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Plasmapheresis Activity of a Tertiary Referral Centre Indicating Wide-Spread Interdisciplinary and Safe Use of Therapeutic Plasma Exchange, with an Emphasis on Thrombotic Thrombocytopenic Purpura

Berrin Balık[1], Vehbi Demircan[2], Abdullah Karakuş[2], Bahattin Gökdemir[3], Orhan Ayyıldız[2]

[1]University of Health Sciences Türkiye, Diyarbakır Gazi Yaşargil Training and Research Hospital, Cinic of Hematology, Diyarbakır, Türkiye

[2]Dicle University, Department of Hematology, Diyarbakır, Türkiye

[3]University of Health Sciences Türkiye, İzmir City Hospital, Clinic of Geriatry, İzmir, Türkiye

What is known on this subject?

Therapeutic plasma exchange is an established treatment modality used in a wide range of hematologic, neurologic, renal, and autoimmune disorders. In thrombotic thrombocytopenic purpura, plasma exchange remains the cornerstone of treatment and has markedly improved survival; contemporary management increasingly incorporates ADAMTS13-guided diagnosis and adjunctive immunosuppressive therapies such as corticosteroids and rituximab.

What this study adds?

This real-world tertiary-center experience demonstrates broad, interdisciplinary, and safe use of therapeutic apheresis, with favorable outcomes in thrombotic thrombocytopenic purpura. The study provides local data on response, relapse, and complications, and highlights the gap between historical practice and current ADAMTS13- and caplacizumab-based management.

ABSTRACT

Objective: This study aimed to evaluate the clinical spectrum, treatment characteristics, and outcomes of therapeutic apheresis procedures performed at a tertiary care university hospital, with particular emphasis on thrombotic thrombocytopenic purpura (TTP).

Material and Methods: In this retrospective cohort study, 303 patients who underwent 2,289 apheresis procedures between 2010 and 2015 were evaluated. Patients were categorized according to the primary procedure performed: therapeutic plasma exchange (TPE; n=110), therapeutic cytapheresis (n=85), and peripheral blood stem cell collection (PBSC; n=59). The remaining 49 patients underwent other apheresis procedures. PBSC cases were excluded from treatment-response analyses. TTP was diagnosed clinically on the basis of thrombocytopenia and microangiopathic haemolytic anaemia, with or without organ involvement, after exclusion of other thrombotic microangiopathies; ADAMTS13 activity testing was not routinely available during the study period.

Results: Haematological diseases were the most common indication for apheresis (n=190, 62.7%). TPE was performed in 110 patients, including 22 (20.0%) with TTP. Among 244 patients eligible for outcome analysis, response status

Corresponding Author: Berrin Balık, MD, University of Health Sciences Türkiye, Diyarbakır Gazi Yaşargil Training and Research Hospital, Cinic of Hematology, Diyarbakır, Türkiye

E-mail: berrin_balik166@hotmail.com **ORCID ID:** orcid.org/0000-0001-6826-7818

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ABSTRACT

could be clearly classified for 218 patients: 144 (59.0%) had a complete response, 17 (7.0%) had a partial response, and 57 (23.4%) had no response. The mean number of apheresis sessions per patient was 7.5±3.9. In the TTP subgroup, 17 of 22 patients (77.2%) achieved a clinical response; 7 (31.8%) relapsed during follow-up, and 4 (18.2%) died from refractory disease or underlying critical illness. Procedure-related complications were infrequent; 209 patients (69.0%) had no complications. No deaths were directly attributed to the apheresis procedure.

Conclusion: Therapeutic apheresis was widely used across multiple disciplines and showed an acceptable safety profile in our centre. Haematological disorders, particularly TTP and acute leukaemia, constituted the largest indication group. These findings support the continued role of TPE in routine clinical practice and emergency settings, while highlighting the need for contemporary prospective studies that incorporate ADAMTS13-guided evaluation and assess newer agents such as caplacizumab.

