Echocardiography in pregnant women

Gebelikte ekokardiyografinin yeri

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ABSTRACT

Beyond evaluating physiologic alterations encountered during pregnancy quantitative pulsed- and continuous Doppler and qualitative color Doppler technology can be used for cardiovascular assessment of the pregnant woman with heart disease or suspected cardiac abnormality. Echocardiography provides information about disease etiology, leads to accurate and non- invasive assessment of disease severity and is a powerful means of monitoring progression. Only with echocardiography it has been clearly demonstrated that during pregnancy congenital heart disease is the first leading abnormality followed by rheumatic heart disease. Doppler and qualitative color Doppler are useful to illuminate the pathophysiology of the hemodynamic consequences of fixed valve stenosis during pregnancy with respect to the labile nature of gradients resulting from variable loading conditions of pregnancy. Accurate cardiac diagnosis leads to accurate estimation of prognosis, illuminates the necessity of noninvasive monitoring throughout pregnancy and labor, and leads to determine whether surgical or medical intervention should be performed. Need for Fetal echocardiography should also be considered after maternal echocardiography is undertaken. Although there are no strictly defined limits established for the use of Doppler ultrasound in the early pregnancy there is an unequivocal demand for carefulness that is best expressed by the ALARA principle,-as low as reasonably achievable. *(Anadolu Kardiyol Derg 2006; 6: 169-73)*

Key words: Echocardiography, Doppler, pregnancy

ÖZET

Ekokardiyografinin gebelerde kullanımı günümüzde gittikçe daha yaygınlık kazanmaktadır. Yeni ekokardiyografi tekniklerinin eklenmesi ile sadece gebelik sırasında oluşan fizyolojik değişikliklerin izlenmesinde değil,olası yada kanıtlanmış kalp hastalığı olan hamilelerin tespiti, kalp hastalıklarının sebebinin ve ağırlık derecesinin belirlenmesi ve ilerleme hızının takibinde de ekokardiyografi tartışılmaz yere sahip olmuştur. Ekokardiyografi sayesinde gebelikteki kalp hastalıkları arasında birinci sıklıkta konjenital kalp hastalıklarının ikinci sırada da romatizmal kalp hastalıklarının izlendiği tespit edilebilmiştir.Dolayısı ile bu yazıda ayrıntılı olarak bu konulara değinilmektedir. Gebeliğin evrelerine göre kapak velositelerinde oluşan değişkenlikler Doppler ve renkli Doppler ekokardiyografi ile izlenebilmekte ve bu değişkenlikler göz önüne alınarak kapaklardaki darlık dereceleri oldukça doğru olarak değerlendirilebilmektedir. Doğru tanı doğru sağ kalım değerlendirmesine yol açacak ve hasta için seçilecek doğru tedaviyi yönlendirecektir.Tanısal tetkikler arasında iyonize radyasyona maruz kalmanın gebelerdeki olumsuz etkileri düşünüldüğünde ekokardiyografinin yeri daha da iyi anlaşılabilir. Ancak ekokardiyografinin gebelerde kullanımında da ALARA prensibinin göz ardı edilmemesi gerekmektedir. *(Anadolu Kardiyol Derg 2006; 6: 169-73)*

Anahtar kelimeler: Ekokardiyografi, Doppler, gebelik

Introduction

Despite continuous improvements in diagnostic cardiology techniques, echocardiography remains the cornerstone both for assessing the reversible physiological cardiac remodeling of pregnancy associated with changes in valve patency or transvalvular flow pattern, which can best be assessed by the complementary use of quantitative pulsed and continuous Doppler and qualitative color Doppler technology and for noninvasive cardiovascular assessment of the pregnant woman with heart disease or suspected cardiac abnormality (1).

Among the physiologic alterations during pregnancy increase in cardiac output (CO) is the most prominent one. Hormonally mediated increases in blood volume, red cell mass and heart rate result in a major increase in CO during pregnancy (2). Cardiac output increases significantly at the early to mid third trimester and is maintained until term. Peak CO of 46-51% occurred from a 15% increase in heart rate and 24% increase in stroke volume (3).

During labor and delivery, pain and uterine contractions result in additional increases in CO(%20 with each contraction) and blood pressure. Immediately following delivery, relief of caval compression and autotransfusion from the emptied and contrac-

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Note: This article has been presented as a lecture at the XVIth Annual meeting of the Mediterranean Association of Cardiology and Cardiovascular Surgery in Bodrum, Turkey, 25-27 September 2004.

ted uterus produce a further increase in CO. Most hemodynamic changes of pregnancy resolve by 2 weeks postpartum (2). The more recent use of Doppler cardiac output measurement techniques has greatly increased our understanding of the magnitude and timing of CO changes during pregnancy.

