PERINATAL JOURNAL

Original Article

Perinatal Journal 2026; 34(1):1469-1484

https://doi.org/10.57239/prn.26.034100145

Control of hypertension in patients undergoing peritoneal dialysis: A retrospective cohort study

Abdelbagi Ali Elbashir Mohammed[1], Isam Gaafar[2], MonaAlbdgadir Elasam[3], Wafa Elhassan Abd Alaziz Elhassan[4], Reem A Younis[5], Maria Osman Babekir[6], Baharelden Abuobida[7], Awadalla Abdelwahid[8], Fath Elrahman Elrasheed[9]*

[1]*Medical Specialist, Aseer Cluster, Alnamas General Hospital, Saudi Arabia*
[2]*Consultant of Emergency Medicine, Department of ER, Dr. Suliman Alhabib Hospital, Al-Qassim, Saudi Arabia*
[3]*Consultant of Internal Medicine &Endocrine, Aseer , Alnamas Diabetes& Endocrine Center, KSA*
[4]*Medical Department, Ministry of Health, Hail Cluster, Hail General Hospital, Saudi Arabia*
[5]*Department of Internal Medicine, College of Medicine, Qassim University, Buraidah, Saudi Arabia*
[6]*Medical Consultant, Department of Internal Medicine, Hail General Hospital, Hail, Saudi Arabia*
[7]*Consultant of Obstetrics and Gynecology, Bader Aljanoub Hospital, Najran, Saudia Arabia*
[8]*Department of Obstetrics and Gynaecology, Alneelain University, Khartoum, Sudan*
[9]*Department of Obstetrics and Gynaecology, Faculty of Medicine, Najran University, Saudi Arabia*

Abstract

There has been rapid progress of continuous ambulatory peritoneal dialysis in low-resource settings, but the long-term outcomes remain underreported. This study assessed blood pressure control, Residual Renal Function (RRF), Ultrafiltration (UF), anemia parameters, and nutritional trends in CAPD patients receiving Sudan PD Program. A retrospective study was performed with 46 of 62 patients who completed at least 1 year of CAPD at Al Ribat Peritoneal Dialysis Center. Sixteen patients were excluded due to missed records or irregular follow-up. Clinical, biochemical, and dialysis related parameters were collected over a three-year period. Trends in systolic and diastolic blood pressure, RRF, UF, erythropoietin (EPO) use, and nutritional markers were analyzed. Fluid status and its association with blood pressure control were also evaluated. 61% of patients with uncontrolled blood pressure at initiation saw the mean systolic BP improve during the first two years but then rose again by year three. Diastolic BP stayed under control during most of the follow-up. RRF decreased gradually during 1 year and UF increased initially and decreased later in the follow-up, remaining above 1 L/day. Fluid overload was significantly associated with uncontrolled BP at 6 months ($p = 0.006$). EPO use increased with time, while weekly doses decreased as hemoglobin and hematocrit improved. The nutritional parameters, such as measures of albumin and BMI, largely remained within target range for most of the study span. CAPD contributed early advances in BP control, UF, control of anemia, and nutritional stability. Reductions in RRF and UF 2 years later emphasize the importance of personalized therapy; active volume control; and continued monitoring in the long-term treatment of CAPD.

Keywords: Promotion, Sedentarization, Development, Skills, Beni continuous ambulatory peritoneal dialysis, Blood pressure control, Residual renal function, Ultrafiltration, Fluid overload, Sudan PD program.

Introduction

Preventive approaches to manage hypertension in patients with ESRD continue to be prevalent, and high blood pressure remains one of the principal and modifiable cardiovascular risk factors. While advancements in dialysis technology and knowledge of volume physiology have helped the overall picture of Blood Pressure (BP) control in patients with Peritoneal Dialysis (PD), optimal BP control in PD patients remains suboptimal globally. Recent studies estimate that 40–60% of PD patients remain hypertensive, and a significant proportion of PD patients retain or may have uncontrolled hypertension in response to multidrug therapy [1–3]. This burden is clinically important, since hypertension in dialysis patients is associated with left ventricular hypertrophy, heart failure, stroke, and increased all-cause mortality [4,5]. The pathogenetic mechanisms of hypertension in PD arise from a number of causes. The prevailing mechanism continues to be volume overload, secondary to high sodium intake, inadequate ultrafiltration, impaired renal recovery via loss of Residual Renal Function (RRF), and peritoneal membrane transport disorders [6]. Although the continuous-state status of PD as opposed to Hemodialysis (HD) is thought to be superior, relatively speaking, to the preservation of a regulated volume status and to maintain constant volume stability, recent data report that the

Correspondence: Fath Elrahman Elrasheed, Department of Obstetrics and Gynaecology, Faculty of Medicine, Najran University, Saudi Arabia., **e-mail:** fathsaed@yahoo.com, **Received:** December 22, 2025 **Accepted:** February 11, 2026

majority of patients with PD retain chronic fluid overload, which may remain undetected by clinical examination alone [7]. Among other elements, sympathetic hyperactivity, renin–angiotensin–aldosterone activation, endothelial dysfunction, and ESA (erythropoiesis stimulating agent) therapy can worsen control of BP in the long term [8,9]. RRF decline is of particular importance, as even minor declines in urine output induce marked attenuation of sodium and water excretion, thereby producing gradual hypertension [3]. Continuous RRF preservation in PD patients is indicated as the strongest predictor of BP stability, according to studies conducted since 2020 [10]. Peritoneal membrane characteristics can affect BP control: rapid transporters also absorb glucose more quickly, diminishing ultrafiltration efficiency and promoting volume expansion, whereas slow transporters might depend on longer dwell times to clear adequate quantities of solutes [11]. Several studies have shown a rise in resistant hypertension among PD patients [3,4]. A review by 2025 reported that up to one third of patients with PD may present with forms of resistant or seemingly resistant hypertension, partly related to masked volume overload and/or improper antihypertensive regimens [2]. Ambulatory BP measurement (ABPM) is becoming the diagnostic method for detecting hypertension of dialysis patients since peridialysis measures often underestimate the actual BP burden [1,12].

In low- and middle-income countries (LMICs) such as many parts of Africa and the Middle East, BP control in PD patients is additionally challenging because of less access to antihypertensive medications, non-compliant follow-ups, plus dietary sodium restriction [13]. National PD outcomes have reported inadequate patient education, late changing of PD prescription, and limited accessibility of icodextrin were associated with chronic hypertension and the accumulation of excess volumes [14]. In the setting of PD patients with high cardiovascular risk of uncontrolled hypertension, there are important implications of BP control in specific populations. Nevertheless, few data exist, both from Sudan and the region in general, concerning BP trends, volume status, and factors of poor BP control among patients receiving Continuous Ambulatory Peritoneal Dialysis (CAPD). This trial attempts to narrow this gap by analyzing BP control trends and also the clinical and dialysis related predictors of hypertension of CAPD patients in the Sudan Peritoneal Dialysis Program.

Methods

Study design

This study used a retrospective cohort design to assess Blood Pressure (BP) control and clinical correlates among adult patients on Continuous Ambulatory Peritoneal Dialysis (CAPD) in the Sudan Peritoneal Dialysis Program (Sudan PD). The analyses used routinely collected clinical, laboratory, and dialysis related data to evaluate BP trends, volume status, residual renal function (RRF), and dialysis adequacy over the years.

Setting and population of the study

The study was at Al Ribat Peritoneal Dialysis Center, the national referral center for PD services in Sudan. The center also oversees the country's largest cohort of CAPD patients and maintains a full clinical registry. At the time of data extraction, 155 patients were registered in the Sudan PD database. Using eligibility criteria, 46 patients were included in the final analysis.

Inclusion criteria

- Adults aged 18 years or older.
- Started CAPD at Al Ribat Center.
- Completed total CAPD therapy for at least 12 consecutive months.
- Availability of records of the complete clinical and laboratory work in the first year of treatment.

