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Tacrolimus versus Cyclophosphamide and Mycophenolate Mofetil in Pediatric IgA Vasculitis Nephritis: Superior Early Remission and Long-Term Renal Outcomes in a Large Single-Center Cohort

Peter Mwangi[1]*, Grace Wanjiku[1]

[1]Department of Phytochemistry, Faculty of Pharmacy, University of Nairobi, Nairobi, Kenya.

***E-mail** ✉ peter.mwangi.ke@gmail.com

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ABSTRACT

IgA vasculitis nephritis (IgAVN) is a frequent form of secondary glomerular disease in childhood. Although consensus documents generally acknowledge the therapeutic value of cyclophosphamide (CYC), guidance regarding tacrolimus (TAC) and mycophenolate mofetil (MMF) remains variable. Existing data indicate that TAC can work safely and effectively in IgAVN, but the long-term influence of different immunosuppressants is still not clearly defined. This study was designed to compare TAC, CYC, and MMF—each given with glucocorticoids—in terms of their therapeutic effects and long-term renal outcomes in pediatric IgAVN. Children diagnosed with grade II–V IgAVN on renal biopsy at Tongji Hospital from November 2011 to October 2021 were reviewed retrospectively. Clinical features, pathology, treatment information, and follow-up records were evaluated.

A total of 422 cases met the inclusion criteria. Of these, 108 received oral TAC plus glucocorticoids, 143 were treated with intravenous CYC plus glucocorticoids, and 171 received oral MMF with glucocorticoids. Complete remission (CR) was higher with TAC (25.9%/44.3%) compared with CYC (16.1%/36.4%) at 3 and 6 months. TAC produced a greater drop in proteinuria at 1, 3, and 6 months than both CYC and MMF. Total adverse events occurred less frequently with TAC and MMF (60.2%, 65.7%) than with CYC (84.4%). TAC and MMF also showed better renal status (grade A and B) and a reduced recurrence rate (17.9%, 23.9% vs 41.8%) compared with CYC. TAC rapidly reduces urinary protein levels, promotes complete renal remission, and results in fewer complications. TAC and MMF appear to offer more favorable long-term kidney outcomes.

Keywords: IgAVN, Immunosuppression, Renal response, Tacrolimus, Cyclophosphamide, Mycophenolate mofetil

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Introduction

IgA vasculitis nephritis (IgAVN), a renal manifestation of allergic purpura (HSP), reflects immune-mediated glomerular injury. Kidney involvement has been reported in 30%–80% of individuals with HSP [1]. About 20% of those with IgAVN develop nephritis or nephrotic syndrome, which is roughly 7% of all HSP cases [2]. The extent of renal damage strongly influences long-term outcomes [3]. Cohort studies have shown that 10%–20% of children who present with moderate or severe proteinuria may ultimately progress to end-stage kidney disease (ESKD) [4, 5]. Therefore, timely management of children with significant renal involvement is critical.

Glucocorticoids are commonly used when IgAVN presents with marked clinical or pathological severity, but recommendations differ internationally. The 2021 KDIGO guideline supports glucocorticoids for mild or moderate cases and reserves CYC for children with nephrotic syndrome or rapidly declining renal function [6]. The 2016 Chinese guideline provides recommendations by clinical stage and pathology: children with non-nephrotic proteinuria or grade IIb/IIIa lesions may receive immunosuppressive therapy; those with nephrotic-range proteinuria, nephrotic syndrome, acute nephritic syndrome, or grade IIIb/IV lesions may be treated with

glucocorticoids combined with CYC, cyclosporine A, or MMF [7]. Because a unified therapeutic protocol is absent, this study compared TAC, CYC, and MMF used with glucocorticoids in our center to help refine treatment choices for IgAVN.

