

СОНОГРАФІЧНІ ОСОБЛИВОСТІ НИРКОВОГО КРОВОПЛИНУ У ДОНОШЕНИХ НОВОНАРОДЖЕНИХ З ПЕРИНАТАЛЬНОЮ ПАТОЛОГІЄЮ

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Реферат

Метою праці було встановити сонографічні особливості ниркового кровоплину у доношених новонароджених із тяжкою перинатальною патологією.

Матеріал і методи. Під час дослідження проведений аналіз результатів сонографічного обстеження 24 критично хворих новонароджених та 28 умовно здорових дітей у період перших 24-72 годин життя. Комплексне ультразвукове обстеження дітей проводили на апараті MyLabTM 25Gold (ESAOTE, Italy) з використанням конвексного датчика на частоті 3,5-5 МГц.

Результати й обговорення. Результати дослідження показали відсутність достовірної різниці щодо лінійних розмірів нирок при проведенні сканування у В-режимі та достовірно вищий відсоток випадків патологічної ехографічної картини у дітей основної групи при застосуванні кольорового доплерівського сканування. При проведенні імпульсно-хвильової доплерографії встановлено загальні тенденції до меншого рівня всіх швидкісних характеристик на рівні правої та лівої головних ниркових артерій (максимальної систолічної швидкості кровоплину, мінімальної швидкості кровоплину у діастолу та середньої швидкості кровоплину) у дітей основної групи обстеження у порівнянні з новонародженими групи контролю. При цьому, спостерігалися виражені тенденції до більш високого пульсаційного індексу та відсутність достовірної різниці індексу резистентності між групами обстеження.

Висновки. Одним з важливих методів діагностики функціонування нирок у новонароджених є комплексне ультразвукове дослідження з використанням кольорового доплерівського сканування та імпульсно-хвильової доплерографії. За умов тяжкої перинатальної патології доношені діти мають достовірно вищий відсоток випадків патологічної ехографічної картини та схильність до процесів вазоконстрикції на рівні головної ниркової артерії. Оцінку особливостей ренальної гемодинаміки необхідно проводити з урахуванням поліорганного пошкодження, морфо-функціональної незрілості та комплексу медикаментного навантаження.

Ключові слова: доношений новонароджений, перинатальна патологія, нирковий кровоплин, доплерографія

Abstract

SONOGRAPHIC FEATURES OF RENAL BLOOD FLOW IN FULL-TERM NEONATES WITH PERINATAL PATHOLOGY

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Aim. The objective of the study was to detect sonographic features of renal blood flow in full-term neonates with severe perinatal pathology.

Materials and Methods. In the course of the study, the results of sonographic examination of 24 critically sick newborns and 28 conditionally healthy infants in the first 24-72 hours of life have been analyzed. A comprehensive ultrasonic examination of infants on the equipment MyLabTM 25Gold (ESAOTE, Italy) with the use of a convex sensor with the frequency of 3,5-5 MHz was performed.

Results and Discussion. The results of the investigation were indicative of the absence of a reliable difference concerning linear sizes of the kidneys while performing scanning in B-regimen and of a reliably higher percentage of cases with pathologic echographic manifestation in infants from the study group by means of coloured Doppler scanning. The pulsed-wave Doppler scanning has revealed general tendencies to a lower level of all velocity characteristics on the level of the right and left major renal arteries (Peak Velocity, End Diastolic Velocity, and Mean Velocity) in the study group compared to the control group. At the same time, marked tendencies to a higher Pulsed index and a lack of a reliable difference of Restrictive index between the groups examined were found.

Conclusions. One of the important methods of renal function assessment in neonates is comprehensive ultrasonic examination with the use of colored Doppler scanning and pulsed-wave Doppler examination. Under conditions of severe perinatal pathology, full-term neonates have a reliably higher percentage of cases of pathologic echographic image and susceptibility to vasoconstriction processes on the level of the major renal artery. The features of renal hemodynamics should be evaluated considering multiple organ lesion, morpho-functional immaturity and a complex of medical treatment.

