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CHANGES IN RENAL BLOOD FLOW IN ACUTE KIDNEY INJURIOUS IN PREMATURE INFANTS WITH HEMODYNAMICALLY SIGNIFICANT PATERN DUCTUS ARTERIOSUS**ЗМІНИ НИРКОВОГО КРОВОТОКУ ПРИ ГОСТРОМУ ПОШКОДЖЕННІ НИРОК У НЕДОНОШЕННИХ ДІТЕЙ З ГЕМОДИНАМІЧНО ЗНАЧУЩОЮ ВІДКРИТОЮ АРТЕРІАЛЬНОЮ ПРОТОВОКОЮ****Obolonska Olha / Оболонська О.Ю.***as. prof*

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Abstract. *The abstracts present data on changes in blood flow in the kidneys in premature infants with hemodynamically significant patern ductus arteriosus (hsPDA)with acute kidney injurious . Were examined 40 premature infants with a gestational age of 29-36 weeks. All children on the first, third and tenth days of life investigated Doppler ultrasound of the kidneys to determine blood flow in the renal arteries (Main Renal Artery and Interlobar Artery) : the maximum systolic blood flow rate, minimum blood flow rate in diastole, and RI . Children were divided into 2 groups in the presence of acute kidney injurious. Group I (n = 17) did not have AKI, group II (n = 23) had AKI. The obtained data allow us to consider the most informative for the diagnosis of acute renal injury in premature infants with HsPDA decrease in systolic and diastolic blood flow in the interlobar artery, and an increase in RI in the first three days of life.*

Key words: *premature babies, acute kidney injury, hemodynamically significant patern ductus arteriosus, Doppler ultrasound kidney.*

Introduction.

Prediction and early diagnosis of acute kidney injury (AKI) in newborns is an important and complex issue in the emergency care setting (1). The development of AKI in newborns in most cases is due to a critical condition and is one of the manifestations of multiple organ failure. The most common causes of AKI in newborns are the development of tissue hypoperfusion (2). Persistent open ductus arteriosus (PDA) is present in every 3 children born prematurely. This figure is inversely proportional to gestational age and can reach 50%. The functioning of the patern ductus arteriosus PDA in premature infants exacerbates hypoperfusion, especially hemodynamically significant patern ductus arteriosus (HsPDA), leading to complications (3). One of the methods of diagnosing disorders of hemodynamics of organ blood flow is Doppler ultrasound test(4,5). The question of what indicators are the most indicative in the diagnosis of signs of AKI (6).

Main text.

Cohort, prospective study was conducted in 2018-2019 on the basis of the Department of Anesthesiology and Neonatal Intensive Care CI "Dnipropetrovsk Regional Children's Clinical Hospital" and was approved by the Commission on Medical Ethics of the hospital.

Inclusion criteria: premature infants at 29-36 weeks of gestation with HsPDA, signed informed parental consent to participate in the study.

Exclusion criteria: congenital malformations, intracerebral, intraventricular



hemorrhage III-IV degree, neonatal sepsis, severe asphyxia in childbirth, skin diseases, intrauterine growth retardation.

Were examined 40 premature infants with a gestational age of 29-36 weeks with HsPDA. Echocardiography with Doppler using a wideband microconvex sensor with a frequency of 5-8 MHz "TOSHIBA" Nemso XG model SSA-580A (Japan) was performed on admission to the department (5-11 hours of life) and then daily to determine PDA, its size, its hemodynamic significance. All children on the first, third and tenth day of life underwent Doppler ultrasound test of the kidneys to determine blood flow in the renal arteries (Main Renal Artery and Interlobar Artery) to determine the maximum systolic blood flow velocity (V_s), the minimum diastolic blood flow velocity (V_d) and Resistance Index (RI) according to standard methods. Diagnosis and stratification of the severity of AKI was performed according to the criteria of neonatal modification of KDIGO (7).

A set of statistical research methods was used to solve the tasks and test the initial assumptions, namely: for independent samples - Mann-Whitney test and Kraskel-Wallis test, to assess the dynamics - Wilcoxon sign rank criterion and McNamara test, for conjugacy tables - χ^2 conjugation tables and Fisher's exact criterion for estimating the degree of dependence between variables - Spearman's correlation. Verification of the normality of the distribution of quantitative samples was performed using the Kolmogorov-Smirnov criterion. Data analysis was performed using the IBM SPSS Statistics suite 23.

Gestational age averaged 32.9 ± 0.22 weeks. Low birth weight 1501-2400 g was observed in half of children in both groups, very low birth weight <1500 g - in every sixth child. Children were divided into 2 groups in the presence of AKI. Group I ($n = 17$) did not have acute kidney injurious, group II ($n = 23$) had acute kidney injurious. Six children dropped out of the study due to the development of exclusion criteria. Children in the groups were representative in the Apgar score, the main diagnosis.

