Volume Flow

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Volume Flow

- Technique initially described by Hottenger and Meindl in 1974
- Describes method for measuring the total flux across a flow tube
- At the time, this method was not practicable.

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Volume Flow

- Actually first described by Gauss:

Just like almost everything.

Present Volume Flow Method

➢ Many limitations and assumptions.

➢ Present assumptions and properties:

← Angle dependent

← Assume circular vessel cross-section

← Assume a cylindrically symmetric flow profile

← Time dependent

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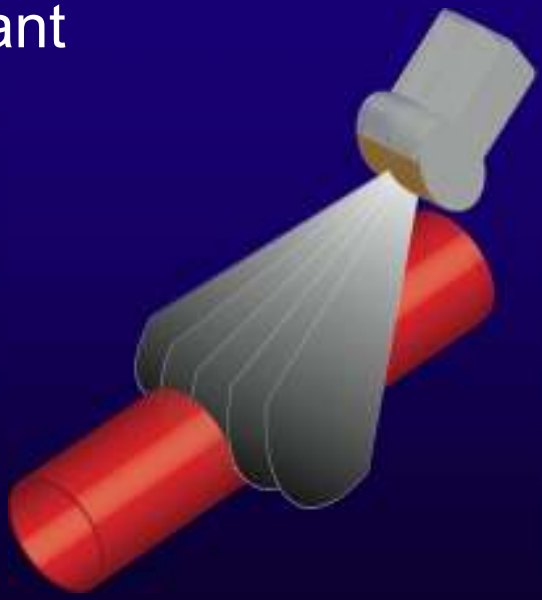
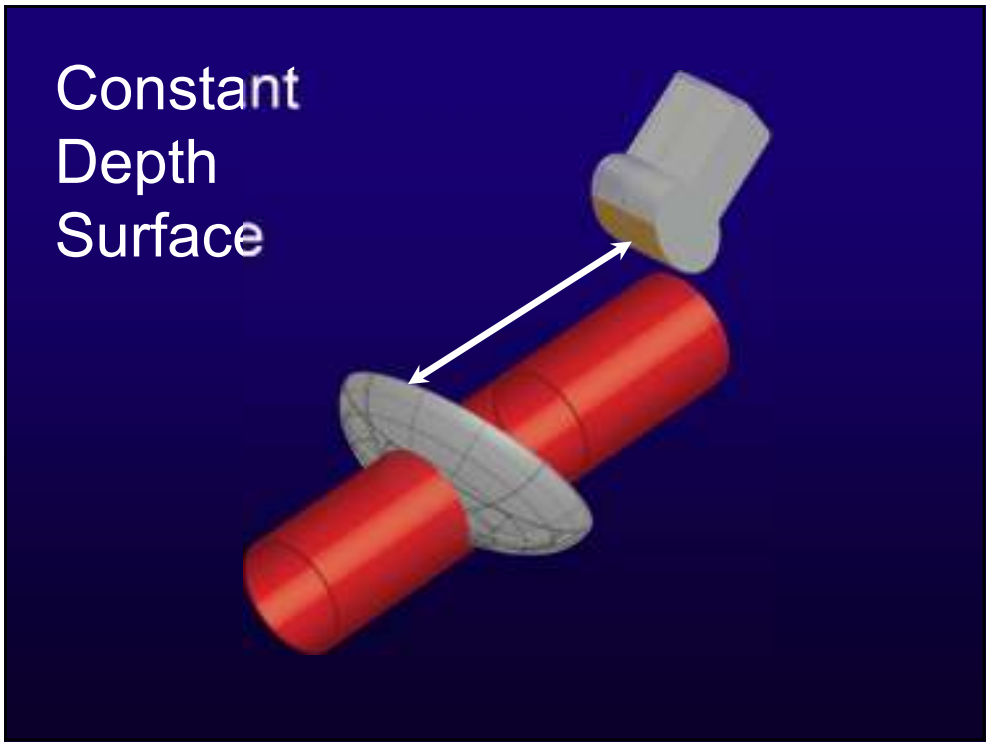
Color Flow Imaging

