

Magnesium Sulfate Effect on Fetal Umbilical Artery and Middle Cerebral Artery Doppler Indices in Women with Severe Preeclampsia and Eclampsia

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Abstract

Objective: To study MgSO₄ effect on fetal MCA and UA blood flow changes using Doppler ultrasound in cases of severe PET and eclampsia. **Materials and Methods:** A total of 40 patients with severe PET admitted to El-Shatby Maternity University Hospital, Alexandria (Egypt) were examined before and after administration of MgSO₄ using Doppler study to measure fetal MCA and UA blood flow changes. **Results:** After administration of MgSO₄, the mean RI of UA, PI of UA showed a statistically significant decrease ($P < 0.001$) also the systolic-diastolic ratio ($p = 0.001$). Mean resistivity index (RI) cerebral showed a statistically significant increasing ($P = 0.001$), pulsatility index (PI)-cerebral and the systolic-diastolic ratio showed a statistically significant increasing ($P < 0.001$). The C/U (cerebroumbilical) ratio increased after the treatment ($P < 0.001$). **Conclusions:** Infusion of MgSO₄ significantly decreases the fetal RI, PI, SDR umbilical and increases the fetal RI, PI, SDR MCA and increases cerebroumbilical ratio indices obtained by Doppler examinations.

Keywords

Doppler Ultrasound, Eclampsia, Magnesium Sulfate, Preeclampsia

1. Introduction

Preeclampsia is diagnosed when the systolic blood pressure is ≥ 140 mmHg or diastolic blood pressure is ≥ 90 mmHg associated proteinuria ≥ 300 mg in 24 hour urine and diagnosed 20 weeks of gestation and it is usually recognized as a systemic disorder resolving with delivery or soon thereafter [1].

PET and eclampsia are among the most important diseases of pregnancy causing maternal morbidity and mortality associated with high vascular resistance due to vascular spasm with impaired placental blood flow [2].

Preeclampsia complicates 3% - 5% of all pregnancies, but approximately 7% of those in nulliparas, it remains a major disease causing of maternal morbidity and mortality [3] [4] [5].

This disease can cause many fetal and maternal complications [6] [7] [8] [9].

MgSO₄ is the best drug used in treatment of severe PET and eclampsia and prevent maternal and fetal complications [10] [11]. Effect of MgSO₄ on the brain vascular blood flow is still unclear as it may reduce the vasospasm [12] [13] [14] [15].

The MgSO₄ changes vascular permeability and reduces the edema [10]. It seems to have no adverse effects on the fetus [16], but in response to MgSO₄ injection, fetal brain perfusion may be also altered [17].

Doppler ultrasound is the best mood to study the mechanisms by which PET affects the fetal circulation [18] [19]. Arterial changes evaluated with Doppler ultrasound can show how the fetus is hemodynamically adapted the changes in PET [20] [21].

Increase in UA PI is associated with decreased fetal perfusion. If the situation continues, MCA RI will decrease [22].

In PET, usually we measure the UA doppler changes but recent studies showed that measuring also MCA Doppler changes is adding more beneficial information about fetal wellbeing state [23] [24] [25]. With using the C/U ratio (cerebroumbilical ratio) is superior in detecting fetal circulation changes and so prognosis [25] [26] [27] [28]. MgSO₄ effect on the fetal adaptive changes in PET is one of the most important research issues [29].

Aim of the Work: To study MgSO₄ effect on fetal MCA and UA blood flow changes using Doppler ultrasound in cases of severe PET and eclampsia.

2. Material and Methods

In this study, all the participants were evaluated before and after MgSO₄ administration. This study was approved by the ethics committee of the Faculty of Medicine University of Alexandria.

Pregnant cases with sever PET and eclamptic fits who attended to El-Shatby Maternity University Hospital during the period between December 2019 and December 2020 were involved in the study. Inclusion criteria were: Age in the range of 18 - 40 years, Singleton pregnancy, Any gravidity or parity, Gestational age equal to or above 28 weeks, Systolic blood pressure \geq 160 mmHg or diastolic pressure \geq 110 mmHg on two occasion six hours or more apart on bed rest, Preeclampsia with new onset grand seizures [30], Spontaneous pregnancy and One or more of the following [30] [31] [32] [33]: (Proteinuria of 24 hour urine of at least 5 g of protein or 3+ or more on two random samples collected four or more hours apart, Sudden oliguria. Central nervous system disturbances, Pul-

monary edema or cyanosis, Epigastric or right upper quadrant pain, Liver dysfunction (increase serum levels of SGOT and SGPT), Thrombocytopenia $< 100,000/\text{cmm}$, Fetal growth restriction calculated by Hadlock formula [34]. Exclusion Criteria were: Cases with other systemic disease (e.g., diabetes, hypertension, and autoimmune disorders), multiple pregnancy, Fetuses with congenital anomaly, History of taking opium, smoking and twin pregnancy.

