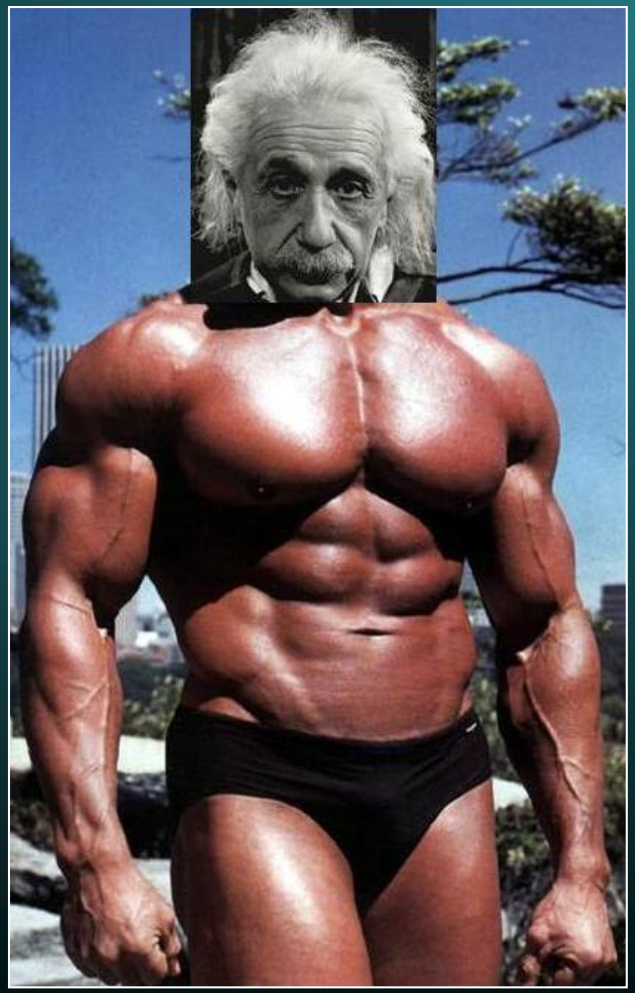
- However, the main goal in creating a "hybrid" should be to obtain a whole that combines the best of either components



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- The hybrid therapy is an emerging field of cardiology in which skills and techniques of both interventional cardiologist and cardiac surgeon are combined to reduce complexity of repair and improve patient outcome

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- Hybrid Interventional/Surgical Approach is defined any combined catheter-based and surgical intervention performed in one setting or in a planned, close sequential fashion
- It typically incorporates an open approach to delivery a device

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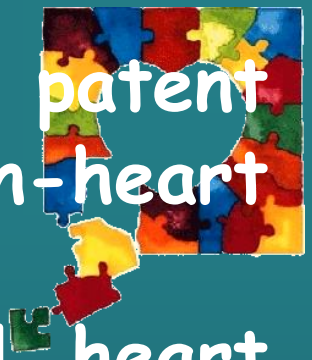
History



- Bhati BS, et al. Closure of patent ductus arteriosus during open-heart surgery. *JTCS, 1972.*
- Fishberger SB, et al. Congenital heart disease: intraoperative device closure of VSDs. *Circulation, 1993*
- Mendelsohn AM, et al. Intraoperative and percutaneous stenting of congenital pulmonary artery and vein stenosis. *Circulation, 1993*
- Gibbs JL, et al. Stenting of the arterial duct combined with banding of the pulmonary arteries and atrial septectomy or septostomy: a new approach to palliation for the HLHS. *Br Heart J 1993*

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Present Domains of Hybrid Therapy

- Muscolar VSD closure in low-weight or high-risk patients using per-ventricular or open heart approach and percutaneous devices
- Vascular stent implantation in clinical or anatomical challenging cases through cardiac or vascular surgical exposure

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- Hypoplastic Left Heart Syndrome palliation or HLHS-like in high-risk neonates destined to Fontan track or as temporary bridge toward biventricular repair
- More and more … based on creativity and concord of the "therapeutic team"

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- ***Current perspectives***

→ valve perforation/angioplasty (critical PV stenosis/atresia; PA-VSD; aortic stenosis) in low-weight or critical patients

→ off-pump valve replacement

→ aortic coarctation angioplasty or stenting in complex cases

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→ per-atrial ASD septal closure (complex cases in low-weight patients; during complex hybrid or conventional surgery)

→ peri-membranous VSD closure

→ intra-operative device interventions before/during/after "complex" surgical procedures

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Indications

- *Clinical*

→ low-weight patients (vascular access, patient/material size mismatch, etc)
→ co-morbidities (need for major or multiple surgical approaches, etc)
→ clinical unstability (basal or anticipated during percutaneous procedures)

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- ***Anatomical***

→ poor vascular access (patient size, previous vascular accesses, etc)
→ tortuous vascular/cardiac course to the target lesion
→ unusual septal orientation

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- *Techinical*

→ associated lesions requiring surgical repair
→ need for multiple surgical accesses in the same procedure
→ anticipated further surgery (cardiac or extra-cardiac)

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Theatre

Hybrid Suite

DIFFERENT FROM CARDIAC CATHETERIZATION LABORATORY AND CARDIO-THORACIC SURGERY OPERATING ROOM THERE ARE NOT FORMAL LEGAL CRITERIA TO BE MET FOR SETTING-UP A HYBRID THEATRE !!!!!

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Actually, in most Centres, because an Hybrid OR doesn't exist, most interventional procedures are performed during a Cardiac surgical procedure in a traditional OR with a portable fluoroscope

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- Before planning a hybrid operating room, a clear vision for the utilization should be established
- Commonly, the theatres are in interdisciplinary usage by interventionalists, anesthesiologists, and cardiac surgeons
- The multitude of requirements determines necessary resources, location, space, and imaging equipment

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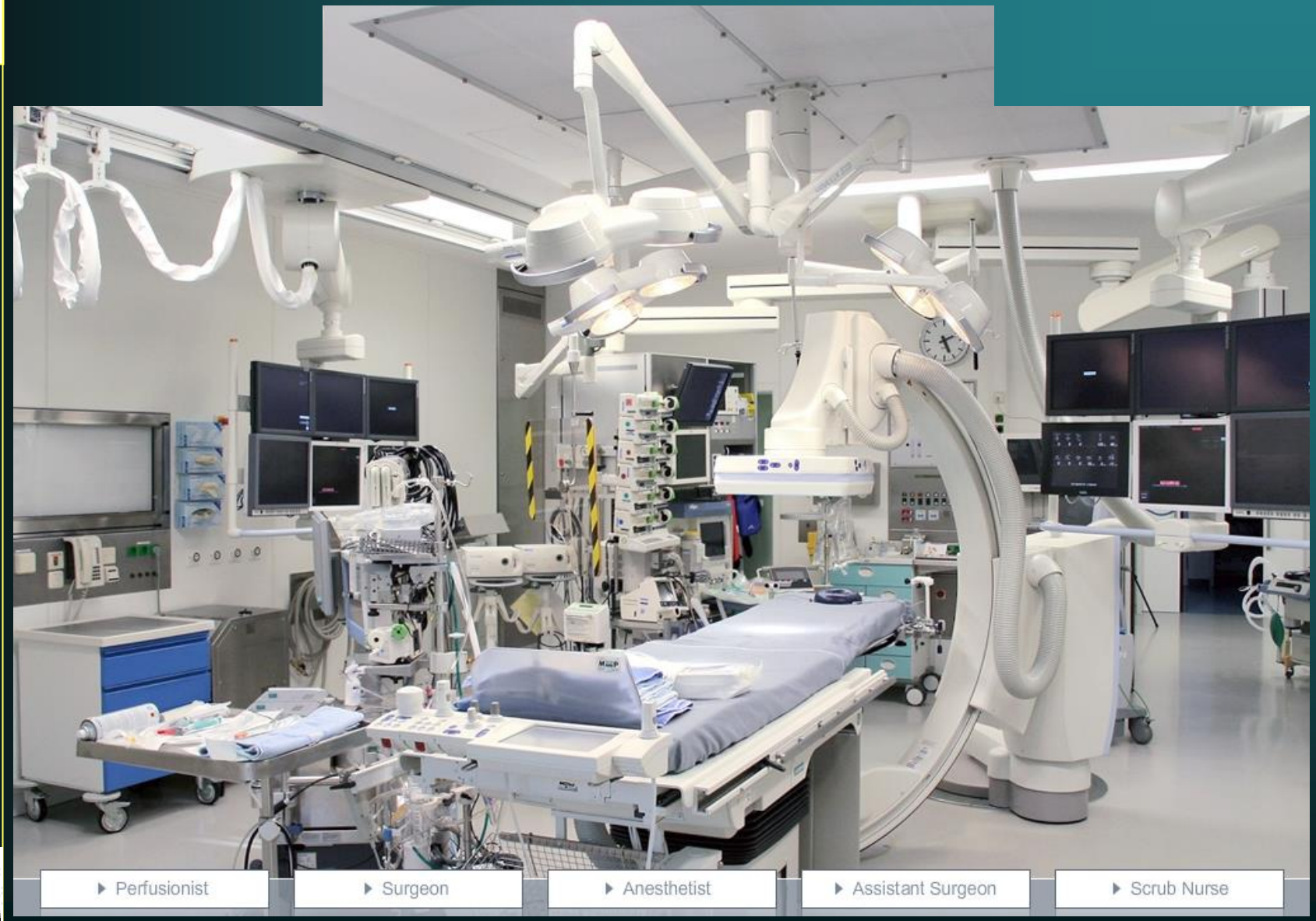
Perfusionist
Surgeon
Anesthetist
Assistant Surgeon
Scrub Nurse

