PIAF study: Placental insufficiency and aortic isthmus flow

## Ductus venosus

### Anatomical landmarks

The ductus venosus is a short venous segment located between the portal sinus and the inferior vena cava. The umbilical vein drains into the portal sinus, just before the departure at almost a right angle of the right portal vein on the one hand, and before the junction of the ductus venosus, on the other hand. The path followed by the ductus venosus toward the upper extremity of the inferior vena cava is almost in the same axis as the umbilical vein. The ductus venosus which presents a constriction along its path has the appearance of a double funnel, causing a typical aliasing effect in colour Doppler coding, which makes it easy to locate.

### Technical aspects

The ductus venosus flow can be analyzed by transverse or sagittal section of the fetal abdomen. In the transverse section, the umbilical vein is first identified by its continuous, low-velocity flow. Following this vein until it joins the portal sinus, the ductus venosus becomes recognizable by its high-velocity flow, due to the characteristic narrowing of the vein.

In the sagittal section, the umbilical vein, in its intrahepatic course, is followed by a smaller vessel almost in the same axis as the umbilical vein which is the ductus venosus and its typical aliasing in colour Doppler. The sagittal approach enables to avoid more easily confusion between the ductus venosus and other adjacent vessels.

Whether we use the transversal or sagittal approach, it is important that the Doppler sample window be placed in such a way as to include, in the one hand, the narrower section where velocities are maximal and, on the other hand, to avoid contamination by blood flowing from the inferior vena cava where the atrial contraction “a” wave is always deeper than that of the ductus venosus. The proximal third of the ductus venosu satisfies these requirements.

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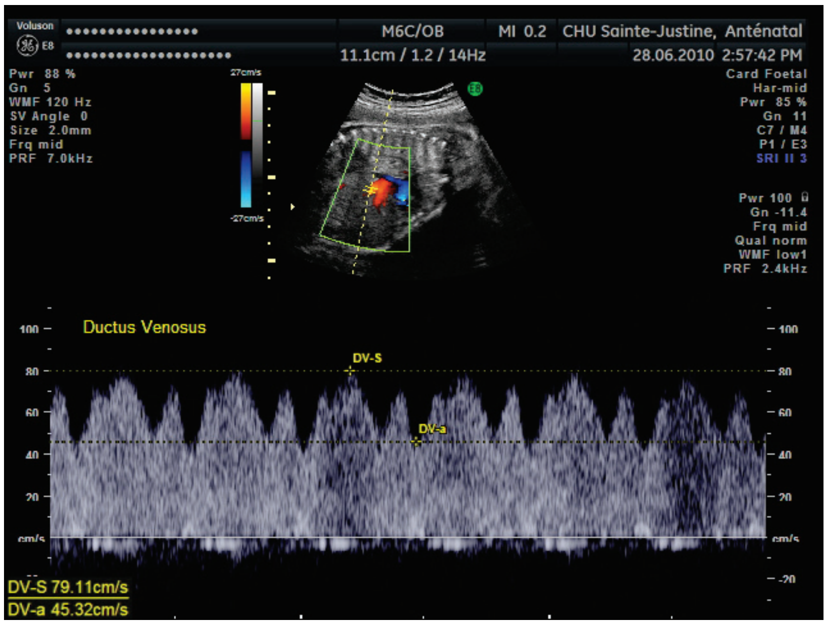
The profile of velocities in the ductus venosus is unique for both quantitative and qualitative reasons. Due to the narrowing of the vein and the great volume of flow coming from the placenta, the ductus venosus has the highest peak velocities of the entire fetal venous system, reaching 0.6 and even 0.7 m/s at the end of the 3rd trimester of pregnancy.




