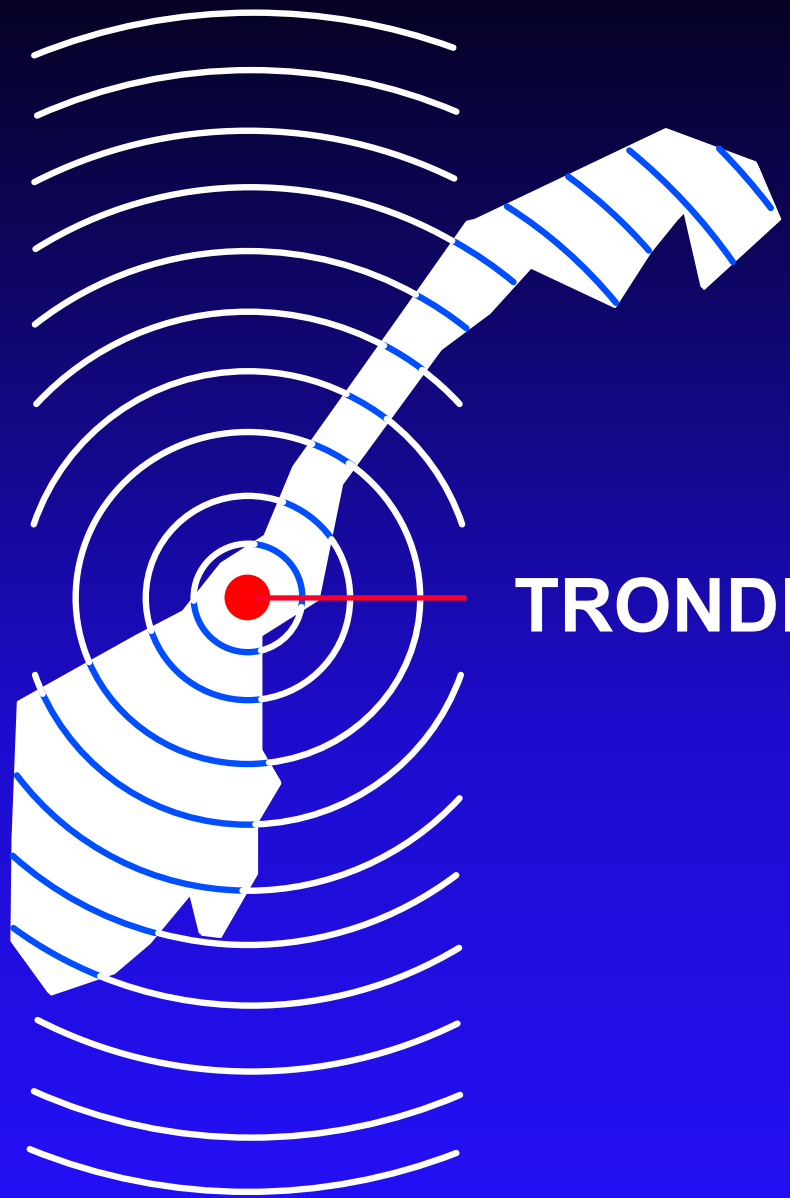
Fetal Imaging



TRONDHEIM

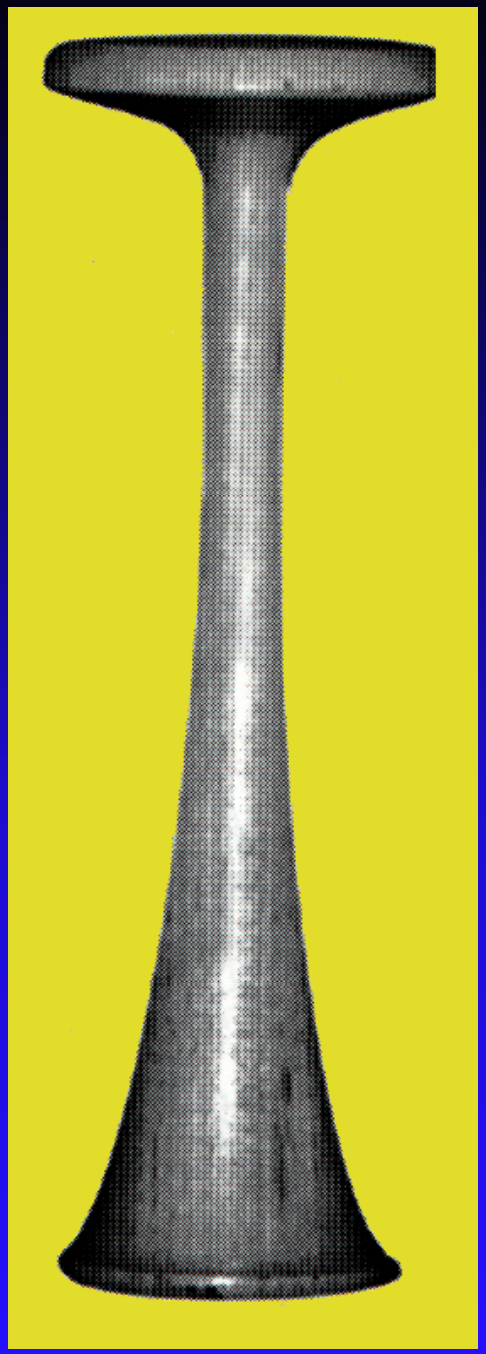
National Center
for Fetal Medicine
Dept Ob & Gyn

Trondheim - Norway

Outline of presentation

- Basic imaging technique
- Normal sonoembryological and fetal development in 2D and 3D imaging
- The routine fetal examination at 18 weeks
- Fetal medicine
- Teaching and training

Those were the days .. ?



Traditional obstetric communication with the fetus has changed

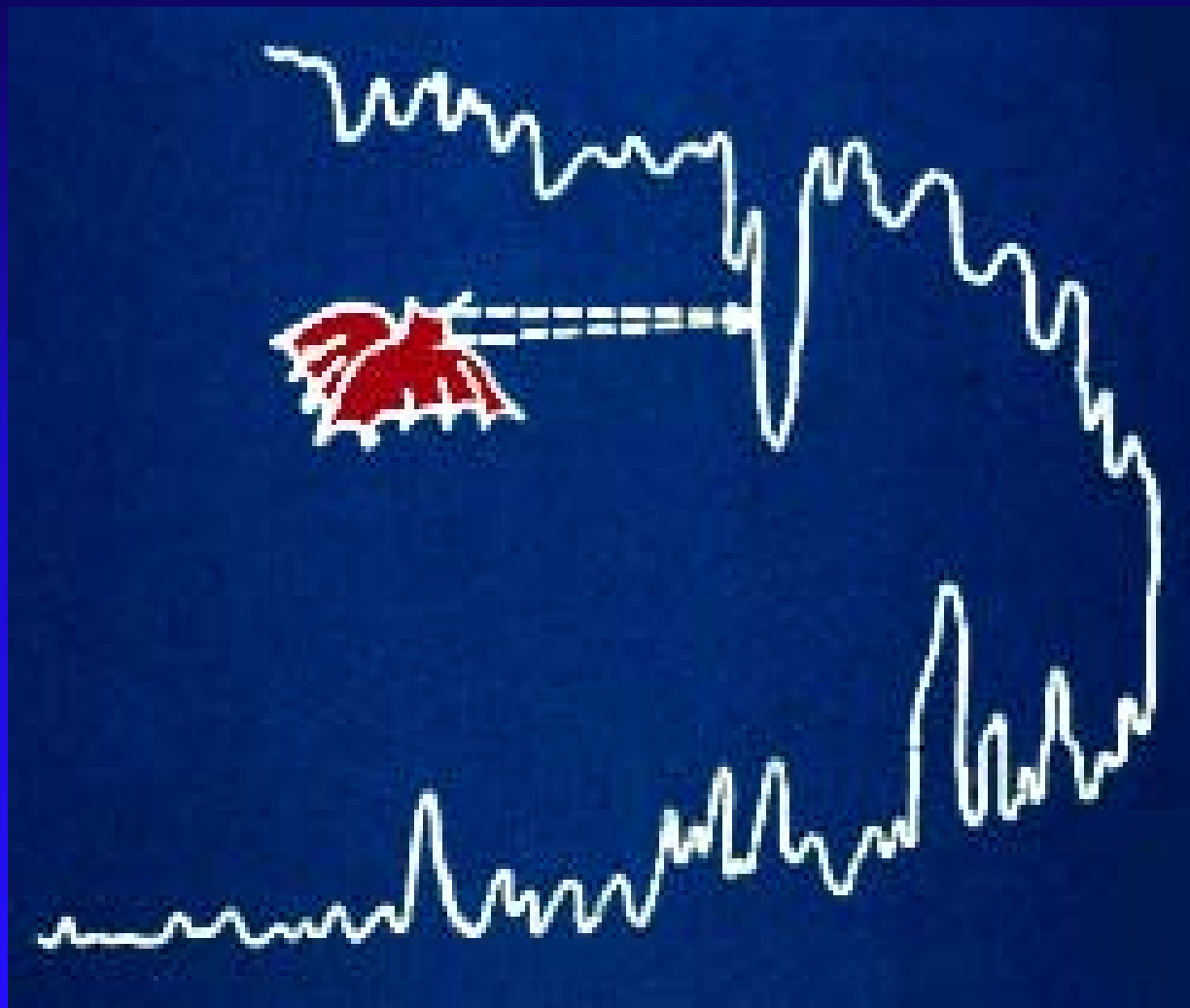
Sound

- Infrasound (0 - 20 Hz)
- Audible sound (20 - 20kHz)
- Ultrasound > 20kHz
- Diagnostic ultrasound (1 - 20 MHz)

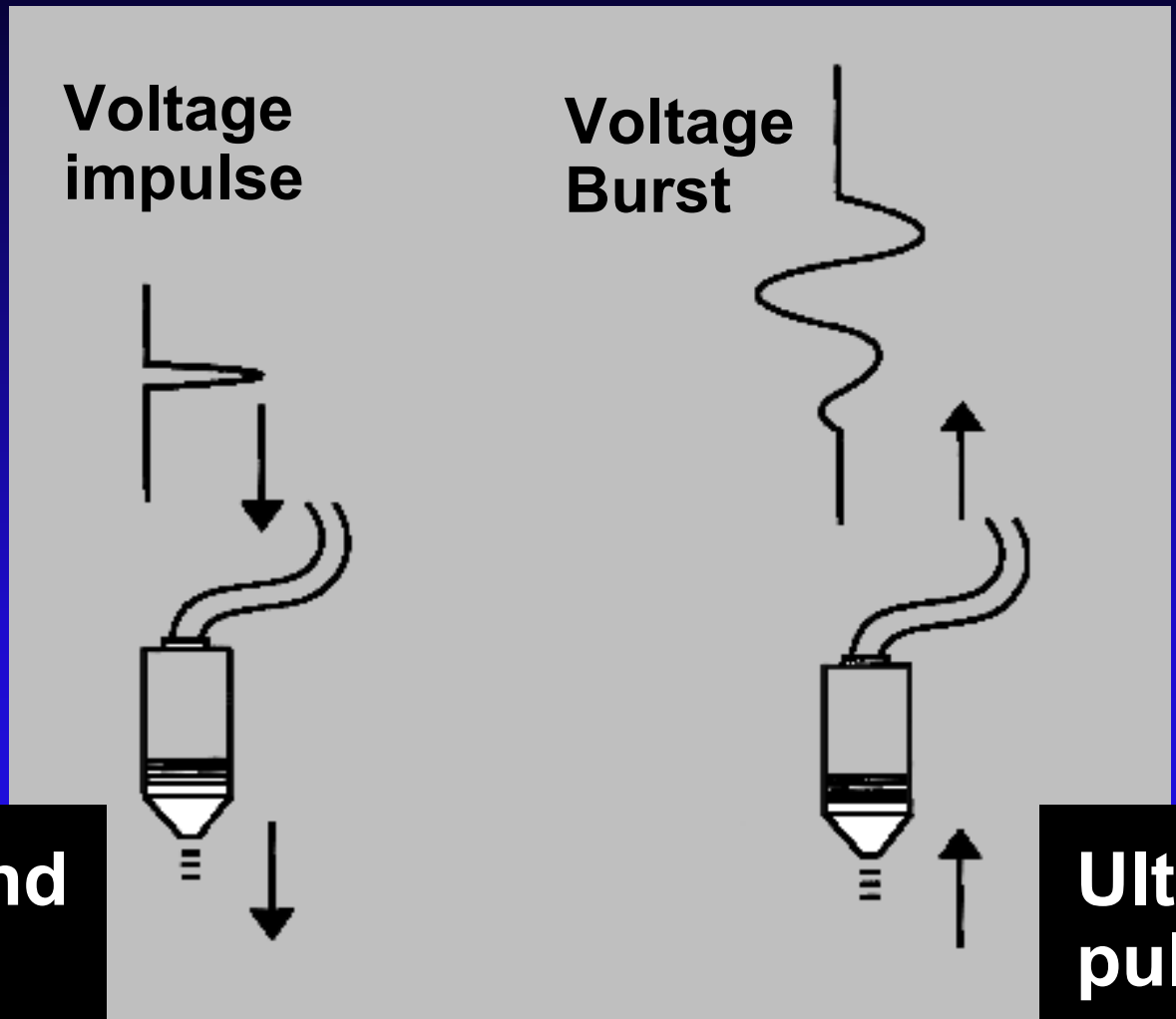
Bats need ultrasound .....

Sound produced by bats is reflected from the walls of their cave.

The echo patterns are picked up by the bat's ears enabling them to avoid obstacles in the dark

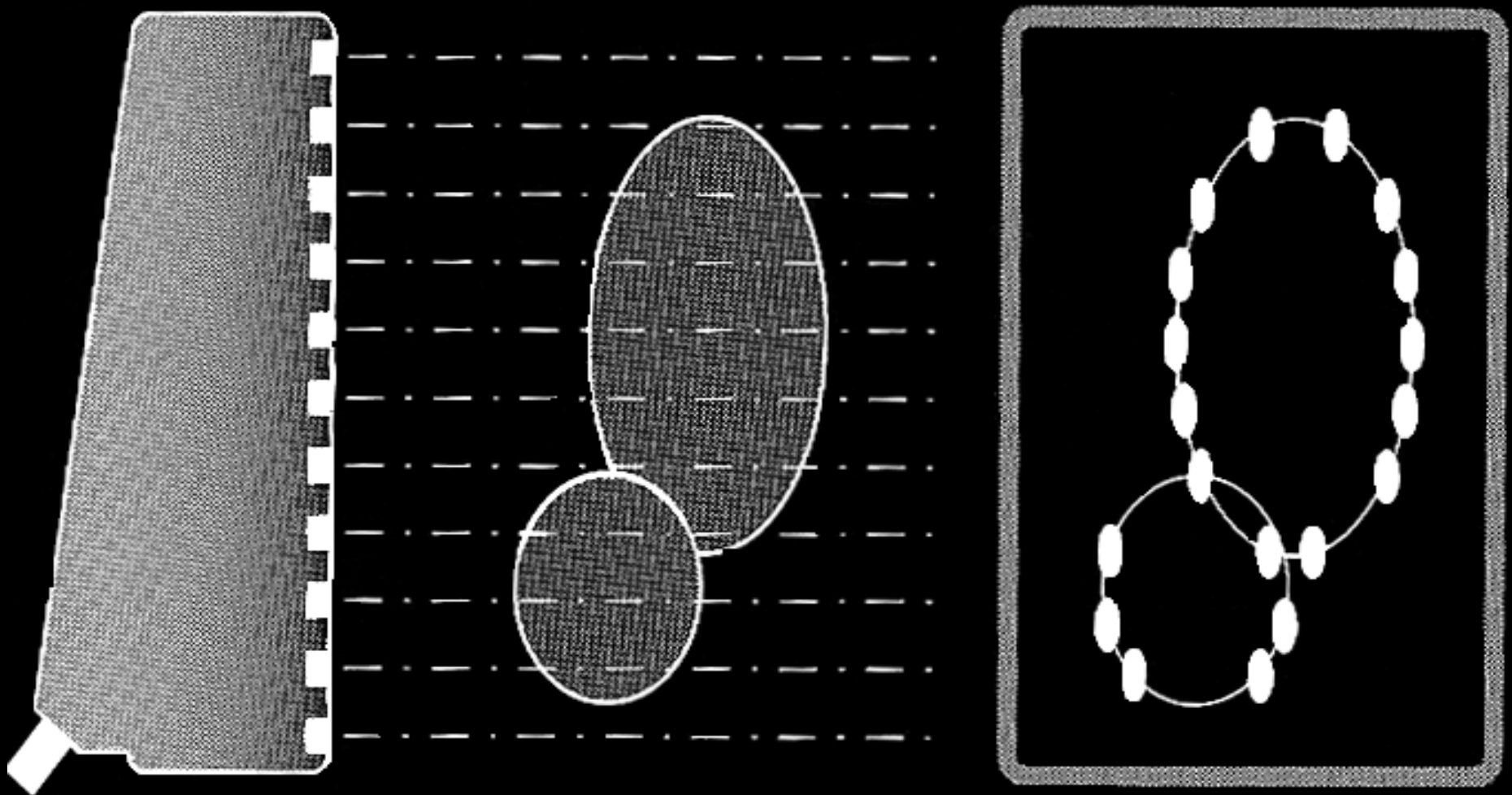


Sending



Receiving

Linear array

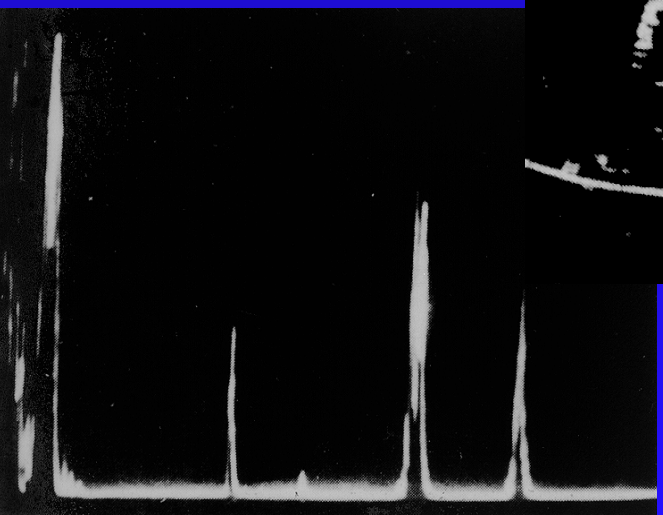


Weldner

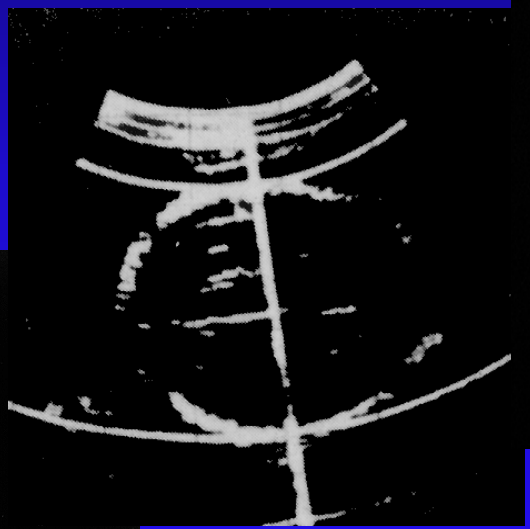
Technical development

Ultrasound imaging of the fetal head

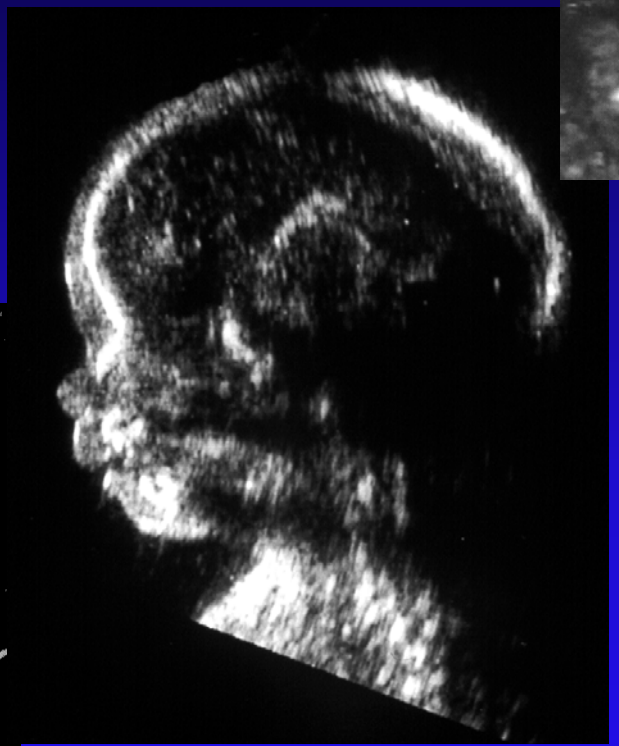
1960



1970

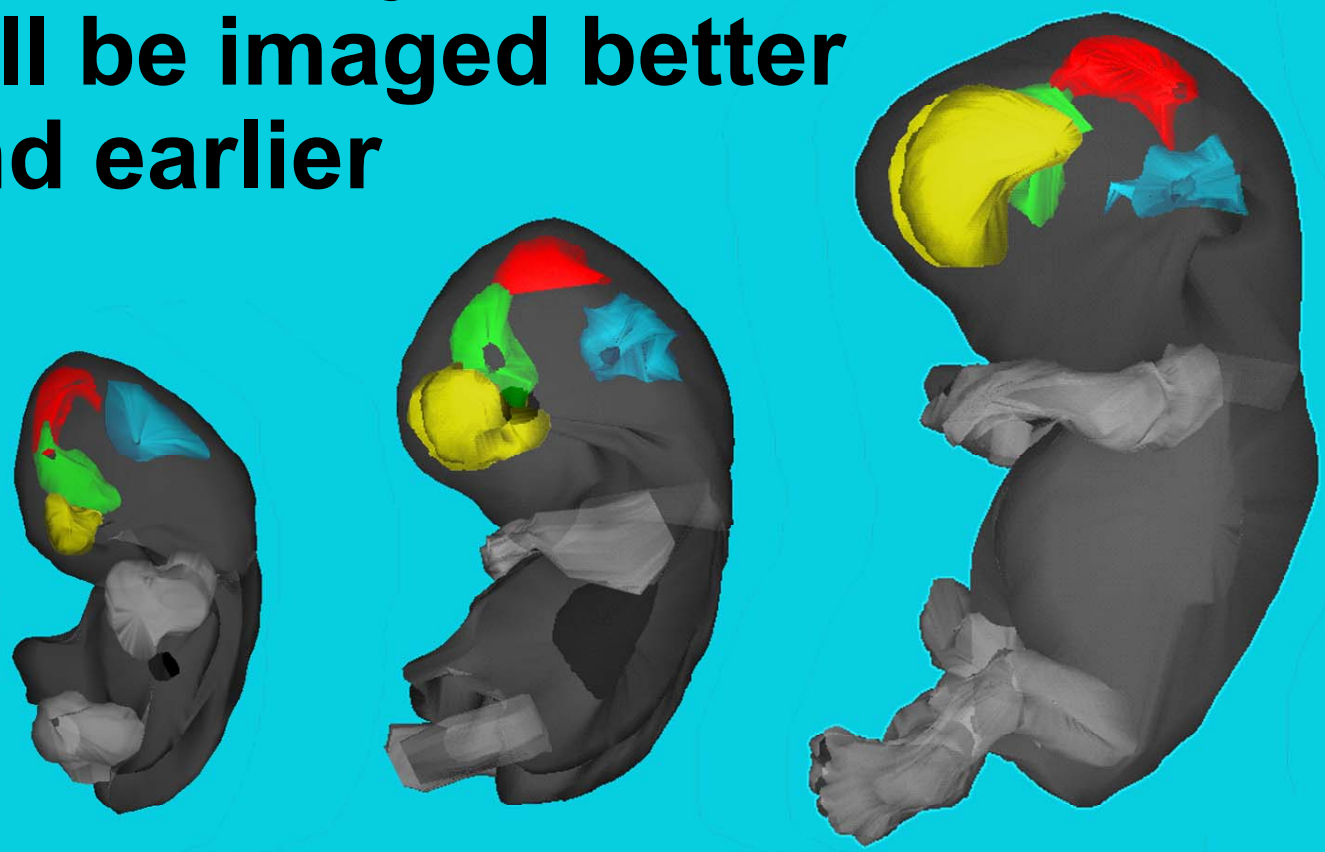


1990



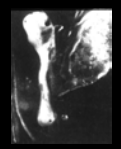
1995

The technical development will go on -
Smaller objects will be imaged better end earlier



What makes the embryo special?