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Hybrid Operating Room Logistic Requirements

- OR wide space necessary to locate:

- complete ECC pump
- tables for surgery and catheterization
- sophisticated invasive monitoring
- overhead surgical lights and accesses
- large number of infusion pumps
- ECMO availability, counterpulsation etc

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- Positive-pressure laminar air-flow (surgical standards) due to the presence of multiple operators and machines

- Temperature control for hypothermic procedures

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- "Imaging" boom including:

• surgical X-ray compatible tilting-table
• high-quality imaging machines (biplane angiography, echocardiography with TEE)
• electro-physiologic mapping traces

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- Audio-visual facilities:

• monitor screens (angiographic and echocardiographic images, physiologic monitoring data, electro-physiologic mapping traces)

• observation surgical cameras

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- Induction/Awake room with monitoring
- Remote control room
- Anaesthesia boom including anaesthetic gasses (also NO), suction and waste scavenging requirements

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Operators needed during an Hybrid surgical procedure:

- 2 cardiac surgeons
- 1 interventional cardiologist
- 1 echocardiographer
- 1 anaesthesiologist
- 4 nurses
- 1 perfusionist
- 1 radiology technician

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Moreover, because there isn't already a real consensus on indications and methods, the hybrid procedures are almost the result of "invention" and inter-personal collaboration between Interventional Cardiologist and Cardiac Surgeon

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A hybrid strategy is characterized by the use of "real-time feedback" intra-operative imaging techniques during a surgical procedure as opposed to perform it on a flaccid heart and "checking the results afterwards"

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Hybrid Approach for per-ventricular MVSD closure: technical notes

→ sternotomic (or mini-thoracotomic or sub-xyphoid) approach

→ RV free wall exposure and purse string suture placement opposite to the VSD perpendicular to the septum

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→ RV wall needle puncture through the pulse string

→ guide-wire probing the VSD and entry inside the LV

→ vascular sheath entry over the guide-wire

→ device deployment under TEE-guide

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- ***Advantages vs conventional surgery***

→ minimal incision (potentially sub-xyphoid)

→ "off-pump" intervention or decrease by-pass time

→ easier approach to apical MVSD (avoiding ventricular incision and transection of the moderator band or other muscle debriding procedures)

→ real-time evaluation of the results by intra-operative TEE/angiography

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M.A. 6 months 5 Kg

DORV + muscular inlet VSD + multiple muscular apical VSD

Hybrid procedure

- First: Perventricular device closure of apical VSD through RV free wall puncture
- Second: Total correction of DORV and closure of muscular inlet VSD with ECC

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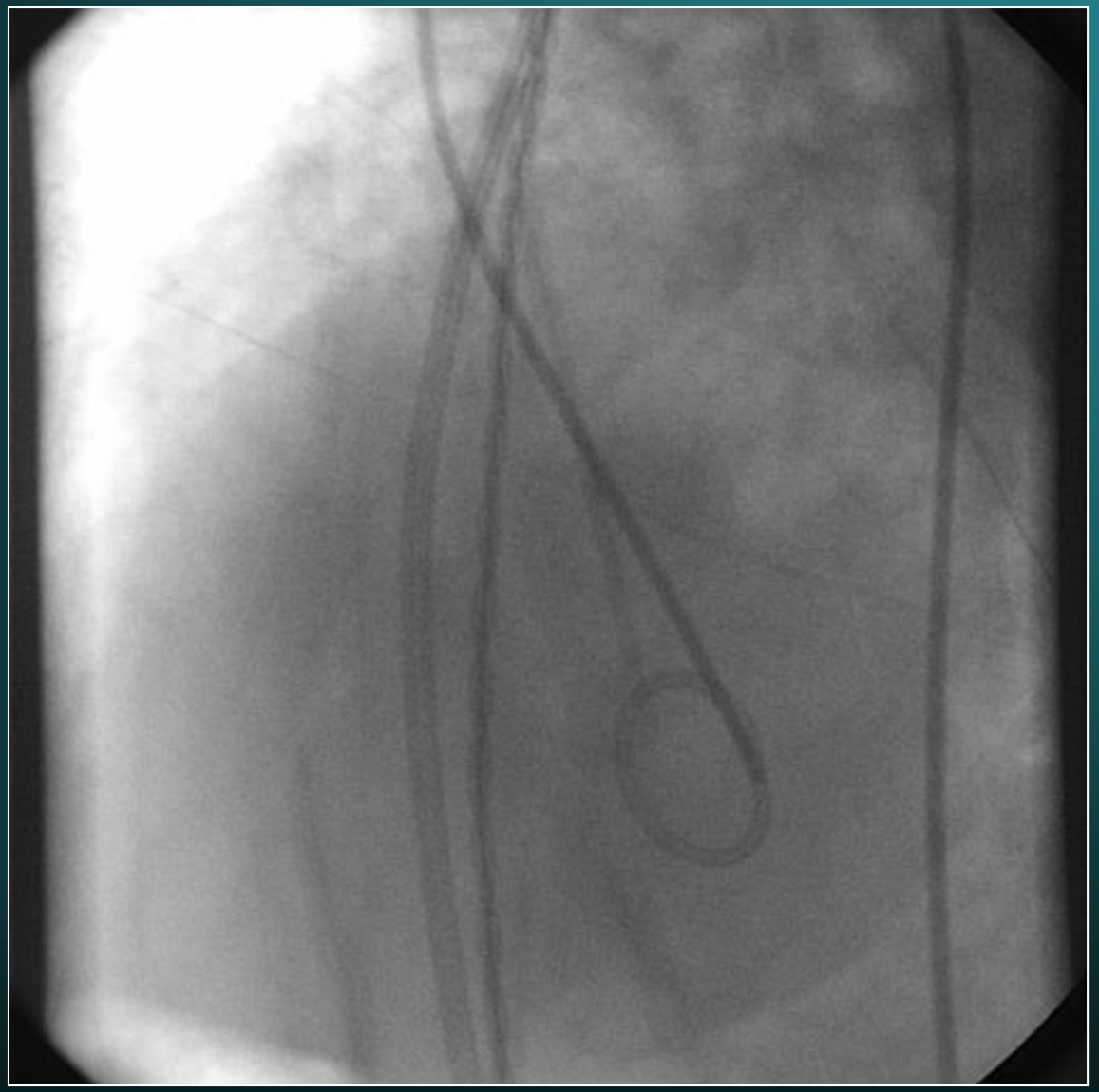

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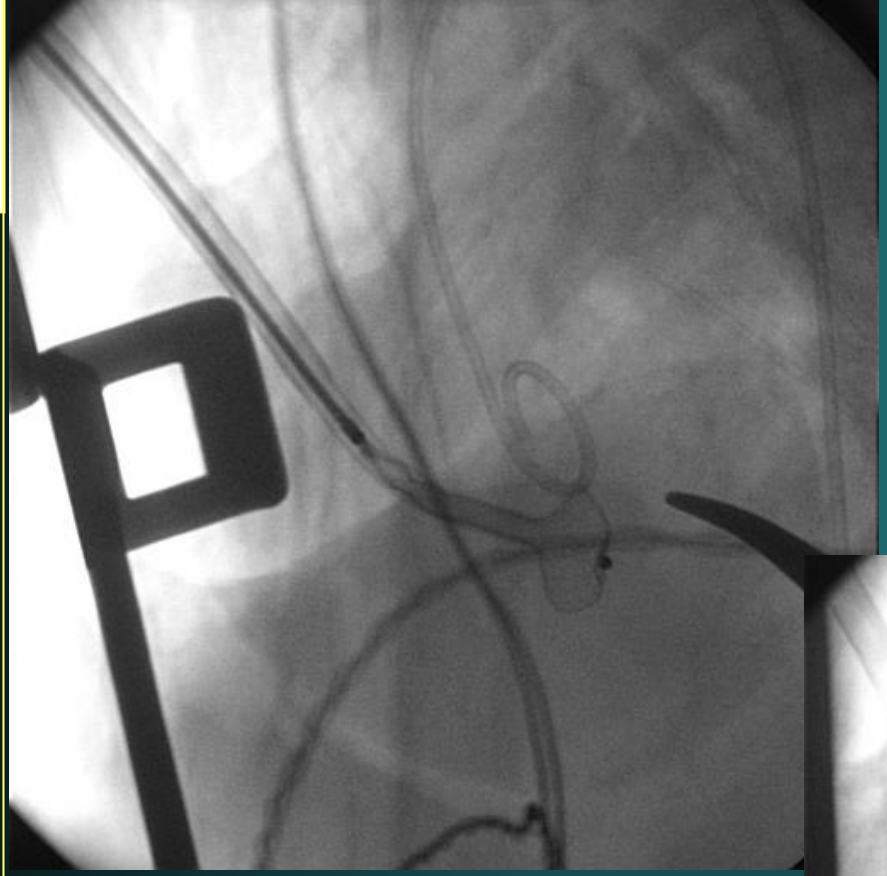

