Original Article

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Pathology Section

Comparative Evaluation of Centrifugation and Filtration Therapeutic Plasma Exchange in Guillain-Barré Syndrome: A Cross-sectional Study

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ABSTRACT

Introduction: Therapeutic Plasma Exchange (TPE) is a cornerstone treatment for Guillain-Barré Syndrome (GBS). Two commonly employed modalities include centrifugation-based TPE (cTPE) and membrane filtration-based TPE (mTPE); however, comparative data on their clinical outcomes, procedural characteristics and safety in low-resource settings remain limited.

Aim: To compare the clinical effectiveness, safety and procedural differences between centrifugation and filtration-based TPE in patients with GBS.

Materials and Methods: A cross-sectional analytical study was conducted at Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Puducherry, India over a 16-month period from January 2021 to April 2022. A total of 36 GBS patients were included: 19 treated with cTPE in the Department of Transfusion Medicine and 17 with mTPE in the Department of Nephrology. Procedural parameters such as the type of TPE machine, anticoagulant used, Total Blood Volume (TBV) processed, Total Plasma Volume (TPV) exchanged, volume of replacement fluid infused, total procedure time, cost, laboratory changes, adverse events and clinical outcomes were compared between the groups.For statistical analysis, the Ranksum test (Mann-Whitney U test) was used to compare procedural details between departments, including median plasma volume, cost incurred (covering vascular access, procedure kit and tubing, anticoagulant, replacement fluid and calcium gluconate injections) and duration of the procedure. The unpaired t-test was used to assess differences in laboratory parameters and clinical parameters {Glasgow Coma Scale (GCS), power} both pre- and post-plasma exchange between the two departments.

Results: The mean age of participants was 48±15 years, with a male predominance of 21 (58.3%). Blood group A+ was the most common, occurring in 15 (41.7%) patients. All patients underwent five sessions of plasma exchange. Centrifugation TPE was associated with a higher mean plasma volume processed of 2316 mL, whereas during filtration plasma exchange, the volume processed was 1980 mL. The cumulative procedure duration for centrifugation TPE was longer at 243 minutes compared to 150 minutes during filtration TPE. There were greater reductions in platelet count of 39% for centrifugation TPE versus 30% for filtration TPE and a more pronounced drop in haemoglobin of 10% for centrifugation TPE versus 5.5% for filtration TPE. Allergic reactions such as itching, hypotension and redness were more frequent in the cTPE group, whereas infections (fever, chills, rigours) were more common with mTPE. Specifically, in the nephrology (mTPE) group, allergic reactions accounted for 57.1% (4) of all adverse events and infections for 42.9% (3). In contrast, in the cTPE group, allergic reactions accounted for 87.5% (7) and infections only 12.5% (1) of the reported events. However, the overall adverse event rates between the two groups were not significantly different.

Conclusion: Both centrifugation and filtration-based TPE are effective in treating GBS, but they differ in cost, procedure duration and safety profiles. In resource-limited settings, mTPE may be preferred due to lower costs and shorter durations, provided that infection control is adequate. cTPE offers advantages in plasma volume processing and adherence to full cycle completion. Modality selection should be individualised based on clinical stability, institutional logistics and patient-specific considerations. Multicentre Randomised Controlled Trials (RCTs) are needed to validate these findings and standardise treatment protocols.

Keywords: Apheresis, Clinical outcomes, Membrane filtration

INTRODUCTION

Therapeutic apheresis is an extracorporeal therapy involving either the removal or discard of selected blood constituents or the collection, ex-vivo manipulation and return of specific blood components to the patient's circulation [1]. Plasmapheresis, one of the earliest and most widely practised therapeutic apheresis procedures, was first described in 1913 by Abel JJ et al., [2]. The development of a continuous-flow centrifuge in the mid-1960s revolutionised the clinical applicability of this method by enabling efficient large-volume plasma exchange [3]. TPE is used to remove pathological substances such as autoantibodies, alloantibodies, immune complexes, lipids and protein-bound toxins or drugs that contribute to various disease processes. It can also serve to replace deficient plasma components, such as ADAMTS13 in thrombotic thrombocytopenic purpura [4]. Depending on the clinical need and available resources, TPE can be performed using either centrifugation-based techniques, which separate blood components based on their specific gravity, or filtration-based techniques, which utilise membrane pore sizes to selectively filter plasma from whole blood [5].