Small size


2


6


10


13


20


30 mm

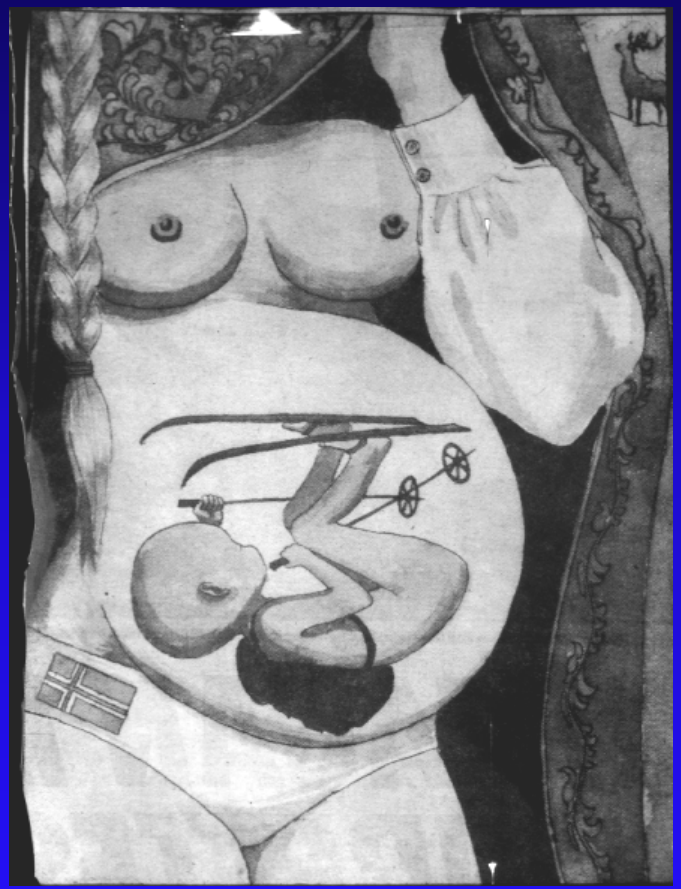
Constantly changing of appearance

5 weeks → 10 weeks

Embryology of Norwegians

At 9 weeks The Norwegian usually has mono-skis

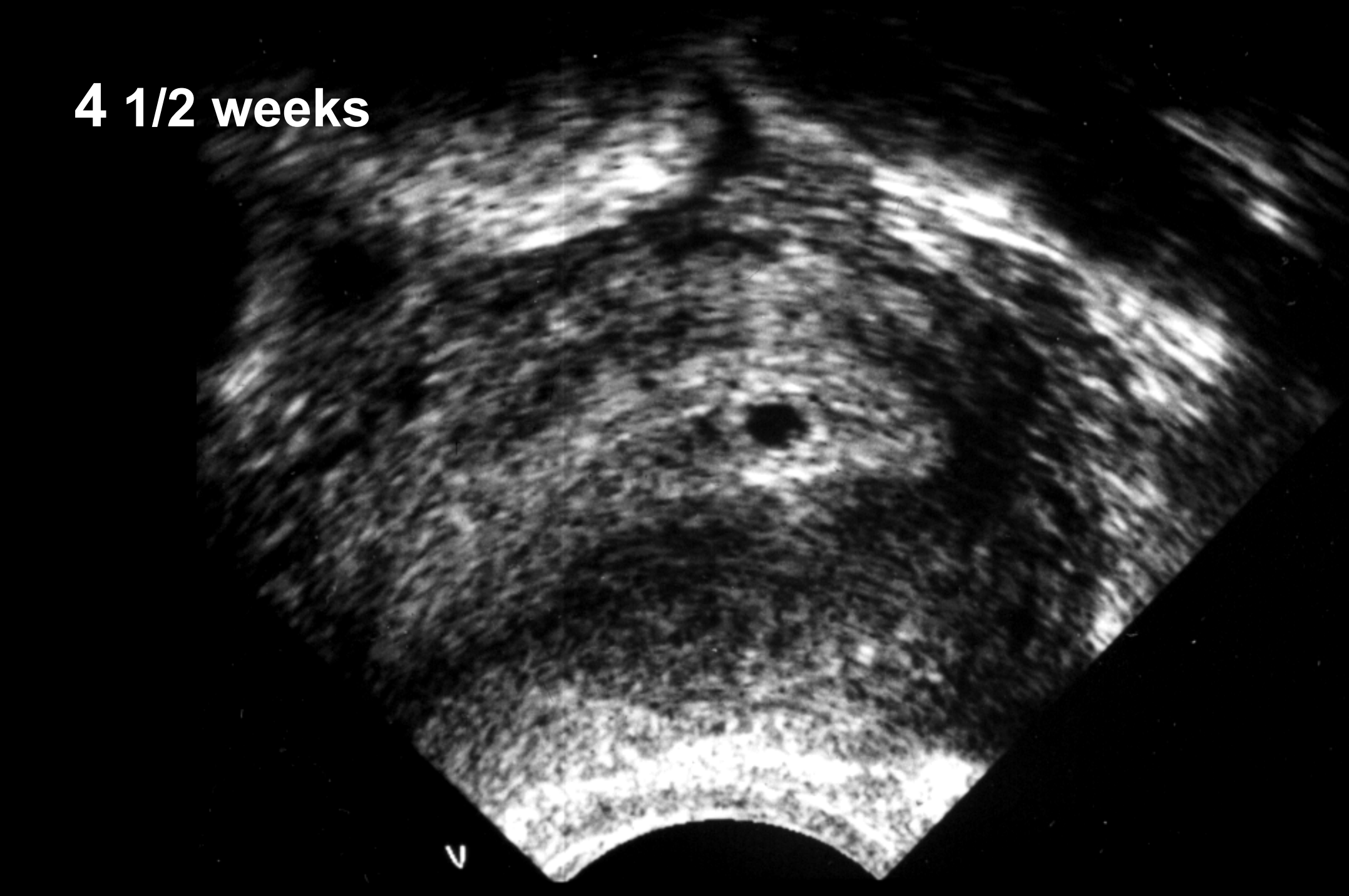
A Norwegian at the routine 18 week scan



Fully developed Norwegian

The implantation

QuickTime™ og en
-dekomprimerer
kreves for å se dette bildet.


4 1/2 weeks

6 weeks

Sonoembryology

Day	CRL 4 mm–8 mm	Carnegie stage
0	Embryonic pole, beating heart	13
1	Upper limb buds, 4 pairs branchial arches	
2	Lower limb buds	
3	Heart rate 120, upper limbs paddle-shaped	14
4	Primordia of cerebral hemispheres	
5	Rhombencephalon on top, mesencephalon anterior	
	Lower limbs paddle-shaped, hand plates	15
6	Amniotic membrane	

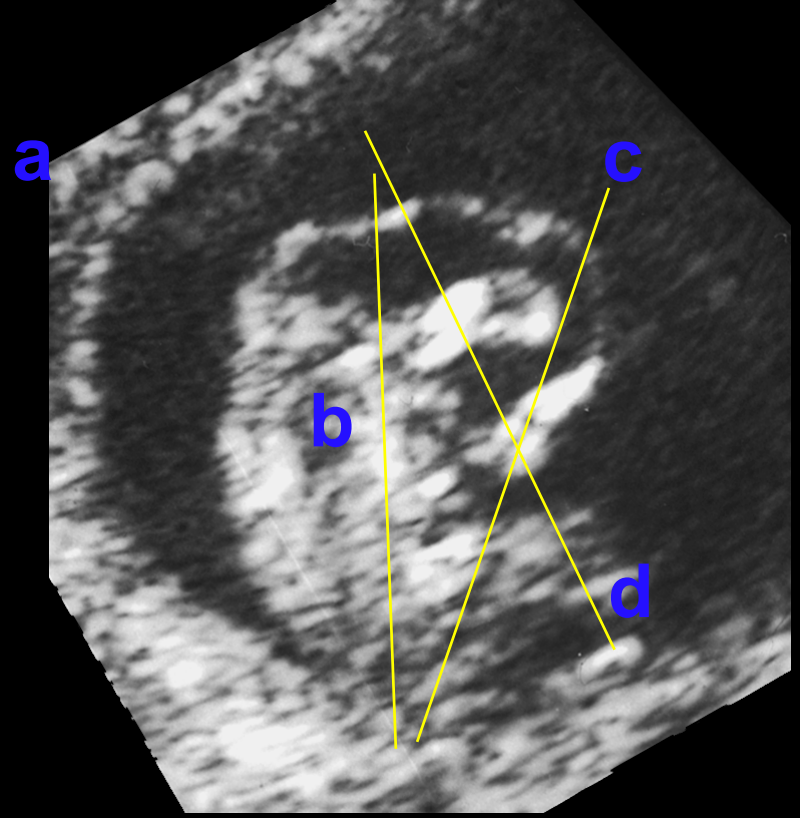
6 weeks, CRL 4 mm

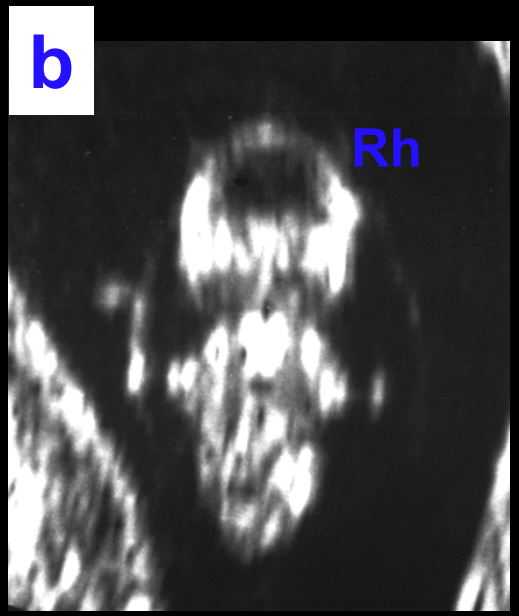
The sagital folding

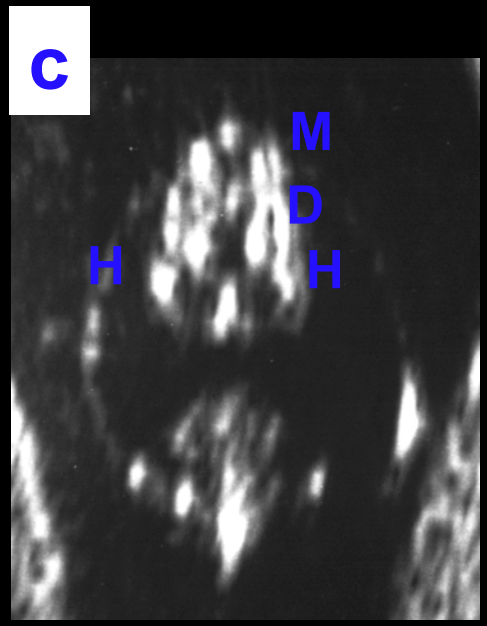
7 weeks

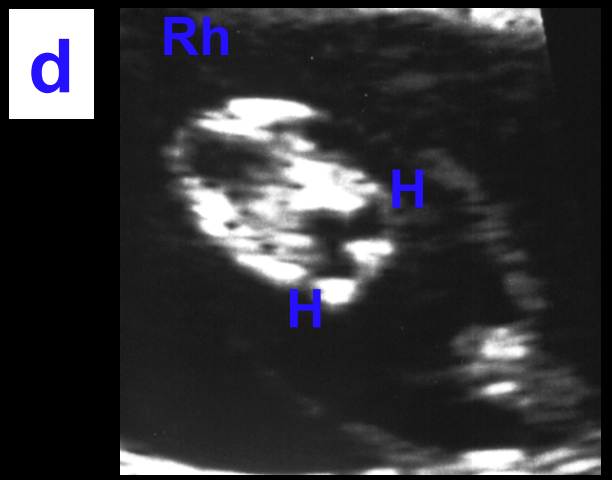
Sonoembryology

Day	CRL 8 mm–14 mm	Carnegie stage
0	Heart rate 130, di- & mes encephalon	
1	Spine, limbs	
2	Telencephalon divided into hemispheres	16
3	Physiological herniation, major calyces	
4	Blood flow in vitelline vessels	
5	Cerebral vesicles prominent, digital rays	17
6	Fourth ventricle largest brain cavity	





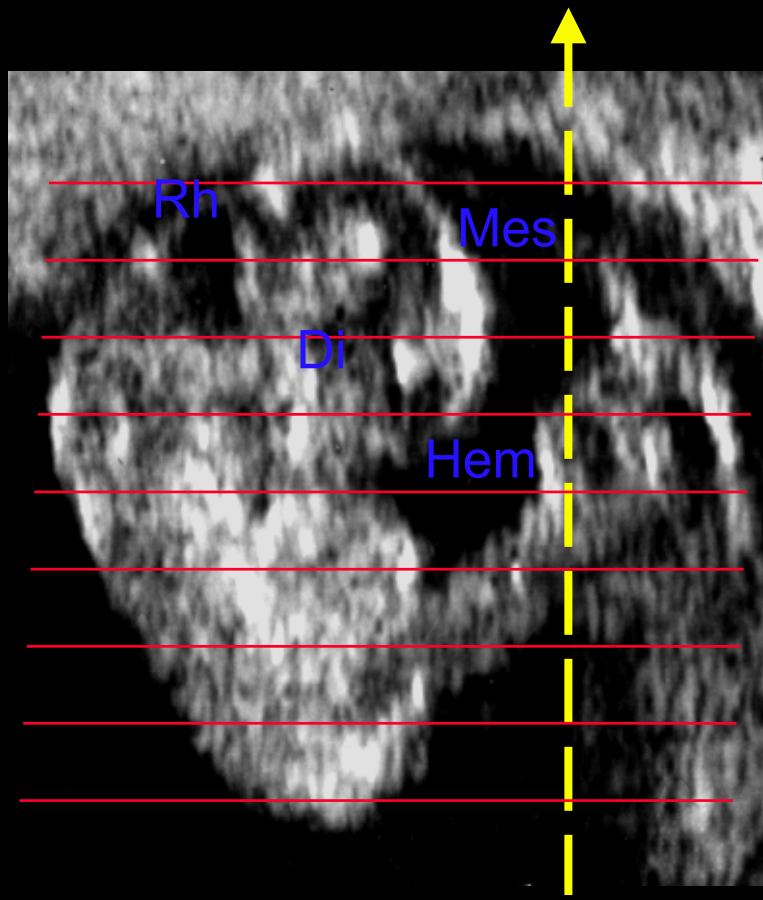




Lennart Nilsson

7 weeks, CRL 12 mm

GE Vingmed Ultrasound



CRL 17 mm

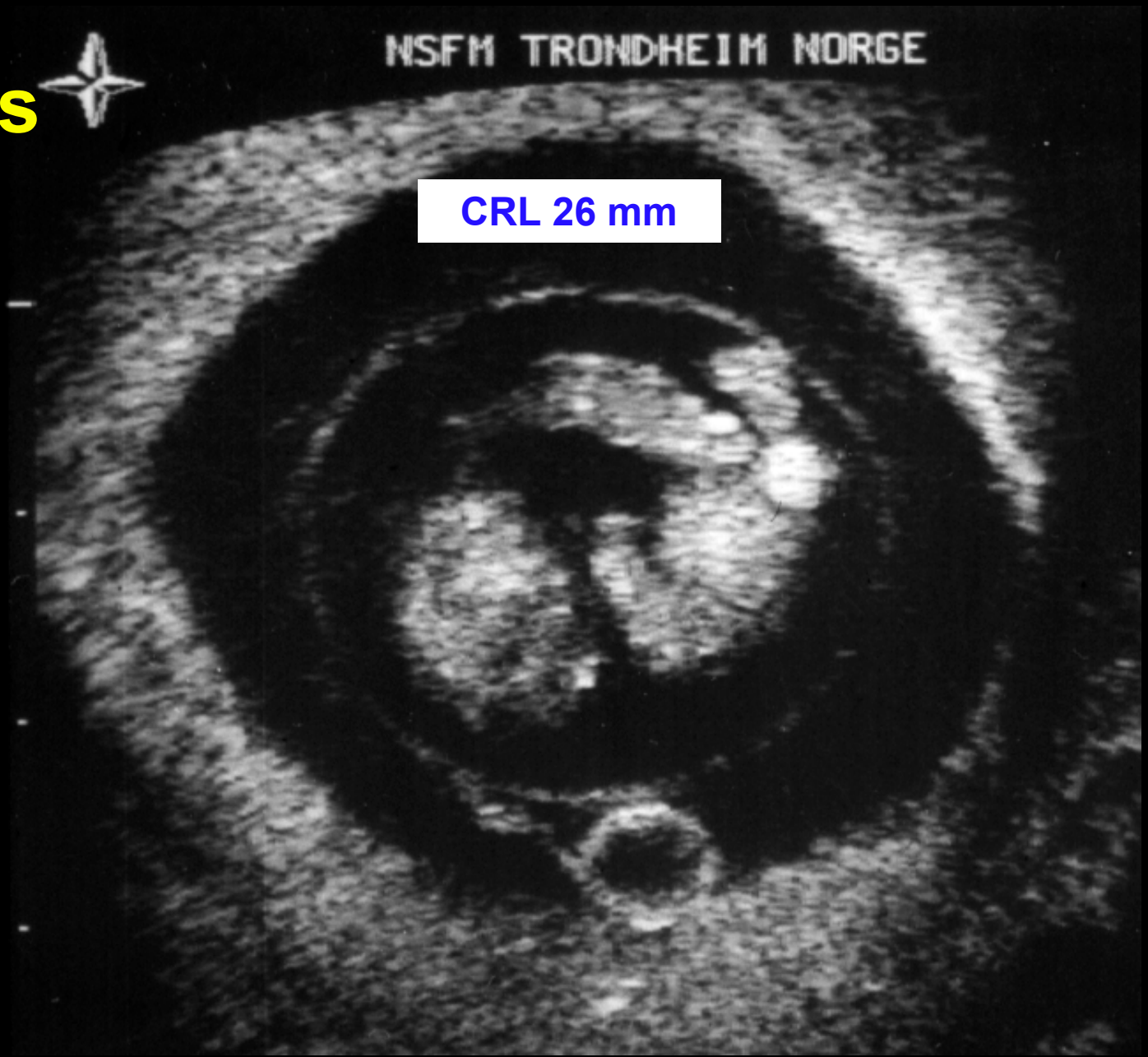
9 weeks

Sonoembryology

Day	CRL 23 mm–31 mm	Carnegie stage
0	Heart rate 175, cerebellar hemispheres	20
1	Stomach, choroid plexuses divide 4th ventricle	
2	Hands & feet approach at the midline, toes	
3	Ossification of clavicle, maxille, mandible	21
4	Width of mesencephalon > diencephalon	
5	All fingers distinguishable	22
6	Large midgut herniation	23

