Cardiac Surgery
A Resource of Experimental Design

- **Complete Transposition:**
  - **a. Atrial switch – the chronically systemic right ventricle**
  - **b. Arterial switch – the suddenly systemic left ventricle**
- **Fontan operation – circulation in series without a subpulmonary ventricle**
- **Ross Operation – the suddenly systemic pulmonary autograph**

The Ross Operation

1960 – Lower, Strofer and Shumway reported that an autologous canine pulmonary valve can function in the aortic position.

1967 – Donald N. Ross replaced a faulty aortic valve with the patient's own pulmonary valve.

The Ross Operation

- **Homografts and nonviable natant freeze-dried valves showed signs of degeneration and calcification. Cryopreservation did not resolve the problem.**

- **1967 – The pulmonary autograft, a step toward ideal replacement of a diseased aortic valve in children and young adults.**

- **1988 – Ross published his long-term results. Overall surgical mortality 6.6% confined to the 1st decade; overall pulmonary autograft survival 85% up to 24 years.**

- **1993 – Established of an International Registry for Ross Operation.**

Deformational Dynamics of The Aortic Root

Complex asymmetric deformations during each phase of the cardiac cycle:

1) **Aortoventricular and sinotubular junction strain**
2) **Aortic root elongation, compression, shear, and tortional deformation**
3) **Area under non coronary / left commissure undergoes the greatest circumferential and torsional deformation**

The Ross Operation

- **A biological valve is assigned to the less demanding and less life-threatening right ventricular outflow track.**

Pulmonary Valve Autotransplantation (The Ross Operation)

DONALD ROSS, F.R.C.S.

National Heart Hospital, London, England

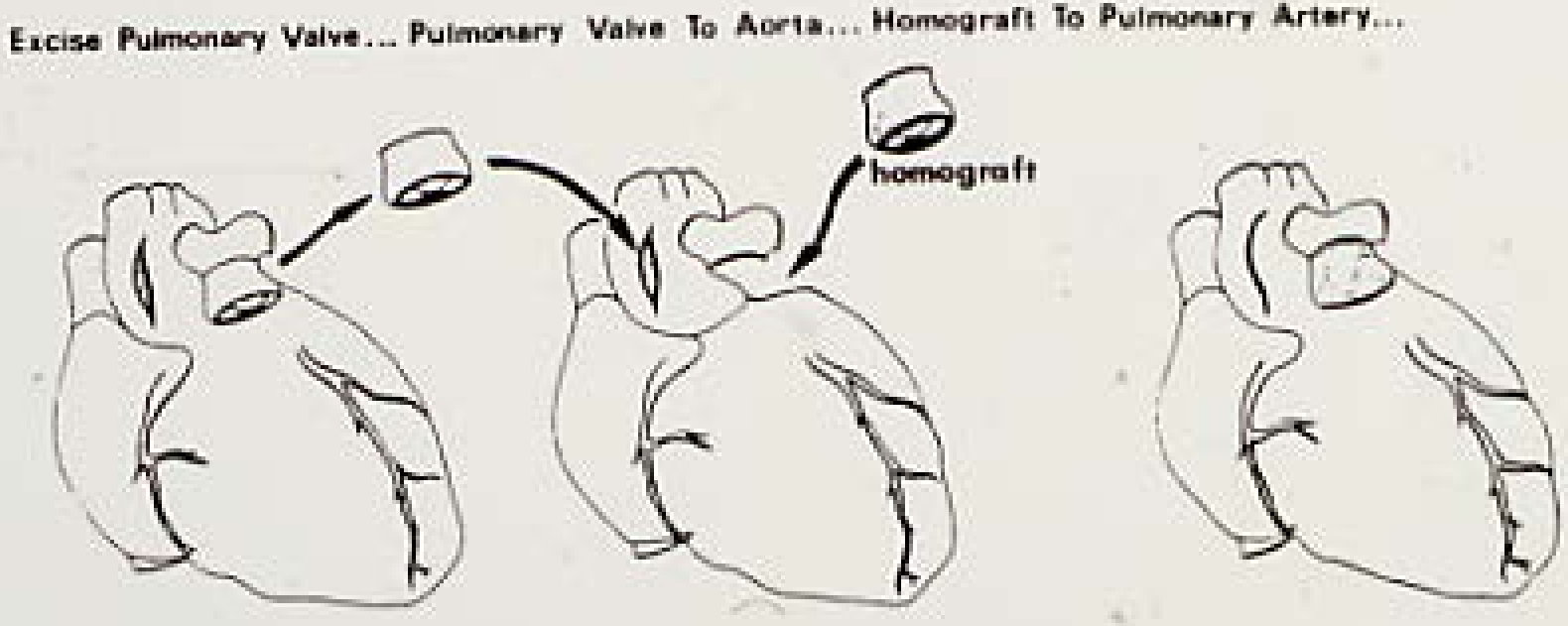
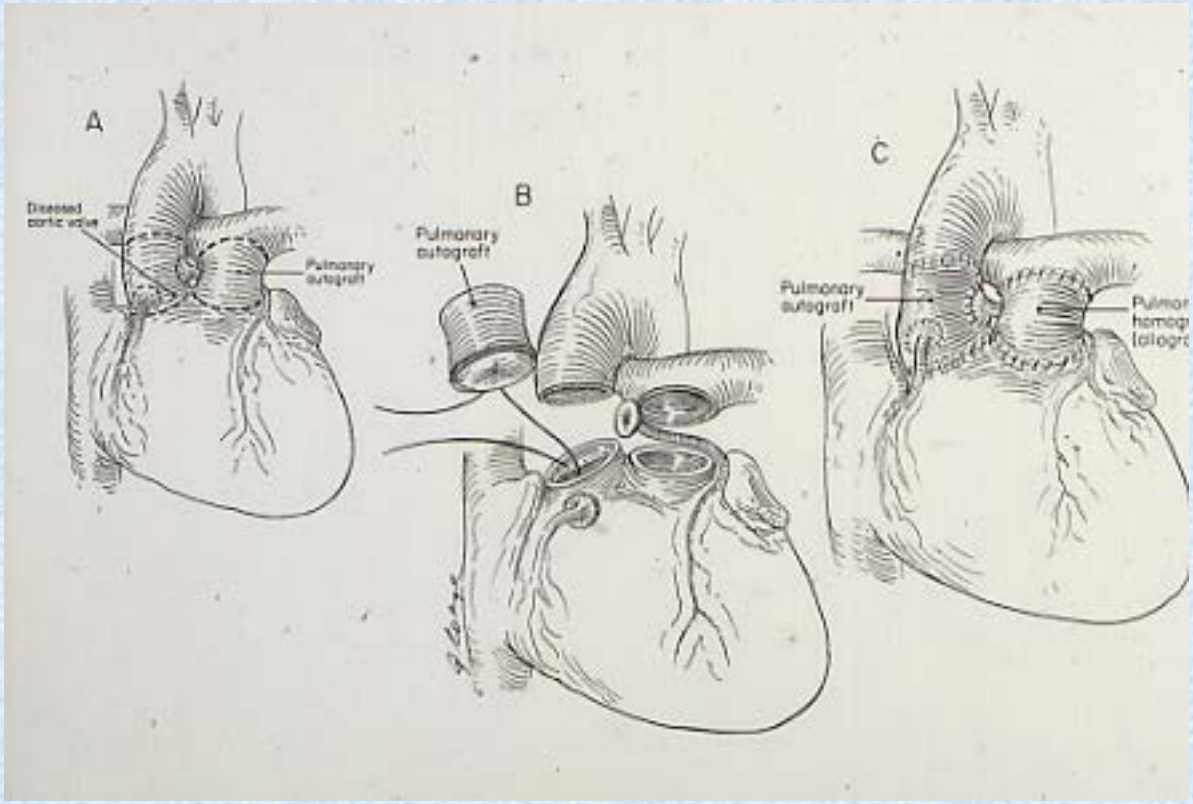