Key words: full-term neonate, perinatal pathology, renal blood flow, Doppler scanning

Introduction

One of the promising methods of investigation enabling to objectively estimate the condition of renal functions is ultrasonic examination, especially application of color Doppler scanning and pulsed-wave Doppler examination with determining the blood flow time curve (BFTC) [1,5,8,9]. Although, application of these

technologies in neonatology is connected with a number of technical difficulties: small size of the organs; low intensity of blood flow; impossibility to fix an infant in one position and estimate blood flow during several cardiac cycles, etc. [5, 7]. In addition, renal blood flow in neonates is connected with other hemodynamic mechanisms, and functioning of the cardio-vascular, central nervous and endocrine systems in particular. It also depends on the volume and intensity of a therapeutic intervention and medicinal load [7]. Investigation of hemodynamic features of the renal blood flow in infants, kept under conditions of intensive care units, will help in timely diagnosing renal dysfunctions, performing the correction of pharmacotherapy, and preventing development of severe irreversible renal lesions.

The objective of the study was to find sonographic features of renal blood flow on the level of the major renal artery in full-term neonates with severe perinatal pathology during the first days of life.

Materials and Methods

The prospective cohort study was conducted on the basis of the Municipal Medical Establishment "Clinical Maternity Home №2", the town of Chernivtsi, in the period from January 2015 to July 2015. The study involved a clinical and paraclinical examination of 24 critically sick infants who received therapy in the intensive care unit of newborns (main group) and 28 conditionally healthy full-term infants who stayed in the wards together with their mothers. Severity of general condition and of disorders in sick infants was detected by means of the Score for Neonatal Acute Physiology Perinatal Extension - (SNAP-PE) [6]. Exclusion criteria from the study were: gestational age less than 37 weeks; body weight less than 2500 g; congenital developmental defects of the urinary system.

A comprehensive ultrasonic examination of infants on the equipment with the use of a convex sensor on the frequency of 3,5-5 MHz was conducted (MyLab™ 25Gold, ESAOTE, Italy). At the beginning of the examination, visualization of the kidneys in B-regimen was performed with detection of the following linear sizes: L - length (cm), P - width (cm), D - thickness (cm), DM - thickness of the medullar layer (cm), DC - thickness of the cortical layer (cm). After that color Doppler scanning and pulsed-wave Doppler examination with determining the blood flow time curve (BFTC) on the major renal artery visualized from the

flank area were performed. In the course of BFTC determining, the following parameters were detected: FVI (Flow-vascularization index), PI (Pulsatility index), RI (Restrictive index), PV (Peak Velocity) (cm/s), EDV (End Diastolic Velocity) (cm/s), Vmn (Mean Velocity) (cm/s), SV/SD (systolic velocity/diastolic velocity), AI (Acceleration index), AT (Acceleration Time) (msec). For statistical analysis of the obtained results of the study, the program Statistica (StatSoft Inc., USA) was applied. Considering a small sampling with the absence of normal distribution of the values (Shapiro-Whilek $<0,05$), non-parametric statistical methods with detection of median (Me) and interquartile range were used [Lq - lower quartile; Uq - upper quartile]. To compare quantitative indices with abnormal distribution non-parametric Mann-Whitney U-test (M-W) was applied. Parameter difference was statistically significant with $p < 0,05$.

The study was conducted according to the main ethic principles of conducting scientific medical examinations approved by the Committee on the Issues of Biomedical Ethics, the HSEE of Ukraine "Bukovinian State Medical University".

Results and Discussion

The results of the study were indicative of similarity of the groups compared concerning gestational age, anthropometric indices at birth and gender signs. Thus, an average gestational age of infants from the main group was 39,0 [37,0; 41,0] weeks, infants from the control group - 39,0 [39,0; 40,0] weeks, $p > 0,05$. Average body weight at birth in the 1st group was 3200,0 [2920,0; 3700,0] g, in the second group - 3300,0 [3080,0; 3600,0] g, $p > 0,05$; average body length - 53,0 [51,0; 54,0] cm and 53,0 [52,0; 55,0] cm respectively, $p > 0,05$. Distribution of the groups by gender was also similar. In the main group of the study there were 16 boys (66,7%) and 8 girls (33,3%); in the control group - 18 boys (64,3%) and 10 girls (35,7%), respectively.