9 weeks, CRL 22 mm

The three sacs



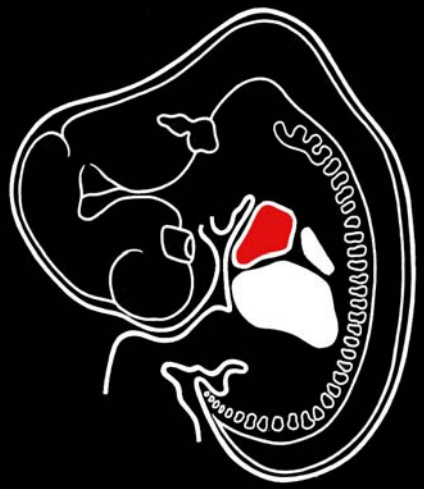
Chorionic cavity

Amniotic cavity

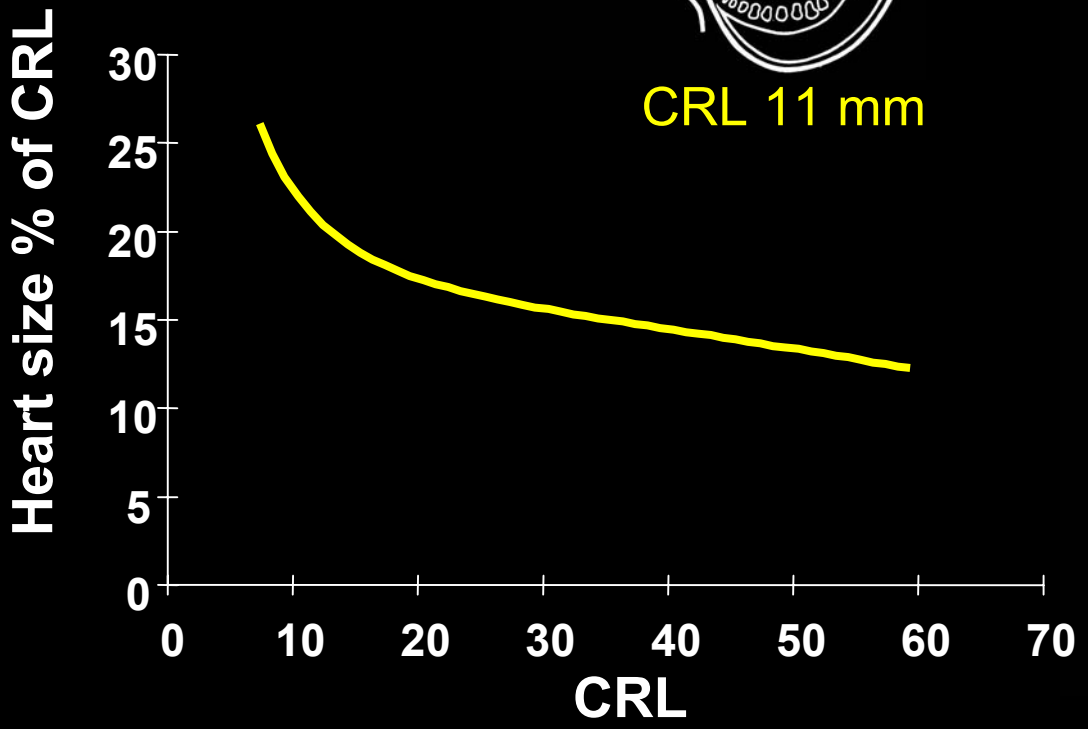
Yolk sac

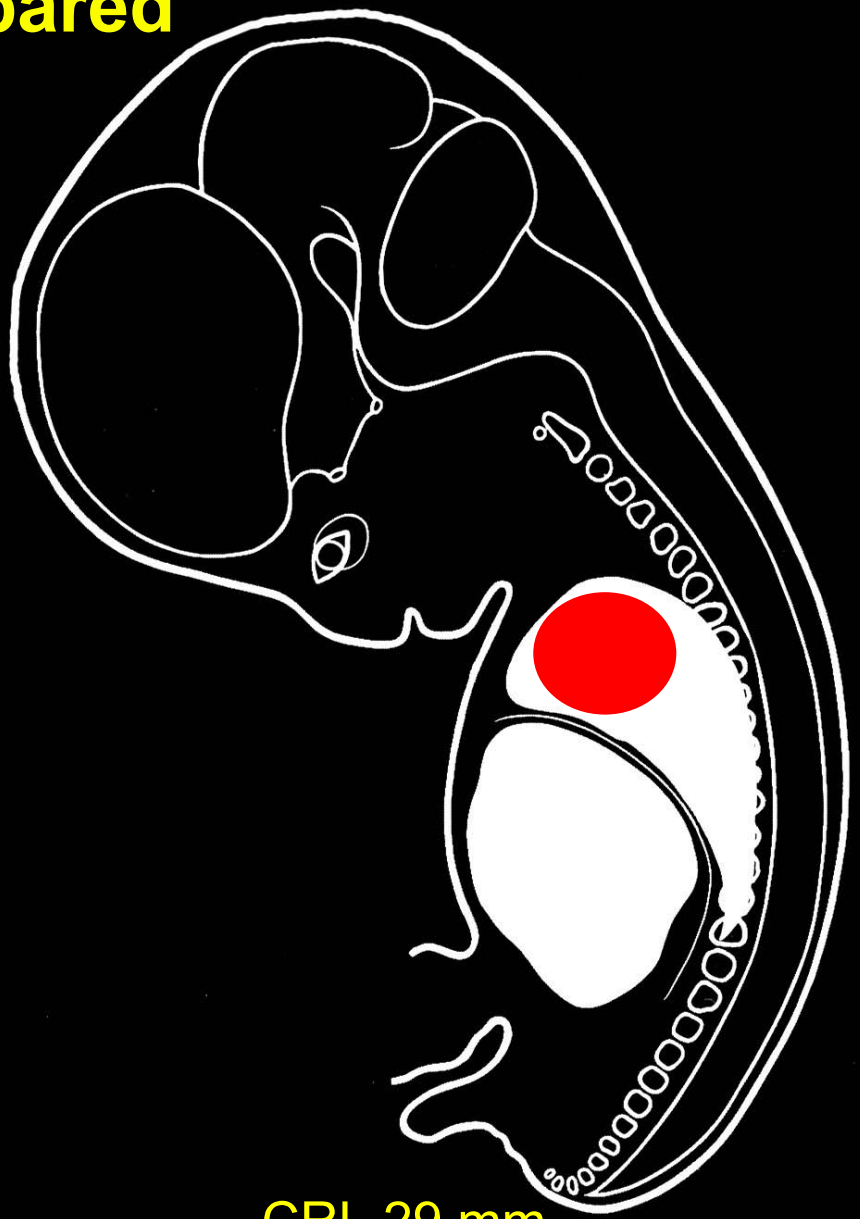
The heart is relatively large compared to the body of the young embryo

CRL 6 mm



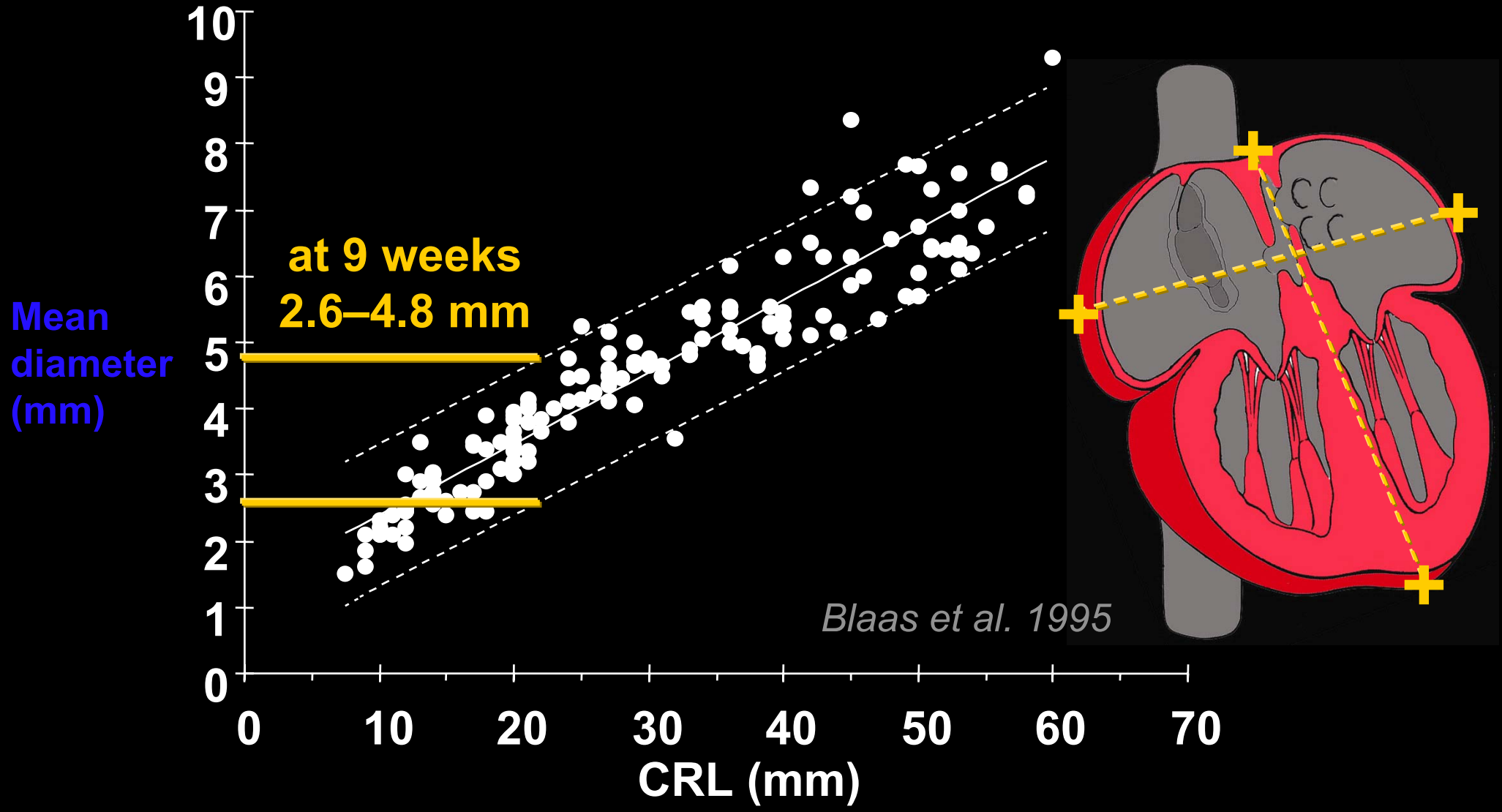
CRL 11 mm





CRL 29 mm

Size of embryonic/fetal heart



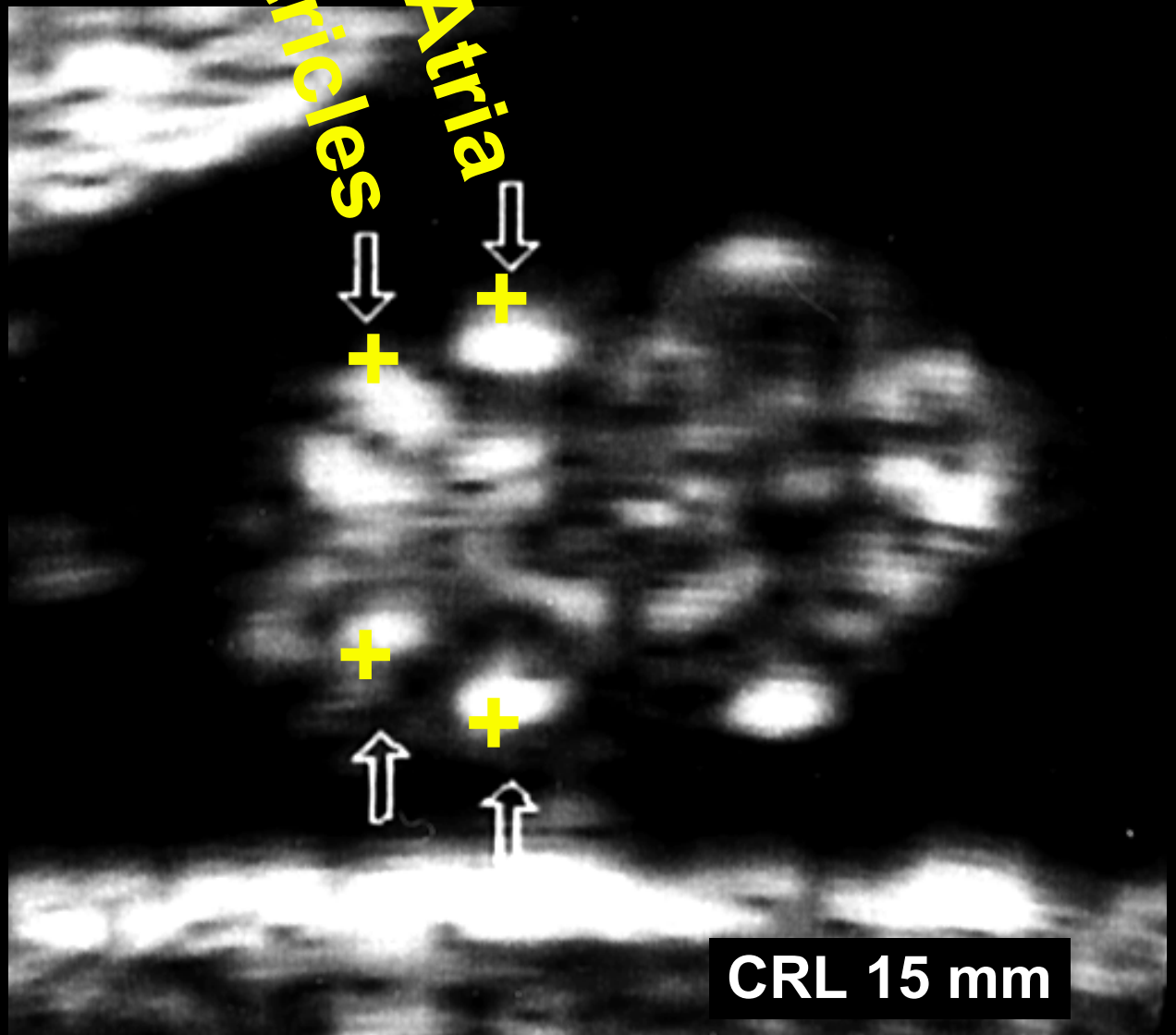
Heart

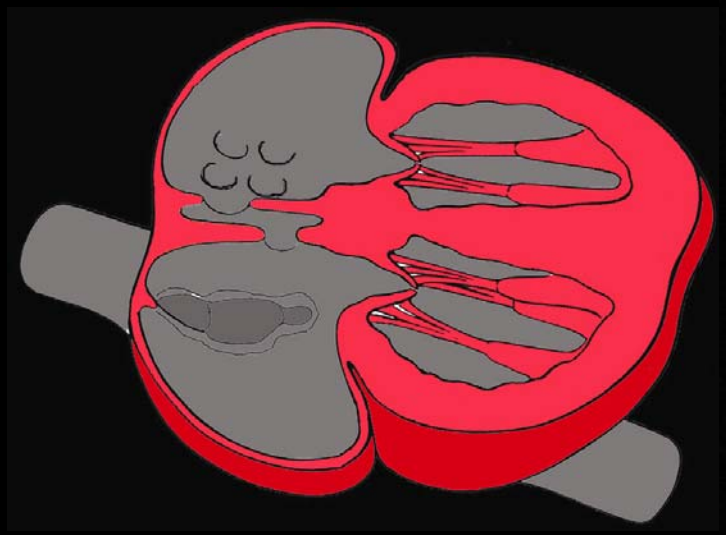
Trondheim, 2001

$6^{1/2}$ weeks, CRL 6 mm

Embryonic organs

Heart chambers





9 weeks; CRL 23 mm

Early diagnosis
10 weeks

- Acrania, anencephaly, encephalocele
- Myelomeningocele
- Large facial defects
- Limb defects; poly-, oligodactyly
- Gross body wall defects (LBWC, gastroschisis, epigastric omphalocele)
- Major heart defects (AV-commune)

10 weeks

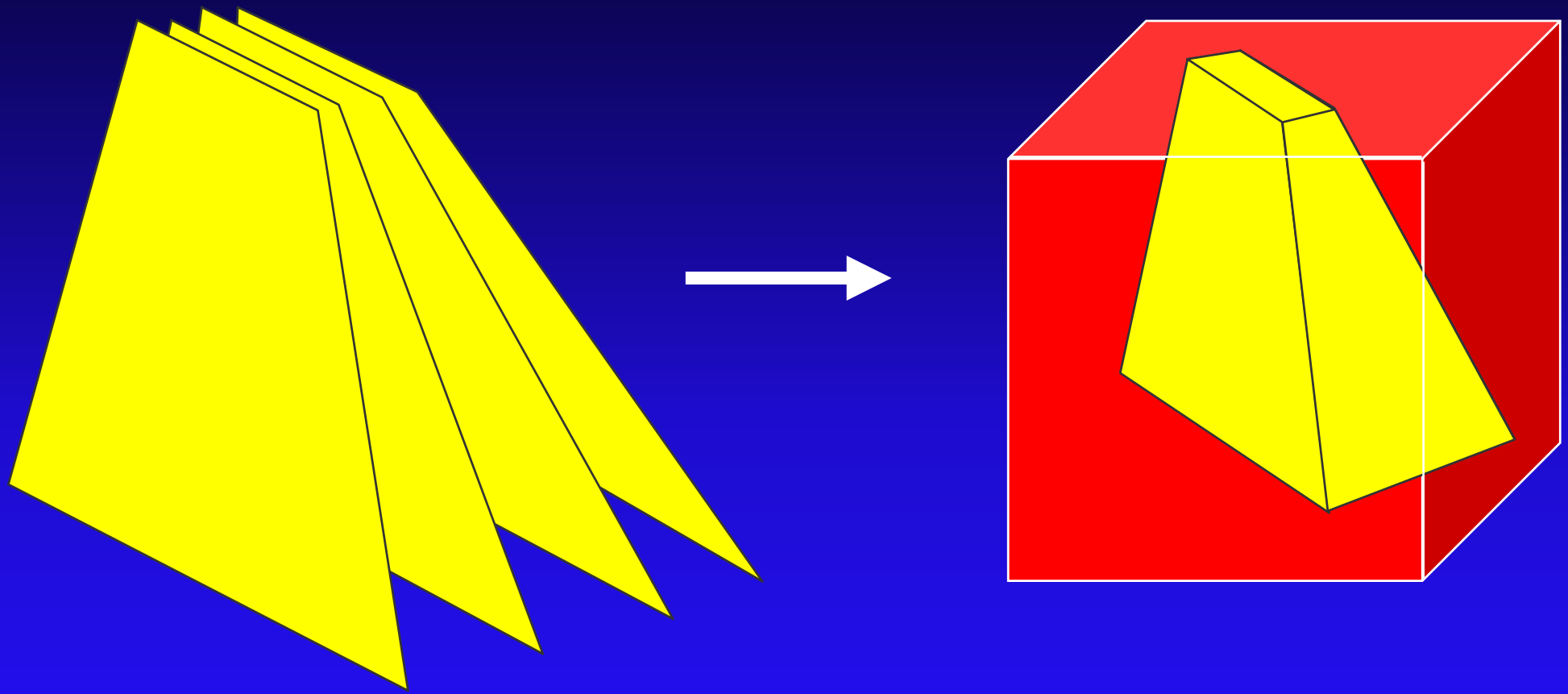
Cerebro-oculo-muscular syndrome
Lissencephaly type II

Cerebro-oculo-muscular syndrome with encephalocele (lissencephaly type II)

Fetus 13 weeks (CRL 65 mm)

QuickTime™ og en
Animation-dekomprimerer
kreves for å se dette bildet.