During pregnancy left ventricular mass increases by 52%. There is an increase in left ventricular end-diastolic and end-systolic diameters (12% and 20%, respectively), left ventricular posterior wall diameter during diastole and systole (22% and 13%, respectively) and left intraventricular septum during diastole and systole (15% and 19%, respectively) (4) . The natural volume overload in pregnancy besides leading to a reversible 'physiological' left ventricular hypertrophy results as a short-term decrease in systolic function and a significant change in left ventricular diastolic function. Left ventricular diastolic function increases in the first two trimesters but declines in the third trimester with a decrease in acceleration, consistent with an increase in ventricular compliance. Mitral valve A-wave maximum velocity increases during pregnancy by 19%, while mitral valve E-wave maximum velocity and the ratio of E-wave/A-wave velocities increases early in pregnancy by about 14% and 6% respectively, with a subsequent decline to 4% and 10%, respectively, below non-pregnant levels (4). Changes in heart rate, preload, and contractility as well as stage of pregnancy influence this alteration (6). While left ventricular systolic function is normal in all patients one week after childbirth, left ventricular hypertrophy and left ventricular diastolic dysfunction persist for nearly two months (7).

Besides evaluating physiological alterations echocardiography provides information about disease etiology, accurate and noninvasive assessment of severity and means of monitoring progression. Women with congenital heart disease now comprise the majority of pregnant women (2). The next largest group includes women with rheumatic heart disease. With the exception of patients with Eisenmenger syndrome, severe surgical noncorrected cyanotic disease, severe pulmonary artery hypertension, pulmonary vascular obstructive disease and Marfan syndrome with aortopathy, maternal death during pregnancy in women with heart disease is rare. However, pregnant women with heart disease do remain at risk for other complications including heart failure, arrhythmia and stroke (2). Doppler echocardiographic measurement of pulmonary pressures allows identification of women with pulmonary hypertension, quantitation of disease severity and evaluation of the respond to therapy with nifedipine or nitric oxide. The major limitation of Doppler data in this setting is that only pressures not vascular resistance can be assessed.

In Eisenmenger syndrome there may not be a tricuspid regurgitant jet so the presence of pulmonary hypertension must then be inferred from the findings of a large nonrestrictive intracardiac communication, a short time to peak velocity in the pulmonary artery, midsystolic notching on the pulmonic valve M Mode and the pattern of ventricular septal motion (8). There are conflicting reports about the estimation of pulmonary artery pressures (PAP) by echocardiography. Echocardiography was found to significantly overestimate PAPs compared with catheterization in pregnant patients with suspected pulmonary hypertension. Patients with structural cardiac defects appear to have a significantly greater difference in PAPs . Thirty-two percent of pregnant patients with normal PAPs may be misclassified as having pulmonary artery hypertension when measured by echocardiography alone as has been reported by Penning et al. (9), which should be kept in mind while using Doppler. Tetralogy of Fallot is the most common form of cyanotic congenital heart disease. In uncorrected or palliated pregnant patients with cyanotic congenital heart disease the usual pregnancy associated fall in systemic vascular resistance and rise in CO exacerbate right to left shunting leading to increased maternal hypoxemia and cyanosis. Cyanotic congenital heart defects reported a high rate of maternal cardiac events (%32), prematurity (%37) and a low live birth rate (%43). The lowest live birth rate (%12) was observed in those mothers with PaO2<85. Factors that predict a poor outcome include functional status before pregnancy, arterial oxygen saturation and blood hemoglobin. Maternal outcome is also strongly related to the degree of right ventricular pressure overload (2) which can be estimated by echocardiography. Patients with Marfan syndrome and aortic root dilatation are at risk for aortic dissection and are difficult to manage. Thus serial echocardiography should be used to identify progressive aortic root dilatation (2). Patients who have cardiac decompensation or aortic dilatation > 40 mm are advised to avoid pregnancy (10).