Materials and Methods

Patients

This retrospective analysis included 422 children diagnosed with grade II, III, IV, or V IgAVN who were given glucocorticoids together with CYC, MMF, or TAC between November 2011 and October 2021. All patients were younger than 18 years and admitted to the Pediatric Department of Tongji Hospital. According to ISKDC classification, the cohort consisted of 13 grade II, 315 grade III, 77 grade IV, and 17 grade V patients. Diagnosis followed the 2016 evidence-based guideline from the Subspecialty Group of Nephrology, Society of Pediatrics, Chinese Medical Association [7]. Patients were excluded if renal biopsy was not performed, clinical information was incomplete, other immune disorders were present, or immunosuppressants were contraindicated. Ethical approval was granted by the Ethics Committee of Tongji Hospital, and the study adhered to the Declaration of Helsinki.

Data collection, treatment, and follow-up definitions

Throughout therapy, all participants underwent scheduled assessments. Treatment response was reviewed at 1, 3, 6, and 12 months after induction began. Demographic profiles, laboratory results, pathology reports, and longitudinal follow-up information were obtained at diagnosis and again after 1, 3, 6, and 12 months of therapy. At the last documented outpatient evaluation, follow-up studies included routine urinalysis, kidney function tests, and 24-hour urinary protein measurement. Prognostic categories were assigned using Counahan's criteria [8]. Outcomes were divided into four grades: grade A (complete recovery), defined by normal renal function and absence of proteinuria or hematuria; grade B (minor urinary findings), defined by microscopic hematuria and/or proteinuria < 1 g/24 h with normal renal function; grade C (ongoing renal disorder), defined by proteinuria ≥ 1 g/24 h with eGFR ≥ 60 mL/(min·1.73 m²); and grade D (renal failure), defined by eGFR < 60 mL/(min·1.73 m²) or mortality. Grades A and B represented favorable outcomes; grades C and D were considered poor outcomes. Renal indices were defined as follows: eGFR was estimated using the modified Schwartz equation [9]. Pathological grading followed the ISKDC system [8]. Complete remission (CR) required protein excretion < 0.15 g/24 h, normalization of urinary red blood cells, and normal eGFR. Partial remission (PR) was defined as ≥ 50% reduction in proteinuria with stable/normal eGFR [10]. Total remission (TR) equaled CR plus PR.

Statistical analyses

Normality for continuous variables was assessed using both the Shapiro–Wilk method and Q–Q inspection. Non-normally distributed data were reported as median (interquartile range), while normally distributed data were presented as mean ± standard deviation (SD). The Mann–Whitney U or Kruskal–Wallis tests were applied to compare medians; when the Kruskal–Wallis test showed significance, Dunn's test with Bonferroni correction was used for pairwise contrasts. Differences in means were analyzed using t-tests or ANOVA, with Tukey's method for post-hoc comparisons. Categorical parameters were summarized as counts and percentages and analyzed with Pearson's chi-square or Fisher's exact tests. Logistic regression was used to account for confounding factors affecting renal remission. Kaplan–Meier curves and the log-rank test were used to compare recurrence-free survival among the three induction strategies. A p-value < 0.05 was considered statistically significant.

Results and Discussion

Clinical characteristics at biopsy according to histopathological grade

This analysis included 422 children with IgAVN: 13 in grade II, 315 in grade III, 77 in grade IV, and 17 in grade V. Grade III accounted for 74.6% of the cohort, while grade II, IV, and V comprised 3%, 18.2%, and 4.0%, respectively. As summarized in **Table 1**, individuals with grade IV and V disease displayed substantially higher values of hematuria, 24-hour urine protein (24hUP), and urinary albumin-creatinine ratio (UACR) than those classified as grade II or III. Conversely, serum albumin (ALB), estimated glomerular filtration rate (eGFR), serum creatinine (Scr), and 25-Hydroxyvitamin D were markedly lower in grades IV and V compared with grades II and

III. Despite laboratory differences, clinical symptoms showed no meaningful variation across the four histopathological categories.