3D scan-conversion

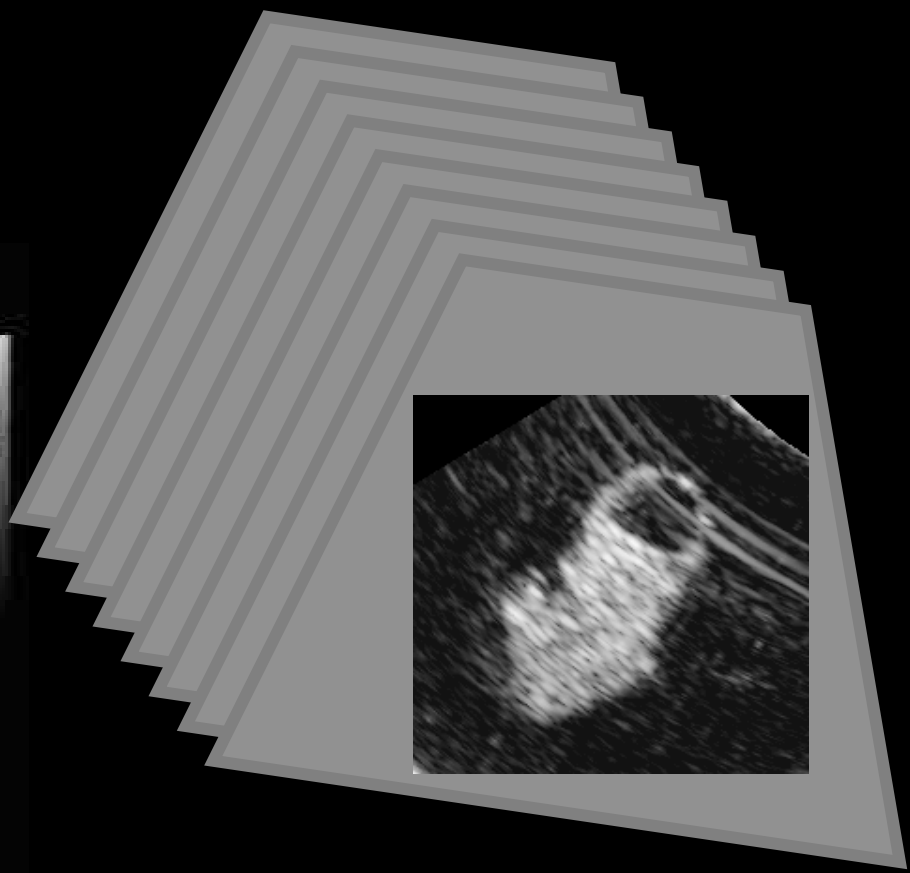


US data

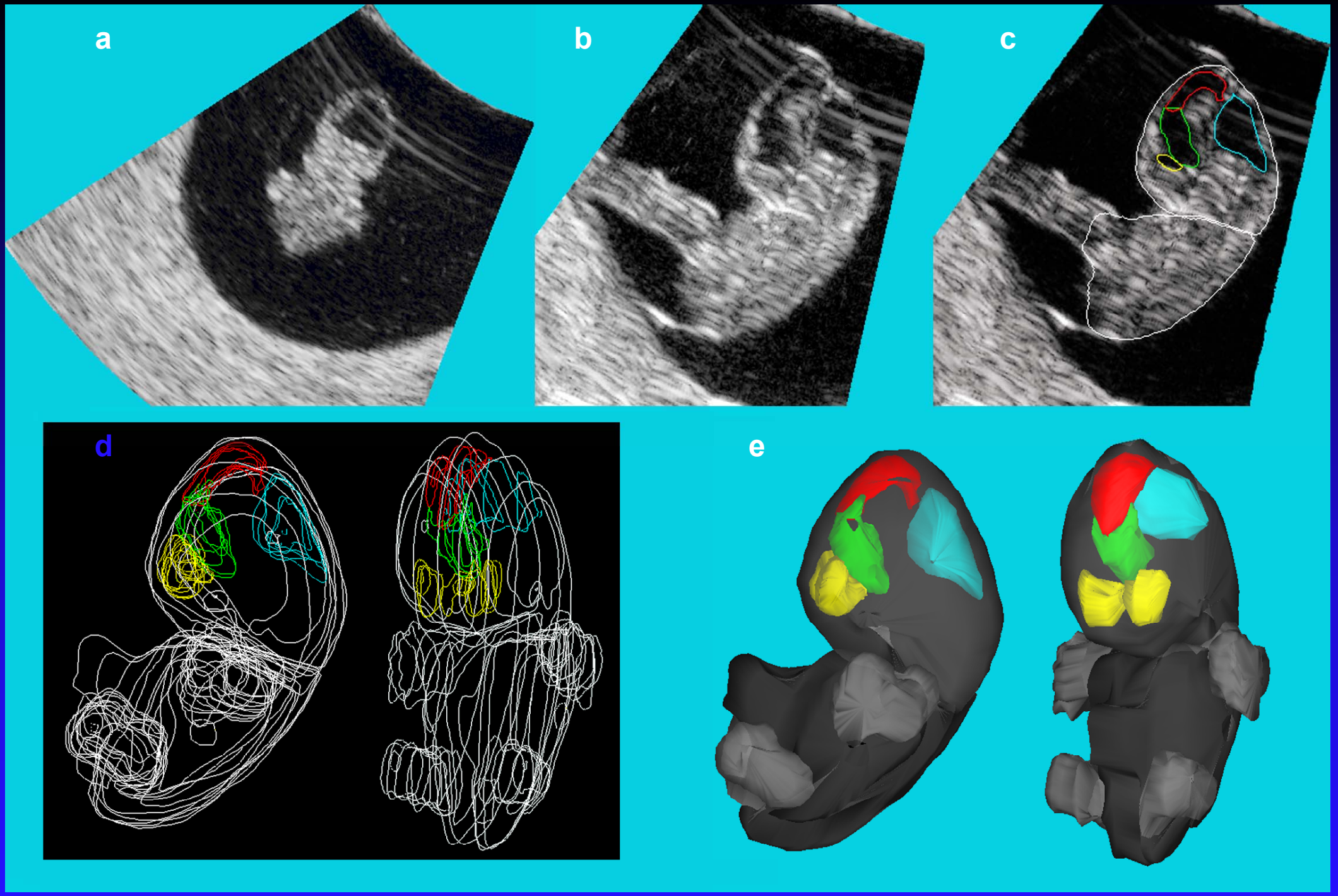
Regular volume

For the evaluation of the small embryo by 3D certain demands have to be made to the ultrasound equipment

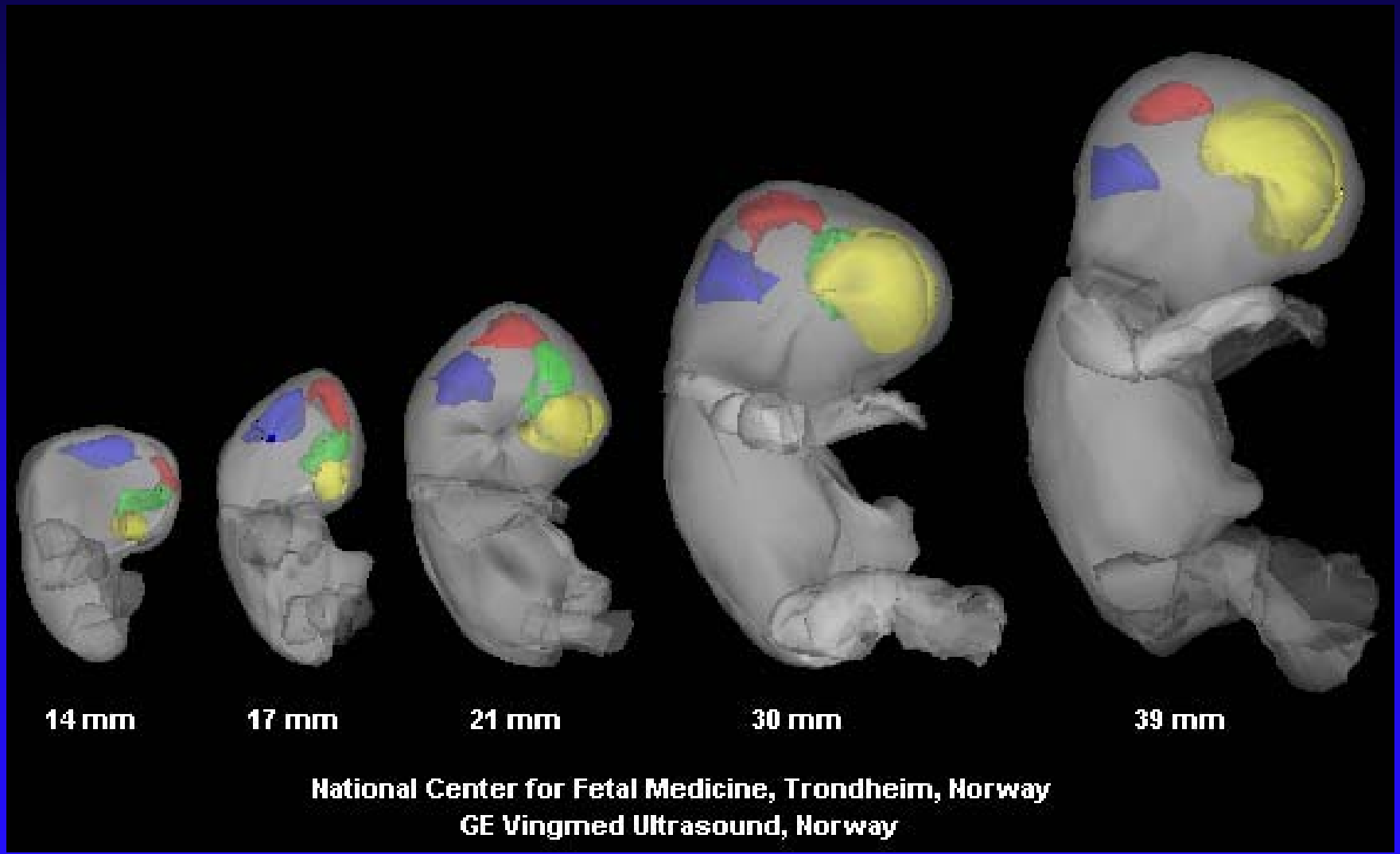
CRL 17 mm



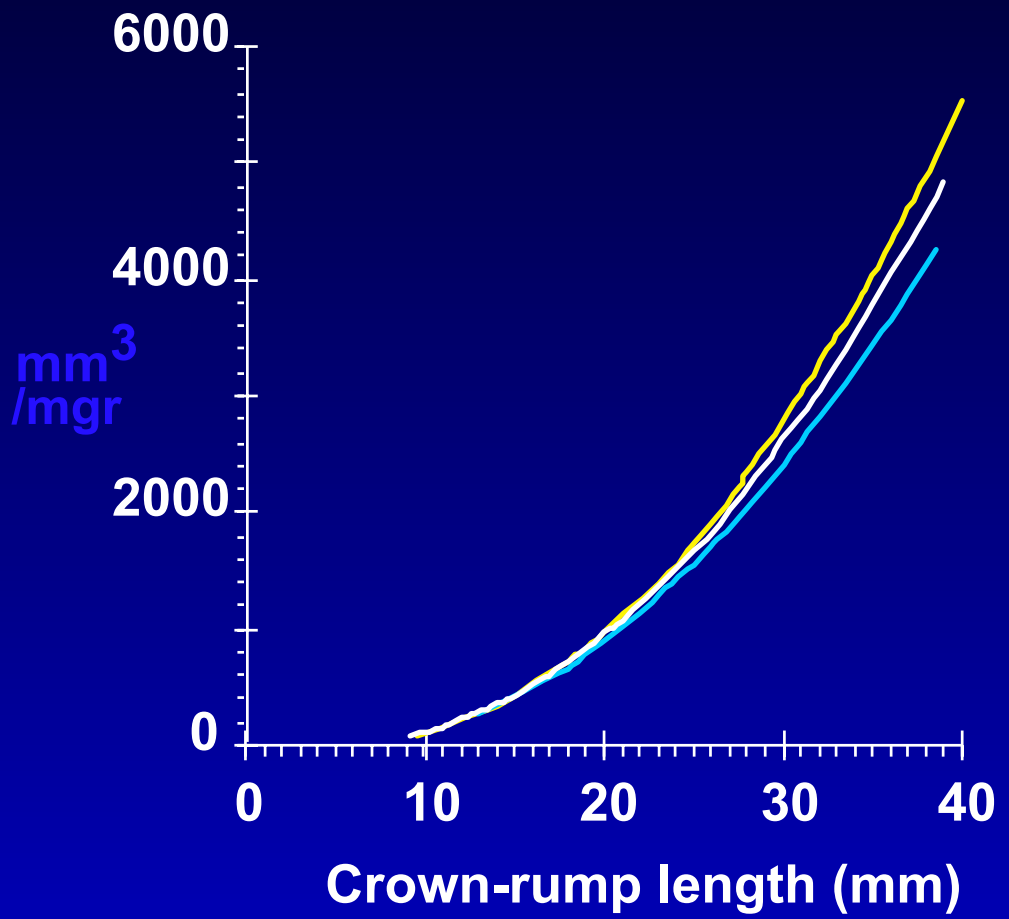
Ultrasound tomograms

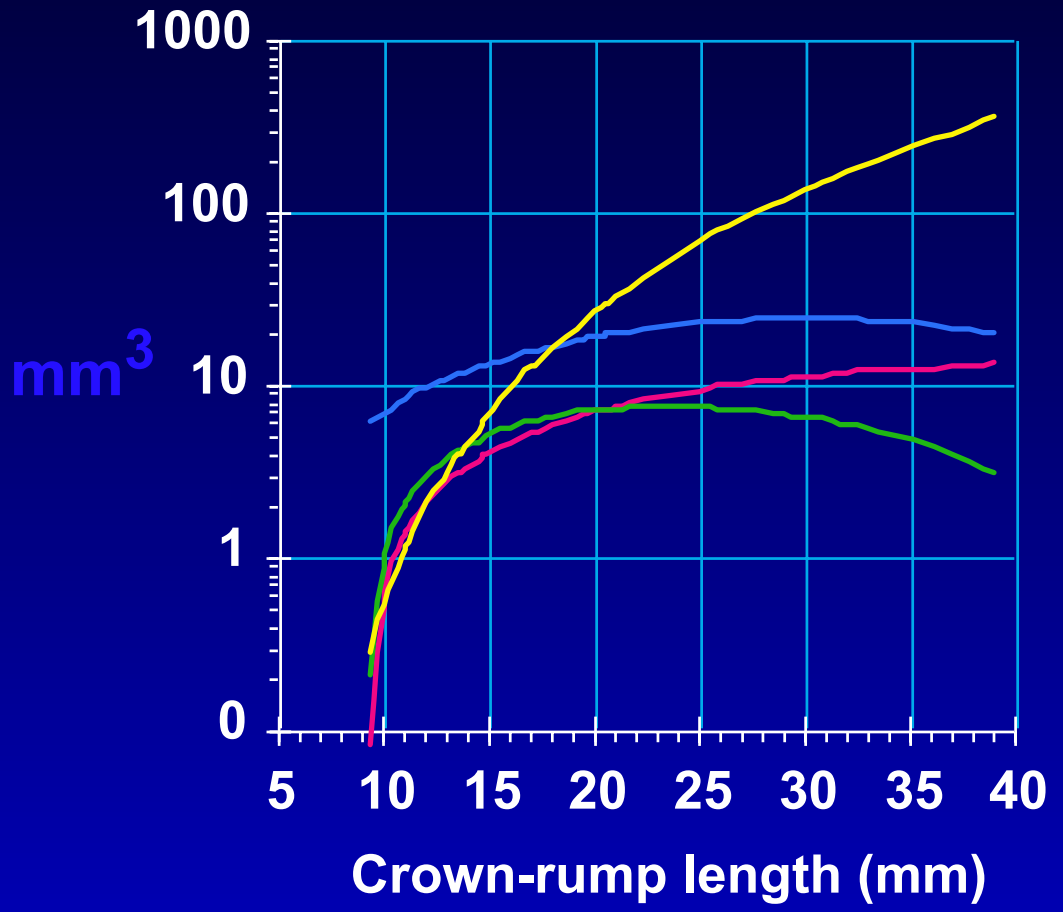

a
b
c
d
e

Embryonic development from 7 - 10 weeks
(Blaas et al. The Lancet 1999)



Volumes of embryos & brain cavities





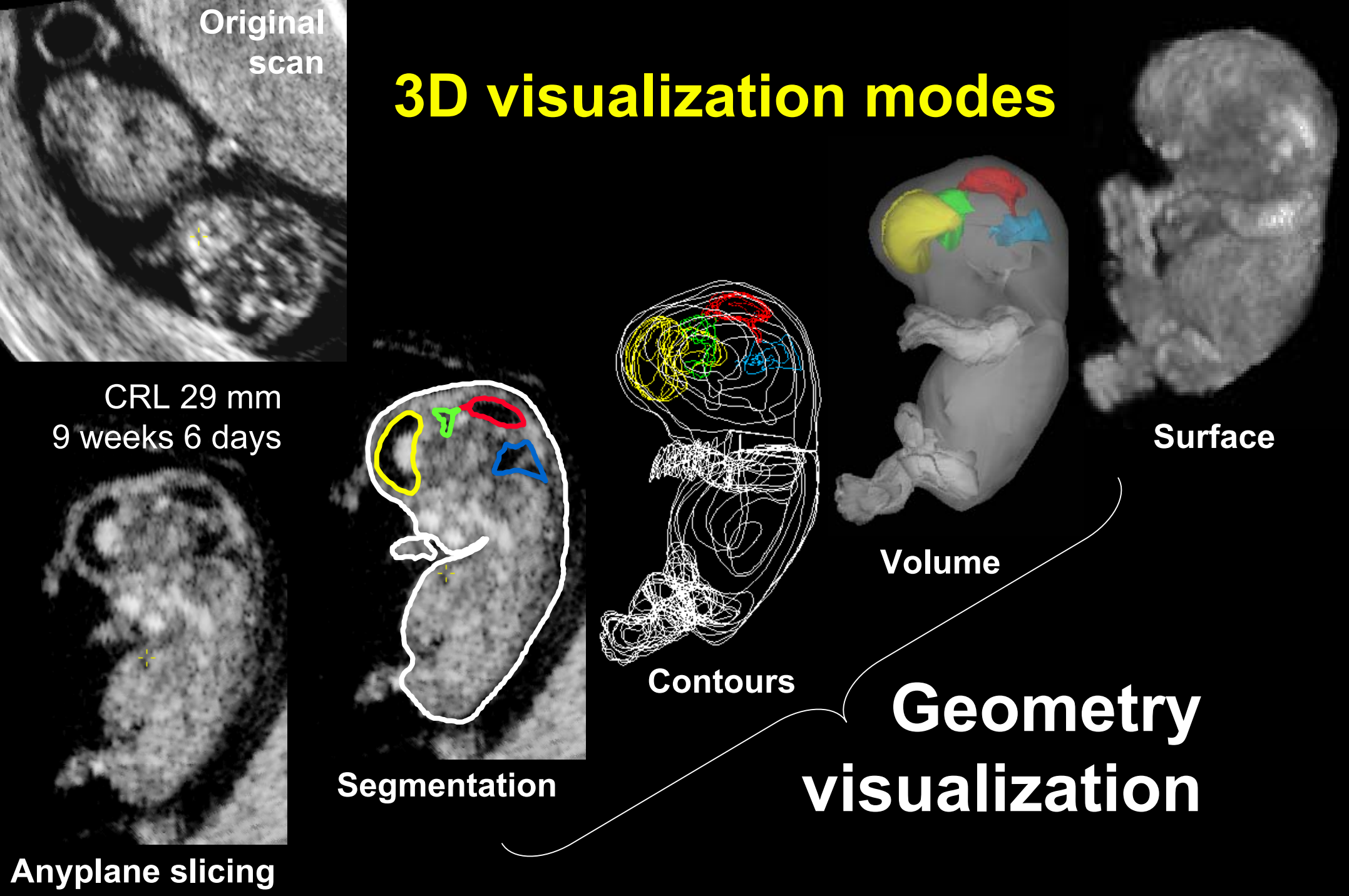
mean weight Streeter (N = 28)
mean weight Jirásek (N = 18)
mean volume Trondheim (N = 34)

Rhombencephalon
Mesencephalon
Diencephalon
Hemispheres

The shape

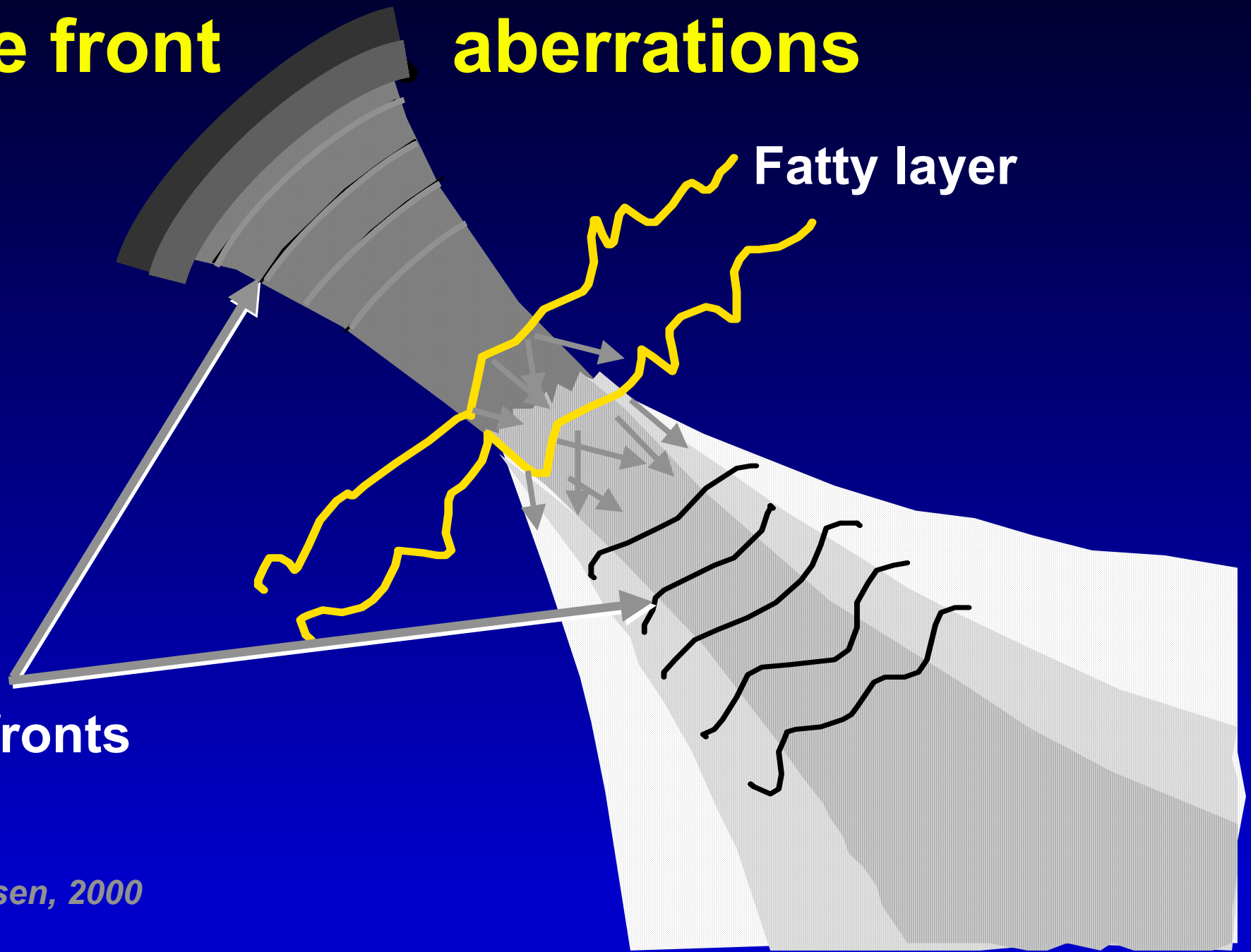
The evolution of a Norwegian -

QuickTime™ og en
Microsoft Video 1-dekomprimerer
kreves for å se dette bildet.


