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E. V. Grigorev[1, 2], A. V. Ivanova[1, 2], A. V. Golomidov[2, 3], O. V. Bessonova[3], A. E. Furman[3]

ROLE OF ULTRASOUND MONITORING IN CRITICALLY ILL NEONATES

[1] Federal State Budgetary Institution "Research Institute for Complex Issues of Cardiovascular Diseases",

[2] State Educational Institution of Higher Professional Educational Institution "Kemerovo State Medical Academy" of Federal Social and Health Care Agency",

[3] Municipal Budgetary Healthcare Institution "City Clinical Hospital N 5",

Kemerovo, the Russian Federation

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Е. В. Григорьев, А. В. Иванова, А. В. Голомидов, О. В. Бессонова, А. Э. Фурман

ВОЗМОЖНОСТИ УЛЬТРАЗВУКОВОГО МОНИТОРИНГА У НОВОРОЖДЕННЫХ ДЕТЕЙ В КРИТИЧЕСКОМ СОСТОЯНИИ

Цель. Оценить эффективность неинвазивного ультразвукового мониторинга гемодинамических расстройств у новорожденных в критическом состоянии.

Материалы и методы. У новорожденных в критическом состоянии (30 ИВЛ-зависимых последовательных пациентов, возраст (19,5±2,1) ч, с массой тела 1300–2650 г) оценивалась эффективность мониторинга гемодинамики ультразвуковым методом. Две группы — с исходной кардиотонической поддержкой и без нее. Исследовали анатомические показатели сердца, сократительную способность миокарда, показатели центральной гемодинамики и регионального кровотока (передняя мозговая, верхнебрыжеечная и почечные артерии).

Результаты. Показано, что УЗИ-показатели нарушений гемодинамики выявляются ранее клинических данных, преимущественно диастолическая дисфункция левого желудочка. Применение дофамина способствовало восстановлению органного кровотока, но провоцировало усугубление дисфункции левого желудочка.

Вывод. УЗИ-показатели внутрисердечной гемодинамики и резистивных индексов могут использоваться для обоснования катехоламиновой поддержки до момента ухудшения стандартных гемодинамических показателей.

Ключевые слова: новорожденные, критическое состояние, ультразвуковой мониторинг, кардиотоническая поддержка.

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E. V. Grigorev, A. V. Ivanova, A. V. Golomidov, O. V. Bessonova, A. E. Furman

ROLE OF ULTRASOUND MONITORING IN CRITICALLY ILL NEONATES

Aim: To evaluate the efficiency of non-invasive ultrasound monitoring of hemodynamic derangements in critically ill neonates.

Materials and methods. The efficiency of non-invasive hemodynamic monitoring using ultrasound methods has been assessed in critically ill mechanical ventilation dependent neonates (age (19.5±2.1) hrs, birth weight 1300–2650 g) consecutively included in the study. All the patients were assigned to two groups according to the hemodynamic derangements: Group 1 (n=10) on cardiotonic therapy and Group 2 (n=20) — without it. The physiological parameters of the heart, myocardial contractility, central hemodynamic parameters and regional blood flow (anterior cerebral, renal and superior mesenteric arteries) have been assessed.

Results. Ultrasound parameters indicating hemodynamic derangements in neonates present with multiple organ dysfunction syndrome (MODS) have been detected earlier compared to the clinical manifestations. Low CI and high RI of the renal arteries preceded the reduction of arterial pressure. In the majority of critically ill neonates during the 1st week of life, grade I diastolic dysfunction was found. It might be associated with impaired cardiorespiratory hemodynamics. The use of dopamine has contributed to a more rapid recovery of organ blood flow, but has provoked LV diastolic dysfunction. Perhaps not all the neonates in Group 1 required cardiotonic therapy. However, an increase of volume loading in some patients could manage hemodynamic derangements.

Conclusion. Ultrasonic intracardiac hemodynamics and resistive indices can be used to justify the catecholamine support until the deterioration of the standard of hemodynamic parameters.

Key words: newborns, critically ill, ultrasound monitoring, cardiotonic therapy.

Introduction

Multiple organ dysfunction syndrome (MODS) is a major cause of death for neonates admitted to neonate intensive care units (NICU) [9]. Hemodynamic factors are known to play a pivotal role in the pathogenic mechanisms underlying MODS. Therefore, hemodynamic monitoring is of key importance in the management of critically ill neonates and includes the monitoring of the following parameters: heart rate, blood pressure, acid-base balance and blood gas analysis.

