Evaluation of the results of the patients who underwent plasmapheresis in the paediatric intensive care unit

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Abstract

Background/aim: Therapeutic plasma exchange (TPE) is an extracorporeal treatment method that removes large molecular weight substances from plasma. In our study, we aimed to retrospectively examine the indications and procedural methods of the patients who had undergone TPE, and the complications that occurred during the procedure.

Materials and methods: 41 patients followed in PICU with TPE indication between 2017-2021 were included in the study. Laboratory parameters were checked before and after TPE procedure. In addition to these, patients' diagnosis, weight, type of procedure and type of device where the procedure was performed, duration of the procedure, amount of blood and plasma processed, complications, number of procedures, and death during the procedure or independent of the procedure were evaluated.

Results: The median age was 93.0 (14.0-167.0) months. Haemolytic Uraemic Syndrome (HUS) was the most common TPE indication with nine patients. The most common complication related to TPE was fever (11 patients), while no complication was observed in 18 patients.

When laboratory results were evaluated according to ASFA categories, a significant improvement was observed in the values of Platelet, AST, ALT, LDH, urea and creatinine in ASFA1 after TPE. No significant improvement was observed in ASFA2 ($p>0.05$). In ASFA3, a significant improvement was observed in INR, AST, ALT, LDH, total bilirubin, creatinine, pH and lactate values after TPE ($p<0.05$). 5 patients from ASFA1, one from ASFA2, and three patients from ASFA3 died.

Conclusion: Since significant adjustments are observed in clinical and laboratory values in sepsis-MOF, which is in the ASFA3 category, we believe that it should be evaluated in the ASFA2 or ASFA1 category in the early treatment of these diseases. In addition, we

think that MIS-C cases, which have not been in any category according to ASFA, should be included in the ASFA2 or ASFA3 category, considering our TPE results.

Key words: Therapeutic plasma exchange, paediatric intensive care unit, mortality, multisystem inflammatory syndrome

1. Introduction

Therapeutic plasma exchange (TPE) is an extracorporeal treatment method that removes large molecular weight substances from plasma. The patient's blood is taken into the

extracorporeal system, and the plasma and cellular elements of the blood are separated from each other. Fresh frozen plasma (FFP), albumin or crystalloid-colloid combinations are substituted for the separated plasma. During the procedure, it is combined with the cell-rich part of the blood and given back to the patient [1].

TPE is performed using one of 2 methods: centrifugal separation or membrane-based (filtration) separation and no method is superior to the other [2]. Target molecular properties such as large molecular weight increase the effectiveness of TPE. This feature makes TPE superior to other extracorporeal therapeutic modalities. Features such as slow formation rate, low turnover, low volume of distribution, and a defined etiological agent may also constitute target molecule properties suitable for TPE [3].

According to the diagnoses, TPE is performed based on the category variables determined by the American Society for Apheresis (ASFA). The ASFA category variables were updated in 2019 and are subject to change every 3 years (Table 1). According to these categories, diseases in which TPE is the primary treatment method fall in ASFA1, diseases in which TPE is the second-line treatment method, alone or together with other treatment methods, in ASFA2, diseases in which the optimum role of TPE cannot be determined in ASFA3, and diseases in which apheresis is shown or suggested to be ineffective or harmful according to published evidence in ASFA4, that is, apheresis treatment applications in such situations should only be performed under approved research protocols [2].

When TPE indications were examined in paediatric intensive care units (PICU), while neurological diseases were in the first place in previous years, it is more frequently applied in sepsis-related multi-organ failure (sepsis-MOF) today [4,5]. The ASFA criteria classify sepsis-MOF cases under category 3 (diseases for which the optimal role cannot

be definitively determined). It has been found that TPE procedures are performed more frequently in patients with a diagnosis of sepsis-MOF [2,6,7].

Liver failure is a rare but fatal clinical condition seen in the paediatric age group. It manifests itself with clinical and laboratory findings such as hepatic encephalopathy, hepatic cardiopathy, hepatorenal syndrome, coagulopathy, especially caused by substances such as toxins, aromatic amino acids, ammonia, endotoxins, and indoles. Therapeutic plasma exchange for liver failure is done as a bridge therapy to save time for liver transplantation or for therapeutic purposes that facilitate complete recovery. TPE is among the first-line treatments for fulminant liver failure, especially in cases of life-threatening coagulopathy and bleeding [8].

