Original Article

Access this article online

Quick Response Code:

Website: www.ijhonline.org

DOI: 10.4103/ijh.ijh_2_23

Outcomes of therapeutic plasma exchange: A 15-year tertiary center experience

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Abstract:

BACKGROUND: Therapeutic plasma exchange (TPE) is a treatment option used in many medical conditions. Response rates are variable as some disorders clearly benefit from TPE as first- or second-line therapy. This study aims to summarize our experience at King Abdulaziz University Hospital at King Abdulaziz University Hospital, Jeddah, Saudi Arabia.

MATERIALS AND METHODS: In a retrospective fashion, wdemographic data, underlying disease, apheresis-related parameters, and outcomes were collected.

RESULTS: Between January 2005 and March 2020, 159 patients with 177 episodes underwent a total of 945 sessions of TPE. The majority of patients (96.8%) undergoing TPE in our center are of categories I to III according to 2019 American Society for Apheresis guidelines. Most patients had neurologic disorders, 74 (46.5%), where myasthenia gravis was the most common indication, 34 (21.4%) patients with response in 44/45 (97.8%) episodes, followed by thrombotic microangiopathies 31 (17.5%) patients with response in 17/34 (50%) episodes, Guillain–Barré syndrome 27 (16.9%) patients with recovery in 20/27 (74.1%) patients, and systemic lupus erythematous 25 (15.7%) patients with recovery in only 11/25 (44%) patients. Complications included hypotension in 29/945 (3.06%) sessions and citrate-induced symptoms in 6/945 (0.6%) sessions.

CONCLUSION: Our center complies with the recommended standards of indications for initiating TPE. Neurologic conditions constitute the largest group of patients requiring TPE.

Keywords:

Apheresis, therapeutic plasma exchange, thrombotic thrombocytopenic purpura

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Submission: 03-01-2023
Revised: 23-01-2023
Accepted: 15-02-2023
Published: 31-03-2023

Introduction

Since its introduction in 1952 with successful outcomes in a patient with Waldenström macroglobulinemia,[1] therapeutic plasma exchange (TPE) has become a promising treatment modality for several medical conditions. These disease entities span a large spectrum of illnesses, including hematologic diseases such as thrombotic thrombocytopenic purpura (TTP), neurological disorders such as myasthenia gravis (MG), and rheumatologic ailments, such as ANCA-positive vasculitis.[2] The principle of TPE relies on removing the plasma as it contains the offending pathogen in the form of autoantibody, immune complex lipoprotein, toxins, and pathogenic proteins.[3] Normal saline, albumin, or fresh frozen plasma may be used as replacement fluids. TPE is an extracorporeal procedure with general risks of hypotension, hypocalcemia, and venous access-related complications but is otherwise generally safe.[4]

How to cite this article: Hindawi S, Radhwi O, Badawi M, Rajab H, Al Mansouri F, Alzahrani A, *et al*. Outcomes of therapeutic plasma exchange: A 15-year tertiary center experience. Iraqi J Hematol 2023;12:20-7.

In addition to TPE, therapeutic apheresis procedures include red cell depletion, red cell exchange, and leukoreduction. Apheresis technology is also widely used to collect donors' blood components.[4]

Since TPE must be prescribed in an evidence-based manner, apheresis teams are expected to follow best-published evidence when evaluating patients for TPE. Evidence is summarized in the American Society for Apheresis (ASFA) guidelines[2] which are updated every 3 years. In the ASFA guidelines, diseases are categorized into four categories based on whether published literature suggests TPE is indicated and whether it should be considered first-or second-line management.[2]

Apheresis teams are also expected to share their experience with TPE since new evidence may be added to the literature about this therapeutic intervention. This project aims to describe King Abdulaziz University Hospital's (KAUH) experience regarding TPE, especially indications, guidelines compliance, number of sessions, and outcomes. Furthermore, this project covers the experience of KAUH in Jeddah, Saudi Arabia, over 15 years to evaluate the efficacy and safety of TPE in treating specific conditions and enrich the literature about responses with a unique case managed successfully with TPE.