Arterial hypotension is generally accepted diagnostic criterion for MODS in adults, but it seems to be less informative in neonates, because it is typically a late finding. Moreover, there is no blood pressure limits for neonates indicating the level of organ dysfunctions and tissue perfusion [13].

Currently, echocardiography (ECHO-CG) is routinely used in the neonate to monitor intracardiac hemodynamics, but there are a limited number of parameters that are being measured, namely ejection fraction (EF), stroke volume and cardiac index [5; 10].

The above-mentioned set of parameters does not allow performing adequate assessment of central hemodynamic derangements and prognosis of the patient's deterioration, whereas the interpretation of the obtained data is complicated by the patient's individual variations. Particularly, cardiac index depends on the neonate's days of life, hypoxic status [4] and gestational age [10]. Currently, the role of left ventricular diastolic function (LVDF) in the neonatal period has been actively discussed [2; 4; 11; 14; 15]. According to the data presented in the medical literature, LVDF precedes left ventricular systolic dysfunction (LVSD) and is accepted as the criterion for early alteration of cerebral hemodynamics [2–4, 8]. Moreover, it is regarded as a risk factor for cardiovascular decompensation [10].

Regional blood flow assessed by Doppler ultrasound should be considered while interpreting hemodynamic derangements. Thus, most of the studies focused on ultrasound monitoring of hemodynamic derangements are referred to a separate assessment of cerebral, renal and mesenteric blood flows. Recently, there has been some research studying the relationship between intracardiac and organ hemodynamics [1; 6; 7; 12].

Aim: To evaluate the efficiency of non-invasive ultrasound monitoring of hemodynamic derangements in critically ill neonates.

Material and Methods

30 consecutive premature newborns admitted in the NICU and received mechanical ventilation (MV) in the first 3 days of life were included in the study. The mean age was (19.5±2.1) hours. Ultrasound examination was performed at admission to the NICU and then daily from 7:00 am — 10:00 am until the seventh day of life. Intracardiac hemodynamics was assessed by ECHO-CG in the B-mode, M-mode and Doppler mode (pulsed-wave, continuous-wave and color flow imaging) using an ultrasound system Logiq Book XP (China) with 4–10 MHz multi-frequency micro-convex probe. Echocardiography measurements should be performed with the neonate quiet and calm in order to obtain more reliable findings and record the true heart rate (HR). The following parameters were assessed:

1) physiological parameters of the heart: left ventricular end-systolic and end-diastolic dimensions (ESD and EDD), left atrial diameter (LAD), ascending aortic diameter (AAoD), right ventricular diameter (RVD);

2) myocardial contractility: LVEF, percentage of anterior-posterior systolic shortening of the left ventricle;

3) hemodynamics: left ventricular end-systolic and end-diastolic volume (ESV and EDV), SV;

4) cardiac output and cardiac index were calculated according to the following formulas:

$$CO\ (ml/min) = SV \cdot HR;$$
$$CI\ (l/(min \cdot m^2)) = CO / S,$$

where S (m^2) is the body surface area;

5) left ventricular diastolic function was assessed using transmitral flow velocity parameters: early diastolic filling velocity (E), late diastolic filling (A) and the ratio of the early to late (E/A) ventricular filling velocities.

Regional blood flow was assessed in the anterior cerebral artery (ACA), superior mesenteric artery (SMA), the celiac trunk (CT) and in the left and right renal arteries (LRA and RRA). Systolic and diastolic velocities, resistance index (RI) were assessed as well.

The Neonatal Multiple Organ Dysfunction Score (NEOMOD) and the Neonatal Therapeutic Intervention Scoring System (NTISS) were used to evaluate daily the severity of the MODS. All the patients were assigned to two groups according to the initial hemodynamic derangements: Group 1 (n=10) — neonates with symptomatic hemodynamic derangements receiving cardiotonic therapy and Group 2 (n=20) — with signs of intracardiac hemodynamic derangements and altered RI, but without cardiotonic therapy. All the patients in both groups were comparable in the gestational age and birth weight (Table 1).

