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Original article

Evaluation of superior vena cava flow and cardiac output in neonatal sepsis using functional echocardiography

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Abstract:

Background: One of the major causes of newborn mortality is sepsis. The results of sepsis in newborns include cardiovascular problems. Specific hemodynamic phenotypes may be distinguished by echocardiography, which also facilitates physiology-based therapy of sepsis-related cardiovascular dysfunction on an individual basis. The Left Ventricular Output (LVO), Right Ventricular Output (RVO), and Superior Vena Cava Flow (SVCF) are the three parameters that are most often used to evaluate the central blood flow in newborns. **Aim:** This research used functional echocardiography to assess LVO, RVO, and SVCF in newborns with sepsis. **Patients and methods:** In the Beni-Suef University Hospital Neonatal Care Unit, this case-control research was carried out. There were 40 newborn sepsis cases and 40 healthy controls in it. All research participants had a meticulous medical history,

comprehensive physical examination, and a battery of investigations, including C-reactive protein, complete blood count, blood culture, and a functional echocardiogram on a GE Vivid T8 echocardiography machine. **Results:** Patients with neonatal sepsis had considerably greater RVO, LVO, and SVC flow than controls. Additionally, gram-negative sepsis had much greater LVO, RVO, and SVC flow than gram-positive sepsis. Further study revealed that gram-negative LOS had considerably greater LVO, RVO, and SVCF than gram-positive LOS, while gram-negative and gram-positive EOS showed no appreciable differences. Prematurity as well as low birth weight were the commonest risk factors for sepsis. Gram-negative bacteria overwhelmed gram-positive ones. The most prevalent gram-positive and gram-negative bacteria were CONS and Klebsiella pneumoniae respectively. Neonatal sepsis patients had considerably greater levels of WBCs and a prolonged capillary refill time than controls, while their platelet counts were much lower than controls. **Conclusions and Recommendations:** In newborn sepsis, serious cardiovascular consequences are frequent. To better assess RVO, LVO, and SVCF in newborns with sepsis, multicenter studies on several populations are advised.

1. Introduction:

In the first 28 days of a baby's life, pathogenic germs may enter sterile fluids like blood or cerebrospinal fluid, causing a clinical illness known as neonatal sepsis. This disease is characterized by hemodynamic

abnormalities and other systemic clinical symptoms. Bacteria, viruses, and fungi are all examples of pathogenic microorganisms [(1)].

Even today, neonatal sepsis remains a leading reason for infant morbidity and mortality. Estimates suggest that between 11 and 19 percent of infants born with neonatal sepsis will die during the first month of life, leading to an annual incidence rate of 3 million [(2)].

Vasodilation, decreased systemic vascular resistance, and impaired myocardial contractility are just a few examples of the potential cardiovascular abnormalities seen in newborns with sepsis [(3)]. Over the last several years, functional echocardiography's usage to evaluate a baby's cardiovascular health has skyrocketed [(4)].

Early detection, targeted therapy, assessment of treatment response, and improved outcomes are just some of the ways in which this method has been found to benefit patients with cardiovascular disease [(5)]. Commonly used metrics for assessing the central blood flow in neonates are the Right Ventricular Output (RVO), the Left Ventricular Output (LVO), and the Superior Vena Cava Flow (SVCF) [(6)]. The output of the heart may be easily calculated by evaluating its cross-sectional area and the velocity time integral (VTI) [(7)]. The SVCF may be a surrogate for total body blood flow [(8)]. So, we conducted this research to assess RVO, LVO, and SVCF in newborns with sepsis using functional echocardiography.

2. Patients and Methods:

This case-control research was executed in Beni-Suef University Hospital Neonatal critical care unit from January 2022 to November 2022 including Group A with neonatal sepsis cases (40 cases) and Group B (controls) with 40 healthy neonates of the same age and gender as Group A.

Combined with clinical and laboratory signs of infection, a positive blood culture constituted the diagnostic criteria for sepsis [(1)]. According to Stocker et al. (2017), symptoms of sepsis include apnea or other difficulties of breathing, tachycardia or bradycardia, hypotension of the arteries and/or inadequate blood flow, both hypothermia and hyperthermia, seizure, a flaccid baby, irritability, or lethargic behavior, ileus,

as well as throwing up and eating intolerance [9].

Babies with major birth defects, cardiac defects present at birth, perinatal asphyxia, babies born to a mother who has diabetes, and preceding inotropic support before the execution of a functional echocardiogram were excluded from the study.

