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Impedance cardiography in evaluation of hemodynamic status of preeclampsia - two case reports

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ABSTRACT

Preeclampsia is a severe disorder that can complicate pregnancy with serious consequences for mother and newborn. Although a specific hemodynamics profile can be observed during normal pregnancy, preeclampsia ischaracterized by several specific changes like increased cardiac output, sodium and water retention leading to blood volume expansion, reductions in systemic vascular resistance and systemic blood pressure. Impedance cardiography is a noninvasive method which can provide hemodynamic parameters in pregnancy. We present two cases of pregnancy complicated with preeclampsia and the hemodynamic particularities each of them has. The first one includes a patient with early onset of preeclampsia. She was monitored with impedance cardiography. We observed thatheather index decreased in the second trimester of pregnancy. The second case is focused on recurrent preeclampsia. The hemodynamic profile determined by impedance cardiography showed increased systemic vascular resistance beginningin the second trimester of pregnancy until delivery. Impedance cardiography is a noninvasive method, but its' accuracy in monitoring patients with high risk of preeclampsia should be proved with randomized control trials.

Key words: preeclampsia, impedance cardiography, haemodynamics

INTRODUCTION

Normal pregnancy is characterized by important hemodynamic changes, such as blood volume expansion, sodium and water retention, increased cardiac output, reduced systemic blood pressure and decreased systemic vascular resistance. Hemodynamic changes begin early during pregnancy, reachtheir maximum in the second trimester and remain constant until delivery (1). In

normal pregnancy cardiac output rises by 30 to 50 percent (1.8 L/min) mainly after 8 weeks of gestation (2). In the supine position a supplemental decrease in cardiac output by as much as 25 to 30 percent is observed due to compression of inferior vena cava by the gravid uterus and decrease of venous return to the heart (3).

Increased cardiac output in early pregnancy is related to an increase in stroke volume and to heart rate during late pregnancy. Ejection fraction is similar in pregnant and nonpregnant women even if the effect of pregnancy on the left ventricle contractility remains controversial. In some cases, the increased cardiac output can reveal asymptomatic heart disease that decompensate during the latter half of pregnancy (4).

Preeclampsia is a multisystemic disorder that occurs after the 20th week of pregnancy in women free of any type of kidney disease or prior vascular condition and is characterized by hypertension (systolic blood pressure values ≥ 140 mmHg and diastolic blood pressure ≥ 90 mmHg) and proteinuria. Complications of preeclampsia include renal dysfunction, thrombocytopenia and / or the existence of microangiopathic haemolytic anemia, epigastric pain and major complications include hepatic dysfunction syndrome HELLP (Hemolysis, Elevated Liver enzymes, Low Platelets), brain and / or visual disorders and seizures (5).

Impedance cardiography (ICG) represents a non-invasive method to evaluate hemodynamics by observing the differences in impedance across the thorax. This technique can measure stroke volume, cardiac output, systemic vascular resistance, heather index and basal impedance (6,7).

Impedance cardiography is based on Ohm's law: R=V/I, where R is resistance (Ohm), V is Voltage (volt) and I is current (Ampere). Resistance in an alternative current is called impedance (Z). For the human body this law is applied to the parallel electrical conductor model. The principle is that the impedance of thoracic tissue is parallel to that of blood. The measurements are made by placing spot electrodes on the patient chest and the results are obtained in few seconds as numeric and ICG waves (8).

CASE REPORTS

Case 1

We report the case of a patient of 30 years old Caucasian woman, I G (I gravida) with no relevant medical history. During her first prenatal visit (in the 7th week of pregnancy) her body mass index was 25.7 kg/m^2 and blood pressure was 110/60 mmHg. As standard of care, she was monitored during the first and the second trimester of pregnancy using impedance cardiography. In the first trimester, the hemodynamics' parameters were: stroke volume86 ml, cardiac output 7l/min, systemic vascular resistance 926 dyne.sec.cm^{-5}, heather index 22 Ohm/sec^2 and basal impedance 44 Ohm. In the second trimester of pregnancy the hemodynamic profile was: stroke volume 67 ml, cardiac output 6,3 l/min, systemic vascular resistance1267dyne.sec.cm^{-5}, heather index 5 Ohm/sec^2 and basal impedance 35.4 Ohm.

During the 25th week of pregnancy she was admitted for epigastric pain, severe headache, scotoma and blood pressure value was 180/90 mm Hg.The laboratory findings showed: thrombocytopenia (89,000/uL) and serum creatinine concentration (1.3 mg/dL). The diagnosis was severe preeclampsia and the patient received 60 mg Labetatol and 6g Magnezium Sulfate. Emergency caesarian section was performed for uncontrolled high blood pressure. The therapy continued with 20 mg Nifedipine. The maternal outcome was uneventful, but the newborn died 4 days after birth. In this case we observed that the patient developed early onset preeclampsia. She had no risk factor and the majority hemodynamics parameters were within normal limits, except heather index that decreased in the second trimester of pregnancy.

