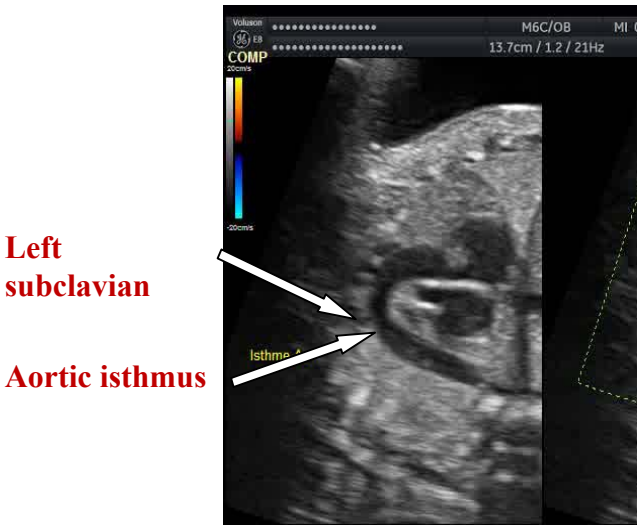
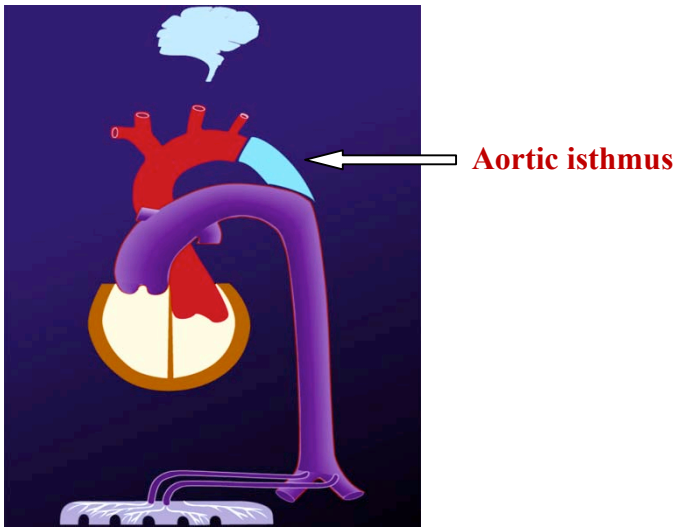
PIAF study: Placental insufficiency and aortic isthmus flow

Aortic isthmus

Anatomical landmarks

The aortic isthmus is the small vascular segment located on the aorta between the origin of the left subclavian artery and the aortic extremity of the arterial duct. During fetal life, this segment establishes a link between the aortic and pulmonary arches, perfusing respectively the upper and lower parts of the fetal body in parallel. Since the isthmus is inserted at the distal extremities of these parallel aortic and pulmonary arches, the influence of systolic ejection on the isthmic flow will be antegrade for the left ventricle, and retrograde for the right ventricle.





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Technical aspects

Two approaches are currently proposed for the Doppler recording of the aortic isthmus flow: either the sagittal approach or the three vessels and trachea view. In the first case, a right anterior or a left posterior transverse thoracic approach is first obtained, followed by a 90° rotation of the transducer to provide a sagittal view of the fetus in which the aortic arch can be easily visualized. The Doppler sample volume is located a few millimetres after the departure point of the left subclavian artery. This approach is favoured in our Unit because it enables us, on the one hand, to consider the subclavian artery as a reliable anatomical landmark and, on the other hand, to identify potential anomalies of the arch, in particular aortic coarctation. The three vessels and the trachea can be viewed from transverse section of the thorax in an anteroposterior plane. Cephalic movement of the probe enables to identify the aortic isthmus just above the crossover between the arterial duct and the aorta. Doppler velocities obtained by these two methods have been found to be similar in normal cases.

Low resistance of the placental vascular bed maintains antegrade isthmus flow both in systole and diastole throughout fetal life. A noticeable decrease in this antegrade flow, particularly in diastole, is observed as the pregnancy progresses because cerebral vascular resistances progressively decrease while placental resistances remain stable throughout the 3rd trimester. This is followed by a relative increase in cerebral output and, secondarily, in venous return to the right ventricle. This phenomenon explains the preponderance of the right ventricle usually observed at the end of pregnancy. The deceleration effect of this increase in right ventricular output on the isthmus flow is well illustrated by the simultaneous recording of the isthmic flow and the arterial duct flow. Indeed, a brief retrograde flow is recorded at the isthmus level at the end of systole, a consequence of the physiological preponderance of the right ventricular output.