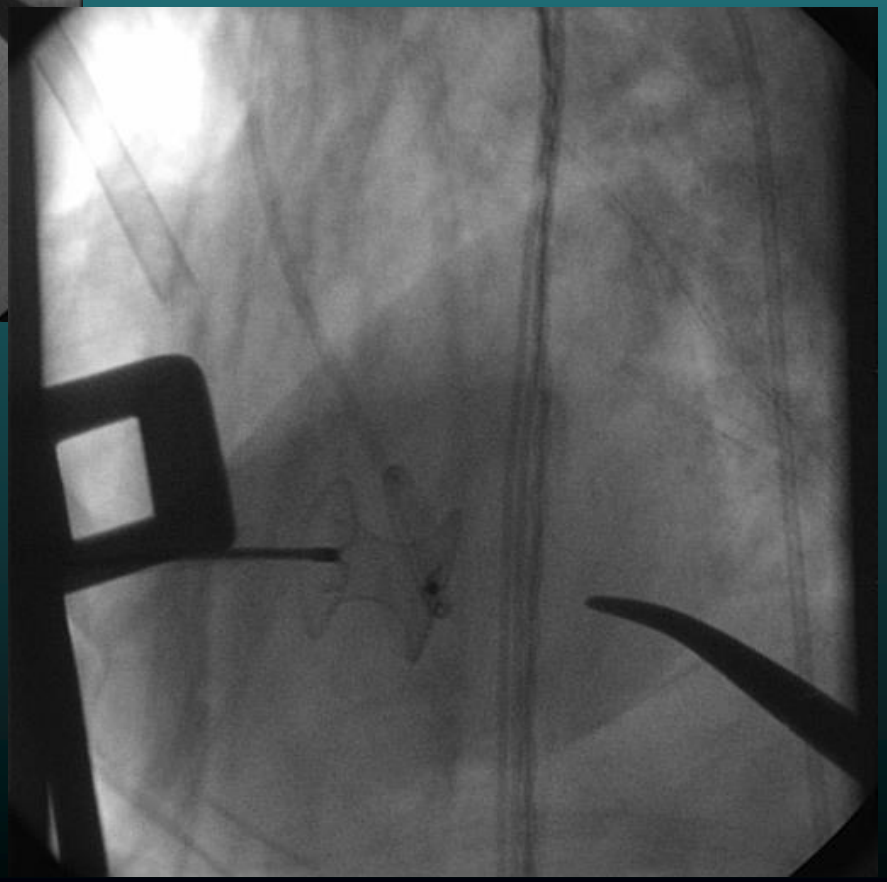

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➢ *Advantages vs conventional cath*

→ free access to the ventricular septum regardless of patient size/VSD location

→ straighter course to the target lesion (critical in unstable patients)

→ no limitation for large delivery sheaths or unusual septal orientation

→ better management of complications (device embolization, AV valve malfunction, etc)

→ possibility of rescue (VSD) surgery or concomitant surgical repair

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➢ *Results*

→ 5 pts (age 4-41 mos; wt 6.2-13 kg)
→ success rate: 100%
→ complication rate: 0%
→ residual shunt: 20% (1 pts)

Murzi B, et al. EJCTS 1997

→ 6 pts (age 17 days-3 ys)
→ success rate: 100%
→ complication rate: 0%
→ residual shunt: 12.5% (1 pt)

Bacha EA, et al. JTCS 2003

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→ 8 pts (age range 2-41 wks; weight range 3-6.6 kg)
→ success rate 100%
→ complication and mortality rate 0%

Crossland DS, et al. CCI 2008

→ 20 pts (8 perventricular, age 3 days-12 mos, weight 3.2-8.9 kg)
→ success rate: 95%
→ complication rate: 20%
→ mortality: 0%
→ residual shunt: 0%

Diab KA, et al. Heart Surg Forum 2009

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➢ *Intra-operative pulmonary vessel stenting: technical notes*

→ sternotomic or mini-thoracotomic approach
→ vascular exposure
→ purse string suture placement, guide-wire entry and vascular sheath insertion

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→ angiographic visualization in multiple views to choose the stent lenght/diameter

→ guide-wire negoziation of the stenosis

→ stent deployment under direct vision or fluroscopic/angiographic guide

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➢ *Advantages vs conventional surgery*

→ "off-pump" intervention or decrease by-pass time

→ easier treatment of distal and/or complex vascular stenoses

→ better structural support to the repaired PA (either vascular wall collapse or external compression)

→ real-time evaluation of the results by intra-operative angiography

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F.V. 15 years

TGV – S/P Mustard (6 months of age)

Sub-occlusion of the left Pulmonary Veins

Hybrid procedure

- Left Thoracotomy
- Stent insertion in the left PV and the left side of the Mustard channel

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- ***Advantages vs conventional cath***

→ free access to circulation regardless anatomic issues

→ straighter course to the target lesion in tortuous vessels

→ no limitation for large delivery sheaths

→ use of stents of "adult" diameter (or potentially re-expandable to "adult" size)

→ better management of complications (vessel tear, balloon rupture, stent migration, etc)

→ possibility of concomitant surgery

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Results

- 15 pts (<10 kg or associate surgery)
- success rate: 100%
- complication rate: 0%

Mendelsohn AM, et al. Circulation 1993

- 27 pts (age 7 days-14 yrs; wt 2.2-41.7 kg)
- success rate: 100%
- mortality rate: 19%

Ungerleider RM, et al. Ann Thorac Surg 2001

- 11 pts (age 7 days-12 yrs; wt 2.5-20 kg)
- success rate 100%
- mortality rate: 9% (1 pt)

Bokenkamp R, et al. EJCTS 2005

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→ 24 pts (age range 3-67 ys) during concomitant surgery
→ success rate 100%
→ complications: 8.3% (stent migration)
→ mortality: 0%

Menon SC, et al. Am J Cardiol 2008

→ 20 pts (median age 5.1 ys)
→ 15 cases under direct vision; 3 cases angiographic guide; 2 cases direct vision and fluoroscopy
→ success rate: 90% (2/20 pts)
→ complications: 5.6% (1/18 pts)

Holzer RJ, et al. CCI 2008

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➢ *When could the INTERVENTIONAL CARDIOLOGIST enjoy the Surgeon co-work in hybrid fashion?*

→ to find the vascular entry in very small patients

→ to make straighter and smoother the course to the target lesion in anatomic challenging cases or unstable patients

→ to have a closer access to the cardiac lesion in the case of vessel entry/delivery catheter mismatch or lack of realiable vascular entries

→ to enjoy a "psycological" and emergency support in high-risk settings

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- 5 day-old premature, very low-weight neonate (1.4 kg) with complex CHD
- PA discontinuity with duct-dependent pulmonary circulation (bilateral ducts)
- ADs stabilization through the right carotid artery approach (surgical cut-down) using multiple chromium-cobalt coronary stents dilated to 3.2 mm
- procedural time 160 min, fluroscopic time 16 min

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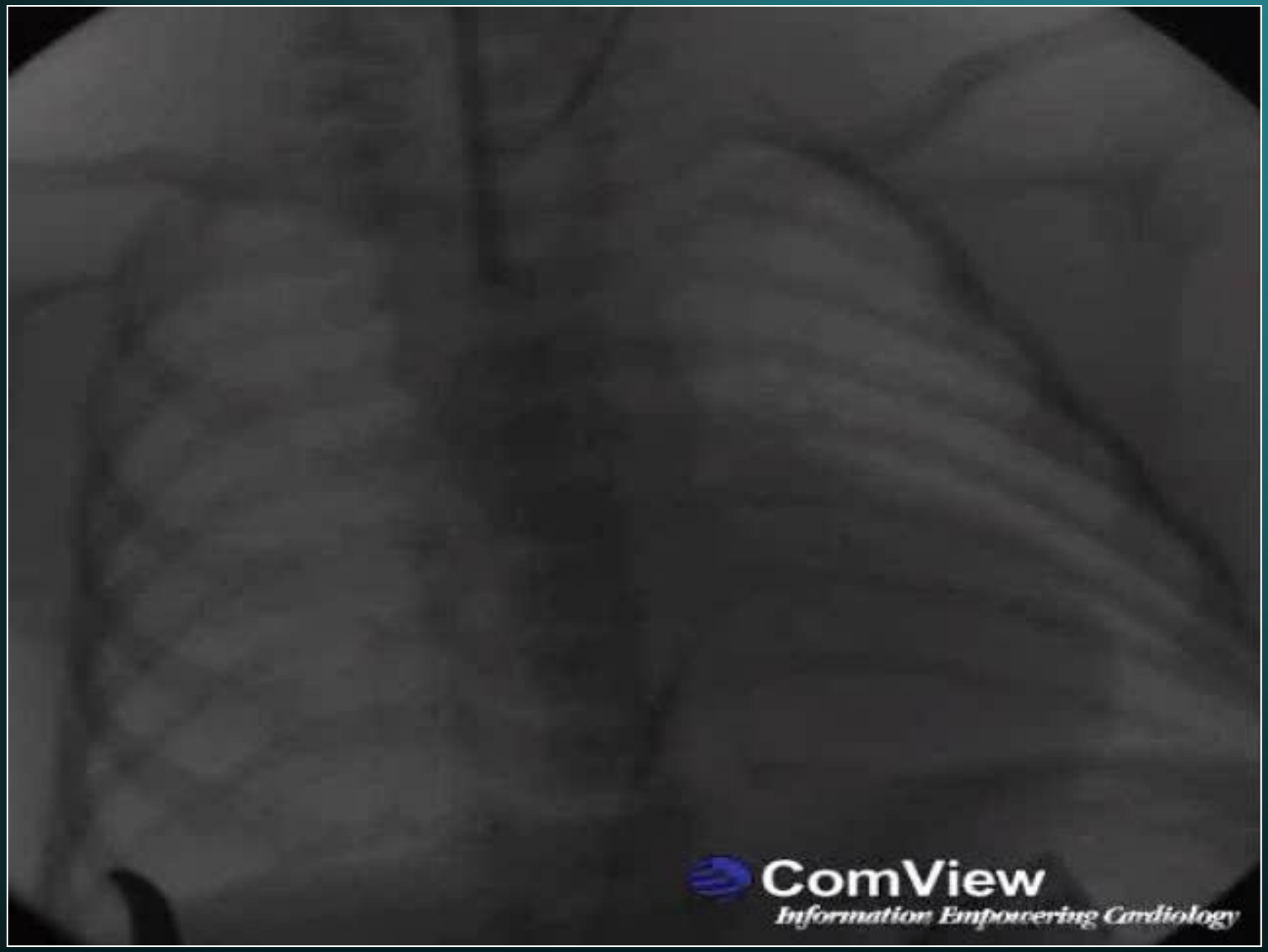