An average estimation of severity of general condition of the disorders in the main group of neonates according to the Score for Neonatal Acute Physiology Perinatal Extension - (SNAP-PE) was 51,0 [41,0; 61,0]. At the same time, severity of perinatal pathology was caused by delivery in the condition of severe asphyxia in 25,6% of cases (6 infants) and in the condition of moderate asphyxia with further negative dynamics in 41,6% of cases (10 infants). The condition of 8 neonates of this group (33,3%) at birth was

Table 1

Indices of linear sizes of the kidneys in neonates of the groups examined

Indices	Main group (n=24)		Control group (n=28)	
	Right kidney	Left kidney	Right kidney	Left kidney
L, cm	4,22 [4,14; 4,71]	4,45 [4,27; 4,56]	4,24 [4,13; 4,35]	4,31 [3,92; 4,62]
P, cm	2,16 [2,03; 2,45]	2,26 [2,12; 2,43]	2,11 [2,0; 2,24]	2,15 [1,9; 2,5]
D, cm	2,27 [1,95; 2,47]	2,34 [2,07; 2,49]	2,22 [2,16; 2,28]	2,19 [2,12; 2,29]
DM, cm	0,56 [0,52; 0,62]	0,63 [0,6; 0,67]	0,55 [0,53; 0,85]	0,59 [0,56; 0,84]
DC, cm	0,26 [0,23; 0,29]	0,24 [0,21; 0,31]	0,3 [0,25; 0,33]	0,29 [0,18; 0,34]

evaluated as satisfactory, but it worsened in dynamics due to the aggravation of pathological neurological symptoms with the development of signs of cerebral edema. The signs of morphologic and functional immaturity of the body were diagnosed in half of infants of the main group.

It should be noted that in the first group of infants the course of the underlying disease was complicated by the formation of the multiple organ failure syndrome with the development of respiratory incompatibility and functional disorders of the central nervous system in 100% of cases (24 infants), cardio-vascular incompatibility - in 58,3% of cases (14 infants), gastro-intestinal disorders - in 50,0% of cases (12 infants), hemostatic disorders - in 25,0% of cases (6 infants). Classical signs of acute renal failure were diagnosed only in 3 neonates (12,5% of cases) of this group.

In the course of the study, the intensity of therapeutic interventions in the main group of infants was evaluated. All the 24 neonates (100%) were nursed under conditions of intensive care unit keeping to the rules of protection regimen; they experienced artificial lung ventilation with oxygen dotation and complex infusion therapy including administration of 10% glucose solution and 0,9% sodium chloride solution in physiological requirements. 12 infants of this group (50,0%) received inotropic support with administration of 0,5% dobutamine solution in the dose of 3-5 mg/kg/min., 1 infant (4,2%) - diuretics after preliminary test with physiological solution load was made.

The neonates from the control group stayed in the wards together with their mothers and were breastfed only.

Ultrasonic examination of the kidneys in B-regimen with detection of angle-dependent linear sizes was performed for all the infants of the groups; the results are presented in the Table 1.

The results of the study were indicative of the absence of a reliable difference between the indices of linear sizes and the thickness of the medullar and cortical layers of the left and right kidneys between the groups examined. According to the literature data, while measuring linear kidney sizes, especially in neonates, a high level of error is found, as the reliability of the values depends on the skills of the examiner, correct visualization of the kidney and the angle of sensor's fixing [5]. It stipulates the necessity to conduct deep ultrasound examination of infants with detection of qualitative characteristics and parameters not depending on the angle of sensor's fixing.

During the study, the quality of echographic image of the kidneys of infants in the groups examined was evaluated. In this respect, according to the standards of USD, the image intensity of the right kidney was compared to the liver echogenicity; the left kidney - with the spleen echogenicity [5]. Ten infants (41,6%) of the main group presented with a decreased echogenicity of the right and left kidneys; in 6 infants (25,0%) there was no clear differentiation between the medullar and cortical layers; in 2 infants (8,3%) "white pyramids" symptom was found. In 8 neonates (28,6%) from the control group there was an increased parenchymal echogenicity of both kidneys found with preservation of clear differentiation between the medullar and cortical layers, which might be connected with transitory conditions and accumulation of uric acid metabolites [3,5]. It should be noted that evaluation of kidney parenchyma echogenicity is a subjective method depending on practical skills of the USD specialist.