Centrifugation methods typically employ dedicated apheresis machines, while filtration-based systems often utilise modified dialysis machines with plasma filters [6]. Both methods are in routine clinical use worldwide and are endorsed by guidelines such as those from the American Society for Apheresis (ASFA) [7]. Despite their broad use, head-to-head comparative studies evaluating their

differences in efficiency, safety, duration, cost and patient outcomes remain limited. A randomised prospective crossover trial by Hafer C et al., along with subsequent studies by Kes P et al., and Keklik M et al., have provided insights into these differences; however, findings remain variable across settings [6,8,9]. Foreign studies including Waitz G et al., Zhu XF et al., have further contributed valuable local data on procedural variations and outcomes [10,11]. Nevertheless, there remains a knowledge gap in standardised comparative data between filtration (mTPE) and centrifugation-based (cTPE) plasma exchange in resource-constrained, mixed ICU-nephrology settings.

To address this gap, present study compared TPE performed using membrane-based filtration (via a modified dialysis machine) and centrifugation-based techniques (using dedicated apheresis machines) among patients with GBS. The study was conducted in a tertiary care hospital setting, with contributions from both the nephrology and transfusion medicine departments.

Primary objective: To compare cTPE and mTPE techniques of TPE based on procedural efficiency, clinical outcomes and safety profiles.

Secondary objectives:

1. To assess haematological and biochemical changes (haemoglobin, haematocrit, platelets, calcium) before and after TPE with each technique.
2. To compare the cost implications associated with centrifugation and filtration methods.
3. To evaluate the procedural differences, including the type of machine, anticoagulant used, plasma volume processed and procedure duration.

MATERIALS AND METHODS

This cross-sectional analytical study was conducted at the Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER), Pondicherry, over a 16-month period from January 2021 to April 2022, including both retrospective (11 months) and prospective (5 months) data collection. Retrospective data were obtained from existing patient records from both departments. Prospective data were collected using a structured data collection proforma for ongoing TPE procedures. Ethical approval was obtained from the Institutional Ethics Committee (IEC) of JIPMER, Pondicherry. IEC Protocol Number: JIP/IEC/2021/362.

Inclution criteria

1. GBS subtype (Acute Inflammatory Demyelinating Polyneuropathy) only included.
2. Cases in which only plasma exchange was the treatment were included.
3. Patients with complete data collection during the course of treatment were the only ones included in the study.

Exclution criteria

1 Missing data GBS cases excluded.

2 Patients taken other treatment along with plasma exchange excluded.

Study design and setting: The study was carried out in the Departments of Transfusion Medicine and Nephrology of a tertiary care teaching hospital. Patients who underwent TPE using either cTPE or mTPE techniques were included. The cTPE procedures were performed in the Medical Intensive Care Unit (MICU) by the Department of Transfusion Medicine using Spectra Optia and Haemonetics apheresis machines, while the mTPE procedures were performed in the Nephrology department using Fresenius Plasmaflux P2 dry filters with dialysis machines.

Protocol for both techniques are as follows: Patients who were critical were referred to the MICU for critical care management and plasma exchanges were conducted in the MICU. The remaining patients were treated under the Nephrology department for plasma exchange using dialysis machines. Patient referrals were received by the apheresis physician in the Transfusion Medicine Department if patients were admitted to the MICU. The apheresis physician evaluates the case and discusses the indication, treatment course (volume exchange, replacement fluid, schedule), vascular access, laboratory requirements, height, weight, blood type sample and time to implementation with the referring physician, which shall be documented in the case sheet. Plasma exchange shall be performed according to the urgency of the condition.