The secundum atrial septal defect (ASD II) is, after bicuspid aortic valve, the second most frequent congenital heart disease. In the majority of patients the course of pregnancy is uncomplicated, however, pregnancy-related cardiovascular changes may affect hemodynamic parameters of the defect An increase in the right ventricular and right atrial enlargement was found to be significantly greater in pregnant women with ASD II compared with healthy pregnant females. Also indirect parameters of the right ventricular strain (paradoxical systolic movement of the interventricular septum or tricuspid regurgitation) were more frequent in patients with ASD II rather than in controls. These alterations were accompanied by a significant decrease in the mean value of the Qp/Qs index which may suggest pregnancy-related favourable changes in the hemodynamic consequences of the defect - a decrease in the left-to-right shunt (11). Ventricular septal defect is also well tolerated except for an increased risk of endocarditis, and further evaluation of treatment is rarely needed. Pregnancy does not significantly alter the echocardiography findings. In patent ductus arteriosus (PDA) diastolic flow reversal in the pulmonary artery is seen with both color flow imaging and pulsed wave Doppler. Left atrial or left ventricular (LV) enlargement in excess of the expected changes of pregnancy or of diastolic flow reversal in the descending thoracic aorta should prompt evaluation of PDA (8).

The effect of increase in CO on the volume loaded right ventricle (ASD) or LV (VSD; PDA) is counterbalanced by the decrease in peripheral vascular resistance, making the evaluation of the shunt ratio problematic in borderline cases. However in the absence of pulmonary hypertension, pregnancy, labour and delivery are well tolerated; not necessitating accurate definition of the shunt ratio during pregnancy. Contrast echocardiography is not needed and should be avoided for detection of the interatrial shunt in pregnant women (8).

Stroke during pregnancy and puerperium is a severe complication that causes high morbidity and mortality. Infrequently, particularly in ASD, paradoxical embolisation may be encountered if systemic vasodilation and/or elevation of pulmonary resis-

tance promote transient right to left shunting (2). To prevent recurrent cerebral embolism during pregnancy, delivery, and puerperium, interventional closure of the patent foramen ovale can be performed without fluoroscopy under echocardiographic guidance (12).

There is an increase in the incidence of congenital heart disease among the offsprings of affected parents. Fetal echocardiography, in combination with a multidisciplinary postnatal approach, can be used in the successful treatment of severe forms of congenital heart disease

Doppler and qualitative color Doppler are useful to illuminate the pathophysiology of the hemodynamic consequences of fixed valve stenosis during pregnancy with respect to the labile nature of gradients resulting from variable loading conditions of pregnancy.

Mitral stenosis (MS) is the most common rheumatic valvular lesion encountered during pregnancy (2).

Although the hypervolemia and tachycardia may exacerbate mitral valve obstruction, echocardiographic measurement of mitral stenosis severity including 2D valve area, Doppler gradients and pressure half time valve area, remain valid in pregnancy allowing optimization of patient monitoring and therapy (8). Mean transvalvular gradient and PAP should be calculated during 3-5 months and thereafter with monthly follow-ups (13-14).

In some severe cases maternal or fetal complications may necessitate mechanical relief of stenosis severity preferably with balloon valvuloplasty which can safely be performed in the second trimester. Echocardiography is then valuable in assessing the likelihood of complications and the expected result of valvuloplasty. Transthoracic or transesophageal echocardiography (TEE) allows fluoroscopy time to be minimized (15). The mitral valve area (MVA), measured by the evaluation of the pressure half-time through an echo-Doppler-cardiogram, and the functional class before pregnancy, using the criteria of the New York Heart Association were found to be the most interesting predictor variables (16).

Operation should be reserved for those with symptoms refractory to medical treatment and low output syndrome and should be delayed till the fetus is mature and if possible sectio before MVR should be performed (17).

When aortic stenosis (AS) complicates pregnancy it is usually because of congenital bicuspid aortic valve. Women with symptomatic AS should delay pregnancy until after surgical correction. With severe AS, the limited ability to augment CO may result in abnormal elevation of LV systolic and filling pressures which in turn precipitate or exacerbate heart failure or ischemia. In addition the noncompliant, hypertrophied ventricle is sensitive to falls in preload (2). As stroke volume increases across the stenotic valve with pregnancy, an increase in the pressure gradient measured by Doppler echocardiography is seen. However calculation of valve area with the continuity equation still provides accurate assessment of stenosis severity.

The role of echocardiography in AS is to accurately delineate disease severity so that monitoring and therapy during pregnancy and in the peripartum period can be optimized (8).

Most pregnant women can be managed medically but balloon aortic valvuloplasty or valve replacement during pregnancy has been required in rare cases. Pulmonary autograft aortic valve replacement (AVR) (Ross procedure) reported favorable outcomes (18).