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- 2 week premature, very low-weight neonate (1 kg) with critical pre-isthmic aortic coarctation/hypoplasia
- difficult management with PGE
- obstruction relief through the left carotid artery approach (surgical cut-down) using a chromium-cobalt coronary stent dilated to 4.8 mm
- procedural time 180 min, fluroscopic time 13 min

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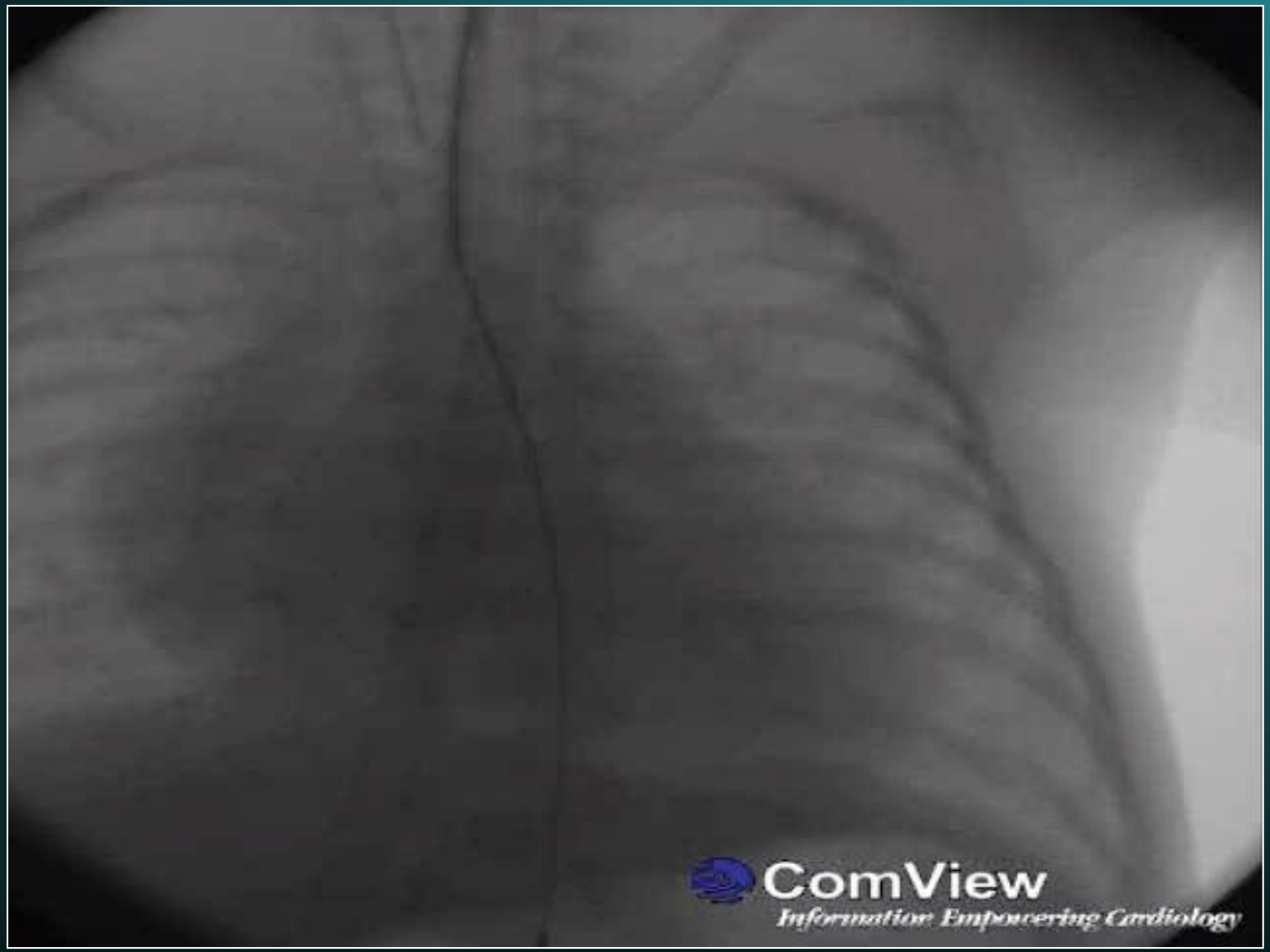

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➢ *When could the CARDIAC SURGEON enjoy the Interventional Cardiologist co-work in hybrid fashion?*

→ to avoid ECC o reduce by-pass time

→ to reach very far target lesions

→ to fix easier challenging malformations

- apical VSD or multiple VSDs
- re-do plasty of peripheral pulmonary vessels
- bail-out therapy of "failed" cases
- minimally-invasive treatment of PA-VSD and severely hypoplastic PAs

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S.R. 1 month 3.2 Kg

Pulmonary atresia and VSD

Hybrid procedure

- Median sternotomy
- Through RV free wall, puncture of the PA and coronary stent insertion in the infundibulum and pulmonary trunk

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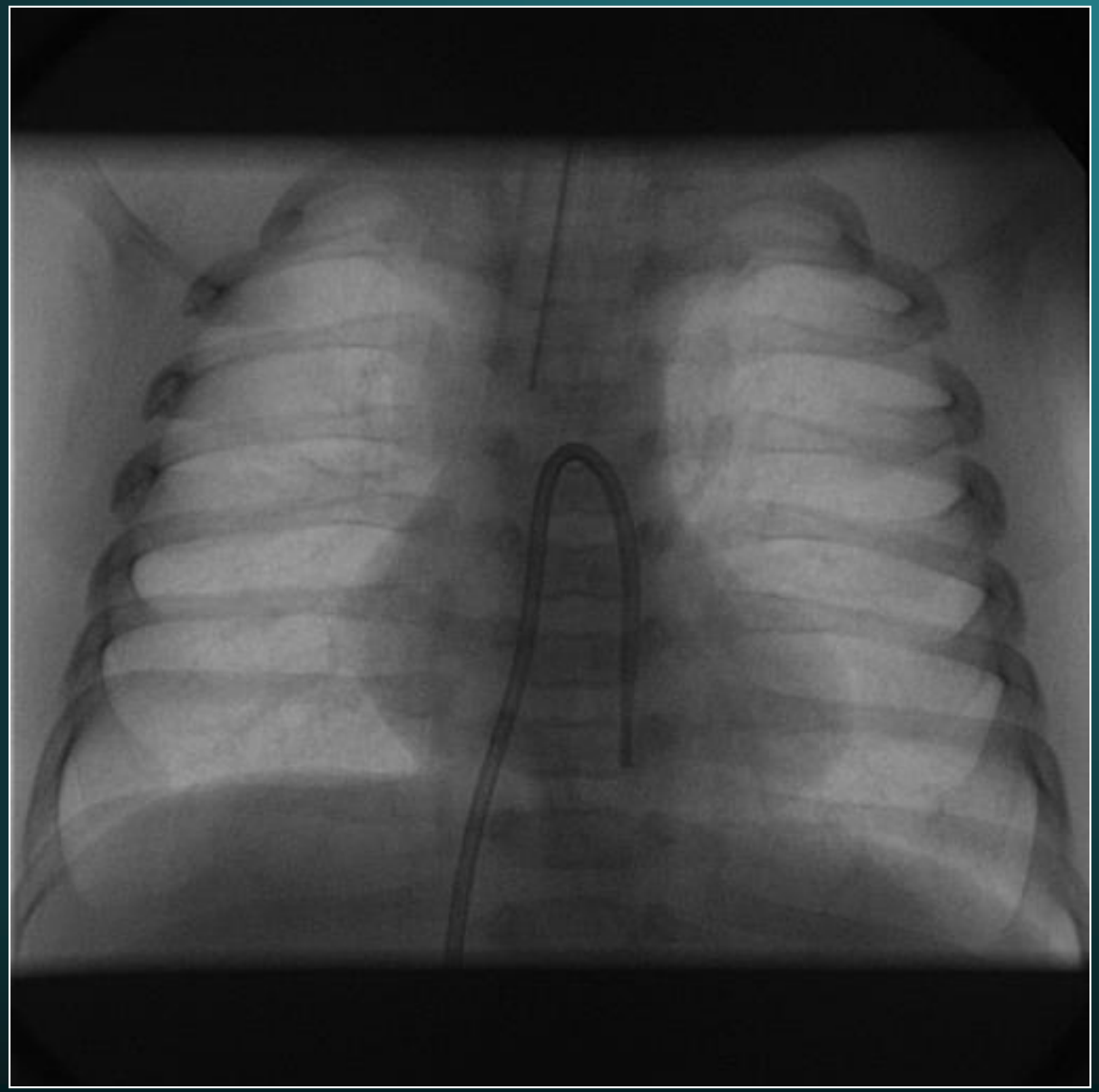