Plasma exchange performed by the Transfusion Medicine department was conducted using Haemonetics MCS Plus 9000 machines, employing new apheresis kits for each cycle of plasma exchange and the anticoagulant used was ACD-A. After the procedure, the details of the procedure, any adverse events that occurred during the procedure and the patients' vitals will be recorded in the case sheet. In the Nephrology department, the nephrologist evaluates the case and discusses the indication, treatment course (volume exchange, replacement fluid, schedule), vascular access, laboratory requirements, height, weight, blood type sample and time to implementation with the referring physician and this information was documented in the case sheet. Plasma exchange in the Nephrology department was conducted using the Fresenius Plasma Flux P2 dry filter, with Heparin as the anticoagulant. The same filter was used for each patient to complete five cycles unless there is any clogging detected in the filter. Both departments conducted five cycles of plasma exchange on alternate days, with the replacement fluid in both departments consisting of 60% Fresh Frozen Plasma (FFP) and 40% Normal Saline (NS) for all GBS cases. Vascular access was secured through a central venous catheter in both departments for all patients mentioned above. The ASFA categorises TPE as a Category I indication for GBS, with level I evidence. The ASFA 2019 Guidelines recommend: "Four to five plasma exchange treatments over 7-14 days for adult patients with severe or rapidly progressing GBS" [7].

Study population: Data from 36 patients diagnosed with GBS who underwent TPE either in the MICU (19 patients) or the Nephrology (17 patients) department during the study period were included. The subtype of GBS (Acute Inflammatory Demyelinating Polyneuropathy) classified as an ASFA Category I indication for plasma exchange was included in the study, as it is more prevalent in our area; hence, it was preferred as the inclusion criterion. Cases in which only plasma exchange was the treatment were included in the study. During the 16-month study period, there were a total of 36 cases of GBS and the total data collected during the treatment courses were selected for the study, thus determining the sample size as 36 patients.

The study consisted of two groups:

Group-1: Patients who underwent plasma exchange using centrifugation (cTPE).

Group-2: Patients who underwent plasma exchange using membrane filtration (mTPE).

Data collection and variables: Variability in laboratory testing for values was minimal, as the study was conducted in the same laboratory. Patients with complete data collection during the course of treatment were the only ones included in the study, thereby excluding cases with missing data.

Pre- and post-procedure clinical and laboratory details were recorded for each TPE session. Data collected included:

Demographics: Age, sex, blood group.

Procedural variables:

1. Type of TPE machine (Spectra Optia/Haemonetics for cTPE; dialysis machine with Plasmaflux P2 filter for mTPE);
2. Anticoagulant used (ACD for cTPE; heparin for mTPE);
3. Total Blood Volume (TBV) processed;

4. Total Plasma Volume (TPV) exchanged;
5. Volume of replacement fluid infused;
6. Total procedure time;
7. Cost.

TPV exchanged was calculated using the formula TPV=TBV×(1-haematocrit).

TBV (males): weight×70 mL/kg; TBV (females): weight×65 mL/kg.

Laboratory parameters (pre- and post-TPE for each session):

1. Haemoglobin (Hb);
2. Haematocrit (Hct);
3. Red Blood Cell Count (RBC);
4. White Blood Cell Count (WBC);
5. Platelet count;
6. Serum calcium.

Clinical outcomes and complications:

1 Adverse events (hypotension, bleeding, infections, etc.);

2 Clinical examination of the CNS;

3 Clinical outcomes.

STATISTICAL ANALYSIS

Categorical variables (gender) were expressed as frequencies and percentages. Continuous variables (e.g., age, haematological values) were expressed as mean±SD or median with range, based on their distribution. The comparison between the cTPE and mTPE groups was performed using the independent Student's t-test or the Mann-Whitney U test, depending on the distribution of the data. For comparisons involving more than two groups, either one-way ANOVA or the Kruskal-Wallis test was applied. Pre- and postprocedure comparisons within each group were carried out using the paired t-test. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 36 GBS patients were recruited for this study, comprising 19 (52.77%) patients from the transfusion medicine department and 17 (47.22%) patients from the nephrology department. All transfusion medicine patients belonged to ASFA I. The type of TPE used was centrifugation in transfusion medicine and filtration in nephrology. The machine used in nephrology was a dialysis machine, while Haemonetics was used in transfusion medicine. The anticoagulant administered was ACD in transfusion medicine and heparin in nephrology.

