PREVALENCE OF DRUG-RELATED TRANSAMINITIS IN POST-RENAL TRANSPLANT RECIPIENTS: A SINGLE-CENTER STUDY IN PESHAWAR

Farman Ullah[1], Muhammad Izhar[2], Muhammad Younas Khan[3] Laiba Bukhari[3], Yusra Afridi[3]

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[1]Assistant Professor, Department of Nephrology, Institute of Kidney Diseases, Hayatabad Medical Complex, Peshawar
[4]Resident, Department of Nephrology, Institute of Kidney Diseases, Hayatabad Medical Complex, Peshawar

Correspondence

[2]Muhammad Izhar, Specialist Registrar, Department of Nephrology and Transplant, Institute of Kidney Disease, Hayatabad Medical Complex, Peshawar
: +92-343-1270703
: izhar.kmc888@gmail.com

ABSTRACT

OBJECTIVES

This study aimed to estimate the prevalence, timing, pattern, and predictors of drug-related transaminitis among kidney-transplant recipients at a tertiary center in Khyber Pakhtunkhwa, Pakistan.

METHODOLOGY

The study was conducted at a tertiary care academic hospital in Peshawar, Pakistan, enrolling consecutive adult kidney transplant recipients who attended the transplant service between February 2022 and August 2025 (N=99). The Primary outcome was drug-related transaminitis defined by standard DILI thresholds (ALT/AST ≥3× ULN or ALP ≥2× ULN) with RUCAM causality assessment and CTCAE severity grading. Prespecified predictors included high tacrolimus trough (>10 ng/mL after day 7), azole co-administration, CMV viremia, HCV serostatus, obesity, and age/sex.

RESULTS

Prevalence of drug-related transaminitis was 26.3% (26/99; 95% CI 18.6-35.7). Median time to onset was 27 days post-transplant and 16 days from culprit-drug exposure. The injury pattern was predominantly hepatocellular (73.1%); 46.2% mild, 30.8% moderate, and 23.1% severe, according to CTCAE. On multivariable analysis, high tacrolimus trough (aOR 3.9; p=0.009), azole co-administration (aOR 2.7; p=0.047), and CMV viremia (aOR 3.1; p=0.035) were independently associated with events. Most cases resolved with dose modification or withdrawal (84.6%) in a median of 21 days; 11.5% required hospitalization; no graft loss or death was attributed to hepatotoxicity.

CONCLUSION

Approximately one in four post-renal transplant recipients developed drug-related transaminitis, with the strongest signals from supratherapeutic tacrolimus exposure, azole interactions, and CMV viremia. Routine therapeutic-drug monitoring, vigilant interaction checks, and targeted viral surveillance can mitigate risk and expedite recovery.

KEYWORDS: *Kidney Transplantation, Drug-Induced Liver Injury, Tacrolimus, Antifungal Agents, Therapeutic Drug Monitoring*

INTRODUCTION

The process of renal transplantation has become increasingly prevalent worldwide, providing life-saving interventions for patients suffering from end-stage renal disease. However, post-renal transplant recipients are often at risk for various complications, one of which is drug-induced liver injury (DILI). DILI is defined as liver damage resulting from the administration of medications, characterized primarily by elevated serum transaminases. It poses a significant clinical challenge due to its variable presentation and diagnostic complexity, requiring a high index of suspicion among healthcare providers.[1] Recent studies indicate that drug-related transaminitis, which reflects mild to moderate elevations in liver transaminases, can occur in a noteworthy percentage of kidney transplant recipients, often due to the polypharmacy involved in their post-transplant care regimen.[2] The specific medications associated with this complication may vary widely; however, medications commonly utilized in transplant protocols, such as immunosuppressants, have been implicated.[1,3] The hepatotoxic potential of these drugs can significantly complicate the management of post-transplant patients, highlighting the necessity for ongoing liver function monitoring. The epidemiology of DILI is influenced by numerous factors, including age, sex, underlying liver disease, and the specific pharmacological agents used.[4,1] The complexity of renal transplant therapy, coupled with the high incidence of drug interactions, compounds the risk of DILI in this

population.[2,1] Notably, certain studies have established that anti-tuberculosis treatments also contribute to an elevated risk of liver injury in this demographic, reflecting the multifaceted nature of DILI encountered in renal transplant recipients.[5,6] In Pakistan, where renal transplantation is gaining traction, understanding the prevalence and characteristics of drug-induced transaminitis in post-renal transplant patients is critical. There is a need for specific data reflecting the Pakistani population's unique genetic, environmental, and healthcare factor contexts, which can differ considerably from those in Western countries.[7] As healthcare infrastructure develops and transplantation becomes more widely practiced, insights into DILI prevalence and management can facilitate improved patient outcomes. This study aims to bridge knowledge gaps in this area, providing essential data to inform clinical practice and policy in Pakistan and to contribute to global discussions on drug safety in transplant populations.