The peculiarity of renal circulation is due to the ability to autoregulate, due to which there is an intrarenal redistribution of blood flow - a decrease in the superficial and increase in the deep layers of the kidney with Trueta shunts in the elimination of hypovolemia and hypoperfusion (8). In premature infants, vascular resistance may remain elevated(9), and then autoregulation may be disrupted, because HsPDA is a factor in the development of the phenomenon of "robbery" of the great circle of blood circulation, which leads to hypoperfusion of organs, including the kidneys (10-11). We conducted an evaluation of indicators blood flow in the renal and lobar arteries in groups of examined children. Analyzing the state of blood flow in the kidneys in children with HsPDA depending on the development of AKI we can observe statistically significant changes from the first to the tenth day (table 1)

The most significant changes in V_s , V_d and RI in children with AKI were in the Interlobar Artery. Moreover, the difference V_s in children with AKI and without AKI from the first day was 39% ($p < 0.001$), remained on the third day -17% ($p = 0.02$). V_d was statistically different on the first and third days - almost twice as high in children without AKI($p < 0.001$), and 40% higher on the third day ($p < 0.001$). RI of vessels at children with AKI was above norm on the first and third days.



Table 1

Indicators of blood flow in the kidneys depending on the AKI

Indicators	day	AKI -, n=17 (17)	AKI + n=23 (17)	p<
<i>Interlobar Artery</i>				
Maximum systolic blood flow rate, cm / sec	I	18,48±3,014 (18,6; 16,35-20,9)	11,10±3,329 (11,3; 7,71-12)	0,001
	III	19,12±4,730 (21; 16-22,5)	15,57±4,541 (16; 12-18) ***	0,02
	X	22,71±5,882 (24; 18,5-25,5) **^^	20,82±5,812 (20; 17,5-23,5) ***^^	ns
Minimum blood flow rate in diastole, cm / sec	I	6,16±2,447 (5,6; 4,75-7,7)	2,83±2,063 (2,2; 1,1-4,15)	0,001
	III	5,83±1,919 (6; 4,5-7)	3,48±1,532 (3,1; 2-5)	0,001
	X	6,71±3,405 (5; 4,5-8,5)	4,65±2,644 (4; 2,5-6,5) ** ^	ns
RI	I	0,666±0,1216 (0,67; 0,6-0,74)	0,758±0,137 (0,8; 0,65-0,83)	0,02
	III	0,693±0,0869 (0,7; 0,63-0,72)	0,76±0,1588 (0,82; 0,69-0,86)	0,03
	X	0,715±0,0937 (0,72; 0,67-0,8)	0,776±0,1127 (0,8; 0,69-0,87)	ns
<i>Main Renal Artery</i>				
Maximum systolic blood flow rate, cm / sec	I	25,4±6,17 (24; 22-27,5)	20,6±5,87 (22; 16-23)	0,02
	III	28,6±5,32 (29; 23-33) *	26,7±6,60 (28; 22-32) ***	ns
	X	30,2±5,57 (30; 26-35) ***	30,5±4,85 (32; 25-34) ***^^	ns
Minimum blood flow rate in diastole, cm / sec	I	6,6±3,08 (6; 4,5-9)	5,2±3,10 (4; 2-8)	ns
	III	7,9±3,17 (7; 5,5-9)	7,1±3,95 (6; 4-11) *	ns
	X	8,8±2,77 (9; 6,5-11) *	6,9±2,03 (7; 5,5-8) *	0,04
RI	I	0,741±0,0921 (0,74; 0,66-0,8)	0,752±0,1256 (0,79; 0,68-0,86)	ns
	III	0,725±0,0789 (0,73; 0,68-0,8)	0,723±0,1516 (0,78; 0,61-0,86)	ns
	X	0,707±0,0877 (0,7; 0,66-0,77)	0,772±0,0636 (0,78; 0,72-0,82)	0,02

Notes:

1. The sample size for the 10th day is given in parentheses.

2. When comparing independent samples, the Mann-Whitney test was used ("ns" - no significant discrepancy was observed).

*, **, *** – significant difference from the level of the 1st day;

^, ^^, ^^ – of the 3 day, relatively $p < 0,05$, $p < 0,01$ i $p < 0,001$ by the criterion of sign ranks of Wilcoxon.



In the Main Renal Artery on the first day, V_s in children without AKI was 25% higher ($p = 0.02$) than in children with AKI, and V_d was lower by 27% ($p = 0.04$) on the tenth day. RI in children with AKI was above normal on the first and third days, while in children without AKI it was within normal limits for the first three days and was significantly lower by 10 days.