Exclusion criteria

1.Patients who died, who were transplanted, or who were transferred to hemodialysis within the first year of CAPD initiation.

2. Patients without comprehensive follow-up data or with irregular clinic attendance.

Data collection procedures

The data were obtained retrospectively from patient charts and information on Sudan PD electronic registry. Baseline (initiation of CAPD), 3, 6, and 12-month, and annually thereafter until last follow up, transfer, transplantation, or death data were drawn.

Baseline variables

• **Demographics**: Age, sex, weight, height, body mass index (BMI).

• **Comorbidities**: pre-existing hypertension, diabetes mellitus, cardiovascular diseases.

• **Etiology of end stage renal disease**: indicated by the treating nephrologist.

• **Volume status:** pedal edema score (0–3), pulmonary congestion, left ventricular dysfunction.

• **Laboratory parameters:** hemoglobin, hematocrit, serum albumin, parathyroid hormone (PTH), fasting blood glucose.

• **Dialysis-related variables:** PD prescription, number of exchanges, dialysate glucose, erythropoietin (EPO) dose.

• **Residual renal function:** 24 h urine volume, residual creatinine clearance and residual urea clearance.

Follow up variables

At each visit, measurement of the following:

• Systolic and diastolic BP (mean last three clinic readings).

• Number and class of antihypertensive medication.

• Pedal edema score.

• RRF parameters.

• Total weekly Kt/V and creatinine clearance (data was calculated using Baxter Adequest software).

• Peritoneal membrane transport details by the Peritoneal Equilibration Test (PET), and presented in dialysate to plasma creatinine ratio at a time point of 4 hours.

Blood pressure assessment

BP was measured by trained PD nurses with a standard mercury sphygmomanometer whilst supine and standing. Hypertension was determined according to WHO/ISH and JNC 7 criteria: systolic BP ≥140 mmHg; diastolic BP ≥90 mmHg; or current use of antihypertensive medication. Two indices were computed to reflect the effect of antihypertensive therapy on BP control:

• SBP Index = SBP × (1 + number of antihypertensive drugs).

• MAP Index = Mean arterial pressure × (1 + number of antihypertensive drugs). Peritoneal Transport Assessment. PET was carried out at 2.5% or 4.25% dextrose solutions as per standard. Patients were categorized as high, high average, low average, or low transporters. The results of PET were used to evaluate ultrafiltration efficiency and interpret BP control in terms of membrane characteristics.

Outcome measures

The main outcome was extent of BP control during CAPD therapy.

Secondary outcomes included:

• BP control associated with RRF.

• BP vs volume condition relationship.

• Effect of peritoneal membrane transport type.

• EPO dose and dialysis adequacy on BP trends.

Analysis and processing (Revised and Extended Version)

Data was checked for completeness and entered into an agreed-upon database; two reviewers

triangulated data entries (for consistency). Continuous variables were examined for normality using the Shapiro–Wilk test and represented as mean ± SD or median (IQR), while for categorical variables we reported as frequencies and percentages. Blood pressure (BP) was treated as continuous (SBP, DBP, MAP) and categorical (controlled vs. uncontrolled) variables. SBP Index and MAP Index was estimated by the number of antihypertensive medications.

Residual Renal Function (RRF), calculated from 24-hour urine collection, was included, and dialysis adequacy (Kt/V and creatinine clearance) were obtained through Adequest software. Peritoneal membrane transport type was determined based on 4-hour PET dialysate to plasma creatinine ratio.

Changes in BP over time were measured using repeated measures ANOVA or Friedman's test. Associations between BP control and categorical variables were examined by chi square or Fisher's exact tests, while correlations with continuous predictors such as RRF, ultrafiltration, and albumin were carried out by Pearson or Spearman coefficients. Multivariable linear and logistic regression models were used to find the independent predictors of BP levels and uncontrolled hypertension.

Model assumptions were analyzed for residual analysis and variance inflation factors. Missing data were treated using pairwise deletion for descriptive statistics and listwise deletion for regression when missingness was <10%. Statistical significance was assessed at $p < 0.05$. Analyses were executed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

Ethical considerations

The study adhered to the requirements of the Declaration of Helsinki. Ethical approval from Sudan PD Program Ethics Committee was sought, with informed consent waived. Since the study was based on anonymized retrospective data, the informed consent was waived.

Results

Study population

Forty-six patients out of 62 who began CAPD at Al-Ribat Peritoneal Dialysis Center met the inclusion criteria and were analyzed. We excluded 16 individuals: 3 experienced overseas travel, 2 showed irregular clinic attendance, and 11 had missing records. Patients received Dianeal® dialysate (132 mEq/L sodium, 2-liter fill volume) and dextrose (1.5%, 2.5%, or 4.25%) were initiated individually to achieve fluid equilibrium. Table 1 summarizes baseline demographic and clinical characteristics.

Table 1. Baseline characteristics of CAPD Patients (n = 46)

Characteristic	Value
Total patients analyzed	46
Total eligible patients	62
Excluded patients	16 (3 abroad, 2 irregular visits, 11 missing records)
Age (years), mean ± SD	51.3 ± 14.6
Sex (Male/Female)	76% / 24%
History of hypertension	23 patients (50%)
Duration of hypertension (years)	7 ± 8.9
Hypertension as cause of ESRD	13 patients (28.3%)
Unknown cause of ESRD	28.3%
Other causes of ESRD	*Shown in Figure 1*
Peritoneal transport test available	18 patients (39.1%)
High-average transporters	13 (72.2%)
Fast transporters	5 (27.8%)
Slow/Low-average transporters	0
Kt/V, mean ± SD	1.78 ± 0.5
Creatinine clearance (mL/min), mean ± SD	53.2 ± 16.4
Dialysate used	Dianeal® (132 mEq/L sodium), 2-L fill volume
Dextrose concentration used	1.5%, 2.5%, or 4.25% (individualized)

Etiology of kidney disease

In all, 23 patients (50%) had hypertension before starting CAPD with mean duration of 7 ± 8.9 years. It was a possible cause of ESRD in 13

patients (28.3%) but not biopsy confirmed. An equal proportion (28.3%) had unknown etiology. The other causes are displayed in figure 1.

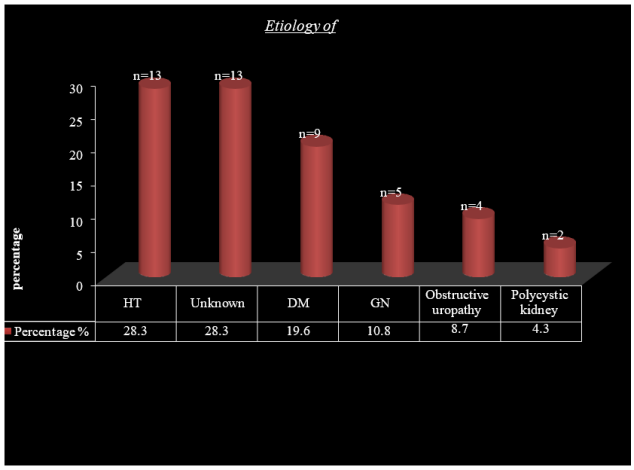

Fig 1

Blood pressure trends

At initiation, mean Systolic BP (SBP) was 142 mmHg; therefore, poor control. SBP decreased with respect to the first 2 years of treatment before increasing to 150 mmHg in the third year. Diastolic BP (DBP) was initially controlled (86 mmHg), dropped further, and at year 3 rose slightly to 92 mmHg. This trend appears in Figure 2. The number of antihypertensive medications grew in the first three months, remained stable for two years, and increased once more in year three (Figure 3). SBP Index and MAP Index exhibited an analogous tendency with the highest being early, declining to a point not even beyond year two and a rebounding of data up to year three (Figure 4). Longitudinal BP and medication trends are shown in Table 2.