There were no significant differences in the registered nosological forms of pathologies in compared groups of neonates (respiratory syndrome, intrauterine pneumonia and severe birth asphyxia followed with MODS). Thus, Group 1-patients, who received cardiotonic therapy, were admitted with more severe clinical conditions at baseline compared to Group 2 (the NEOMOD score of 4–6 in Group 1 vs. 2–5 in Group 2). The criteria for the appointment of cardiotonic therapy was a reduction of mean blood pressure less than 70 mmHg. If there is inadequate perfusion of the microvasculature in the level of lactate and/or a reduction in venous saturation. Dopamine dose varied 5–15 mcg/kg/min. The mean duration of therapy was 2,4 days before the normalization of hemodynamic parameters. The exclusion criteria were as follows: neonates with congenital malformations, surgical pathology and/or genetic and chromosomal abnormalities. Group 2 patients was appointed crystalloid infusion therapy at a dose of 50 ml/kg. As the assessment of the effectiveness was used a normal recovery rate of diuresis and normalization of tissue perfusion.

Statistical analyses were performed using "STATISTICA 6.0" (StatSoft). The Shapiro-Wilk test was used to check for normality of the distribution. Since the tested variables were not normally distributed, the median and interquartile range (IQR) of each variable were calculated. The statistical significance of differences between the two groups was determined using the non-parametric Mann Whitney U test for independent samples. The results were considered statistically significant with a p value <0.05.

Results and Discussion

The assessment of the hemodynamic parameters on admission reported significantly lower arterial pressure (AP) in Group 2 compared to Group 1. Thus, it did not exceed the lower limit of normal for AP at this age group (Table 2).

Cardiac index was not significantly different between the two groups. However, it was (2.6±0.2) l/(min·m^2) in Group 2 and exceeded the lower limit of normal (3.0–

Table 1

Clinical data of the studied groups

Parameters	Group 1, n=10	Group 2, n=20	p
Gestational age, weeks	32.5 (32–34)	30.5 (29–34)	0.097
Birth weight, g	1900 (1620–2650)	1490 (1300–1930)	0.117
NEOMOD	5 (5–6)	3 (2–3)	0.0001*
NTISS	23 (22–24)	16 (19–22)	0.05

Note. * — p<0.05; NEOMOD — the Neonatal Multiple Organ Dysfunction Score; NTISS — the Neonatal Therapeutic Intervention Scoring System.

Table 2

Hemodynamic parameters on admission

Parameters	Group 1, n=10	Group 2, n=20	p
MAP, mm Hg	51.6 (42–63)	38 (34–46)	0.015*
EF, %	67.4 (67–71)	67.5 (66–70)	0.074
FS, %	34.6 (34–37)	34.5 (33–36)	0.065
CI, l/(min·m^2)	3.3 (2.8–3.7)	2.65 (2.1–3.0)	0.093
E/A	0.75 (0.7–0.76)	0.73 (0.66–1.3)	0.56

Note. * — p<0.05; AP — arterial pressure; EF — ejection fraction; FS — fractional shortening of the left ventricle; CI — cardiac index; E/A — the ratio of the early (E) to late (A) ventricular filling velocities.

5.5 l/(min·m^2)), indicating reduced preload and impaired myocardial relaxation. Since LV systolic function was within normal range (ejection fraction (normal range 60–80%) and fractional shortening (normal range: 28–41%), the main reason for lower CI is the reduction in preload caused by hypovolemia. It is displayed graphically as an increase in blood flow velocity during atrial systole (A), a decrease in early diastolic filling velocity (E) and a decrease in the E/A ratio (normal E/A ration > 1.0) (Fig. 1).

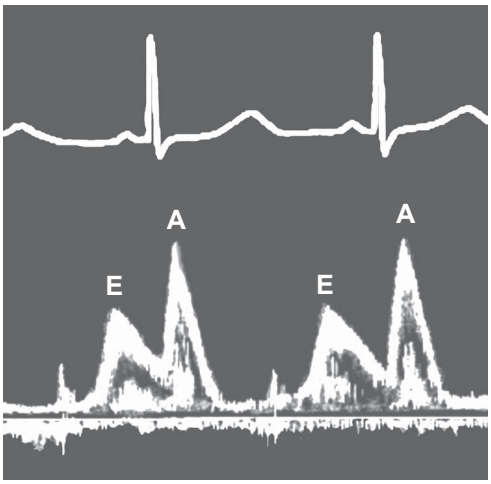

Fig. 1. Transmitral flow parameters

The impairment of organ blood flow was found in the ACA in both groups; thus, the RI was significantly higher in Group 2 (Table 3). Despite of increased RI in the SMA in Group 2, there were no significant differences between the groups.