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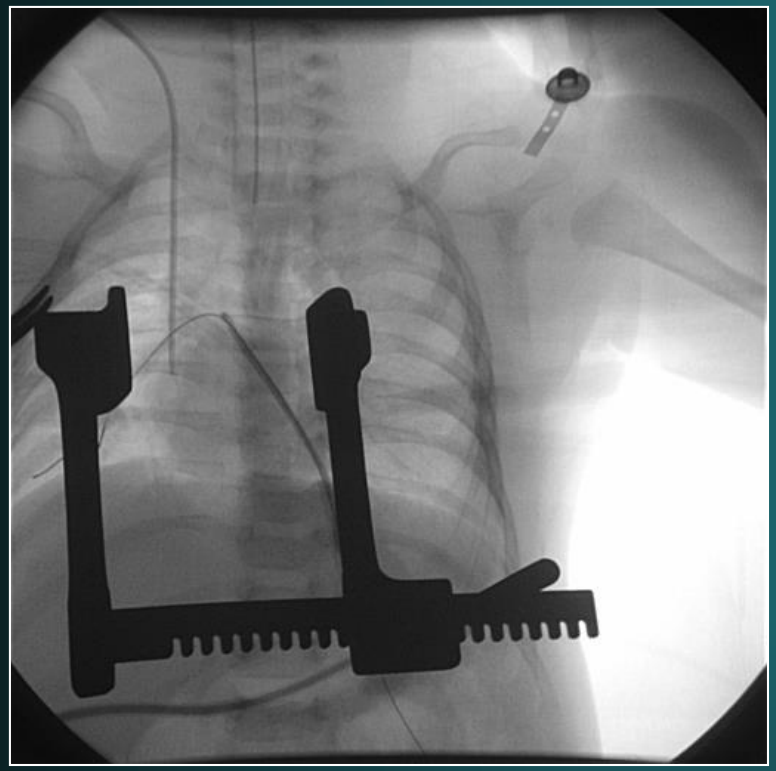

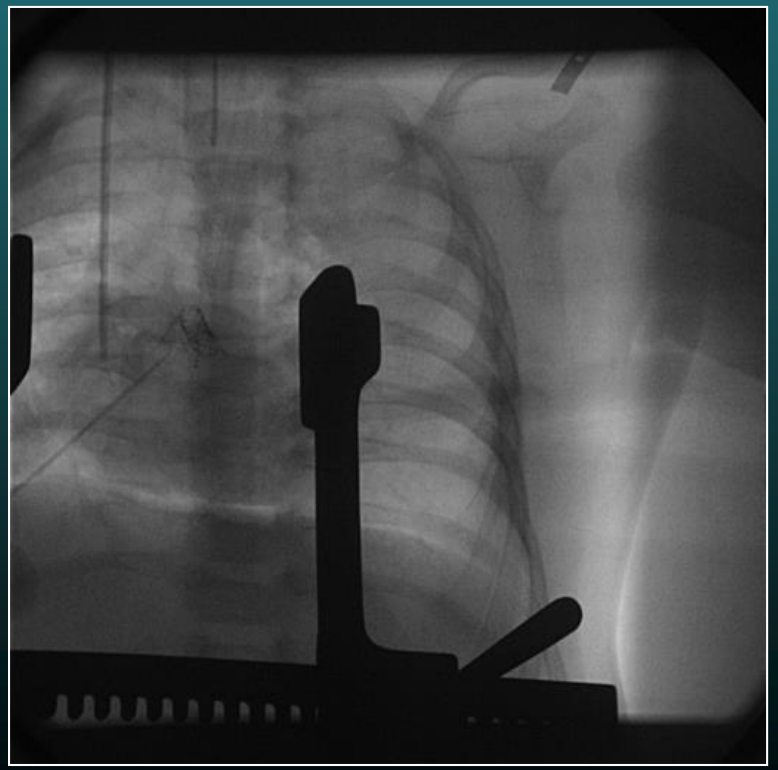

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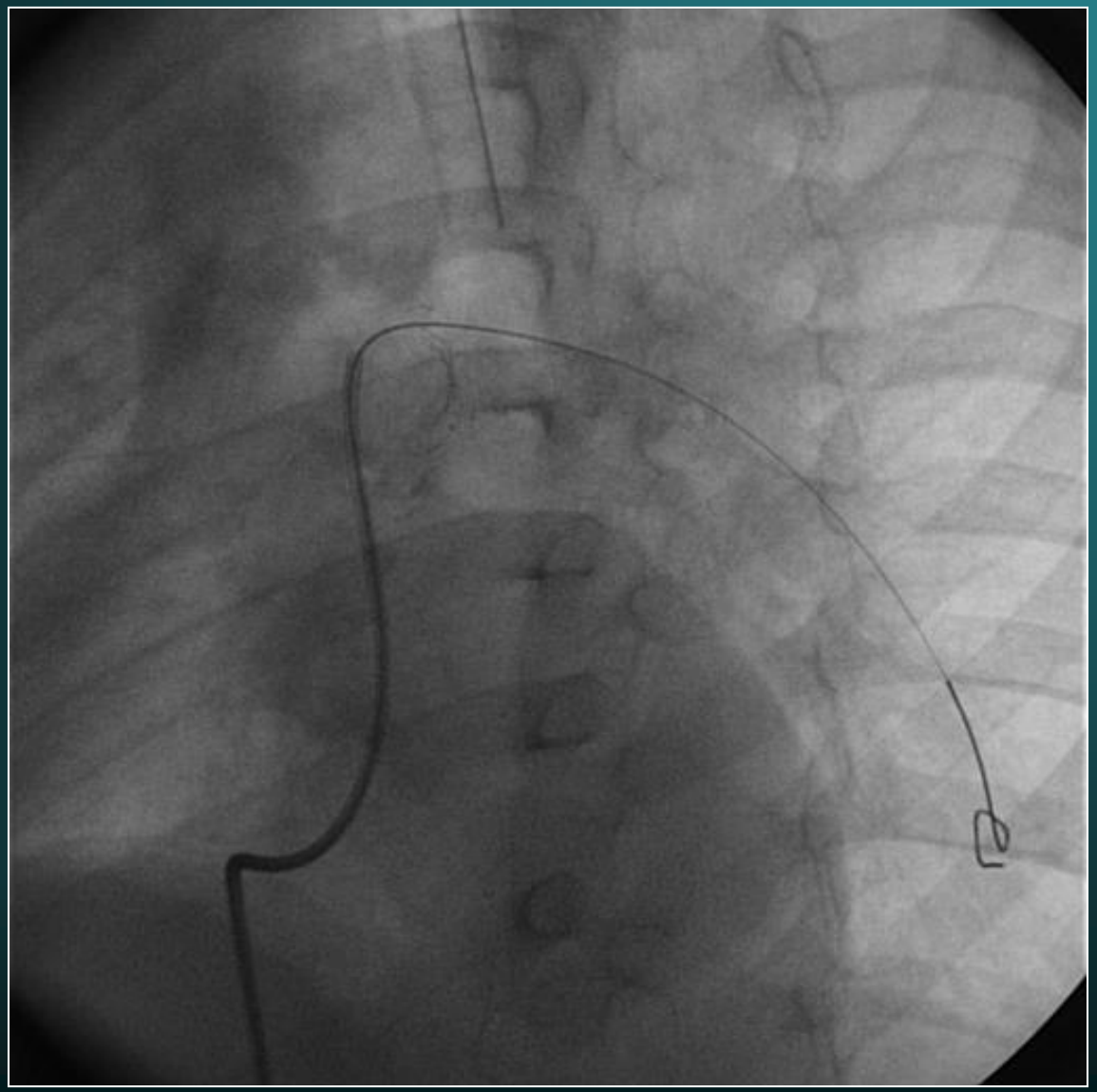

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➢ *When could the PATIENT enjoy the Interventional Cardiologist and Surgeon work together?*

→ whenever the repair may be too risky in the catheterization laboratory and too aggressive in the operative room

→ when the same result may be achieved without ECC

→ when the "device" approach may resolve part of the whole problem, so avoiding multiple surgical accesses or decreasing the by-pass time

- neonate with severe ToF and PA discontinuity (very hypoplastic RPA, LPA feeded by an AD in impending closure. Right aortic arch
- at emergency cardiac catheterization, LPA feeded by a huge MAPCA and RPA feeded by a left AD
- hybrid approach of LPA recruitment by AD stabilization followed by a left B-T shunt and surgical recruitment of the MAPCA via right thoracotomy