Figure 1. Principles of the operative procedure.

The Ross procedure – Native pulmonary valve (autograft) replaces a diseased aortic valve; a homograft replaces the removed pulmonary valve.



Inherent Complexity of the Ross Operation

“Intolerant of errors in judgment or technique.”

DN Ross

The Ross Operation
Transesophageal Echocardiography

- **Preoperative measurement of the aortic and pulmonary annuli and sinotubular junctions.**

- **Intraoperative**

The Ross Operation
Indications

- **Single valve disease – aortic.**
- **Failure of a mechanical or bioprosthetic aortic valve.**
- **Infective endocarditis limited to the aortic valve.**
- **Females anticipating or at childbearing age.**
- **Infants and growing children.**
- **When anticoagulants are contraindicated.**

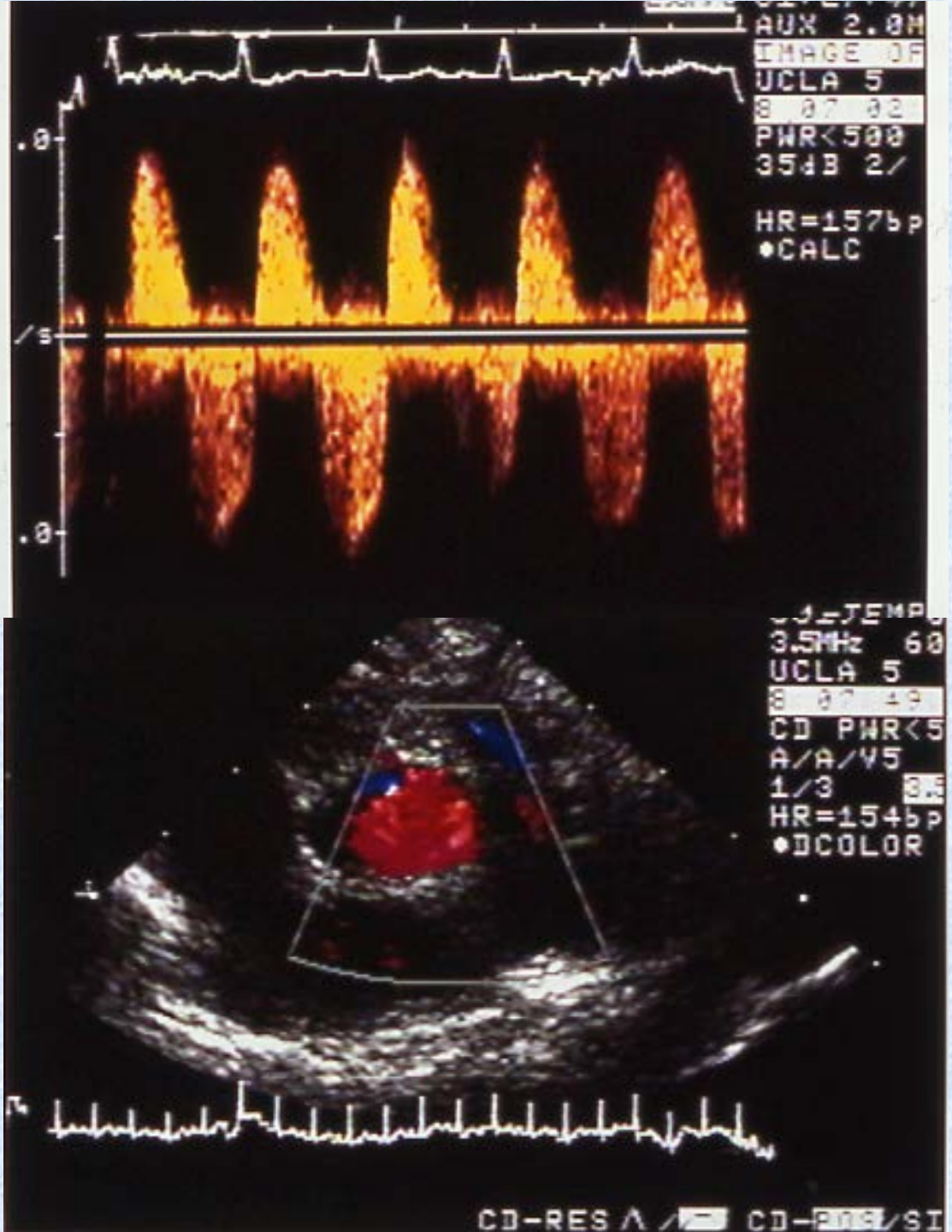
Ross Operation and Infective Endocarditis

