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Hemodynamic Monitoring In Critically Ill Patients in Paediatric ICU

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REVIEW

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ABSTRACT

Background

Monitoring hemodynamic in septic shock in pediatric age group. Aim of study was to compare the effects of dopamine, nor-epinephrine and epinephrine.

Results

Sixty patients were divided into three groups according to vasoactive drug used dopamine, adrenaline or noradrenaline and subjected to measure cardiac functions by echocardiography. Differences between three groups were significant regarding vital data (MAP) and echocardiography parameters (EF & FS & SV) and blood gases and oxygenation parameters (P-value <0.001).

Conclusion

The use of echocardiography can help to differentiate type of septic shock and in choosing and escalating vasoactive drug.

Key Words

Septic shock, vasoactive drug dopamine, Adrenaline, Noradrenaline, Hemodynamic, Echocardiography, Blood gases.

Introduction

Sepsis is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection and "septic shock" the subset of sepsis with circulatory and cellular/metabolic dysfunction associated with a higher risk of mortality[1].

Sepsis is a major public health concern, accounting for more than $20 billion (5.2%) of total united state hospital costs in 2011 [2]. The reported incidence of sepsis is increasing likely reflecting more co morbidities, greater recognition[3]. Although the true incidence is unknown, conservative estimates indicate that sepsis is a leading cause of mortality and critical illness worldwide[4].

Early diagnosis and prompt treatment have the greatest impact on clinical course and patient outcome. Early recognition of septic shock and institution of antibiotic therapy, fluid therapy and vasoactive medications can reduce mortality in children, furthermore may prevent the child from entering uncompensated or irreversible shock[5].

It is reasonable to begin vasoactive infusions after 40–60 mL/kg of fluid resuscitation if the patient continues to have evidence of abnormal perfusion, or sooner if fluid overload develops[6].

In pediatrics, selection of the appropriate vasoactive agent should be driven by the clinical features of a patient's presentation with either low cardiac output and high systemic vascular resistance ("cold shock") or high cardiac output and low systemic vascular resistance ("warm shock"). Dopamine and epinephrine should be used to improve cardiac output in "cold shock," whereas norepinephrine should be preferentially used to increase SVR in patients with warm shock[7].

Echocardiography is a rapid, noninvasive, comprehensive cardiac assessment option for patients presenting with hemodynamic instability. Sepsis-induced myocardial dysfunction can be diagnosed, and responses to therapy can be monitored with echocardiography[8].

Methods

This study aims to monitor hemodynamic in septic shock in pediatric age group and to compare the effects of dopamine, nor-epinephrine and epinephrine.

This prospective observational study included 60 patients (male& female) with septic shock presented to Pediatric Intensive Care Unit, Children's hospital, Ain Shams University who recruited randomly from March 2019 to

March 2020 after fulfilling inclusion criteria.

Inclusion and exclusion criteria

The inclusion criteria of these patients included

Patients within paediatric age group at time of enrolment aged between 30 days and 18 years. Patient presented with sepsis according to pSOFA score system at time of enrolment

Exclusion criteria included

Any structural heart disease either congenital or acquired, macrophage activation syndrome, chronic kidney disease, known Raynaud's phenomenon, after gastrointestinal surgery or having inflammatory bowel disease or other chronic disease affecting gastro intestinal tract.

Samples

The sample sizes calculate by PASS program, type-1 error (α) / 5%, power (1-β) at 90%. Based on a previous study (9), the needed sample was 60 cases.

Study procedures

Study population included Sixty Paediatric Patients admitted to Paediatric Intensive Care Unit (PICU) Ain Shams University Hospitals fulfilling criteria of septic shock. Those patients were divided randomly into three groups (group A, B, C) according to the vasoactive agent used.

Group (A)

Twenty patients had septic shock had started dopamine infusion at dose ranging between 5-20 mic/kg/min The dose titrated at increases of 1µg/kg/min to achieve and maintain goal directed therapy.

Group (B)

Twenty patients had septic shock had started noradrenaline infusion at dose ranging between 0.05-2 mic/kg/min. The dose titrated at increases of 0.1µg/kg/min to achieve and maintain goal directed therapy.

Group (c)

Twenty patients had septic shock had started adrenaline infusion at dose ranging between 0.05-2 mic/kg/min. The dose will be titrated at increases of 0.1µg/kg/min to achieve and maintain goal directed therapy.

Titration of dose or combination therapy had been done if failed to achieve goal directed therapy.

The following was done for all patients fulfilling the inclusion criteria include detailed history, physical examination, laboratory investigations, recording of blood pressure, pulse, peripheral Temperature Urine output, central venous pressure (CVP) and pSOFA score.

Echocardiography to measure ejection fraction, fraction shortening, stroke volume and cardiac index at initiation and at the termination of 24 hour after starting vaso active drug.

