ORIGINAL RESEARCH

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Assessment of system-related hemodynamics and tissue hydration in female patients with preeclampsia

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Abstract

Hypertension disorders are reported to cover up to 10% of pregnancies in the world. It is precisely the arterial hypertension that is the leading cause of developing serious complications, long-term invalidation and high maternal and infant mortality rates. In the context of the maternal mortality, preeclampsia may be attributed to 25% of all lethal outcomes. Preeclampsia occupies the second place in the maternal mortality structure. Multifetal pregnancy is a risk factor for developing of preeclampsia. The given study has been designed to obtain main data measured in pregnant patients experiencing preeclampsia. The obtained data have been compared with parameters showing changes in intra-abdominal pressure (IAP) and biochemistry data in singleton versus multifetal pregnancies. Our study has shown that arterial hypertension in multifetal pregnancies may develop due to some factors not typical of preeclampsia pathogenesis. As a result, we may assume that establishing diagnosis Preeclampsia on the basis of arterial hypertention alone may involve an inaccuracy. Therefore, in making the proper diagnostics to differentiate between preeclampsia and other causes of arterial hypertension, it is reasonable to use some additional examination techniques like an impedance measuring method. The hemodynamic data collected therewith can be effectively used in selection of the most suitable hypotensive therapy and adjustment of infusion therapy.

Keywords

Preeclampsia, Hemodynamics, Tissue hydration, Intra-abdominal hypertension, Arterial hypertension, Multifetal pregnancy

Imprint

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Introduction

According to the applicable WHO statistics data referred to 2017, hypertension conditions in pregnancies occupy the second place in the maternal mortality structure that is reported in 14% of the parturient women lethal outcomes [1,11,24-25]. As to the Russian national statistics data, at least the 19% parturiency cases are accompanied by arterial hypertension. So, arterial hypertension reaching the 15,7% level ranks the 4th in the framework of the maternal mortality [4]. The high likelihood of invalidation or even maternal and infant mortality requires further particular attention to be paid to studies of possible causes and approaches to treatment of arterial hypertension [12-16]. The proposed personalized approach to health care for this sort of patients will result in a reduction of the perinatal loss and an optimization of intensive unite costs.

The aim of our study has been to identify types of possible hemodynamics disorders in singleton and multifetal pregnancies complicated with arterial hypertension. Besides, it has been designed to assess changes in fluid distribution in a pregnant woman versus the respective normal value recorded in non-pregnancy, with the use of the technique of impedance measuring. Thereupon, it has been designed to reveal a relationship between the type of the hemodynamic disorders involving arterial hypertension and the respective clinical symptoms & laboratory data.

Materials and methods

Our studies have been conducted in two groups covering a total of 154 examinees, having age-, BMI-, intervention-scope- and anesthesia-technique-comparable features. All patients have been observed in the early post-surgery period in intensive care unit after the completed caesarean section procedures involving regional anesthesia techniques. In order to find the most descriptive, typical, values in our sorted sampling data set, we have utilized the median, since it has been required to minimize effects by some outliers in the sequence that skew the average of our statistics

values [6]. Both groups are homogenous by all analyzed indices that has been established with the use of the variance estimator [7]. The main test group of the patients (n=75, with an average age of 29, an average BMI = 27) has included multifetal pregnancies versus the reference group, which has covered the singleton pregnancies only (n=79, with n average age of 31.5, an average BMI = 29.5). For all the patients, their medical history records have not contained any events of arterial hypertension before their pregnancies. Under the pregnancy conditions, for the patients in both groups, AP systolic values exceeding 140 mm Hg and AP diastolic values exceeding 100 mm Hg have been reported.