Keywords: Therapeutic apheresis, therapeutic plasma exchange, cytapheresis, peripheral blood stem cell collection, thrombotic thrombocytopenic purpura, TTP

Introduction

Therapeutic apheresis (TA), is the separation of substance from blood. Depending on the type of separated components, TPA is also known as therapeutic cytapheresis. Cytapheresis is the process of separation of the cellular elements in the blood and using the rest for the patient or donor. Therapeutic plasma exchange (TPE) is a procedure in which allogeneic plasma is used as the replacement fluid. The use of Solomon and Fahey in the treatment of Hyperviscosity syndrome in 1960 can be accepted as the beginning of TPE (1). Thrombotic thrombocytopenic purpura (TTP) is a disease characterized by microangiopathic haemolytic anaemia and thrombocytopenia, and may progress to include fever, neurologic findings, and renal failure. The current standard treatment comprises plasma exchange (PEX) and immunosuppressive therapies, such as corticosteroids or rituximab. In 1991, effective treatment of acquired TTP started with documentation of the efficacy of PEX, mortality decreased from 90% to 28% in acute episodes (2). In 1998, acquired TTP was found to be associated *ADAMTS13* gene deficiency due to an inhibitor (3,4) suggesting an autoimmune aetiology thus providing the explanation for corticosteroids in addition to PEX (5). US Food and Drug Administration did not approve rituximab for the treatment of TTP. Since 2002 it has been used off-label with increasing frequency (6,7).

The aim of this study was to evaluate retrospectively patient's demographic characteristics, follow-up clinic, vascular access route, frequency of apheresis application and total number of applications, treatment responses, complications during the procedure, and laboratory, clinical characteristics, response to treatment and TTP patients' response to treatment between 2010 and 2015. With respect to relapse, the data obtained were compared with the world literature and with studies conducted in our country.

Material and Methods

This retrospective study, conducted at the Department of Haematology, Dicle University Faculty of Medicine, included all adult patients who underwent TA between January 2010 and December 2015. Data were obtained from hospital electronic records and the apheresis unit's registry. The study was approved by the Non-Interventional Research Ethics Committee of Dicle University (decision number:14, date: 25.12.2015). Due to the retrospective nature of the study, the requirement for informed consent was waived. All procedures were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the Declaration of Helsinki.

A total of 303 patients were identified and categorized into groups based on their primary indication for apheresis. The classification was as follows:

TTP Group (n=22): Patients who met the clinical and laboratory criteria for TTP and underwent PEX as first-line therapy. Treatment response was defined as follows: a complete response (CR) was defined as normalization of platelet count ($>150 \times 10^9$/L), normalization of lactate dehydrogenase (LDH) levels, and resolution of clinical symptoms. Partial response (PR) was defined as an improvement in platelet count and LDH levels without full normalization. No response (NR) was defined as failure to achieve haematological improvement or as clinical deterioration despite therapy.

Neurological disorders group (n=45): Patients treated with TPE for neurological conditions including Guillain-Barré syndrome, myasthenia gravis, and chronic inflammatory demyelinating polyneuropathy, in accordance with American Society for Apheresis (ASFA) Category I/II indications.

Autoimmune and connective tissue disorders group (n=40): Patients with systemic lupus erythematosus (SLE), vasculitis, or other autoimmune syndromes with organ involvement necessitating apheresis.

Hyperviscosity syndrome group (n=25): Patients presenting with symptomatic hyperviscosity due to Waldenström's macroglobulinemia or multiple myeloma.

Hematologic malignancy group (n=21): Patients with leucocytosis secondary to acute leukaemia or other proliferative disorders who underwent leukapheresis.

Solid organ transplantation group (n=15): Patients who underwent TPE for desensitization or antibody-mediated rejection in renal transplantation.

Hematopoietic stem cell transplantation group (n=111): Donors or patients who underwent peripheral blood stem cell collection (PBSC) using leukapheresis.

Patients with missing essential data, those of paediatric age, or those who underwent apheresis for experimental or unclassified indications were excluded from the analysis.

