

ORIGINAL ARTICLE

Effect of Magnesium Sulfate on Doppler Parameters of Fetal Umbilical and Middle Cerebral Arteries in Women with Severe Preeclampsia

Nazanin Farshchian, Negin Rezavand¹, Saeed Mohammadi

Departments of Radiology and ¹Gynecology, Kermanshah University of Medical Sciences, Kermanshah, Iran

Address for correspondence:

Dr. Negin Rezavand,
Department of Gynecology, Imam Reza Hospital, Kermanshah, Iran.
E-mail: nrezavand@kums.ac.ir



Received : 26-09-2012

Accepted : 08-11-2012

Published : 31-12-2012

ABSTRACT

Objective: To assess the effect of injecting magnesium sulfate on Doppler parameters of fetal umbilical and middle cerebral arteries (MCA) in women with severe preeclampsia. **Materials and Methods:** A total of 21 patients with severe preeclampsia admitted to Imam Reza Hospital, Kermanshah (Iran), were evaluated. Before and after administration of magnesium sulfate, Doppler ultrasound scan was carried out to measure fetal middle cerebral artery and umbilical artery blood flow. Paired *t*-test was used for statistical analysis. **Results:** After injection of magnesium sulfate, the mean resistivity index (RI)-umbilical, and pulsatility index (PI)-cerebral showed a statistically significant reduction ($P < 0.001$). The cerebroumbilical C/U ratio increased after the intervention ($P < 0.001$). The PI-umbilical ($P = 0.1$) and pre- and post-RI-cerebral ($P = 0.96$) did not have statistically significant changes. **Conclusions:** Infusion of magnesium sulfate significantly decreases the flow in the fetus RI-umbilical and PI-MCA, and it increases C/U ratio indices in color Doppler ultrasound.

Key words: Doppler ultrasound, eclampsia, magnesium sulfate, preeclampsia

INTRODUCTION

Preeclampsia is defined as increase in systolic blood pressure ≥ 140 mmHg or diastolic ≥ 90 mmHg and

proteinuria ≥ 300 mg protein/24 hours urine and starts after 20 weeks of pregnancy. Eclampsia is the condition in which generalized seizure occur in the absence of other neurologic defects.^[1]

Preeclampsia and eclampsia are among the common causes of death and disability in pregnant women and are associated with increased vascular resistance and decreased uteroplacental perfusion.^[2] It is characterized by vascular contraction, lesions in the placenta and umbilical arteries, high blood pressure, proteinuria, and seizure.

Access this article online

Quick Response Code:



Website:

www.clinicalimagingscience.org

DOI:

10.4103/2156-7514.105269

Copyright: © 2012 Farshchian N. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

This article may be cited as:

Farshchian N, Rezavand N, Mohammadi S. Effect of Magnesium Sulfate on Doppler Parameters of Fetal Umbilical and Middle Cerebral Arteries in Women with Severe Preeclampsia. J Clin Imaging Sci 2012;2:85. Available FREE in open access from: <http://www.clinicalimagingscience.org/text.asp?2012/2/1/85/105269>

This disease can cause many fetal and maternal complications. Maternal complications include acute renal failure, liver damage, intracerebral hemorrhage, pulmonary edema, and death. Fetus complications are preterm birth or intrauterine growth restriction.^[3-5]

Magnesium sulfate ($MgSO_4$) is used for the treatment of severe preeclampsia and can help prevent serious complications.^[6,7] Effect of $MgSO_4$ on cerebral vessels are still controversial and it is unclear whether it reduces cerebrovascular vasospasm. Studies in this area are still ongoing.^[8-11] The mechanism of action may include changes in vascular permeability and reduction of edema.^[6] It seems to have no adverse effects on the fetus,^[12] but in response to $MgSO_4$ injection, fetal brain perfusion may also alter.^[13]

In pregnancy, usually umbilical artery is tested by Doppler ultrasound but some recent studies also test maternal and fetal middle cerebral arteries (MCA).^[14-17] In one study, the reference value of resistive index (RI) and pulsatility index (PI) have been investigated in Iranian patients.^[16] The ratio of middle cerebral artery/umbilical artery (C/U ratio) can be a good indicator of fetal prognosis and fetal well-being.^[16-20]

