Aortic isthmus
Fetal growth restriction

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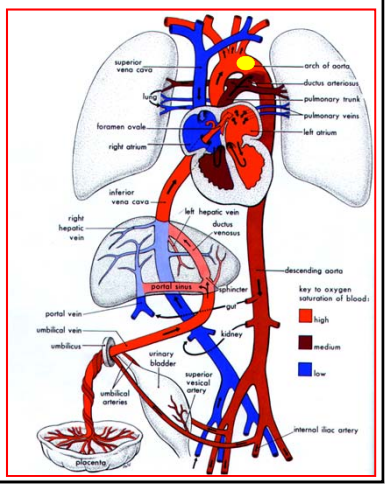
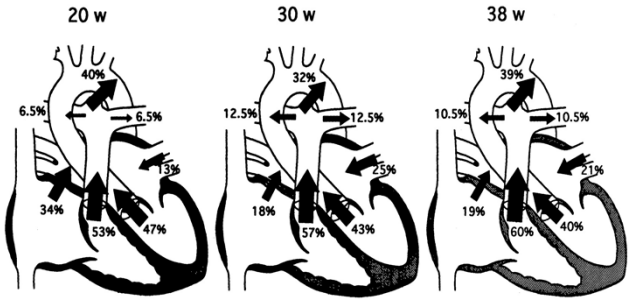
Aortic Isthmus

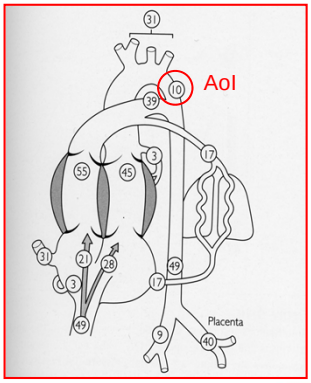


Blood flow distribution



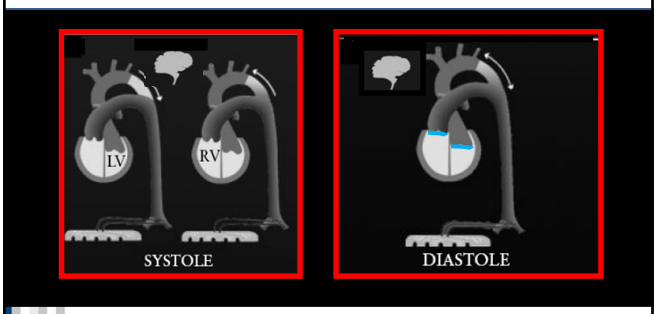
Rasanen J et al Circulation 1996

Blood flow distribution



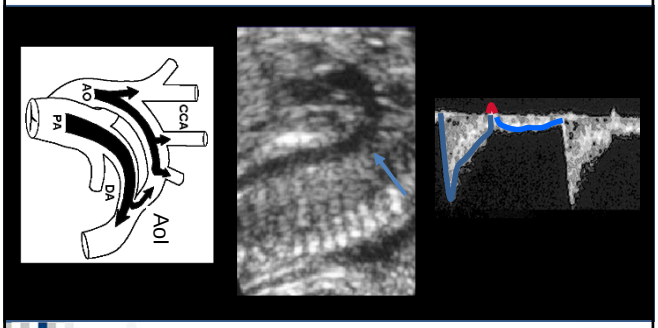
Rudolph AM: Congenital diseases of the heart. Futura 2001

Aortic isthmus

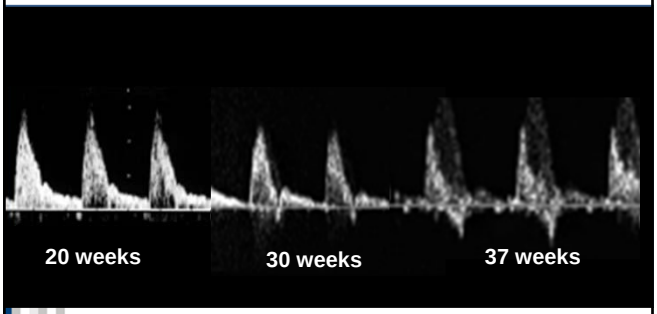


Fouron JC Ultrasound Obstet Gynecol 2003

Aortic isthmus Doppler evaluation

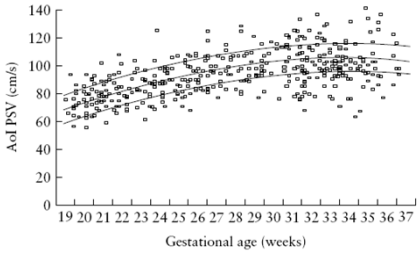


Normal aortic isthmus waveforms



Fouron JC Ultrasound Obstet Gynecol 2003

Aortic isthmus Doppler evaluation



Intraobserver reproducibility (ICC)

