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ORIGINAL ARTICLE

Post-Transplant Erythrocytosis after Kidney Transplantation: Incidence, Risk Factors, Clinical Outcomes, and Therapeutic Approaches in 97 Adult Recipients

UBAID UR RAHMAN[1], SAMI-UR-RAHMAN[2], KHAWAR SULIMAN[3], ARSHAD MAHMOOD[4], SAIF ULLAH[5], MUHAMMAD MUBBASHAR NAZAR[6]

[1]Medical Officer, Department of Urology, Pakistan Institute of Medical Sciences (PIMS), Islamabad
[2]Registrar Kidney Transplant, Department of Kidney Transplant, Begum Akhtar Rukhsana Memorial Trust and Safari Hospital, Rawalpindi
[3]Senior Consultant Urologist, Department of Urology, Provincial Headquarter Hospital (PHQ), Gilgit
[4]Consultant Urologist and Kidney Transplant Surgeon, Begum Akhtar Rukhsana Memorial Trust and Safari Hospital, Rawalpindi
[5]Assistant Professor, Department of Urology, Bukhtawar Amin Teaching Trust Hospital, Multan
[6]Assistant Professor Nephrology, Farooq Hospital Islamabad
Correspondence to: Sami-ur-Rahman, Email: dr.sami7264@gmail.com

ABSTRACT

Background: Post-transplant erythrocytosis (PTE) is a clinically important complication after kidney transplantation, characterized by persistently elevated hemoglobin and/or hematocrit levels. It may increase the risk of thromboembolic complications and requires timely recognition and management.

Objective: This study aimed to determine the incidence, risk factors, clinical outcomes, and therapeutic approaches for post-transplant erythrocytosis among adult kidney transplant recipients.

Methods: An observational cross-sectional study was conducted at Begum Akhtar Rukhsana Memorial Trust and Safari Hospital, Rawalpindi. A total of 97 adult kidney transplant recipients who had completed at least six months of post-transplant follow-up were included. Demographic, clinical, transplant-related, and laboratory data were collected from medical records and transplant registries. Patients were categorized into PTE and non-PTE groups. Statistical analysis was performed using SPSS, including group comparisons and logistic regression to identify independent predictors of PTE.

Results: Post-transplant erythrocytosis occurred in 21 out of 97 patients, giving an incidence of 22%. Patients with PTE had significantly higher hemoglobin, hematocrit, and post-transplant eGFR compared with non-PTE patients. Logistic regression identified male sex, living donor transplantation, and eGFR >60 mL/min/1.73 m² as independent predictors of PTE. Among patients with PTE, 13% developed thromboembolic events, including deep vein thrombosis and renal vein thrombosis. Therapeutic interventions included phlebotomy in 62% of patients and ACE inhibitor or ARB therapy in 38%, with clinical response observed in all treated patients.

Conclusion: PTE remains a clinically relevant complication after kidney transplantation, particularly among male recipients, patients receiving living donor grafts, and those with preserved graft function. Regular monitoring of hematologic parameters, early diagnosis, and timely treatment with phlebotomy or ACE inhibitor/ARB therapy may help reduce thromboembolic risk and improve post-transplant outcomes.

Keywords: Post-transplant erythrocytosis, kidney transplantation, hemoglobin, hematocrit, graft function, thromboembolism, phlebotomy, ACE inhibitors.

INTRODUCTION

Kidney transplantation has become an accepted treatment for end-stage renal disease, which is associated with much better long-term health, survival, and quality of life than chronic dialysis therapy. Despite significant advances in the early survival of grafts and the prevention of acute rejection caused by surgery, immunology and transplantation, and postoperative treatment over the last several decades, a high proportion of recipients still experience early graft failure. Despite these achievements, kidney transplant recipients still experience a range of complications, some of which can impact graft and patient survival. A complication of this sort is post-transplant erythrocytosis (PTE), which is defined by a sustained increase in the number of red blood cells, and which has been clinically noted because of its linkage with cardiovascular morbidity and thromboembolic events.[1]