The development of AKI in preterm infants was accompanied by changes in blood flow, which indicated the predominance of vasoconstriction of renal vessels, as evidenced by minimal diastolic blood flow in the renal and lobar arteries and high resistance index in these vessels. More pronounced changes in the cranial arteries, as vessels of smaller caliber, show impaired mechanisms of autoregulation in them and blood shunting, which is an attempt to compensate for hypovolemia, but up to 10 days with the development of AKI, this shunting is pathological.

Summary and conclusions.

1. Decreased maximal systolic blood flow rate, minimum diastolic blood flow rate in the Interlobar Artery, and increased RI in the first three days of life are predictors of the development of AKI in premature infants with HsPDA.

2. In the Main Renal Artery decrease in the minimum rate of diastolic blood flow on the tenth day may indicate the possibility of developing AKI in premature infants with HsPDA.

3. Children with HsPDA and a decrease in blood flow in the kidneys in the first day of life should be assigned to the group at risk of developing AKI.

References

1. Godovanets UD, Babintseva AG, Nikorich SI. Acute damage to the kidneys of newborns: unresolved issues of diagnosis and stratification of the severity of the pathology. *Neonatology, surgery and perinatal medicine*. 2014; IV, №3 (13): 89-94. doi.org/10.24061/2413-4260.IV.3.13.2014.16.

2. Babintseva AG. The state of renal hemodynamics in full-term infants with perinatal pathology. *Perinatology and Pediatrics*. 2017.2 (70): 113-120; doi 10.15574 / PP.2017.70.113

3. Majed B, Bateman DA, Uy N, Lin F. Patent ductus arteriosus is associated with acute kidney injury in the preterm infant. *Pediatrician Nephrol*. 2019. Vol. 34, № 6. R. 1129-1139. doi: 10.1007 / s00467-019-4194-5.

4 Olkhova EB. Echographic variants of renal hemodynamic disorders in newborns. *Radiology*. 2012. № 2.: 53—67;

5. Chavhan GB, Parra DA, Mann A, Navarro OM. Normal Doppler spectral waveforms of major pediatric vessels: specific patterns. *Radiographics*. 2008 May-Jun; 28 (3): 691-706. doi: 10.1148 / rg.283075095.

6. Granata A, Zanolli L, Clementi S [et al.] Resistive Intrarenal Index: Myth Or Reality? . *Br. J. Radiol*. 2014. Doi: 10.1259 / Bjr.20140004. ;

7. Selewski DT, Charlton JR, Jetton JG, Guillet R, Mhanna MJ, Askenazi DJ, et al. Neonatal Acute Kidney Injury. *Pediatrics*. 2015 Aug; 136 (2): e463-473. doi: 10.1542 / peds.2014-3819

8. Kaplunova OA Juxtamedullary path of blood flow. *Bulletin of urology*. 2019; 7 (1): 46-52. doi: 10.21886 / 2308- 6424-2019-7-1-46-52.



9. Boubred F., Simeoni U. Buonocore G., Bracci R., Weindling M. Pathophysiology of Fetal and Neonatal Kidneys. Neonatology. Springer, Cham. 2017; doi.org/10.1007/978-3-319-18159-2_261-1

10. Rios DR, Bhattacharya S, Levy PT, McNamara PJ. Circulatory Insufficiency and Hypotension Related to the Ductus Arteriosus in Neonates. Front Pediatr. 2018; 6: 62. Doi: 10.3389/fped.2018.00062/

11. El Hajjar M, Vaksmann G, Rakza T, Kongolo G, Storme L Severity of the ductal shunt: a comparison of different markers Arch Dis Child Fetal Neonatal Ed. 2005; 90 (5): F419-22. Doi: 10.1136/adc.2003.027698.

Анотація. В статті наведені дані щодо змін кровотоку в нирках у недоношених новонароджених з гемодинамічно значущою відкритою артеріальною протокою з гострим пошкодженням нирок. Обстежено 40 недоношених дітей терміном гестації 29-36 тижнів. Всім дітям на першу, третю та десятю добу життя здійснено доплерсонографічне обстеження нирок з визначенням кровотоку в ренальних артеріях (головній реальній артерії та сегментарній артерії) з визначенням максимальної систолічної швидкості кровотоку, мінімальної швидкості кровотоку в діастолу, та індексу резистентності RI за стандартною методикою. Діти були розділені на 2 групи за наявності гострого пошкодження нирок. I група (n=17) гострого пошкодження нирок не було, II група (n=23) гострого пошкодження нирок було. Отримані дані дозволяють вважати зниження швидкості систолічного та діастолічного кровотоку в сегментарній артерії, та збільшення RI в перші три доби життя предиктором розвитку ГПН у недоношених дітей з ГЗВАП.

Ключові слова: недоношені діти, гостре ушкодження нирок, гемодинамічно значуща відкрита артеріальна протока, доплерівські показники нирок.

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