Original scan
3D visualization modes
CRL 29 mm
9 weeks 6 days
Surface
Volume
Contours
Segmentation
Anyplane slicing
Geometry visualization

3D - Still limited resolution

Phase front aberrations



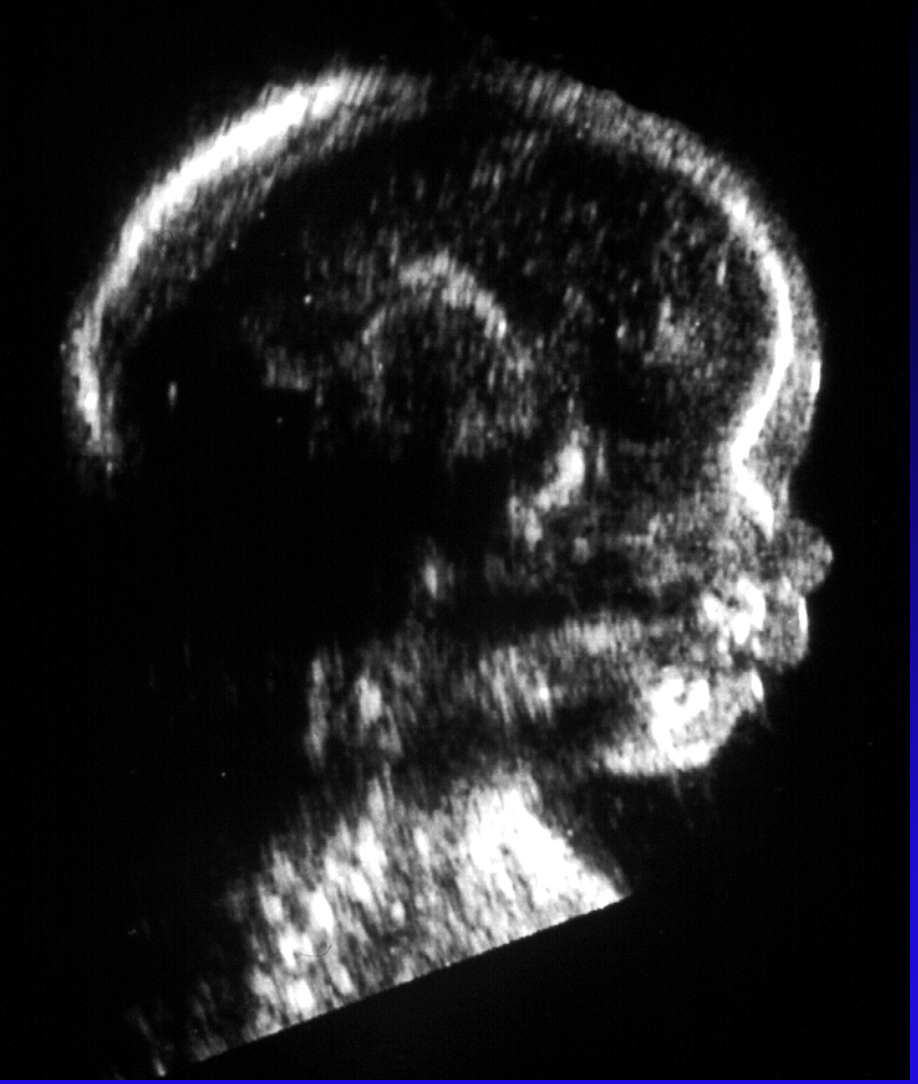
Bjørn Angelsen, 2000

”Make embryology come alive!”

- An embryology text book
- An artist - Heather Spears
- A sonoembryologist - Blaas
- Computer power - Visual Knowledge ©

The development of the embryonic face

QuickTime™ og en
Sorenson Video-dekomprimerer
kreves for å se dette bildet.



The Routine use of Ultrasound:

The fetal examination

Officially introduced ultrasound monitoring programs

	Year	Scans	Weeks	New German program (1995)
Germany	1980	2	18 - 32	10 - 20 - 30
Norway	1986	1	18	
Iceland	1987	1	18	
Austria	1988	2	18 - 32	
Switzerland	1996	2	10 - 18	

Routine ultrasound

Monitoring around the world

Country	% of pop. scanned	GA
Australia	95	18
Belgium	95	10-20-32
Canada	90	18
Croatia	90	18-32
Czech Republic	96	18-32
Denmark	51	17
Finland	87	18
France	90	12-22-33
Hungary	95	10-18-28-37
Italy	?	12-20-36

Marsal, 1997

Routine ultrasound Practice around the world

Country	% of pop. scanned	GA
Poland	40	10-24
Portugal	?	12-20-30-36
Romania	25	8-20-35
Slovakia	70	10-20-32-38
Spain	95	10-18-35
Sweden	97	18
The Netherlands	70	18
Turkey	?	12-17-32
United Kingdom	96	18
USA	60	20

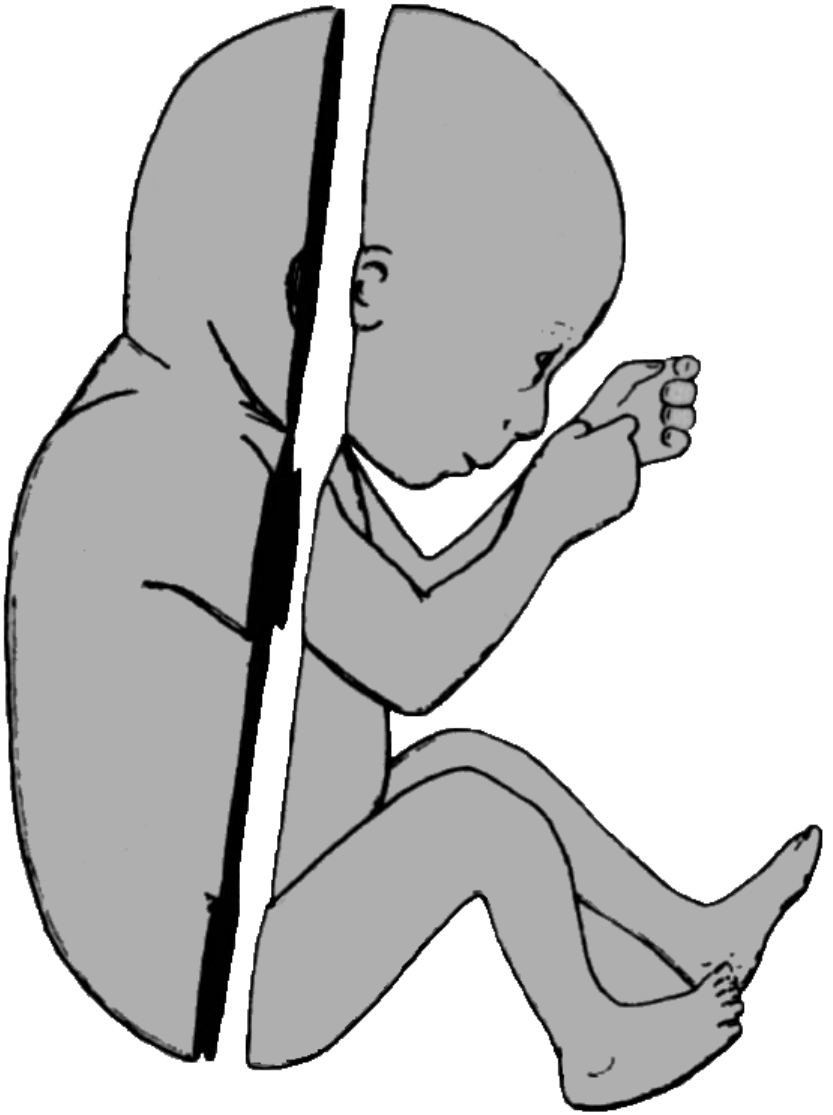
Marsal, 1997

The second trimester fetal examination

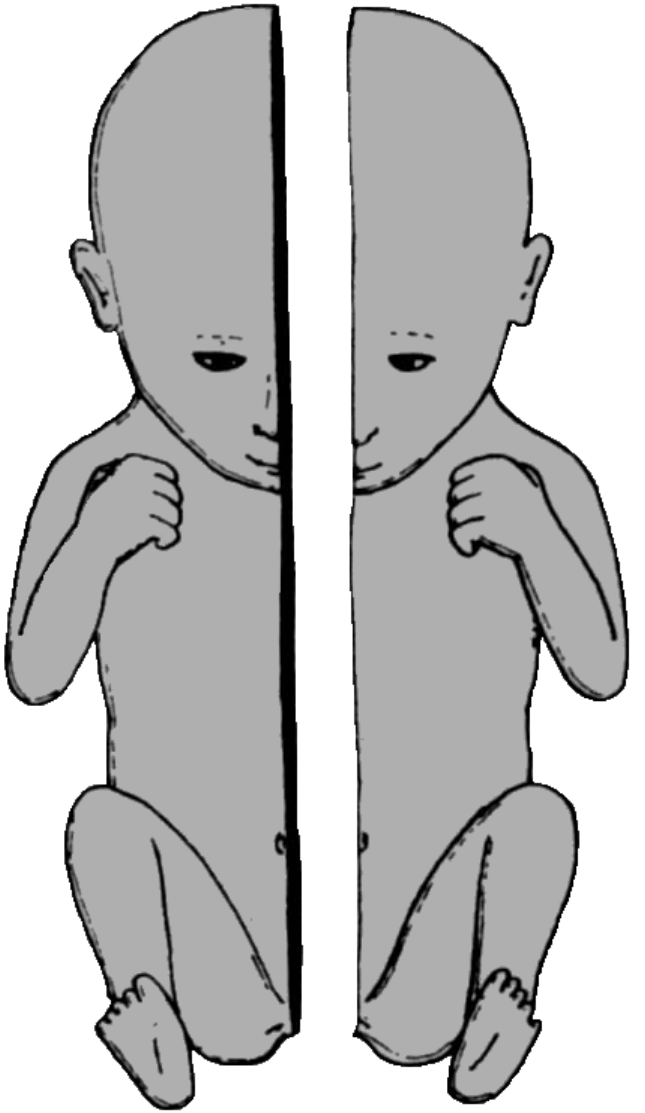
- Assess the gestational age
- Detect multiple pregnancies
- Locate the placenta
- Detect developmental disorders

Fetus at 18 weeks

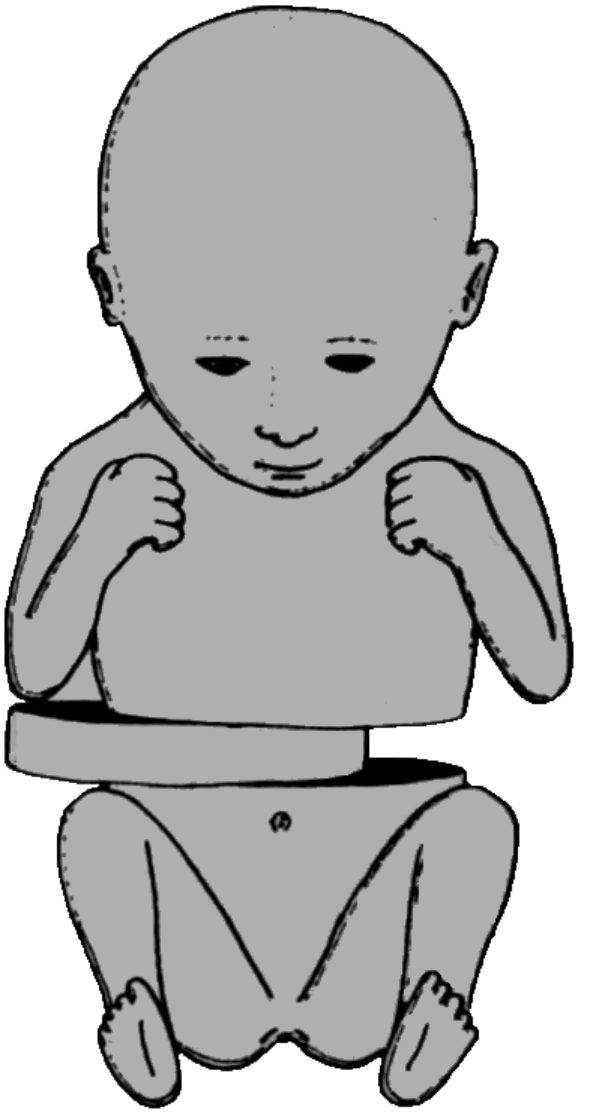
Fetal sections



Frontal section



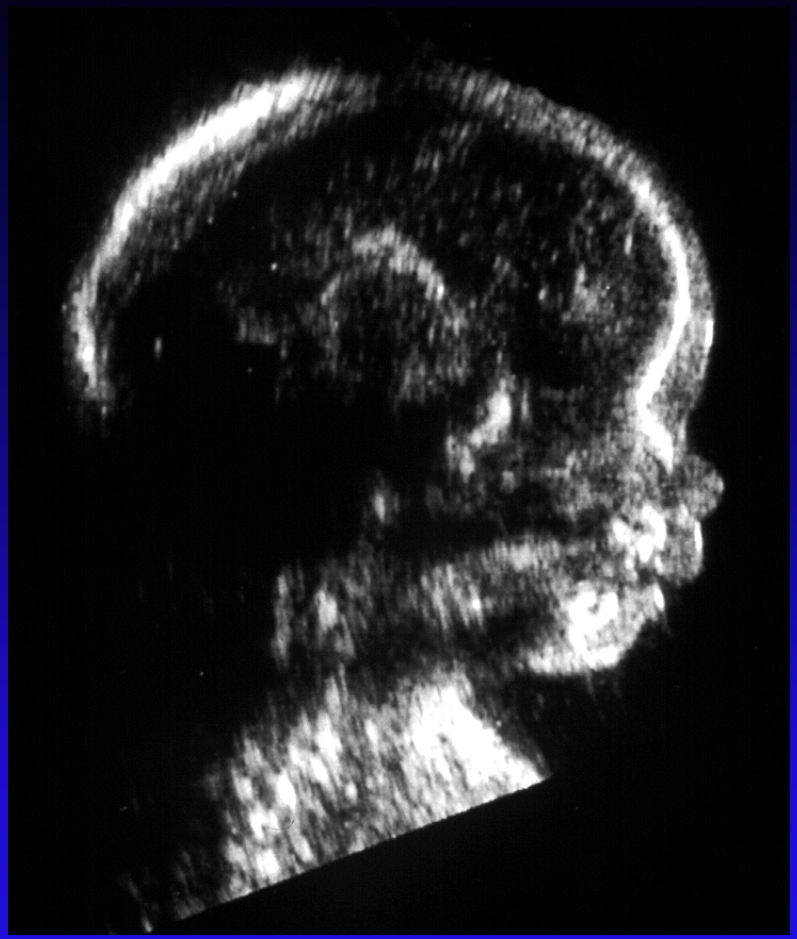
Sagittal section



Horizontal section

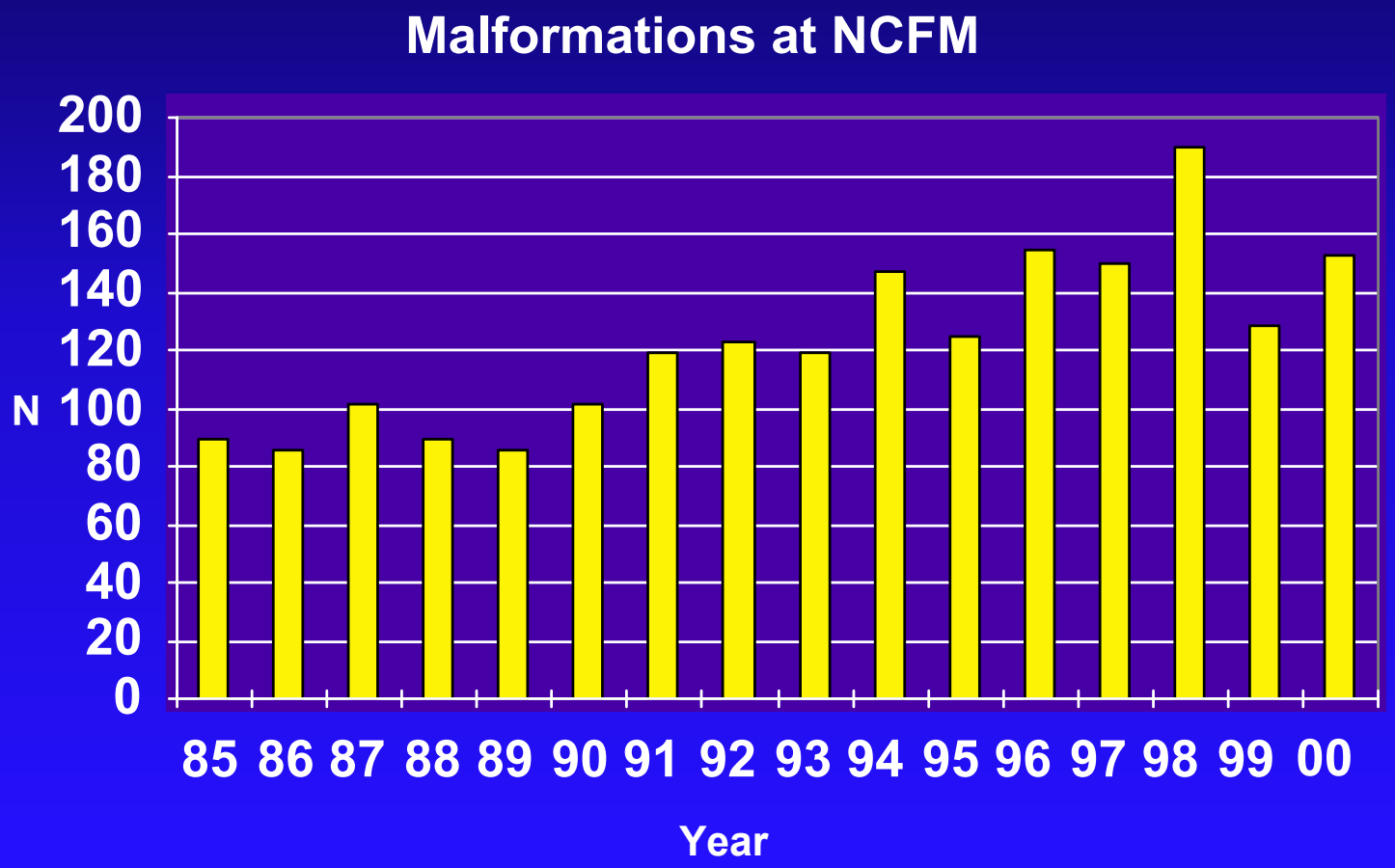
In this world of evidence based medicine Improved quality of care - definition

- Decrease mortality rate
- Decrease morbidity rate
- Reduce unnecessary intervention
- Provide lifesaving information
- Provide important, but not lifesaving information
- Make obstetrical management more secure
- “Be prepared”