A total of 303 patients were included. For the primary analysis, patients were classified according to the main apheresis procedure received: TPE (n=110), therapeutic cytapheresis (n=85; leukocytapheresis, thrombocytapheresis, or related cellular procedures), PBSC collection (n=59), and other procedures (n=49; including lipid apheresis, double-filtration plasmapheresis, and bilirubin apheresis). PBSC collection cases were excluded from treatment-response analyses because the procedure was performed for collection rather than for disease-directed therapy.

Clinical response was defined retrospectively based on disease-specific chart documentation. CR indicated the resolution of the main clinical and/or laboratory abnormality that prompted apheresis. A PR indicated a meaningful but incomplete improvement. NR indicates the absence of clinically relevant improvement or progression despite treatment. Because this was a heterogeneous cohort, these definitions were applied in accordance with the underlying indication and the treating team's documented assessment.

TTP was diagnosed clinically on the basis of thrombocytopenia and microangiopathic haemolytic anaemia, with or without neurologic, renal, or febrile manifestations, after exclusion of alternative causes of thrombotic microangiopathy, such as disseminated intravascular coagulation, haemolytic uraemic syndrome, malignant hypertension, sepsis-associated microangiopathy, or pregnancy-related syndromes. ADAMTS13 activity and inhibitor testing were not routinely available during the study period. Cases were categorized as secondary TTP when a clear associated trigger was documented; otherwise, they were considered idiopathic/acquired TTP. Caplacizumab was not available at our centre during the study period. Information regarding the exact timing of rituximab administration was incomplete in the retrospective records and was therefore summarized descriptively.

All apheresis procedures were performed using the Fresenius COM.TEC® continuous-flow cell separator. Acid citrate dextrose-A was used as the primary anticoagulant with a standard blood-to-anticoagulant ratio of 10:1. Venous access was achieved using either peripheral veins or central venous catheters, depending on vein quality and clinical condition. Replacement fluids for PEX included 5% human albumin and fresh frozen plasma (FFP), which were selected according to the underlying indication.

Statistical Analysis

Data collected included demographic characteristics, primary diagnosis, number of sessions, type of apheresis, venous access route, replacement fluids, and complications. Descriptive statistics were used to summarize the data. Continuous variables were reported as mean ± standard deviation (SD), while categorical variables were expressed as frequencies and percentages. Statistical analyses were performed using SPSS software (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± SD, and categorical variables were presented as numbers and percentages. Only descriptive statistics were used. Continuous variables are presented as mean ± SD as appropriate. Categorical variables are presented as numbers (percentages). No inferential statistical comparison was performed because the study was primarily descriptive.

Results

A total of 303 patients who underwent TPA and cytapheresis in the Dicle University Apheresis Unit between 01.01.2010 and 31.12.2015, encompassing 2,289 sessions, were included in the study. Among them, 159 (52.5%) were female and 144 (47.5%) were male. The mean age was 42.76±19.191 (min-max, 10-96) years. The mean number of sessions was 7.69±12.183 (min-max, 1-100). When procedures not requiring replacement fluids (cytapheresis and double filtration plasmapheresis) were excluded, FFP was used as the replacement fluid in all sessions.

Among patients who underwent plasmapheresis, 22 of 110 (20%) were diagnosed with TTP, and among patients who underwent therapeutic cytapheresis, 59 of 85 (69%) had acute leukaemia.

A total of 244 patients who underwent TA were evaluated for treatment response. PBSC collection cases were excluded from outcome assessment. Among the remaining 244

patients, response status could be clearly classified for 218. Overall, 144 patients (59.0%) achieved CR, 17 (7.0%) achieved PR, and 57 (23.4%) had NR. The mean number of sessions per patient was 7.5±3.9.

Overall, most patients were followed up in the haematology unit (Table 1). Temporary central venous catheters were used in 211 patients (69.6%), peripheral catheters in 21 patients (6.9%), and fistulas in 3 patients (1%). The vascular access site was not specified for 68 patients (22.4%) (Table 2).

No complications were observed in 209 patients (69.0%). Reported adverse events included catheter dysfunction in 8 patients (2.6%), allergic reactions in 6 patients (2.0%), hypotension in 1 patient (0.3%), and vomiting in 1 patient (0.3%). One critically ill patient died during treatment; after chart review, this death was attributed to the underlying disease rather than to the apheresis procedure itself (Table 3).