1) The autograft is a low risk substrate.

2) Preferable if operation is required before bacteriologic cure.

Advantages of The Ross Operation

- Anticoagulants are not required
- Low risk substrate for infective endocarditis
- Good durability of the pulmonary autograft
- Infants and young children:
  a) Growth capacity of the autograft
  b) No primary tissue failure of autograft
  c) No anticoagulants
- Pregnancy:
  a) No anticoagulants
  b) No gestational acceleration of primary tissue failure of autograft


AUX 2.0M
IMAGE 0F
UCLA 5
PWR<500
HR=157bp
•CALC
.0
/s
.0
3.5MHz 60
UCLA 5
CD PWR<5
A/A/45
1/3
HR=154bp
•DCOLOR
CD-RES

Pregnancy and Aortic Valve Replacement

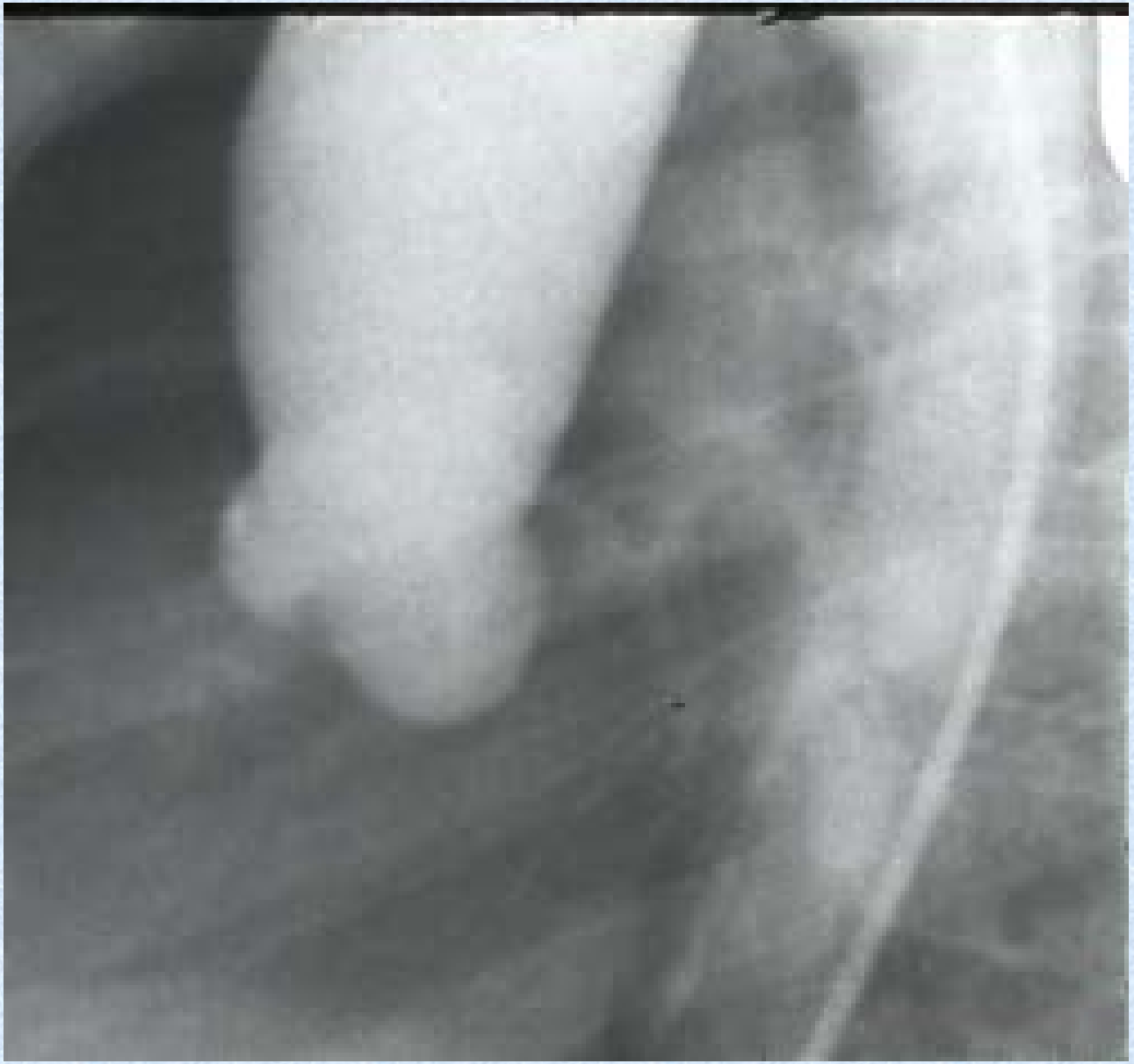
1) Mechanical valves require anticoagulants.

