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IMAGING

Quantitative analysis of fetal pulmonary vasculature by 3-dimensional power Doppler ultrasonography in isolated congenital diaphragmatic hernia

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KEY WORDS
Three-dimensional power Doppler ultrasound
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Objective: The purpose of this study was to evaluate the potential of 3-dimensional (3D) power Doppler imaging to predict neonatal outcome and pulmonary arterial hypertension (PAH) in congenital diaphragmatic hernia (CDH).

Study design: In this prospective observational study, 3D-power Doppler ultrasonography was performed in 21 cases with isolated CDH between 23 and 33 weeks of gestation and in 58 controls between 20 and 40 weeks. Using the same preestablished settings for all cases, power Doppler was applied to each lung, and fetal lung volumes (FLV) were estimated using the rotational technique. The 3D power Doppler histogram was used to determine the vascular indices, which were plotted against gestational age and compared with neonatal outcome, PAH, gestational age, and FLV.

Results: Fetal pulmonary vascular indices showed a constant distribution throughout gestation, being significantly lower in cases with CDH than in controls ($P < .001$). Among CDH cases, the vascular indices were significantly lower in fetuses who died ($P < .05$), and in fetuses with neonatal PAH ($P < .05$). The severity of neonatal PAH was also associated with a progressive reduction in prenatal vascular indices ($P < .05$). All vascular indices correlated with o/e-FLV, but not with gestational age.

Conclusion: All vascular indices seem to be constant throughout gestation. In isolated CDH, perinatal outcome and postnatal PAH can be predicted using the vascular indices assessed by 3D power Doppler histogram.

Congenital diaphragmatic hernia (CDH), occurring with an incidence of approximately 1 in 2200 livebirths, has an overall neonatal mortality rate of 50% in cases with a prenatal diagnosis.[1] Prenatal prediction of neonatal prognosis remains a challenge, and is crucial for immediate neonatal care and for the selection of candidates for

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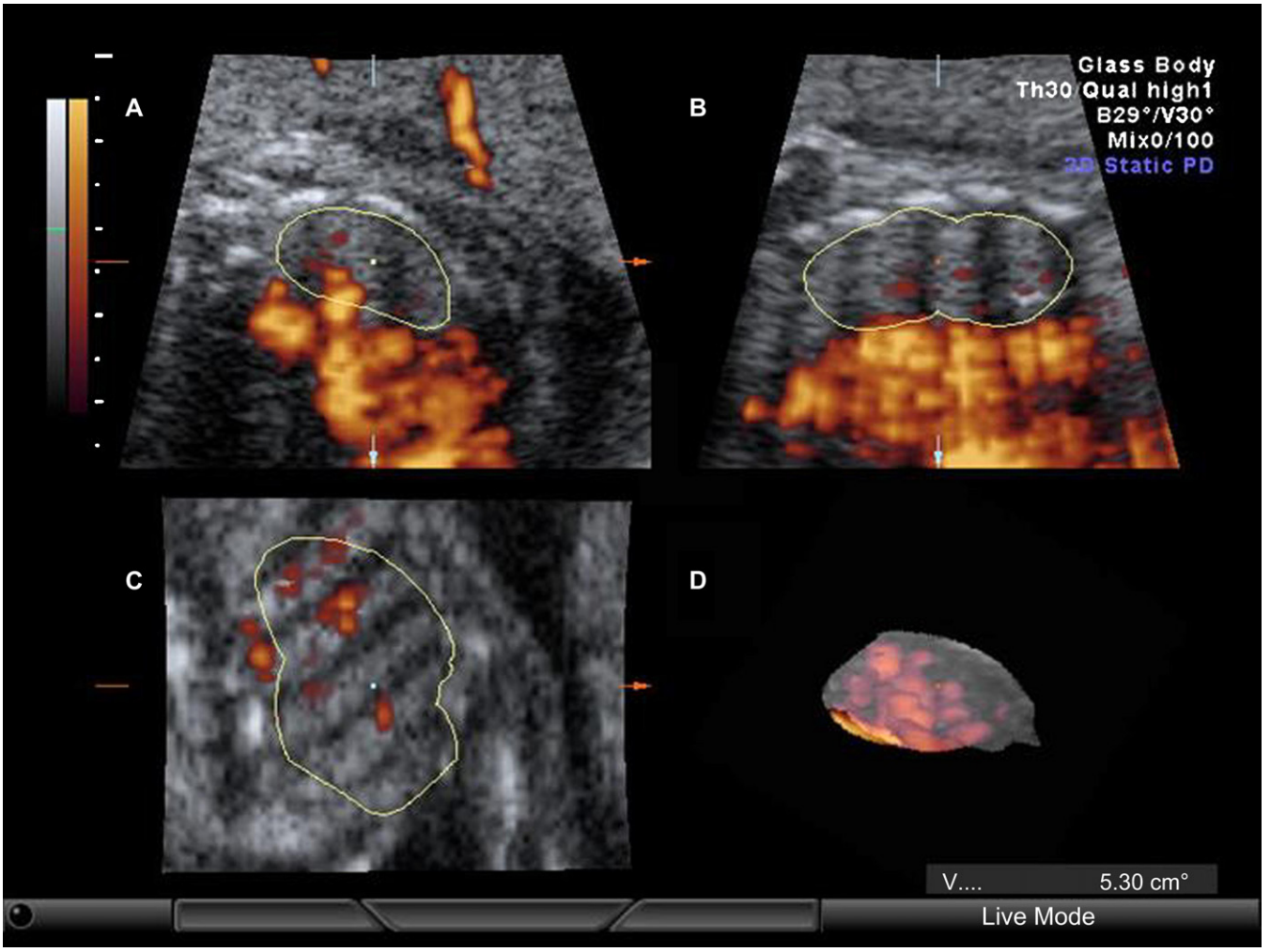