Doppler ultrasound is a useful tool for studying pathophysiological mechanisms that can affect the fetal hemodynamic status.^[19,21,22] Assessing the changes in the arteries with Doppler ultrasound can show the adaptation of fetus to the situation.^[17,23] An increase in umbilical artery resistance shows as a decrease in perfusion. If the situation continues, RI in the middle cerebral artery will decrease.^[24] Investigating the mechanism of action of $MgSO_4$ on the fetus is one of the important issues in this disease.^[25] The purpose of this study is to evaluate the effect of $MgSO_4$ in severe preeclampsia on fetal middle cerebral artery and umbilical artery using Doppler parameters.

MATERIALS AND METHODS

This is a quasi-experimental study (before-after). This study was approved by the ethics committee of Kermanshah University of Medical Sciences. Patients who needed injections of $MgSO_4$ were included in the study. $MgSO_4$ injection was administered under the supervision of a gynecologist. Prior to the intervention, Doppler ultrasound was used to evaluate the fetal middle cerebral and umbilical arteries of the patients.

Patients with severe preeclampsia who attended Imam Reza hospital, Kermanshah Iran during the period 2011-2012 were included in the study. Inclusion criteria were: Age in the range of 20-35 years, first pregnancy, gestational age above 28 weeks, systolic blood pressure ≥ 140 mmHg, and

diastolic pressure ≥ 90 mmHg with the proteinuria of at least 300 mg in 24 hour urine or having urinary protein level $\geq +2$, and epigastric pain. Exclusion criteria were: Any type of systemic disease (e.g., diabetes, hypertension, and autoimmune disorders), history of taking opium, smoking, twin pregnancy, and history of taking specific drugs.

During the study period 21 patients were evaluated. The goal of the study and the method were described to all patients and written consent form was taken prior to the initiation of study.

After admission of the patient in a room that had cardiopulmonary resuscitation (CPR) facilities, a radiologist recorded the color Doppler ultrasound of fetal umbilical and MCA, using a Siemens Ultrasound device (Germany), model G40, with a deep probe of 3/5-5 MHz. The mean RI and PI of MCA from the proximal part of two MCA arteries (left and right) and the C/U ratio (middle cerebral artery RI/umbilical artery RI) were evaluated. Parameters related to the umbilical artery close to the navel were evaluated.

RI = Peak systolic velocity - end diastolic velocity/peak systolic velocity

PI = Peak systolic velocity - end diastolic velocity/mean velocity

After initial assessment, a gynecologist injected the primary and maintenance dose of $MgSO_4$. The primary dose had 14 g of $MgSO_4$ of which 4 g in the form of a 20% solution was injected intravenously for at least 4 min and then immediately 10 g of $MgSO_4$ in the form of 50% solution was injected muscularly. Twenty minutes after intravenous injection (4 g), Doppler ultrasound was again performed to measure blood flow in fetal MCA and umbilical arteries.

Data were analyzed using SPSS version 11.5 software (SPSS Inc., Chicago, IL, USA). Kolmogorov-Smirnov test was used to prove the normal distribution of variables and all variables had normal distribution. Then the before and after intervention values were compared by Paired *t*-test. A level of 0.05 was considered significant.

RESULTS

In the 21 patients studied, average RI-umbilical before and after the intervention were 0.72 (± 0.1) and 0.62 (± 0.09), respectively, which showed a statistically significant decrease ($P < 0.001$). The before and after PI-umbilical values were 1.35 (± 0.47) and 1.28 (± 0.49), respectively, which was not a significant change ($P = 0.1$). In addition, the average before and after RI-MCA were 0.71 (± 0.16) and 0.71 (± 0.11), respectively, and this particular index