Materials and Methods

This was a retrospective analysis of data collected from all patients who underwent TPE at KAUH in Jeddah, Saudi Arabia, from January 2005 to March. KAUH is an academic center that provides tertiary care to adults and pediatric patients. In KAUH, TPE procedures are performed by trained blood donation nurses and technologists, supervised by apheresis physicians within blood transfusion services. When patients are referred to apheresis physicians for TPE consideration, the decision to perform TPE is taken after a thorough discussion between the primary team and the apheresis physician with consideration of the indications listed by the ASFA. The replacement fluid and the number of sessions are decided according to the disease, guided by the response of the patient and ASFA guidelines, and individualized to each patient until the treatment goal is achieved or TPE is found ineffective. Evaluation of response was agreed upon among authors based on the specific clinical and laboratory criteria for each clinical entity. The data were collected by reviewing patients' files and apheresis records in electronic and paper formats. Some patients were discharged after the resolution of initial presentations but had to be readmitted for recurrence. These patients were captured as having two or more episodes. In this report, TPE is counted per episode. Collected data included the additional treatment modalities given along with TPE, including immunosuppressive therapy given by the primary team according to the underlying disease. In addition, supportive measures were captured to improve outcomes, such as ICU setting, mechanical ventilation, and dialysis. TPE procedures were performed using either Spectra Optia (Terumo BCT, Lakewood, CO, USA) or Haemonetics MCS + cell separator (Braintree, MA, USA). All episodes were performed through central venous access, and intravenous calcium was routinely infused during the procedure. The replacement fluids were mostly albumin and normal saline, except when suggested otherwise by ASFA guidelines, such as in patients with TTP. In this project, compliance with ASFA guidelines was determined based on the most recent version of the guidelines,[2] regardless of the year the procedure was performed. Mortality was defined as death during the hospitalization when the procedure(s) was performed.

Ethics

Ethical approval was obtained from the KAUH research ethics committee (IRB Reference Number 270-15), and the participants' consent was waived, given the nature of the study.

Results

A total of 159 patients with 177 episodes underwent 945 TPE sessions during the study period, with an average of 5.94 sessions per patient (range: 1–15) [Table 1]. Of the total patients, 81 (50.9%) were males and 78 (49.1%) were females. Patients were between 5 and 88 years (median: 36 years). Only ten patients were below 15 years of age. The majority of patients 108/159 (67.9%), who underwent TPE in our center had conditions listed as category I in ASFA guidelines 2019,[2] for which TPE is typically effective, including MG 34 (21.4%) patients, TTP 31 (19.5%), and Guillain–Barré syndrome (GBS) 27 (16.9%) patients. Another 46 patients also underwent TPE for conditions that belonged to ASFA categories II and III (28.9%). Some of the cases were uncategorized in ASFA guidelines, such as methemoglobinemia (MetHb), pulmonary alveolar proteinosis (PAP), and suspected hemolytic uremic syndromes (HUSs), were all treated with TPE along with the frontline management and showed variable outcomes [Figure 1].

Neurological conditions

Out of 34 cases of MG, only one patient did not have a clinical response and succumbed to death. The patient was diagnosed with malignant thymoma and received neoadjuvant chemotherapy in addition to thymectomy. All patients received steroids and pyridostigmine. The use of intravenous immunoglobulin (IVIg) was variable in terms of timing and response. Overall, 9/34 (26.5%) patients received IVIg. In addition, two patients