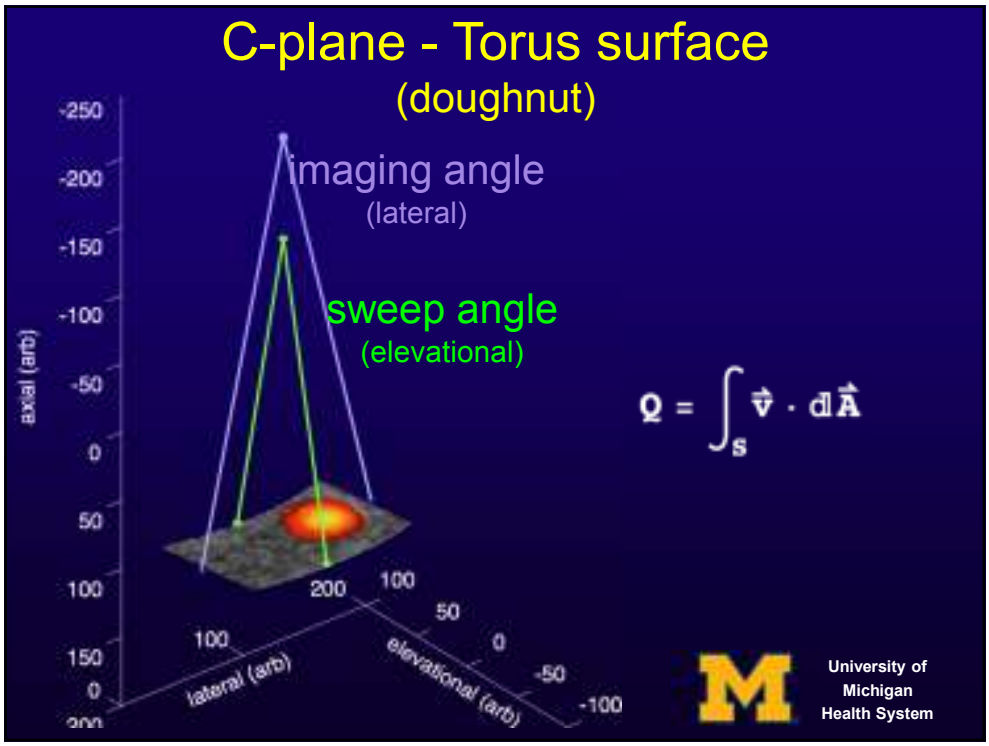
Elevationally Swept Color Flow Imaging

Constant
Depth
Plane



Constant
Depth
Surface


Constant
Depth
Surface


C-plane - Torus surface
(doughnut)
imaging angle
(lateral)
sweep angle
(elevational)
$Q = \int_S \vec{v} \cdot d\vec{A}$
axial (arb)
-250
-200
-150
-100
-50
0
50
100
150
200
lateral (arb)
elevational (arb)
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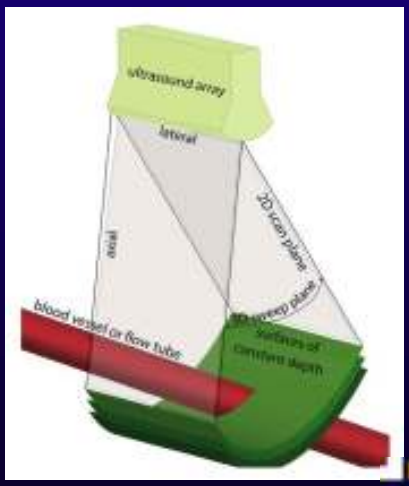
C-plane - Torus surface (doughnut)