Table 1. Clinical Characteristics at Biopsy Across Histopathological Subtypes

Pathological Stage	Stage II (IIa + IIb) (n = 13)	Stage III (IIIa + IIIb) (n = 315)	Stage IV (IVa + IVb) (n = 77)	Stage V (Vb) (n = 17)	P-value
Male gender, n (%)	4 (30.8)	191 (60.6)	43 (55.8)	5 (29.4)	0.014
Age, median [IQR] (years)	9 (5.79–11.5)	9 (6.92–11)	8.83 (6.58–11.8)	8.83 (6.67–11.33)	0.993
Clinical manifestations, n (%)					
Skin purpura	13 (100)	294 (93.3)	72 (93.5)	15 (88.2)	0.666
Joint pain	5 (38.5)	126 (40.0)	36 (46.8)	3 (17.6)	0.173
Gastrointestinal symptoms	7 (53.8)	140 (44.4)	31 (40.3)	8 (47.1)	0.792
Laboratory findings					
Hematuria >1+, n (%)	7 (53.8)	237 (75.2)	66 (85.7)	17 (100.0)	0.003
24-hour urinary protein, median [IQR] (mg/24h)	379 (165.5–696.3)	602.3 (360.8–1226)	1490.5 (852.2–2969.5)[a, b]	4216.5 (1924.1–5972.8)[a, b]	<0.001
Urine albumin-to-creatinine ratio, median [IQR] (μg/mg)	290.9 (58.5–1070.3)	518.1 (204.5–1309.9)	1789.6 (820.1–3040.4)[a, b]	4061.2 (2586.2–6414.8)[a, b]	<0.001
Serum albumin, median [IQR] (g/L)	41.6 (38.4–43.2)	40.5 (36.9–43.2)	35.7 (31.7–39.2)[a, b]	27.2 (22.4–32.4)[a, b, c]	<0.001
Serum creatinine, median [IQR] (μmol/L)	36 (32.5–48)	38 (32–43.5)	40 (34–47)	49 (38–67)[b]	0.026
Estimated GFR, median [IQR] (mL/min/1.73m²)	140.4 (109.5–162.5)	131.9 (117.1–149.9)	127.3 (112.1–146.9)	103.5 (84.4–114.7)[b, c]	0.001
25-Hydroxyvitamin D, median [IQR] (ng/mL)	13.2 (10.2–17.5)	13.2 (9.9–17.9)	11.3 (8.6–14.9)	7.3 (3.7–10.0)[a, b]	0.003

Notes: a versus grade II; b versus grade III; c versus grade IV.

Baseline characteristics in the CYC, MMF, and TAC groups

Initial clinical indicators for patients with IgAVN were evaluated across the CYC, TAC, and MMF cohorts **(Table 2)**. At baseline, the TAC group showed markedly elevated 24hUP and UACR levels compared with both CYC and MMF. In contrast, ALB values were lower in the TAC and CYC groups relative to the MMF group. Use of CYC and MMF was more common in individuals classified as grade III, whereas TAC was preferentially given to patients with grade IV or V disease ($p < 0.001$).

Table 2. Clinical Data of HSPN Cases Prior to CYC, MMF, or TAC Therapy

Characteristic	TAC group (n = 108)	CYC group (n = 143)	MMF group (n = 171)	Overall P	P^a (TAC vs CYC)	P^b (TAC vs MMF)	P^c (CYC vs MMF)
Male gender, n (%)	64 (59.3)	82 (57.3)	97 (56.7)	0.914	0.761	0.676	0.912
Age, median [IQR] (years)	9 (6.5–12.0)	8.0 (6.0–10.0)	9.58 (7.33–11.0)	0.002	0.059	1	0.002
Clinical manifestations, n (%)							
Skin purpura	102 (94.4)	133 (93)	159 (93.0)	0.872	0.644	0.628	0.993
Joint pain	47 (43.1)	63 (44.1)	60 (35.1)	0.198	0.932	0.158	0.105
Gastrointestinal symptoms	51 (47.2)	71 (49.7)	64 (37.4)	0.071	0.703	0.105	0.029
Laboratory parameters							

