



# The first Fetal Echocardiography experience for Prenatal diagnosis of Congenital Heart Disease in Lebanon: Successes and challenges

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**Objectives:** To describe the first Lebanese fetal echocardiography experience for prenatal diagnosis of congenital heart diseases (CHD), showcase successes, and hurdles.

**Methods:** This was a retrospective study from January 2014 to December 2017. A total of 350 fetal echocardiograms for 299 fetuses were performed at the Children's Heart Center at the American University of Beirut, the only fetal center in Lebanon. Data were collected regarding diagnosis, reasons for referral, and timing of referral.

**Results:** The mean gestational age at presentation was 25.3 weeks (standard deviation 4.9 weeks). The primary reasons for referral were abnormal anomaly scan (81.27%), history of previous child with CHD (48.16%), and pre-existing maternal congenital heart disease (15.5%). A total of 144 fetal echocardiograms were normal and 155 patients were diagnosed prenatally with CHD giving a detection rate of 44%. The most identified cardiac lesions were ventricular septal defects (31, 20%), atrial septal defects (15, 9.7%). Significant CHD defined as major abnormalities which would impact pregnancy and future quality of life of the baby were identified in 78 fetuses, with a detection rate of 22%.

**Conclusion:** High rates of detection are mainly due to low rates of referral when indicated and possibly parental anxiety regarding CHD diagnosis.

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**Keywords:** Fetal echocardiography, Prenatal diagnosis, Congenital heart disease

**Disclosure:** Authors have nothing to disclose with regard to commercial support.

Received 2 December 2018; revised 22 January 2019; accepted 4 April 2019.  
Available online 11 April 2019

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Peer review under responsibility of King Saud University.  
URL: [www.ksu.edu.sa](http://www.ksu.edu.sa)  
<https://doi.org/10.1016/j.jsha.2019.04.001>



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## 1. Introduction

Congenital cardiac defects are found in ~6.5 of 1000 live births and are the leading cause of infant mortality from congenital malformations; around 42% of infant deaths as per the World Health Organization [1]. In fact, structured cardiac anomalies were among the abnormalities most commonly missed by prenatal ultrasonography [2]. Fetal echocardiography screening is thus deemed an important strategy in managing pregnancies and postnatal complications [3,4]. It is also a more effective screening method than prenatal ultrasonography to detect congenital heart diseases. It comes as no surprise that the International Society of Ultrasound in Obstetrics and Gynecology [5] published an updated version for cardiac screening guidelines, pushing to improve the rate of prenatal detection [5].

As a general rule, performing the outflow tract views in addition to the standard four-chamber view improves considerably the rate of detection of congenital heart disease. For instance, transposition of great arteries, common arterial trunk, and some forms of coarctation of the aorta are the main examples where the four-chamber view of the heart is nearly normal and require the outflow tract view for accurate diagnosis [5].

Reasons for referral for fetal echocardiography may be divided into (1) fetal-related factors: extra cardiac anomalies (omphalocele, duodenal atresia, or spina bifida), polyhydramnios, hydrops, increased nuchal translucency); (2) maternal related factors (history of congenital heart disease, metabolic disorders, autoantibodies, and exposure to a teratogen or specific viruses coxsackie or parvovirus); or (3) familial (history of previous congenital heart disease with autosomal Mendelian inheritance) [6]. Implications of fetal echocardiography can range from reassurance, termination of pregnancy, or postnatal referral to a specialized center [3].

The Children's Heart Center at American University of Beirut Medical Center (AUB-MC) is a specialized cardiac center and is one of the major referral centers in Lebanon for pediatric patients with congenital heart disease, where congenital cardiac surgeries are readily performed on a daily basis. The Fetal Heart Program was recently developed in 2014. In this study, we will review the reasons of referral for fetal echocardiography at the AUB-MC and its impact on the rate of prenatal diagnosis and neonatal outcomes from January 2014 to December 2017.