Plasma exchange is effective in the treatment of disease by eliminating circulating antibodies associated with the disease in the plasma. In autoimmune haemolytic anaemia, plasmapheresis is recommended as a third-line treatment in patients who urgently need transfusion until the effect of immunosuppressive treatments is observed, and in patients who fail immunosuppressive therapy and splenectomy and whose disease recurs [9,10].

In May 2020, a national health guide was published by the Centres for Disease Control and Prevention (CDC) to identify patient groups meeting criteria for multisystem inflammatory syndrome (MIS-C) in children. According to this definition, MIS-C occurs approximately 4-6 weeks after acute SARS-CoV-2 infection and is a disease that develops with an excessive immune response triggered by infection, rather than an acute manifestation of viral disease[*] Intravenous immunoglobulin (IVIG), pulse steroid and plasmapheresis are effective in its treatment [11].

[*] Centers for Disease Control and Prevention Health Alert Network (HAN)Multisystem inflammatory syndrome in children (MIS-C) associated with coronavirus disease 2019 (COVID-19). Available at https://emergency. cdc.gov /han/ 2020/han00432.asp accessed on 5 November 2020.

The complication rate associated with the TPE procedure is between 0.2-0.025%. Serious life-threatening complications are collected in two groups. The first group is catheter-related complications, catheter-related thrombosis, haemorrhage, infection, pneumothorax, and mechanical complications. The second group is procedure-related complications, hypotension requiring catecholamine, arrhythmia requiring drug therapy, and haemolysis. Non-life-threatening complications are hypotension, fever, urticaria, hypercalcaemic findings, itching, tachycardia, nausea, vomiting, abdominal pain, anxiety, and muscle cramps that do not require catecholamines [12].

In our study, we aimed to retrospectively examine the indications and procedural methods of the patients who had undergone TPE, and the complications that occurred during the procedure.

2. Materials and methods

41 patients followed in Gazi Yaşargil Training and Research Hospital PICU with TPE indication between 01.01.2017 and 27.10.2021 were included in the study. Demographic data and pre- and post-procedural laboratory parameters of the patients were recorded. The effects of the applied procedure on the effectiveness, safety and life span were examined. Laboratory parameters (Biochemistry, Hemogram, Coagulation and Blood gas) were checked before and after TPE procedure. In addition to these, patients' diagnosis, weight, type of procedure and type of device where the procedure was performed, duration of the procedure, amount of blood and plasma processed, complications, number of procedures, and death during the procedure or independent of the procedure were evaluated. Patients who were in another study and were older than 18 years were excluded from the study.

TPE procedure was applied to the patient at the bedside in the PICU by placing a central venous catheter providing adequate blood flow. Central venous route was used in all patients, and peripheral route was not used. The total number of TPE procedures to be performed on the patients and the session intervals were determined according to the clinical and laboratory response of the patients. Total plasma volume: Total blood volume was found using the x (1-haematocrit) formula. The amount of replacement fluid was calculated as 1 or 1.5 times the plasma volume calculated according to the clinical condition of the patients. FFP was used in therapeutic plasmapheresis procedures. TPE procedures were performed with a Prismaflex 2015 model automatic apheresis device using venous access.

The data of the patients were shown in the study as descriptive data, and as n, % values, and median interquartile range (25-75 percentile values) in categorical data. The normality analysis of the data was done with the Shapiro Wilk test. Wilcoxon analysis was performed to compare the values before and after plasmapheresis. The statistical significance level in the analyses was accepted as $p<0.05$.

Approval for the study was obtained from the ethics committee of Diyarbakır Gazi Yaşargil Training and Research Hospital, with the date of 26.11.2021 and number 935.