Table 1: Overall characteristics of the studied group

ASFA (2019) category	Disease	Number of patients	Number of episodes	Age (years) (range if multiple)	Total number of sessions	Improved post-TPE	Number of response	Mortality
I (*n*=108)	GBS	27	27	82-5	150	20	7	5
	MG	34	45	68-16	234	44	1	1
	TTP	27	29	76-16	152	13	16	16
	Hyperviscosity in hypergammaglobulinemia	4	4	81-57	11	1	3	3
	Anti-GBM with DAH	3	3	70-22	34	3	0	0
	GPA with DAH	4	4	54-12	25	1	3	1
	CAPS	6	6	47-19	41	1	5	4
	CIDP	3	3	88-32	20	3	0	0
II (*n*=37)	ADEM	2	2	45-29	16	1	1	1
	MS-Acute attack	1	1	45	4	0	1	0
	NMOSD-Acute attack	7	7	57-17	45	4	3	2
	Renal transplantation antibody-mediated rejection	2	2	66-14	10	0	2	0
	SLE	25	25	58-12	108	11	14	12
III (*n*=9)	IgA nephropathy	1	1	41	3	1	0	0
	Postpartum-HELLP	1	1	44	2	1	0	0
	Hyper triglyceridemic pancreatitis	6	10	51-7	42	10	0	0
	Complement and coagulation TMA-mediated	1	2	13	21	1	1	0
IV (*n*=0)								
Undetermin (*n*=2)	HUS, atypical	2	2	22-9	21	2	0	0
Uncategorized	MetHb	1	1	52	2	1	0	0
	Pulmonary alveolar proteinosis	1	1	18	2	0	1	1
	Sideroblastic anemia (confirmed Pearson syndrome later)	1	1	21	2	0	1	1

ASFA=The American Society for Apheresis, GBS=Guillain-Barré syndrome, MG=Myasthenia gravis, TTP=Thrombotic thrombocytopenic purpura, DAH=Diffuse alveolar hemorrhage, GPA=Granulomatosis with polyangiitis, CAPS=Catastrophic antiphospholipid syndrome, CIDP=Chronic inflammatory demyelinating polyneuropathy, TMA=Thrombotic Microangiopathy, ADEM=Acute disseminated encephalomyelitis, MS=Multiple sclerosis, NMOSD=Neuromyelitis optica spectrum disorder, SLE=Systemic lupus erythematosus, GBM=Glomerular basement membrane, TPE=Therapeutic plasma exchange, HELLP=Hemolysis, elevated liver enzyme, and low platelet, IgA=Immunoglobulin A, HUS=Hemolytic uremic syndrome, MetHb=Methemoglobinemia, PAP=Pulmonary alveolar proteinosis

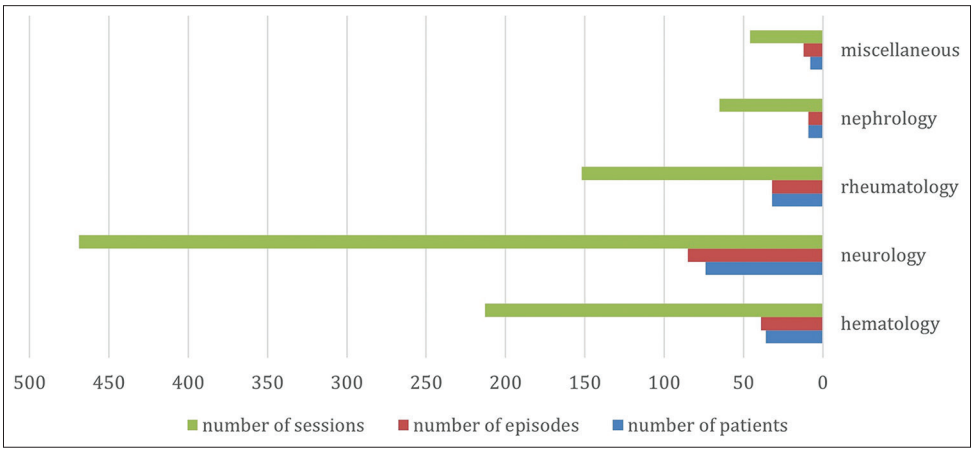

Figure 1: Indications for TPE at KAUH. TPE = Therapeutic plasma exchange, KAUH = King Abdulaziz University Hospital

required biological therapy, anti-CD-20 (rituximab), and 19/34 (55.9%) patients underwent TPE before thymectomy.