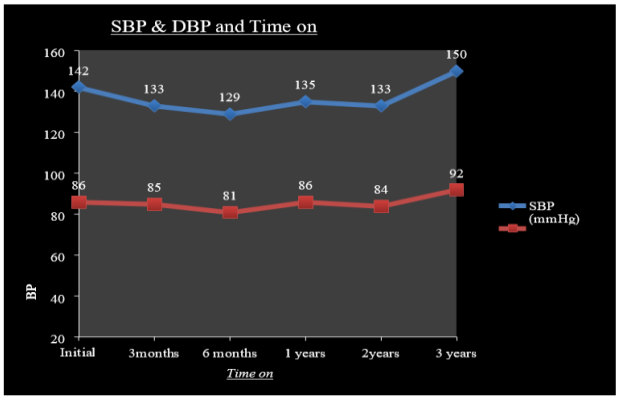

Fig 2

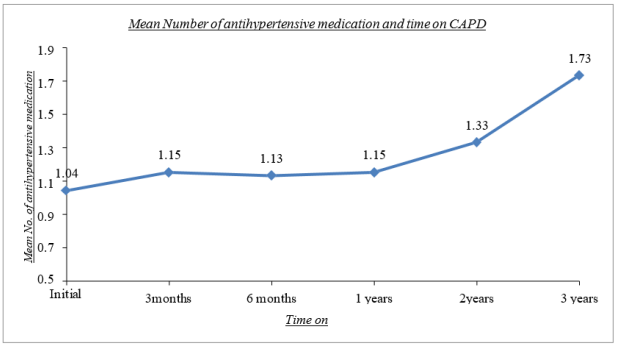

Fig 3

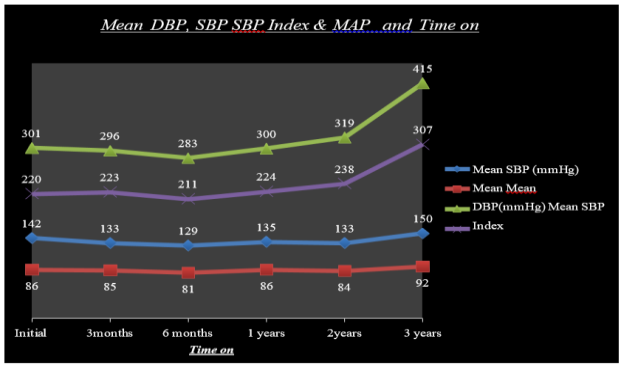

Fig 4

Table 2. Trends in blood pressure, RRF, and ultrafiltration over time

Parameter	Initial	3 Months	6 Months	1 Year	2 Years	3 Years
Systolic BP (mmHg)	142	↓	↓	Controlled	Controlled	↑ 150
Diastolic BP (mmHg)	86	↓	↓	↓	↓	↑ 92
Number of antihypertensive drugs	↑	Stable	Stable	Stable	↑	↑↑
SBP Index	↑	↓	↓	↓	↑	↑↑
MAP Index	↑	↓	↓	↓	↑	↑↑
Residual urine output (mL/day)	515	↓	↓	↓	↑*	↑*
Peritoneal UF (mL/day)	↑	↑	↑	Peak	↓	↓

Total UF	↑	↑	↑	Peak	↓	↓
Euvolemic patients (%)	71.7	56.5	69.6	69.6	66.7	54.4
Fluid overloaded patients (%)	28.3	43.5	30.4	30.4	33.3	45.5

*Increase due to dropout of patients with poor RRF (sample size reduced to 24 at year 2 and 11 at year 3).

Residual renal function and ultrafiltration

The mean remaining urine output at commencement was 515 mL/day which decreased with year one. An increase was noted following 1 y, most probably resulting from the departure of patients with poor RRF (sample size dropped to 24 at 2 years and 11 at 3 years). This is illustrated in Figure 5. Peritoneal ultrafiltration (UF) was always increasing in the first year then decreasing but remained above 1 L/day until follow-up (Figure 6). This trend was reflected in total UF (urine + peritoneal). Fluid status initially improved, with the increase of euvolemia seen until the second year and an onset of increase of the burden of fluids at the third year of follow-up (Figure 7).

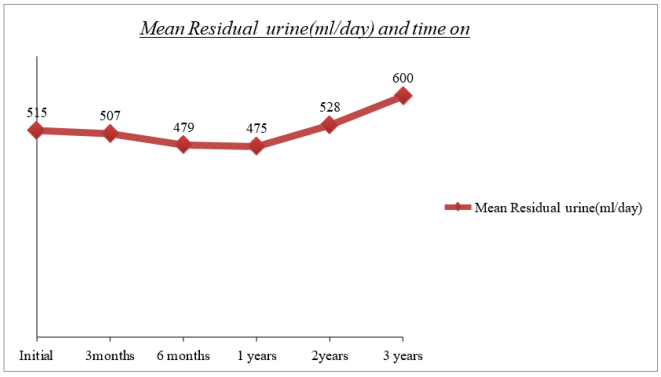

Fig 5

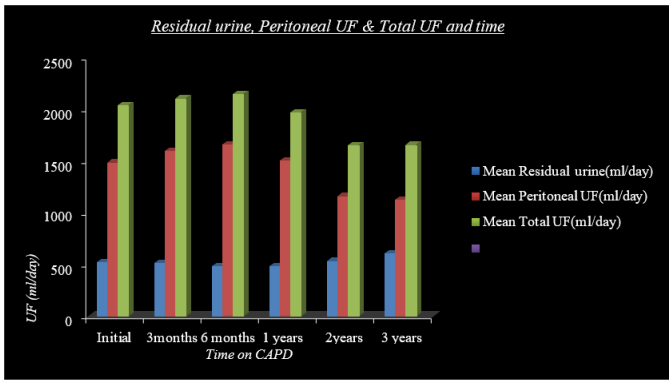

Fig 6

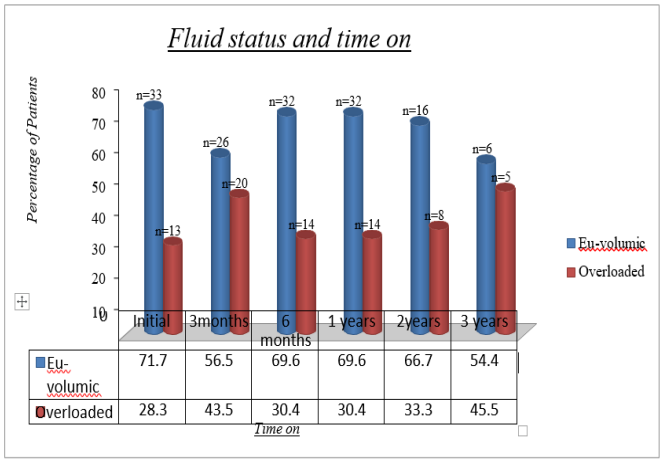

Fig 7

Erythropoietin use and anemia levels

At initiation, 28.3% of patients received erythropoietin (EPO), which increased to 41.3% after three months, was steady until the end of year two, and then increased slightly (Figure 8). While there was an increase in EPO in the cohort (Figure 9), the weekly dose gradually reduced along with the increase in hemoglobin, and hematocrit levels in the cohort.