According to the latest data, preeclampsia develops as a result of a placenta anomaly that leads to a release of antiangiogenic factors of the sFlt1 type and soluble endoglins (sEng) produced in higher than normal quantities, which provoke an endothelial dysfunction. At stage two of preeclampsia developing, permeability of the vascular walls increases that initiates a vasoconstriction, an increase in the total peripheral resistance (TPR), an activation of coagulation and thrombotic microangiopathy. Further rise in the transmural pressure triggers TPR growing and aggravates the developing pathology process [5,17-20]. All the above listed factors make an effect on developing arterial hypertension, alterations in the heart performance and, in some severe cases, even polyorganic insufficiency [8]. Based on these data, we think that for the pregnant patients suffering from arterial hypertension it is reasonable to assess the volume of extracellular liquid, which is made up of the circulating blood volume (CBV), the interstitial fluid quantity and the intracellular fluid volume. An assessment of hemodynamics data, like the total peripheral resistance (TPR), the minute volume (MV) and the stroke volume (SV), is the most informative way indicating the actual condition of the vascular bed and the heart performance status. In doing so, the contractility of the heart should be estimated preferably by assessing stroke volume values (SV). This parameter shows the most sensitivity to alterations in hemodynamics, since under developing pathology process conditions, at the stage of compensation, certain mechanisms are activated to maintain the MV values within the conditionally specified normal range [9]. So, in case of a decreased stroke volume, tachycardia develops that finally contributes to the maintenance of the MV values within their normal range. An assessment of the integral tonicity coefficient (ITC) is descriptive of the actual condition of the arterial system tonus. ITC readily illustrates what shared time takes the diastolic span within the total cardiac cycle duration. An increased value of this parameter, exceeding the norm, reaching the level of 76 ± 1,6, is an indication of the centralization in the blood supply. The respiratory variation factor (RVF) responsible for stroke volume changes is a fingerprint to characterize the venous return. The RVF normal values are within the range from 1.14 to 1.24. Values exceeding the normal parameters thereof are indicators of respiration disorders, the genesis of which are attributed to pulmonary, cardiac or combined diseases.

The collected data have been automatically analyzed with the use of monitor-equipped system KM-AR-01 DIAMANT V11.0. The respective normal value is taken to be 100%. The norms of the MV and SV parameters have been computed on the basis of the clinical data obtained with utilization of the impedance measuring technique that involves an application of the sigma interval as a limit of allowable measurements for the given device. Based on the clinical data collected, the normal value of MV is 3.1 ± 0.7 l×min-1×m-2, and the normal value of the SV parameter in females reaches 42± 8 ml×m-2. The normal value of TPR is assumed to be 1100 – 1900 din×s.×cm-5. The proper normal values of the extracellular fluid volume have been derived from the formulas by Hidalgo at al. The respective extracellular blood volume = the circulating blood volume x 2,60, where 2.60 is an empirical coefficient proposed by S.Albert. The interstitial fluid volume has been taken to be equal to the difference between the total fluid volume and the extracellular fluid volume [9]. Besides, we have calculated complete sets of the following data with the above monitor-based system as listed below: a pre-ejection period (PEP), an ejection time (LVT), an isovolemic relaxation time (IVR), a filling time (FT), a diastole time (DTI), a systole time (QX), a blood volume parameter (BV) and a homeostasis load index (HL).

Preeclampsia is a severe complication in pregnancy, and it is very often is accompanied by developing polyorganic pathology. When the first symptoms of preeclampsia appear, laboratory testing is mandatorily required to deliver the biochemistry markers as follows: Alanine Aminotransferase (ALT), Aspartate aminotransferase (AST), Blood urea nitrogen (BUN),

Creatinine, Lactate dehydrogenase (LDH), free Hemoglobine and Proteinuria.

The patients from the above mentioned groups have been examined with the use of the monitor-based equipment system KM-AR-01 DIAMANT V11.0 designed for examination of the cardiac & respiratory system performance and tissue hydration. The patient's position in the examination should be as follows: she should be in the supine position with her head supported and arms to be placed along the body. The paired electrodes are applied within the lower third volar surface areas and on the inside surface of the legs in such a manner that the current electrodes are placed distally. The current and measuring electrodes are connected to an impedance measuring instrument. Upon expiration of 10 minutes the resistance values are recorded at a low and a high frequency, respectively. Upon recording, the values required for computation of the above mentioned different fluid volumes are delivered to a PC to be processed with the specific software. The impedance measuring technique is based on the use of the impedance phenomenon. Following this way, it should be noted that an impedance of biological tissues is a complex electrical resistance of the tissues to a harmonic signal delivered thereto. Depending on the frequency of the passing electrical signal, the tissues in an organism show different permeability. With an increase in the signal frequency, the cell membrane becomes permeable, and the total resistance of all fluids grows. Our impedance-based equipment system is capable of data recording at various frequencies and analyzing the obtained measuring results. The developed mathematical model takes into account BMI and the general state of the organism that provides for an unbiased assessment of the studied parameters in critical state patients.

Results and discussion

We have completed our studies on central hemodynamics in patients of both groups in the early post-surgery period against developing AH. According to Clinical Guidelines "Hypertension Disorders in Pregnancy and Post-Partum Period. Preeclampsia, Eclampsia. Clinical Recommendations. Treatment procedure records" approved by the Russian National Association of Anesthesiologists and Resuscitators, an abnormal increase in the AP level has been treated as a preeclampsia marker; in connection therewith the patients have received magnesium therapy in accordance with the schedule as follows: intravenous 25% magnesium MgSo4, 4000 mg within 15 minutes, subsequently micro-jet injection of 1000 mg/hr [10].