Marked improvement (100%) was seen in 3/3 of patients with chronic inflammatory demyelinating disease (CIDP). On the other hand, the acute form of the disease, GBS, had a 21/27 (77.7%) response rate.

A total of nine patients were diagnosed with autoimmune encephalitis, including acute disseminated encephalomyelitis (ADEM) and neuromyelitis optica

spectrum disorder (NMOSD). The overall complete response was seen in five patients (55.5%), and a pattern of delayed diagnosis was associated with increased mortality. Only one patient with relapse-remitting multiple sclerosis (MS) was referred for TPE after exhausting other treatment modalities. Unfortunately, his neurological status with quadriplegia did not improve after four sessions, and he was transferred to another facility and lost follow-up.

Hematological conditions

TPE was performed for 27 patients with TTP diagnosed clinically based on the PLASMIC[5] and the FRENCH[6] scores. ADAMTS-13 (A disintegrin and metalloproteinase with a thrombospondin type 1 motif, member 13) enzyme assay was sent for one patient and returned negative. The therapeutic effect on presumed TTP was not achieved in 16 (59.2%) patients. Two patients had HUS, where one patient had a complete response, and the other did not improve and succumbed to death. In addition, a 12-year-old patient had atypical HUS (aHUS), and genetic testing revealed a heterozygous deletion encompassing the CFHR1 and CFHR3 genes and a heterozygous variant in the THBD gene. Eculizumab was considered but not available, and the patient underwent three daily sessions of TPE with an improvement in all of his hematological and renal laboratory markers. He was then put on twice-weekly TPE for 8 weeks till discharged safely home. After 13 months, the patient presented again with hematuria, hemolysis, and acute kidney injury. He required only three sessions of TPE to return to his normal baseline. The day after TPE, he developed generalized clonic–tonic seizures, which were aborted successfully with antiepileptic medications, and was discharged after a week.

One patient presented with HELLP syndrome (hemolysis, elevated liver enzyme, and low platelet) at 31-week gestation. She required TPE postpartum for ongoing HELLP manifestation, and her laboratory markers returned to normal after two successful TPE sessions.

With elevated immunoglobulin M (IgM) monoclonal antibodies, four patients required TPE. One patient had it before the start of chemotherapy (bendamustine-rituximab), while the three others presented late in their disease before therapy and died soon after TPE was initiated.

Renal conditions

Three patients presented with renal failure and hemoptysis and were found to have anti-glomerular basement membrane and diffuse alveolar hemorrhage (anti-GBM and DAH). Excellent response was seen with TPE, as it was used in the first line with a 100% response rate. TPE was performed for two cases with antibody-mediated kidney rejection postkidney transplant with no clinical success despite additional immunosuppression, and both patients ended on hemodialysis. On the other hand, TPE successfully managed one adult patient with IgA crescent nephropathy and was discharged, not requiring renal replacement therapy.

Rheumatological conditions

Catastrophic antiphospholipid syndrome (CAPS) is a severe form of antiphospholipid antibody disease and leads to high mortality. Out of the six patients who presented with suspected CAPS, one benefited from TPE and intense immunosuppression. At the same time, one was transferred to another facility, and four patients died despite maximum medical support.

Patients with systemic lupus erythematosus (SLE) underwent TPE for a variety of indications considered under the term of "severe SLE"; SLE cerebritis (5/25), SLE psychosis (2/25), SLE with DAH (2/25), SLE pneumonitis (1/25), and SLE nephritis (15/25). TPE was effective in 6/15 (40%) of SLE nephritis, 3/5 (60%) SLE cerebritis, 0/2 psychosis, 1/2 SLE with DAH, and 1/1 in pneumonitis. Almost all patients with SLE had TPE as second-line management.

Regarding ANCA-associated rapidly progressive glomerulonephritis, such as granulomatosis with polyangiitis and DAH (GPA with DAH), four cases were treated with TPE besides steroids and only one responded after five sessions.

Miscellaneous conditions

Seven patients with acute pancreatitis due to hyperlipidemia underwent TPE with successful outcomes (100%). One case had familial hypertriglyceridemia (HTG). Most patients had TPE on several occasions due to the recurrence of the disease.