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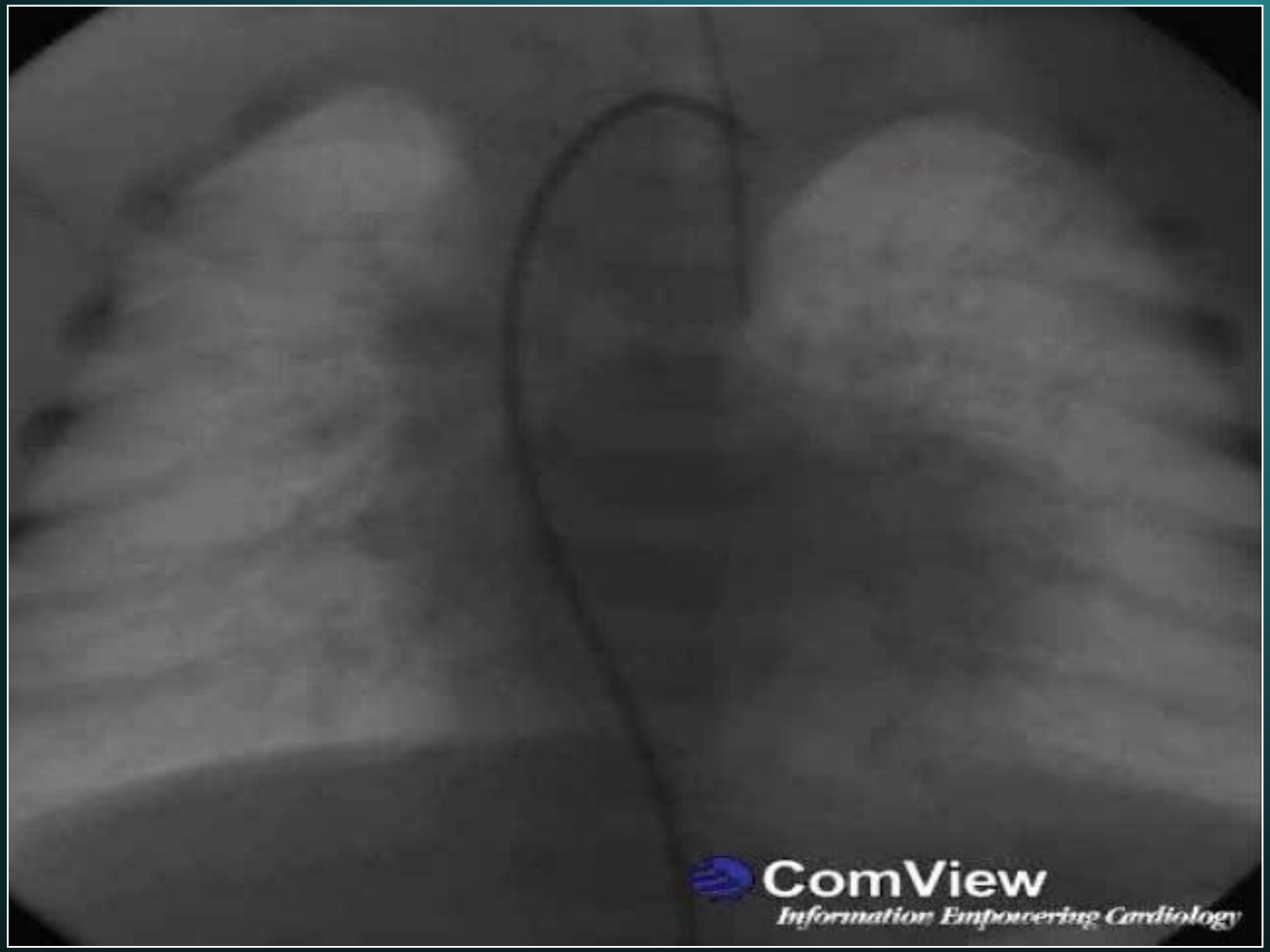

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- 2 month-old, critical infant referred for failure to thrive and cardiac murmur
- clinical signs and symptoms of severe heart failure and echocardiographic findings of "pink" ToF, right aortic arch and absence of the LPA
- hybrid approach of "recruitment" of the left LPA by recanalization of the closed AD followed by RPA banding
- successful surgical repair performed 3 months later when the right/left PA size discrepancy was reduced

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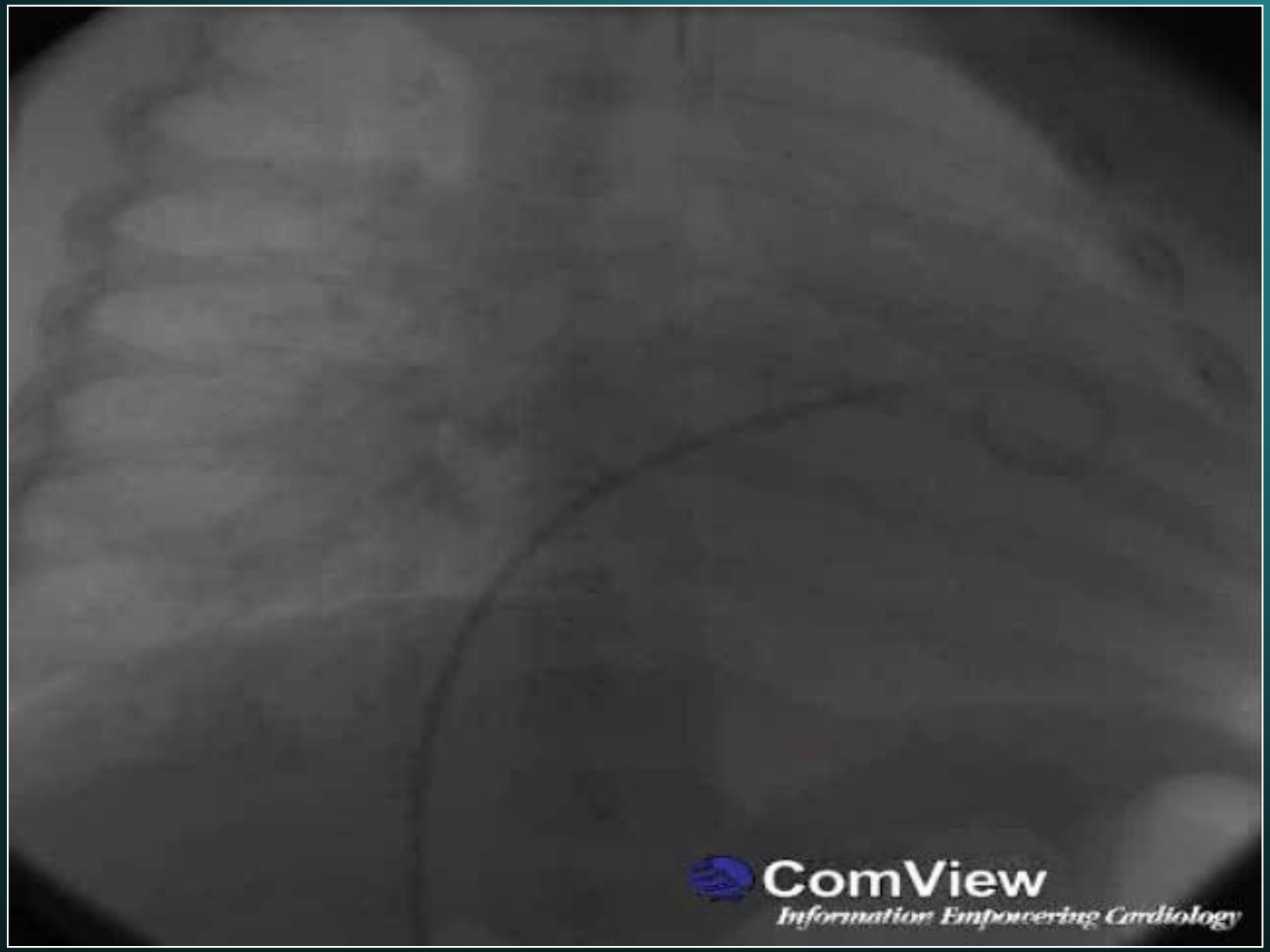

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- 3 year-old, 12 kg baby with signs and symptoms of RV failure
- Echocardiographic signs of aortic pseudo-coarctation (mild gradient without diastolic run-off) and RV hypertension due to severe bilateral PAs stenoses
- At cardiac catheterization, no AoCo and RV pressure overload (systemic RV pressure) due to PA elongation and tortuosity (ATS)