On day 1 after admission to the NICU, cardiotonic therapy was initiated in 6 neonates in Group 2 because of the clinically manifested hemodynamic derangements (reduced arterial pressure). The gestational age of these neonates ranged from 29–38.5 weeks

Table 3

Organ blood flow parameters (RI) on admission

Parameters	Group 1, n=10	Group 2, n=20	p
ACA	0.76 (0.59–1.0)	0.83 (0.55–1.0)	0.04*
SMA	0.71 (0.7–0.73)	0.82 (0.69–1.0)	0.12
LRA	0.7 (0.67–0.7)	0.72 (0.65–0.8)	0.94
RRA	0.73 (0.67–0.69)	0.75 (0.6–0.81)	0.32

Note. * — p <0.05; ACA — anterior cerebral artery; SMA — superior mesenteric artery; RRA — right renal artery; LRA — left renal artery.

and birth weight form 1300–3400 g. A NEOMOD of 3–5 scores was associated with more severe clinical conditions (p=0. 001) compared to the group of neonates who did not require cardiotonic therapy (n=14). The findings of hemodynamic assessment reported a decrease in arterial pressure and cardiac index (from 1.73 to 3.0 l/(min·m^2)), but without significant differences between the groups. Importantly, the RI of the renal arteries was significantly higher (p=0.0005) in Group 1. Grade 1 diastolic dysfunction was found in 66% of the neonates in this group. The retrospective analysis of these data suggested that these patients probably did not require cardiotonic therapy, and the hemodynamic disturbances could be managed using the infusion therapy. Since these patients began to receive cardiotonic therapy, they were transferred from Group 2 into Group 1.

The serial monitoring on the third day of life reported that the differences in arterial pressure, the E/A ratio and the RI of the ACA and renal arteries remained significant (Table 4). Perhaps a more rapid recovery of organ blood flow in Group 1 was associated with pharmacodynamics of dopamine reducing vascular resistance.

On the seventh day of life, there were no significant differences in the severity of the clinical conditions scored by the NEOMOD between the two groups (p>0.05). 8 (50%) neonates in Group 1 and 6 (42.8%) in Group 2 required respiratory support. 12 (75%) and 10 (71%) neonates received partial parenteral nutrition, respectively. The AP, CI, EF, FS were within normal ranges in both groups. Thus, arterial pressure was significantly higher in Group 1 (p=0.01) during the monitoring period. The RI values of the studied vessels were also within normal ranges, but the RI value of the ACA was significantly higher in Group 2 (p=0.01). LV diastolic dysfunction was found in 14 (87.5%) neonates in Group 1 and in 10 (71.4%) neonates in Group 2 (p=0.3). This may be associated with the effects of dopamine, as it increases left ventricular end-diastolic pressure resulting in LV diastolic dysfunction.

Table 4

The dynamic changes in hemodynamic parameters

Parameters	The 3rd day of life		The 7th day of life	
	Group 1, n=16	Group 2, n=14	Group 1, n=16	Group 2, n=14
mAP, mm Hg	51.5 (45–57)*	41.5 (40–44)*	58.5 (45–64)*	45 (41–58)*
CI, l/(min·m^2)	3.3 (3.0–3.6.5)	3.3 (2.8–3.5)	3.25 (2.9–3.7)	3.7 (2.6–4.3)
EF, %	72 (67–74.5)	70.5 (66–75)	73.5 (70.5–76.5)	74 (68–76)
FS, %	38 (34.5–40.5)	37 (33–40)	39 (36–41.5)	39 (34–41)
E/A	0.74 (0.65–0.91)*	0.6 (0.53–0.71)*	0.78 (0.72–0.9)	0.75 (0.73–1.0)
ACA	0.57 (0.51–0.62)*	0.74 (0.68–1.0)*	0.64 (0.63–0.64)*	0.72 (0.68–0.82)*
SMA	0.72 (0.68–0.75)	0.72 (0.63–0.75)	0.74 (0.57–0.67)	0.75 (0.72–0.77)
RRA	0.59 (0.52–0.65)*	0.75 (0.71–0.8)*	0.7 (0.66–0.74)	0.7 (0.65–0.75)
LRA	0.61 (0.51–0.7)*	0.80 (0.73–1.0)*	0.74 (0.67–0.78)	0.75 (0.66–0.79)

