

Fetal Circulation: Sonographer's Cheat Sheet

A Quick Reference Guide for Fetal Echocardiography

Core Principles of Fetal Hemodynamics

- **Shunt-Dependent Circuit:** The fetal cardiovascular system is a parallel network that relies on preferential streaming rather than simple mixing [1] [2].
- **Placental Gas Exchange:** Oxygenation occurs entirely in the placenta, bypassing the unventilated, fluid-filled fetal lungs [1] [3].
- **Ventricular Function:** Both ventricles pump simultaneously into the systemic circulation. The right ventricle (RV) handles a higher combined output to overcome elevated pulmonary vascular resistance (PVR) [1].

The Three Essential Fetal Shunts

1. Ductus Venosus (DV)

- **Anatomy:** Connects the intra-abdominal umbilical vein directly to the inferior vena cava (IVC) [4].
- **Physiology:** Bypasses the hepatic sinusoids, accelerating oxygen-rich blood toward the right atrium [1] [4].
- **Sonographic Profile:** Normal flow presents as **high-velocity, continuous forward flow** throughout the cardiac cycle (systole and diastole) [5].
- **Clinical Marker:** Absent or reversed flow during atrial contraction is a critical marker of fetal compromise or right heart failure [6].

2. Foramen Ovale (FO)

- **Anatomy:** Connects the right atrium to the left atrium [7].
- **Physiology:** Shunts highly oxygenated venous blood directly into the left heart for systemic distribution (preferentially to the brain and myocardium) [7].
- **Sonographic Profile:** Normal flow requires a **phasic right-to-left pattern**, directed by the Eustachian valve [7].

- **Clinical Marker:** Left-to-right flow or bidirectional flow indicates pathological pressures, often seen in structural anomalies like severe valvar aortic stenosis [8].

3. Ductus Arteriosus (DA)

- **Anatomy:** Connects the main pulmonary artery to the descending aorta [7].
- **Physiology:** Bypasses the high-resistance, non-ventilated pulmonary vascular bed [3].
- **Sonographic Profile:** Dominant outflow pathway for the RV. Normal flow presents as **high-velocity right-to-left systolic and diastolic continuous forward flow** [5].

Hemodynamic Watershed Areas

Aortic Isthmus

- **Function:** Acts as a hemodynamic watershed area partitioning bloodstreams based on flow resistance between the brachiocephalic and placental circulations [9].
- **Sonographic Marker: Diastolic flow reversal** at the isthmus indicates a pathological drop in brachiocephalic resistance (brain sparing) or a rise in subdiaphragmatic (placental) resistance [9].

Umbilical-Portal-Systemic Axis

- **Function:** Oxygenated blood enters the fetal abdomen via the umbilical vein. Most shunts through the DV into the IVC [4].
- **Sonographic Marker:** Anomalies (UPSVS) present with complete absence or rerouting of the DV, drastically altering prenatal counseling [10].

Fetal to Neonatal Transition

- **Normal Transition:** Umbilical cord clamping removes the placenta, precipitating a sharp rise in systemic vascular resistance (SVR) [11]. Spontaneous respiration drops PVR, initiating the functional closure of all three fetal shunts [11] [12].
- **Persistent Fetal Circulation (PFC):** If PVR remains elevated postnatally, high right-sided pressures force continued right-to-left shunting across the patent DA and FO [11] [13]. This leads to a vicious cycle of severe systemic hypoxia and acidosis [13].

Echocardiography Protocol Fundamentals

Professional guidelines require strict documentation of:

1. Systemic and pulmonary venous connections.
 2. Patency and flow direction of all three major shunts.
 3. Validation of normal forward flow profiles in the transverse aortic arch and ductal arches.
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References

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