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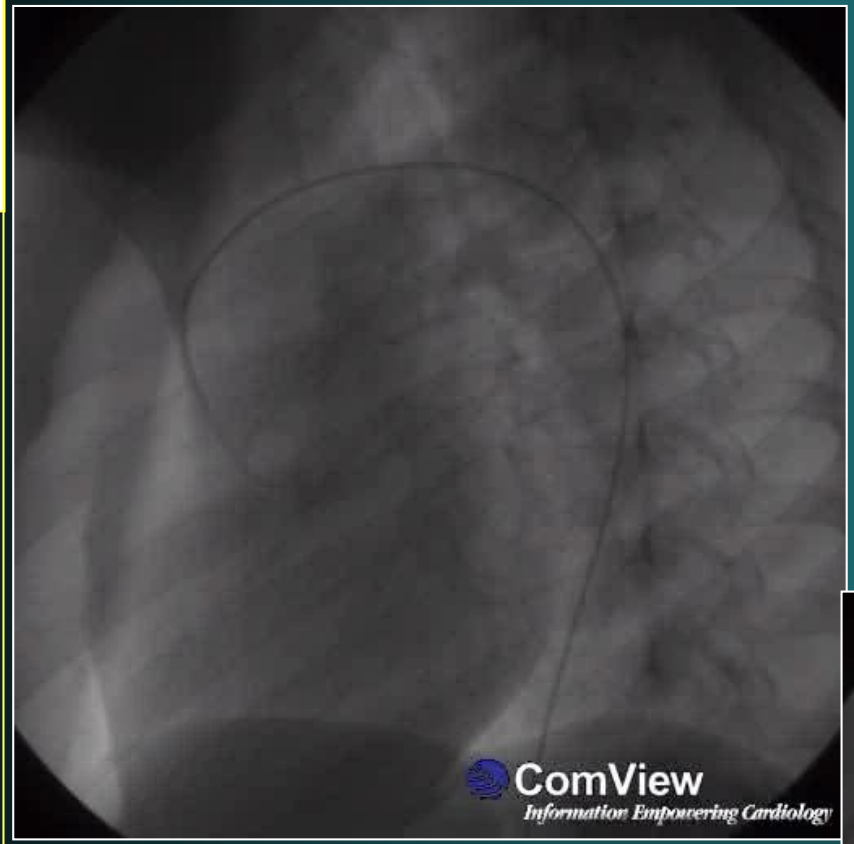
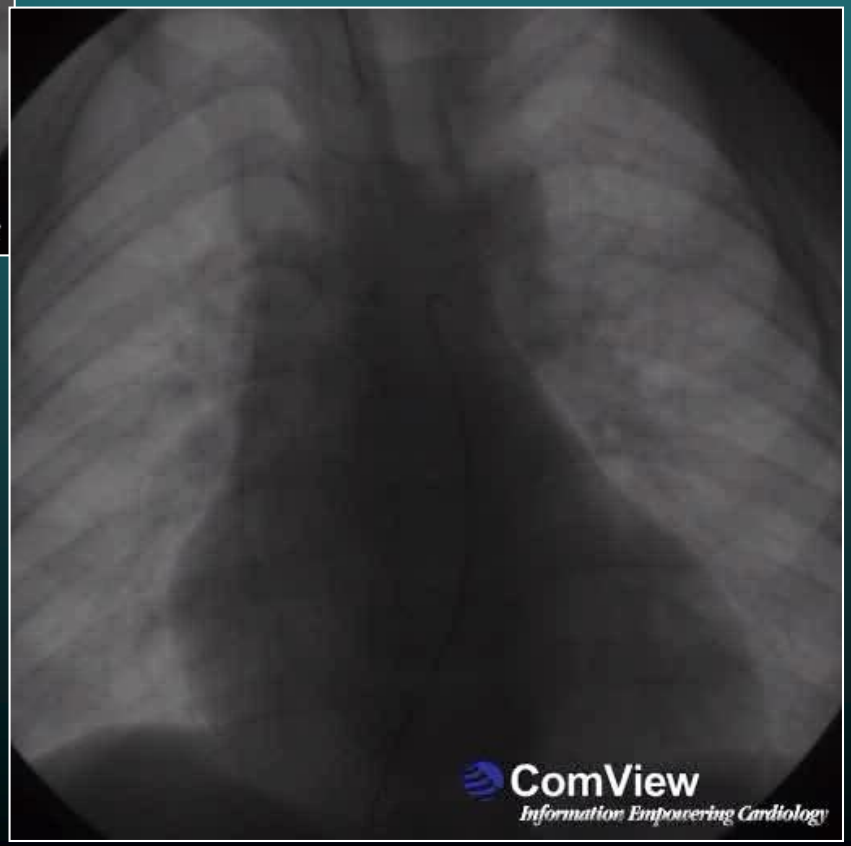

ComView
Information Empowering Cardiology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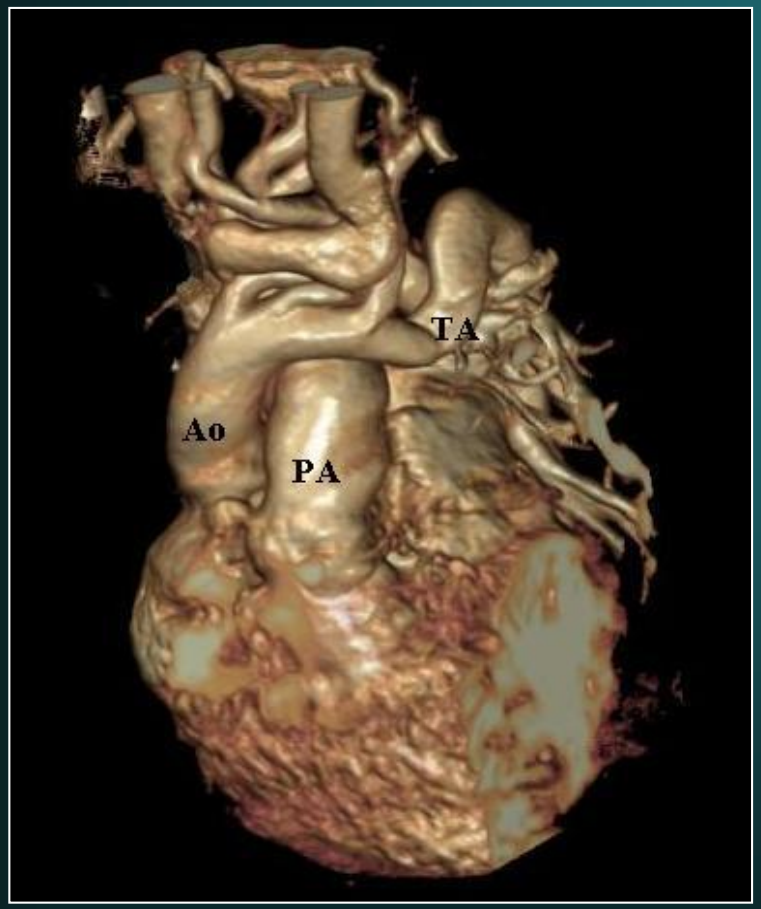