The data on hemodynamics, reported upon the studies, have shown significant differences in some indicator values. To illustrate this statement, it should be noticed that the MV and SV values: MV = 2.46 l/min×m2, SV = 33.95 ml/m2 recorded in the main test group have markedly exceeded those reported for the reference group: MV = 1.7 l/min×m2, SV = 24.55 ml/m2 (by 44% in case with MV and by 38% in case with SV, respectively). In its turn, the TPR, CBV values and extracellular fluid parameter recorded in the main test group have been found to be lower than those reported in the reference group (TPR is lower by 55%, CVB is lower by 8,5%, and the intracellular fluid volume has a decrease by 10,5%). The ITC parameter is at the lower limit of the norm (74.6) in the main test group that points to the fact that there is no peripheral vascular spasm available. The RVF parameter in the reference group patients exceeds the normal values (1,3) that bears witness to the fact that there is a strong impact of the intrathoracic pressure on the venous return. A brief survey of the compared hemodynamics data are given further herein in Table 1.

Table 1

	APs /APd, mmHg	MV, l/min·m^2	SV, ml/m^2	TPR, din · sec · cm^{-5}	ITC	RVF	PEP, sec	LVT, sec	IVR, sec	FT, sec	DTI, sec	QX, sec	HL	BV, %	Extrac.Fl., %	Intrac.Fl., %
Main test group	163 /95	2.46	33,95	1936	74,6	1,23	0,12	0,32	0,17	0,26	0,44	0,44	114	107	105	98
Reference group	165 / 107	1.7	24.55	3014	75,9	1,3	0,12	0,3	0,15	0,27	0,43	0,42	100	116	115.5	99

Table 2

	No. of ind.	BMI	Age, years	Hb, g/l	Ht, %	PLT, 109/l	Urea mmol/l	Phosphocr. µmol/l	ALT, Un./l	AST, Un./l	Free Hb, g/l	LDH, Un.l	Proteinur., g/l	IAT, cmH2O.
Main test group	75	27	29	110	32	184	4	68	32	36	0,22	375	0.8	5.1
Reference group	79	30	31.5	111	34	177	4,7	75	63	77	0,66	628	4.5	9.9

The recorded significant differences in the lab biochemistry data have engaged our attention, too. The deviations of the most important markers of preeclampsia ALT, ACT and LDH have been reported to be doubled values in the reference group, and the respective values of biochemistry in the main test group have primarily remained within the tolerable range. The proteinurea level in the main test group has reached 0,8 g/l, and the averaged level thereof in the reference group has been reported to be 4,5 g/l that is an indication of involvement of kidneys in pathology process. Intra-abdominal hypertension in the reference group is added to the developing preeclampsia process as mentioned above. In the main test group, the average IAP value has remained at the upper limit of the norm. The major biochemistry markers of preeclampsia are summarized by Table 2 given further herein.

The validity of the survey statistics data on the main test group patients shows that the arterial hypertension pathogenesis in multifetal pregnancies may be related to the stroke volume parameters. As to the reference group, covering the singleton pregnant patients, high TPR levels, indicating vascular spasm, may be treated as the deciding factor for developing AH. The increased averaged values of the extracellular fluid volume, exceeding the norm by 15,5%, in the reference group patients with singleton pregnancies demonstrate that there is an increase in the interstitial fluid volume that may partly explain the high averaged BMI valves of the mentioned patients that is manifested by pronounced edema cases.

Conclusions

1. With respect to developing AH in the main test group covering multifetal pregnancies, attention should be drawn to the fact that there is a relatively high level of the SV (MV) parameter with the normal TPR data. The obtained evidence data show that AH in multifetal pregnancies may develop without vascular spasm.
2. The conducted studies have demonstrated that Arterial Hypertension in the singleton pregnant patients from the reference group develops fully in accordance with the modern concept of the preeclampsia pathogenesis.
3. Administration of the proper hypotensive therapy, considering the pathogenesis aspects in a proper manner, taking into account the systemic hemodynamics data and tissue hydration assessments, can produce a positive outcome in the therapy with minimized medication.
4. The corrective measures to improve the infusion loading on the basis of the tissue hydration assessments are substantiated by the valid pathogenesis assumption.

Statement on ethical issues

Research involving people and/or animals is in full compliance with current national and international ethical standards.

Conflict of interest

None declared.

Author contributions

The authors read the ICMJE criteria for authorship and approved the final manuscript.

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