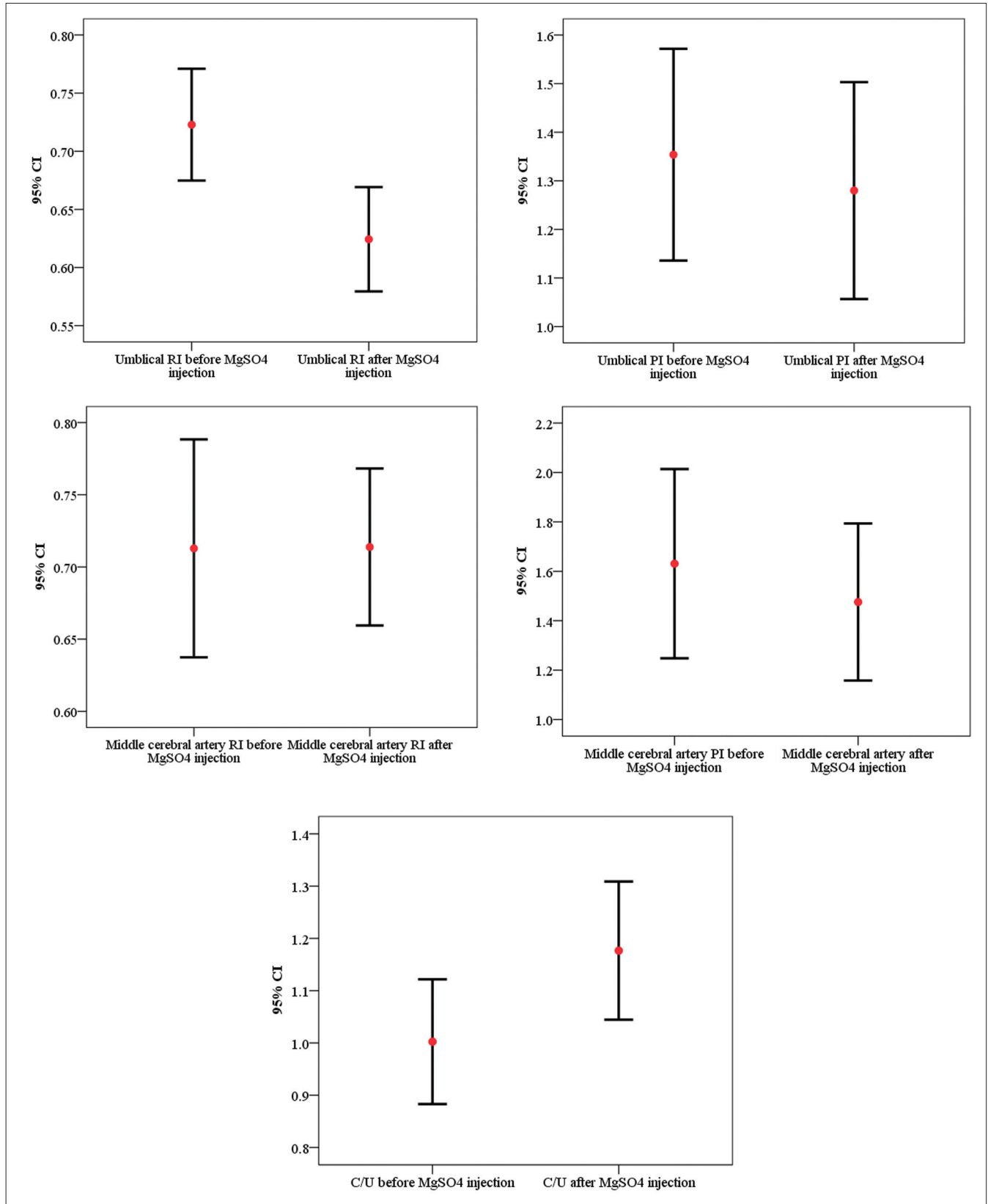


Figure 1: Comparison of resistivity index (RI) and pulsatility index (PI) of umbilical and middle cerebral artery and C/U ratio before and after 20 min of administering magnesium sulfate (MgSO₄) injection.

did not show any significant change ($P = 0.96$). But, a statistically significant decrease ($P = 0.001$) was observed in the average amount of before PI-MCA 1.63 (± 0.84) and the after value 1.47 (± 0.69). According to calculations, the before C/U ratio value was 1 (± 0.26) and the after value was 1.17 (± 0.29), which showed a statistically significant increase ($P < 0.001$) [Figure 1]. The power of the test to compare before and after PI-umbilical values was calculated as 61.6% and 33.3% for RI-MCA.