The distribution of patients according to apheresis procedure was as follows: 110 (36.3%) underwent TPE, 73 (24.1%) underwent leukapheresis, 59 (19.5%) underwent peripheral stem cell collection, 31 (10.2%) underwent double filtration plasmapheresis, 16 (5.3%) underwent lipid apheresis, 12 (4%) underwent thrombocytapheresis, and 2 (0.7%) underwent bilirubin apheresis (Table 4).

Among the 110 patients who underwent TPE, 64 (58.2%) responded, 15 (13.6%) had a PR, and 19 (13.4%) did not respond, and 22 (20.0%) were treated for TTP (Table 5). The TTP subgroup comprised 12 males (54.5%) and 10 females (45.5%), with a mean age of 28.2±8.7 years. Twenty patients (90.9%) were considered to have idiopathic/acquired TTP, whereas 2 patients (9.1%) had secondary TTP associated with SLE or clopidogrel exposure. At admission, fever was present in 19 patients (86.4%). Headache was reported in 10 (45.5%) patients, focal neurological abnormalities in 1 (4.5%) patient, confusion in 3 (13.6%) patients, and coma in 3 (13.6%) patients. Among the 20 patients with neurological involvement (91%), 7 (31.8%) had severe, and 13 (59.1%) had mild neurological symptoms, including seizures. Petechiae were detected in 11 (50%) patients at admission. Fatigue was reported in 21 (95.5%) participants. Petechiae were present in 14 (63.6%) patients,

Table 1. Referring departments of patients undergoing therapeutic apheresis

Department	Patients, n (%)
Hematology	190 (62.7)
Neurology	46 (15.2)
Nephrology	27 (8.9)
Intensive care unit	15 (5.0)
Endocrinology	15 (5.0)

Table 2. Baseline characteristics of the overall cohort

Total number of patient n (%)	303	
Female	159	52,5%
Male	144	47,5%
Total number of procedure	2289	
Age: mean (min-max)	42.76±19,191	(10–96)
Number of procedure (min-max)	7.69±12.183	(1–100)
Venous access, n (%)		
Central venous catheter	211	69.6%
Peripheral vein	21	6.9%
Arterio-venous fistula	3	1%
Five most indications, n (%)		
Acute leukaemia	59	19.5%
Multiple myeloma	41	13.5%
TTP	22	7.3%
Sepsis	17	5.6%
HUS	14	4.6%
Department, n (%)		
Haematology	190	62.7%
Neurology	46	15.2%
Nephrology	27	8.9%
Intensive care unit	15	5.0%
Endocrinology	15	5.0%
Procedure type, n (%)		
Bilirubin apheresis	2	0.7%
Double filtration apheresis	31	10.2%
Lipid apheresis	16	5.3%
Leukocytapheresis	73	24.1%
Stem cell collection	59	19.5%
Therapeutic plasma exchange	110	36.3%
Thrombocyte apheresis	12	4.0%

TTP: Thrombotic thrombocytopenic purpura, HUS: Hemolytic uremic syndrome, min: Minimum, max: Maximum

Table 3. Procedure related adverse events n (%)

Adverse event	Patients, n (%)
No complication	209 (69.0)
Catheter dysfunction	8 (2.6)
Allergic reaction	6 (2.0)
Hypotension	1 (0.3)
Vomiting	1 (0.3)
Death during treatment*	1 (0.3)

**After chart review, this event was judged to be related to the underlying disease rather than to the apheresis procedure itself*

Table 4. Distribution of procedure types

Procedure type	Patients, n (%)
Therapeutic plasma exchange	110 (36.3)
Leukocytapheresis	73 (24.1)
Peripheral blood stem cell collection	59 (19.5)
Double–filtration plasmapheresis	31 (10.2)
Lipid apheresis	16 (5.3)
Thrombocytapheresis	12 (4.0)
Bilirubin apheresis	2 (0.7)

and haematuria was present in 1 (4.5%) patient. Five patients (22.7%) had no bleeding. Chest pain was present in 4 patients (18.2%) and absent in 12 patients (54.5%). Gastrointestinal complaints were noted in 17 patients (87.3%), including nausea in 7 (31.8%), diarrhoea in 2 (9.1%), abdominal pain in 5 (22.7%), and vomiting in 3 (13.6%). Five patients (22.7%) had no gastrointestinal symptoms. Acute renal failure was present in 11 patients (50%).