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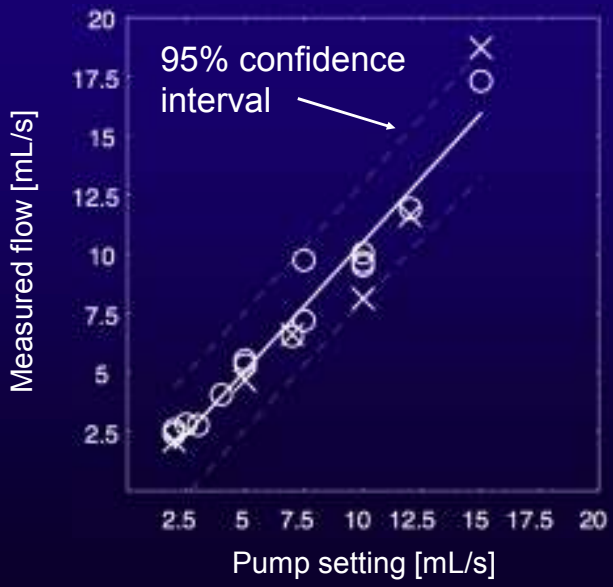
Results - varying flow



two realizations:

X = aperture ⊥ tube

O = aperture ∥ tube

line fit:

Y = (1.09±0.06) • X - (0.36±0.52)

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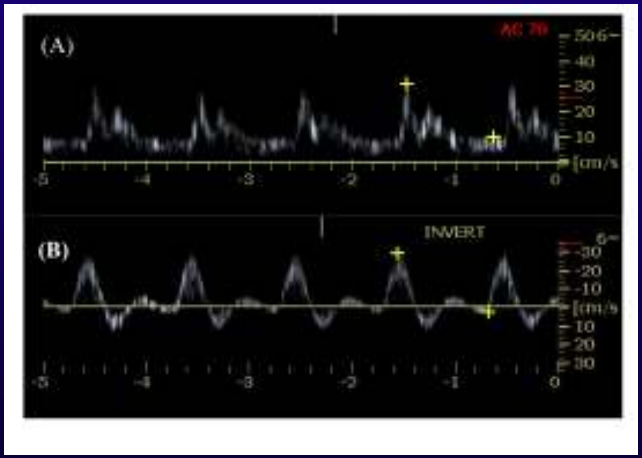
Pulsatile Inputs - Phantom



Carotid

Femoral

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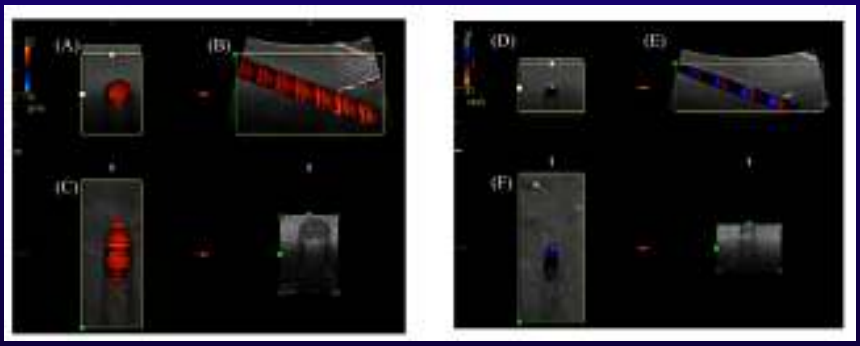
Pulsatile Flow - Phantom



Carotid Flow

Femoral Flow

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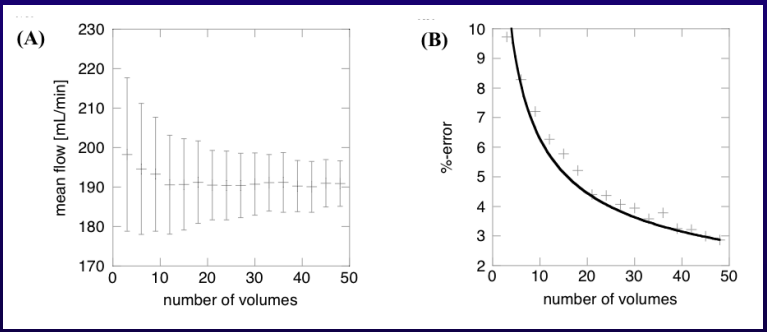
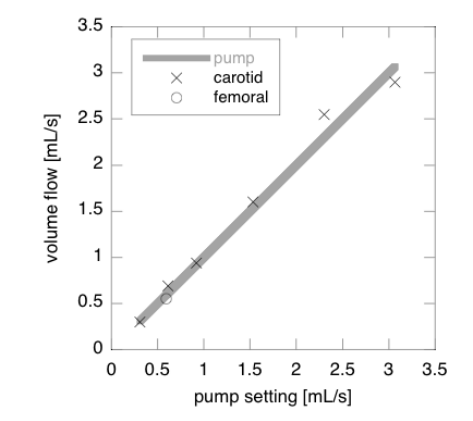
Law of Large Numbers



This is only necessary at the present degree because of the requirement of using a mechanical scanhead for elevational sampling.