Two sessions of TPE were performed to treat acquired MetHb in a 52-year-old male who presented with

Table 2: Pharmaceutical interventions used within all 177 episodes

Associated treatment	*n* (%)
None	18 (10.16)
Yes	159 (89.84)
Steroid	126 (79.24)
IVIG	5 (3.14)
Steroid + IVIG	28 (17.61)
Rituximab	10 (6.28)
Azathioprine	14 (8.8)
Cyclophosphamide	16 (10.06)
Cyclosporin	1 (0.62)
Methotrexate	1 (0.62)
Methylene blue	1 (0.62)

IVIG=Intravenous immunoglobulins

Table 3: Adverse effects in 945 sessions for plasma exchange

Adverse effect	*n* (%)
None	891 (94.3)
Yes	54 (5.7)
Hypotension-did not require aborting the procedure	24 (44.4)
Hypotension-procedure aborted	5 (9.2)
Hypertension-procedure aborted	2 (3.7)
Bradycardia-procedure aborted	1 (1.8)
Severe citrate-induced symptoms-procedure aborted	6 (11.1
Seizure intraprocedure-did not require aborting the procedure	2 (3.7)
Seizure intraprocedure-procedure aborted	1 (1.8)
Dysfunctional line-procedure aborted	11 (20.4)
Central line infection	1 (1.8)
Cardiac arrest intraprocedure	1 (1.8)

acute renal failure and hypoxemia after ingestion of an unidentified herbal medicine. In addition to TPE, he received methylene blue and required hemodialysis. Rapid respiratory status improvement after TPE allowed rapid weaning from mechanical ventilation.

A young patient presented with PAP with negative viral respiratory samples. The patient underwent TPE but did not improve and ended up on extracorporeal membrane oxygenation with no suitable donor for a lung transplant and died.

Associated immunosuppressive therapies

As TPE is used in severe conditions, it is often performed in conjunction with other therapies. For example, the most commonly used immunosuppressant, steroids, was given in almost 80% of cases [Table 2].

Adverse effects and complications

Most patients tolerated TPE well. However, adverse effects were observed in 54 (5.7%) procedures [Table 3], out of which half of them (50%) led to procedure abortion.

Discussion

The utilization of TPE in clinical practice has progressed quickly due to awareness and accessibility. ASFA continuously reviews the most updated evidence; the most recent eighth edition was published in 2019.[2] Our institution showed (67.9%) TPE compliance with category I recommendation, and when including category II and III, the rate goes up to 96.8% over the 15-year period.

Following the updated ASFA guidelines and recommendations since 1986,[7] the literature reveals worldwide consensus that TPE benefits many neurological conditions. TPE is often used alone as frontline therapy or as an adjuvant or alternative therapy in neurologic diseases, i.e., GBS, MG, and CIDP.[8] The benefits of immunomodulation with TPE and IVIG have been demonstrated to be equally effective.[9] In our experience, TPE has been shown to deliver a more rapid and robust effect on MG. All patients with MG responded to TPE 44/45 apart from one refractory case. Since immunomodulation treatments are costly, it is essential to determine whether the treatments are comparable to help guide the therapy of patients with MG. Despite limitations, TPE is accepted as a therapy that acts rapidly and often enables patients to discontinue ventilator assistance or regain normal strength. TPE will facilitate the management of the disease and markedly shorten the duration of a crisis. In addition, TPE is useful for temporizing the disease status and improving the clinical outcome postoperatively if done before thymectomy.[10]

A Cochrane Review reported moderate-quality evidence supporting the superiority of TPE to supportive management in patients with GBS, mainly when used in the 1st week of disease presentation.[11] While in this report, a 20/27 (74%) response rate was observed.