DISCUSSION

This study investigated the effect of administration of $MgSO_4$ in severe preeclampsia cases on fetal umbilical and MCA blood flow. Based on the results of this study, the injection of $MgSO_4$ could significantly decrease the RI-umbilical, PI-MCA, and increase C/U ratio.

Fetal distress caused by hypoxia is one of the effects of preeclampsia on the fetus. Probably, circulation disorder is the most important cause of hypoxia and distress.^[26] Inadequate placental perfusion can cause fetal reduction of oxygen supply, and thus lead to fetal distress.^[21,27]

Several studies have shown the medical effects of $MgSO_4$ in treating patients with preeclampsia and eclampsia.^[28,29] Souza et al,^[30,31] assessed fetal MCA and umbilical artery Doppler parameters and measured these parameters 20 min after injection of $MgSO_4$. They showed that umbilical and MCA RI and PI values are significantly reduced. While in our study these parameters showed no significant change.

In addition, another study showed the reduction of PI in the fetal umbilical artery and MCA due to the injection of $MgSO_4$.^[30] In Dasgupta's study, when compared with control group, the umbilical artery PI value decreased, but the fetal MCA-PI did not change significantly.^[32] In another study, the MCA did not change.^[33] The impaired perfusion in fetal MCA can be associated with hypoxia and fetal complications.^[24,34]

In our study, after injection of $MgSO_4$, C/U ratio had a significant increase, which shows that the fetal blood supply had improved. Various studies confirmed the efficacy of Doppler ultrasound examination for assessing the vascular status of the fetus and have introduced the C/U ratio as a parameter in assessing fetal blood supply.^[35] The C/U ratio shows both inadequate fetal circulation and changes and adaptations in the artery.^[17] Hence, this drug ($MgSO_4$) can cause vasodilatation in the fetal umbilical artery.^[36] Some studies did not show the same result.^[30,31] The fetal MCA resistance increases in normal pregnancy slightly^[21] and the increase is more substantial in preeclampsia and eclampsia. The administration of $MgSO_4$, therefore, can have beneficial effects on the fetus and can increase perfusion. C/U ratio

is a good indicator for assessing the growth and prognosis of the fetus, while the fetal MCA alone does not have the same value.^[37,38]

This study also had certain limitations. One of the limitations of this study was the lack of a control group. However, due to the special status of patients with severe preeclampsia, there are inevitable limitations in the design of this study and similar studies. The small sample size was another limitation, which reduced the test power of PI-umbilical and RI-MCA to less than 80%. The lack of significant statistical differences in these two indicators might result from the small sample size of patients. Results of our study and studies of others indicate more extensive studies with larger patient numbers are required to be conducted and if possible a meta-analysis of the results of all existing studies to confirm conclusions about the effects of $MgSO_4$ on fetal blood flow is also essential.

CONCLUSIONS

Infusion of $MgSO_4$ significantly decreases the fetal RI-umbilical and PI-MCA and increases C/U ratio indices obtained with color Doppler ultrasound evaluations.

ACKNOWLEDGEMENT

The authors sincerely thank the Head of Research in Kermanshah University of Medical Sciences, who approved and funded the study. This article is extracted from the thesis compiled by Dr. Saeed Mohammadi.