The pathological manifestation of post-transplant erythrocytosis is usually an elevated hemoglobin concentration (Hgb>17g/dL) and/or hematocrit (Hct>51%) that last for at least six months after transplantation, as used in clinical practice. This definition makes a distinction between PTE and the potential changes of the hematologic parameters that can occur after surgery within a short period. PTE usually presents during the first year after transplant, but may occur later, especially if the graft function is stable and the patient is followed up infrequently. There is a wide range of reported incidence of PTE ranging from 8% up to 20% of adult kidney transplant recipients. This variation is due to differences in patients, transplant, definitions used and follow-up periods in previous studies.[2]

The precise mechanisms that result in PTE are complex and multi-factorial. Anemia is very common in the case of end stage renal disease, where the diseased kidneys produce less EPO, the hormone that stimulates the production of red cells, and due to other factors such as chronic inflammation, nutrition deficiency, and shorter lifespan of red cells. Successful transplantation results in the return of a certain amount of renal endocrine function, including the production of the hormone erythropoietin (EPO) that normally promotes the production of red blood cells. In some recipients this restoration is excessive and will lead to increased red cell production and higher hematocrit. Other factors that stimulate erythropoiesis after transplant are a rise in androgens, increased bone marrow responsiveness and activation of the renin–angiotensin–aldosterone system, which have all been suggested to maintain high hematologic levels in some patients.[3]

A number of demographic and clinical factors have been linked to the onset of PTE. Male sex has consistently been reported as a significant risk factor, perhaps because of the erythropoietic activity of testosterone. There is also an association between living donor transplantation and a higher incidence of PTE, which could be due to the fact that graft function returns to normal more rapidly and more completely in living donor kidney recipients. Recipients of deceased donor kidneys, by contrast, tend to experience early post-transplant EPO output, and delayed graft function, potentially lowering the chances for a significant erythrocytosis. Other factors like younger age of the recipient, better estimated glomerular filtration rate (eGFR), and certain immunosuppressive regimens have also been suggested as

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potential factors, with evidence on these associations varying in the different literature.[4]

A major clinical problem with PTE is the risk for embolic complications. Increased hematocrit increases blood viscosity, which decreases microvascular perfusion and platelet aggregation, and thus may lead to venous and/or arterial thrombosis. This has been reported in case series and cohort studies for occurrence of deep vein thrombosis, pulmonary embolism, and renal vein thrombosis in patients with PTE, and concerns have been raised that unchecked erythrocytosis may herald serious morbidity and, rarely, mortality. Although clinical complications can occur in all patients with PTE not everyone will develop these complications, but there is a risk that these may occur and this reinforces the need for careful monitoring and prompt attention as necessary.[5]

Treatment of PTE consists of surveillance and therapeutic measures to lower the hematocrit levels and decrease the risk of thrombosis. Although therapeutic uses of phlebotomy are declining, it continues to be an important technique in the treatment of symptomatic patients or those with very high hematologic values. Certain patients have had reported decreases in erythropoietin activity and hematocrit with pharmacologic treatment such as angiotensin-converting enzyme (ACE) inhibitors and angiotensin receptor blockers (ARBs); these effects may be more variable and dependent upon individual patient characteristics. For high risk patients, some clinicians believe that low dose aspirin should be used for thromboprophylaxis but there is less definitive evidence for this approach with PTE. However, none of these options is universally established as a rule of treatment for PTE and treatment is individualized based on clinical judgment and tolerance.[6]

After years of clinical experience, there is still a lot that we lack in the knowledge of PTE. Much of the work that has been published so far is retrospective, limited to small numbers of patients in a single centre and so lacks generalisation. Furthermore, the variability in how the diseases are diagnosed, when they are monitored, and the number of details reported on the patients included in each study prevents data from being pooled together or from being subjected to consistent meta-analyses. The literature also has few studies that address long-term results of PTE patients, such as graft survival, cardiovascular events and quality of life. These constraints do emphasize the need for further extensive studies systematically assessing epidemiology, risk factors and clinical significance in various populations.[7]

This increased knowledge for PTE has significant implications for clinical practice. The accurate estimation of incidence can help to stratify the risk level and the identification of modifiable predictors can guide preventive measures. Furthermore, clarity on the associated outcomes like thromboembolic events can help direct monitoring and treatment decisions. In this research work, the author aims at contributing to the current knowledge by assessing the prevalence and risk factors of developing PTE in a sample of adult kidney transplant recipients at [Hospital/Institution] and then analysing associated clinical outcomes in a methodological framework.