3. Results

A total of 41 patients, 23 of whom were male, who underwent TPE were included in the study. Three of these patients were the ones we accepted to our unit for the TPE procedure while they were being followed up in other centres. The median age was 93.0 (14.0-167.0) months. Haemolytic Uraemic Syndrome (HUS) was the most common TPE indication with nine patients. Eight of the patients were hospitalised in the PICU with the diagnosis of Gullian Barre Syndrome, eight MIS-C, five liver failure, three sepsis-MOF, two acute

disseminated encephalomyelitis (ADEM), two autoimmune haemolytic anaemia, two autoimmune encephalitis, one hypertriglyceridemia, and one drug intoxication. When the ASFA classification of the patients was examined, it was determined that 19 of them were category 1, 3 were category 2 and 11 were category 3 (Table 2). Eight of our patients were not included in the ASFA category because of MIS-C.

A total of 119 sessions of TPE were performed. Standard TPE was applied to 28 (56%) patients at a one-to-one ratio, and 13 (26%) patients at a one-to-one-half ratio. The mean plasma volume given during the procedure was 1514.39±1111.26 ml. Twenty-seven of the patients who underwent TPE responded to the treatment and were transferred to the service. 23 received mechanical ventilator (MV) support, 5 patients were transferred to their own centre after TPE procedure, and 9 patients died. Ten of the patients did not receive additional treatment, 19 received intravenous immune globulin (IVIG), 6 received hemodiafiltration, 5 received peritoneal dialysis, and 1 (2.4%) received pulse steroids. The most common complication related to TPE was fever (11 patients), while no complication was observed in 18 patients. None of our patients died due to the TPE procedure (Table 3).

The comparison of pre- and post-procedural blood values of the patients who underwent TPE is given in Table 4. Platelet ($p=0.035$) and active partial thromboplastin time test (aPTT) ($p<0.001$) values of the patients increased significantly after TPE procedure. The aPTT increase may be due to the use of heparin anticoagulation during the TPE procedure. Prothrombin time test (PTZ) ($p=0.01$), International Normalized Ratio (INR) ($p=0.001$), Aspartate Aminotransferase (AST) ($p<0.001$), Alanine Aminotransferase (ALT) ($p<0.001$), Lactate Dehydrogenase (LDH) ($p<0.001$), total bilirubin ($p=0.032$), urea ($p<0.001$) and creatinine ($p<0.001$) values of patients decreased significantly after TPE.

When laboratory results were evaluated according to ASFA categories, a significant improvement was observed in the values of Platelet, AST, ALT, LDH, urea and creatinine in ASFA1 after TPE ($p<0.05$). No significant improvement was observed in ASFA2 ($p>0.05$). In ASFA3, a significant improvement was observed in INR, AST, ALT, LDH, total bilirubin, creatinine, pH and lactate values after TPE ($p<0.05$). Similar to the patients in the ASFA category, MIS-C patients showed significant improvement in neutrophil-lymphocyte ratio (NLR), thrombocyte, PTz, INR, AST, ALT, LDH, Urea, creatinine, pH and lactate values ($p<0.05$) (Table5)

Two of our patients who underwent plasmapheresis due to liver failure were referred to an advanced centre due to the need for liver transplantation. We transferred our three patients whose plasmapheresis procedure was completed to the centre where they were followed up after the procedure.

5 patients from ASFA1, one from ASFA2, and three patients from ASFA3 died. Seven of our patients who died 48-72 hours after the TPE procedure, and two died after the 7th day.

4. Discussion

Eleven of the patients in our study were in the ASFA3 category. The ASFA3 category includes sepsis-MOF, Liver failure, IgA nephropathy, Focal segmental glomerulosclerosis, Hemophagocytic Lymphohistiocytosis. The majority of our patients in ASFA3, in which we applied TPE, consisted of hepatic failure and sepsis-MOF cases. We lost one patient from each of these two disease groups, and the reason for these losses was not due to the TPE procedure. In cases in ASFA3, laboratory and clinical improvement was better than ASFA1 and ASFA2 (Table 5). It is not clear whether the cases in the ASFA3 category will benefit from the TPE procedure. Considering our own

cases, we observed that the results of the procedure were at least as effective as the cases of ASFA1 and ASFA2. As a matter of fact, Emeksiz et al. reported in their study that 76.2% of the patients to whom TPE was applied were ASFA category 3 diseases. Again, in the same study, they applied TPE to 23 (53.5%) patients due to sepsis-MOF and they discharged 19 (82.6%) of the patients [6]. Similarly, in our study, we applied TPE to three patients due to sepsis-MOF and discharged two (66.7%) patients.