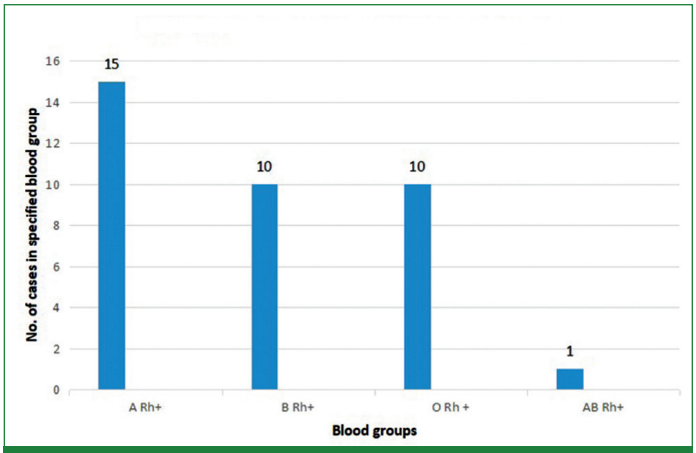
Age and gender: The mean age among the study participants was 48±15 years (as shown in [Table/Fig-1]). The majority, 21 (58.3%) (as shown in [Table/Fig-1]), were male. Age and gender were comparable between the patients of both departments.

Factors	Nephrology Mean (SD) (mTPE)	Transfusion Mean (SD) (cTPE)	p-value
Age (years)	49.9±14.6	46.2±14.9	0.46
Gender	**N (%)**	**N (%)**	
Female	7 (46.7)	8 (53.3)	0.61
Male	10 (47.6)	11 (52.4)	

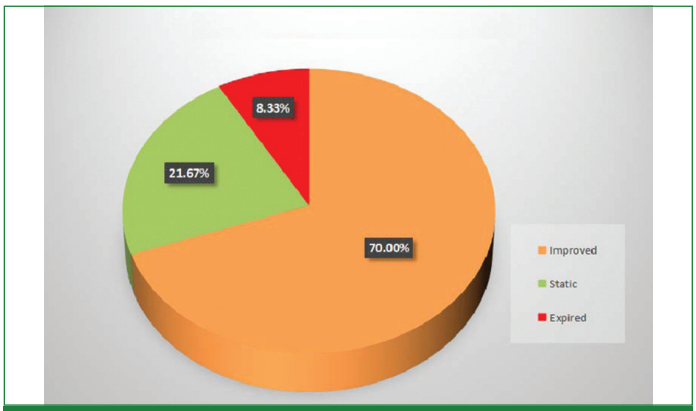
[Table/Fig-1]: Comparison of demographic variables between groups.

ABO group: The majority, 15 patients (41.67%) (as shown in [Table/Fig-2]), of the study participants had the ABO blood group A+. Only one patient (2.8%) (as shown in [Table/Fig-2]) had the AB+ blood group.

Clinical outcome of study participants: The outcomes of study participants were assessed following five cycles of plasma exchange. More than three-quarters, 25 patients (70%) (as shown in [Table/Fig-3]), improved following plasma exchange.



[Table/Fig-2]: Distribution of ABO blood groups among participants.



[Table/Fig-3]: Clinical outcome of study participants.

[Table/Fig-4] shows clinical examination and laboratory findings of study participants.

Factors*	Preplasma exchange Median (IQR)	Preplasma exchange Median (IQR)	p-value
GCS (Score)	15 (11-15)	15 (12-15)	0.12
Power (Score)	2 (1-3)	4 (2-4.5)	<0.001
Factors#	**Preplasma exchange Mean (SD)**	**Preplasma exchange Mean (SD)**	**p-value**
Haemoglobin (gm/dL)	13.1±2.1	11.2±2.2	<0.001
RBC (µL)	4.8±0.7	3.9±0.8	<0.001
WBC (WBC/µL)	11271±4632	12157±6404	0.42
Haematocrit (%)	39.9±6.1	32.9±6.1	<0.001
Platelet (Platlet/µL)	280542±111617	192790±70859	<0.001
Calcium (mg/dL)	8.7±0.6	8.1±0.7	<0.001

[Table/Fig-4]: Clinical examination and laboratory findings of study participants. *Sign rank test was used to assess the difference in GCS and Power pre and post plasma exchange. There was statistically significant increase in the neurological GCS and power post the plasma exchange sessions; #Paired t-test was used to assess the difference in lab parameters pre and post plasma exchange. There was a statistically significant decrease in haemoglobin, RBC count, haematocrit, platelets and calcium post plasma exchange.