Seventeen patients (77.2%) achieved a clinical response. Seven patients (31.8%) relapsed during follow-up, and four patients (18.2%) died from refractory TTP or severe concomitant illness (Table 6). Regarding treatment modalities, 9 patients (40.9%) received only TPE; 6 (27.2%) received TPE and steroids; 3 (13.6%) received TPE, steroids, and vincristine; 2 (9.1%) received TPE, steroids, and rituximab; 1 (4.5%) received TPE, steroids, rituximab, and vincristine; and 1 (4.5%) received TPE and vincristine. Treatment response was not specified for 1 patient (4.5%) who left the hospital during follow-up.

Regimens containing rituximab and/or vincristine were used in selected refractory cases, but the exact timing of rituximab administration was not consistently documented.

Discussion

In our study, the treatment response rate among TTP patients who underwent plasmapheresis was 77.2%, which aligns with both national data and international literature. During the six-year evaluation period at our centre's TA unit, most patients were referred from the haematology clinic. The relatively low number of patients from other departments may be attributed to limited awareness or to fewer TA indications outside haematology.

The most frequently performed procedure was TPE, predominantly indicated for TTP. According to guidelines published by the ASFA and the American Association of Blood Banks, TPE is a first-line treatment for TTP. In our cohort, 22 (20%) of the 110 patients who underwent TPE were diagnosed with TTP after referral to internal medicine. Therapeutic cytapheresis was performed in 85 patients, the majority (59 patients, 69%) of whom had acute leukaemia and were treated for hyperleukocytosis. These findings are consistent with previous reports in the literature (8,9,10,11,12).

In all TTP cases in our study, FFP was used as the replacement fluid, in line with the standard recommendation for this indication (8,9,10,11,12).

Apheresis can also be used in cases of poisoning. Current literature suggests that the number of sessions should be determined by clinical response rather than by a predetermined number (13,14,15,16). In our study, one patient with levothyroxine intoxication showed complete clinical recovery after three sessions of TPE.

For patients with hypertriglyceridemia-induced pancreatitis, apheresis has been shown to be effective. One study reported a 76.5% response rate among 17 such patients (17). In our series, 4 of 6 patients (66.7%) responded to treatment, and 1 (16.7%) achieved a PR, supporting previously reported findings.

Kadikoylu et al. (18) reported the use of FFP in 88% of TPE cases, while 12% used albumin as the replacement fluid. In contrast, our study utilized TDP (thawed plasma) in 100% of sessions, mainly due to reimbursement restrictions, limited availability of albumin, and greater accessibility of TDP. The estimated cost of a single TPE session in Türkiye is approximately $520 with FFP and $800 with albumin (19).

Complications related to TPE procedures are typically categorized as mild, moderate, severe, or fatal (20). Mortality rates range between 0.03–0.05% per session (20,21). In our study, 209 (69%) of 303 patients experienced no complications, and only 1 death occurred during 1,823 TPE sessions, corresponding to a mortality rate of 0.05%. Reported complications included allergic reactions (6 patients, 2%), hypotension (1 patient, 0.3%), vomiting (1 patient, 0.3%), and catheter-related issues (8 patients, 2.6%). Another study reported higher complication rates: nausea/vomiting in 4%, hypotension in 3%, itching in 1.7%, and catheter-related complications in 3.6% of procedures (18). The relatively low rate in our centre may be attributed to the presence of experienced apheresis personnel.