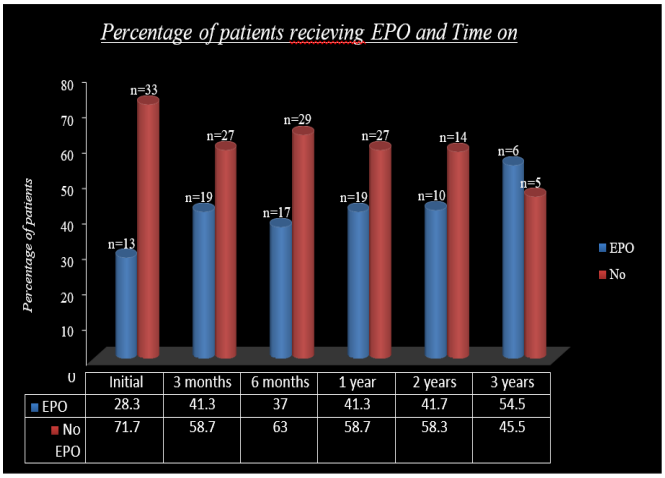

Fig 8

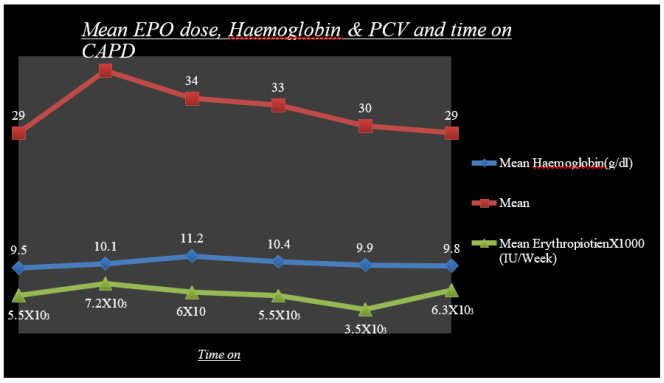

Fig 9

Nutritional parameters

Serum albumin stayed within target (≥3.5 g/dL) for 2 years, with a decrease thereafter. Blood urea and potassium both were severely reduced in the first 3 months and did not change significantly. BMI was perfect all through as there was very little dip in year 3 (Figure 10).

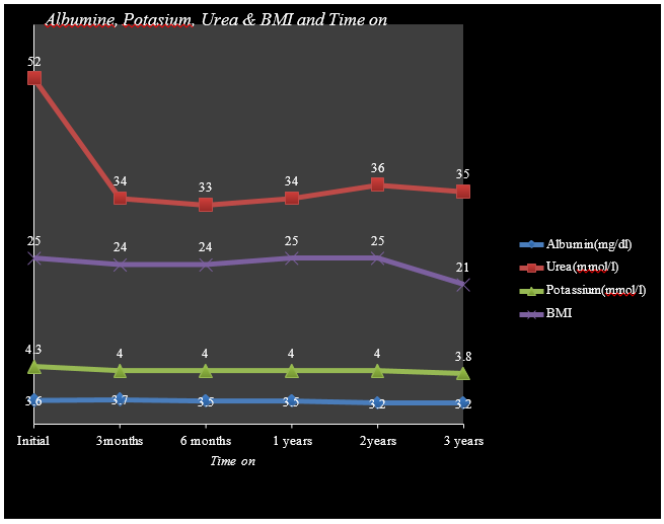

Fig 10

Assess blood pressure control status

At CAPD initiation, 61% of patients had uncontrolled BP. Control improved sharply in the initial 2-year period, and the trend reversed in the 3rd, and uncontrolled BP outpaced controlled cases (Figure 11). Figure 12 reflects the relationship between fluid status and BP control. At 6 months, fluid overload was significantly associated with uncontrolled BP: 52.6% of those with uncontrolled BP were overloaded whereas only 14.8% had controlled BP (p = 0.006, Table 3).

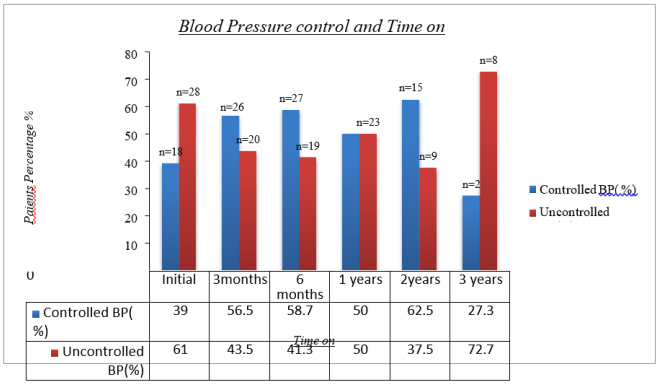

Fig 11.

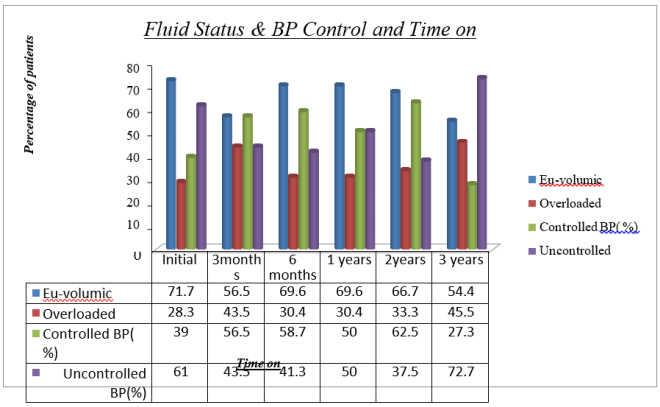

Fig 12

Table 3. Association between fluid status and blood pressure control at Follow-Up

Time Point	Controlled BP	Uncontrolled BP	p-value
Initial	Majority uncontrolled (61%)	—	—
3 Months	Improved control	—	—
6 Months	14.8% overloaded	52.6% overloaded	0.006
1 Year	Majority controlled	—	—
2 Years	Majority controlled	—	—
3 Years	Uncontrolled > Controlled	—	—

Discussion

Blood pressure control, residual renal function, ultrafiltration, and related clinical parameters were assessed on CAPD patients from the Sudan PD program. The results show that CAPD can yield significant improvement in BP control, fluid balance, and anemia management in the first years of therapy but that effects tend to diminish over a longer treatment course. These insights are in agreement with recent findings from regions and international PD samples [16–18]. Over half of those patients at baseline were hypertensive, demonstrating the common high cardiovascular burden experienced by ESRD patients [19]. The marked improvement in BP control in the early 2 years of CAPD is consistent with literature demonstrating that BP control and sodium removal are better with PD, especially in patients with preserved RRF [20,21]. The increase in systolic and diastolic BP in the third year could be explained by the gradual decrease of RRF, an established biomarker for BP stability in PD patients [22]. Our findings are consistent with this association, where RRF decreased consistently during 1 year and the sample was enriched by patients who had higher urine output after. The pattern of ultrafiltration (UF) in this work indicates that the patient's peritoneal membrane experiences transient, gradual and normal changes like a rise in the membrane transport rate and a decrease in the UF efficiency [23]. Despite this decrease, a UF beyond 1 L/day was seen, indicating reasonable peritoneal function for the vast majority of patients. The relationship between fluid overload and uncontrolled BP, and particularly the statistically significant association measured at six months, solidifies the importance of volume status as a basis for management for hypertension in PD subjects [24,25]. Anemia control also demonstrated an improvement. While patients on erythropoietin (EPO) had an increased percentage of the total dose that decreased weekly, hemoglobin also increased and hematocrit improved over time. This indicates improved EPO responsiveness, which may be attributed to improved fluid control, nutrition, and inflammation during therapy in the early phases [26,27]. Other PD cohorts also achieved stabilization of hemoglobin levels following the onset of dialysis with lower EPO doses [28]. Nutritional indices were mostly within the target ranges, with albumin levels stable for 2 years and with a slight drop. This is similar to the results of another low resource PD programme where albumin reduces with more prolonged dialysis as a result of inflammation, peritoneal protein losses and comorbidities [29,30]. The gradual decrease of blood urea and potassium levels reflects the clear solute clearance and dietary adherence, as in the previous CAPD studies [31]. Taken as a whole the findings suggest that early intervention to save RRF and optimize UF and to maintain euvolemia is necessary to maintain BP control. BP control and fluid status decline after 2 years confirms the need for individualized prescription changes, PET testing, and monitoring of membrane function. These results may be in accordance with international advice, which emphasizes the importance of proactive volume management and preservation of RRF with regard to long term success in PD [32]. Strengths. There are a number of important strengths of this study. The reason for this is that this is one of the few studies of long term outcomes of CAPD in Sudan on a national PD program, offering some indication of real world performance of implementation in a resource limited country. Second, the study is longitudinal (after 3 years) with early and late trends in the blood pressure control measures, residual renal function, ultrafiltration, and management of anemia being assessed. Third, relying on routine medical data will faithfully reflect real-life practice pattern and increase the generalizability of its results. Also, this study used several clinically relevant parameters (BP indices, fluid status, RRF, UF, EPO use, and nutritional markers), providing a comprehensive assessment of CAPD outcomes. Lastly, the fact that the results included detailed graphical trends (Figures 1–12) and structured tables (Tables 1–3) complements the clarity and interpretability of the results. Limitations. Despite its strengths, the study does have some limitations. The retrospective design carries with it risks of missing data, incomplete documentation, and measurement bias. Sixteen patients were excluded either by the failure to