Figure 1 Three-dimensional (3D) power Doppler imaging of the right lung vasculature in a case with left congenital diaphragmatic hernia at 27 weeks of gestation. **A,** Cross-section; **B,** sagittal section; **C,** coronal section; **D,** 3D rendered mode.

minimally invasive therapeutic interventions such as intermittent tracheal occlusion by fetoscopy.[2,3]

Because neonatal mortality is directly related to severe pulmonary hypoplasia, many prognostic factors have been suggested based on the prenatal assessment of lung size (fetal lung volumes),[4-7] lung-to-head ratio,[8,9] and lung diameter to thoracic circumference ratio.[10] Other prenatal findings indirectly related to the size of fetal lungs have also been associated with prognosis, such as the degree of herniation of abdominal organs (liver and stomach positions)[8,11-13] and compression of fetal lungs by herniated organs (left/right ventricle ratio, amniotic fluid volume, and mediastinal shift).[14] Recent studies have demonstrated that total fetal lung volume estimated by magnetic resonance imaging or 3-dimensional (3D) ultrasonography is significantly correlated with neonatal outcome in isolated CDH.[4,5] These authors found that neonatal death mainly occurs when the observed/expected fetal lung volume (o/e-FLV) is lower than 0.35, suggesting this value as the cut-off. Nevertheless, recent experiences showed that neonatal deaths occur in a few cases despite higher o/e-FLV or markedly high pulmonary weights, mainly when the onset of pulmonary arterial hypertension (PAH) has been linked to neonatal death. Moreover, histopathologic studies have demonstrated that pulmonary hypoplasia is associated with different degrees of alterations in pulmonary vasculature that contribute to the development of PAH.[15] Based on these findings, many authors have proposed to study fetal pulmonary vasculature on the basis of fetal pulmonary artery diameter[16] or by the use of the acceleration time/ejection time ratio of pulmonary arteries by Doppler blood flow velocimetry,[17] but small series do not allow definitive conclusions. Recently, Mahieu-Caputo et al[18] suggested the number of bifurcations of the pulmonary vessels in the lung contralateral to the diaphragmatic hernia evaluated by conventional 2D power Doppler imaging as a potential