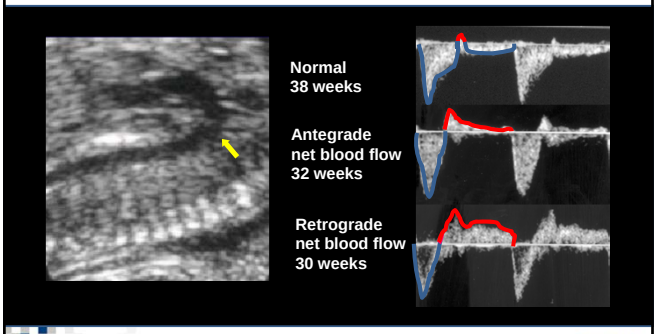
AoI PSV 0.88

Interobserver reproducibility (ICC)

AoI PSV 0.89

Del Rio M et al Ultrasound Obstet Gynecol 2005, 2006

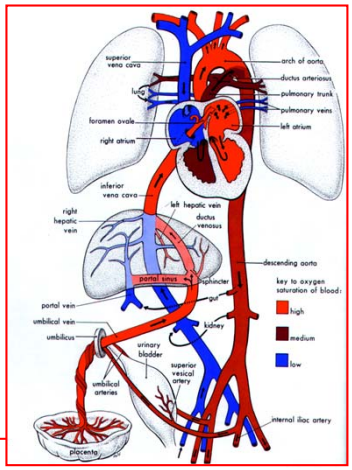
Aortic isthmus blood flow profiles



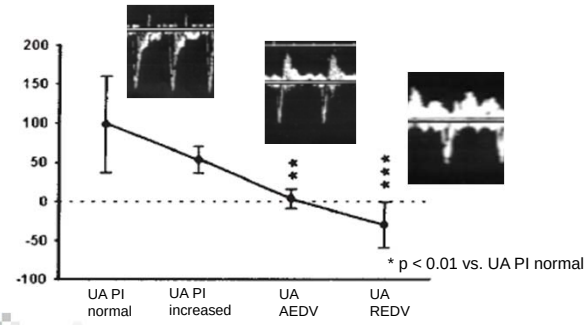
Makikallio K et al Ultrasound Obstet Gynecol 2003