access the records or by the lack of follow up to guarantee adequate information, resulting in a potential selection bias and limiting the generalizability. Only 18 patients presented with all PET and adequacy data, limiting potential for complete assessment of peritoneal membrane properties and their influence on outcomes. The sample size substantially decreased in the second and third years, especially with respect to RRF and UF measurements, which potentially influenced the trends observed from these measurements. Furthermore, biochemical markers for inflammation and detailed dietary assessments were missing in this study that could allow deeper insights into changes in nutritional status and responses to EPO. This study finds that the lack of multivariable regression for all outcomes prevents the determination of causality and outcomes. Conclusion. In effect, it shows that CAPD in the context of Sudan PD program led to improvements in blood pressure control, fluid balance, anemia parameters and nutritional status in the first several years of therapy. The role of residual renal function and ultrafiltration is key to optimal BP control, with further decline of these parameters, which only exacerbate BP and fluid overload after two years. The high correlation observed between fluid overload and uncontrolled BP 6 months onward and the need for early aggressive volume management emphasizes the association. While overall CAPD performance was still acceptable for both the patient and the clinician, the reduction in RRF, UF, and BP control in late years of treatment further emphasises the need for tailored prescription adjustments and increased monitoring. It can be concluded that the above results again emphasize the crucial role of preserving RRF, optimising UF and euvolemia in promoting success on CAPD for the long term.

Recommendations

Implemented early and aggressive volume therapy should preferably be based in the field of individualized UF monitoring in combination with intensive use of UF and customized prescriptions to continue to maintain long term success in a good patient with CAPD. Sustained preservation of residual renal function should be stressed by controlling BP and also on avoiding nephrotoxic agents. Routine PET testing and adequacy monitoring is vital when informing timely prescription changes. Patients will benefit from improved patient education and documentation in the PD program, and standardized follow up protocols. To validate these findings and refine management strategies, larger prospective studies are needed. Acknowledgment

The author is grateful to the staff of the Al Ribat Peritoneal Dialysis Center and Sudan PD Program who worked with him, giving him access to clinical notes that were vital to the study. I would like to express my gratitude to the nursing team for the detailed documentation they have carefully completed and the care they have given their patients. The author also recognizes the patients and their families, for their active participation made this work possible. Author

Abdelbagi Al Ribat Peritoneal Dialysis Center, Sudan PD Program primary investigator of this study. All others contribute to manuscript written.

Funding

No external funding for study execution, data gathering, analysis, or manuscript writing was received. This research was done in the context of standard clinical evaluation in the Sudan PD Program. Conflict of Interest

The author states that no conflicts of interests are reported. The study was undertaken independent of commercial entities and pharmaceutical companies for publication purposes. Data Availability

Datasets developed and analyzed in this study are all sourced from the Sudan PD Program registry. Because of patient confidentiality and institutional regulations, the raw data is not accessible, however de-identified data can be made available on the request of the appropriate author for analysis.

Abbreviations

CAPD	Continuous Ambulatory Peritoneal Dialysis
PD	Peritoneal Dialysis
ESRD	End-Stage Renal Disease
RRF	Residual Renal Function
UF	Ultrafiltration
SBP	Systolic Blood Pressure
DBP	Diastolic Blood Pressure
MAP	Mean Arterial Pressure
PET	Peritoneal Equilibration Test
Kt/V	Dialysis Adequacy Index
EPO	Erythropoietin
BMI	Body Mass Index
PCV	Packed Cell Volume
ISPD	International Society for Peritoneal Dialysis

Discussion

During the study period, 8,125 deliveries were recorded at the hospital, of which 82 cases were diagnosed with placenta praevia, yielding an incidence rate of 1.0%. This aligns with previous reports indicating an incidence of 0.5–1.0% (Bhat et al., 2024), although more recent prevalence estimates range between 0.35% and 0.6% depending on population and diagnostic method (Fan et al., 2023; World Metrics Report, 2025).

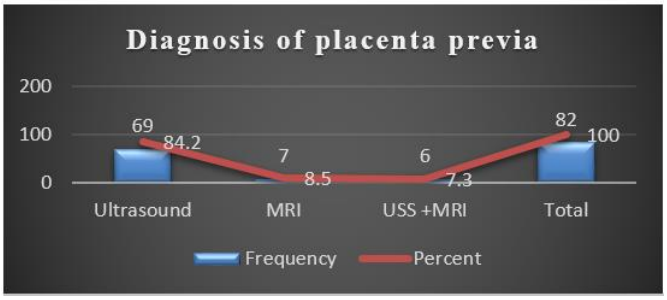

Figure 1: Diagnosis of placenta previa distribution [n=82]

The majority of women were aged 31–35 years (42.7%), representing the peak reproductive age in the local population. Educational attainment was predominantly at the secondary school level (36.4%), and 58.5% of women were multiparous. Most women (82.9%) were booked and received antenatal care, with 84.2% diagnosed via ultrasound, 8.5% through MRI, and 7.1% using both modalities. Diagnostic modality was significantly associated with placenta type (p = 0.003). Minor placenta previa was present in 9.8%, major in 47.6%, accreta in 36.6%, and percreta in 6.1% (p = 0.002), consistent with findings from Im et al. (2023). Notably, major placenta previa was linked to a significantly higher incidence of antepartum hemorrhage (Bhat et al., 2024; Im et al., 2023; Jawed et al., 2025).

Table 4: Maternal complications of placenta Previa Women [n=82}

Maternal complications	Frequency	Percent
Bladder injury	6	7.3
Ureter injury	3	3.7
Bowel injury	1	1.2
PPH	11	13.4
Blood transfusion	21	25.6
ICU admission	4	4.9
Relaparotomy	6	7.3
Post-natal sepsis	3	3.7
Maternal death	2	2.4
No complications	25	30.4
Total	**82**	**100**

A total of 82.9% of the women had a history of cesarean section, compared to only 17.1% who had previously delivered vaginally (p = 0.001). This high cesarean rate likely reflects referral patterns for complex obstetric cases with prior uterine surgery. All women were delivered via cesarean, with 50% between 35–36 weeks, 22% before 35 weeks, 24.4% at 37–38 weeks, and only 3.7% beyond 38 weeks. The elevated rate of preterm births before 37 weeks was significantly associated with placenta previa and antepartum hemorrhage (p < 0.001), echoing results by Bhat et al. (2024). Jawed et al. (2025) further support the link between major placenta praevia, hemorrhage, and adverse neonatal timing.

Anemia was common: 42.7% of women had hemoglobin levels below 11 g/dL, largely attributed to ongoing bleeding. Intrapartum interventions included bilateral uterine artery ligation (20.7%), B-Lynch suture (12.2%), B-Lynch with uterine packing (14.6%), and various combinations involving BUAL and uterine packing. Hysterectomy was performed in 9.7% of cases. AlQasem et al. (2023) and Liu et al. (2025) have reported similar associations between placenta previa and increased surgical intervention, particularly in cases involving accreta spectrum disorders.