Statistical analysis

Data analyzed using SPSS 20). Median and Interquartile range for quantitative non-parametric data. Qualitative data, Frequency and percentage used. Student T-Test or Mann Whitney test used for quantitative data while chi-square test and Fisher exact test used for qualitative data. $P < 0.05$.

Results

No significant difference among patients groups who received dopamine, noradrenaline or adrenaline regarding to age, weight, height and gender was found in the study (Table 1).

Vital data

There was a statistically significant difference in mean blood pressure between three groups as shown in (Table 2).

As regards the blood gas (ABG) there was a significant difference regarding the outcome between the two groups in pH, PaO2, PaO2/FiO2 (P/F) ratio and base excess as shown in (Table 3).

As regards the echocardiography paramaters there was a significant difference regarding the outcome between the three groups in SV, EF and FS as shown in (Table 4).

Discussion

In our study, we sought to monitor hemodynamic in septic shock patients in pediatric age group and to compare the effects of dopamine, nor-epinephrine and epinephrine on cardiac hemodynamic.

Prospective observational study included 60 patients with septic shock presented to Pediatric Intensive Care Unit, Children's hospital, Ain Shams University who were enrolled after consideration of inclusion and exlusion criteria. They were evaluated before starting vasoactive drug and after twenty four hours[9].

In our study male to female ratio was 1:1 with median age ranging in three groups between 11- 27 months.

In our study mechanical ventilation was needed in 48 patients (80%). In agreement with our study Razzaque et al. reported that mechanical ventilation was recorded in 75(75%) in his prospective study to evaluate 100 patients suffering from septic shock with mean age the as 2.16±3.26 years[10].

Concerning the mean readings of vital data obtained before and after twenty four hours of initiating vasoactive medication, our analysis showed that mean blood pressure

values were significantly higher in patients in noradrenaline group compared to other groups (P-value < 0.000).

This is consistent with Baske et al. Which stated that septic shock patients who received noradrenaline had mean blood pressure higher than who received adrenaline[11].

On the other hand Ventura et al. Recorded higher mean blood pressure in 120 children septic patients, who received adrenaline compared to others who received dopamine. This variation may be due to the variable nature and severity of the major disease and various ages of the sample population[12].

Regarding ABG data were recorded before and after twenty four hours of starting inotropic medications, our study showed significantly lower pH, PaO2 and lower P/F ratio in the adrenaline group in comparison to noradrenaline and dopamine groups.

This is consistent with Becker et al. Who reported a high statistically significant difference between the studied groups regarding PaO2 & P/F ratio [13]. Also, Labib et al. found that ABG parameters including PaO2, PaO2/FiO2 were significantly lower in septic patients who received adrenaline than those who received dopamine or terlipressin.

Several studies had used other indices of oxygen supply and delivery in patients with septic shock and comparing their levels before and after treatment[14]. Who reported that patients who received dopamine showed a significantly higher increase in post-treatment index of oxygen delivery compared to patients who received adrenaline?.

In our study, there was a statistically significant difference between the echocardiography parameters that were recorded before and after twenty four hours of starting inotropic medications, in the form of higher EF, FS, SV in the adrenaline group in comparison to noradrenaline and dopamine groups.

In agreement with our study[15]. Showed left ventricular ejection fraction was significantly higher in group who received adrenaline at the end of the study.

Several studies get to the conclusion of ejection fraction and fractional shortening improved after receiving fluid and different inotroping management. One of these studies[16]. Who found that ejection fraction and shortening fraction improved after adrenaline infusion?. But this study has some limitations as heterogeneity of the population both for indications and age and samples size is small. Larger studies which include all ages are recommended.

Conclusion

The use of echocardiography can help to differentiate type of septic shock and in choosing and escalating vasoactive drug

Adrenaline is more effective than noradrenaline and dopamine in improving cardiac function. However noradrenaline is more potent on blood pressure

Abbreviations

HR: Heart rate; MAP: Mean arterial blood pressure; CVP: Central venous pressure; EF: Ejection fraction; FS: fractional shortening; SV: Stroke Volume; PICUs: Pediatric Intensive Care Units; FiO2: Fraction of inspired oxygen; RR: Respiratory Rate; PaO2: Partial pressure of oxygen (mmHg); PaO2 / FiO2: Partial pressure of oxygen/ fraction of inspired oxygen.