Aortic isthmus

O2 saturation
10-12 % less in RV

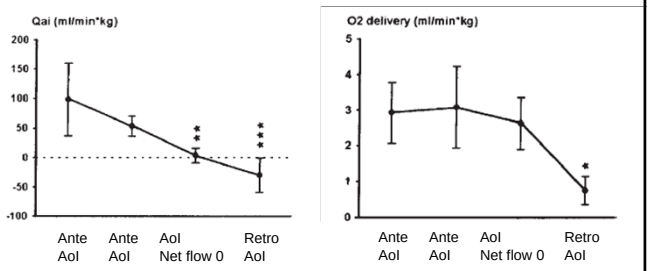


Aortic isthmus



Fouron JC et al AJOG 1999

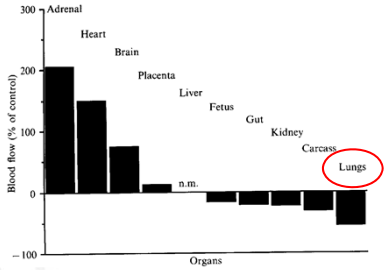
Aortic isthmus



Fouron JC et al AJOG 1999

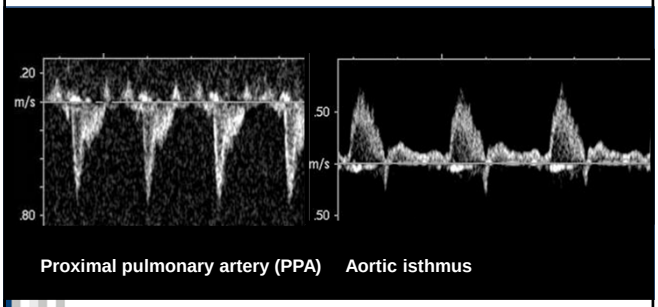
Acute hypoxemia

Blood flow distribution



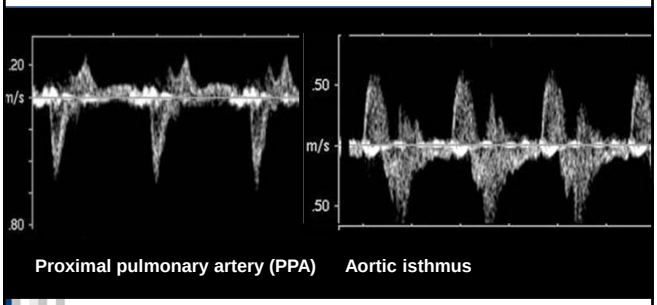
Jensen et al 1991

Normoxemia



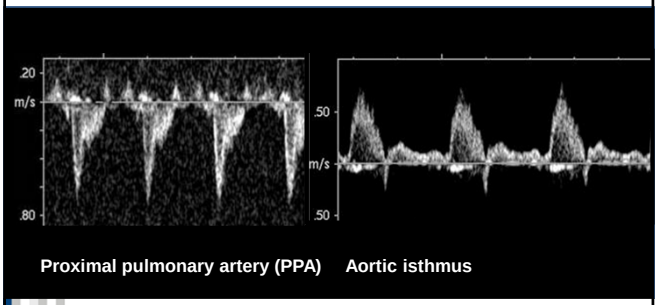
Makikallio K et al AJOG 2006

Hypoxemia



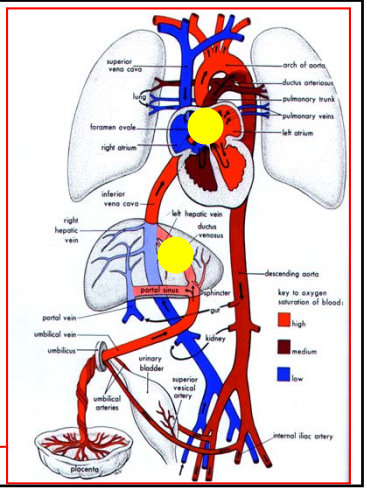
Makikallio K et al AJOG 2006

Recovery



Makikallio K et al AJOG 2006

Hypoxemia



Placental insufficiency

Aortic isthmus net blood flow

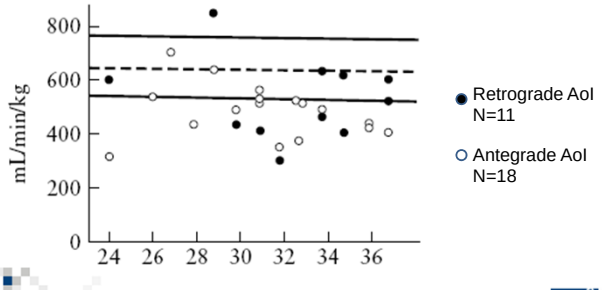
	Control	Antegrade AoI (n=18)	Retrograde AoI (n=11)
Maternal age (years)	27.3 (5.7)	29.2 (3.3)	32.8 (6.7)
GA at delivery	39.8 (1.4)	30.8 (4.0)‡	32.5 (3.9)‡
Apgar 5 min	9.0 (0.3)	7.8 (2.4)*	6.6 (3.2)†
Birth weight (g)	3487 (351)	1282 (674)‡	1252 (540)‡
Umbilical artery pH		7.24 (0.05)	7.26 (0.06)
Umbilical artery pO_2(kPa)		2.13 (0.68)	2.31 (0.95)