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, the following was done:

- 1) Complete history taking.
- 2) General and local examination.
- 3) Color Doppler ultrasound of fetal UA and MCA, the cerebro-umbilical ratio (middle cerebral artery resistance index/umbilical artery resistance index), pulsatility index (PI) and S/D ratio will were evaluated.
- 4) After initial assessment, the obstetrician gives the loading and maintenance dose of MgSO_4 . The loading dose has 4 g of MgSO_4 in 250 ml saline intravenously infusion for 20 min and then the maintenance dose which has 8 g MgSO_4 in 500 ml saline/8 hours.

Then again MCA and UA Doppler evaluation was done to evaluate blood flow changes.

Outcome

This result was compared with APGAR Score of the baby and the out-come of the mother.

3. Results

1) Umbilical artery Doppler indices

There were statistical significant differences between umbilical artery PI, RI and cerebroplacental ratio with administration of MgSO_4 ($p < 0.001$); as shown in **Table 1**.

2) Middle cerebral artery [MCA] Doppler indices

There were statistical significant differences between MCA them ($p < 0.001$); as shown in **Table 2**.

3) Relation between ultrasonographic assessment of amount of liquor and cerebro-placental ratio (C/U) before and after mgSO_4 administration

The Cerebro-placental ratio(C/U ratio) before and after mgSO_4 has statistical significant differences in both groups ($p = 0.009$) and ($p = 0.004$) with no statistical significant differences between both of them ($p = 0.211$); as shown in **Table 3**.

4) Relation between estimated fetal weight (gm) and cerebro-placental ratio (C/U) before and after mgSO_4 administration

There were 28 cases of normal fetal biometry and 12 case of intrauterine growth restriction. As shown in **Table 4**.

The Cerebro-placental ratio (C/U ratio) before and after mgSO_4 has statistical

Table 1. Comparison between umbilical artery ultrasonographic Doppler evaluation before and after MgSO₄ administration (n = 40).

Umbilical artery	Before	After	p
RI (resistance index)			
Min. - Max.	0.46 - 1.0	0.4 - 0.90	
Mean ± SD.	0.69 ± 0.15	0.63 ± 0.12	<0.001*
Median	0.66	0.62	
PI (pulsatility index)			
Min. - Max.	0.6 - 2.16	0.40 - 2.0	
Mean ± SD.	1.16 ± 0.43	1.05 ± 0.41	<0.001*
Median	1.08	1.0	
SDR (Systolic-diastolic ratio)			
Min. - Max.	0.7 - 7.80	0.8 - 6.33	
Mean ± SD.	3.30 ± 1.37	3.03 ± 1.11	< 0.001*
Median	2.90	2.69	

p: p value for Paired t-test or Wilcoxon signed ranks test for comparing between before and after; *: Statistically significant at $p \leq 0.05$.

Table 2. Comparison between middle cerebral artery ultrasonographic Doppler evaluation before and after MgSO₄ administration (n = 40).

Umbilical artery	Before	After	p
RI (resistance index)			
Min. - Max.	0.06 - 0.98	0.07 - 0.90	
Mean ± SD.	0.70 ± 0.15	0.75 ± 0.14	tp = 0.001*
Median	0.73	0.78	
PI (pulsatility index)			
Min. - Max.	0.1 - 2.60	0.14 - 2.70	
Mean ± SD.	1.35 ± 0.49	1.47 ± 0.46	Wxp < 0.001*
Median	1.29	1.44	
SDR (Systolic-diastolic ratio)			
Min. - Max.	0.80 - 10.60	1.0 - 11.0	
Mean ± SD.	4.0 ± 1.86	4.31 ± 1.83	Wxp < 0.001*
Median	3.61	3.95	

p: p value for Paired t-test or Wilcoxon signed ranks test for comparing between before and after; *: Statistically significant at $p \leq 0.05$.

significant differences in both groups ($p = 0.013$) and ($p = 0.008$) with no statistical significant differences between both of them ($p = 0.250$). As shown in **Table 4**.

Maternal outcome

There were no cases of maternal deaths and all cases recovered well.

Table 3. Relation between ultrasonographic assessment of amount of liquor and cerebro-placental ratio (C/U) before and after MgSO₄ administration.