Keskin et al. emphasised that the combination of IVIG, steroid, and plasmapheresis could be lifesaving in a patient diagnosed with MIS-C and having cardiac involvement [11]. In our study, clinical improvement was achieved in 7 patients (87.5%) who were treated with IVIG as well as plasmapheresis amongst the 8 patients diagnosed with MIS-C and had cardiac and/or cerebral involvement, and one patient (12.5%) died 48 hours after plasmapheresis. Laboratory improvement in MIS-C cases was similar to that in the ASFA3 category. We performed plasmapheresis in MIS-C disease because of thrombotic microangiopathy secondary to inflammation and multi-organ involvement. The diagnosis of MIS-C was not yet in any category according to ASFA at the time we authored our study. We observed that the results of the procedure were as effective as the ASFA2 and ASFA3 cases in our MIS-C patients who underwent TPE. In the light of the data we obtained from our study, it was evaluated that it would be appropriate to include MIS-C disease in the ASFA 2 or 3 category.

The use of TPE in the treatment of immune-mediated renal diseases is increasing. It is suggested that the early implementation of TPE in adult patients will improve the prognosis of HUS [13]. In a study reporting TPE application in children, 2 of 43 (4.6%) patients were diagnosed with haemolytic uraemic syndrome (9). In our study group, TPE was applied to 9 (22%) patients with the most common diagnosis of atypical haemolytic

uraemic syndrome. Three of these patients (33.3%) died due to sepsis and pneumonia in their subsequent clinical follow-up.

TPE treatment applied in patients diagnosed with Guillain Barre Syndrome accelerates the recovery in motor nerves and reduces the duration of mechanical ventilation [4,6]. In various studies, between 9.4% and 46.4% of the cases who underwent TPE procedure were patients with a diagnosis of GBS [4,6,14]. Eight of the patients in our study group underwent TPE due to GBS. Clinical improvement was achieved in seven of these patients (87.5%), tracheostomy was performed in two of our patients, and one of them died due to pneumonia 11 days after the plasmapheresis procedure.

Larsen et al., in their study on adults, showed that plasmapheresis treated patients with acute liver failure without undergoing liver transplantation [15]. In another study, it was reported that TPE can be applied in cases where there is no response to other treatments in hepatic failure due to sepsis [16]. In our study, two of the 5 patients who underwent TPE due to liver failure were discharged, two were transferred to the transplantation centre, and one patient died. The satisfactory response of the patients to the treatment was evaluated in line with this result.

In our study, TPE was performed in one patient for intoxication due to carbamazepine intake, and in one patient for pancreatitis due to hypertriglyceridemia. Consistent with the literature, clinical improvement was observed in both cases [17-19].

Studies have shown that TPE may be beneficial in patients with autoimmune haemolytic anaemia (AIHA) who do not respond to steroid and intravenous immunoglobulin (IVIG) treatment [10,20]. In our study, we applied TPE to 2 cases due to AIHA. In the acute period, clinical improvement was achieved in both patients, and they were discharged with steroid treatment.

Studies have reported that the complication rate of TPE in paediatric patients is 1-40% [21]. In a study by Tolunay et al., the most common complication was hypotension with a rate of 29.2% (12/41). Allergic reactions such as urticaria and fever were 9.7% (4/41) and hypertension 4.8% (2/41). Again, in the same study, they did not observe any catheter-related complications, and none of their patients died due to the plasmapheresis procedure [4]. In our study, complications were observed in 23 (56%) patients. Allergic reactions such as urticaria and fever were the most common complications in 34.1% (16/41). No catheter-related complications were observed.

In studies, mortality due to TPE was reported as 0.05%. However, in addition to this information, it was stated that the cause of death of these patients included in the study was due to underlying diseases [22]. In our study, none of the patients died due to the TPE procedure.

