Prenatal Diagnosis of Isolated Ventricular Noncompaction of the Myocardium

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Isolated ventricular noncompaction (IVNC), also known as spongy ventricular myocardium, is a rare cardiomyopathy characterized by numerous ventricular trabeculations and deep intertrabecular recesses, thought to be due to an arrest in cardiac embryogenesis. The clinical spectrum varies from asymptomatic patients to cardiac failure with neonatal death. Prenatal diagnosis has been reported sporadically. We report a case of IVNC diagnosed prenatally at 31.5 weeks' gestation. First-trimester screening revealed increased nuchal translucency, but the parents declined invasive prenatal diagnosis. Routine sonography at 31.5 weeks showed marked cardiomegaly with no other anomalies. Fetal echocardiography revealed numerous trabeculations and deep intertrabecular recesses within the cardiac ventricular myocardium. Diagnosis of ventricular noncompaction was made. Postnatal echocardiography confirmed the diagnosis and showed suboptimal left ventricular function. Isolated ventricular noncompaction is rare but needs to be considered in the differential diagnosis of left ventricular hypertrophy. Isolated ventricular noncompaction can be associated with other cardiac and extracardiac disorders, particularly neuromuscular. Diagnosis is made by echocardiography and color Doppler sonography, showing direct blood flow from the ventricular cavity into deep intertrabecular recesses.

Abbreviations

IVNC, Isolated ventricular noncompaction

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Case Report

A 22-year-old woman, gravida 2, para 1, underwent routine sonography at 31.5 weeks' gestation. Of interest in her history was the death in childhood of 2 brothers and 1 sister of an unknown metabolic disorder. Her first child, then 3 years of age, was perfectly healthy. The patient and her husband were consanguineous.

First-trimester screening at 11 weeks' gestation had shown increased nuchal translucency of 3.3 mm, but the parents had declined prenatal invasive testing. Second-trimester structural sonography was unremarkable. Third-trimester sonography revealed a striking cardiomegaly (cardiac-chest circumference ratio of 68.75%) in the absence of other cardiac and extracardiac anomalies (Figure 1). More in-depth 2- and 3-dimensional fetal echocardiography (Figures 2 and 3 and Video 1) showed

Figure 1. Two-dimensional gray scale sonogram showing marked cardiomegaly and the presence of numerous excessively prominent ventricular trabeculations with deep intertrabecular recesses (arrowheads).

numerous trabeculations and deep intertrabecular recesses of both ventricles with diminished ventricular contractility and normal function of the atrioventricular and semilunar valves. These findings were highly suggestive of IVNC. Cardiac size and cardiac output remained stable until birth. A male neonate of 3030 g was born by assisted vaginal delivery. The Apgar scores were 9, 9, and 10 at 1, 5, and 10 minutes, respectively. The child had some dysmorphic features, including a broad forehead with a triangular face, a flat nasal bridge, low-set ears, and a short neck. Postnatal echocardiography confirmed

the prenatal findings of dilated ventricles, particularly the left one, with numerous trabeculations and deep intertrabecular recesses (Figure 4 and Video 2). The decreased contractility of the left ventricle was more pronounced along the anteroposterolateral wall. The diagnosis of IVNC was established. Oral positive inotropic therapy with digoxin was commenced. Metabolic test results were normal. However, the parents declined a skin biopsy as well as a genetic workup despite consanguinity, the dysmorphic features, and the family history. The hemodynamic status of the infant had remained stable at regular follow-up to 10 months of age while he continued to receive medication.

Discussion

Isolated ventricular noncompaction, also known as spongy ventricular myocardium, is a rare congenital cardiomyopathy characterized by the presence of numerous excessively prominent ventricular trabeculations and deep intertrabecular recesses. The prevalence varies from 0.05% to 0.24% per year.¹⁻⁴ The pathogenesis is still unclear. Several pathogenic mechanisms have been proposed.⁴ One hypothesis is that IVNC results from an arrest in the compaction process of the myocardium. Other theories suggest that ventricular noncompaction might be (1) the result of an attempt of an impaired myocardium to grow, (2) the consequence of a cardiac neuropathy, (3) the effect of an impaired adhesion of

Figure 2. Color Doppler sonogram showing direct blood flow from the ventricular cavity into the spaces between the prominent trabeculations (arrowheads).