[Table/Fig-5] shows comparisons of TPE procedural details (filtration vs. centrifugation). Ranksum test was used for comparison of procedural details in both the departments. The median plasma volume, cost incurred and duration of procedure was significantly lower in Nephrology department compared to Transfusion department. Cost calculated include vascular access, procedure kit and tubing, anticoagulant, replacement fluid, calcium gluconate injections. Cost in centrifugation TPE is 10341.34 Indian rupees which was comparatively higher than the filtration TPE which was 6134.2.

[Table/Fig-6] shows laboratory parameters prior to exchange. All patients in nephrology department had full GCS score compared to transfusion department where the mean score was 11.5 and this was statistically significant. There was no difference in the lab parameters of both department pre-exchange.

Factors*	Nephrology (mTPE) Median (IQR)	Transfusion (cTPE) Median (IQR)	p-value
Blood volume processed (mL)	5301.75 (4601.75-5780.35)	6016.33 (5585.33-7116.33)	0.08
Plasma volume processed (mL)	1980 (1850-2280)	2316.67 (2000-2583.67)	0.03*
Replacement fluid (mL)	2440.3 (2147.3-2739)	2714.66 (2373.33-2915.5)	0.42
Substitution fluid (mL)	114.5 (109.7-129.1)	110 (106.3-112.2)	0.11
Duration (minutes)	150 (134.5-182.3)	243.25 (164.6 -290)	0.002*
Cost (Indian Rupees)	6134.2 (4669.4-8961.6)	10341.34 (9278.73-11842.04)	0.009*
NS (mL)	1000 (850-1225)	1120 (1000-1500)	0.06
FFP (mL)	1440 (1162-1520)	1450 (1320-1575)	0.78

[Table/Fig-5]: Procedural details of study participants in both departments.
*Ranksum test was used for comparison of procedural details in both the departments.

Factors*	Nephrology Mean (SD) (Filtration TPE)	Transfusion Mean (SD) (Centrifugation TPE)
GCS (Score)	15	11.5±3.7
Power (Score)	2.3±1.1	1.9±0.9
Haemoglobin (gm/dL)	13.5±1.7	12.7±2.3
Haematocrit (%)	41.6±4.8	38.4±6.9
RBC (µL)	4.8±0.6	4.6±0.8
WBC (WBC/L)	11762.3±4254.6	11970±3207.7
Platelet (Platlet/L)	279941.2±93385.2	281111.1±129261.2
Calcium (mg/dL)	8.9±.80	8.6±0.46

[Table/Fig-6]: Clinical and laboratory investigation findings of study participants in both departments prior to exchange.
*Unpaired t-test was used to assess the difference in lab parameters pre plasma exchange.

[Table/Fig-7] shows laboratory parameters postplasma exchange. There was a statistically significant decrease in Hematocrit and calcium following postplasma exchange in Transfusion department. However the WBC count post exchange was significantly higher in the Transfusion department compared to Nephrology. There was statistically significant increase in the GCS post exchange in Department of Transfusion medicine (p-value <0.001).

Factors*	Nephrology Mean (SD) (Filtration TPE)	Transfusion Mean (SD) (Centrifugation TPE)
GCS (Score)	15	11.5±3.7
Power (Score)	3.6±1.4	3.3±1.2
Haemoglobin (gm/dL)	11.7±2.1	10.6±2.3
Haematocrit (%)	35.4±5.2	30.8±6.1
RBC (µL)	4.1±0.7	3.6±0.8
WBC (WBC/L)	2556.7±5335.2	10285.1±9300.3
Platelet (Platlet/L)	191666.4±100234.8	175648.3±67389.75
Calcium (mg/dL)	8.4±0.6	7.8±0.6

[Table/Fig-7]: Clinical and laboratory investigation findings of study participants in both departments post plasma exchange.
*Unpaired t-test was used to assess the difference in lab and clinical (GCS, Power) parameters post plasma exchange.

[Table/Fig-8] shows diffidence in pre and post exchange. All parameters dropped in patients of both departments but there was no significant difference in both departments. There was improvement in GCS and power but the improvement was similar in both departments.