The limitation of our study is that it is single-centred, and the sample size is not large enough to make a healthy evaluation.

As a result, we can say that TPE, which is applied in addition to standard treatments in underlying autoimmunity diseases, liver failure, and sepsis-MOF, increases survival rates and is beneficial for prognosis. Differences in plasmapheresis experiences of each centre can be observed. Since significant adjustments are observed in clinical and laboratory values in sepsis-MOF, which is in the ASFA3 category, we believe that it should be evaluated in the ASFA2 or ASFA1 category in the early treatment of these diseases. In addition, we think that MIS-C cases, which have not been in any category according to ASFA, should be included in the ASFA2 or ASFA3 category, considering our TPE results.

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Table 1: ASFA categories by diagnosis

Diagnosis	ASFA 2019 category
Hemolytic Uremic Syndrome	I
Guillain Barre Syndrome	I
Autoimmune Encephalitis	I
Acute Disseminated Encephalomyelitis	II
Intoxications	II-III
Sepsis, multiple organ failure	III
Liver failure	III
IgA nephropathy, Focal segmental Glomerulosclerosis	III
Hemophagocytic Lymphohistiocytosis	III

ASFA; American Society for Apheresis

Category I: Diseases for which Therapeutic plasma exchange (TPE) is the primary treatment method on its own
Category II: Diseases in which TPE is the second-line treatment method, alone or together with other treatment methods.
Category III: Diseases in which the optimum role of TPE cannot be determined in
Category IV: Diseases for which apheresis is shown or suggested to be ineffective or harmful based on published evidence. Apheresis treatment practices in this situation should only be performed under approved research protocols.

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Table 2. ASFA categories and diagnoses of the patients					
	n (%)	**Diagnosis**	**n (%)**	**Exitus n(%)**	**Exitus n(%)**
ASFA Category 1	**19 (46.3)**	**Hemolytic Uremic Syndrome**	9 (22.0)	3 (7.3)	5 (12.2)
		Guillain Barre Syndrome	8 (19.5)	1 (2.4)	
		Autoimmune Encephalitis	2 (4.9)	1 (2.4)	
ASFA Category 2	**3 (7.3)**	**Acute Disseminated Encephalomyelitis**	2 (4.9)	1 (2.4)	1 (2.4)
		Intoxications	1 (2.4)	-	
ASFA Category 3	**11 (26.8)**	**Liver failure**	5 (12.2)	1 (2.4)	3 (7.3)
		Sepsis, multiple organ failure	3 (7.3)	1 (2.4)	
		Autoimmune hemolytic anemia	2 (4.9)	-	
		Hypertriglyceridemia	1 (2.4)	-	
MIS-C	**8 (19.5)**			1 (2.4)	1 (2.4)
ASFA; American Society for Apheresis, MIS-**C:** Multisystem inflammatory syndrome in children					

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Table 3. All characteristics of the patients			
		Person	**%**
Gender	**Female**	18	43.9
	Male	23	56.1
Age,months, Mean (IQR)		93.0 (14.0-167.0)	
Body surface area, Mean (IQR)		.9 (.4-1.6)	
Application period, hours, Mean (IQR)		6.0 (4.0-9.0)	
Number of applications, Mean (IQR)		2.0 (2.0-4.0)	
Glasgow Coma Scale, Mean (IQR)		12.0 (10.0-15.0)	
Pediatric Risk of Mortality Score, Mean (IQR)		15.0 (11.0-19.0)	
Exitus		11	26.8
Mechanical Ventilator support		23	56.1
Time on Mechanical Ventilator, hours, Mean (IQR)		11.0 (6.0-22.0)	
ICU length of stay,days, Mean(IQR)		13.0 (7.0-24.0)	
Length of stay in hospital, days, Mean (IQR)		18.0 (12.0-39.0)	
Complication	**High body temperature**	11	26.8
	Rash, allergic reaction	6	14.6
	Hypotension	3	7.3
	Hypertension	2	4.9
	Hypovolemia	1	2.4
	Without complications	18	43.9