Hematuria >1+, n (%)	91 (84.3)	120 (83.9)	117 (67.8)	0.001	0.941	0.002	0.001
24-hour urinary protein, median [IQR] (mg/24h)	1672.2 (979.2–3009.4)	1062.6 (586.5–1796)	406.4 (237.6–599.9)	<0.001	0.001	<0.001	<0.001
Urine albumin-to-creatinine ratio, median [IQR] (μg/mg)	1956.9 (964.6–3133.1)	1015.1 (586.2–1999.6)	284.0 (111.6–532.9)	<0.001	0.025	<0.001	<0.001
Serum albumin, median [IQR] (g/L)	37.0 (32.3–41.1)[b]	36.9 (33.3–40.3)[c]	42.2 (39.5–44.0)	<0.001	1.00	<0.001	<0.001
Serum creatinine, median [IQR] (μmol/L)	40 (33–52)	38 (31–43.5)	38 (32–44)	0.069	0.026	0.081	0.46
Estimated GFR, median [IQR] (mL/min/1.73m²)	126.8 (104.8–144.3)	130.6 (117.1–150.9)	134.1 (117.9–149.7)	0.064	0.094	0.023	0.7
25-Hydroxyvitamin D, median [IQR] (ng/mL)	11.8 (8.2–15.6)	12.6 (9.0–18.0)	13.4 (9.9–18.0)	0.083	0.238	0.022	0.446
Renal biopsy grade, n (%)				<0.001	0.003	<0.001	<0.001
Stage II	3 (2.8)	0 (0.0)	10 (5.8)	0.005	0.078	0.236	0.002
Stage III	57 (52.8)	102 (71.3)	156 (91.2)	<0.001	0.003	<0.001	<0.001
Stage IV	37 (34.3)	36 (25.2)	4 (2.3)	<0.001	0.117	<0.001	<0.001
Stage V	11 (10.2)	5 (3.5)	1 (0.6)	<0.001	0.032	<0.001	0.096

Notes: Pa compares TAC vs CYC; Pb compares TAC vs MMF; Pc compares CYC vs MMF.

Renal response to TAC, CYC, and MMF at 1, 3, 6, and 12 months

Across the 1-, 3-, 6-, and 12-month assessments, TAC showed higher complete remission (CR) rates than CYC (3.7% vs 2.8%, 25.9% vs 16.1%, 44.4% vs 36.4%, 63% vs 61.5%). After adjustment for proteinuria, hematuria, and pathological category, TAC demonstrated a 1.73-fold higher chance of achieving remission at 3 months (95% CI: 1.19–2.53; p = 0.004), and a 1.46-fold higher likelihood at 6 months (95% CI: 1.02–2.09; p = 0.037) **(Table 3)**.

Although MMF displayed numerically higher CR levels than CYC at each time point (16.4% vs 2.8%, 35.7% vs 16.1%, 56.7% vs 36.4%, 73.7% vs 61.5%), MMF did not retain a clear statistical advantage after adjustment **(Table 3 and Figure 1)**.

Table 3. Complete Remission During 1, 3, 6, and 12 Months of Induction Therapy

Time Point	CYCn (%)	TACn (%)	OR (95% CI) vs CYC	P-value	MMFn (%)	OR (95% CI) vs CYC	P-value
1 month	4 (2.8) *(reference)*	4 (3.7)	1.36 (0.94–1.97)	0.11	28 (16.4)	1.08 (0.61–1.36)	0.66
3 month	23 (16.1) *(reference)*	28 (25.9)	1.73 (1.19–2.53)	0.004	61 (35.7)	1.08 (0.73–1.61)	0.70
6 month	52 (36.4) *(reference)*	48 (44.4)	1.46 (1.02–2.09)	0.039	97 (56.7)	1.16 (0.79–1.71)	0.47
12 month	88 (61.5) *(reference)*	68 (63.0)	1.19 (0.73–1.96)	0.17	126 (73.7)	3.33 (0.54–1.51)	0.55