### Abbreviations

AUBMC	American University of Beirut Medical Center
M.A	Dr. Mariam Arabi
ECEE	extend cardiac echography examination (ECEE)
CHD	Congenital Heart Disease
IVF	IN vitro Fertilization
TOF	Tetralogy of Fallot
TGA	Transposition of the great arteries
TA	truncus arteriosus
ASD	Atrial Septal Defect
VSD	Ventricular Septal Defect
ART	Assisted Reproductive Technologies

To this date, no Arab country has published any data regarding fetal echocardiography, and whereas this study might not be the first of its kind in the region as Turkish counterparts have already published their corresponding experience, this study is the first of its kind in an Arab country.

## 2. Materials and methods

This study is a retrospective review of our experience with fetal echocardiography over a 4-year period, from January 2014 to December 2017. The study population consists of pregnant patients referred for fetal cardiac evaluation as prenatal heart assessment for suspicion of or at risk of fetal congenital heart defects. The exams were performed by a single pediatric cardiologist who is the director of the Fetal Heart Program (M.A), in the Fetal Cardiac unit at the Children's Heart Center at AUB-MC. The Children's Heart Center at AUB-MC is a specialized cardiac center and is one of the major referral centers in Lebanon for pediatric patients with congenital heart disease, where congenital cardiac surgeries are readily performed on a daily basis. The Fetal Program was recently developed in 2014. The parameters looked at included: the indications for referral categorized into fetal and maternal factors; the maternal and gestational age at time of referral; fetal heart screening findings; the number of cardiac neonates newly diagnosed at the Children's Heart Center, including those born at AUB-MC and those referred from other hospitals. Having all data collected, the percent of prenatal diagnosis of cardiac babies is then inferred.

The fetal cardiac examination was performed using Philips Machine IE33 Philips Ultrasound. Bothell WA, USA. Equipped with S8-3 and S5-1 MHz sector transducers. All exams include a two-dimensional evaluation of heart chambers (4-chamber view) and the extend cardiac echography examination (ECEE) is the scan protocol used.

The ductal, aortic arch position, cardiac situs, rhythm, systemic and pulmonary venous inflow, atrial and ventricular chambers, atrioventricular and semilunar valves, and ventricular–arterial connections are reported.

The Institutional Review Board at the American University of Beirut approved the study prior to data collection as per the Helsinki Declaration. Consent was waived as no active intervention was performed on the patient and chart review was purely retrospective did not affect the standard of patient care. Patient information was kept in a safe place with the primary investigators.

### 2.1. Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 23, IBM Corporation, USA.

## 3. Results

The Children Heart Center at AUB-MC is considered a main healthcare facility in Lebanon that performs fetal echocardiography. From January 2014 to December 2017, a total of 350 fetal echocardiograms were performed by a single pediatric cardiologist (M.A.) with a total of 299 patients who presented to the center based upon referral from within and outside AUB-MC. The overwhelming majority of patients were referred by a gynecologist (283; 94.6%), followed by pediatricians (6; 2%) and with only four patients presenting as self-referral. The mean gestational age at presentation was 25.3 weeks (standard deviation 4.9 weeks). The most common indications for the study are featured in Table 1. The primary reasons for referral were by order of occurrence are abnormal anomaly scan (81; 27%), history of previous child with CHD (48; 16%), pre-existing maternal congenital heart disease (15; 5%), *in vitro* fertiliza-

tion (IVF) pregnancy (14; 4.6%), and increased nuchal translucency (8; 2.6%). This pattern was consistent throughout the 4 years of the study. Abnormal fetal scan was the most common fetal factor for referral (38% in 2014, 33% in 2015, 50% in 2016, and 42.6% in 2017) and a previous history of a child of congenital heart disease being the most common familial factor for referral (24.8% in 2014, 23.8% in 2015, 19.3% in 2016, and 32.8% in 2017). The two most common maternal factors for referral were a pre-existing congenital heart disease and IVF. The increasing trend for IVF-related referral (4.7% in 2014 to 7.14% in 2015 and 8.1% in 2016) is related to a better knowledge by the obstetricians and gynecologists of the availability of the Fetal Imaging program at AUB-MC as this program did not exist before 2014.