The fetal examination

Malformations at NCFM 1985 – 2000



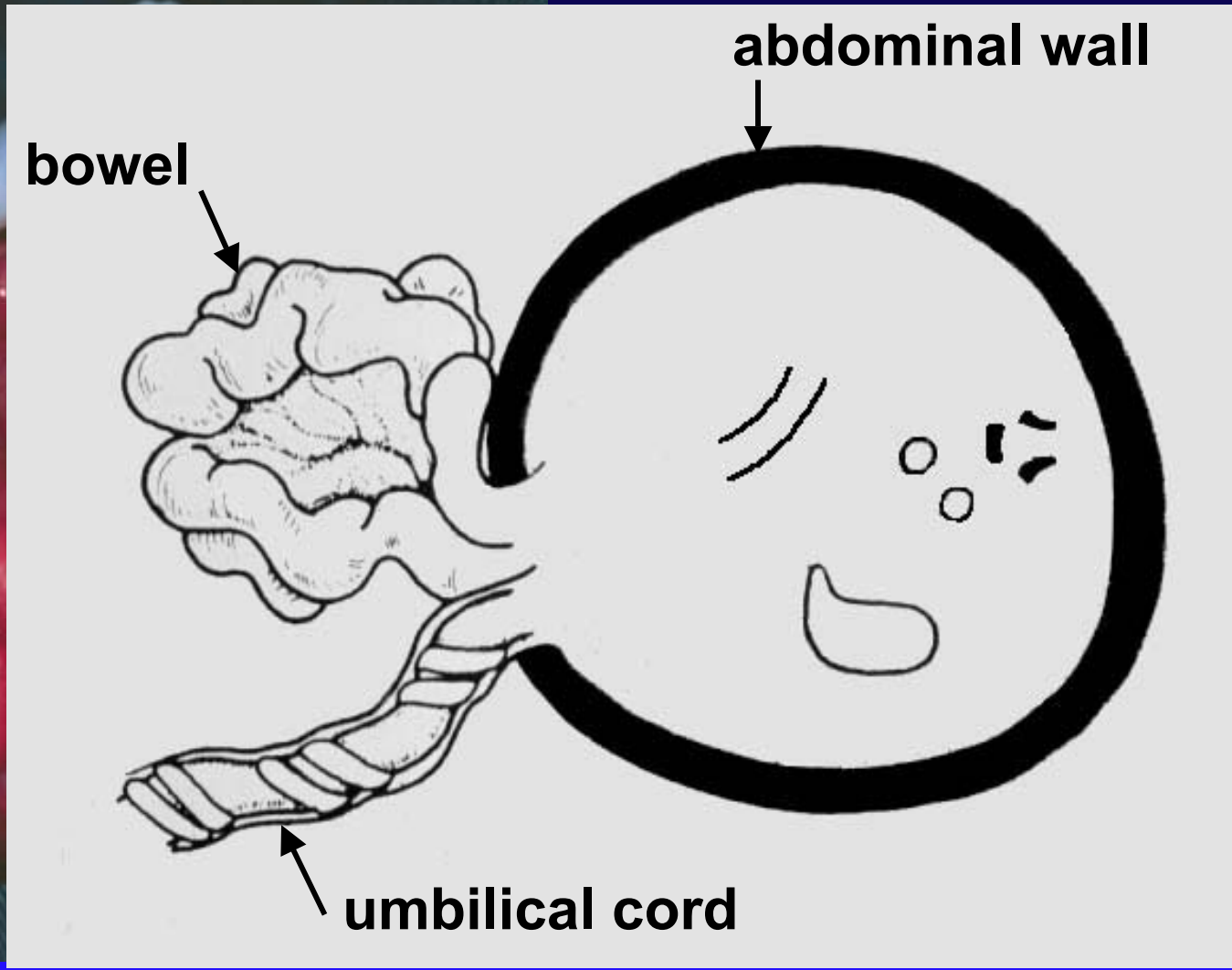
N = 1960

- some conditions where antenatal diagnosis may decide between life and death

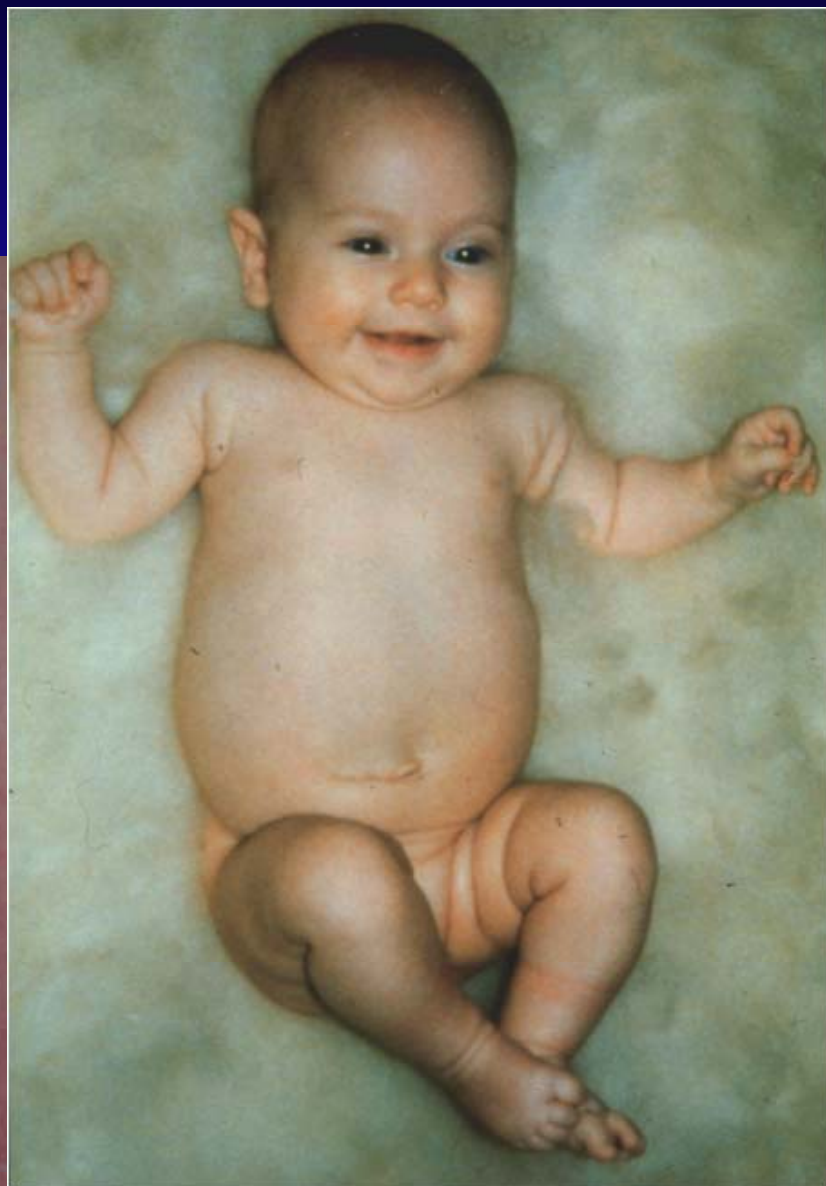
- Sacrococcygeal teratoma
- Cystic hygroma of the neck
- Diaphragmatic hernia
- Ductus dependent CHD
- Abdominal wall defects
- Cystic adenomatoid malformation of the lung

Sacro coccygeal teratoma

Gastroschisis



Gastroschisis

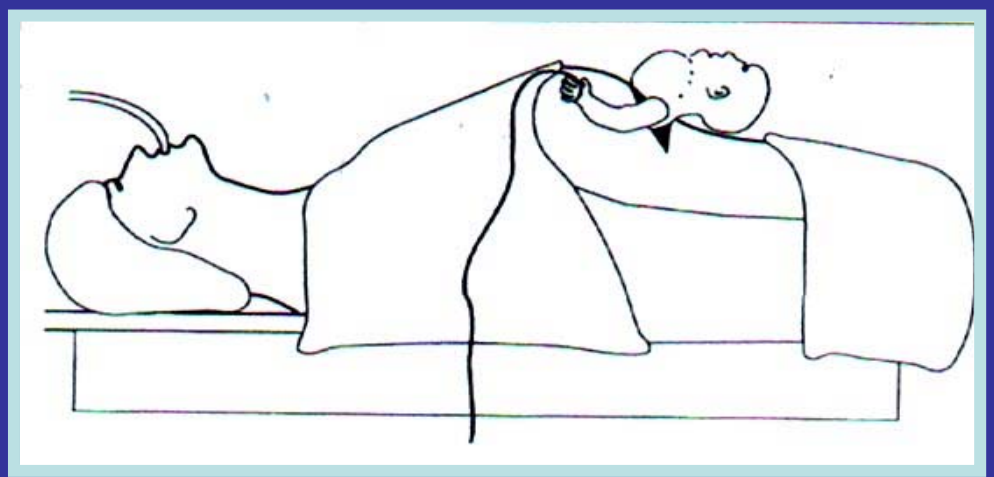


Cystic hygroma

”EXIT”-procedure

EX utero **I**ntrapartum

Treatment procedure



EXIT-procedure

Originally developed to secure open respiratory system during delivery following fetal tracheal occlusion treatment (”PLUG”) for diaphragmatic hernia.

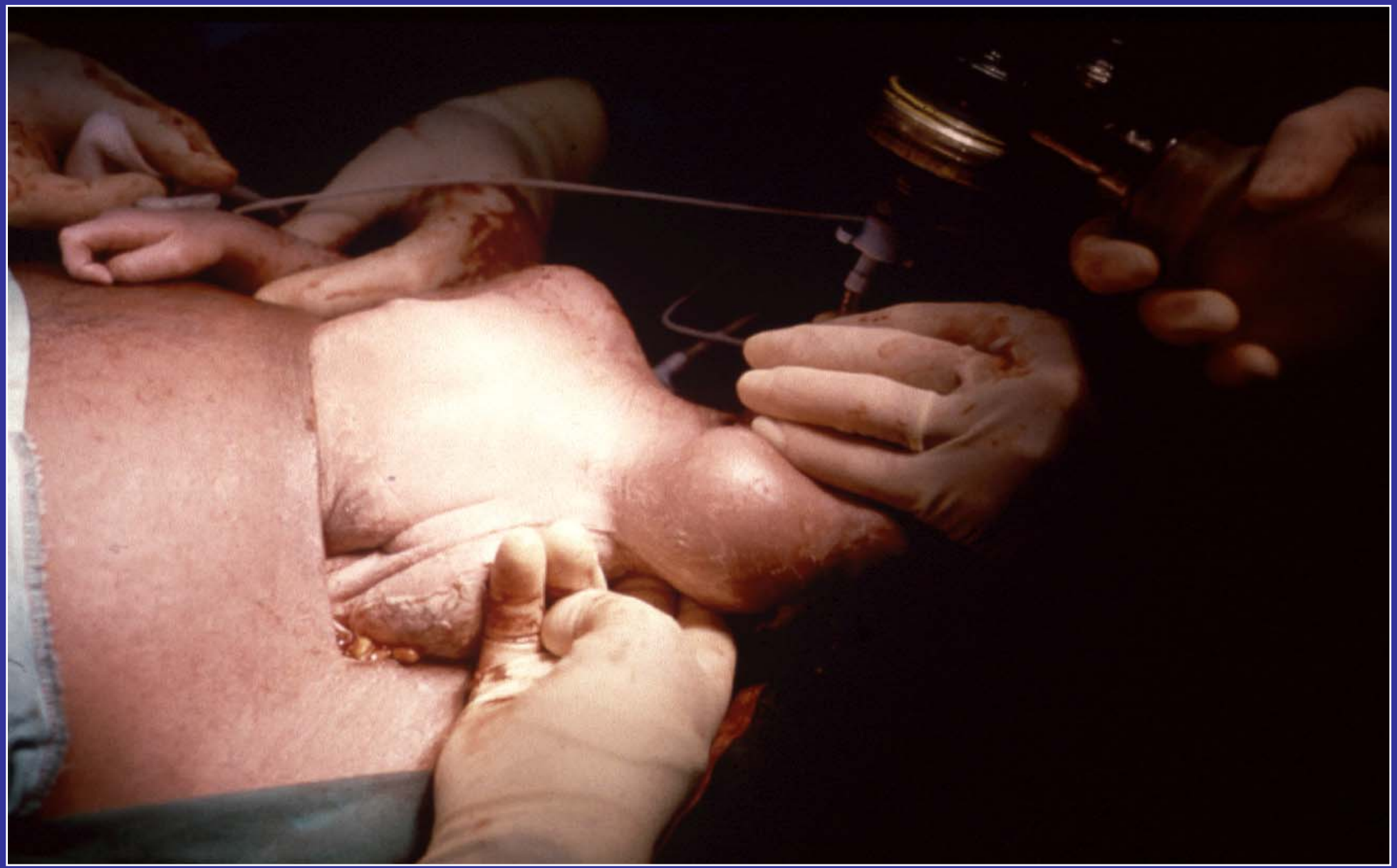
Harrison, Adzick et al, 1997

”PLUG”: Plug the Lung Until it Grows

EXIT-procedure

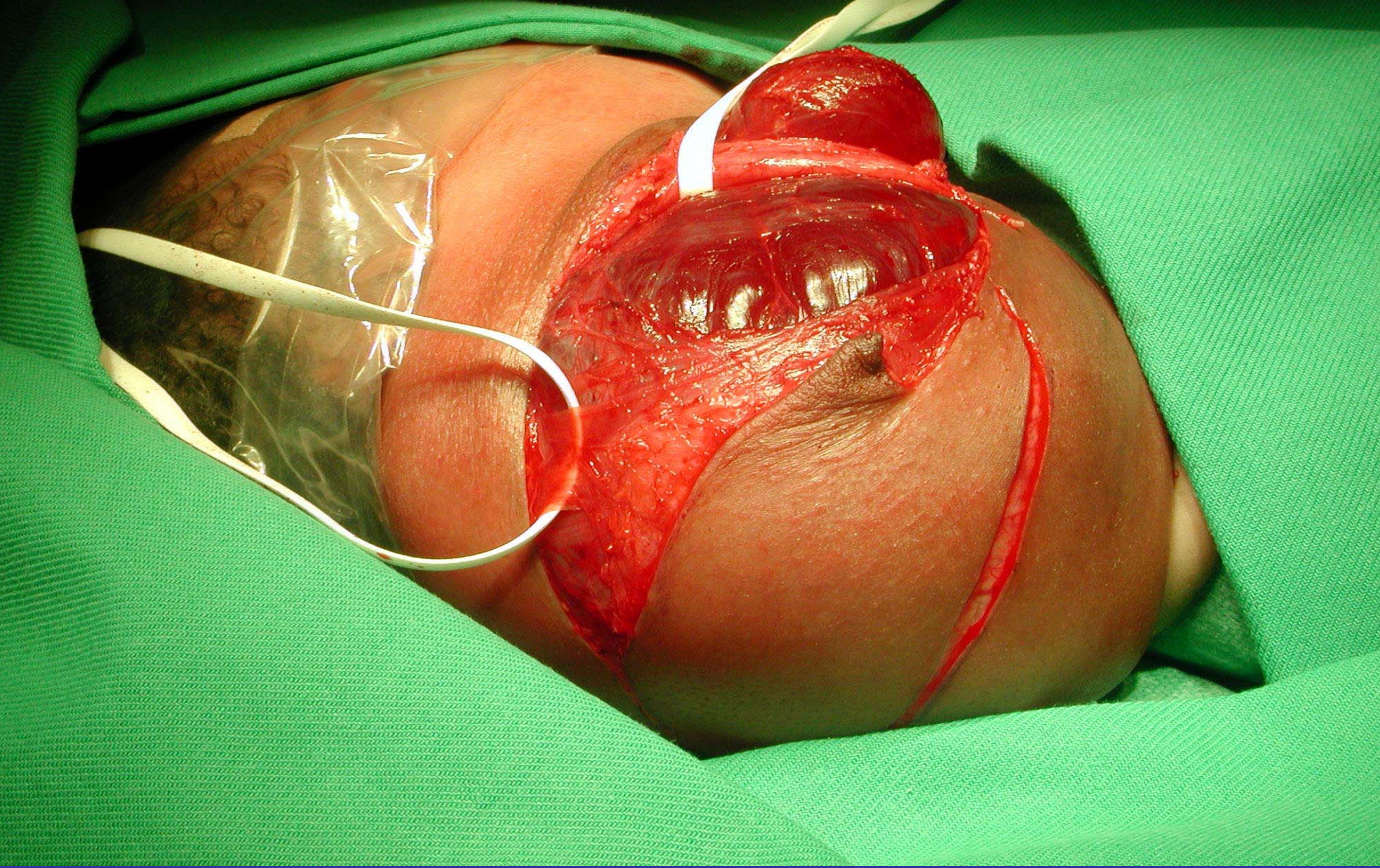
- Caesarian section
- Head, arm, upper trunk extracted
- Umbilical cord intact
- Secure airways by endotracheal intubation or tracheostomy
- Cut umbilical cord and deliver child
- Procedure may last 1 hour

EXIT-procedure

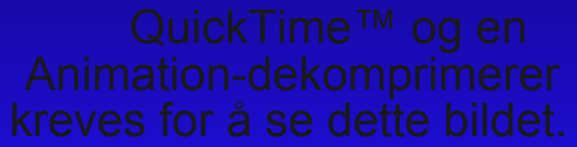


EXIT-team

- Anesthetist
- Pediatric surgeon
- Midwife
- Neonatologist
- Obstetrician



The difficult heart



Transposition of great arteries
Effect of prenatal detection

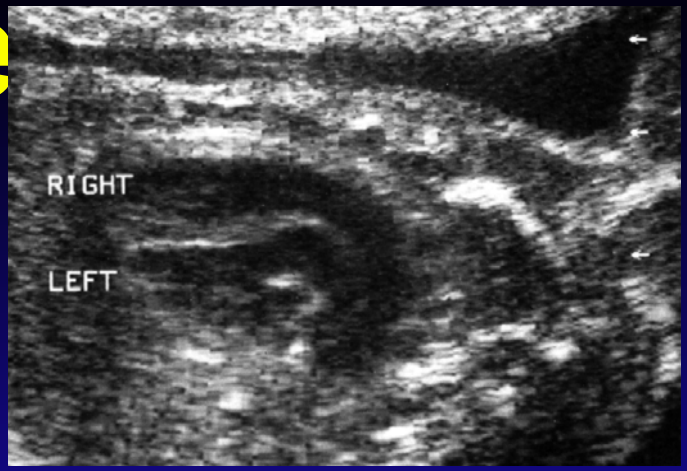
	Neonatal group	%	Prenatal group
Patients (N)	250		68
Mean delay birth - admission (h)	73		2 *
Preoperative mortality	15	6 (3-9)	0 *
** Postoperative mortality	20	8	0

* $p < 0.01$

** Known risk factors for operative mortality identical in groups

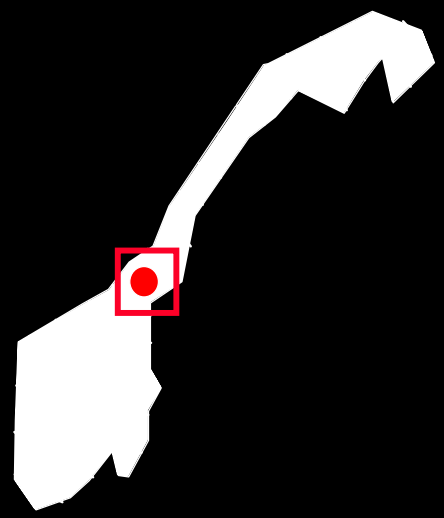
Bonnet, Circulation, 1999

Transposition of the Great Arteries

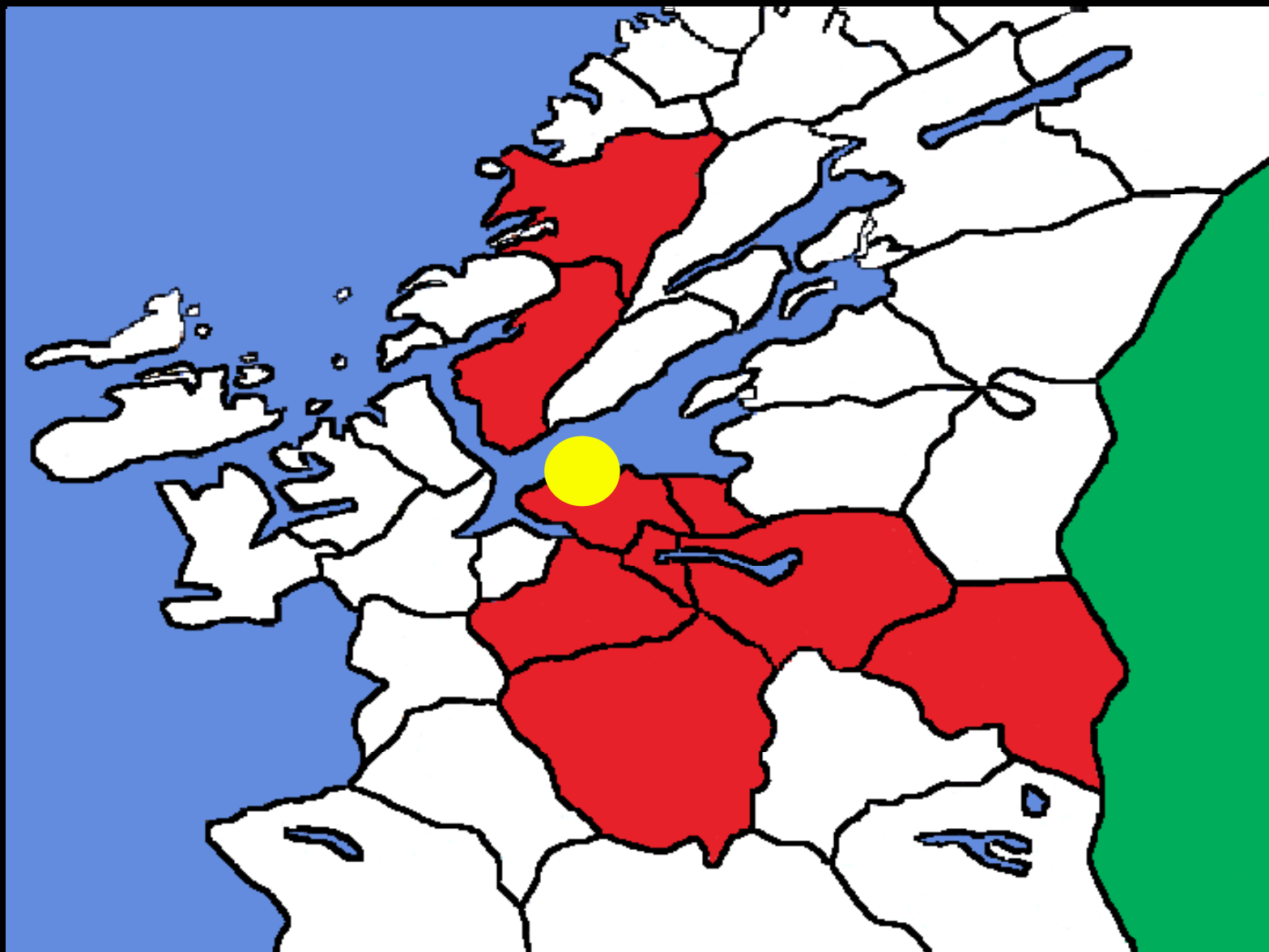


- Prevalence 1: 3000
- To get 68 you need 204 000 pregnancies
- We only find 50% of TGA
  --> So: 408 000
- Large numbers are needed!