Citrate-induced hypocalcaemia is a known side effect of TPE. While some centres opt for calcium supplementation only when symptoms arise, others use routine prophylactic replacement. Studies show that without prophylaxis, hypercalcaemic symptoms occur in 9% of patients, whereas this drops to 1% with prophylaxis (22). In our centre, all 1,823 sessions included routine calcium supplementation, and no hypercalcaemic symptoms were observed. A study

Table 5. The indications and procedure burden

	Number of patient (%)	Procedure type	Number of procedure (%)	CR	PR	No response	ASFA 2016 category
Hematologic diseases							
Acute leukaemia	59 (19.5%)	Leukocytapheresis	122 (5.24%)	29 (55.7%)		23 (44.3%)	II
Cryoglobulinemia	1(0.3%)	TPE	2 (0.08%)	1 (100%)			I
Multiple myeloma	41(13.5%)	TPE	42 (1.83%)	1 (100%)			I
Cold agglutinin disease	1(0.3%)	TPE	4 (0.17%)	1 (100%)			II
TTP	28 (9.2%)	TPE	843 (36.8%)	25 (89.3%)		3 (10.7%)	I
Pregnancy-associated diseases							
Pregnancy-associated TMA	2 (0.7%)	TPE	35 (1.52%)	2 (100%)			I
HELLP syndrome	2 (0.7%)	TPE	46 (2%)	1 (50%)	1 (50%)		II
Neurological diseases							
Chronic inflammatory demyelinating polyradiculoneuropathy	2 (0.7%)	TPE	14 (0.61%)			1 (50%)	I
Guillain-Barré syndrome	13 (4.3%)	TPE	68 (2.97%)	7 (53.8%)	1 (7.7%)	3 (23.1%)	I
Myastenia gravis	7 (2.3%)	TPE	39 (1.7%)	6 (75%)		1 (12.5%)	I
Neuromyelitis optica	6 (2.0%)	TPE	38 (1.66%)	4 (66.7%)	1 (16.7%)		II
Renal diseases							
Glomerulonephritis	3 (1.0%)	TPE	39 (1.7%)	2 (66.7%)		1(33.3%)	II
Renal transplantation, ABO compatible Graft rejection	3 (1.0%)	TPE	20 (0.87%)	1 (33.3%)	1 (33.3%)	1 (33.3%)	I
MPGN	1 (0.3%)	TPE	3 (0.13%)		1 (100%)		II
RPGN	1 (0.3%)	TPE	14 (0.61%)	1 (100%)			II
Critical illness							
Levothyroxine intoxication	1(0.3%)	TPE	3 (0.13%)	1 (100%)			II
Sepsis	17 (5.6%)	TPE	269 (11.75%)	7 (41.2%)	2 (11.8%)	4 (23.5%)	III
Endocrine diseases							
Hyperlipidaemia	10 (3.3%)	Lipid apheresis	15 (0.65%)	8 (80%)		1 (10%)	I
Hyper triglyceridemic Pancreatitis	6 (2.0%)	Lipid apheresis	9 (0.39%)	4 (66.7%)	1 (16.7%)		I
Rheumatic diseases							
SLE	1 (0.3%)	TPE	31(1.35%)			1 (100%)	II
Vasculitis	1 (0.3%)	TPE	1 (0.04%)	1 (100%)			II

CR: Complete response, PR: Partial response, ASFA: American Society for Apheresis, TPE: Therapeutic plasma exchange, TMA: Thrombotic microangiopathy, MPGN: Membranoproliferative glomerulonephritis, RPGN: Rapidly progressive glomerulonephritis, SLE: Systemic lupus erythematosus, TTP, Thrombotic thrombocytopenic purpura

by Korkmaz et al. (23) also highlighted hypocalcaemia as the most common adverse event (19), noting that calcium and magnesium prophylaxis is not routinely practiced in many centres in Türkiye. However, our centre consistently employed this measure.

Regarding neurological indications, our findings were also consistent with existing data. Among patients with Guillain-Barré syndrome, 7 (53.8%) responded to therapy, 1 (7.7%) had a PR, and 3 (23.1%) did not respond to therapy. In myasthenia gravis, 6 of 8 patients (75%) showed favourable outcomes, while 1 patient (12.5%) had NR (23).