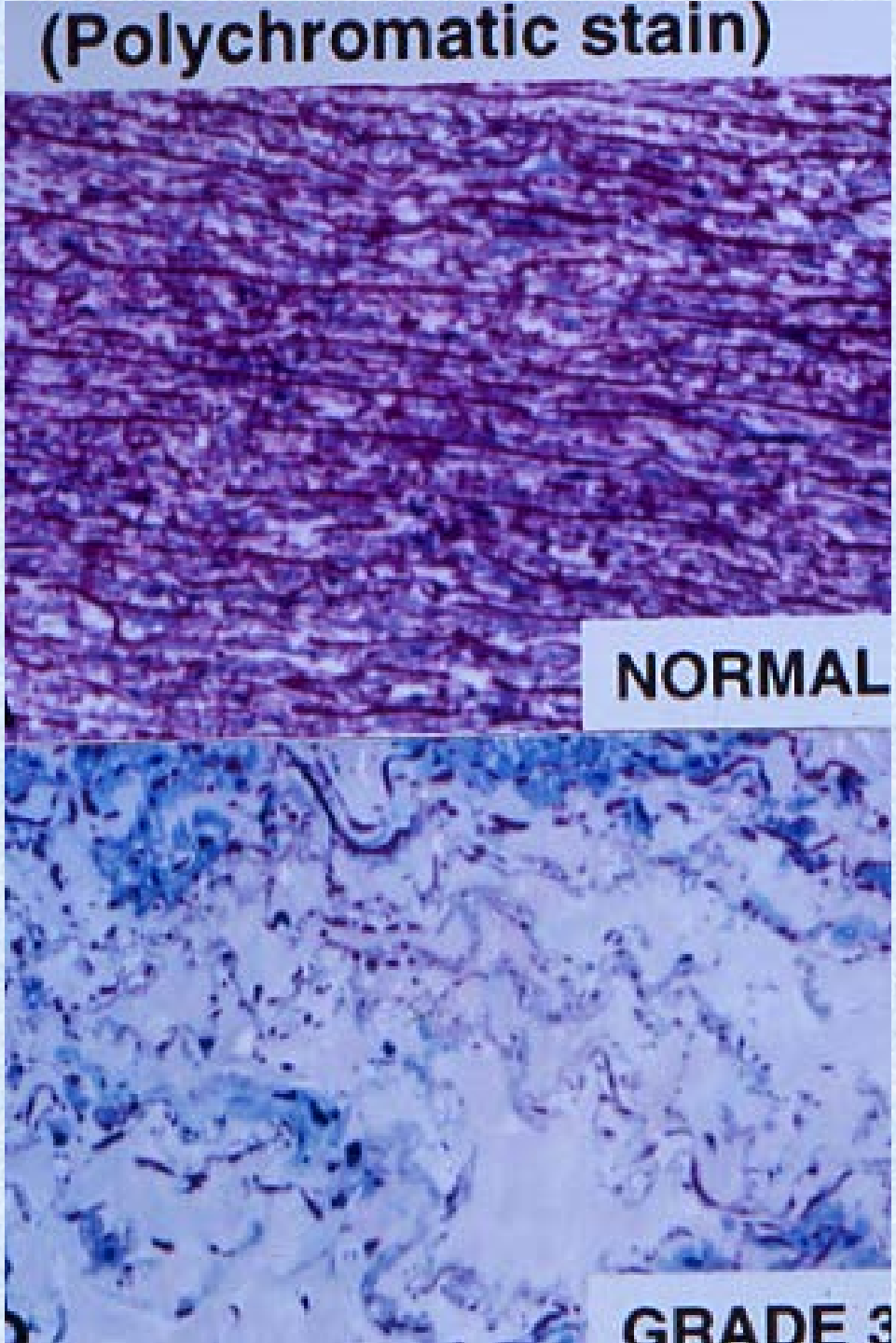
2) Pregnancy accelerates primary failure of tissue valves in the systemic but not in the pulmonary location.

Ross Operation with Abnormal Aortic Root

1) Aortic root dilatation with tricuspid aortic valve (inherent medial abnormalities of elastin, collagen, and smooth muscle).