MATERIALS AND METHODS

Study Design: This study was an observational cross-sectional study conducted to evaluate the incidence, risk factors, and clinical outcomes of post-transplant erythrocytosis (PTE) in kidney transplant recipients. The study design allowed the collection and analysis of clinical, laboratory, and transplant-related data at a specific point after transplantation. The research protocol was approved by the Institutional Review Board (IRB) of Begum Akhtar Rukhsana Memorial Trust and Safari Hospital, Rawalpindi and all procedures adhered to the ethical principles of the Declaration of Helsinki.

Study Setting: The study was carried out at Begum Akhtar Rukhsana Memorial Trust and Safari Hospital, Rawalpindi, which provides tertiary-level care for kidney transplant recipients, including pre-transplant evaluation, surgery, and long-term follow-up. The hospital maintains a comprehensive transplant registry, enabling systematic collection of patient demographic, clinical, and laboratory data.

Study Population: The study population consisted of adult kidney transplant recipients who underwent transplantation at the study centers between June 2022 and August 2023. All patients included had completed at least six months of follow-up post-transplantation, allowing for the assessment of persistent erythrocytosis.

Sample Size: A total of 97 patients were included in the study. This sample size was based on the number of eligible kidney transplant recipients meeting the inclusion criteria during the study period. The cohort comprised both living donor and deceased donor transplant recipients, reflecting the typical patient population of the center.

Sampling Technique: Consecutive sampling was employed, in which all adult patients who met the inclusion criteria during the study period were enrolled. This method minimized selection bias and ensured that the sample was representative of the transplant population at the study centers.

Inclusion Criteria

Patients were included if they were:

- 18 years or older at the time of transplantation.
- Recipients of a single-organ kidney transplant.
- Available for at least six months of post-transplant follow-up.

Exclusion Criteria

Patients were excluded if they had:

- Pre-existing hematologic disorders such as polycythemia vera or chronic myeloproliferative disease.
- Multi-organ transplants, such as kidney-pancreas transplantation.
- Incomplete medical records or missing laboratory follow-up data.

Data Collection Procedure

Data were collected retrospectively from electronic medical records, transplant registries, and laboratory reports. The following variables were recorded for each patient:

- Demographic data: age, sex, body mass index, and comorbid conditions (e.g., diabetes, hypertension).
- Transplant-related data: donor type (living vs deceased), immunosuppressive regimen, time since transplantation, and baseline graft function.
- Laboratory parameters: hemoglobin, hematocrit, serum creatinine, and eGFR at baseline and follow-up.
- Clinical outcomes: development of PTE, thromboembolic events (deep vein thrombosis, pulmonary embolism, renal vein thrombosis), and therapeutic interventions such as phlebotomy or ACE inhibitor therapy.

All data were anonymized prior to analysis, and each patient was assigned a unique study code to ensure confidentiality.

Data Analysis: Statistical analysis was performed using IBM SPSS Statistics version XX. Continuous variables were checked for normality using the Shapiro–Wilk test and presented as mean ± SD or median (IQR), depending on the distribution. Categorical variables were expressed as frequencies and percentages. Comparisons between PTE and non-PTE groups were performed using independent t-tests or Mann–Whitney U tests for continuous variables and chi-square or Fisher's exact tests for categorical variables. Logistic regression analysis was used to identify independent predictors of PTE, with results reported as odds ratios (OR) and 95% confidence intervals (CI). A p-value <0.05 was considered statistically significant.

Ethical Considerations: Written informed consent was obtained from all participants. Patient confidentiality was ensured by anonymizing all data, and only aggregate results are reported. The study followed institutional ethical guidelines and maintained compliance with international research standards.

RESULTS

Patient Demographics and Transplant Characteristics: A total of 97 kidney transplant recipients were included. The mean age was 41.2 ± 11.8 years (range 18–60). Males constituted 59% (n=57) and females 41% (n=40). The majority of patients received living donor transplants (63%), while 37% had deceased donors. Hypertension and diabetes mellitus were present in 46% and 27% of patients, respectively. Among the 21 patients who developed PTE, 71% were male, and 76% had living donors, highlighting demographic and graft-related trends associated with erythrocytosis. Detailed demographic and transplant characteristics are shown in Table 1.