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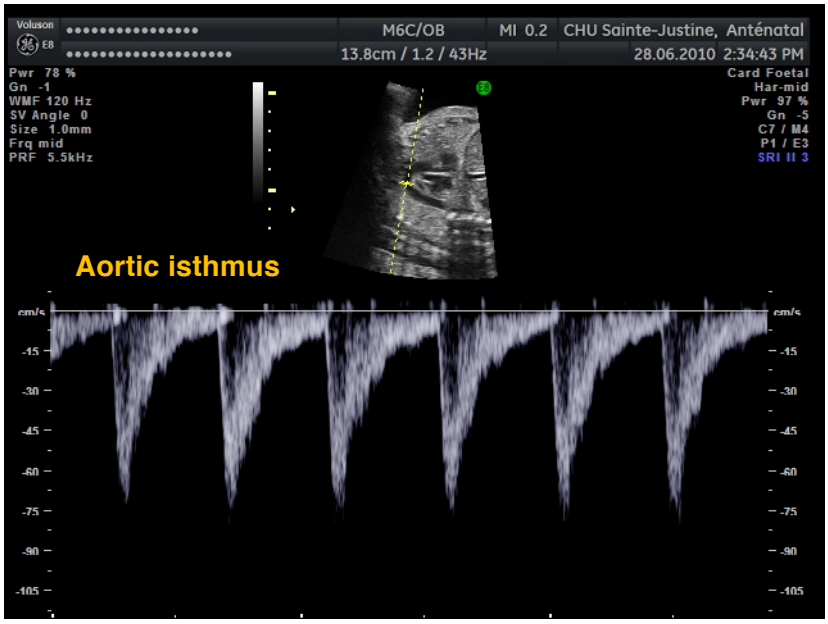
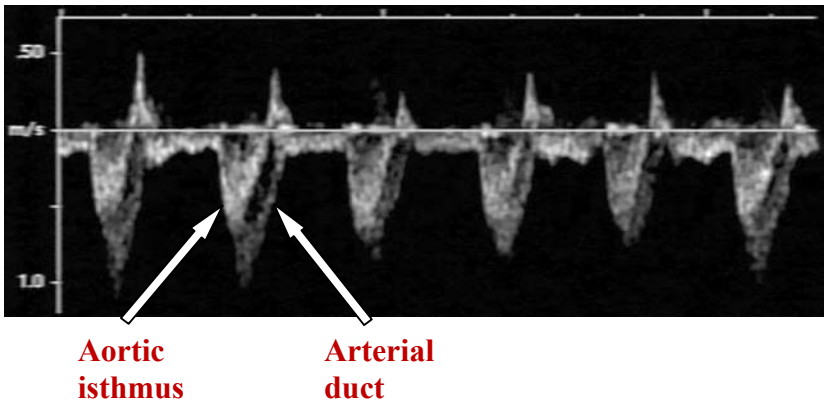
Aortic isthmus Doppler recording



Simultaneous recording of the aortic isthmus flow and the arterial duct flow



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Parameters and indices

The pulsatility index and the resistance index have been proposed for the quantitative evaluation of changes in velocity profiles in the isthmus. However, these indices were designed to evaluate the impedance of only one vascular bed and do not reflect the balance between both supra- and infradiaphragmatic vascular resistances. For these reasons, an index specific to the isthmus has been proposed. The isthmic flow index (IFI) is obtained by applying the following formula: the systolic velocity integral plus the diastolic velocity integral, divided by the systolic velocity integral. This index is particularly sensitive to variations in the balance between peripheral resistances of the two vascular systems. The most typical clinical example is the intrauterine fetal growth restriction associated with placental circulatory insufficiency. In these cases, the increase in placental resistances can, on its own, reduce antegrade flow in the isthmus. However, to this mechanical effect, fetal hypoxemia created by the reduction of umbilical flow must be added. Hypoxemia is responsible for cerebral vasodilatation with a drop in supradiaphragmatic resistances. These two factors, the rise in placental resistance combined with the drop in cerebral vascular resistance have a direct influence on the isthmic Doppler flow velocity waveforms.