Non-selected population
Trondheim area, Pop. 200 000, 2 700 births



Norway



Non-selected population
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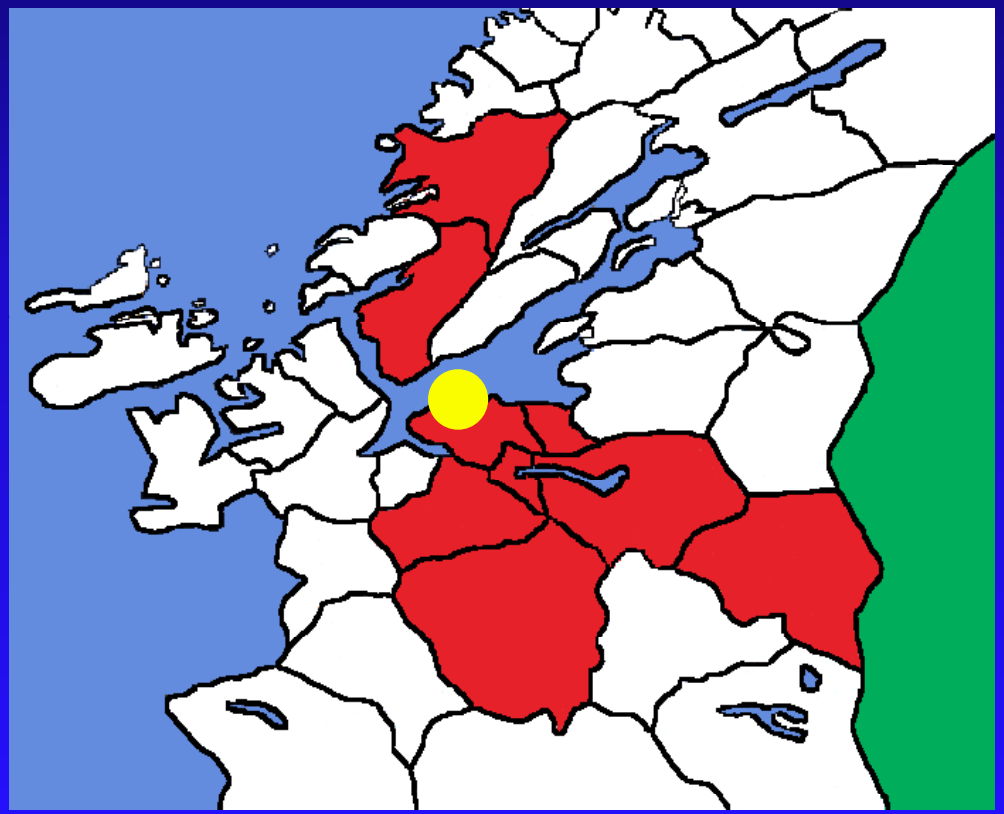


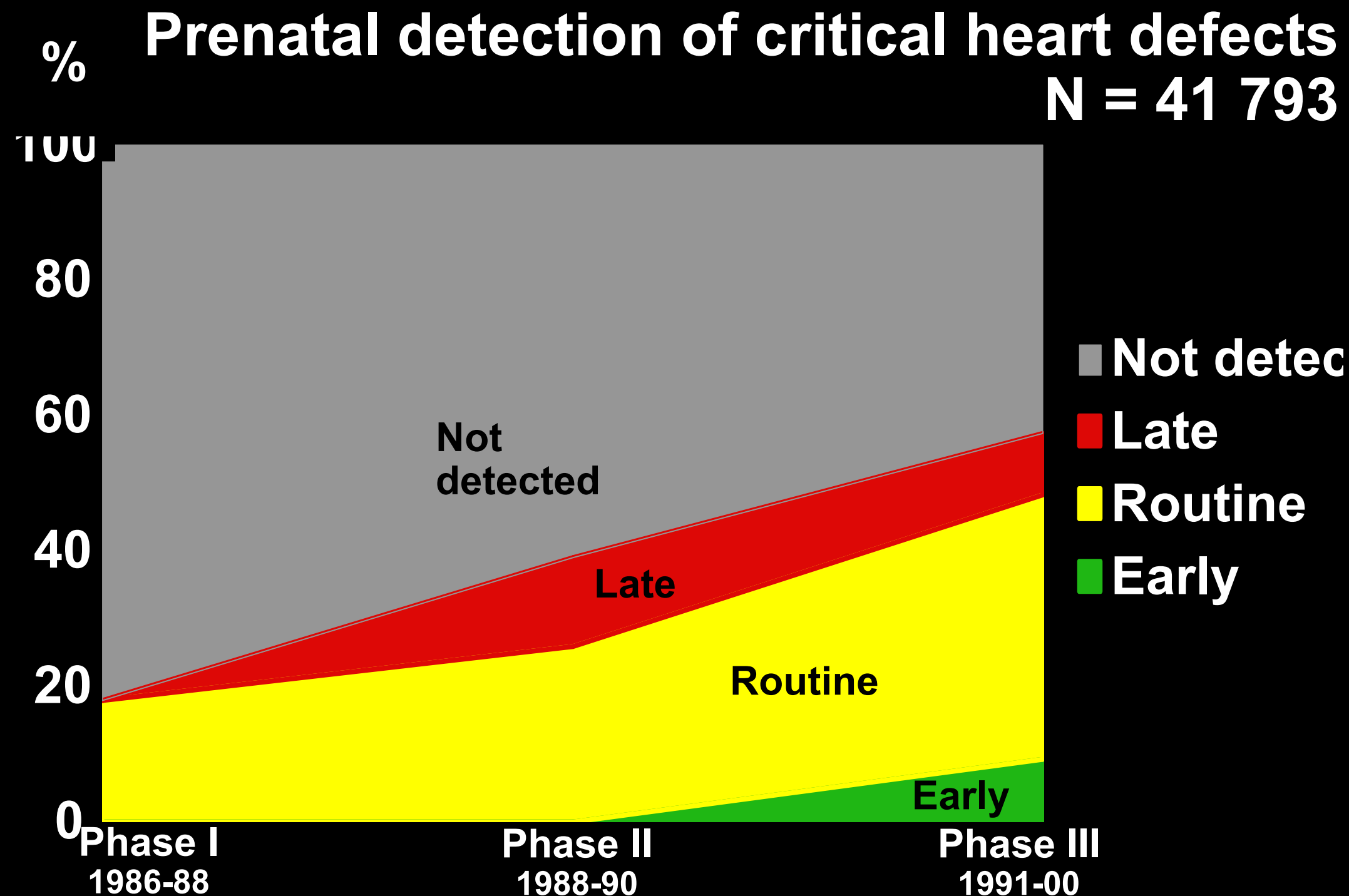
- One non-selected population
- One scanning unit
- One delivery dept.
- One pediatrician – neonatal exams
- One NICU
- One pediatric cardiology dept.

Routine fetal examination

A prospective study

Phase	Registration	Period	N
I	Rough	Aug. 86 - May 88	4 435
II	4-chamber view	June 88 - Jan. 91	7 459
III	4-ch. view + outlets	Febr. 91 - Dec. 00	25 899
Total			37 793

Tegnander et al. UOG 1995


Prenatal detection of critical heart defects
N = 41 793
%
100
80
60
40
20
0
Not detected
Late
Routine
Early
Not detec
Late
Routine
Early
Phase I
1986-88
Phase II
1988-90
Phase III
1991-00

Future obstetrics

Maternal transport of a fetus rather than a sick neonate

Invasive procedures

- Blood sampling
- Blood transfusion
- Acute drainage of fluid
- Cronic drainage of fluid
- Laser surgery

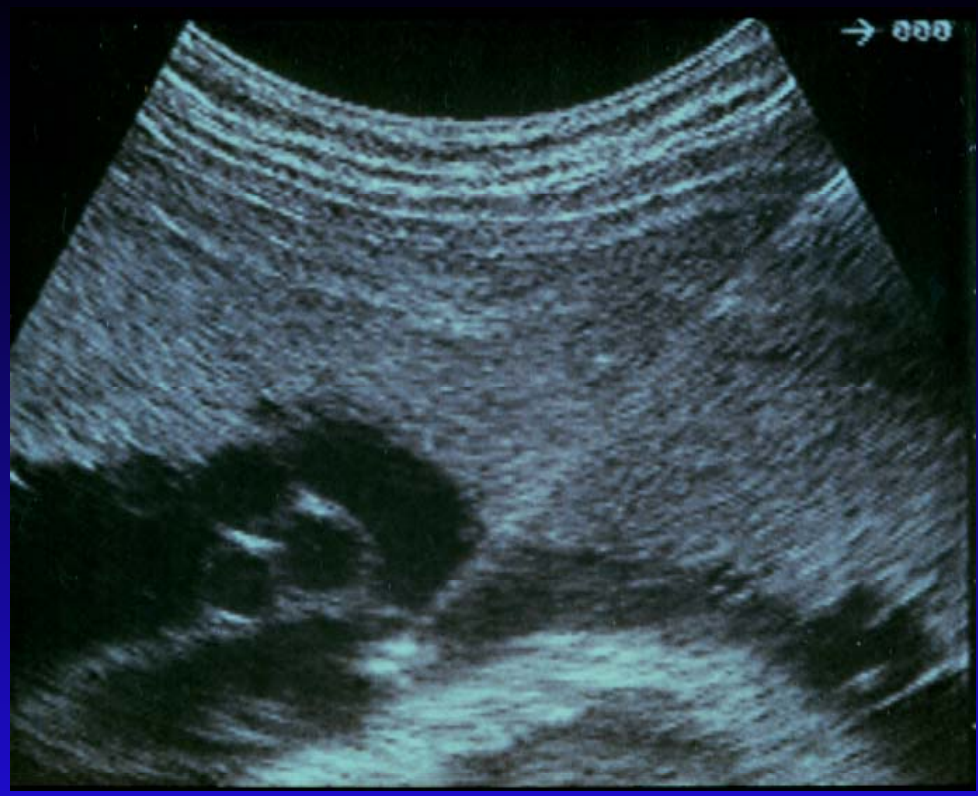
Fetal blood transfusions

- Direct intravascular
- Umbilical vein, placental insertion
- Infusion of packed cells, Hct ≥ 80%
- Computer calculation of volume to be transfused
- Infused volume up to 50% of fetoplacental volume
- Tranfusion velocity approx. 5 ml/min

Fetal blood transfusion

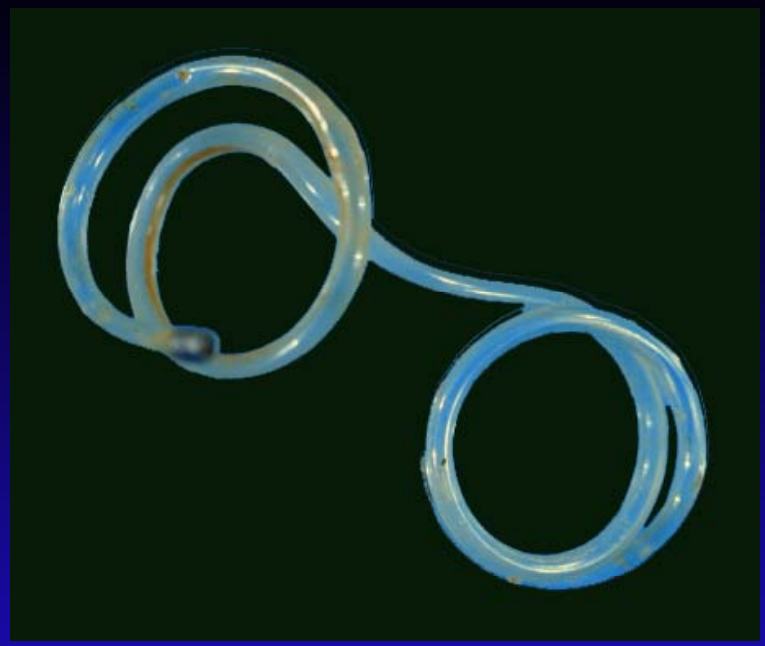
QuickTime™ og en
Animation-dekomprimerer
kreves for å se dette bildet.

Conclusion



- Fetal blood transfusion for fetal Rh-disease has over 30 years been developed to perfection using ultrasound

Drainage of fluid in fetal / amniotic cavities

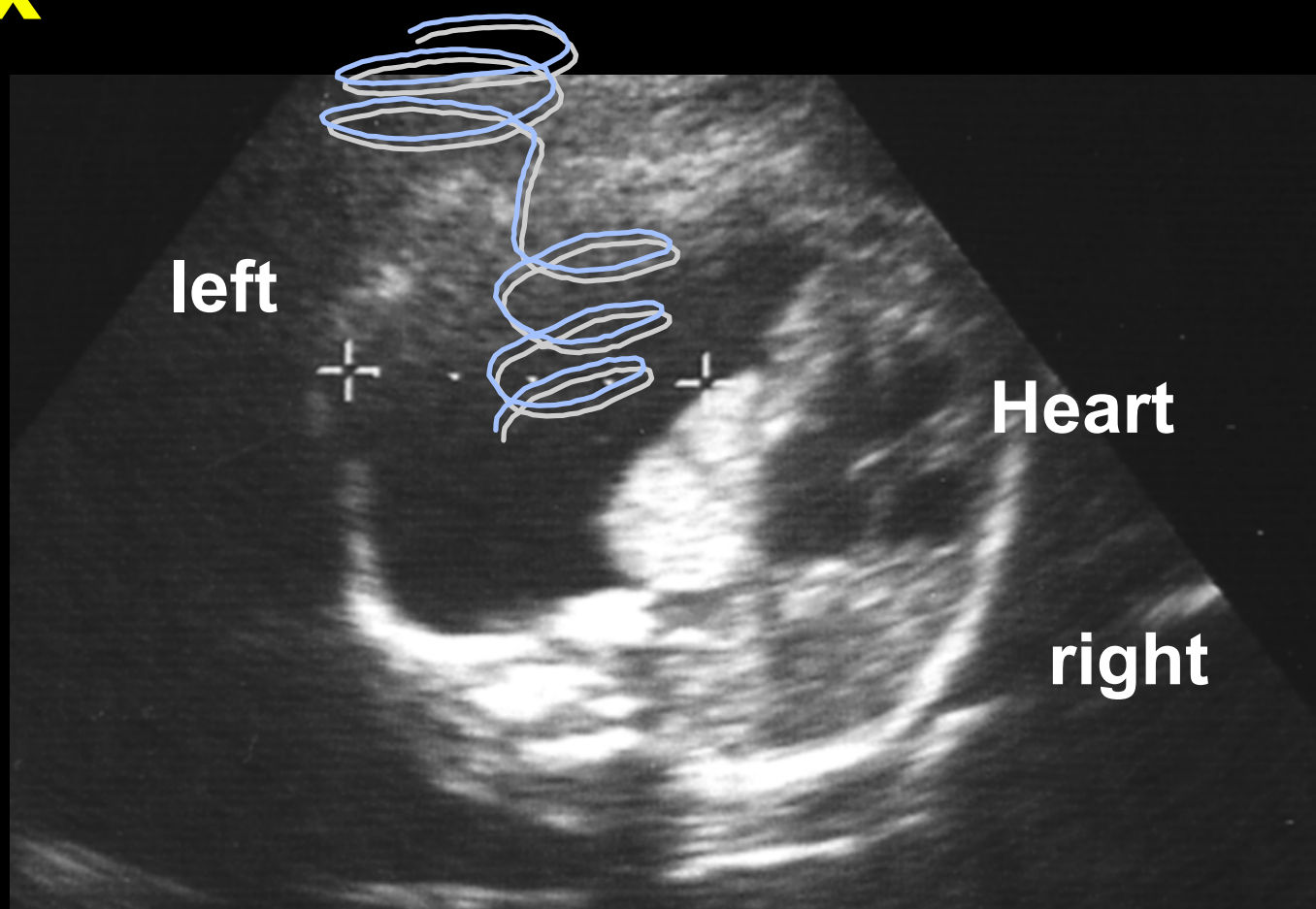


- Single or repeated aspirations
- Application of pig-tail catheter

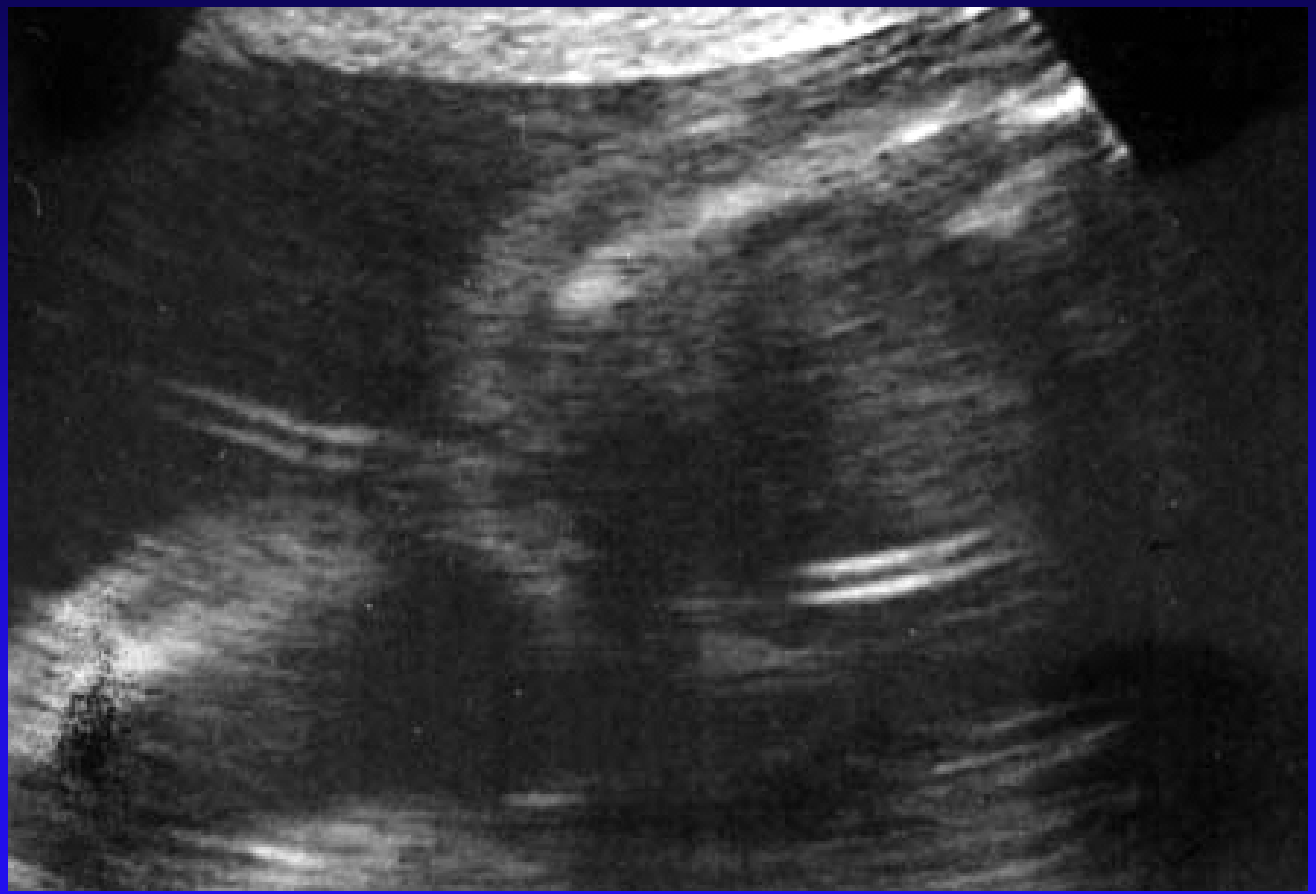
Hydrothorax
Pericardial fluid
Thoracic tumors (CCALM)
Ovarian / mesenteric cyst
(Urinary tract obstruction)