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Figures and Tables

Table 1: **Demographic data of studied groups**

Character	Dopamine group (n=20)	Noradrenaline group (n = 20)(%)	Adrenaline group (n =38)(%)	P-value	Sig
Age (months) Median((IQR)	27.5 (6-48)	21 (9.5-48)	11 (8-42)	0.721	NS
Weight Median (IQR)	8.8 (5.4-14)	10.5 (8-13.5)	8.6 (7.4-11)	0.310	NS
Height Median(IQR)	75.5(60-98.5)	82(69-96.5)	71.5(65.5-89.5)	0.549	NS
Body surface area Median (IQR)	0-4(0.3-0.6)	0.5 (0.4-0.6)	0-4(0.4-0.5)	0.393	NS
Sex: **Male** **Female**	8 (40) 12(60)	10 (50) 10 (50)	11 (55) 9 (45)	0.627	NS
Age (month), Weight (kg), Height (cm), Body surface area (m2) Data presented as median ± IQ, P-value > 0.05 Non significant (NS), *P value < 0.05 Significant (S).					

Table 2: **A comparison between the three studied groups regarding the vital data.**

Vital Data	Dopamine group (n=20)	Noradrenaline group (n = 20)(%)	Adrenaline group (n =38)(%)	P-value	Sig
HR Mean (confidence interval)	135.1 (132.3-137.9)	137.8 (135.2-140.3)	139.3 (136.7-142)	0.116	NS
MAP Mean (confidence interval)	63.74 61.85 - 65.63)	69.36 (67.37 - 71.43)	67.66 (65.8 - 69.71)	0.000**	HS
CVP Mean (confidence interval)	7.54 (6.88 - 8.2)	8.39 (7.78 – 9.01)	8.65 (8.02-9.23)	0.066*	NS
Temp Mean (confidence interval)	36.91 (36.76-37.04)	36.96 (36.83-37.10)	36.79 (36.66-36.93)	0.205	NS
UOP Mean (confidence interval)	3.84 (3.12 – 3.84)	3.50 (3.17 – 3.84)	3.06 (3.72 – 3.40)	0.129	NS
MBP: mean blood pressure (mmHg), HR: heart rate (beat/min), RR: respiratory rate (breath/min), urine output: (cc/kg/hr), P-value > 0.05 Non significant (NS), *P value < 0.05 Significant (S), **P-value < 0.001 Highly Significant (HS).					

Table 3: **A comparison between the three studied groups regarding the ABG parameters and oxygen index.**

ABG Parameters	Dopamine group (n=20)	Noradrenaline group (n = 20)(%)	Adrenaline group (n =20)(%)	P-value	Sig
pH Mean (confidence interval)	7.30 (7.28-7.32)	7.32 (7.30-7.33)	7.28 (7.26-7.30)	0.031*	S
P_aO_2 Mean (confidence interval)	98.84 (95.96-101.72)	97.51 (94.82 -100.20)	93.80 (91.05-96.54)	0.04*	S
P_aO_2/F_iO_2Ratio Mean (confidence interval)	206.23 (189.51-222.95)	210.16 (194.53-225.79)	174.21 (158.29-190.13)	0.003*	S
Base Excess Mean (confidence interval)	-1.56 (-2.82- -0.314)	-3.03 (-4.26 - -1.80)	-6.88 (-8.20 - -5.57)	0.000**	HS
ABG: Arterial blood gas, pH: Potential hydrogen, PaO2: Partial pressure of oxygen in arterial blood (mmHg), PaCo2: Partialpressure of carbon dioxide in arterial blood (mmHg), P/F: PaO2/FiO2. P-value > 0.05 Non significant (NS), *P value <0.05 Significant (S), **P-value < 0.001 Highly Significant (HS).					

Table 3: A comparison between the three studied groups regarding the ABG parameters and oxygen index.

Eccho Parameters	**Dopamine group (n=20)**	**Noradrenaline group (n = 20)(%)**	**Adrenaline group (n =20)(%)**	**P-value**	**Sig**
SV Mean (confidence interval)	10.17 (8.93 – 11.41)	9.46 (8.31 – 10.67)	11.54 (10.38 – 12.70)	0.041*	**S**
EF Mean (confidence interval)	54.81 (53.24 -56.37)	51.92 (50.46-53.39)	54.99 (53.54 -57.37)	0.021*	**S**
FS Mean (confidence interval)	27.04 (26.19-27.90)	25.28 (24.46 -26.09)	27.25 (26.39-28.12)	0.01*	**S**
LVOT VTI Mean (confidence interval)	14.58 (14.04 - 15.21)	14.87 (14.36 - 15.37)	14.91 (14.40 - 15.42)	0.675	NS
CI Mean (confidence interval)	2.83 (2.72 - 2.94)	2.64 (2.54 - 2.75)	2.75 (2.65 - 2.86)	0.058	NS
SV: stroke volume (mml), EF: ejection fraction (%), FS: fractional shortening (%), LVOT VTI: Left Ventricular Outflow Tract Time Velocity Index , CI: Cardiac Index . P-value > 0.05 Non significant (NS), *P value < 0.05 Significant (S), **P-value < 0.001 Highly Significant (HS).					

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