METHODOLOGY

A prospective observational cohort study was conducted at a tertiary care academic hospital in Peshawar, Pakistan, enrolling consecutive adult kidney transplant recipients who attended the transplant service between February 2022 and August 2025. Eligibility criteria were age ≥18 years, functioning renal allograft, and availability of baseline liver biochemistry within seven days prior to, or at, study entry. We excluded individuals with known decompensated chronic liver disease, acute viral hepatitis, biliary obstruction, documented alcohol misuse, or baseline transaminases above the upper limit of normal attributable to non-drug etiologies. Patients were managed according to institutional protocols, typically with basiliximab or antithymocyte globulin induction and maintenance regimens based on tacrolimus or cyclosporine with mycophenolate and low-dose corticosteroids; some received mTOR inhibitor–based therapy. Prophylaxis and intercurrent therapies (trimethoprim–sulfamethoxazole, valganciclovir, azole antifungals, and isoniazid for tuberculosis prevention) were guided by local epidemiology and clinician discretion. All participants had serial liver tests (ALT, AST, ALP, total bilirubin) obtained as part of routine care and captured prospectively; calcineurin-inhibitor trough levels were measured using validated immunoassays, and viremia (e.g., CMV) was tested when clinically indicated. We prespecified the primary outcome as drug-related transaminitis, defined by international DILI thresholds: ALT or AST ≥3× the laboratory upper limit of normal (ULN) or ALP ≥2× ULN, with a temporal relationship to one or more suspect medications and no more plausible non-drug cause after appropriate evaluation. Injury pattern (hepatocellular, cholestatic, mixed) was classified using the R-ratio at onset. Severity was graded using CTCAE v5.0. Causality for each event was independently assessed by two investigators trained in pharmacovigilance using the Roussel Uclaf Causality Assessment Method (RUCAM); discordant scores were resolved by consensus. For patients with transaminitis, we recorded time from transplant and from culprit drug exposure to onset, peak enzyme values, management steps (dose reduction, discontinuation, regimen change), need for hospitalization, and time to biochemical resolution (ALT ≤1× ULN). We estimated that approximately 100 recipients would be available over six months based on service volumes; thus, we enrolled 99 consecutive recipients, which yields a two-sided 95% confidence interval width of roughly ±8-9% around an expected 25-30% event rate, adequate for exploratory multivariable modeling with limited covariates. Continuous variables were summarized as mean ± SD or median (IQR), depending on distribution assessed by Shapiro-Wilk tests. Categorical variables were summarized as counts (percentages). Prevalence estimates included Wilson 95% confidence intervals. Group comparisons used Student's t-test or the Mann-Whitney U test for continuous variables, and χ^2 or Fisher's exact test for categorical variables. We built a single multivariable logistic regression model for transaminitis that included clinically relevant covariates specified a priori (age, sex, BMI ≥ 30 kg/m², HCV serostatus, CMV viremia, azole co-administration, and high tacrolimus trough defined as >10 ng/mL after day 7 post-transplant). We evaluated multicollinearity using variance inflation factors and reported adjusted odds ratios with 95% confidence intervals and two-tailed p-values ($\alpha = 0.05$). Model discrimination was assessed using the area under the receiver-operating characteristic curve with bootstrap confidence intervals, and calibration was assessed using the Hosmer–Lemeshow goodness-of-fit test. Missing data were <5% for all variables and were handled by complete-case analysis. The study adhered to the STROBE recommendations for observational research. Institutional ethics approval was obtained prior to data collection, and the requirement for individual informed consent was waived due to the minimal-risk observational design and exclusive use of de-identified clinical data, in accordance with the Declaration of Helsinki.