Pulsatile Flow - Phantom



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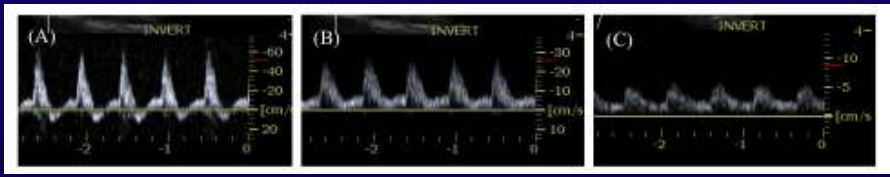
Femoral Artery - Dog



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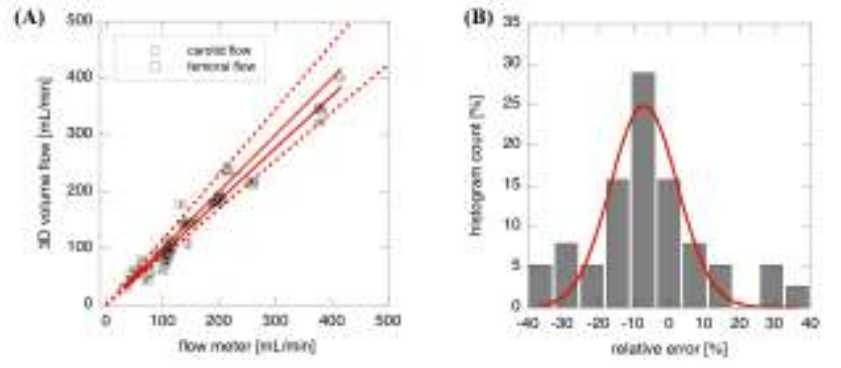
Flow in Dog Femorals and Carotids



$R^2 = 0.9537$

$R^2 = 0.928$ when forced through zero

Mean error = - 7.04%

FWHM = ± 13.4%

Medical Applications

- Cardiac Output and Stroke Volume
- Renal or Hepatic – TIPS
  - Including perfusion measurements
  - Transplants
- Umbilical cord
- Cerebral blood flow
- Peripheral run-off studies
- Aortic aneurysm assessments
- Dialysis shunt evaluations
- Anywhere were flow indices e.g. RI, PI, S/D are presently used.