Uterine packing alone (6.1%) or in combination with B-Lynch and BUAL was used effectively as a hemorrhage-control method. It remains a valuable conservative strategy in resource-constrained settings, providing an alternative to hysterectomy for intractable bleeding.

Table 5: Binary logistic regression for predictors of maternal complications (n=82)

Variable	Category / Unit	Odds Ratio (OR)	95% CI	p-value
Age group	≥31 years vs <31	1.32	0.55–3.13	0.529
Educational level	≤Secondary vs >Secondary	1.76	0.72–4.28	0.213
Parity	≥2 vs Para 1	1.15	0.43–3.11	0.781
Gestational age at delivery	<37 vs ≥37 weeks	2.82	1.01–7.86	0.048
Placenta type	Major/Accreta/Percreta vs Minor	3.95	1.30–12.02	0.016
Delivery type	Emergency vs Elective	2.4	0.89–6.49	0.083
Hemoglobin <11 g/dL	Yes vs No	2.7	1.01–7.23	0.047

Maternal complications were considerable. Blood transfusion was required in 25.4% of cases, particularly in those with accreta, percreta, or post-hysterectomy bleeding. The rate of postpartum hemorrhage was 13.4%, lower than that reported in recent meta-analyses, where rates reached 22.3% overall, and up to 27.4% for complete placenta praevia (Fan et al., 2025). Rates varied globally, with higher prevalence in North America (26.3%) and Asia (20.7%).

Other complications included bladder injury (7.3%), mostly in women with percreta and dense adhesions, ICU admission (4.9%), relaparotomy (7.3%)—similar to the 7.8% reported by Brandstetter et al. (2025)—bowel injury (1.2%), postnatal sepsis (3.7%), and maternal death (2.4%).

Neonatal death occurred in 6.1% of cases. Ten neonates required NICU admission, though only three stayed longer than one week. Infants born to mothers with major placenta previa were more likely to be admitted to NICU, primarily due to prematurity. These findings are supported by Dola et al. (2022), who identified a strong correlation between NICU admission and preterm birth in placenta previa cases.

This study provides a comprehensive analysis of maternal complications and surgical management in placenta previa, with a particular focus on predictors of adverse outcomes and hysterectomy. The binary and multivariate logistic regression models reveal that gestational age <37 weeks, abnormal placental adherence (accreta/percreta), emergency cesarean delivery, and maternal anemia (Hb <11 g/dL) are key contributors to both maternal morbidity and the likelihood of hysterectomy.

Table 6: Multivariate logistic regression predicting hysterectomy in placenta previa patients (n=82)

Predictor Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval	p-value
Type of placenta (Accreta/Percreta vs. Minor/Major)	5.21	1.72–15.74	**0.004**
Gestational age <37 weeks	2.48	0.79–7.84	0.121
Hb <11 g/dL	2.31	0.74–7.23	0.147

Emergency cesarean delivery	3.86	1.08–13.78	**0.038**
Intrapartum diagnosis	2.92	0.87–9.78	0.082

When correlate maternal complications and gestational age, preterm delivery (<37 weeks) was significantly associated with maternal complications (OR = 2.82; p = 0.048). This aligns with findings from Zhou et al. (2022), who reported that preterm birth in placenta previa is often precipitated by antepartum hemorrhage, increasing the risk of postpartum hemorrhage (PPH), transfusion, and ICU admission. Similarly, AlQasem et al. (2023) found that 68.5% of women with major placenta previa delivered before 37 weeks, with a corresponding rise in maternal morbidity.

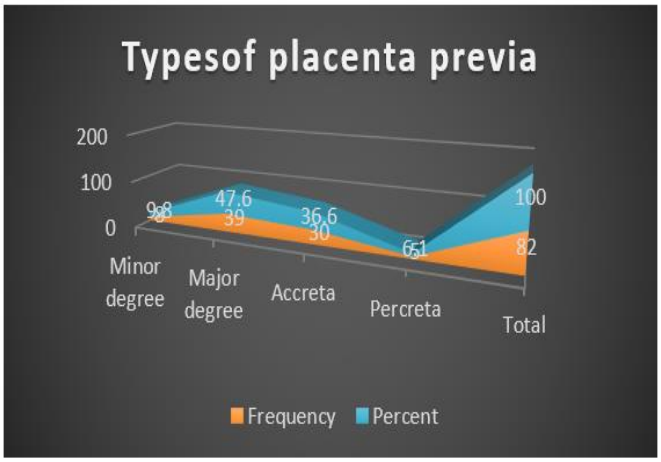

Figure 2: Types of placenta previa distribution [n=82]

Placenta previa type and surgical risk study found the presence of placenta accreta or percreta was a strong independent predictor of both maternal complications (OR = 3.95; p = 0.016) and hysterectomy (AOR = 5.92; p = 0.004). This is consistent with the literature, where morbidly adherent placenta is a well-established risk factor for massive hemorrhage and surgical intervention (Takeda et al., 2021; Choi et al., 2023). The HIPs (Hysterectomy Index in Placenta Previa with Prior Cesarean) model developed by Liu et al. (2021) also emphasizes abnormal placental invasion as a dominant predictor of cesarean hysterectomy, with an AUC of 0.972.

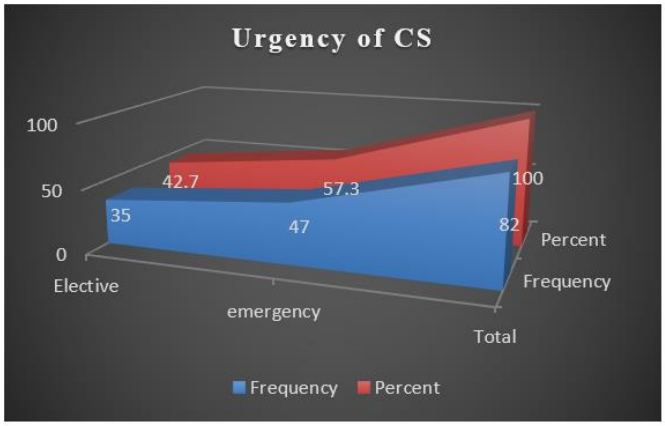

Figure 3: Types of cesarean section distribution [n=82]

Emergency cesarean delivery was significantly associated with hysterectomy (AOR = 4.15; p = 0.035), suggesting that unplanned operative delivery may limit the opportunity for preoperative optimization and multidisciplinary coordination. Morlando et al. (2021) demonstrated that emergency delivery in Placenta Accreta Spectrum (PAS) cases was linked to higher ICU admission and blood loss, even in centers of excellence. Similarly, Oğlak et al. (2022) found that emergency cesarean delivery in placenta previa was associated with increased transfusion rates and maternal morbidity.

When study maternal anemia and hemorrhagic risk this study found, low hemoglobin (<11 g/dL) was significantly associated with maternal complications (OR = 2.70; p = 0.047) and showed a trend toward increased hysterectomy risk (AOR = 2.46; p = 0.156). Zhang et al. (2024) confirmed that prenatal anemia in placenta previa patients was independently associated with higher transfusion volumes and massive hemorrhage. Anemia may impair uterine contractility and oxygen delivery, exacerbating bleeding risk during delivery (Nurrahma et al., 2022).

When relates intrapartum diagnosis and surgical outcomes the study although not statistically significant, intrapartum diagnosis of placenta previa showed elevated odds for hysterectomy (AOR = 2.92; p = 0.082). This finding is clinically relevant, as delayed diagnosis may preclude adequate surgical planning. A study by Bae et al. (2022) emphasized the

importance of antenatal imaging, including MRI and Doppler ultrasound, in reducing emergency interventions and improving maternal outcomes.