Additional treatment	**Intravenous immunoglobulin**	19	46.3
	Hemodiafiltration	6	14.6
	Peritoneal dialysis	5	12.2
	Steroid	1	2.4
	No additional treatment	10	24.4

Table 4. Comparison of blood values before and after plasmapheresis

	Before	**After**	**p***
	Mean (IQR)	**Mean (IQR)**	
Neutrophil/lymphocyte ratio	3.7 (0.24-28.09)	2.84 (0.12-68.11)	0.12
Hemoglobin	10.6 (0.9-16.14)	9.4 (5.2-16.3)	0.52
Hemotocrit	32.0 (2.3-50.2)	29.5 (16-48)	0.75
Platelet	187000.0 (17000-430000)	212000.0 (53000-505000)	0.035
Prothrombin time	14.9 (11-43)	13.2 (10-40)	0.015
aPTT	27.7 (17-94)	25.8 (13.3-42.2)	0.52
INR	1.31 (1.0-3.9)	1.23 (0.9-1.7)	0.009
Calcium	8.26 (5.45-10.40)	8.6 (5.47-10.7)	0.76
AST	103 (12.3-4202)	37.3 (11.3-1675)	0.000
ALT	221.1 (10-4113)	29.4 (9-1134)	0.000
LDH	543 (134-13330)	374 (122-1619)	0.000
Sodium	137 (124-165)	137.0 (130-151)	1.0
Potassium	3.9 (2.15-5.39)	3.81(2.73-5.25)	0.874
Albumin	32 (13-55)	31 (22-46)	0.735
Total bilirubin	0.62 (0.2-19.28)	0.60 (0.14- 6.91)	0.337
Indirect bilirubin	0.9 (0.32-10.84)	0.28 (0.04-3.95)	1.0
Urea	57 (9-222)	30 (14-148)	0.012
Creatinine	0.9 (0.32-6.76)	0.57 (0.28-5.5)	0.000
pH	7.32(7.0-7.56)	7.38(7.29-7.51)	0.061

aPTT; active Partial thromboplastin time test, **INR:** International normalized ratio, **AST;** Aspartate Aminotransferase. **ALT;** Alanine Aminotransferaz. **LDH;** Lactate dehydrogenase, **pH;** Power of hydrogen.
*Wilcoxon analysis applied

Table 5. Comparison of blood values before and after plasmapheresis in ASFA Categories

ASFA Categories		ASFA 1		ASFA 2		ASFA 3		MIS-C	
		Mean (IQR)	**P***	**Mean (IQR)**	**P***	**Mean (IQR)**	**P***	**Mean (IQR)**	**P***
Neutrophil/ lymphocyte ratio	Before	3.78(0.35-28.09)	.658	3.89(1.23-9.32)	.593	1.58 (0.24 – 11.05)	0.48	18.67(3.09-22.32)	0.012
	After	3.07 (0.12 - 68.11)		3.21 (1.38 - 13.98)		1.56(0.15 -9.71)		3.38(0.8-11.73)	
Hematocrit	Before	27(17.7-50.2)	1.00	32.4(32-40.3)	.655	31.30(2.30 – 43.10)	0.86	31.5(18-37.6)	0.76
	After	28.2(16-48)		33.5(31-40.3)		26.9(22 -41.5)		30.25(20-38.8)	
Platelet	Before	89(26-43)	.067	227(187-228)	,109	228(20- 395)	0,37	177.5(17-277)	0.02
	After	212(53-493)		243(194-248)		144(65-310)		239(152-505)	
Prothromb in time	Before	12.4(10.8-21)	.623	14.9(14-14.9)	,285	18 (11- 34)	0,09	17.35(12-43)	0.02
	After	12.6(10-16.4)		17.8(13.2-18.2)		14.5(12-40)		12.95(10-16)	
INR	Before	1.15(0.95-2.73)	.642	1.3(1.3-1.37)	,593	1.54 (1.1 - 2.9)	0,01	1.62(1.1-3.9)	0.02
	After	1.16(0.9-1.54)		1.32(1.22-1.6)		1.24(1.0-1.7)		1.205(0.9-1.5)	
Calcium	Before	8.26(6.34-10.4)	.295	8.8(8.4-9.1)	,109	8.12 (5.45 - 9.9)	0,25	8.06(5.6-9.0)	0.141
	After	8.6(7.1-10.7)		8.1(7.7-8.59)		8.73(5.47-10.26)		8.7(8.1-9.5)	
AST	Before	102(12.3-2086)	.001	30(17-638)	,593	949.7 (25 - 4202)	0,003	79.85(21.1-4202)	0.04
	After	36(18.3-317)		29(25.3-403)		41(11.3-1675)		47.15(22.30-182)	
ALT	Before	47(10.5-2716)	.002	19(10-537)	1,000	990.5 (16 - 4113)	0,004	311.45(143.4-3799)	0.012
	After	21(9-74)		28.2(17-261)		83.1(13 -1134)		42(9.6-342)	