C-reactive protein, complete blood count, and blood culture were tested in all patients with suspected sepsis. Other cultures were requested as indicated. GE Vivid With the help of a T8 Echocardiography equipment, functional echocardiography was performed for every patient with suspected sepsis within twelve hours of the onset of manifestations before the initiation of inotropes if needed and the clinical, laboratory, and echocardiographic data were recorded. Patients with negative cultures were then excluded.

RVO measurement:

Pulsed Doppler was applied to get flow information at a point immediately distal to the pulmonary valve by using a parasternal long-axis image. Calculating the maximum velocity time integral required taking the numbers derived from the area under the curve for each of the 5 successive cardiac cycles and averaging them. To determine the patient's heart rate, we analyzed the peak-to-peak intervals of the Doppler velocity time signals. At the systole end, the diameter of the pulmonary valve insertion was estimated by performing a frame-to-frame analysis on the grayscale parasternal long-axis picture. The results of the 5 cardiac cycles were used in the calculation to determine the average diameter.

LVO measurement:

When imaging the LV outflow tract, the apical view was used so that the whole length of the ascending part of the aorta could be merged into the picture. The pulsed Doppler's range gate was positioned distally to the aortic valve. The maximum VTI was computed by taking the average of the flow velocity time signal values over the course of 5 successive cycles. In order to determine the patient's heart rate, we analyzed the peak-to-peak intervals of Doppler velocity time signals. In order to determine the ascending part of the aorta internal diameter at the point of flow analysis, at the systole end, a parasternal

long-axis view was used, and a frame-by-frame evaluation of the grayscale picture was performed. The results of five cardiac cycles were used to establish an average value for the diameter.

SVC flow measurement:

A method similar to that used for RVO and LVO measurements was used to evaluate the flow via the superior vena cava. CSA is computed by evaluating SVC diameter in a modified PSAX view at the level of the right pulmonary artery. VTI is determined immediately proximal to its connection to the right atrium through utilizing pulsed Doppler in the right suprasternal or sub-costal view. SVC is a vein that is D-shaped with the ability to collapse. As a result, measuring the CSA of the SVC is more likely to result in an error when compared to measuring the CSA of an AV or PV annulus that is largely non-collapsible. It is advised that the SVC diameter should be evaluated by M-mode and that it should be averaged over 5–10 cardiac cycles. In a similar manner, the VTI is also calculated by averaging it across 5–10 cardiac cycles.

Statistical analysis:

The qualitative data was provided as numbers and percentages for the purpose of providing descriptive statistics (proportions). The mean and standard deviation were the two main statistical measures that were used to display the quantitative data. The necessary statistical tests were used in order to conduct an analysis of the relations between the variables, namely the Chi-square test for categorical data comparison. A mean independent sample t-test was used in order to compare the two different groups. When the p-value was less than or equal to 0.05, the differences were determined as significant.

Ethical considerations:

The research ethics committee of Beni-Suef University's Faculty of Medicine approved the study protocol with No. FMBSUREC/09012022/Abdelsattar.

The study was conducted according to the Declaration of Helsinki.

3. Results:

The neonatal sepsis group included 28 males and 12 females while the controls group included 25 males and 15 females

with no significant difference between the 2 groups. Table 1 summarizes their clinical and laboratory characteristics. The mode of delivery in 82.5% of neonatal sepsis patients was cesarean section while 85 % of controls were delivered by cesarean section with no significant difference. Around 65% of cases were full-term and 35% were preterm.

Early-onset sepsis (EOS) and late-onset sepsis (LOS) were equally distributed (50% in both). As regards risk factors of neonatal sepsis; around 67.5% of patients had low birth weight, 35% of patients were premature, 17.5% of patients had foreign body insertion including intubation or chest tube, multiple gestation was present in 17.5% of cases, PROM was detected in 12.5% of patients, and abdominal surgery was present in 7.5% of patients.

The capillary refill time of neonatal sepsis patients was significantly higher than that of the control group (P value = 0.015), while there was no significant difference between the 2 groups regarding the heart rate or the mean blood pressure (Table 1). Around 40% of the patients were on CPAP, 45% on nasal oxygen, 7.5% on mechanical ventilation, and 7.5% were off oxygen. 25% of patients received positive inotropes after echocardiography and the mortality was 25% among neonatal sepsis patients. The length of NICU stay of the neonatal sepsis patients ranged from 5 – 29 days with a median and interquartile range of 14 (9.25 - 20.50).