During the study period, 144 fetal echocardiograms were normal and 155 patients were diagnosed prenatally with congenital heart disease. These patients were then referred, depending on the severity of the cardiac lesion to an appropriate multidisciplinary team for counseling composed of a pediatric cardiologist, a pediatric cardiothoracic surgeon, a neonatologist at AUB-MC. The distribution of cardiac lesions diagnoses is summarized in Table 2. The 155 patients were selected for diagnosis out of the available 350 fetal echocardiograms done on 299 fetuses, giving a detection rate of 44%. We subsequently divided the congenital heart diseases into two categories. Major anomalies that have a significant impact on the pregnancy and future quality of life of the baby. These include AV septal defects, AV connection abnormalities [hypoplastic left heart syndrome (HLH) and Ebstein Anomaly], outflow anomalies [tetralogy of Fallot (TOF)], transposition of the great arteries (TGA), truncus arteriosus (TA)]. Minor anomalies were defined as septal defects that are unlikely to affect future quality of life. These were divided between atrial septal defects

Table 1. Results of fetal echocardiography by the most common indications for referral.

Reason for referral	Total	Normal (% of total)	Abnormal (% of total)	Major abnormal (% of total)
<i>Maternal factors</i>				
Mother with CHD	15	11 (73)	4 (26.7)	1 (6.67)
Metabolic disease	11	9 (81.2)	2 (18.8)	1 (9)
Advanced maternal age	4	4 (100)	0	0
<i>In vitro</i> fertilization	14	10 (71.4)	4 (28.5)	3 (21.4)
<i>Fetal factors</i>				
Abnormal anomaly scan	81	22 (27.1)	59 (72.8)	40 (49.4)
Increased NT	8	5 (62.5)	3 (37.5)	2 (25)
Twins	8	6 (75)	2 (25)	1 (12.5)
<i>Familial factors</i>				
Previous Hx of CHD	48	36 (75)	12 (25)	2 (4.16)

CHD = congenital heart diseases. Hx = History. NT = Nuchal thickness.

Table 2. Distribution of congenital cardiac defects by category.

Heart defect	N (%)
AV septal defect	15 (9.7)
AV connection abnormality	21 (13.5)
Hypoplastic left ventricle	15 (9.7)
Ebstein anomaly	6 (3.8)
Outflow abnormalities	31 (20)
Tetralogy of Fallot	10 (6.4)
Transposition of the great arteries	7 (4.5)
Double outlet right ventricle	10 (6.4)
Truncus arteriosus	4 (2.5)
Left to right shunt	46 (29.7)
Ventricular septal defect	31 (20)
Atrial septal defect	15 (9.7)
Obstructive lesions (aortic stenosis, pulmonary stenosis)	11 (7)
Echogenic focus	21 (13.5)

AV = Atrioventricular.

(ASD) and small ventricular septal defects (VSD) [7]. Significant CHD was detected in 78 of these patients with a detection rate of 22.2%.

#### 4. Discussion

In 1954, Edler and Hertz were among the first to start time motion and M-mode recordings using ultrasound in a machine then called a reflectoscope [8]. Ten years later, Wang was the first to document M-mode recordings of the fetal heart. This is the first documented fetal echocardiography. Others, such as Wisenberg, followed suit in the USA [8]. Further advances in fetal echocardiography allowed detection of structural defects and cardiac arrhythmias [8]. Studies over the years proved that transabdominal fetal ultrasound could be done starting 18 weeks of gestation [9]. Due to antenatal fetal echocardiography correlations with postnatal follow up and/or fetal autopsies, regulations for screening were put into place to better prepare for immediate postnatal action [8].

Early detection of congenital heart defects continues to be highly important in managing the course of the fetus especially in the immediate postdelivery settings. This study reviews 350 fetal echocardiograms performed in the only fetal program in Lebanon. To our knowledge, no such data exists in the Arab World and thus we are the first Arab country to report our trend in such a practice.