LDH	Before	496(154-3775)	.001	194(183-1462)	,593	1456 (419- 6978)	0,003	391.5(134-13330)	0.03
	After	330(155-876)		294(122-681)		520(124-1619)		225.5(164-781)	
Sodium	Before	133(124-144)	.211	137(131-141)	,285	142 (125-165)	0,13	136(131-158)	0.778
	After	138(130-144)		136(135-143)		137(133-146)		137(132-151)	
Potassium	Before	4.03(2.4-5.03)	.828	3.5(3.3-3.9)	,109	4.09(2.15-5.39)	0,66	3.18(2.7-4.49)	0.401
	After	3.81(2.76-5.25)		4.3(3.4-4.75)		3.66(3.01-4.69)		3.85(2.73-5.1)	
Albumin	Before	28(19-55)	.641	34(32-37)	,157	34(13-41)	0,64	28(18-33)	0.268
	After	32(24-39)		33(32-36)		31(26-46)		29(22-35)	
Total bilirubin	Before	0.51(0.28-1.1)	.760	0.53(0.4-0.86)	,655	9.58(0.38-19.28)	0,02	0.44(0.2-1.3)	0.89
	After	0.54(0.21-1.31)		0.59(0.4-0.59)		1.2(0.45-6.91)		0.49(0.14-1.0)	
İndirect bilirubin	Before	0.3(0,14-0,7)	.632	0.26(0.2-0.55)	,180	1.14(0.04-10.84)	0,29	0.19(0.1-0.3)	0.917
	After	0.28(0.1-0.79)		0.2(0.18-0.22)		0.66(0.22-3.95)		0.2 (0.04-0.4)	
Urea	Before	54.5(9-222)	.010	38(36-58)	1,000	24(9.1-147)	0,06	107.3(84-156)	0.012
	After	32(0.14-148)		37(31-51)		21(5.2-98)		33.5(13-101)	
Creatinine	Before	0.82(0.34-6.76)	.000	0.77(0.44-1.1)	,180	0.46(0.32-4.97)	0,03	1,61(0.82-5.4)	0.017
	After	0.59(0.4-4.07)		0.59(0.44-0.86)		0.44(0.28-2.17)		0.62(0.37-5.5)	
pH	Before	7.39(7.2-7.5)	.841	7.42(7.3-7.42)	1,000	7.3(7-7.56)	0,04	7.29(7.17-7.39)	0.012
	After	7.37(7.29-7.5119)		7.33(7.32-7.48)		7,.0(7.36-7.49)		7.38(7.35-7.48)	
Laktate	Before	1.7(0.5-4.11)	.702	1.61(1.55-3.9)	,593	3.4(1.21-25.28)	0,03	6.5(3.6-7.8)	0.012
	After	2.18(0.74-3.84)		1.65(1.1-2.12)		1.97(1.16-3.84)		1.98(1.1-2.95)	

ASFA; American Society for Apheresis . **MIS-C:** Multisystem inflammatory syndrome in children, **INR:** international normalized ratio. **AST;** Aspartate Aminotransferase,. **ALT;** Alanine Aminotransferase. **LDH;** Lactate dehydrogenase, **pH;** Power of hydrogen.

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