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Medical Applications

- Cardiac Output
- Renal or Hepatic – TIPS
- Umbilical cord

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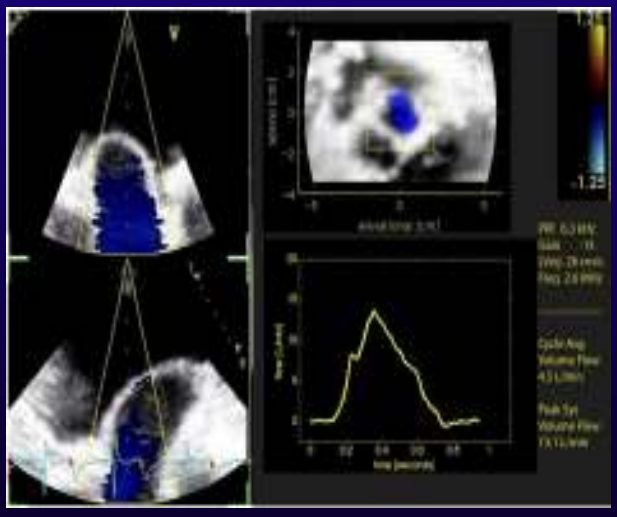
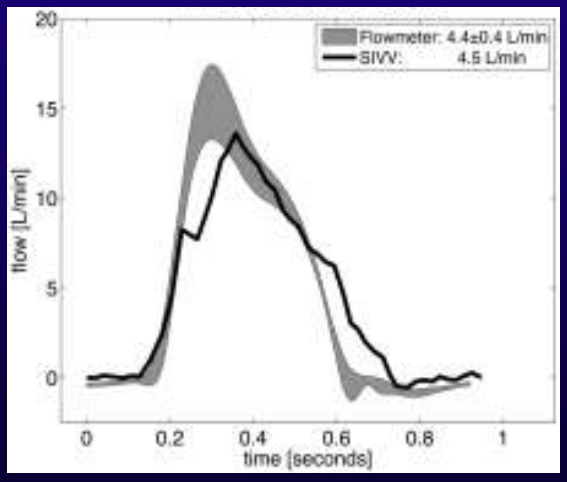
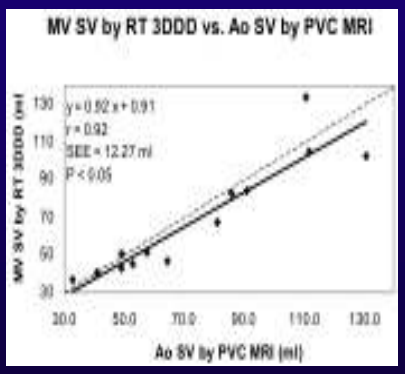
Cardiac Output



Cardiac Output



Cardiac Output



Ge et al. J Am Soc Echocardiogr 2005;18:1-7.

Medical Applications

- Cardiac Output
- Renal or Hepatic – TIPS
- Umbilical cord

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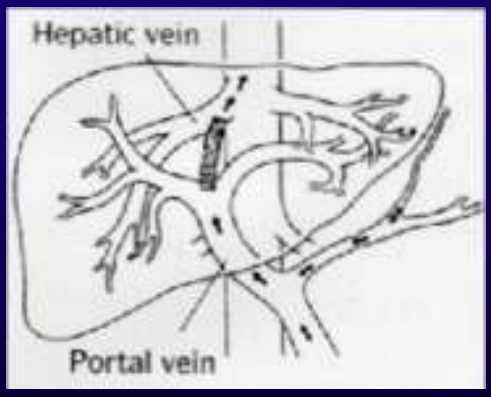
Transjugular Intrahepatic Portalsystemic Shunt - TIPS



TIPS = Short circuit between portal and systemic venous circulations

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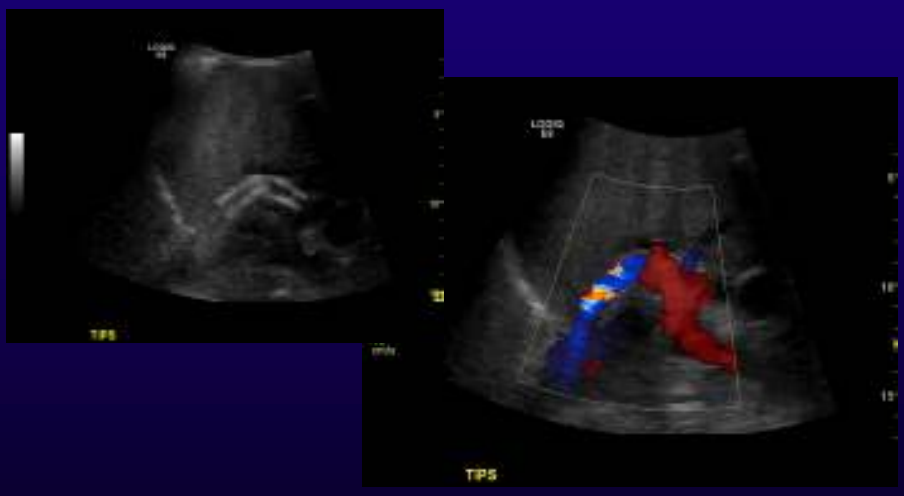
Ultrasound of TIPS