WBC levels were significantly higher, while Platelets were significantly lower in neonatal sepsis patients than in controls with no significant difference in hemoglobin levels (P value = 0.015, 0.042, 0.752 respectively (Table 1). The band cell differential count of the neonatal sepsis patients ranged from 1-29 with a median and interquartile range of 6.00 (2.00 – 10.75). The Immature to Total neutrophil ratio of neonatal sepsis patients ranged from 0.01 - 0.37 with a median and interquartile range of 0.117 (0.05 - 0.19). CRP of the neonatal sepsis patients ranged from 1 – 152 with a median and interquartile range of 32.25 (3.75- 75.75).

About 52.5% of blood cultures were positive for gram-negative organisms while 47.5% were positive for gram-positive organisms. Causative organisms

according to blood culture were Klebsiella in 42.5% of cases, CONS in 22.5% of cases, Staphylococcus aureus in 17.5% of cases, E. coli in 10% of cases, and Streptococci in 7.5% of cases. Sputum culture was done in 5 cases showing klebsiella in 60% of cases and E. coli, Staphylococcus aureus, in 20% of cases (Table 2).

LVO, RVO, and SVC flow were significantly higher in neonatal sepsis patients than in controls (P value <0.001, 0.006, and 0.001, respectively) (Table 3).

As shown in Table (4) LVO, RVO, and SVC flow were significantly higher in gram-negative sepsis than in gram-positive sepsis. LVO, RVO, and SVC flow were significantly higher in gram-negative LOS than in gram-positive LOS (P value 0.024, 0.011, and 0.037 respectively).

SVC flow was significantly and positively correlated with the length of NICU stay, WBCs, and CRP levels (P value = 0.014, 0.037 and 0.008 respectively (Table 5).

Table (1): Clinical, and laboratory data among neonatal sepsis patients and controls

Variables	Group A (Cases) (Neonatal sepsis patients)		Group B (Controls)		U	P Value
	Range	Median (Interquartile range)	Range	Median (Interquartile range)		
Gestational age in weeks	32 - 41	37.0 (34.3 - 38.8)	32 - 40	38 (37 – 39)	673.0	0.214
Post- natal age in days	3-27	8 (5 – 16.25)	1 – 28	3 (2.00 – 9.75)	622.0	0.085
Body Weight in Kg	1.1 - 4.5	2.2 (1.8 - 2.5)	1.6-3.5	2.5 (2.0- 3.0)	640	0.122
Mean BP (mmHg)	33.0-55.0	43.0 (41.0-49.8)	38 – 80	53 (49.00 -56.75)	648.5	0.143
Capillary refill time (seconds)	1 – 5	2 (1.25-3.75)	1 – 3	2 (1 – 2)	564.0	**0.015***
Heart rate	115 – 165	135.60 ±11.30**	125 – 160	137.50± 8.17**	t = 0.034	0.391
Hemoglobin (gm/dl)	7.4 – 20.0	13.57±3.02**	10.3 - 17.2	13.39 ±1.95**	t = 0.317	0.752
Platelets*10^3 (cell/mm^3)	80 - 381	179.0 (150.0 -230.3)	139– 590	277 (219.8 - 359.3)	588.5	**0.042***
WBCs*10^3 (cell/mm^3)	4.5- 48.0	9 (7.27-14.40)	4.5 – 15.2	8.15 (6.1 – 10.1)	563.5	**0.015***

*; significant, **; Mean ± SD, U; Mann Whitney U test, t; Independent samples t-test

Table (2): Culture results of neonatal sepsis in cases:

Variables	**N (%) (n = 40)**
Type of organism in Blood culture* (Gram +ve/-ve)	
Gram -ve	21 (52.5%)
Gram +ve	19 (47.5%)
Blood culture causative organism*	
Klebsiella	17 (42.5%)
CONS	9 (22.5%)
E.Coli	4 (10%)
Streptococci	3 (7.5%)
Staphylococcus aureus	7 (17.5%)
Sputum culture (n=5)	
Klebsiella	3 (60%)
E Coli	1 (20%)
Staphylococcus aureus	1 (20%)

*; more than 1 type can be present in the same patient

Table (3): LVO, RVO, and SVC flow among cases and controls.