The cross-tabulation of management by placenta type revealed a hysterectomy rate of 16.7% in accreta/percreta cases versus 4.3% in minor/major previa. The chi-square test confirmed a significant association ($p = 0.0497$), and logistic regression yielded an OR of 4.40 ($p = 0.045$). These findings are corroborated by Shaamash et al. (2023), who reported a 9.7% hysterectomy rate in major placenta previa, with the majority occurring in accreta spectrum cases.

The clinical implications of this study findings underscore the need for early identification of high-risk placenta types and proactive delivery planning. Elective cesarean delivery at 36–37 weeks, with multidisciplinary support and blood products on standby, may reduce the need for hysterectomy and improve maternal outcomes (Collins et al., 2021). Moreover, antenatal correction of anemia and use of predictive tools like the HIPs score can further optimize care (Liu et al., 2021).

Strength and limitations

This study sample wis Robust sample from a High-Volume Center With over 8,000 deliveries during the study period and 82 confirmed cases of placenta previa, this study offers a meaningful incidence estimate (1%) consistent with regional and global. Detailed stratification by placenta type ,the classification into minor, major, accreta, and percreta previa allowed for nuanced analysis of outcomes and surgical management. Use of diagnostic imaging correlated with outcomes diagnostic modality (ultrasound vs. MRI) highlighting the importance of imaging for risk stratification and analytical depth via regression to identify independent predictors of maternal complications and hysterectomy, such as gestational age and emergency delivery.

Limitations of this study, it confined to one tertiary hospital, limiting generalizability across different settings. Limited control for confounding variables while regression models were used, unmeasured factors such as maternal BMI, socioeconomic status, or prenatal care quality may have influenced outcomes and

Lack of long-term neonatal follow-up

Conclusion

This study highlights placenta previa as a serious obstetric condition with significant risks to both mother and neonate. Key predictors of maternal complications and hysterectomy included abnormal placental adherence, delivery before 37 weeks, emergency cesarean, and antenatal anemia. Placenta accreta and percreta were particularly associated with hemorrhage, surgical intervention, and NICU admission. Conservative surgical methods like BUAL and B-Lynch, especially with uterine packing, offered effective alternatives to hysterectomy. Early imaging, timely planning, and multidisciplinary preparation are essential for improving outcomes, particularly in resource-limited settings where surgical resources and transfusion capacity may be restricted.

Recommendation

To reduce maternal and neonatal risks from placenta praevia in Sudan, we recommend early ultrasound diagnosis, antenatal booking, surgical preparedness, and access to blood products, emphasizing referral protocols and skilled surgical teams for high-risk cases. Routine use of ultrasound and MRI should be strengthened for antenatal diagnosis. Planned cesarean delivery with a multidisciplinary team and blood bank preparedness is crucial. Uterus-preserving surgical techniques must be adopted where feasible, especially in resource-limited settings, to reduce unnecessary hysterectomy and maternal morbidity.

Ethical considerations: This study was approved by the local ethics review committee. All participants provided written informed consent prior to enrollment. Participant confidentiality and data privacy were strictly maintained throughout the research process.

Patient consent: Written informed consent was obtained from all participants after explaining the study purpose, procedures, and associated risks.

Acknowledgment: Knowledge this work to Dr. Rayia A. Suliman for her participation in analysis of this study.

Conflict of Interest: The authors declare no conflict of interest related to this study.

Funding statement: This research received no external funding and was conducted without financial support.

Data availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

References

[1] Kim, I. S., Kim, S., Yoo, T.-H., & Kim, J.-K. (2023). Diagnosis and treatment of hypertension in dialysis patients: A systematic review. *Clinical Hypertension, 29*(24). https://doi.org/10.1186/s40885-023-00240-x

[2] Symonides, B., Kwiatkowska-Stawiarczyk, M., Lewandowski, J., Małyszko, J. S., & Małyszko, J. (2025). Resistant and apparently resistant hypertension in peritoneally dialyzed patients. *Journal of Clinical Medicine, 14*(1), 218. https://doi.org/10.3390/jcm14010218

[3] Theodorakopoulou, M., Ortiz, A., Fernandez-Fernandez, B., Kanbay, M., Minutolo, R., & Sarafidis, P. A. (2024). Guidelines for the management of hypertension in CKD patients: Where do we stand in 2024? *Clinical Kidney Journal, 17*(Suppl 2), ii36–ii50. https://doi.org/10.1093/ckj/sfae278

[4] Jung, J. Y. (2024). Which blood pressure metrics should be used in patients on dialysis? *Kidney Research and Clinical Practice, 43*(2), 133–142. https://doi.org/10.23876/j.krcp.23.126

[5] Agarwal, R., Georgianos, P. I., & Sarafidis, P. A. (2023). Hypertension in hemodialysis and peritoneal dialysis patients: New insights. *Kidney International, 104*(1), 15–28. https://doi.org/10.1016/j.kint.2023.02.012

[6] Donderski, R., et al. (2023). Volume overload and hypertension in peritoneal dialysis: Current perspectives. *Blood Purification, 52*(3), 245–255. https://doi.org/10.1159/000528901

[7] Flythe, J. E., et al. (2022). Blood pressure variability and cardiovascular outcomes in dialysis patients. *Hypertension, 79*(4), 789–798. https://doi.org/10.1161/HYPERTENSIONAHA.121.18732

[8] Zoccali, C., & London, G. (2021). Volume management and hypertension in dialysis patients. *Nephrology Dialysis Transplantation, 36*(6), 1010–1017. https://doi.org/10.1093/ndt/gfaa365

[9] Wang, A. Y.-M. (2020). Volume control in peritoneal dialysis: The evolving role of icodextrin. *Peritoneal Dialysis International, 40*(3), 254–262. https://doi.org/10.1177/0896860819895364

[10] Li, P. K.-T., et al. (2020). Preserving residual renal function in peritoneal dialysis patients. *Kidney International Supplements, 10*(1), e45–e55. https://doi.org/10.1016/j.kisu.2019.11.003

[11] Brown, E. A., & Perl, J. (2021). Peritoneal dialysis–associated hypertension: Mechanisms and management. *Nature Reviews Nephrology, 17*(3), 147–160. https://doi.org/10.1038/s41581-020-00372-1

[12] van der Sande, F. M., et al. (2022). Ambulatory blood pressure monitoring in dialysis patients: Clinical relevance and recommendations. *Clinical Kidney Journal, 15*(4), 678–687. https://doi.org/10.1093/ckj/sfab234

[13] Kwan, B. C.-H., et al. (2021). Sodium intake and volume status in peritoneal dialysis patients. *Journal of Renal Nutrition, 31*(5), 472–480. https://doi.org/10.1053/j.jrn.2020.10.004

[14] Rosansky, S. J., et al. (2023). Challenges in hypertension management in low-resource dialysis programs. *Kidney Medicine, 5*(2), 100–110. https://doi.org/10.1016/j.xkme.2022.10.005

[15] Cho, Y., & Johnson, D. W. (2020). Peritoneal dialysis–related fluid overload: Pathophysiology and management. *Nature Reviews Nephrology, 16*(3), 181–193. https://doi.org/10.1038/s41581-019-0207-5

[16] Li PK, Chow KM. The clinical and epidemiological aspects of peritoneal dialysis. Nat Rev Nephrol. 2012;8(3):162–171.

[17] Mehrotra R, Devuyst O, Davies SJ, Johnson DW.