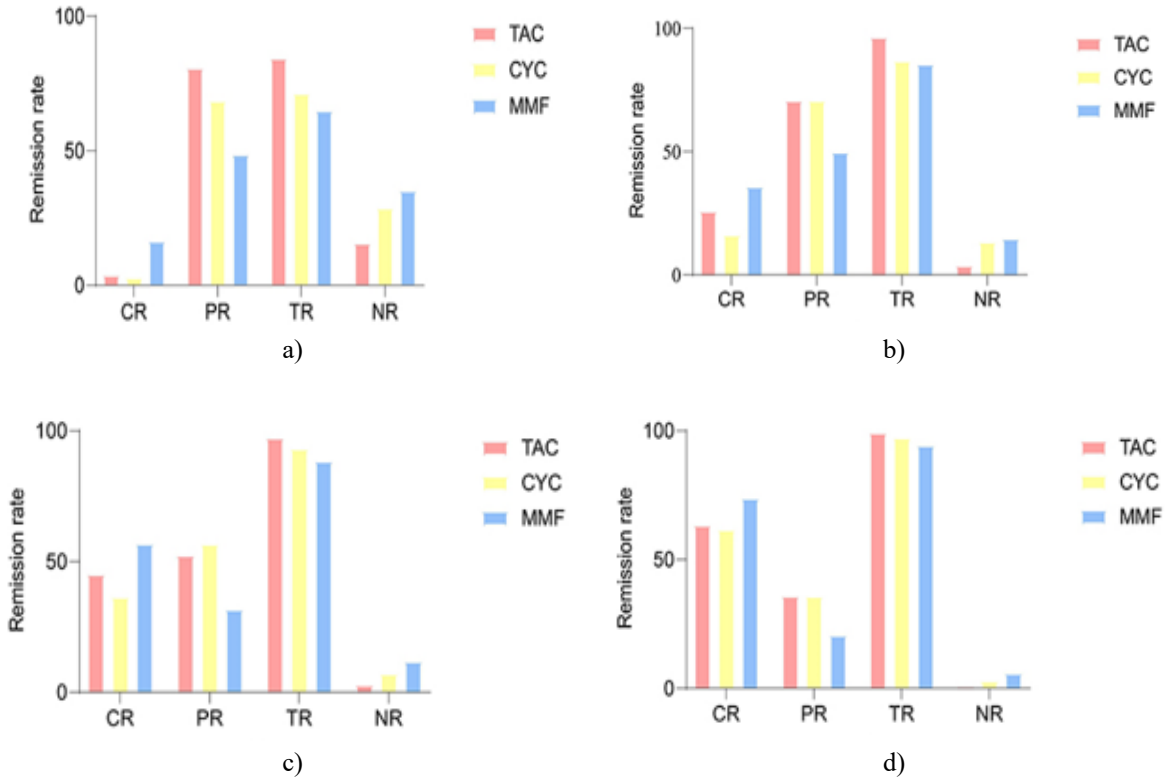
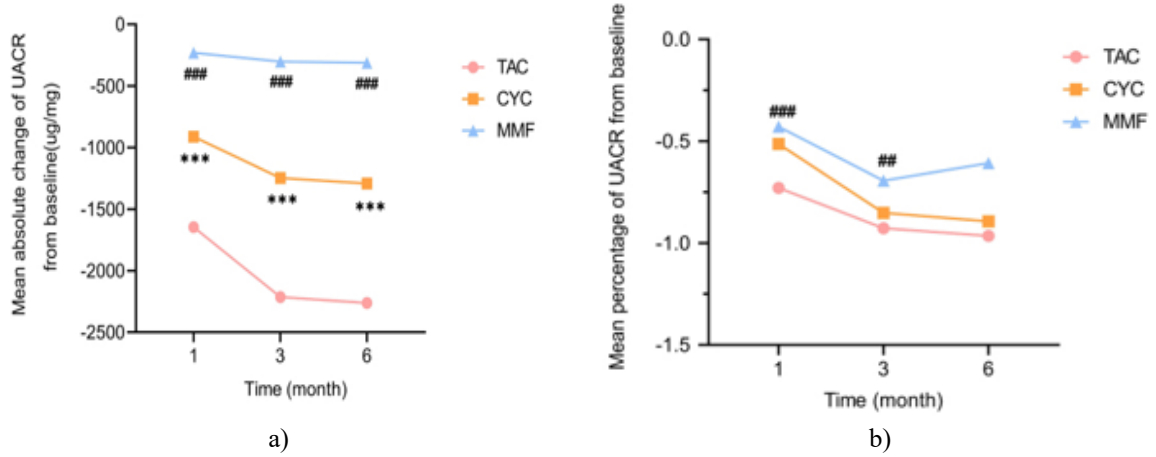


Figure 1. Kidney response at 1 month (a), 3 months (b), 6 months (c), and 12 months (d).Abbreviations: CR = complete remission; PR = partial remission; TR = total remission; NR = non-remission.