All three patients who underwent TPE for CIDP in our center responded. This is consistent with the literature. TPE showed improvement against a placebo in a randomized, double-blind controlled trial.[12] Furthermore, another confirmatory randomized trial[13] reported similar efficacy but with signs of disease relapse after 2 weeks. Moreover, TPE was equally effective in tryptophan immunoadsorption (IA) (44.4% vs. 66.7%) when 20 patients with CIDP were equally and randomly assigned to receive six sessions of TPE or IA.[14]

Patients with ADEM can have variable courses ranging from a single phase to repetitive relapses making it difficult to be distinguished from MS. The typical presentation is multifocal neurologic disturbance accompanied by a change in mental status. Some case reports show that TPE could be effective after corticosteroid failure.[15] TPE was examined in a randomized controlled trial against a placebo and was found effective in patients who were unresponsive to corticosteroids.[16] In MS patients, TPE is deemed ineffective in the chronic form.

On the other hand, the acute relapse manifest as humoral demyelination and elevated antibodies to myelin oligodendrocyte glycoprotein, which can explain the excellent TPE effect reported by the Mayo Clinic[17] when treating MS patients in their acute relapse with TPE. Our experience with ADEM and MS is insufficient to conclude efficacy in both disorders. On the contrary, patients with NMOSD showed a 4/7 (57.14%) response rate in the acute phase, consistent with a large retrospective series of 185 patients with NMOSD favoring TPE over pulse corticosteroid in the acute phase.[18]

Thrombotic microangiopathies constituted less than a quarter of our patients 31/177 (17.5%). Hematologic conditions were the second most common cause for referral for TPE after neurologic disorders. The TTP subgroup had a recovery rate of 13/29 (44.8%) sessions, which is suboptimal to the reported literature of more than 80% recovery rate post-TPE.[19,20] This unsatisfactory outcome could be attributed to the late presentation or referral of patients with TPE. Based on available resources, the diagnostic pathway in our institution is likely affecting the accuracy of diagnosis of these cases. At our institution, once the clinical suspicion of TTP arises with significant PLASMIC and FRENCH scores, daily TPE is initiated until the platelet count and lactate dehydrogenase enzyme normalization. Confirmatory tests, e.g., ADAMTS13 in TTP and complement factor H (in complement-mediated HUS), were not readily available and not awaited. When genetic testing was performed in the case of aHUS, mutations falling under both coagulation-mediated thrombotic microangiopathy (TMA) (THBD mutation) and complement-mediated TMA (complement factor gene mutation) were discovered. Both of these are classified as category III indications in ASFA guidelines. In patients with hyperviscosity secondary to hypergammaglobulinemia, TPE is indicated in patients with symptoms or before the initiation of rituximab to avoid the rebound effect in 30–70% of patients with IgM monoclonal gammopathy.[21] In our experience, only one patient benefited from TPE, and the other three presented late in their disease, and salvage TPE did not improve their condition or prolong their survival.

TPE has been investigated in treating various types of rapidly proliferative glomerulopathy for rapid removal of autoantibodies, immune complexes, and other inflammatory mediators such as complement and fibrinogen. In general, TPE has been found to be a relatively safe but costly addition to more conventional treatment regimens. The added expense should be viewed in the context of the eventual long-term cost of maintenance dialysis for those patients who are not successfully treated and whose outcomes will terminate with end-stage renal disease. Studies on the treatment of DAH, a life-threatening feature of pulmonary-renal syndromes, showed that such therapy could be lifesaving concerning the pulmonary component of this syndrome.[22] In our experience, an excellent response of 3/3 (100%) was observed when TPE was added to other immunosuppressants in patients with anti-GBM-mediated nephropathy with DAH. This was not seen in patients who suffered from GPA with DAH 1/4 (25%).

Antibody-mediated rejection (ABMR) lead to the initiation of TPE in two of our renal-transplant patients. TPE is highly effective in ABMR,[23] the most common cause of transplanted kidney loss.[24] However, our two patients did not improve despite daily sessions of TPE over 5 days and ended up requiring intermittent hemodialysis.

TPE can remove circulating IgA and IgA complexes from circulation, aiding the management course of diseases such as IgA nephropathy. In this report, only one patient with IgA crescentic nephropathy was treated with TPE and had successfully improved his disease course with no renal replacement therapy.