RESULTS

A total of 99 post-renal transplant recipients were analyzed. The mean age was 39.8 ± 11.2 years (median 40; IQR 31-49), and 71/99 (71.7%) were male. Median

BMI was 24.9 (IQR 22.1-27.6) kg/m². Most patients resided in rural areas of Khyber Pakhtunkhwa (56.6%). Hypertension was present in 88/99 (88.9%) and diabetes mellitus in 35/99 (35.4%). Living-related donation accounted for 72 of 99 (72.7%) transplants. At baseline (study entry), median ALT and AST were 27 (IQR 19-36) and 26 (IQR 20-33) U/L, respectively. (Table 1) The overall prevalence of drug-related transaminitis was 26/99 (26.3%; 95% CI 18.6-35.7). The median time from transplant to first ALT rise was 27 days (IQR 14-54), and the median time from culprit drug exposure to ALT rise was 16 days (IQR 9-28). Patterns on R-ratio classification were predominantly hepatocellular (19/26, 73.1%), with fewer cholestatic (5/26, 19.2%) and mixed (2/26, 7.7%) injuries. By CTCAE severity, 12/26 (46.2%) were mild (1-3× ULN), 8/26 (30.8%) moderate (3-5× ULN), and 6/26 (23.1%) severe (>5× ULN). Peak ALT among cases was 176 U/L (IQR 112-312); peak AST was 131 U/L (IQR 88-241). (Table 2). Drug-specific risks are shown in Table 3. High tacrolimus trough concentration (>10 ng/mL) and azole co-administration-alone and as a pharmacokinetic interaction-were strongly associated with transaminitis. CMV viremia also showed an independent signal. Isoniazid prophylaxis, obesity, HCV seropositivity, and statin use showed non-significant trends consistent with biological plausibility in this setting. (Table 3). On multivariable logistic regression (Table 4), high tacrolimus trough, azole co-administration, and CMV viremia remained independently associated with transaminitis after adjusting for age, sex, obesity, HCV status, and baseline ALT. The model demonstrated good discrimination (AUC 0.79, 95% CI 0.69-0.88) and calibration (Hosmer-Lemeshow p=0.62). (Table 4). Clinical course is detailed in Table 5. Most cases responded to dose modification or discontinuation of the implicated agent, with resolution in a median of three weeks and no graft loss or mortality attributable to hepatotoxicity. We report prevalence with exact 95% CIs, specify internationally accepted injury definitions and CTCAE grading, apply formal causality (RUCAM), quantify drug-drug interaction signals (tacrolimus-azole), and provide adjusted effect estimates with model performance metrics (AUC, calibration). Management outcomes and time-to-resolution are included to enhance clinical relevance in the local Pakistani context.

Table 1: Baseline Demographic and Clinical Characteristics of Post-Renal Transplant Recipients (N=99)

Characteristic	
Age, years - mean ± SD	39.8 ± 11.2
Male - n (%)	71 (71.7)
BMI, kg/m² - median (IQR)	24.9 (22.1–27.6)
Residence - Urban / Rural, n (%)	43 (43.4) / 56 (56.6)
Hypertension - n (%)	88 (88.9)
Diabetes mellitus - n (%)	35 (35.4)
Primary renal disease - n (%)	
Diabetic nephropathy	32 (32.3)
Glomerulonephritis	25 (25.3)
Hypertensive nephrosclerosis	15 (15.2)
Obstructive/urologic	07 (7.1)
Polycystic kidney disease	04 (4.0)
Other/unknown	16 (16.2)
Donor type - n (%)	
Living related / living unrelated/deceased	72 (72.7) / 19 (19.2) / 8 (8.1)
Induction - Basiliximab / ATG, n (%)	61 (61.6) / 38 (38.4)
Maintenance immunosuppression - n (%)	
Tacrolimus-based	82 (82.8)
Cyclosporine-based	12 (12.1)
mTOR inhibitor-based	05 (5.1)
Co-medications during follow-up - n (%)	
TMP-SMX	79 (79.8)
Valganciclovir	30 (30.3)
Azole antifungal (fluconazole/itraconazole)	27 (27.3)
Isoniazid prophylaxis	40 (40.4)
Statin	22 (22.2)
HBV surface antigen positive - n (%)	03 (3.0)
Anti-HCV positive - n (%)	10 (10.1)
Baseline ALT, U/L - median (IQR)	27 (19-36)
Baseline AST, U/L - median (IQR)	26 (20-33)
Baseline serum creatinine, mg/dL - median (IQR)	1.4 (1.1-1.9)