*p< 0.05 vs. Control, † p<0.01 vs. Control, ‡ p<0.0001 vs. Control

Makikallio K et al Ultrasound in Obstetrics and Gynecology 2002

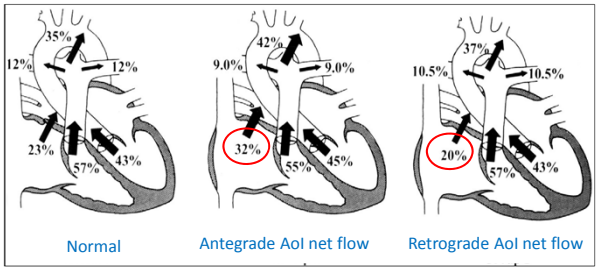
Aortic isthmus net blood flow

Combined cardiac output



Makikallio K et al Ultrasound in Obstetrics and Gynecology 2002

Placental insufficiency



Makikallio K et al Ultrasound in Obstetrics and Gynecology 2002

Aortic isthmus

Arterial circulation

	Control	Antegrade AoI	Retrograde AoI
Fetal heart rate (bpm)	143 (8)	143 (6)	141 (10)
Umbilical artery PI	1.01 (0.18)	2.57 (1.44)†	2.80 (1.91)†
Ductus arterisus PI	2.67 (0.29)	3.05 (0.42)†	3.15 (0.72)†
Desc aorta PI	2.03 (0.22)	2.67 (0.60)*	3.13 (1.08)†
Proximal pulm artery PI	3.33 (0.26)	4.51 (1.44)*	7.55 (3.87†,¶
Middle cerebral artery PI	1.96 (0.29)	1.44 (0.43)†	1.33 (0.25)†

*p< 0.05 vs. Control, † p<0.01 vs. Control, ¶ p<0.001 vs. Antegrade AoI

Makikallio K et al Ultrasound in Obstetrics and Gynecology 2003

Short term outcome

Aortic isthmus net blood flow

	Antegrade N=41 (40)	Retrograde N=10 (5)
GA diagnosis	31.1 (27.6-34.6)	25.8 (22.7-28.9)*
GA delivery	32.2 (24-37)	27.2 (22.7-28.9)*
Birth weight (g)	1256 (270-2080)	561 (275-1050)*
UA pH	7.23 (7.110-7.31)	7.16 (7.07-7.30)
Apgar 5 min < 7 n(%)	1 (3%)	1 (20%)
Vaginal delivery n(%)	6 (15)	0(0)
Cesarean section n(%)	34 (85)	5 (100)

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Short term outcome

Aortic isthmus net blood flow

	Antegrade N=41	Retrograde N=10	p
Composite adverse outcome (*n* (%))	10/41 (24.3)	9/10 (90)	< 0.001
NICU > 14 days*	3/40 (7.5)	2/5 (40)	0.03
Stillbirths	1/41 (2.4)	5/10 (50)	< 0.001
Perinatal death	2/41 (4.8)	7/10 (70)	< 0.001
Postnatal complications (*n* (%))*	9/40 (22.5)	4/5 (80)	0.02
Neonatal death	1/40 (5)	2/5 (40)	0.02
PVH/IVH			
Bronchopulmonary dysplasia			
Respiratory distress syndrome			
Necrotizing enterocolitis			
Sepsis			

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Neurodevelopmental outcome

1 year

	Suboptimal outcome, n=7	Optimal outcome, n=10	p
RVCO (mL/min/kg)	221.3 ± 68.4	367.0 ± 122.8	.030
LVCO (mL/min/kg)	146.8 ± 23.6	212.0 ± 59.9	.038
CCO (mL/min/kg)	368.1 ± 89.8	579.0 ± 166.7	.022
UA PI	3.7 ± 0.8	2.0 ± 1.0	.005
MCA PI	1.4 ± 0.3	1.4 ± 0.3	.974
DAo PI	3.1 ± 0.9	2.5 ± 0.5	.106
Retrograde AoI, n (%)	2 (29)	4 (40)	.633
LHV PIV	4.9 ± 2.5	3.6 ± 1.7	.218
DV PIV	1.3 ± 0.7	0.7 ± 0.3	.029
IVC PIV	4.6 ± 1.6	3.1 ± 0.9	.034

GA at delivery < 32 weeks

Kaukola T et al AJOG 2003

Neurodevelopmental outcome

2-4 years

Umbilical arteries	*Aortic isthmus*	*Optimal*	*Nonoptimal*
Decreased	Net antegrade	13	16
	Net retrograde	—	—
Absent	Net antegrade	6	2
	Net retrograde	—	2
Retrograde	Net antegrade	1	1
	Net retrograde	—	3
TOTAL	Net antegrade	20	19
	Net retrograde	—	5

Fouron JC et al AJOG 2001

Conclusions

Fetuses with retrograde aortic isthmus net blood flow fail to increase the shunting fraction through foramen ovale and show signs of increased systemic venous pressure.

Conclusions

Retrograde aortic isthmus blood flow indicates decreased oxygen delivery to cerebral circulation.

Conclusions

Retrograde aortic isthmus blood flow is associated with non-optimal neurodevelopmental outcome at the age of 2-4 years in fetuses delivered after 32 weeks.