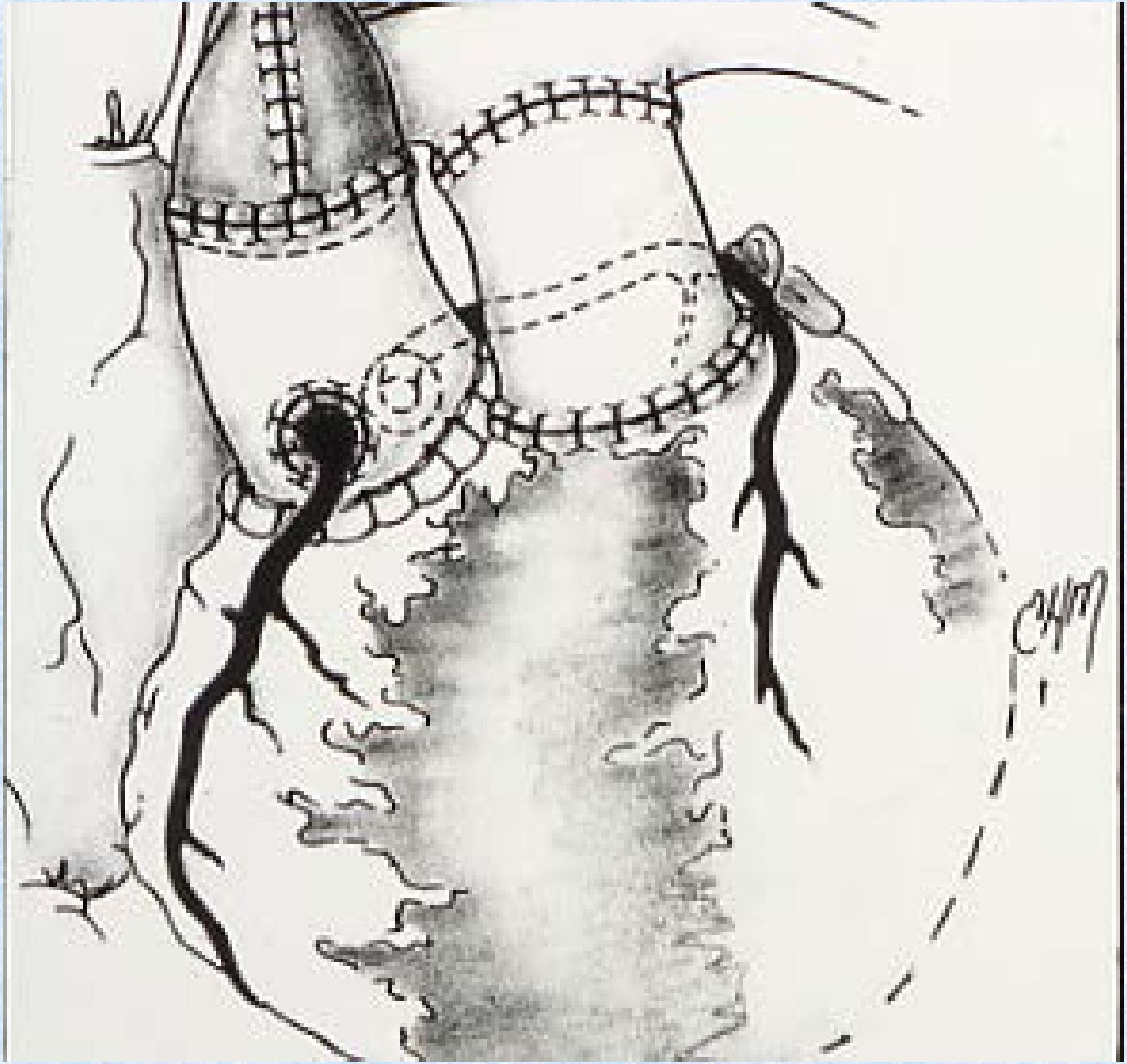
2) Aortic root dilatation does not obviate Ross procedure when the root replacement technique is employed.




(Polychromatic stain)
NORMAL
GRADE 3

The Ross Operation
Aneurysmal Aortic Root

- **Replacement or external support to achieve a diameter equal to that of the pulmonary sinotubular junction.**



The Ross Operation
Morphology of the Autograft

- **The proximal autograft consists of muscular conal tissue in its entire circumference. The distal autograft consists of relatively thin elastic pulmonary arterial tissue.**

The Ross Operation
The Chief Initial Concern

- **Whether pulmonary valve cusps could withstand the sudden fivefold increase in diastolic pressure in the aortic position.**

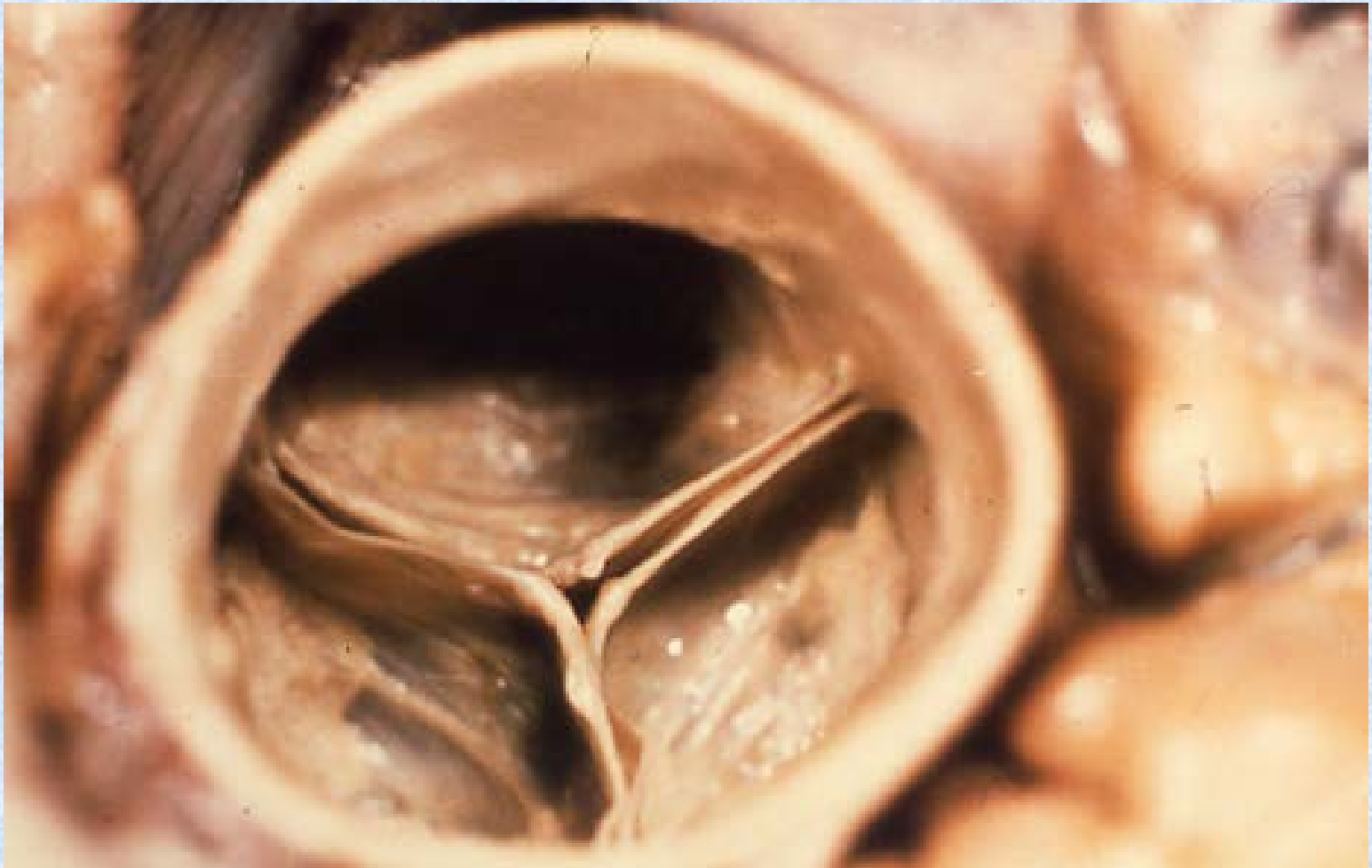
The Ross Operation
Biomechanics of the Pulmonary Autograft in the Aortic Position