With the purpose of an objective evaluation of renal hemodynamic condition, we have performed color Doppler scanning and pulsed-wave Doppler examination to detect the indices of BFTC on the level of the major renal artery. These findings are presented in Table 2.

Table 2

Indices of renal blood flow on the level of the major renal artery in neonates of the groups examined

Indices	Main group (n=14)		Control group (n=18)	
	Right kidney	Left kidney	Right kidney	Left kidney
VP, cm/s	13,1 [9,7; 20,9]	14,55 [6,2; 27,2]	13,9 [12,8; 20,9]	17,65 [14,7; 20,3]
EDV, cm/s	2,2 [1,9; 3,1]	2,35 [0,9; 4,1]	2,95 [1,9; 4,1]	4,1 [2,8; 5,3]
Vmn, cm/s	5,85 [4,1; 6,6]	5,15 [#] [3,3; 9,8]	7,6 [6,1; 8,75]	9,65 [8,6; 10,7]
PI	1,82 [1,67; 3,12]	1,82 [#] [1,01; 3,45]	1,41 [1,29; 1,96]	1,33 [1,12; 1,45]
RI	0,80 [0,76; 0,88]	0,82 [0,6; 0,96]	0,78 [0,74; 0,88]	0,75 [0,65; 0,8]
SV/SD	5,0 [4,1; 8,2]	5,57 [2,5; 5,86]	6,44 [4,16; 10,89]	4,26 [3,25; 9,16]
A	3,03 [1,53; 4,83]	2,45 [1,81; 3,5]	3,51 [0,98; 7,58]	4,51 [1,69; 7,16]
AT, msec	38,0 [32; 51,0]	45,0 [57,0; 31,5]	41,5 [25,5; 79,5]	38,0 [22,0; 76,5]
FVI	2,05* [1,95; 2,3]	2,4 [#] [1,7; 4,2]	3,35 [2,5; 4,05]	4,05 [3,4; 4,6]

* - difference significance level of the right kidney hemodynamics between the groups examined, $p < 0,05$

- difference significance level of the left kidney hemodynamics between the groups examined, $p < 0,05$

It should be noted that in the main group of the study as compared to the controls, there were general tendencies to a lower level of all velocity characteristics on the level of the right and left major renal arteries (Peak Velocity, End Diastolic Velocity, and Mean Velocity). At the same time, marked tendencies to a higher pulsed index and a lack of a reliable difference of the Restrictive index between the examined groups were found.

According to the literature data, neonates under unfavorable conditions present with a compensatory increase of maximal blood flow with simultaneous increase of the Restrictive index, which ensures preservation of renal perfusion on a sufficient level. A considerable decrease of blood flow with a simultaneous increase of the Restrictive index is always indicative of deep structural lesions of the kidneys; it is a prognostically unfavourable situation requiring careful dynamic echographic control [2, 3, 4, 7].

The lack of a considerable difference between the levels of the Restrictive index in the sick and the healthy full-term neonates might be connected with activation of mechanisms of arterial-venous blood shunting (AVBS). This phenomenon consists of a massive blood shunt along Truet's shunts from the afferent to the efferent arterioles on the level of juxtamedullar nephrons avoiding the glomerular apparatus proper. Accordingly, in infants of the main group the resistant characteristics of renal blood flow are relatively preserved, but they do not reflect a real

condition of renal hemodynamics. Involvement of AVBS mechanisms can be also suspected with combination of relatively normal resistant characteristics of arterial blood flow with a sharp decrease of Peak Velocity and a marked depletion of the intrarenal vascular image [3].

In the course of our study, we have evaluated FVI (Flow vascularization index), reflecting correlation of an average weighed amount of color voxels to general number of voxels, and enabling to evaluate the amount of blood passing through the given volume of the substance [8]. Under the conditions of severe perinatal pathology, a reliably lower level of this index is found in the right and left kidneys of full-term neonates, which is indicative of a considerable deterioration of renal hemodynamic intensity in infants of this group.