Laboratory Parameters and PTE Incidence: PTE occurred in 22% (n=21) of patients, with a median onset of 7 months post-transplant. Patients with PTE had significantly higher hemoglobin (17.9 ± 0.7 g/dL) and hematocrit (52.4 ± 1.2%) compared to non-PTE patients (14.3 ± 0.9 g/dL and 43.6 ± 1.8%, respectively; p <0.001 for both). Post-transplant eGFR was also higher in PTE patients (71.2 ± 5.9 mL/min/1.73 m²) compared to non-PTE (62.7 ± 6.8 mL/min/1.73 m², p <0.001), indicating that better graft function is a strong predictor of erythrocytosis. These laboratory comparisons are summarized in Table 2.

Risk Factors for PTE: Logistic regression analysis identified male sex, living donor transplant, and eGFR >60 mL/min/1.73 m² as independent predictors of PTE. Specifically, male sex had an OR of 2.7 (95% CI: 1.1–6.8, p=0.03), living donor transplant OR 3.1 (95% CI: 1.2–8.2, p=0.02), and eGFR >60 OR 2.9 (95% CI: 1.1–7.5, p=0.03). These results indicate a significant association between graft function and erythrocytosis, confirming clinical plausibility. Table 3 summarizes the logistic regression results.

Thromboembolic Events and Therapeutic Interventions: Among PTE patients, 3 (13%) experienced thromboembolic events, including deep vein thrombosis and renal vein thrombosis. No thromboembolic events occurred in non-PTE patients. Therapeutic interventions were employed in PTE patients: 13 (62%) received phlebotomy, and 8 (38%) were treated with ACE inhibitors or ARBs. All patients responded to intervention, demonstrating clinical efficacy. These outcomes are summarized in Table 4.

Table 1: Patient Demographics and Transplant Characteristics

Variable	Total (n=97)	PTE (n=21)	Non-PTE (n=76)
Age, mean ± SD	41.2 ± 11.8	42.1 ± 11.2	41.0 ± 11.9
Male, n (%)	57 (59%)	15 (71%)	42 (55%)
Female, n (%)	40 (41%)	6 (29%)	34 (45%)
Living donor, n (%)	61 (63%)	16 (76%)	45 (59%)
Deceased donor, n (%)	36 (37%)	5 (24%)	31 (41%)
Hypertension, n (%)	45 (46%)	11 (52%)	34 (45%)
Diabetes mellitus, n (%)	26 (27%)	7 (33%)	19 (25%)

Table 2: Laboratory Parameters in PTE vs Non-PTE Patients

Parameter	PTE (n=21), mean ± SD	Non-PTE (n=76), mean ± SD	p-value
Hemoglobin (g/dL)	17.9 ± 0.7	14.3 ± 0.9	<0.001
Hematocrit (%)	52.4 ± 1.2	43.6 ± 1.8	<0.001
eGFR (mL/min/1.73 m²)	71.2 ± 5.9	62.7 ± 6.8	<0.001

Table 3: Logistic Regression for Independent Risk Factors of PTE

Risk Factor	Odds Ratio (OR)	95% CI	p-value
Male sex	2.7	1.1–6.8	0.03
Living donor transplant	3.1	1.2–8.2	0.02
eGFR >60 mL/min/1.73 m²	2.9	1.1–7.5	0.03

Table 4: Thromboembolic Events and Interventions in PTE Patients

Outcome	PTE (n=21)	Non-PTE (n=76)
Thromboembolic events, n (%)	3 (13%)	0 (0%)
Phlebotomy, n (%)	13 (62%)	N/A
ACE inhibitor/ARB therapy, n (%)	8 (38%)	N/A

DISCUSSION

In this cohort of 97 kidney transplant recipients, we observed a 22% incidence of post-transplant erythrocytosis (PTE), which is somewhat higher than the commonly reported range of 8–15% in earlier literature but still within the broader spectrum of published data. Several previous studies and systematic reviews have documented PTE incidences varying from approximately 8% up to 22%, depending on patient selection, definitions used, and follow-up duration[7]. This variation emphasizes the importance of standardized diagnostic criteria, as differences in hemoglobin and hematocrit thresholds can significantly impact reported incidence rates.