Catastrophic antiphospholipid syndrome (CAPS) is the worst form of antiphospholipid syndrome (APS) and affects <1% of APS patients. Multiple organs are affected by a thrombus shower in a short-time period, with high mortality rates approaching 50%.[25] Aggressive immunosuppression had led to decreased mortality in CAPS patients,[26] but in our experience, catastrophe was averted in only one out of six cases, carrying a mortality rate of 66.6%. Sepsis was the cause of death in those cases, possibly explained by the concomitant use of cyclophosphamide and other immunosuppressive therapies in those who died out of sepsis.

Patients with SLE presented in various forms, and TPE was used in refractory cases. Up to 2016,[27] and according to ASFA guidelines, lupus nephritis (LN) was considered category IV, and severe forms of SLE were considered grade II. In the newest edition of 2019, all complications of SLE are considered in category II. The addition of LN to SLE complications was based on smaller clinical trials that proved efficacy in rapidly proliferating LN and pregnancy.[28-30] Of our 15 patients with LN, 12/15 (80%) had clinical improvement with no need for renal replacement therapy. For other severe manifestations of SLE, the clinical efficacy was variable.

HTG is the 3rd leading cause of pancreatitis after gallstones and alcohol.[31] TPE can decrease TG levels in the plasma and reduce the cytokines with a possible increase in endothelial lipoprotein lipase activity. All six patients who received TPE for HTG had an excellent response (100%) with no complications. In 3/6 (50%) patients, repeated sessions were warranted and treated successfully again with TPE.

Acquired MetHb occurs when hemoglobin oxidization is accelerated after ingestion of certain drugs (e.g., benzocaine and[32] dapsone[33]) or toxins (e.g., nitrous oxide in laughing gas and[34] amyl nitrate in poppers[35]) leading to the change of ferrous to the ferric state. The fatality rate is high when MetHb exceeds 90% of the body's hemoglobin concentration. The usual management course includes halting the

offensive agent and aggressively supporting the patient with fluids, glucose, ascorbic acid, N-acetylcysteine, and methylene blue.[36] In some refractory cases, TPE has been used successfully in conjunction with other modalities[37,38] and is currently being studied for evidence strength by the ASFA group.[2] The etiology of acquired MetHb could not be established in the single case reported here. The use of methylene blue and supportive packed red blood cells did not improve his methemoglobin level (33%). The initiation of TPE improved his methemoglobin level to <1% after two sessions, but unfortunately, the patient became dialysis-dependent, possibly because of the potential nephrotoxic nature of the offending agent.

Despite proper settings, TPE carries the risks of any extracorporeal procedure. This can be related to the port-of-entry and line-related infections, the volume shift causing labile blood pressure, and the anticoagulant used. Significant hypotension with procedure abortion occurred during only 5/945 (0.95%) sessions. On the other hand, 11 sessions (1.1%) were aborted secondary to a dysfunctional central line. In one patient with TTP, after his 8th session, the TPE line led to sepsis, but the infection and the TTP improved. Another patient with refractory TTP, on his 3rd session, was arrested and succumbed to death.

The major limitation of this study is its retrospective design which leads to a deficiency in reporting a few important aspects when initiating TPE. This includes, but is not limited to, the type of the central line, minor adverse events, and specific laboratory parameters unique for each condition.

Conclusion

Our study proves that patients respond better than starting it late when TPE is initiated early in the disease course. Another observation in our study is that patients' conditions classified as category III (hypertriglyceridemic pancreatitis) responded to TPE effectively and may need to be considered for a shift to category II. When a qualified health practitioner performs TPE, it becomes an effective and safe therapy modality. Neurologic conditions make up the majority of patients for whom TPE may be required. Adherence to evidence-based guidelines ensures patients receive appropriate treatment without delay, improving overall quality and safety.

Acknowledgment

We would like to acknowledge the efforts of our apheresis staff, including members from the Nursing Department at KAUH. Special appreciation to Ms. Kaniz Fatima Laique for her outstanding services.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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