Institution of Surgery, Medical Academy, Gdansk, Poland

- **The thinner pulmonary valve cusps have almost three times greater tensile strength than aortic valve cusps probably because of fiber orientation as a consequence of systemic pulmonary arterial pressure in the fetus.**

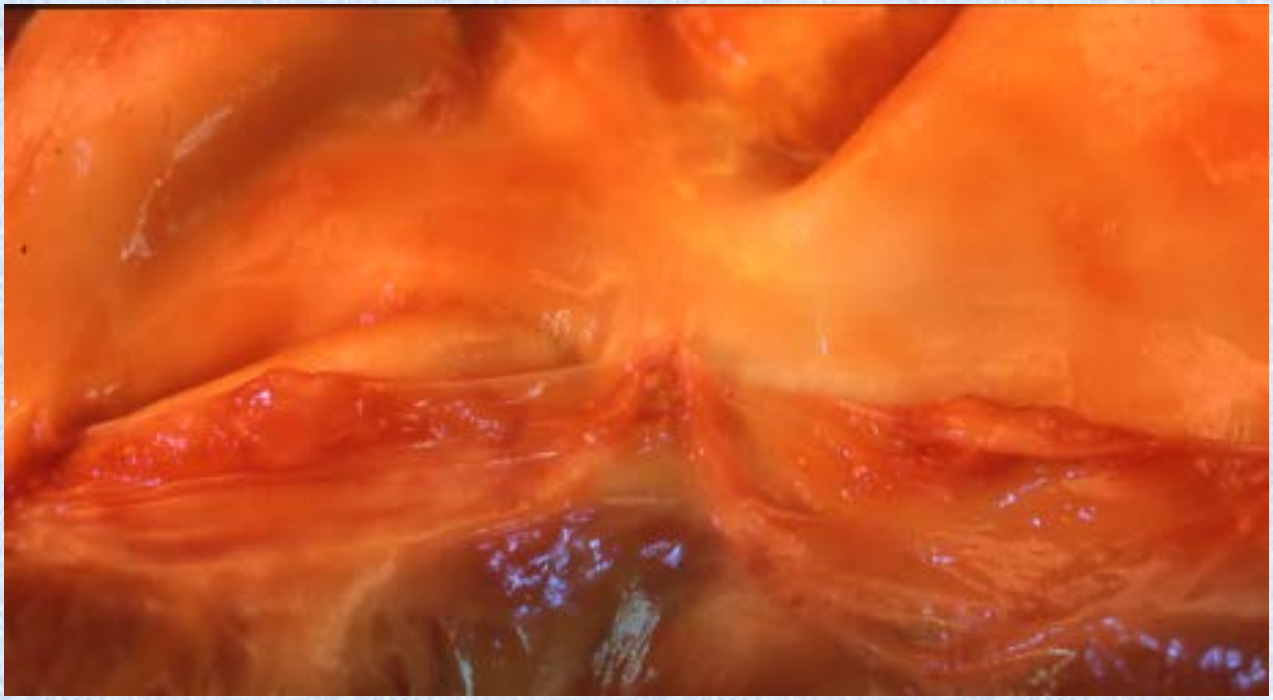
- **Greater tensile strength of the pulmonary valve cusps permits tolerance of systemic arterial closing pressure from the moment of autograft implantation.**
- **The pulmonary valve at its lowest level of leaflet attachment is less distensible than the aortic valve at an analogous level, thus serving to maintain competence in the face of systemic closing pressure.**
- **Growth potential of the pulmonary autograft permits adaptation to hydraulic conditions within the aortic root.**

Aortic **valve cuspal equality is important in the high pressure systemic circulation, and is responsible for the infrequency of "normal" aortic regurgitation.**