REFERENCES

1. American College of Obstetricians and Gynecologists. Hypertension in pregnancy. ACOG Technical Bulletin No. 219. Washington, DC: ACOG, 1996.
2. Organization WH. Geographic variation in the incidence of hypertension in pregnancy. WHO International collaborative study of hypertensive disorders of pregnancy. Am J Obstet Gynecol 1988;158:80-3.
3. Roberts JM, Lain KY. Recent insights into the pathogenesis of pre-eclampsia. Placenta 2002;23:359-372.
4. Sibai B, Dekker G, Kupferminc M. Pre-eclampsia. Lancet 2005;365:785-99.
5. Tuffnell DJ, Jankowicz D, Lindow SW, Lyons G, Mason GC, Russell IF, et al. Outcomes of severe pre-eclampsia/eclampsia in yorkshire 1999/2003. BJOG 2005;112:875-80.
6. Euser AG, Cipolla MJ. Magnesium sulfate for the treatment of eclampsia: A brief review. Stroke 2009;40:1169-75.
7. Witlin AG, Sibai BM. Magnesium sulfate therapy in preeclampsia and eclampsia. Obstet Gynecol 1998;92:883-9.
8. Euser AG, Bullinger L, Cipolla MJ. Magnesium sulphate treatment decreases blood-brain barrier permeability during acute hypertension in pregnant rats. Exp Physiol 2008;93:254-61.
9. Hatab MR, Zeeman GG, Twickler DM. The effect of magnesium sulfate on large cerebral artery blood flow in preeclampsia. J Matern Fetal Neonatal Med 2005;17:187-92.
10. Sherman R, Armory P, Moody P, Hope T, Mahajan RP. Effects of