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Ultrasound of TIPS

- Ultrasound is primary way to evaluate TIPs.
  - Present best result is flow or no flow.
  - Evaluation criteria are based on flawed assumptions.
- Examples:
  - Absolute Velocity < 50 cm/sec
  - Absolute Velocity > 185 – 220 cm/sec
  - Time Δ < 40 – 50 cm/sec
  - Time Δ > 60 cm/sec
  - Δ max and min velocity > 100 cm/sec

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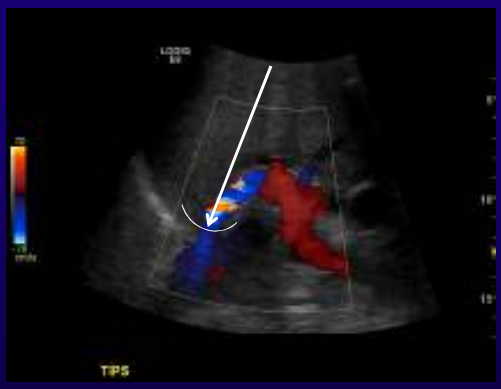

- Perfect application
  - No bifurcations
  - Flow change is desired parameter
- Easy access

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Medical Applications

- Cardiac Output
- Renal or Hepatic – TIPS
- Umbilical cord

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Umbilical Cord Flow

- Holy Grail of parameter of fetal well-being
  - Placental blood flow in fetus ↔ cardiopulmonary flow in adults
  - "Measurement of venous blood flow in the human fetus: a dream comes true, but now for some standardization" – Ferrazzi 2001.
- Primary diagnostic criteria for IUGR.
- Using present techniques cord volume flow is very hard to measure – Multiple surrogates presently used.

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- Which diameter?
- Which angle?
- Which flow?

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Umbilical Cord Flow

- Perfect geometry – Multiple areas for access
- No clutter background
- Internal control → artery = vein

Routine component of Ob exams!

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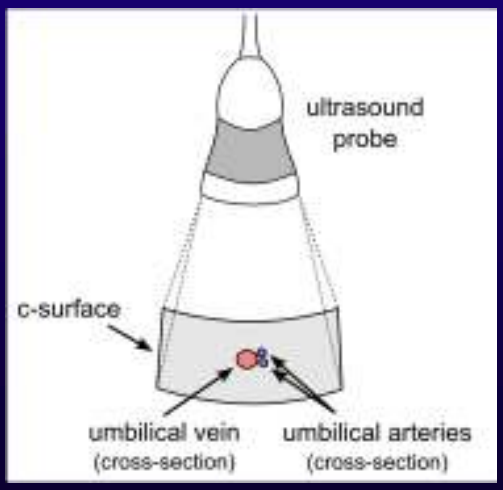
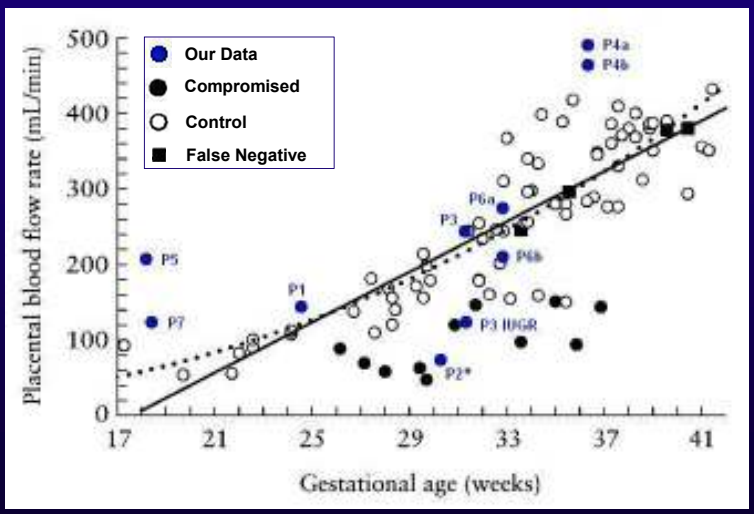
Umbilical Cord



Umbilical Cord



Tchirikov M et al . *Ultrasound Obstet Gynecol* 2002; 20:580-585.

Thanks!

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