C/U ratio	Liquor		T	P
	Normal (n = 32)	Oligohydramnios (n = 8)		
Before				
Min. - Max.	0.09 - 2.13	0.40 - 1.60		
Mean ± SD.	1.08 ± 0.38	1.08 ± 0.40	0.010	0.992
Median	1.04	1.16		
After				
Min. - Max.	0.11 - 2.25	0.62 - 1.88		
Mean ± SD.	1.20 ± 0.37	1.31 ± 0.41	0.716	0.478
Median	1.17	1.40		
p1	0.009*	0.004*		
% of change			U = 91.000	0.211
Mean ± SD.	15.13 ± 21.60	26.09 ± 18.14		

t, p: t and p values for Student t-test for comparing between the two groups; U, p: U and p values for Mann Whitney test for comparing between the two groups; p1:p value for **Paired t-test** for comparing between before and after in each group; *: Statistically significant at $p \leq 0.05$.

Table 4. Relation between estimated fetal weight (gm) and cerebro-placental ratio (C/U) before and after MgSO₄ administration.

C/U ratio	Estimated fetal weight (gm)		T	P
	Normal (n = 28)	Oligohydramnios (n = 12)		
Before				
Min. - Max.	0.09 - 2.13	0.40 - 1.36		
Mean ± SD.	1.14 ± 0.40	0.93 ± 0.27	1.656	0.106
Median	1.14	0.91		
After				
Min. - Max.	0.11 - 2.25	0.62 - 1.88		
Mean ± SD.	1.27 ± 0.39	1.12 ± 0.34	1.141	0.261
Median	1.22	1.04		
p1	0.013*	0.008*		
% of change			U = 129.000	0.250
Mean ± SD.	14.81 ± 20.36	23.18 ± 22.88		

t, p: t and p values for Student t-test for comparing between the two groups; U, p: U and p values for Mann Whitney test for comparing between the two groups; p1:p value for **Paired t-test** for comparing between before and after in each group; *: Statistically significant at $p \leq 0.05$.

4. Discussion

Preeclampsia is one of the most important serious diseases of pregnancy and

occurs in 5% to 7% of pregnant women [34].

Doppler mood ultrasonic evaluation is used to evaluate blood flow in fetal vessels [35].

A low index of pulsatility in the MCA associated with fetal decompensation has been described [36].

Because the cerebroumbilical ratio is providing information about placental perfusion and about fetal changes so its an important factor in estimating fetal outcome and well being [37].

The objective of this study was to assess the effects of administration of $MgSO_4$ on Doppler parameters of middle cerebral and umbilical arteries in cases of severe PET and eclampsia.

The study was conducted on 40 pregnant female selected from EL Shatby Maternity University Hospital during the period between December 2015 and December 2016.

There were 28 cases with normal fetal growth and 12 cases with intrauterine fetal growth restriction. There was statistically significant improve in the C/U ratio after $MgSO_4$ administration in both of them.

Regarding the Doppler indices studied in our study, the injection of $MgSO_4$ could significantly decrease the RI, PI and SD ratio of the umbilical artery, increase the RI, PI and SDR-MCA, thus increase the C/U ratio.

Souza, *et al.*, [38], assessed MCA and UA Doppler parameters of the fetus. They agree with our study as regard the umbilical artery only but against it as regard the MCA.

In addition, Souza *et al.*, [38] [39] showed the reduction of PI in the fetal umbilical artery and MCA due to the injection of $MgSO_4$.

Qiao, *et al.*, [40] have found significant changes in parameters after administration of $MgSO_4$. In our study, we found significant improvement of C/U ratio after using $MgSO_4$ treatment with improvement of fetal circulation as it cause umbilical artery vasodilation [41].

Coleman *et al.* [42] have found a significant relationship between the resistance index and pregnancy outcomes in 114 pregnant women at 24 - 22 weeks who underwent Doppler sonography. Results of another study have showed a significant relationship between the vascular index and pregnancy outcomes, including fetal growth restriction [43], but results of our study were not in concordance with the last two studies. This difference could be due to the time of Doppler sonography in our study. There was also a control group in order to compare the two groups (treatment and control groups) in terms of resistance index and pregnancy outcomes in these studies, which could produce impressive different results.

5. Conclusions

- Infusion of $MgSO_4$ significantly decreases the fetal RI, PI, SDR umbilical and increases the fetal RI, PI, SDR MCA and increases cerebroumbilical ratio in-

dices obtained with Doppler ultrasound study.

- MgSO₄ significantly improves the fetoplacental blood flow.
- MgSO₄ significantly increases C/U ratio regardless the amount of liquor and the estimated fetal weight were normal or not.

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Compliance with Ethics Requirements

All Institutional and National Guidelines for the care and use of animals (insects) were followed.

Author's Contributions

DE designed the study and performed data collection and analysis. **MR** interpreted and supervised the Lab analysis results. **NE** and **NH** supervised the clinical examinations and US findings. **DE** wrote the manuscript. **All authors** were involved in the revision of the manuscript.

Conflicts of Interest

The author has declared no conflict of interest.

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