CCALM type I

Intrauterine drainage of pleural effusion or chylothorax

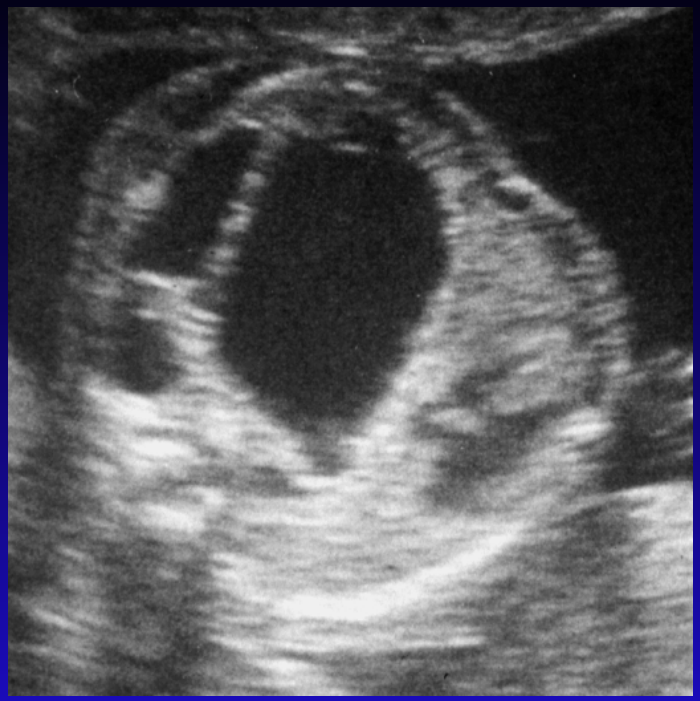


Chylothorax



2 catheters inserted. 22 weeks

CCALM Type I



Chylothorax

35 weeks

Polyhydramnion

Slight upper body edema

Drainage of fetal chylothorax at 35 weeks

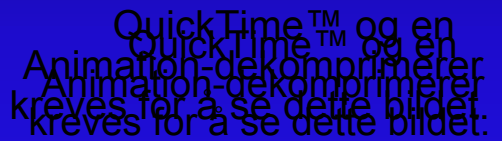
Needle tip

Aspiration of 115 ml completed

2000 challenge

Twin - twin transfusion

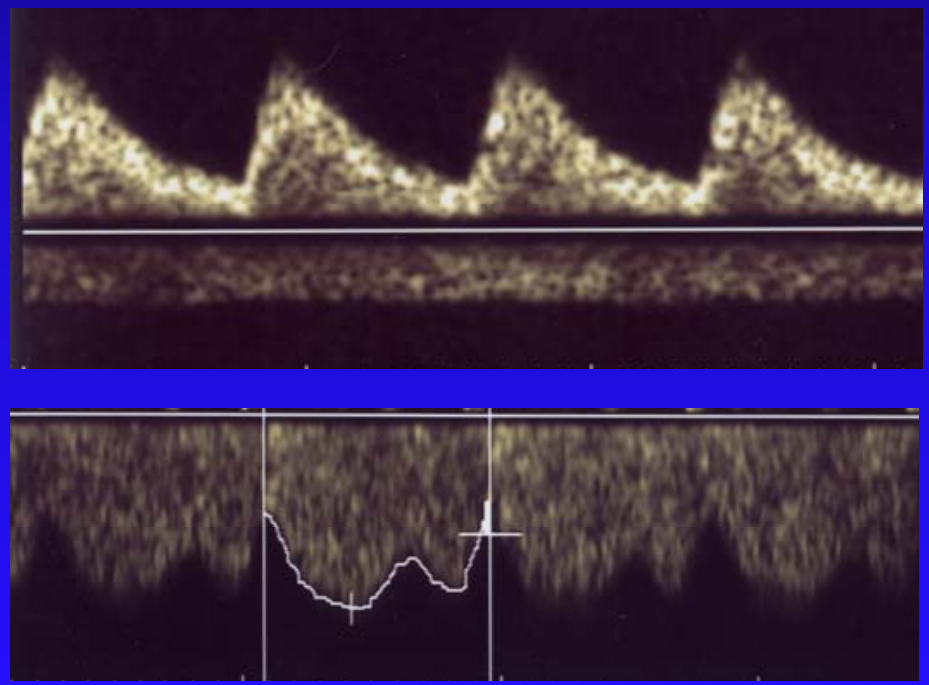
Laser ablation



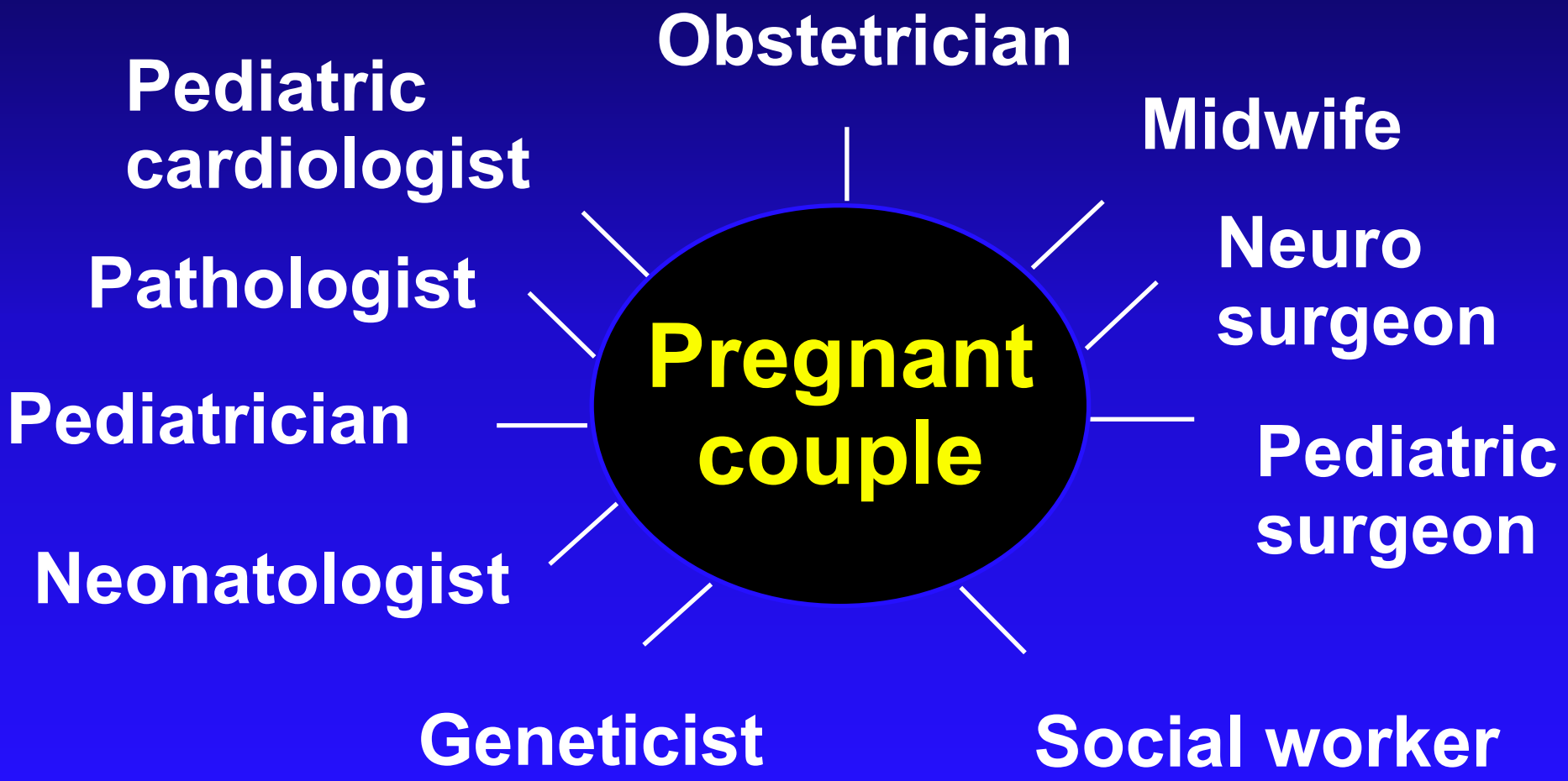
Ultrasound made the evaluation of fetal hemodynamics possible

Fetal vessels

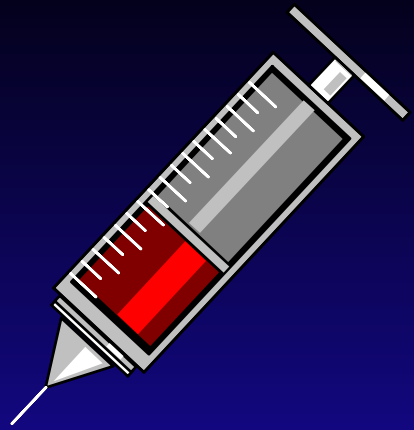
- A. cerebri media
- Aorta
- A. umbilicalis
- Umbilical vein
- Ductus venosus



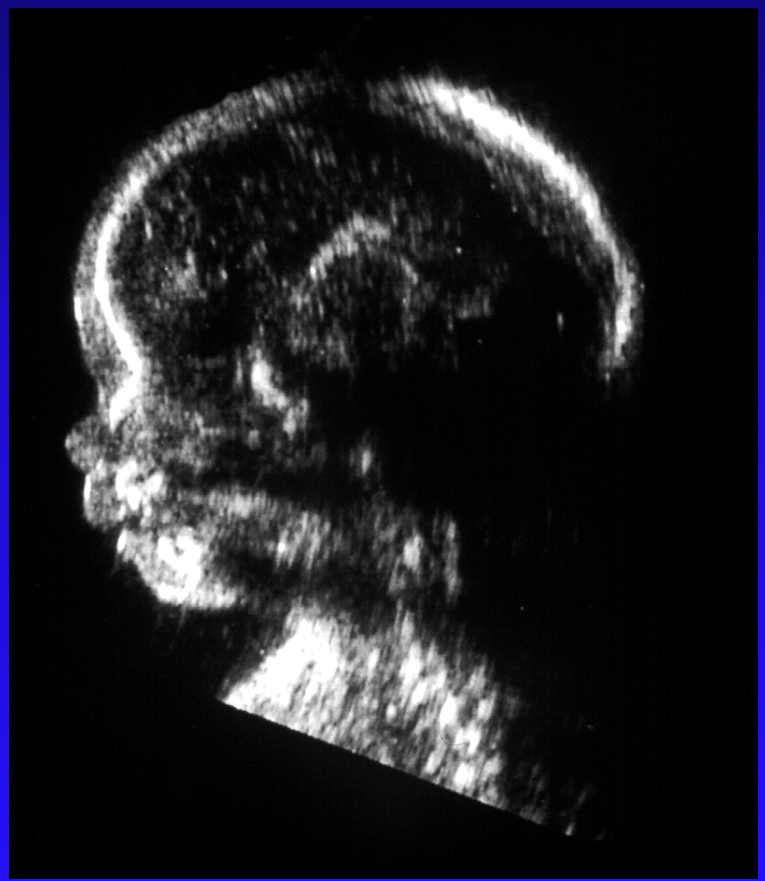
The perinatal team



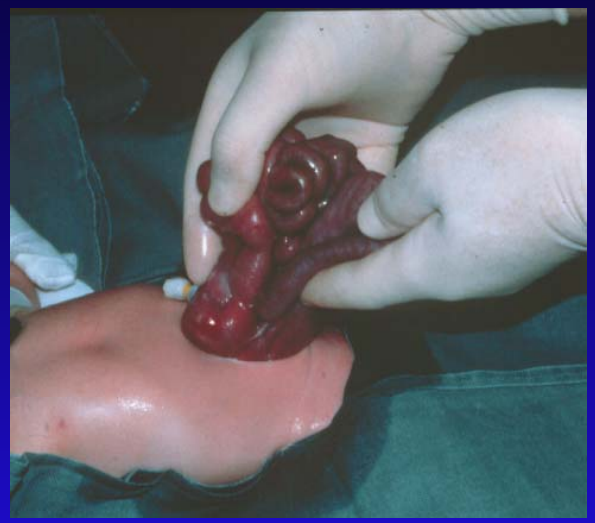
Fetal medicine Aim



- **Diagnose fetal disease and abnormal conditions**
  - **Cure or improve disease or abnormal conditions**
  - **Prepare parents**
  - **Prepare postnatal staff**
  - **Make prognosis better than it would have been without D_x**

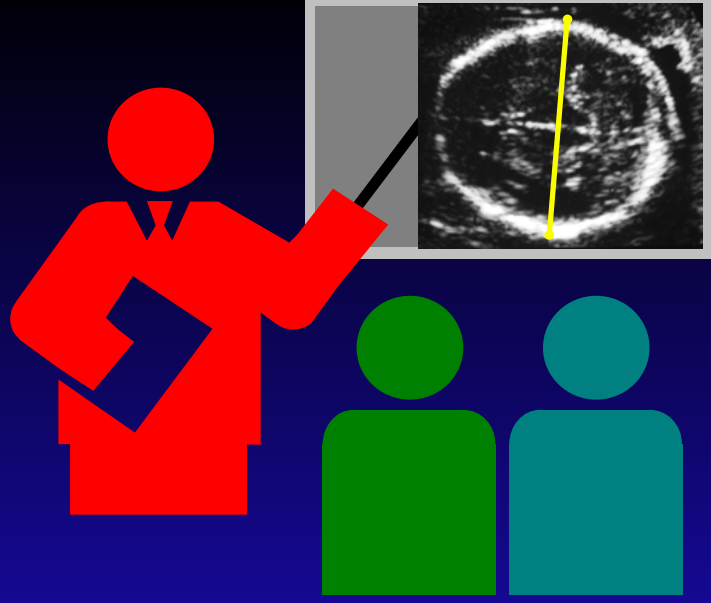


Fetal medicine



- Will remain controversial
- Balance between obviously ”good” and ”bad”

The teaching challenge



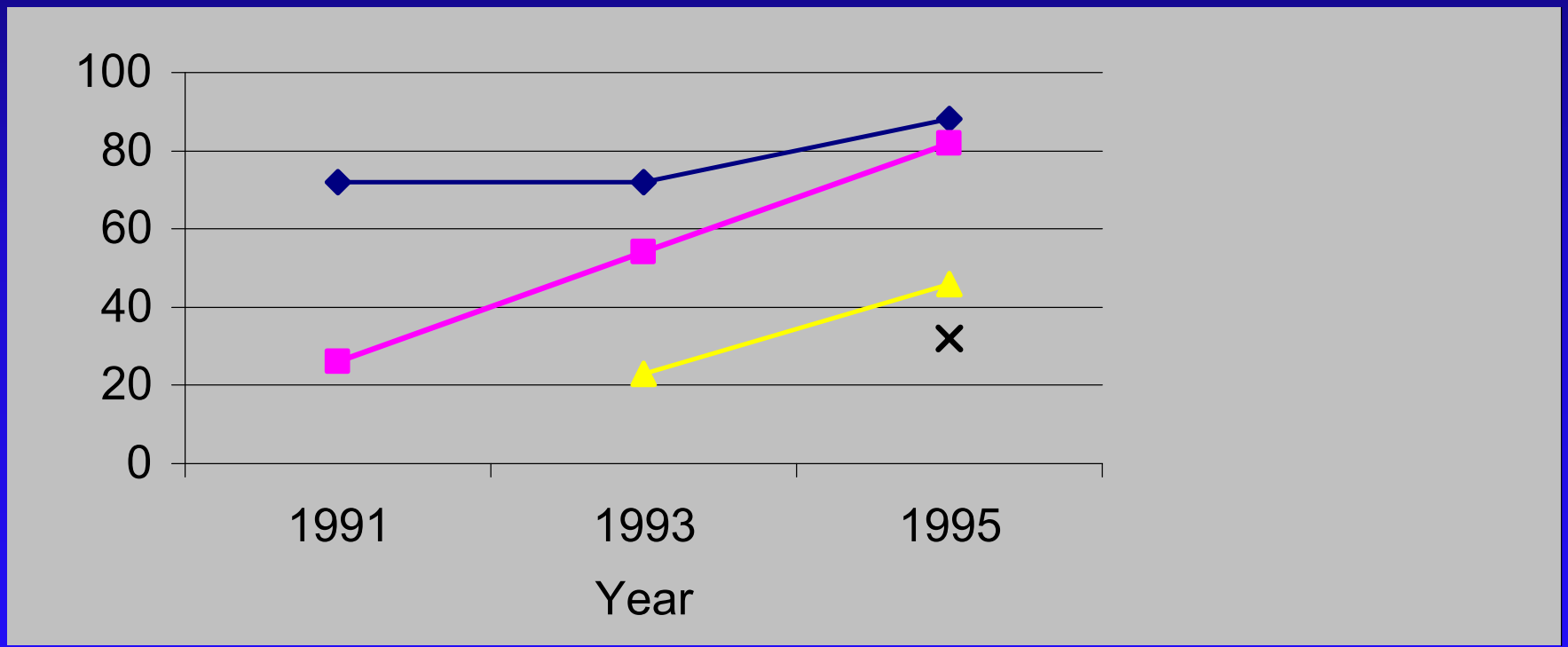
- The diagnostic potential of ultrasound technology is great
- Diagnosis be made during the examination
- Requires high level of skill

Definition of level of experience

- Experienced
  - Basic ultrasound training
  - Performed more than 2000 routine ultrasound scans
- Inexperienced
  - Basic ultrasound training
  - Performed between 500 – 1500 ultrasound scans

18 weeks scan

4-chamber view and great arteries obtained over time



18 weeks scan

Level of experience and detection rate among midwives

Isolated critical CHD's

	N	Detected n	%
Experienced	20	9	45
Inexperienced	21	6	29

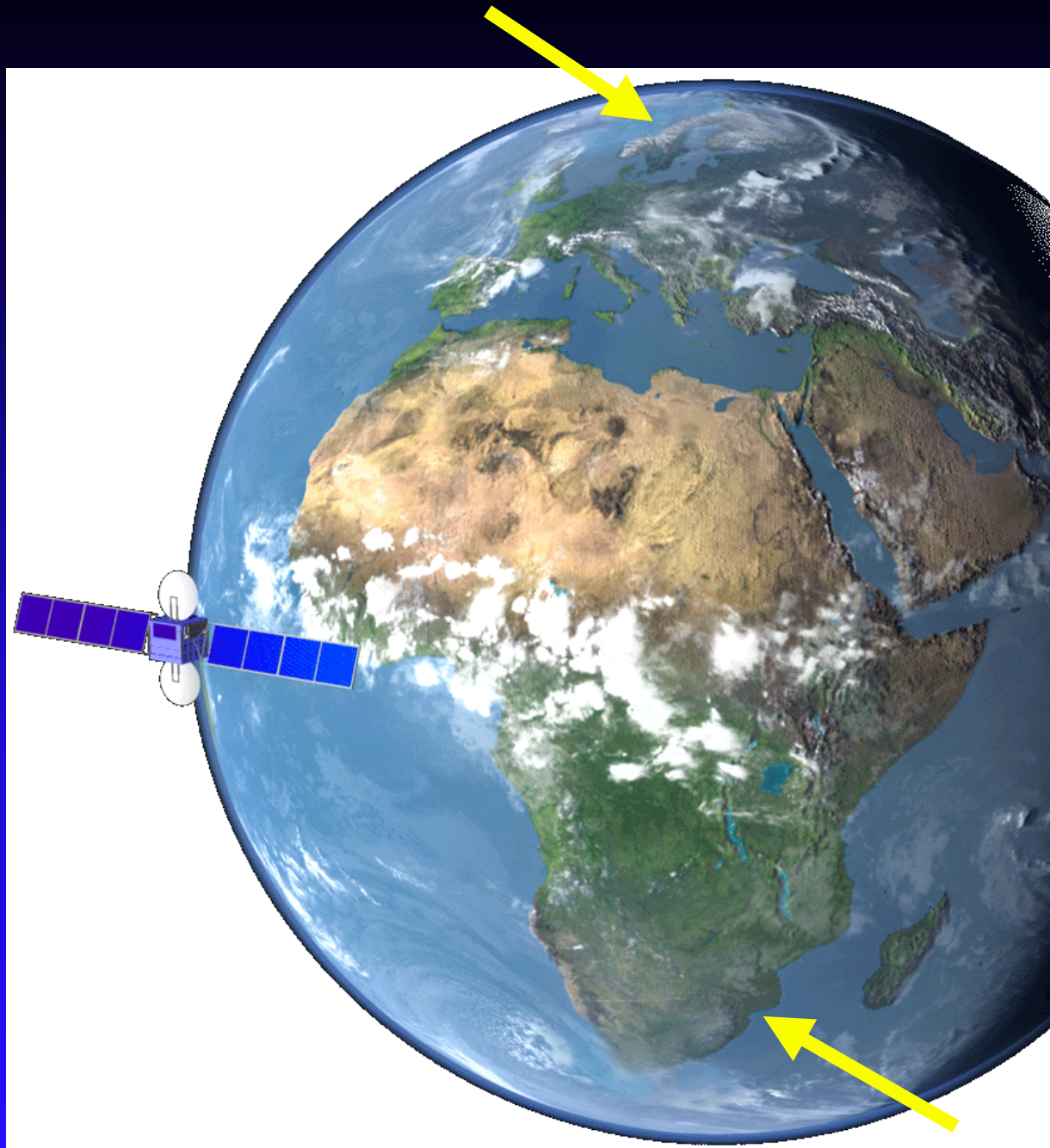
Critical CHD's with associated malformations

	N	Detected n	%
Experienced	30	19	63
Inexperienced	16	4	25

The solution

- Focus on dedicated personel (sonographers, midwives) to do the fetal examination
- But - introduce formal training and certification

Teaching across the latitudes



NCFM
International relations

WHO Collaborating Center
for
Diagnostic Ultrasound
in
Obstetrics and Gynaecology

NCFM/ISUOG Outreach Program

- Reaching out to countries where systematic teaching is less developed and/or need for international cooperation

N□CFM/ISUOG Outreach Program

- Manila 96 - 98
- Bangkok 96 - 98
- Hong Kong 98
- Murmansk 97 - 99
- Anthalya 99
- Cape Town 02

Drakensberg - 2001

Priorities in perinatal medicine

- Ed Coetzee
- Sturla H. Eik-Nes
- Gerald Mantel
- Jack Moodley
- Bob Pattison
- Eva Tegnander

Drakensberg - 2001
Priorities in perinatal medicine

- Is it possible to make a condensed education for African midwives working in rural Health care centers?

Drakensberg - 2001

Priorities in perinatal medicine

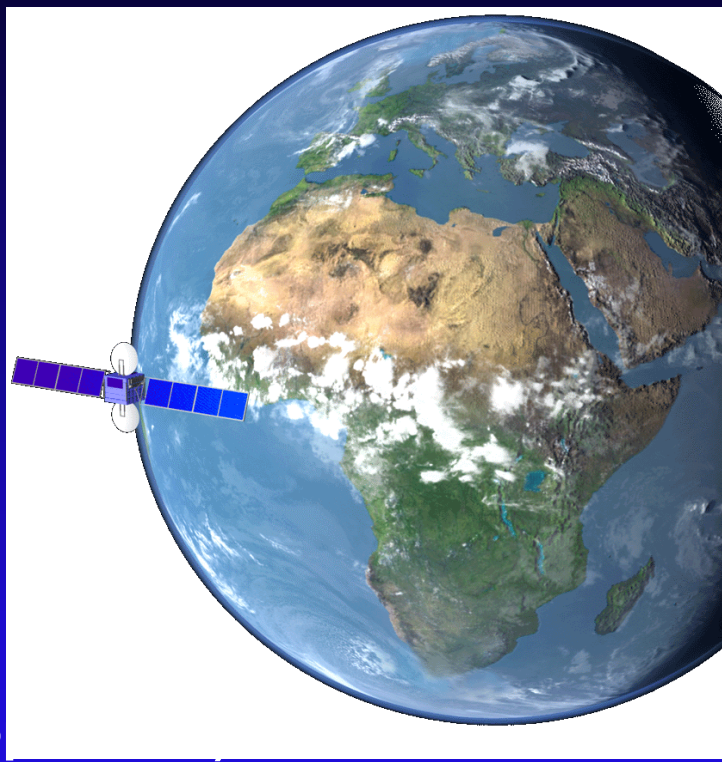
- If possible - is it worth doing?
- If yes - what would the objective be?

Modified teaching plan for midwives in rural Health Care Centers

- Objective
  - Dating
    - » Growth, prematurity
  - Multiple pregnancies
  - Placenta
  - (Anomalies)
  - Delivery management

Teaching across the latitudes

”Drakensberg Project”



Project funded by

- **Norwegian Government**
  (NORAD - Norwegian Agency for Development Coo
- **National Center for Fetal Medicine**
  University of Trondheim

Thank you!

Åbødalen - my favorite mountains

So far - so good