Figure 3. Diagnostic spatiotemporal image correlation showing marked cardiomegaly with numerous trabeculations and deep recesses (arrowheads).

cardiac myocytes as a result of a malfunction of gap junctions, or (4) the result of an adaptation to special hemodynamic conditions.⁴

The clinical appearance varies from asymptomatic patients to progressive ventricular dysfunction, arrhythmias, and systemic and pulmonary embolism to cardiac failure with (neonatal) death.^{1,5} Isolated ventricular noncompaction can be associated with other cardiac⁴ and extracardiac disorders. Neuromuscular anomalies, especially metabolic myopathies, have been described in up to 81% of cases with isolated ventricular abnormal trabeculations.^{3,6,7} Several syndromes may be associated with ventricular noncompaction, such as Barth syndrome,^{8,9} Ohtahara syndrome,¹⁰ Roifman syndrome,¹¹ Melnick-Needles syndrome,¹² MLS (microphthalmia with linear skin defects) syndrome,^{13,14} Nail-Patella syndrome,^{15,16} and Noonan syndrome.¹⁷ Inheritance is X linked (Xq28 region)⁸ or autosomal recessive.¹⁸ A possible dominant form in association with specific facial features has also been reported,¹⁹ as well as a case of distal chromosome 5q deletion.²⁰

Prenatal diagnosis has been reported previously in only 6 fetuses,^{21,22} this being the seventh (Table 1). Five of these cases were sporadic; 2 of the neonates were born from the same mother. A study by Bleyl et al⁸ suggests that fetal echocardiography is not reliable for prenatal diagnosis of IVNC. The authors described the fetal echocardiographic findings obtained between 24 and 30

Figure 4. Postnatal 2-dimensional gray scale sonograms (with and without Color Doppler imaging) confirming the diagnosis of IVNC (arrowheads).

weeks' gestation in 3 members of a family in whom IVNC subsequently developed. In only 1 case was a dilated left ventricle diagnosed prenatally without other characteristics of ventricular noncompaction. The other 2 cases showed normal findings. Winer et al²³ illustrated a case of prenatal diagnosis of a fetal cardiomyopathy of unknown etiology at 22 weeks' gestation. The pregnancy was terminated, and the diagnosis of IVNC was made by pathologic examination. The authors emphasized the difficulty of diagnosis of ventricular noncompaction in minor forms without associated anomalies. Recently, Kitao et

Table 1. Overview of the 7 Prenatally Diagnosed Cases of Isolated Ventricular Noncompaction of the Myocardium, Including Our Case

Reference	GA, wk	Karyotype	Outcome	Cardiac Features	
				Other Than IVNC/NIHF	Extracardiac Features
Karatza et al ²¹ (n = 2)	27	46,XX	NND 12 h	NIHF	Cystic dysplasia left kidney
	29	46,XX	A/W, asymptomatic	None	Exomphalos, hepatomegaly, absent gallbladder, hydronephrosis
Moura et al ²² (n = 4)	26	46,XY	TOP 31 wk	SVT, pericardial effusion	Microcephaly, dysmorphic face
	24	Declined	A/W, asymptomatic	Tricuspid regurgitation	SUA
	25	46,XY	TOP 25 wk	NIHF	None
	22	46,XY	TOP 23 wk	Pulmonary atresia	None
This report	31	Declined	A/W, asymptomatic	None	Dysmorphic face

A/W indicates alive and well; GA, gestational age at diagnosis; NIHF, nonimmune hydrops fetalis; NND, neonatal death; SUA, single umbilical artery; SVT, supraventricular tachycardia; and TOP, termination of pregnancy.

al²⁴ described a case of maternal IVNC during pregnancy in which cardiomegaly and hydrops also developed in the fetus during the second trimester. Fetal echocardiography revealed a cardiomegaly with tricuspid regurgitation and pulmonary stenosis but could not show any features of IVNC. An emergency caesarean delivery was performed because of deterioration of maternal cardiac function. The neonate died of cardiac failure on the second day, and autopsy established the diagnosis of IVNC of the myocardium.

Prenatal diagnosis of IVNC is made by echocardiography and color Doppler sonography. In the adult, Jenni et al²⁵ defined 4 echocardiographic diagnostic criteria: (1) Coexisting cardiac anomalies caused by high-pressure exposure of the ventricle during intrauterine development are absent, and various forms of semilunar valve obstruction or left ventricular outflow tract obstruction have to be ruled out. (2) The left ventricular wall is thickened and consists of a 2-layered structure: a compacted epicardial band of uniform tissue and a much thicker noncompacted endocardial layer of prominent trabeculations and deep intertrabecular recesses. A maximal end-systolic ratio of noncompacted to compacted layers of greater than 2 is diagnostic. (3) The features are found predominantly in the apical and mid-ventricular segments of the left ventricle. (4) Direct blood flow from the ventricular cavity into the spaces between the prominent trabeculations is visualized by color Doppler sonography throughout the cardiac cycle. The involvement of the right ventricle during fetal life, as seen in our case and postulated by Moura et al,²² is probably related to the hemodynamics of the fetal circulation, which is characterized by a dominant right ventricle. As illustrated in our case, prenatal diagnosis of IVNC is possible but, as previously published, may be difficult and not always emphasized. However, prenatal diagnosis is important because the outcome can be highly variable, and neonatal death can be imminent. Isolated ventricular noncompaction should be considered when fetuses with increased first-trimester nuchal translucency are evaluated. Familial occurrence should also be kept in mind for early diagnosis of ventricular noncompaction of the myocardium.

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