Doppler echocardiography was used as a pre-pregnancy predictor of outcome in women with moderate-to-severe aortic stenosis. The patient's hemodynamic measurements during exercise before conception closely approximated those of the hemodynamic burden placed on her heart during pregnancy (19).

Pregnancies with asymptomatic regurgitant lesions are better tolerated. Pregnancy may result in a decrease in regurgitant severity due to afterload reduction of decreased systemic vascular resistance but this effect may be counterbalanced by the hormonal and vascular changes of pregnancy. In patients with severe regurgitation, decreased systemic vascular resistance due to pregnancy can result in an apparent decrease in regurgitant severity and improvement in LV systolic function. In these patients surgery may be inappropriately delayed. Quantitation of regurgitant jet may be misleading but when decompensation occurs echocardiography can differentiate whether increased CO demands of pregnancy or worsening of the underlying valvular abnormality is the underlying reason (8). Repair of the valve should be preferred in those patients with severe cardiac insufficiency and aortic or mitral valve regurgitation.

Doppler evaluation of velocities, pressure gradients and thus pressure half time method across prosthetic valves is also influenced by alterations in loading conditions and increased heart rate and stroke volume so the volume flow rate should be taken into consideration when evaluating a prosthetic valve in pregnant women. Due to accelerated valve deterioration during pregnancy the use of bioprostheses in women who need valvular heart surgery before pregnancy necessitate later valve replacement again and perhaps an autograft or homograft can be an alternate approach (8-20). Key factors influencing successful course of pregnancy and labour in patients with prosthetic valves are: adequate left ventricular function, properly functioning valves and effective anticoagulation (21).

Endocarditis prophylaxis is initiated at onset of active labor when indicated. AHA states that delivery by sectio and vaginal delivery in the absence of infection do not require endocardirtis prophylaxis, except perhaps in patients at high risk (2).

When a pregnant woman with mechanical heart valve requires anticoagulation, heparin and warfarin are used but controversy continues as to which is better at different stages of pregnancy. Oral anticoagulation with warfarin is better accepted by patients and is effective. However warfarin embryopathy may be produced during organogenesis and fetal intracranial bleeding can occur throughout pregnancy. A daily warfarin dose of <5 mg was associated with no cases of embryopathy. Fetal intracranial hemorrhage during vaginal delivery is a risk with warfarin unless it has been stopped at least 2 weeks before labor. Recent practice guidelines have favored use of warfarin and low dose aspirin either during the entire pregnancy or substituted by heparin only during the peak teratogenic period (6-12th week of gestaton) (2).

Echocardiography can also be used to evaluate the source of embolism, which can frequently be encountered during pregnancy. Timely placement of TEE has been reported to reveal catastrophic pulmonary vasoconstriction as the cause of circulatory collapse in a patient with amniotic fluid embolism (22). Detection of a massive pulmonary embolism and thrombi in the right and left atria has also been reported (23).

One of the other applications of echocardiography is the evaluation of changes due to hypertension during pregnancy. Pregnancy induced hypertension is defined as an increase in systolic blood pressure (SBP) from baseline>30 mmHg, a diastolic blood pressure (DBP) increase>15 mmHg, SBP>140 mmHg or DBP>90 mmHg. Preeclampsia is defined as hypertension after the 20th week of pregnancy and proteinuria > 300 mg per 24 hrs (8).

Gestational hypertension (GH), which is noted in some pregnancies during the third trimester and being considered a temporary condition and essential hypertension (EH) induce similar early altered diastolic filling of the left ventricle. In one recent report left atrial function was found to be similar in GH and normal subjects (N) and lower than that in EH patients. Both GH and EH patients had early left ventricular diastolic filling pattern significantly different as compared to normal subjects (longer isovolumetric relaxation time, deceleration time of the E wave, and lower E wave velocity in GH and EH vs. N), whereas the late filling properties were similar in GH and normal subjects with a lower A velocity, and velocity-time integral vs. EH. Systolic fraction of the pulmonary vein flow was similar in GH and EH patients and lower in normal subjects. Altered left ventricular geometry was more common in GH than in EH, whereas normotensive subjects did not show any alteration of the geometric pattern in this report. Gestational hypertension was found to be characterized by altered left ventricular geometry, which was far less common during essential hypertension (24).