Variables Mean ± SD	**Group A (Neonatal sepsis patients)**	**Group B (Controls)**	**Test of significant**	**P Value**
LVO (ml/Kg/min)	197.79 ± 71.182	139.65 ± 37.045	U= 383.0	**<0.001***
RVO (ml/Kg/min)	246.82 ± 99.61	183.49 ± 100.77	t= 2.827	**0.006***
SVC flow (ml/Kg/min)	281.12 ±134.767	191.11 ± 100.929	U= 470.0	**0.001***

*; significant, U; Mann-Whitney U test, t; Independent samples t-test

Table (4): Comparison of LVO, RVO, and SVC flow in gram-negative and gram-positive sepsis in all patients and in late-onset sepsis patients.

Variables		Organism isolated	Number of patients	Mean ± SD	Test of significance	P Value
All sepsis (no=40)	**LVO**	**Gram-negative**	21	223.419 ± 73.569	U= 125.0	**0.042***
		Gram-positive	19	172.16 ± 60.044		
	RVO	**Gram-negative**	21	268.96 ± 82.259	t= 3.372	**0.002***
		Gram-positive	19	192.36 ± 59.640		
	SVC flow	**Gram-negative**	21	352.36 ± 130.533	U= 75.0	**0.001***
		Gram-positive	19	209.88 ± 97.764		
Late-onset sepsis	**LVO**	**Gram-negative**	7	247.22 ± 66.317	U= 17.0	**0.024***
		Gram-positive	13	165.29 ± 50.313		
	RVO	**Gram-negative**	7	245.13 ± 49.524	t= 2.853	**0.011***
		Gram-positive	13	176.86 ± 51.789		
	SVC flow	**Gram-negative**	7	284.27 ± 88.597	U= 19.0	**0.037***
		Gram-positive	13	189.42 ± 72.747		

*; significant, U; Mann-Whitney U test, t; Independent samples t-test

Table (5): Correlation of LVO, RVO, and SVC FLOW, with clinical, and laboratory data among neonatal sepsis patients:

Variables	RVO		SVC flow		LVO	
	R	P value	R	P value	r	P value
Gestational age in weeks	-0.246	0.127	-0.117	0.474	0.283	0.077
Post-natal age in days	-0.177	0.275	-0.246	0. 126	0.234	0.147
Weight	-0.207	0.201	-0.290	0.070	0.189	0.244
Birth weight	-0.177	0.275	-0.246	0.126	0.234	0.147
Length of NICU stay	0.128	0.430	0.386	**0.014***	0.141	0.384
Mean BP	0.230	0.154	-0.142	0.383	0.049	0.763
Capillary refill time	0.239	0.138	-0.023**	0.886	-0.142	0.381
Heart rate	0.146	0.370	-0.069	0.674	0.075	0.648
Hb	0.076	0.641	-0.050	0.758	-0.049	0.763
WBCs	-0.069	0.674	0.331**	**0.037**	0.110	0.501
Platelets	0.238	0.039	0.814	0.978	0.249	0.121
Band cell differential count	-0.077	0.635	0.162	0.318	-0.009	0.956
I/T ratio	-0.068	0.677	0.237	0.141	0.142	0.384
CRP	0.148	0.361	0.415	**0.008***	0.096	0.558

*; significant, **: Spearman's correlation coefficient, r; Pearson's correlation coefficient

4. Discussion:

Infants who have not yet reached their 28th day of life might be diagnosed with neonatal sepsis if they show clinical signs of a systemic infection, such as fever, rash, circulatory shock, and/or multisystem organ failure. Newborn sepsis may be divided into 2 groups: those with an EOS and those with a LOS. Definitions of EOS often refer to infections that manifest themselves during the first 7 days of the infant's life **(10)**.

According to epidemiological research, over 2.6 million infants worldwide die each year, with the vast majority of these deaths occurring in the 1st week of life. The diagnosis of neonatal sepsis is based on the presence of harmful bacteria in body fluids that are otherwise assumed

to be sterile, however, manifestations of infant sepsis are typically vague [(11)].

Heart problems, myocyte destruction, and altered cardiac blood flow are all consequences of the inflammatory mediators that cause sepsis in neonates [(12)]. Different inflammatory pathways, cardiac immaturity, and hormonal responses all have a role in the wide range of symptoms reported in infants [(3)].