Note. * — p<0.05; mAP — mean arterial pressure; EF — ejection fraction; FS — fractional shortening of the left ventricle; CI — cardiac index; E/A — the ratio of the early (E) to late (A) ventricular filling velocities; ACA — anterior cerebral artery; SMA — superior mesenteric artery; RRA — right renal artery; LRA — left renal artery.

Conclusion

Ultrasound parameters indicating hemodynamic derangements in neonates present with MODS have been detected earlier compared to the clinical manifestations. Low CI and high RI of the renal arteries preceded the reduction of arterial pressure. In the majority of critically ill neonates during the 1st week of life, grade I diastolic dysfunction was found. It might be associated with impaired cardiorespiratory hemodynamics. The use of dopamine has contributed to a more rapid recovery of organ blood flow, but has provoked LV diastolic dysfunction. Perhaps not all the neonates in Group 1 required cardiotonic therapy. However, an increase of volume loading in some patients could manage hemodynamic derangements. The comprehensive assessment of ultrasound parameters can detect changes in intracardiac hemodynamics, regional blood flow and determine the need for cardiotonic and/or volume therapy.

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Rewierer G. I. Posternak, MD, prof.

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О. М. Нестеренко, Ю. В. Щербина, І. М. Бойцун, О. М. Харченко, Г. Г. Сихарулідзе, О. О. Нестеренко, І. О. Нестеренко, Т. І. Воробйова

СУЧАСНІ ПІДХОДИ ДО ВИБОРУ АНТИБІОТИКОТЕРАПІЇ ШПИТАЛЬНОЇ ХІРУРГІЧНОЇ ІНФЕКЦІЇ, ЯКА СПРИЧИНЕНА *ACINETOBACTER BAUMANNII*

Донецький національний медичний університет імені Максима Горького, МОЗ України, Красний Лиман, Україна

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А. Н. Нестеренко, Ю. В. Щербина, И. Н. Бойцун, Е. Н. Харченко, А. Г. Сихарулидзе, Е. А. Нестеренко, И. А. Нестеренко, Т. И. Воробьева

СОВРЕМЕННЫЕ ПОДХОДЫ К ВЫБОРУ АНТИБИОТИКОТЕРАПИИ ГОСПИТАЛЬНОЙ ХИРУРГИЧЕСКОЙ ИНФЕКЦИИ, ВЫЗВАННОЙ *ACINETOBACTER BAUMANNII*

Введение. Увеличение числа пациентов, требующих выполнения обширных операций, инвазивных методов ведения периоперационного периода на фоне вторичного иммунодефицита, составляющих группу риска по развитию госпитальной хирургической инфекции, побудило нас провести анализ этиологической роли *A. baumannii* в ее развитии, трендов ее антибиотикорезистентности (АБР) за 12-летний период (2003–2014 гг.) для обоснования выбора рациональной антибактериальной терапии (АБТ).

Материал и методы. Нерандомизированное ретроспективное (2003–2014 гг.) эпидемиологическое исследование результатов локального микробиологического мониторинга — высевов 12 243 изолятов патогенов, в том числе 1325 изолятов неферментирующих грамотрицательных бактерий (НГОБ) — возбудителей госпитальной хирургической инфекции, выполнено в многопрофильном 1100-коечном Донецком областном клиническом территориальном медицинском объединении (ДОКТМО). Критерии включения: клинические признаки инфекции, выделение НГОБ спустя 48 ч после госпитализации в стационар; выделение изолятов НГОБ в количестве не менее 10^5 КОЕ/мл. Микробиологические исследования крови, мочи, отделяемого ран, дренажей проводили с использованием автоматизированной системы VITEK®2 compact (bioMerieux Inc, Франция) со встроенной экспертной программой с элементами интеллекта Advanced Expert System (AES™). Компьютерная обработка данных выполнялась по программе WHONET (v. 5.4). До 2008 г. использовали