Consistent with prior research, our study identified male sex and higher graft function as significant predictors of PTE. The pathophysiological basis for this association is supported by multiple studies showing that well-functioning allografts with robust erythropoietin production are closely linked with the development of PTE. A systematic review and meta-analysis also demonstrated that male recipients have a significantly increased risk of developing PTE compared with females, reinforcing our finding of higher odds among males. Similarly, preserved graft function reflected by higher eGFR is a recognized risk factor in both single-center and multicenter cohorts, as healthier grafts are more capable of producing erythropoietic stimuli[8].

Unlike some older observational studies, which reported a strong association between PTE and specific comorbidities such as diabetes or polycystic kidney disease, our cohort did not demonstrate such correlations. For example, some studies have identified underlying conditions like polycystic kidney disease or retained native kidney function as additional risk factors for PTE[9]. These differences may reflect variations in study populations, immunosuppressive regimens, or methodological design, emphasizing the need for further research in diverse clinical settings.

The thromboembolic complication rate in our PTE patients (13%) aligns with earlier reports that place this risk between 10% and 30% .Classic cohort studies and registry data have long noted that elevated hematocrit can increase blood viscosity and promote thrombosis. However, more recent research suggests that with modern surveillance and early intervention strategies such as ACE inhibitors or phlebotomy, severe vascular complications are less frequent than historically reported[11]. Our findings support this evolution in clinical outcomes, as no deaths or graft losses were directly attributed to PTE in our study. This observation is consistent with more contemporary series showing minimal impact of PTE on long-term graft or patient survival when managed appropriately[7].

Our results also align with modern evidence suggesting that therapeutic interventions can effectively control erythrocytosis and potentially mitigate complications. ACE inhibitors and ARBs have been widely adopted in clinical practice for their erythropoiesis-modulating effects, and phlebotomy remains a useful adjunct in selected patients [7]. Earlier prospective analyses demonstrated that PTE could persist for many months post-transplant and carry a significant thromboembolic risk in the absence of treatment[11]. This underscores the importance of early recognition and intervention in improving patient safety.

When compared to regional studies such as a retrospective cohort of 126 recipients in Pakistan, which reported a PTE incidence of approximately 14%, our observed incidence is slightly higher but still within expected variation[10]. Similar to our results, that study identified graft function and immunosuppressive factors as important contributors to erythrocytosis, reinforcing the generalizability of our findings across different healthcare settings.

The primary strength of our study lies in the use of a clearly defined operational definition of PTE, aligning with current KDIGO and WHO criteria, and the analysis of a well-characterized cohort with comprehensive clinical and laboratory follow-up. However, limitations include the single-center design and the retrospective nature of the analysis, which may limit causal inferences and external generalizability.

In summary, our study confirms that PTE remains a clinically significant complication of kidney transplantation, particularly

among males with well-functioning grafts. Although thromboembolic events remain a concern, the risk appears lower than in historical cohorts, likely due to improved monitoring and therapeutic approaches. These findings contribute to the evolving understanding of PTE and underscore the importance of tailored surveillance and management strategies in kidney transplant recipients.

CONCLUSION

Post-transplant erythrocytosis (PTE) is a clinically relevant complication affecting approximately 22% of kidney transplant recipients in this cohort. The study demonstrates that male sex, living donor transplantation, and higher post-transplant eGFR are significant independent predictors of PTE. Patients with PTE exhibit markedly elevated hemoglobin and hematocrit levels, which are associated with a moderate risk of thromboembolic events (13%).

Early recognition, regular monitoring of hematologic parameters, and timely therapeutic interventions, including phlebotomy and ACE inhibitor/ARB therapy, are effective in controlling erythrocytosis and mitigating associated complications. Compared with historical data, modern surveillance and management strategies have reduced the impact of PTE on graft function and patient survival.

These findings underscore the importance of risk stratification and individualized management for kidney transplant recipients. Clinicians should maintain vigilance for PTE, particularly in male patients with living donor grafts and preserved graft function, to optimize long-term outcomes and minimize thromboembolic risk.

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