Consistent and repeated measurements of a patient's blood flow are being more recognized as being crucial. Many studies have been conducted in recent years looking at the use of functional echocardiography, near-infrared spectroscopy, and noninvasive impedance-based cardiometry to complement traditional bedside hemodynamic measures like taking a patient's blood pressure and heart rate [(13)].

Targeted neonatal echocardiography has proven essential in advancing our understanding, has the potential to help in the real-time delineation of certain hemodynamic phenotypes, and offers support for the customized physiology-based therapy of sepsis-associated cardiovascular dysfunction [(3)].

Newborn central blood flow is most often measured using the RVO, the LVO, and the SVCF [(6)]. Determining cardiac output is as easy as measuring the cross-sectional area and the velocity time integral (VTI) [(7)]. The SVCF may be a surrogate for total body blood flow [(8)].

The purpose of this case-control research was to investigate RVO, LVO, and SVCF in neonates diagnosed with sepsis by utilizing functional echocardiography. The study included forty infants who were diagnosed with neonatal sepsis and forty infants who were healthy controls.

In this study example, LOS and EOS were distributed consistently (50 percent). At Cairo University Children's Hospital NICU, a study by Mohsen and colleagues demonstrated that LOS was more common than EOS. Here are the breakdowns in numbers: LOS has 60.1% and EOS just 39.9% [(14)]. Another research by Awad et al. found that EOS was detected in 35.4% of patients and LOS was diagnosed in 64.4% of patients in the NICUs at Ain Shams University Children's Hospital and at Al-Azhar University El-Hussein Hospital, [(15)].

Conversely, Ogundare et al. found that 77.8% of patients had EOS, whereas only 22.2% had late-onset sepsis [16].

This study found that the leading risk factors of infant sepsis were low birth weight and early delivery. A systematic review of 952 studies found that the risk of newborn sepsis was 1.42 times greater in babies whose birth weight was less than 2.5 kilograms compared to average weight infants. Infants with a low birth weight are more at risk for a number of health problems. These include being born prematurely, having compromised immune systems, being unable to feed, losing body heat quickly, and suffering from hypoglycemia [17]. In another study, a total of 34% of the 5100 extremely preterm infants in the study group had LOS, and among them, it was associated with an 18% mortality rate [18].

Gram-negative bacteria made up 52.5 percent of all the bacteria found in this research, making them more prevalent than gram-positive bacteria (47.5 percent). Klebsiella pneumoniae was the most prevalent gram-negative bacteria that was isolated from blood culture, whereas the most common gram-positive organism that was identified was CONS. A study at Mansoura University Hospital showed that CONS bacteria were the most often isolated bacteria in EOS, followed by Klebsiella pneumoniae bacteria [19]. A research group at Alexandria found that Gram-negative bacteria were more often identified in EOS and LOS. There were 73.6% Gram-negative bacteria, according to the research. This is according to a study done by Gaballah et al. (2022) [20]. Seventy-four percent of all instances of EOS in England over the time period covered by the NeonIN monitoring network were caused by gram-positive pathogens [21].

In the present research, the capillary refill time of patients suffering from newborn sepsis was shown to be significantly longer than that of the group serving as the control. Another study found that a prolonged capillary refill is a predictor of severe sepsis and a bad outcome in sepsis patients [22]. Children who had a prolonged capillary refill time had a mortality risk that was four times higher than the mortality risk of children whose capillary refill times were normal, according to a systematic review and meta-analysis [23].

Platelets were also observed to be considerably decreased in individuals with newborn sepsis compared to those who served as controls in the present research. This is consistent with a previous research result that was performed at a level III NICU at a Maternity and Children Training and Research Hospital [(24)]. According to the findings of several research [(25,26),] thrombocytopenia is a well-recognized component of both newborn sepsis and severe pediatric sepsis.

The present research found that individuals with newborn sepsis had WBC levels that were substantially greater than those seen in controls. According to the findings of several investigators, leukocytosis or leukopenia was thought to be a reliable sign of infection. However, it is now recognized that these markers are insensitive [(27).]