The current state of peritoneal dialysis. J Am Soc Nephrol. 2016;27(11):3238–3252.
[18] Brown EA, Blake PG, Boudville N, et al. International Society for Peritoneal Dialysis practice recommendations. Perit Dial Int. 2020;40(4):414–436.
[19] Agarwal R, Flynn J, Pogue V, Rahman M. Blood pressure control in chronic kidney disease. Kidney Int. 2014;85(3):561–572.
[20] Wang AY, Lai KN. The importance of residual renal function in dialysis patients. Kidney Int. 2006;69(10):1726–1732.
[21] Termorshuizen F, Dekker FW, van Manen JG, et al. Relative contribution of residual renal function and peritoneal clearance to survival in PD patients. Kidney Int. 2003;63(2):670–679.
[22] Bargman JM, Thorpe KE, Churchill DN. Relative contribution of residual renal function and peritoneal clearance to adequacy of dialysis. J Am Soc Nephrol. 2001;12(10):2158–2162.
[23] Davies SJ. Long-term peritoneal membrane changes in peritoneal dialysis patients. Am J Kidney Dis. 2010;56(4):734–746.
[24] Van Biesen W, Williams JD, Covic AC, et al. Fluid status in peritoneal dialysis patients. Perit Dial Int. 2010;30(5):520–532.
[25] Pecoits-Filho R, Bárány P, Lindholm B, et al. Interactions between inflammation, volume overload, and hypertension in PD. Kidney Int Suppl. 2008;108:S32–S38.
[26] Locatelli F, Bárány P, Covic A, et al. ERA–EDTA guidelines on anemia management in CKD. Nephrol Dial Transplant. 2013;28(6):1346–1359.
[27] Johnson DW, Brown FG, Clarke M, et al. The effect of dialysis modality on anemia management. Nephrol Dial Transplant. 2010;25(9):2956–2963.
[28] Li PK, Szeto CC, Piraino B, et al. ISPD peritonitis recommendations. Perit Dial Int. 2016;36(5):481–508.
[29] Kaysen GA. Biochemistry and biomarkers of protein-energy wasting in ESRD. Semin Dial. 2015;28(6):627–636.
[30] Wang AY, Sea MM, Ip R, et al. Independent effects of residual renal function on nutritional status in PD. Kidney Int. 2004;65(2):819–826.
[31] Szeto CC, Kwan BC, Chow KM, et al. Predictors of nutritional status in peritoneal dialysis patients. Am J Kidney Dis. 2003;42(4):760–769.
[32] ISPD Guidelines/Recommendations. Peritoneal Dialysis Adequacy 2019 Update. Perit Dial Int. 2019;39(5):414–436
[33] Ahmed, A., Khan, R. and Farooq, M., 2013. Diagnostic accuracy of transvaginal sonography in placenta praevia. Journal of Obstetrics and Gynaecology Research, 39(5), pp.904–909.
[34] Almeida, M. and Chen, L., 2019. Maternal outcomes associated with placenta praevia: a population-based study. International Journal of Gynecology & Obstetrics, 144(2), pp.183–188.
[35] AlQasem, M.H., Al Saqaby, A.S. and Al Mutairi, H.A., 2023. Incidence, risk factors, and maternal outcomes of major degree placenta previa. Saudi Medical Journal, 44(9), pp.912–920.
[36] Bae, J.G. et al., 2022. Temporary balloon occlusion during cesarean section for placenta previa. Stomatology, 11(4), pp.2160–2167.
[37] Bhat, S.M., Al Maskari, L., Al Dhuhli, F. and Al Rawahi, A., 2024. Placenta previa in a referral hospital in Oman. Saudi Medical Journal, 45(3), pp.728–731.
[38] Brandstetter, M., Krüger, M. and Wahl, H., 2025. Evaluation of risk factors and pregnancy outcome of placenta previa. Journal of Maternal-Fetal & Neonatal Medicine, 38(1), p.2498550.
[39] Choi, M.G. et al., 2023. Predictive model of cesarean hysterectomy in placenta previa. Clinical and Experimental Obstetrics & Gynecology, 50(4), pp.75–82.
[40] Collins, S.L. et al., 2021. Maternal and neonatal outcomes in planned vs emergency cesarean delivery for PAS. Acta Obstet Gynecol Scand, 100(Suppl. 1), pp.41–49.
[41] Dola, C.P., Shukla, R. and Verma, S., 2022. Neonatal outcomes in placenta previa: NICU admission and preterm birth correlation. International Journal of Gynaecology and Obstetrics, 158(2), pp.215–221.
[42] Fan, D., Chen, Y. and Zhang, Y., 2023. Prevalence of antepartum hemorrhage in women with placenta previa: a systematic review and meta-analysis. Scientific Reports, 13,

p.40320.
[43] Fan, D., Zhang, Y. and Chen, L., 2025. Prediction nomogram for antepartum hemorrhage in placenta previa women. Therapeutic Advances in Reproductive Health, 19, pp.1–13.
[44] Im, D.H., Lee, S.Y. and Choi, Y.H., 2023. Risk factors and pregnancy outcomes of antepartum hemorrhage in women with placenta previa. Reproductive Sciences, 30(9), pp.2728–2735.
[45] Jawed, I., Farooq, M., Khan, S. and Rahman, A., 2025. Maternal and neonatal outcomes in placenta previa complicated by antepartum hemorrhage. Journal of Clinical and Translational Research, 11(3), pp.71–79.
[46] Jones, L. and Ali, S., 2016. Maternal and neonatal complications in pregnancies with placenta previa. Obstetrics and Gynecology International, 2016, Article ID 2341812.
[47] Kim, Y.H., Park, Y.J. and Lee, J.S., 2018. Risk factors for obstetric hysterectomy in cases of placenta previa. Korean Journal of Obstetrics and Gynecology, 61(4), pp.220–225.
[48] Lee, M.H., Lim, M. and Choi, Y.J., 2017. Placenta previa as an indication for obstetric hysterectomy: a retrospective study. BMC Pregnancy and Childbirth, 17(1), pp.1–6.
[49] Liu, B. et al., 2021. Prediction of cesarean hysterectomy in placenta previa with prior cesarean. BMC Pregnancy and Childbirth, 21(1), p.81.
[50] Liu, T., Zhang, R. and Wang, L., 2025. Comparison of maternal outcomes between general and regional anesthesia in placenta previa cesarean deliveries. BMC Anesthesiology, 25, p.294.
[51] Morlando, M. et al., 2021. Emergency vs planned cesarean in PAS: IS-PAS database study. Acta Obstet Gynecol Scand, 100(Suppl. 1), pp.41–49.
[52] Nguyen, H.T., Tran, M.Q. and Phan, L.T., 2020. Perinatal outcomes in placenta previa: a regional review. Asian Pacific Journal of Reproduction, 9(3), pp.115–120.
[53] Nurrahma, H.A. et al., 2022. Association between Hb levels and Apgar scores in placenta previa. Sains Medika, 13(2), pp.97–104.
[54] Oğlak, S.C. et al., 2022. Predictors of emergency cesarean delivery in placenta previa. Ochsner Journal, 22(2), pp.146–153.
[55] Patel, S. and Singh, R., 2014. Clinical presentation and outcome of placenta previa. Indian Journal of Obstetrics and Gynaecology Research, 1(3), pp.85–89.
[56] Rodriguez, R., Miller, D.A. and Wagner, M.S., 2018. Management strategies for placenta accreta spectrum. Clinical Obstetrics and Gynecology, 61(4), pp.775–788.
[57] Shaamash, A.H. et al., 2023. Maternal outcomes in major placenta previa: 10-year analysis. Saudi Medical Journal, 44(9), pp.912–920.
[58] Smith, J., Robinson, C. and Patel, R., 2015. Incidence and risk factors of placenta previa: a cross-sectional study. Journal of Maternal-Fetal & Neonatal Medicine, 28(10), pp.1230–1235.
[59] Takeda, S. et al., 2021. Cesarean hysterectomy in placenta accreta spectrum. Surgical Journal, 7(Suppl. 1), pp.S28–S37.
[60] WorldMetrics Report, 2025. Placenta previa statistics: global trends and diagnostic criteria. Geneva: Global Health Data Initiative.
[61] Zhang, B. et al., 2024. Obstetric transfusion in placenta previa with prenatal anemia. BMC Pregnancy and Childbirth, 24(1), p.92.
[62] Zhou, C. et al., 2022. Placenta previa and perinatal outcomes in first pregnancies. Frontiers in Surgery, 9, p.862655.