Case 2

In the second case we report a 32-year-old caucasian women with adequate prenatal care from the first trimester of pregnancy. Her medical history included: no abortion, one previous caesarian section for severe preeclampsia in the 38th week of pregnancy. She was non-smoker, with a body mass index of 27.3 kg/m^2 during the first trimester and blood pressure within normal limits (110/60 - 100/55 mmHg). She was monitored by impedance cardiography in each trimester and the hemodynamic parameters were within normal values (stoke volume, heart rate, cardiac output, basal impedance, heather index). The systemic vascular resistance increased from 1206 dyne.sec.cm^{-5} in the first trimester of pregnancy to 2265 dyne.sec.cm^{-5} in the third trimester. Using Doppler ultrasound we identified normal velocity in umbilical artery and mean cerebralartery. The systemic vascular resistance registered values about 2265-2274 dyne.sec.cm^{-5} until delivery. The patient was admitted with 38 weeks of gestation pregnancy for severe vaginal bleeding, headache and epigastric pain. Her blood pressure was 200/110 mmHg. Emergency caesarean section was performed for preeclampsia and placental abruption

with favorable outcome for both mother and newborn. The issue is if in this case the increased systemic vascular resistance is the result of the first pregnancy complicated with preeclampsia or anticipation of preeclampsia in the current pregnancy

DISCUSSIONS

Hemodynamic changes that occur during pregnancy return gradually to baseline at term, but they are still slight different compared to non-pregnancy values. It is believed that this persistence has an important role in reducing the cardiovascular risk in later life (9). The arterial pressure decreses, during the first trimester of pregnancy, augments during the next trimester and returns to normal after birth. However, there were no correlations between the mean arterial pressure and the possibility to develop preeclampsia or eclampsia during pregancy (10,11). The thoracic fluid content at the end of the second trimester has significantly lower values than postpartum (12).

During normal pregnancies, the major cardiovascular adaptative changes are secondary to estrogen effects on the renin-angiotensin-aldosterone system and involve an increase in sodium and water retention that leads to fluid overload and increased cardiac output. The plasma volume expands starting from the 6^{th} week of pregnancy and reaches a peak between the 30^{th} and 34^{th} week. At term, volemia is up to 1100-1600 ml above the normal values. Other modified hemodynamic parameters during pregnancy include: cardiac output, whose increase is significant from the 5^{th} week, heart rate and left ventricular performance, which expand during the first and second trimesters, in order to facilitate the venous return.

Most cases of preeclampsia involve multiparous women in association with one of the following factors: the change in current paternity, large range of tasks, age, and history of preeclampsia, especially in the second trimester. Among the predisposing factors for preeclampsia are gestational diabetes, chronic hypertension, body mass index ≥ 26.1 kg/m^2, chronic renal disease and antiphospholipidic syndrome (14,15)

Recent studies that monitored multiparous with prior eclampsia during their first pregnancy demonstrated an increased recurrence risk of preeclampsia especially for the subset of women whose disorder occurred before the 30^{th} week of gestation. In addition, those with a history of severe preeclampsia/eclampsia present a higher risk of obstetrical complications in subsequent pregnancies, such as: abruption placentae, premature delivery, intrauterine growth restriction or perinatal mortality (16). Our second case involved a multiparous patient with a first pregnancy complicated by preeclampsia andrecurrence in the second pregnancy.

The diagnosis of preeclampsia may be inadequate in women who suffer from cardiovascular or renal disorders. Rigorous monitoring and paraclinical investigations have a decisive role in order to prevent an error. Mild cases of preeclampsia require weekly laboratory tests to supervise the development of the disease. Severe cases are associated with elevated bilirubin, decreased values of serum haptoglobin, thrombocitopenia (<100.000/mm^3), elevated serum creatinin concentration (>1.1 mg/dl) and increased values of hepatic enzymes (double versus normal) (17,18). Moreover, laboratory tests used in recent studies include impedance cardiography in the evaluation of gestational hypertension, preeclampsia and treatment evaluation (19). That is why we chose this method to evaluate the hemodynamic profile for patients with preeclampsia.

The results of another study confirm that cardiac and arterial function are different between gestational hypertensive diseases and normal pregnancies, and that venous hemodynamic dysfunction in preeclampsia is more pronounced than in gestational hypertension (20). We observed that heather index was modified in the first case, with preeclampsia and systemic vascular resistance in the second one, but extensive study should be performed to certify to certify this as a recurrent pattern.

There are more than 40 years since the impedance technique was designed for measuring and monitoring the basic haemodynamic parameters in humans by means of impedance cardiography, also known as "impedance plethysmography of the chest", "electrical bioimpedance of the chest" or "reocardiography". The accuracy and repeatability of the results have been confirmed in comparative studies with results obtained through invasive methods and echocardiography (21). A recent study aimed to evaluate the agreement between measurements of cardiac index provided by a new-generation thoracic electrical bioimpedance device and an invasive approach based on thermodilution in humans. Cardiac index values yielded by impedance technique compares favorably with that obtained with thermodilution in cardiac patients (22).

We report two cases of preeclampsia and hemodynamics changes in this situations. We observed that impedance cardiogrphy offered important informations about systemic vascular resistance and heather index, but the limitation of our presentation is the reduced

number of cases. This hemodynamics parameters should be evaluated in extensive studies with pregnant patient and cardiovascular pathology such as pre-eclampsia.

CONCLUSION

Preeclampsia remains a challenging disorder of pregnancy, with both maternal and fetal consequences. At the same time, noninvasive methods should be available to evaluate and predict preeclampsia. Impedance cardiography must be evaluated in randomized control studies to prove or disprove its efficiency.

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