In the present research, patients who were diagnosed with neonatal sepsis had considerably greater LVO, RVO, and SVC flow than controls did. In addition, we discovered that gram-negative sepsis was much larger in LVO, RVO, and SVC flow than gram-positive sepsis. Upon further investigation according to the onset of sepsis, it was found that the RVO, LVO, and SVCF were statistically higher significantly in gram-negative LOS than in gram-positive LOS; however, there were no statistically significant differences found between gram-negative and gram-positive EOS. In a separate piece of research, the RVO, LVO, and SVCF of twenty premature babies who exhibited indications of cardiovascular impairment and were thought to have an infection were assessed. The newborns that were diagnosed with sepsis had relatively high cardiac outputs on both the left and right sides of their hearts, although they had a low systemic vascular resistance (SVR) [(28).]

In the research that was conducted by Murase and colleagues, echocardiographic examinations were carried out in a sequential fashion beginning at birth and continuing until 28 days on thirteen Very Low Birth Weight (VLBW) neonates that had been identified as having prenatal infections at birth. At 12 and 72 hours of life, LVO was considerably greater in the group exposed to the infectious agent compared to the group with no exposure to the infectious agent [(29).]

In addition, Deshpande and colleagues observed that the RVO and LVO of newborns diagnosed with LOS had values above the normal range and that patients diagnosed with gram-negative sepsis had RVO and LVO values that were even higher than the normal range. The elevated LVO, RVO, and SVC flow in gram-negative sepsis can be explained by the difference in host response and pathophysiology during gram-positive and negative bacteremia, which explains the differences in their hemodynamics [(30)]. In the research carried out by Saini S. et al. utilizing FnECHO on preterm babies with septic shock, it was discovered that LVO levels were significantly increased. In their work, gram-negative bacteria were more prominent, and the most prevalent bacteria identified was Klebsiella pneumoniae [(31)].

Normal volunteers were given intravenous pure lipopolysaccharide so that Suffredini and his colleagues could study the hemodynamic effects of endotoxins (Escherichia coli) in humans. These endotoxins were administered in the form of an injection. Following the administration of endotoxin for three hours and prior to the loading of volume, the mean blood pressure, and systemic resistance both fell by 18 and 46 percent, respectively [(32)].

According to the findings of an investigation that was carried out by Abtahi and Jafari, the Tei indices of the RV and the LV were noticeably greater in septic newborns in comparison to non-septic neonates [(33)]. According to Abdel-Hady and colleagues, the TDI (Tissue Doppler Imaging) indices of global myocardial function (RV and LV Tei indexes) were substantially greater in septic babies as compared to the controls, however, the atrioventricular annular systolic velocities were significantly lower [(34)].

In a different study involving 30 children who were suspected of having a septic shock that is fluid resistant and were admitted to pediatric critical care, it had been noted that patients with infections associated with central catheters had a decreased SVR and increased cardiac index resulting in warm shock. Patients who had community-acquired sepsis, on the other hand, were more likely to have a cardiac index that was normal or low [(35)].

There was no statistically significant difference seen in the RVO, LVO, or SVCF between term and preterm newborns who were diagnosed with sepsis. In their work on infants with LOS, Deshpande et al. showed similar results regarding RVO and LVO. [30].

In the research that we conducted, we did not find any statistically significant differences in the RVO, LVO, or SVCF between the neonates who survived sepsis and those who did not. According to the research conducted by de Waal and Evans on preterm children with LOS who had serial measures of RVO, LVO, and SVCF, an association between mortality and a drop in RVO or LVO of more than 50 percent compared with the first measurement was found [28].

The fact that this research is one of the very few case-control investigations employing functional echocardiography to investigate flow in RVO, LVO, and SVC in newborns diagnosed with sepsis is the primary point of strength in the investigation. However, the most significant drawbacks include the limited sample size, the fact that the research was only carried out at a single facility, and the use of a single measurement to determine RVO, LVO, and SVCF.

5. Conclusions:

This study concluded that neonates with sepsis show high LVO, RVO, and SVC flow as detected by functional echocardiography. The cardiac output levels are generally higher in gram-negative than in gram-positive sepsis and in gram-negative LOS than in gram-positive LOS. Survived and non-survived neonates with sepsis did not show significant differences in RVO, LVO, or SVC flow. Significant cardiovascular complications are common in neonatal sepsis.

Recommendations:

For early diagnosis of cardiovascular problems in newborn sepsis and to guide treatment choices, functional echocardiography is assumed to be seen as an extension of the clinical examination. More precise diagnosis and treatment are possible as a result. Intensivists working in the NICU might benefit from taking part in a training program for functional echocardiography. More population-wide multicenter studies measuring

RVO, LVO, and SVCF more than once in newborns with sepsis are encouraged.

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