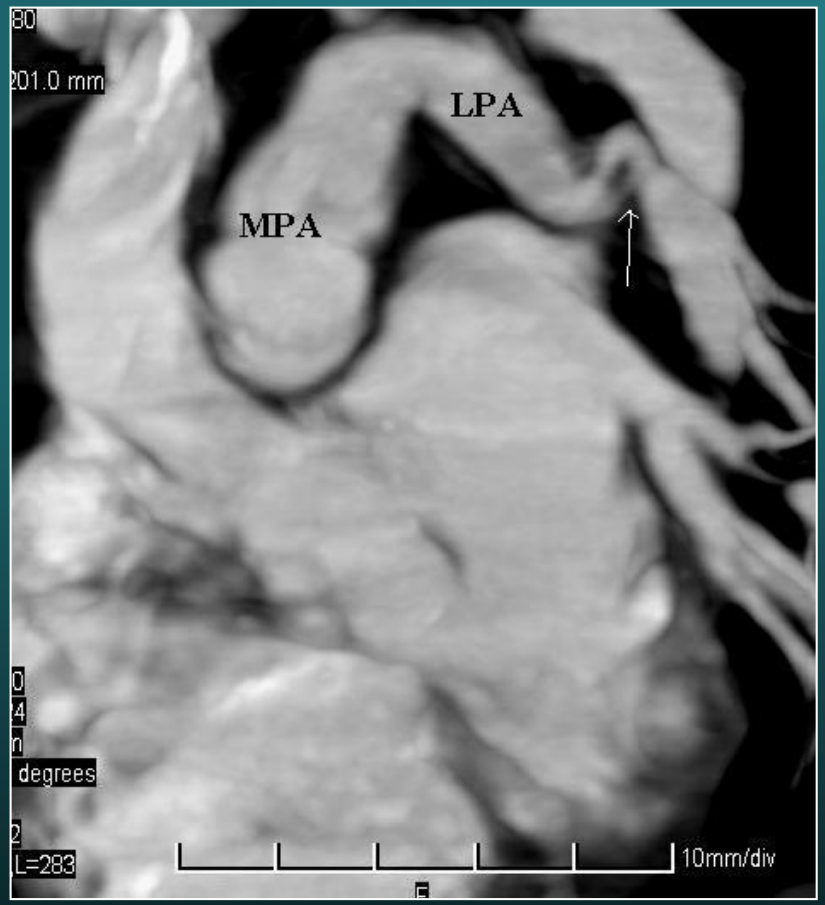

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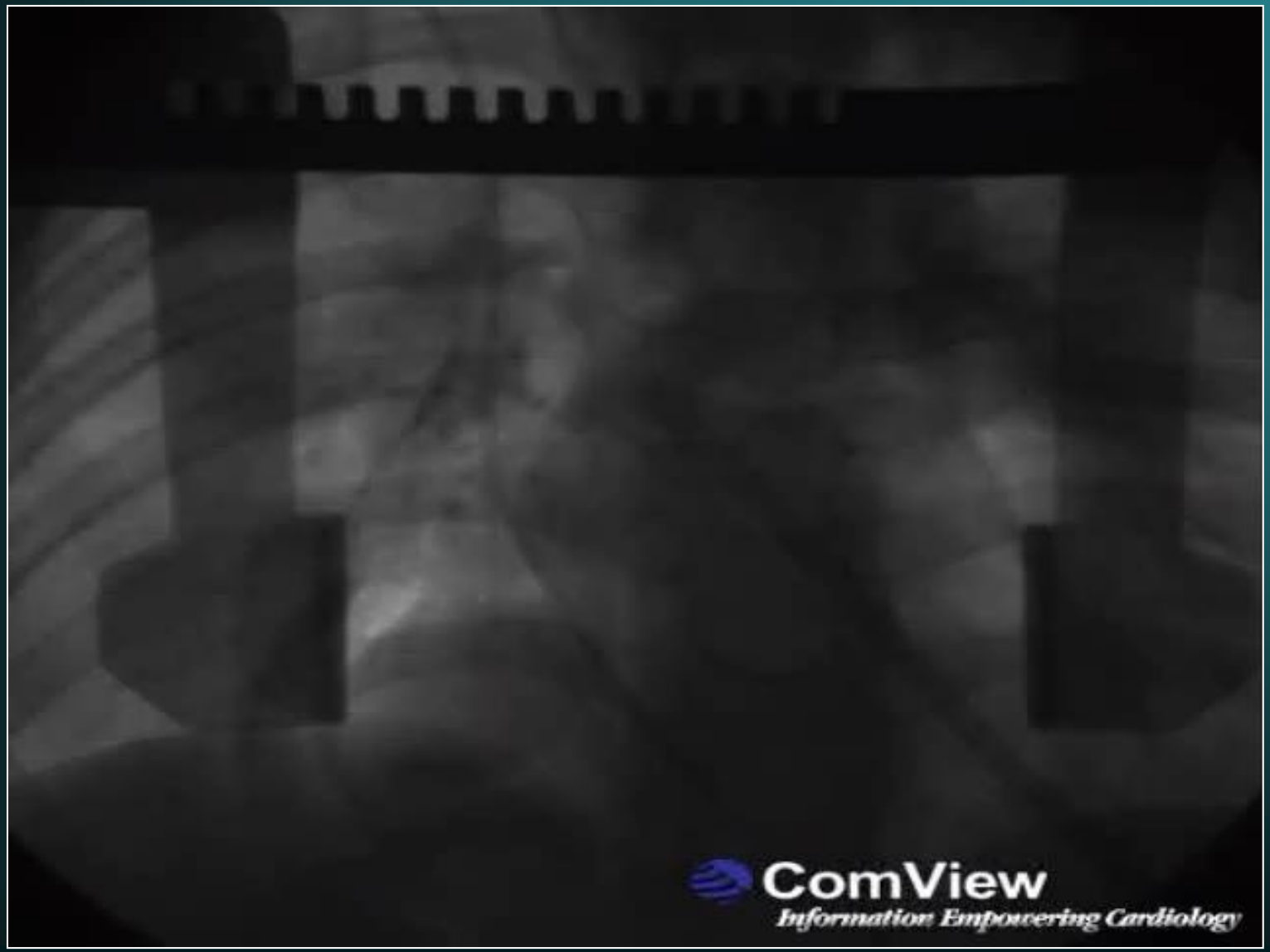

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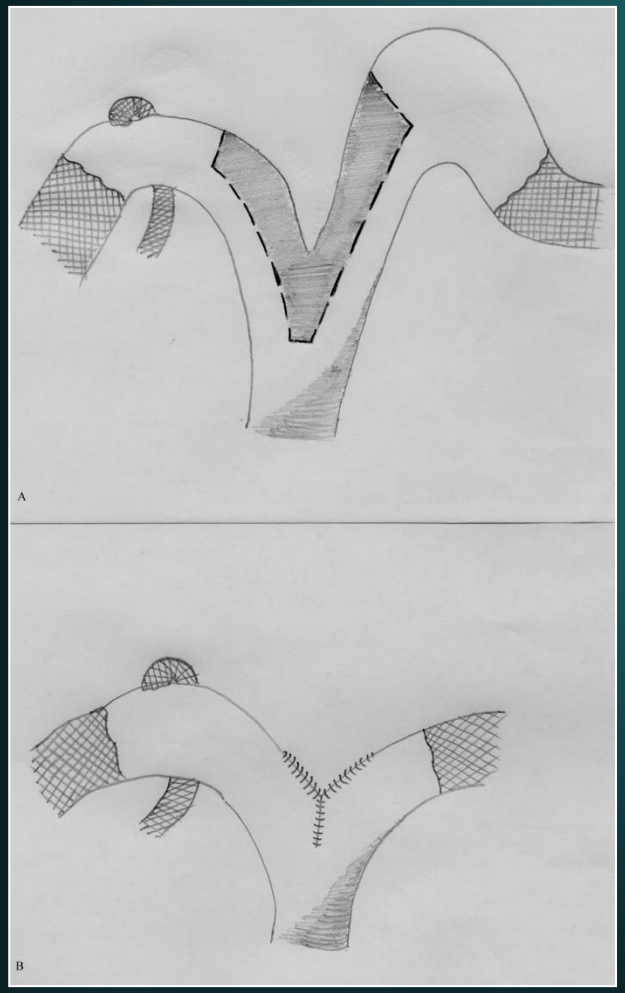

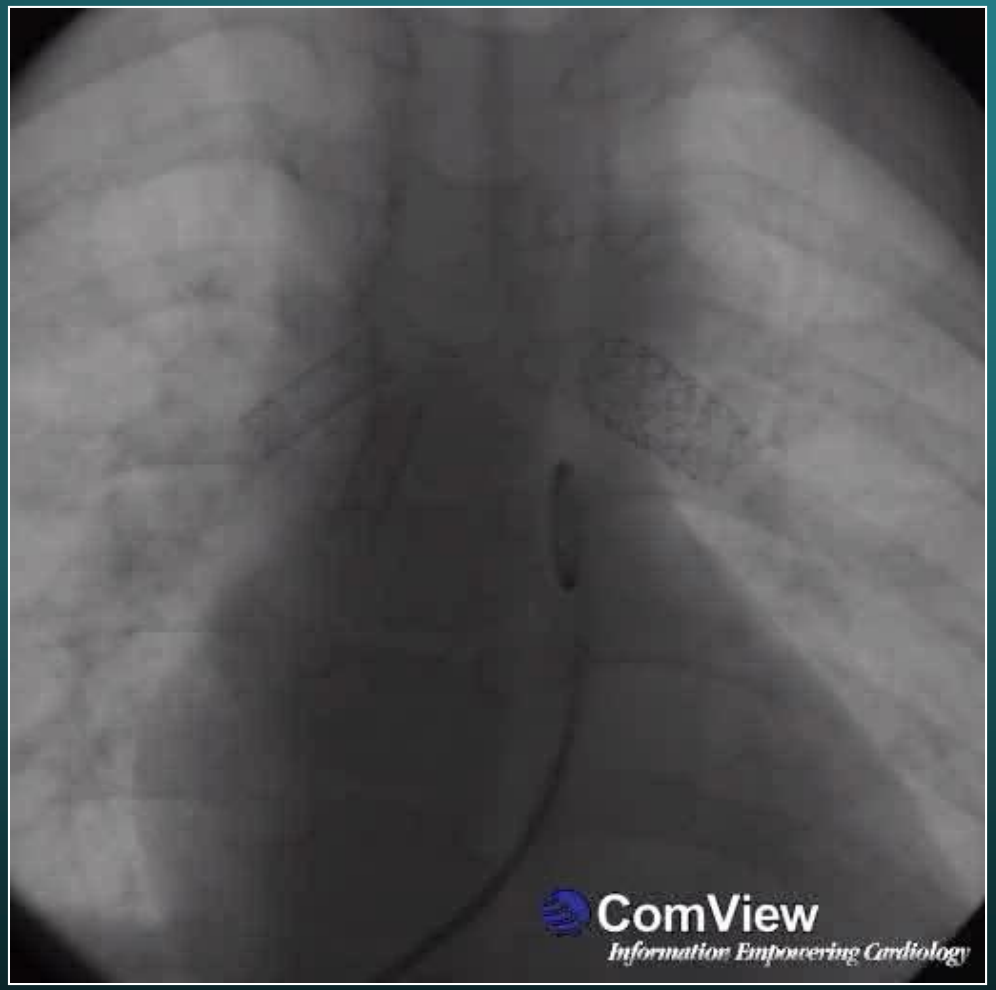

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Conclusions

- Hybrid interventional/surgical approach should be certainly considered as a mile-stone step in treatment of congenital heart malformations, in view of an ever and ever less invasive and cost-effective therapy
- As experience in hybrid cardiac surgery is gained, thoracoscopic or robotic device delivery into a pulmonary artery, peripheral vessel or septal defect by perventricular puncture may become reality

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- However, critical key point of this approach is a tight cooperation between interventional cardiologist, anesthetist and cardiac surgeon working as a "single team" to set and carry out strategic, individualized therapies

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Minotauros of ancient Greek mythology did not survive…

Will hybrid cardiac surgery meet a similar fate ??!!

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Thank you !!!