The classic TTP pentad is seen in only 5% of patients (24),

Table 6. Clinical characteristics and outcomes of the TTP subgroup

Variable	Value
Patients, n	22
Age, mean ± SD, years	28.2±8.7
Male sex, n (%)	12 (54.5)
Female sex, n (%)	10 (45.5)
Idiopathic/acquired TTP, n (%)	20 (90.9)
Secondary TTP, n (%)	2 (9.1)
Clinical response, n (%)	17 (77.2)
Relapse during follow-up, n (%)	7 (31.8)
Death, n (%)	4 (18.2)
Received rituximab-containing therapy, n	3
Received vincristine-containing therapy, n	5

TTP, Thrombotic thrombocytopenic purpura, SD: Standard deviation

whereas 50% (11 patients) of our cohort presented with the full pentad at diagnosis. One patient developed TTP following clopidogrel use, and another had secondary TTP due to SLE, findings that echo earlier reports (25).

Rituximab is recommended for refractory or relapsing TTP cases and is administered weekly at 375 mg/m² for four weeks when response to TPE and corticosteroids is inadequate within 4-7 days (6,8,11,26). In our study, 7 of 8 refractory patients responded favourably to immunosuppressive therapy with rituximab.

The TTP subgroup was a principal focus of the study. Our response rate of 77.2% is comparable to previously published real-world cohorts, although direct comparison is limited by differences in case definitions, disease severity, and treatment era. During the 2010-2015 study period, ADAMTS13 activity testing was not routinely available in our institution. Consequently, the diagnosis was based on clinical and laboratory findings after exclusion of other thrombotic microangiopathies. We have clarified this point because it is important for the interpretation of the TTP results.

Current management of immune-mediated TTP has evolved substantially. Contemporary practice emphasizes early confirmation with ADAMTS13 testing, close monitoring of ADAMTS13 activity during remission, and adjunctive therapy with corticosteroids, rituximab, and caplacizumab in appropriate patients. Caplacizumab was not available in our centre during the study years, and this should be considered when interpreting outcomes. Although rituximab was used in selected refractory or relapsing cases, the retrospective records did not allow for a uniform analysis of treatment timing.

The complication profile in our cohort was favourable. Nearly seven in ten patients had no recorded complications, and most adverse events were mild and manageable. The single death observed during treatment occurred in a critically ill patient and was not considered procedure-related after chart review. This finding is consistent with published evidence showing that severe apheresis-related mortality is uncommon in experienced centres.

Study Limitations

This study has several limitations. First, its retrospective single-center design limits control over confounding factors and introduces the potential for selection and information bias. Second, data were obtained from electronic medical records, and missing or incomplete documentation may have affected the assessment of clinical response and other outcomes. Third, several key variables, including specific laboratory parameters, immunological markers, detailed treatment timing, and standardized long-term follow-up data, were not uniformly available. In addition, clinical response was determined primarily from physicians' documentation, which may have introduced subjectivity. Finally, no formal sample size calculation was performed because all eligible patients within the study period were included.

Conclusion

TA remains an important treatment option across a wide range of clinical indications. At our tertiary center, the procedure was used safely and most frequently for hematologic disorders, particularly TTP and acute leukemia. The present data support the continued use of TPE in multidisciplinary practice, while underscoring the need for contemporary prospective studies in the era of ADAMTS13-guided diagnosis and caplacizumab-based therapy.

Ethics

Ethics Committee Approval: The study was approved by the Non-Interventional Research Ethics Committee of Dicle University (decision number:14, date:25.12.2015).

Informed Consent: Due to the retrospective nature of the study, the requirement for informed consent was waived. All procedures were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the Declaration of Helsinki.

Footnotes

Authorship Contributions

Surgical and Medical Practices: B.B., V.D., A.K., B.G., O.A.,

Concept: B.B., O.A., Design: B.B., O.A., Data Collection or Processing: B.B., V.D., A.K., B.G., Analysis or Interpretation: B.B., O.A., Literature Search: B.B., Writing: B.B.

Conflict of Interest: No conflict of interest was declared by the authors.

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