- magnesium sulphate on cerebral haemodynamics in healthy volunteers: A transcranial Doppler study. *Br J Anaesth* 2003;91:273-5.
11. Idama TO, Lindow SW. Magnesium sulphate: A review of clinical pharmacology applied to obstetrics. *Br J Obstet Gynaecol* 1998;105:260-8.
 12. Altman D, Carroli G, Duley L, Farrell B, Moodley J, Neilson J, et al. Do women with pre-eclampsia, and their babies, benefit from magnesium sulphate? The Magpie Trial: A randomised placebo-controlled trial. *Lancet* 2002;359:1877-90.
 13. Reynolds JD, Chestnut DH, Dexter F, McGrath J, Penning DH. Magnesium sulfate adversely affects fetal lamb survival and blocks fetal cerebral blood flow response during maternal hemorrhage. *Anesth Analg* 1996;83:493-9.
 14. Gramellini D, Folli MC, Raboni S, Vadora E, Merialdi A. Cerebral-umbilical Doppler ratio as a predictor of adverse perinatal outcome. *Obstet Gynecol* 1992;79:416-20.
 15. Bahlmann F, Reinhard I, Krummenauer F, Neubert S, Macchiella D, Wellek S. Blood flow velocity waveforms of the fetal middle cerebral artery in a normal population: Reference values from 18 weeks to 42 weeks of gestation. *J Perinat Med* 2002;30:490-501.
 16. Tarzamni MK, Nezami N, Gatreh-Samani F, Vahedinia S, Tarzamni M. Doppler waveform indices of fetal middle cerebral artery in normal 20 to 40 weeks pregnancies. *Arch Iran Med* 2009;12:29-34.
 17. Ebrashy A, Azmy O, Ibrahim M, Waly M, Edris A. Middle cerebral/umbilical artery resistance index ratio as sensitive parameter for fetal well-being and neonatal outcome in patients with preeclampsia: Case-control study. *Croat Med J* 2005;46:821-5.
 18. Yalti S, Oral O, Gurbuz B, Ozden S, Atar F. Ratio of middle cerebral to umbilical artery blood velocity in preeclamptic and hypertensive women in the prediction of poor perinatal outcome. *Indian J Med Res* 2004;120:44-50.
 19. Rana MJ, Amanullah A, Farooq O. The role of umbilical artery doppler in detection and management of fetal growth retardation. *Biomedica* 2005;21:4-7.
 20. Kassanos D, Siristatidis C, Vitoratos N, Salamalekis E, Creatsas G. The clinical significance of Doppler findings in fetal middle cerebral artery during labor. *Eur J Obstet Gynecol Reprod Biol* 2003;109:45-50.
 21. Mihiu D, Diculescu D, Costin N, Mihiu CM, Blaga L, Ciortea R, et al. Applications of Doppler ultrasound during labor. *Med Ultrason* 2011;13:141-9.
 22. Baschat AA, Gembruch U. The cerebroplacental Doppler ratio revisited. *Ultrasound Obstet Gynecol* 2003;21:124-7.
 23. Divon MY. Umbilical artery Doppler velocimetry: Clinical utility in high-risk pregnancies. *Am J Obstet Gynecol* 1996;174:10-4.
 24. Vyas S, Nicolaides KH, Bower S, Campbell S. Middle cerebral artery flow velocity waveforms in fetal hypoxaemia. *Br J Obstet Gynaecol* 1990;97:797-803.
 25. Keeley MM, Wade RV, Laurent SL, Hamann VD. Alterations in maternal-fetal Doppler flow velocity waveforms in preterm labor patients undergoing magnesium sulfate tocolysis. *Obstet Gynecol* 1993;81:191-4.
 26. Cunningham FG, Lindheimer MD. Hypertension in pregnancy. *N Engl J Med* 1992;326:927-32.
 27. Dubiel M, Gudmundsson S, Gunnarsson G, Marsal K. Middle cerebral artery velocimetry as a predictor of hypoxemia in fetuses with increased resistance to blood flow in the umbilical artery. *Early Hum Dev* 1997;47:177-84.
 28. Moslemizadeh N, Yousefnejad K, Moghadam TG, Peyvandi S. Urinary protein assessment in preeclampsia: Which sample is more suitable? *Pak J Biol Sci* 2008;11:2584-8.
 29. Girard B, Beucher G, Muris C, Simonet T, Dreyfus M. Magnesium sulphate and severe preeclampsia: Its use in current practice. *J Gynecol Obstet Biol Reprod (Paris)* 2005;34:17-22.
 30. Souza AS, Amorim MM, Coelho IC, Lima MM, Noronha Neto C, Figueroa JN. Doppler of the umbilical and fetal middle cerebral arteries after magnesium sulfate in preeclampsia. *Rev Assoc Med Bras* 2008;54:232-7.
 31. Souza AS, Amorim MM, Coutinho IC, Lima MM, Noronha Neto C, Figueroa JN. Effect of the loading dose of magnesium sulfate (MgSO₄) on the parameters of Doppler flow velocity in the uterine, umbilical and middle cerebral arteries in severe preeclampsia. *Hypertens Pregnancy* 2010;29:123-34.
 32. Dasgupta S, Ghosh D, Seal SL, Kamilya G, Karmakar M, Saha D. Randomized controlled study comparing effect of magnesium sulfate with placebo on fetal umbilical artery and middle cerebral artery blood flow in mild preeclampsia at ≥ 34 weeks gestational age. *J Obstet Gynaecol Res* 2012;38:763-71.
 33. Twickler DM, McIntire DD, Alexander JM, Leveno KJ. Effects of magnesium sulfate on preterm fetal cerebral blood flow using Doppler analysis: A randomized controlled trial. *Obstet Gynecol* 2010;115:21-5.
 34. Katayama M, Yamamuro A, Ueda Y, Tamita K, Yamabe K, Ibuki M, et al. Coronary flow velocity pattern assessed noninvasively by transthoracic color Doppler echocardiography serves as a predictor of adverse cardiac events and left ventricular remodeling in patients with acute myocardial infarction. *J Am Soc Echocardiogr* 2006;19:335-40.
 35. Makhseed M, Jirous J, Ahmed MA, Viswanathan DL. Middle cerebral artery to umbilical artery resistance index ratio in the prediction of neonatal outcome. *Int J Gynaecol Obstet* 2000;71:119-25.
 36. Poranen AK, Nurmi H, Malminiemi K, Ekblad U. Vasoactive effects and placental transfer of nifedipine, celiprolol, and magnesium sulfate in the placenta perfused *in vitro*. *Hypertension in Pregnancy* 1998;17:93-102.
 37. Nanthakomom T, Somprasit C. The value of middle cerebral artery-umbilical artery pulsatility index ratio in prediction of severe fetal growth restriction. *Thammasat Medical Journal* 2010;10:264-70.
 38. Ozeren M, Dinc H, Ekmen U, Senekayli C, Aydemir V. Umbilical and middle cerebral artery Doppler indices in patients with preeclampsia. *Eur J Obstet Gynecol Reprod Biol* 1999;82:11-6.

Source of Support: Kermanshah University of Medical Sciences, **Conflict of Interest:** None declared.