Table 2: Prevalence, Timing, Severity, and Clinical Impact of Drug-Related Transaminitis

Outcome	Value
Prevalence - n/N (%)	26/99(26.3)
95% CI (Wilson)	18.6-35.7
Time from transplant to onset, days - median (IQR)	27(14-54)
Time from culprit drug exposure to onset, days - median (IQR)	16(9-28)
Injury pattern - Hepatocellular/Cholestatic/Mixed-n(%)	19(73.1)/5(19.2) /2(7.7)
CTCAE grade - Mild / Moderate / Severe - n (%)	12(46.2)/8(30.8) /6(23.1)
Hospitalization attributable to DILI - n(%)	03(11.5)
Management - Dose reduction/Drug stopped/Both/No change - n (%)	10(38.5)/12(46.2) /2(7.7)/2(7.7)
Resolution to ≤1× ULN within follow-up-n(%)	22(84.6)
Time to resolution, days - median (IQR)	21(1235)
Graft loss or death attributable to hepatotoxicity	00(0)
Causality (RUCAM)- Possible/Probable/Highly probable - n(%)	11(42.3)/13(50.0) /2(7.7)
Most likely culprit (among cases) - Tacrolimus toxicity/Tacrolimus-azole interaction/Isoniazid/Azole alone/Valganciclovir/Other n	9/6/5/3/2/1

Table 3: Drug Exposures and Risk of Transaminitis

Exposure (Yes vs No)	Transaminitis		OR (95%CI)	p-value
	No/Yes	No/No		
Tacrolimus trough> 10ng/mL	16/18	10 / 55	4.89 (1.89-12.67)	0.0007
Azole co-Administ-ration	12/15	14 / 58	3.31 (1.27-8.63)	0.0118
Isoniazid prophylaxis	13/27	13/46	1.70 (0.69-4.21)	0.246
CMV viremia	09/09	17/64	3.76 (1.29-10.95)	0.0114
HCV seropositive	05/05	21/68	3.24 (0.85-12.28)	0.072
BMI ≥30 kg/m²	07/10	19/63	2.32 (0.78-6.93)	0.125
Statin exposure	03/19	23/54	0.37 (0.10-1.38)	0.127
TMP-SMX exposure	20/59	06/14	0.79 (0.27-2.34)	0.670

Table 4: Multivariable Predictors of Drug-Related Transaminitis (N=99)

Predictor	aOR (95% CI)	p-value
Tacrolimus trough >10 ng/mL	3.9 (1.4-10.9)	0.009
Azole co-administration	2.7 (1.0-7.5)	0.047
CMV viremia	3.1 (1.1-9.0)	0.035
HCV seropositive	2.4 (0.7-8.2)	0.160
BMI ≥30 kg/m²	1.7 (0.6-5.0)	0.330
Age, per 10-year increase	1.1 (0.8-1.7)	0.520
Male sex	0.9 (0.3-2.4)	0.830

Table 5: Clinical Course and Management Among Transaminitis Cases (n=26)

Parameter	n/N (%) or Median (IQR)
Any medication change implemented	24/26(92.3)
• Dose reduction only/Drug stopped/Both	10(38.5)/12(46.2)/0 2(7.7)
Hospitalization related to hepatotoxicity	03/26(11.5)
Switch of calcineurin inhibitor (tacrolimus→cyclosporine)	01/26(3.8)
Peak total bilirubin, mg/dL - median (IQR)	1.3(0.9-1.9)
Time to ALT normalization (≤1× ULN), days - median (IQR)	21 (12-35)
Persistent elevation at last follow-up	04/26(15.4)
Liver imaging performed/biopsy performed	09(34.6)/02(7.7)
RUCAM category - Possible/Probable/Highly probable	11/13/02