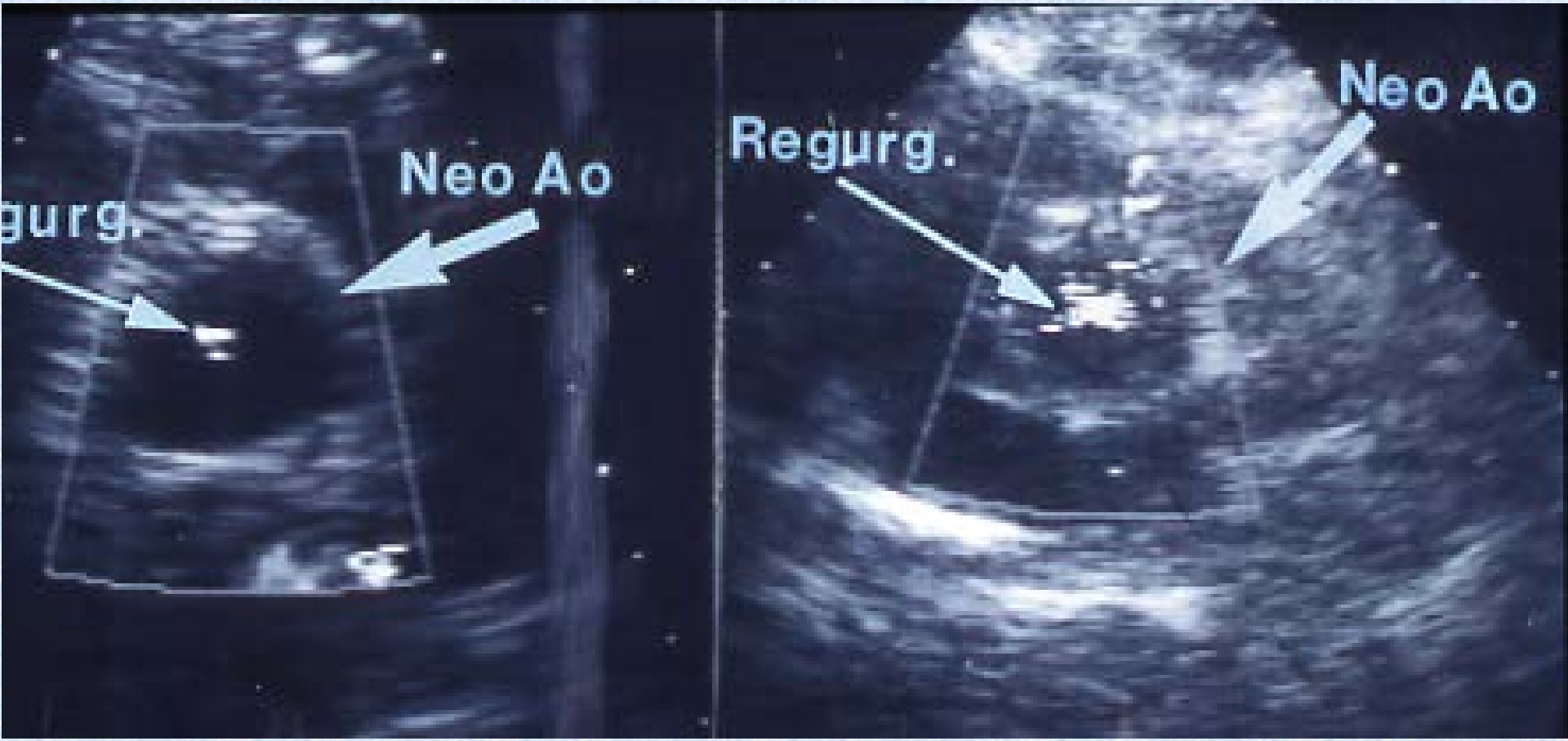


The Ross Operation Potential Long-Term Sequelae

The normal trileaflet pulmonary valve has a greater degree of inherent cuspal inequality then does the normal trileaflet aortic valve.



Pulmonary valve **cuspal inequality is relatively unimportant in the low pressure lesser circulation, but is responsible for the frequency of "normal" low pressure pulmonary regurgitation, and for the predisposition to incompetence with pulmonary hypertension.**