[Table/Fig-4] shows clinical examination and laboratory findings of study participants.

[Table/Fig-5] shows comparisons of TPE procedural details (filtration vs. centrifugation). Ranksum test was used for comparison of procedural details in both the departments. The median plasma volume, cost incurred and duration of procedure was significantly lower in Nephrology department compared to Transfusion department. Cost calculated include vascular access, procedure kit and tubing, anticoagulant, replacement fluid, calcium gluconate injections. Cost in centrifugation TPE is 10341.34 Indian rupees which was comparatively higher than the filtration TPE which was 6134.2.

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[Table/Fig-7] shows laboratory parameters postplasma exchange. There was a statistically significant decrease in Hematocrit and calcium following postplasma exchange in Transfusion department. However the WBC count post exchange was significantly higher in the Transfusion department compared to Nephrology. There was statistically significant increase in the GCS post exchange in Department of Transfusion medicine (p-value <0.001).

[Table/Fig-8] shows diffidence in pre and post exchange. All parameters dropped in patients of both departments but there was no significant difference in both departments. There was improvement in GCS and power but the improvement was similar in both departments.

Factors*	Nephrology Mean (SD) (Filtration TPE)	Transfusion Mean (SD) (Centrifugation TPE)
GCS (Score)	0	0.7±1.5
Power (Score)	1.3±1.4	1.4±1.3
Haemoglobin (gm/dL)	-1.75±1.9	-1.9±2.3
Haematocrit (%)	-8.3±11.1	-5.2±11.9
RBC (µL)	-0.9±1.1	-0.7±0.8
WBC (WBC/L)	-137.64±5550.9	655.78±6088.6
Platelet (Platlet/L)	-69000±94010.6	-99912.1±102923.6
Calcium (mg/dL)	-.97±2.2	-1.16±1.9

[Table/Fig-8]: Comparison chart of pre & post-exchange difference in clinical and laboratory investigations.
*Unpaired t-test was used to assess the difference in lab and clinical (GCS, Power) parameters pre & post plasma exchange.

Safety profiles and adverse events: Events such as itching, hypotension and redness were considered allergic reactions, while fever, chills and rigours were considered signs of infection. There was no significant difference in the occurrence of adverse events between the two departments. However, allergic reactions were noted to occur more frequently in the transfusion medicine department [Table/Fig-9].

Adverse effects*	Nephrology (Filtration TPE)	Transfusion medicine (Centrifugation TPE)
Allergy (Number of patients)	4 (57.1%)	7 (87.5%)
Infection (Number of patients)	3 (42.9%)	1 (12.5%)

[Table/Fig-9]: Adverse events following plasma exchange.
*Fisher's exact test used to assess the difference in the adverse events following plasma exchange.

DISCUSSION

Comparison of TPE techniques and clinical improvement: Present study compared TPE using cTPE and mTPE techniques among patients with GBS. Both techniques led to clinical improvement in more than three-fourths of the participants. However, significant differences were observed in several procedural and laboratory parameters, including plasma volume processed duration, cost, blood cell indices and occurrence of adverse reactions in both departments was not significant.

Plasma volume processed and removal efficiency: Centrifugation consistently processed a higher plasma volume than filtration in our

cohort (2316 mL vs. 1980 mL), which aligns with the findings of Linenberger ML and Price TH, who reported 80% plasma removal efficiency via centrifugation compared to 35% by filtration [12]. This difference was largely due to technical factors such as circuit design, flow rates and separation mechanisms. While present study observed an average plasma removal efficiency of 60% with cTPE, data specific to filtration plasma removal were limited, making direct comparison difficult.

White blood cell and platelet changes: Present study observed a post-procedure increase in WBC count in the centrifugation group, whereas a decrease was noted in the filtration group. Hafer C et al., reported an increase in leukocytes with both methods, although greater with centrifugation [6]. This divergence in present study results could be due to variations in patient baseline conditions, sampling time post-procedure, or leukocyte sequestration dynamics. It also highlights the need for further investigation into leukocyte behaviour following TPE using different modalities.