In preeclampsia the concept of a hyperdynamic disease model with a subsequent hemodynamic crossover to low CO and high resistance circulation coinciding with the onset of the clinical syndrome has been reported. Women with gestational hypertension had no such hemodynamic crossovers and maintained hyperdynamic circulation throughout pregnancy (25). So, on the basis of these hemodynamic subsets, appropriate medical therapy can be chosen after Doppler CO measurements and calculation of systemic vascular resistance in patients with pregnancy-induced hypertension and preeclampsia (8).

In patients with hypertrophic cardiomyopathy maternal mortality is increased compared with the general population. However, absolute maternal mortality is low and appears to be principally confined to women at a particularly high risk (26). No echocardiographic or clinical feature is a useful indicator of pregnancy related complications. However, rare complications can occur and therefore planned delivery and fetal monitoring are still required for some patients (27).

Peripartum cardiomyopathy (PPCM) is a rare cardiac complication and diagnosis includes clinical (development of cardiac failure in the last month of pregnancy or within 5 months after delivery, absence of an identifiable cause of cardiac failure and absence of recognizable heart disease prior to the last month of pregnancy) and echographic (left ventricular systolic dysfunction) criteria (28-29). Clinically, PPCM shows pulmonary symptoms such as dyspnea, tachypnea and coughing. It is possible to misdiagnose PPCM for pulmonary embolism (PE). As massive PE is the leading cause of maternal death, it is the most feared diagnosis and PPCM can easily be forgotten. However, distinguishing between the two is vital for the patient as management of PPCM is quite different from that of PE. Echocardiography is a valuable tool in the differential diagnosis (30). Echocardiography can also provide prognostic information in PPCM as patients who deteriorate have higher LV end- diastolic diameters as compared to those who improve. It remains unclear whether pregnancy is safe in those with recovery of systolic function. Dobutamine stress echocardiography may have a role in evaluating contractile reserve in women with recovered systolic function who are contemplating further pregnancies, but there are as yet insufficient data to confirm the validity of this approach (2-31).

Hydropericardium is the most frequent form of pericardial involvement in pregnancy. Small amounts of fetal pericardial fluid (< 2 mm in echocardiography, in diastole) can be detected after 20 weeks of gestation. Larger effusions should raise clinical concern for hydrops fetalis, Rh disease, hypoalbuminemia, and infectious or autoimmune disorder. Pericardiocentesis should be performed only for very large effusions causing clinical signs of cardiac tamponade or if presence of suppurative, tuberculous or neoplastic pericardial effusion is suspected. Echocardiographic guidance of pericardiocentesis is preferred to fluoroscopic guidance in order to avoid fetal X-ray exposure (32).

The treatment of the pregnant patient with cardiac arrhythmias requires important modifications of the standard practice of arrhythmia management (2). Electrical cardioversion is safe in pregnancy (33) and implantable cardoverter defibrillators reported favorable maternal and fetal outcomes (34). Echocardiographic monitoring has a role during electrophysiological testing and pacemaker implantation by transesophageal echocardiographic guidance (35) can safely be performed when necessary.

As has been explained echocardiography can be used in pregnant women to illuminate many underlying pathologies. But 2 questions will arise.

The first is about the safety of echocardiography.

As very well known, diagnostic ultrasound has been used for many years with a remarkable history of safety during the standard clinical practice. Introduction of color and pulsed Doppler modes resulted with higher levels of transmitted and absorbed ultrasonic energy which raised the question for the safety of its use in early pregnancy. Potential bioeffects of ultrasound energy can be categorized as thermal, or relating to increase in temperature in the region of insonation, or mechanical, relating primarily to cavitation. However one of the advantages of echocardiographic monitoring during pregnancy is the avoidance of exposure to ionizing radiation. Although there are no strictly defined limits established for the use of Doppler ultrasound in the early pregnancy there is an unequivocal demand for carefulness that is best expressed by the ALARA principle,-as low as reasonably achievable (36).

And the second question is about whether all pregnant women should undergo echocardiographic evaluation. The answer to this question is no. As expected the physiologic adaptation in pregnancy may result in flow murmurs, which are very common in pregnants and do not need echocardiographic exam. However murmurs with >3/6 grade, which also radiate to different locations over the chest do need further evaluation. Also those patients with cardiovascular symptoms of congestive heart failure and those with known preexisting heart disease require further echocardiographic follow-ups.

Since, echocardiography is a safe and noninvasive test (37) echocardiographic evaluation will probably remain for long time as a cornerstone in diagnosis, assessment of disease severity and patient monitoring in pregnant women who strongly wish to become a mother.

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