From a qualitative point of view, the profile of ductus venosus blood velocity waveforms is comparable to that of all systemic veins near the heart. This profile is influenced essentially by pressure variations within the right atrium. At each cardiac cycle, two antegrade acceleration waves precede a deceleration wave. The first acceleration, the “S” wave, corresponds to ventricular systole, when intra-atrial pressure is lowest, increasing the gradient at the ductus venosus level. The 2nd antegrade acceleration wave corresponds to the active relaxation phase of the ventricular myocardium and tricuspid valve opening at that point. It is regrettable that we are now accustomed to identifying this wave, the second acceleration wave, by the letter “D” for diastole, when it actually covers only one part of the diastolic cycle. I would prefer to call it the “e” wave (for “early filling”) by analogy to the “E” wave that is described at the level of the atrioventricular (AV) valves. Both have indeed the exact same origin. Finally, a deceleration wave can be seen at the end of diastole, corresponding to the increase in atrial and venous pressures caused by atrial contraction, this is the “a” wave.

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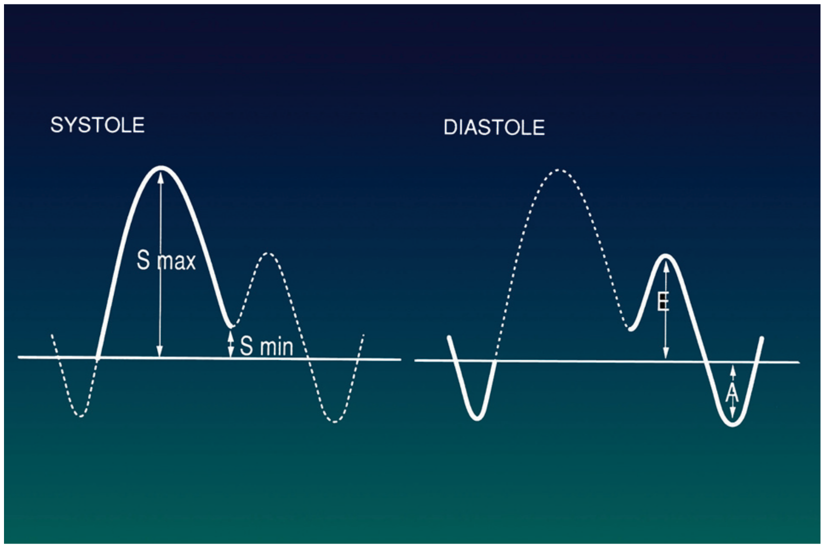


Normally, the “a” wave of the inferior vena cava or superior vena cava is always deeper than that of the ductus venosus. This characteristic difference is explained by the fact that the gradient persists at the level of the ductus venosus despite the increase in central venous pressures created by atrial contraction. The depth of the “a” wave is an excellent reflection of right intraventricular pressure in telediastole. This pressure increases in the failing heart. So, the more severe is the cardiac failure, the more the venous deceleration “a” wave deepens. The nadir of the “a” wave can reach the zero velocity line and, in severe cases, can be retrograde. In this last situation, the central venous pressure is higher than that of the ductus venosus during atrial contraction and blood flow is momentarily reversed.

Parameters and indices

In clinical practice, flow analysis at the ductus venosus level is intended essentially to evaluate cardiac diastolic function, and thus the degree of alteration of the “a” wave. For qualitative evaluation, “a” wave is described as “positive,” “nil” or “inverted.” This classification suffers from a lack of nuance between the three levels of severity described. On the other hand, the venous pulsatility index (PIv), or more simply the S/a ratio, offers a wider ranging scale to evaluate venous repercussions of cardiac functional impairment.

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In the context of IUGR, appearance of a reverse “a” wave at the ductus venosus level corresponds to a stage of advanced decompensation and breakdown of cardiocirculatory defense mechanisms against hypoxia.

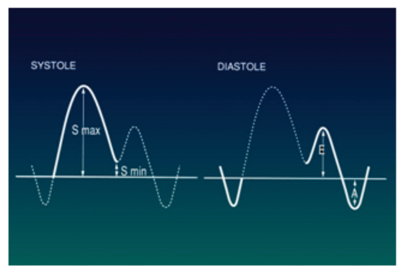
## Ductus venosus indices

Venous pulsatility index

$$\mathbf{IP_{(v)}} = \frac{V_s - a}{V_m} = \frac{(S - a)}{m}$$

S/a ratio

**S/a**




S = Peak systolic velocity
$V_m$ = Mean velocity
a = Late diastolic velocity (atrial contraction)

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