Present study findings showed a 39% reduction in platelet count in the centrifugation group versus a 30% reduction in the filtration group. While Siami GA and Siami FS reported no platelet loss with filtration and a significant 56% drop with centrifugation [13], Kes P et al., observed only about a 10% loss in both methods [8]. Conversely, Hafer C et al., found greater platelet loss with filtration than centrifugation [6]. These inconsistencies reflect the influence of device-specific features, anticoagulation protocols and patient factors, underscoring the need for multicentre data to validate these trends.

Anticoagulation effects and haemoglobin changes: Citrate, the anticoagulant used in centrifugation, is known to induce hypocalcaemia and haemolysis. Present study observed a 10% post-procedure haemoglobin drop with cTPE, compared to a 5.5% reduction in mTPE. This supports prior findings and highlights the metabolic side effects of citrate use, particularly with repeated procedures.

Procedure duration and methodological differences: Contrary to most studies, present study results showed a longer median duration for cTPE (243 minutes) compared to mTPE (150 minutes). Hafer C et al., and Kes P et al., reported shorter durations for cTPE [6,8]. This discrepancy may stem from present study and reported cumulative median duration over five sessions per patient, while other studies reported mean duration per individual session. Additionally, more consistent follow-up and the completion of five-cycle exchanges in the cTPE group contributed to the extended procedure duration observed.

Replacement fluids and treatment risks: Present study used NS, FFP and albumin as replacement fluids which aligns with standard practices. Plasma exchange not only removes pathogenic components but also essential plasma proteins (e.g., clotting factors, transport proteins, cytokines). Appropriate substitution is critical to minimise treatment-associated risks such as coagulopathy or hypotension.

Cost differences and resource utilisation: Despite expectations of lower costs and shorter procedure times with filtration, present study found that cTPE was more costly, primarily due to the higher number of completed cycles and resource utilisation. In resource-limited settings, this underscores the importance of tailoring the TPE modality to the patient's ability to adhere to the protocol.

Haematologic effects and unexpected findings: A significant postprocedure drop was noted in haemoglobin and haematocrit for both modalities, more so with cTPE. Hafer C et al., had shown a rise in these parameters postprocedure [6], which contradicts present study findings. Possible explanations include haemolysis, fluid shifts, or haemodilution, particularly in critically ill patients undergoing prolonged exchanges.

Adverse events and safety profiles: Adverse events were more frequent with mTPE, mainly due to infections, while hypotension was more commonly observed in cTPE. These findings are consistent with those of Kielstein JT et al., who noted a higher rate of membrane-induced complement activation and leucocyte mobilisation in filtration, predisposing patients to infectious complications [14]. The sterile, closed-circuit design of cTPE may offer an advantage in this regard.

Study variations and need for standardisation: While many of present study findings are consistent with existing literature, contradictions persist, particularly regarding platelet loss, procedure duration and haematologic effects. These variations are likely due to differences in:

1. Device-specific technology and flow rates;
2. Patient populations and diagnoses;
3. Replacement fluids used;
4. Study design (mean vs. median reporting).

Current data is insufficient to definitively favour one technique over the other across all parameters, especially in specific diseases like GBS. No uniform protocol exists for patient stratification, cycle numbers, or exchange volumes across studies.

Limitation(s)

This study has several important limitations. First, it was conducted at a single centre, which limits the generalisability of the findings to broader populations or different healthcare settings. Second, the relatively small sample size reduces the statistical power to detect subtle differences between the two TPE techniques and increases the risk of Type II errors. Additionally, treatment allocation was non randomised; patients were assigned to either membrane-based or cTPE based on departmental logistics and availability, which introduces a risk of selection bias. Inconsistencies in adherence and follow-up were also observed.

CONCLUSION(S)

Device selection should be individualised based on patient stability, cost considerations and departmental expertise. Filtration-based TPE may be preferred in resource-limited settings for shorter durations and lower costs, assuming that infection risks are mitigated. cTPE may offer advantages in terms of plasma volume processed and tighter cycle completion. Prospective multicentre RCTs are needed to standardise procedural parameters and to evaluate long-term outcomes and recurrence rates. In conclusion, while both filtration and centrifugation-based plasma exchange are effective and safe, their differences in safety profiles, costs and efficiency necessitate a context-specific, patient-centred approach in choosing the modality.

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