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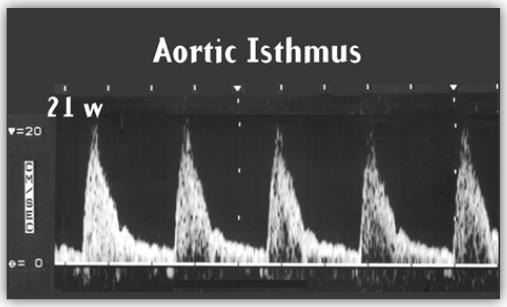
« IFI »
Fetal Isthmic Flow Index

$$\mathbf{IFI} = \frac{\int (\text{Systolic + Diastolic) velocities}}{\int \text{Systolic velocity}}$$

Normal values

≥ 1.2



For the purpose of correctly measure systolic flow in the aortic isthmus, it is important to take into account the opposite effect of right and left ventricles on the direction of the flow. The precisions given in the technical supplement explain how the opposite effect of right and left ventricles affect the direction of the isthmic flow during systole and justify the importance of measuring both antegrade and retrograde systolic velocity integral as a whole.

Five types of IFIs can then be described:

- Type I: IFI > 1, antegrade diastolic flow is still present, but reduced;
- Type II: IFI = 1, diastolic flow is absent;
- Type III: IFI is a fraction of 1 but greater than 0, which reflects the appearance of a diastolic retrograde flow, but with a dominant antegrade flow;
- Type IV: IFI = 0, antegrade and retrograde isthmic flows are equal, which is equivalent to an absence of flow in the isthmus;
- Type V: IFI < 0, retrograde diastolic flow is predominant, the index being negative.

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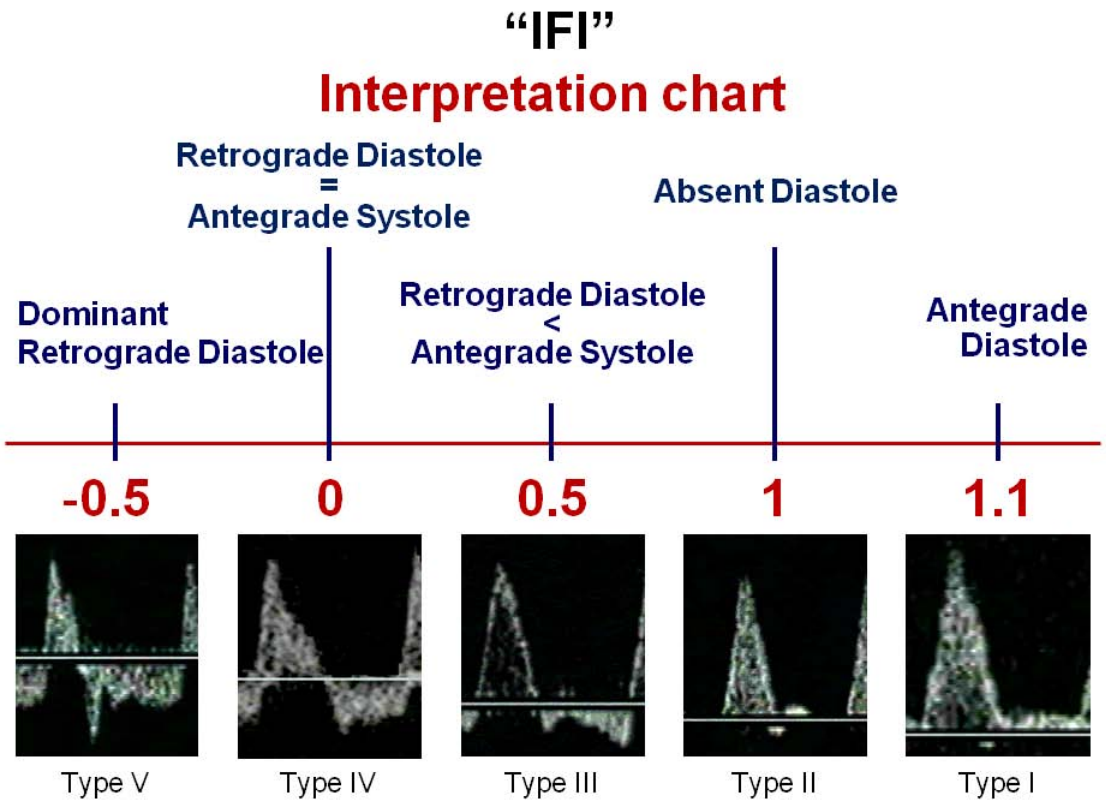

Fouron JC *et al*. Am J Obstet Gynecol 2005;192:497-503

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