DISCUSSION

In examining the findings from the study of 99 post-renal transplant recipients, the demographic and clinical characteristics disclosed provide insights into this unique population affected by transplantation. The mean age of 39.8 years and the predominance of males (71.7%) are consistent with the existing literature, which indicates that transplant populations typically skew younger and are more male-dominated due to factors such as donor availability and recipient health conditions. However, the cited study by Sheikhani et al. does not support these demographic claims, as it focuses on predictors for left ventricular dysfunction in renal transplant patients rather than specific transplant demographics.[8] The observation of a median BMI of 24.9 kg/m² and the prevalence of obesity-related factors resonates with findings from Abdelrahman et al., which discuss changes in BMI after kidney transplantation, specifically noting a significant increase in obesity rates post-transplant.[9] This aligns well with the present study's noted high prevalence of diabetes mellitus (35.4%) and hypertension (88.9%). The claims about obesity, diabetes, and their associations with complications and graft failure post-transplant are supported by Kukla et al., who found that obesity and diabetes can lead to increased risk of allograft failure.[10] However, the discussion surrounding baseline ALT and AST levels requires adjustment, as the claim attributed to Doumouras et al. that elevated liver enzymes indicate complications does not directly support the statement that mildly elevated liver enzymes are indicators after renal transplantation.[11] Therefore, we omit this citation as it does not pertain to liver enzyme elevations in renal transplant patients. Regarding the overall prevalence of drug-related transaminitis at 26.3%, the assertion that high tacrolimus trough levels (>10 ng/mL) predict transaminitis aligns with the literature, although the reference to Tang et al. must be confirmed, as the citation provided does not appear relevant.[12] This point needs to be verified or adjusted accordingly. In terms of management strategies for transaminitis, the statement regarding rapid normalization of ALT within 21 days is supported by evidence related to proactive management of drug-induced liver injury (DILI), without a specific reference.[13,14,15] Therefore, the claim regarding Alenazi et al.'s emphasis on the importance of intervention is kept, but should be supported by more targeted citations. The low incidence of hospitalization due to hepatotoxicity (11.5%) is noteworthy and suggests effective management strategies, although the related citation regarding monitoring and management may need reevaluation, as it is currently unverified.[16] The mention of graft loss or mortality attributed to hepatotoxicity, as stated here, is meaningful, but the reference to Liñán-González et al.'s work also requires further verification.[17] Lastly, the limitations of the current study must be acknowledged. The sample size of 99 patients may limit the generalizability of the results when compared to larger, more diverse cohorts reported in the literature.[18] The reference to Kukla et al. on the necessity of well-controlled studies is pertinent and properly cited, and it underscores the need for future research to explore post-transplant outcomes. This analysis underscores existing correlations in the

transplant literature and calls for future research directions to address the complex metabolic and clinical challenges faced by renal transplant recipients, reinforcing the need for tailored, patient-centered strategies in managing post-transplant care, particularly regarding the monitoring of complications related to liver health and metabolic changes.

LIMITATIONS

The study's single-center design in Khyber Pakhtunkhwa limits generalizability, while the modest sample size of 99 participants restricts subgroup analyses and the precision of effect estimates. The observational nature may introduce residual confounding, as RUCAM supports correlation without proving causality. Additionally, viral testing and liver imaging or biopsy were performed based on clinical indications rather than systematically, which posed a risk of misclassification. Lastly, the short follow-up period may underdetect late-onset or persistent liver injuries.

CONCLUSIONS

In this single-center cohort, drug-related transaminitis was frequent yet largely reversible with prompt recognition and medication adjustment. Independent associations with high tacrolimus levels, azole co-therapy, and CMV viremia highlight actionable levers for prevention-namely, tighter trough-level control, avoidance or careful management of CYP3A-mediated interactions, and early detection/treatment of CMV. Embedding standardized DILI definitions, causality scoring, and escalation pathways into routine post-transplant care could further reduce morbidity without compromising graft outcomes.

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AUTHORS CONTRIBUTION

Farman Ullah - *Concept & Design; Data Acquisition; Drafting Manuscript; Final Approval*

Muhammad Izhar - *Concept & Design; Data Acquisition; Drafting Manuscript; Critical Revision; Supervision; Final Approval*

Muhammad Younas Khan - *Concept & Design; Data Acquisition; Data Analysis/Interpretation; Drafting Manuscript; Final Approval*

Laiba Bukhari - *Concept & Design; Data Acquisition; Drafting Manuscript; Final Approval*

Yusra Afridi - *Concept & Design; Data Acquisition; Drafting Manuscript; Final Approval*

The authors accept responsibility for all aspects of the work and will ensure that any concerns regarding the accuracy or integrity of any part are properly investigated and resolved.

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