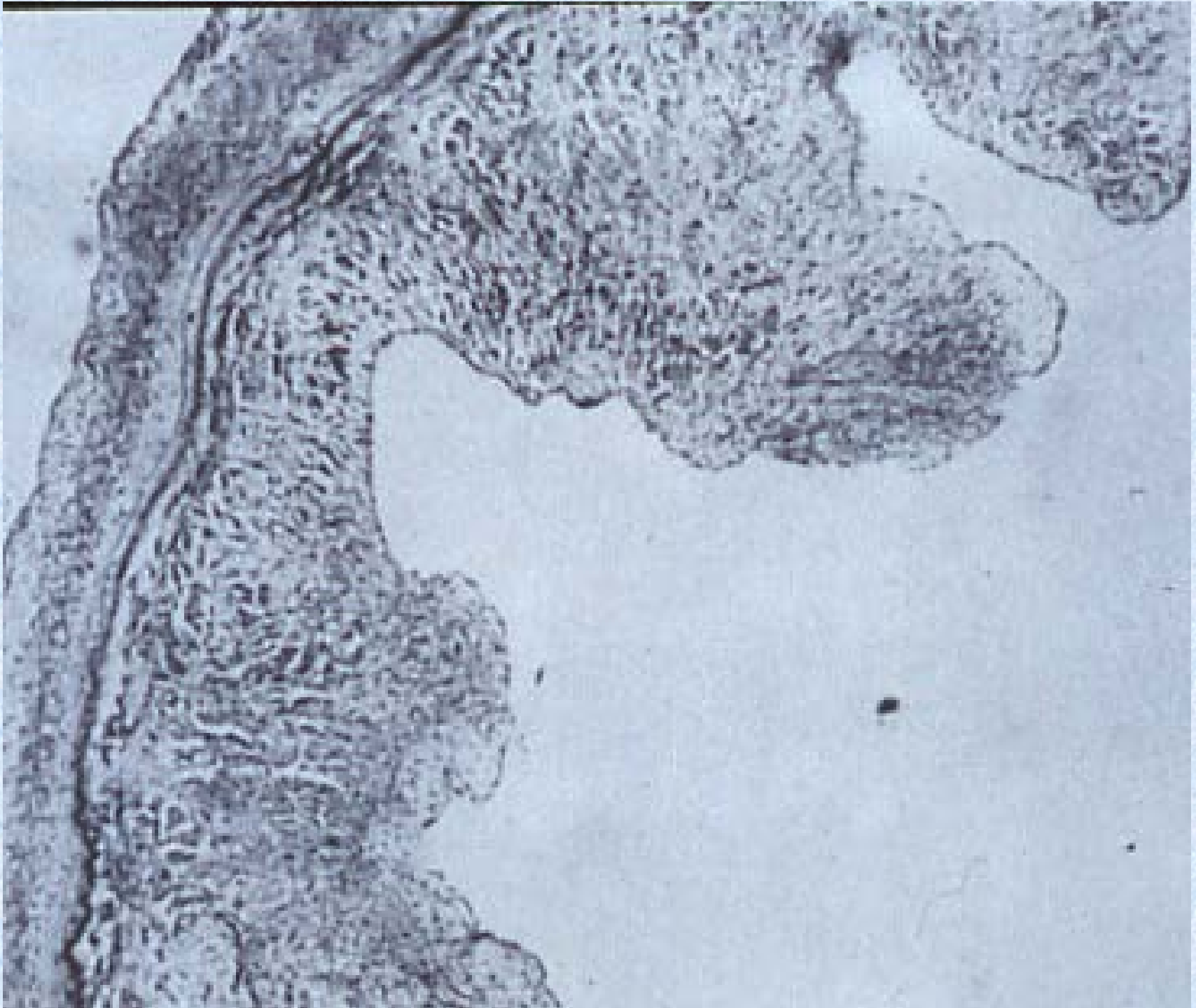

gurg.
Neo Ao
Regurg.
Neo Ao

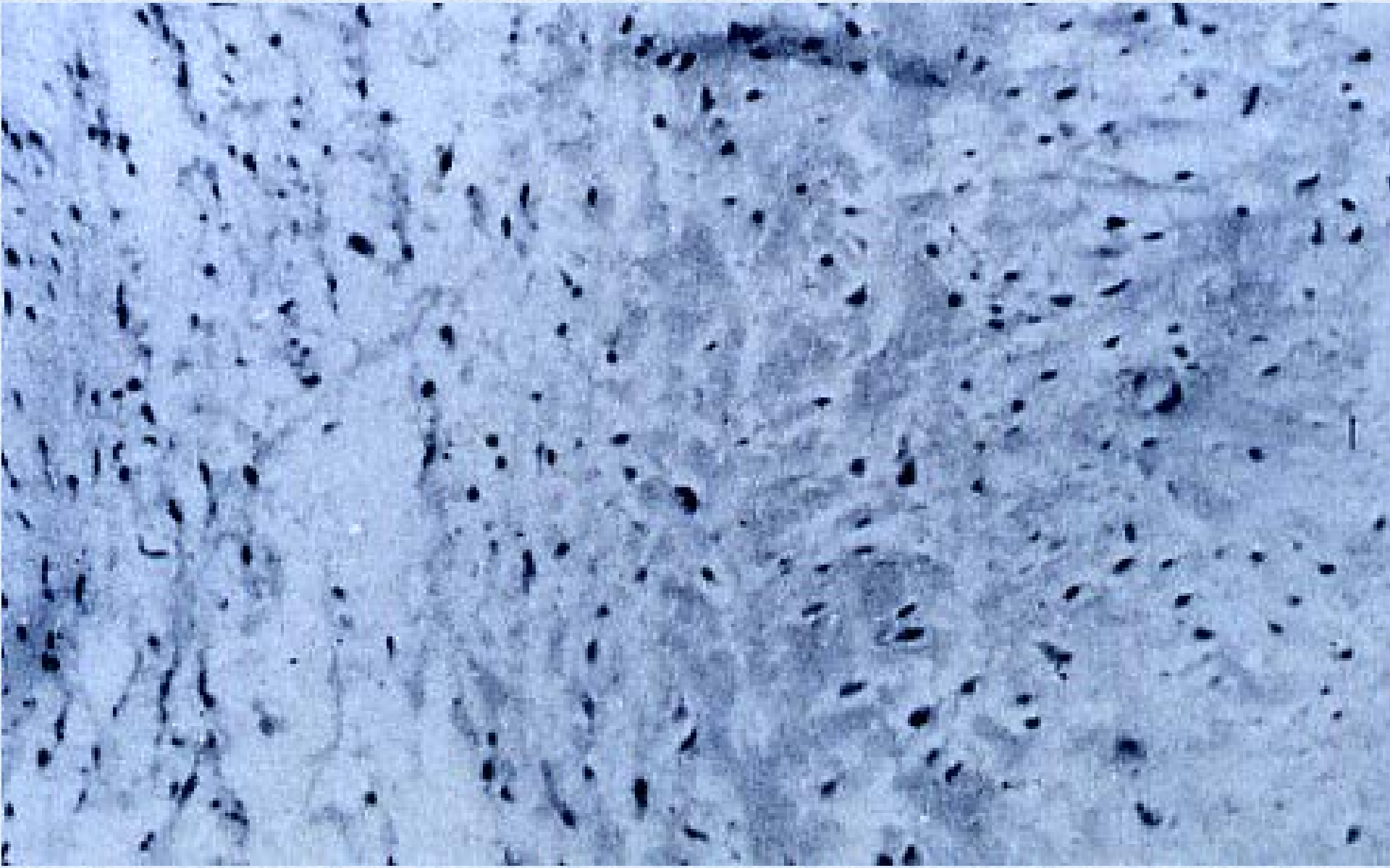

Neo Ao Regurg

Cuspal inequality of a pulmonary valve in the aortic location lends itself to maldistribution of stress exerted upon the three cusps during high pressure valve closure. Maldistribution of stress predisposes to incompetence and degeneration.

Ross Procedure
Autograft vs Homograft
Freedom from Primary Tissue Failure

	5 yr %	10 yr %
Pulmonary Autograft	99.5	91.0
Aortic Homograft	93.5	59.5





The Ross Operation
Evidence for Pulmonary Autograft Growth

- **Cell viability – leaflet microstructure is retained with endothelium and a full cellular complement.**
- **Enlargement of the autograft is proportional to somatic growth.**
- **Normal function is maintained.**
- **In the Ross operation and in the arterial switch (Jatene) operation, growth of the neo-aortic valve and neo-aortic root are similar.**

“Flee the study whose operation dies with its operator.”

Leonardo da Vinci, 1452-1519