Conclusions

1. Critically sick full-term neonates constitute a high risk group in terms of formation of renal dysfunctions; its clinical diagnosis is complicated by the accompanying multiple organ lesions and intensive therapeutic intervention.
2. One of the important methods of diagnosing renal functions in neonates is a comprehensive ultrasonic examination with the use of the color Doppler scanning and pulsed-wave Doppler examination.
3. Under the conditions of severe perinatal pathology, full-term neonates have a reliably higher percentage of cases of a pathologic echographic image and

susceptibility to vasoconstriction processes on the level of the major renal artery.

4. The features of renal hemodynamics should be evaluated considering multiple organ lesions, morpho-functional immaturity and a complex of medicinal load.

The future studies must be directed to continue investigation of renal hemodynamic features in infants with perinatal pathology on the levels of the central and peripheral renal arteries together with biochemical and immunologic markers with the purpose of elaborating a mathematical model to foresee and diagnose the degree of severity of renal dysfunction in neonates during the first week of life.

References

1. Chavhan Covind B., Parra Dimitri A., Mann Andrea, Navarro Oscar M.: Normal Doppler Spectral Waveforms of Major Pediatric Vessels: Specific Patterns. *Radiographics* 2008, 28 (3), 691-707.
2. Krishtafovich A.A., Vilchuk K.U., Devyaltovskaya M.G., Leonovich I.V. Diagnosis of hemodynamic disorders of the brain and kidneys in neonates with hypoxic encephalopathy. *Vestnik Natsionalnoy akademii nauk Belarusi* 2015; 1: 59-64. Russian (Криштафович А.А., Вильчук К.У., Девялтовская М.Г., Леонович И.В. Диагностика нарушений гемодинамики мозга и почек у новорожденных при гипоксической энцефалопатии. *Вестник Национальной академии наук Беларуси* 2015; 1: 59-64).
3. Olhova E.B. Echographic variants of disorders of renal hemodynamics in neonates. *Radiologiya* 2012; 2: 53-67. Russian (Ольхова Е.Б. Эхографические варианты нарушений ренальной гемодинамики у новорожденных. *Радиология* 2012; 2: 53-67.
4. Popov S.V. Regional renal blood flow in neonates with different types of renal failure and hypoxic-ischemic CNS lesions. *Visnik Sumskogo Derzhavnogo universitetu. Seriya Meditsina* 2010; 1: 148-152. Russian (Попов С.В. Региональный почечный кровоток у новорожденных с почечной недостаточностью различного типа на фоне гипоксически-ишемического поражения ЦНС. *Вісник Сумського державного університету. Серія Медицина* 2010; 1: 148-152).
5. Pyikov M.I., Gurevich A.I., Trufanov A.V., Koshechkina N.A., Shvetsova M.A. Pediatric ultrasonic diagnostics in uronephrology. Moscow: Vidar-M Publishers; 2007. 200p. Russian (Пыков М.И., Гуревич А.И., Труфанов А.В., Кошечкина Н.А., Швецова М.А. Детская ультразвуковая диагностика в уронефрологии. Москва: Издательский дом Видар-М; 2007. 200с).
6. Richardson D.K., Gray J.E., McCormick M.C., Workman K., Goldmann D.A. Score for Neonatal Acute Physiology: a physiologic severity index for neonatal intensive care. *Pediatrics* 1993; 91(3): 617-623.
7. Riga O.O. State of renal hemodynamic in newborns in the early neonatal period. *Ultrazvukova perinatalna diagnostika* 2010; 30: 181-183 Ukrainian (Ріга О.О. Стан ренальної гемодинаміки у новонароджених дітей в ранньому неонатальному періоді. *Ультразвукова перинатальна діагностика* 2010; 30: 181-183).
8. Tuhbatullin M.G. Modern ultrasound technologies in clinical practice. *Prakticheskaya meditsina* 2012; 5(60): 30-35. Russian (Тухбатуллин М.Г. Современные ультразвуковые технологии в клинической практике. *Практическая медицина* 2012; 5(60): С.30-35).
9. Wael Magdy Elsaify: Neonatal renal vein thrombosis: grey-scale and Doppler ultrasonic features. *Abdominal Imaging* 2009, 3(3), 413-418.