The average gestational age for fetal echocardiography at presentation was 25.3 weeks, which is slightly outside the optimal window of 18–

22 weeks [10,11]. The American Society of Echocardiography mentions that obtaining images after 30 weeks of gestation can be difficult; therefore our center continues to perform fetal echocardiography studies in an adequate timing to obtain the various cardiac views [10].

Reasons for referral at AUB-MC were also in line with current guidelines. The main maternal indications in our center were pre-existing congenital heart defect and *in vitro* fertilization pregnancy consistent with the guidelines as per Nayak et al [12]. *In vitro* fertilization is an indication to refer due to the increased incidence of congenital heart defects in babies conceived with this method. Tararbit et al [14,15] showed a 40% increase in the overall risk of congenital heart defects in children conceived with Assisted Reproductive Technologies (ART) [13,14]. Specifically, TOF was associated with a 2.4 times more likelihood to occur with ART when compared with controls after adjustment for maternal age, occupation, geographic origin, paternal age, and year of birth [15]. There were statistically significant associations between ARTs and hypoplastic left heart syndrome, transposition of the great arteries or coarctation [15]. In spite of all the evidence and the well-established indication for referral, the number of pregnant patients referred for fetal echocardiography after IVF is substantially small (14 out of 350). Given the huge number of IVFs performed yearly in Lebanon with 20 fertility clinics currently operating, several factors contribute to this low census. First, in Lebanon, 37% of obstetricians are reported to encourage their patients to consider undergoing or foregoing prenatal diagnosis [16]. Another factor is the attitude of pregnant mothers with IVF towards prenatal diagnosis in general. In a study conducted in Lebanon by Au-Musa et al [17], the investigators found that women who conceived through IVF were less likely to perform prenatal diagnosis of any sort, yet alone fetal echocardiography. Several factors contribute to this finding, mainly parental anxiety after so many years suffering infertility and the looming prospect of a successful pregnancy [17].

Another interesting result is the elevated detection rate of congenital heart disease in our study population (42% CHD and 22.2% of major abnormalities) compared with rates reported worldwide. In 2009, an evaluation of 3965 fetal echocardiograms in Israel detected only 228 fetuses (5%) with CHD, of whom only 47 (1.2%) had significant CHD [18]. A review of the 1035 fetal echocardiograms performed in the Children Heart Center, Las Vegas, which is the sole provider of prenatal cardi-

ology services in Clark County Nevada detected only 58 fetuses (4.4%) with CHD [19]. This major contrast highlights the fact that prenatal care specialists in Lebanon are lagging behind in applying guidelines of when to refer patients for fetal cardiac evaluation. Indeed, a closer look at our study population showed that the most common cause for referral was an abnormal anomaly scan (23%), but the most common anomaly was actually a suspected cardiac lesion in 95% of the cases. No parent with a fetus showing an extra cardiac abnormal scan such as polyhydramnios, oligohydramnios, Intrauterine growth restriction (IUGR), anencephaly, spina bifida, cleft lip, gastroschisis, omphalocele, renal agenesis, or skeletal dysplasia was referred to the fetal program clinic in all 4 years of the study despite the fact of the very strong association of extra cardiac anomalies and congenital heart diseases [20,21]. Only 11 pregnant women with metabolic diseases such as diabetes and only four with advanced were referred during the entire study period, despite clear indications for referral.

This study was the first in the Arab region to evaluate the trend of fetal echocardiography in the only referral center for prenatal cardiac care in Lebanon. In spite of high success rates of detecting congenital heart disease, the program still does not receive as many referrals as it should. These limitations are due to multiple factors. The program at AUB-MC was only established in 2014 and is the first of its kind in Lebanon; thus, many obstetricians may still be unaware of its existence especially in peripheral medical centers. The financial cost and the unwillingness of health insurers to financially support an extra screening test may be a hurdle to many pregnant women who may require this imaging. In addition, a lack of guidance for obstetricians and unaddressed anxiety of parents together lead to low referral rates and thus to missed opportunities of detecting congenital heart diseases earlier on during a pregnancy course.

## Acknowledgments

This manuscript received no sources of funding from any party.

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