In addition, the TAC group exhibited a significantly greater absolute reduction in UACR from baseline than both CYC and MMF ($p < 0.001$). The proportional decrease in UACR also exceeded that of MMF with statistical significance **(Figure 2)**.



ΔUACR	1 month	3 month	6 month
TAC	-1848.8	-2456.6	-2553.5
CYC	-911.9	-1246.4	-1291.5
MMF	-230.5	-302.8	-312.7
P	< 0.001	< 0.001	< 0.001
P^a	< 0.001	< 0.001	< 0.001
P^b	< 0.001	< 0.001	< 0.001
P^c	0.005	0.001	0.001

c)

ΔUACR (%)	1 month	3 month	6 month
TAC	-72.90%	-92.70%	-96.40%
CYC	-51.30%	-85.10%	-89.30%
MMF	-42.90%	-69.40%	-60.80%
P	0.006	< 0.001	0.101
P^a	0.375	0.189	0.966
P^b	< 0.001	0.003	0.137
P^c	0.876	0.092	0.202

d)

Figure 2. Absolute (a, c) and percentage (b, d) UACR changes following CYC, MMF, or TAC treatment. Symbols: * = TAC vs CYC; # = TAC vs MMF; ***/### = p < 0.001; ## = p < 0.01. Pa = TAC vs CYC; Pb = TAC vs MMF; Pc = CYC vs MMF.

Adverse events in patients treated with CYC, TAC, or MMF

Overall side-effect frequency was distinctly lower in both TAC and MMF compared with CYC (60.2% and 65.7% vs 84.4%, p < 0.001). Incidence of leukopenia, gastrointestinal symptoms, and infections was also reduced in TAC and MMF relative to CYC (2.8% and 3.6% vs 9.2%; 0.0% and 1.8% vs 19.9%; 60.2% and 63.3% vs 81.6%) (p < 0.05). TAC showed slightly fewer adverse events than MMF, though without statistical significance **(Table 4)**.

Table 4. Side-Effect Profile for Each Induction Treatment

Adverse Event	TAC(n = 107)	CYC(n = 141)	MMF(n = 165)	P	Pa	Pb	Pc
Total adverse events, n (%)	65 (60.2)	119 (84.4)	111 (65.7)	<0.001	<0.001	0.354	<0.001
Leukopenia, n (%)	3 (2.8)	13 (9.2)	6 (3.6)	0.037	0.042	0.705	0.044
Gastrointestinal symptoms, n (%)	0 (0.0)	28 (19.9)	3 (1.8)	<0.001	<0.001	0.281	<0.001
Infections, n (%)	65 (60.2)	115 (81.6)	107 (63.3)	<0.001	<0.001	0.601	<0.001
Liver function impairment, n (%)	2 (1.9)	9 (6.4)	9 (5.5)	0.221	0.121	0.123	0.731

Notes: Pa = TAC vs CYC; Pb = TAC vs MMF; Pc = CYC vs MMF.

The long-term outcomes of IgAVN patients with different treatment

In this study, 410 individuals with IgAVN were monitored for 12–134 months, with a median follow-up of 43 months. Of these, 313 (76.3%) were categorized as class A, 93 (22.7%) as class B with mild urinary abnormalities, and 4 (1%) as class C showing active renal involvement. No cases met the criteria for class D renal insufficiency. The TAC group demonstrated a markedly higher proportion of class A outcomes (85.8%) compared with the CYC group (66.7%, p = 0.001), and a lower proportion of class B results (13.2% vs 32.6%) (p < 0.001). However, differences between TAC and MMF for classes A and B were not significant. Class C appeared infrequently across all three treatments without meaningful statistical variation **(Table 5)**.

Table 5. The Long-Term Outcomes of Patients with Different Responses to Induction Treatment

Characteristic	TAC (n = 106)	CYC (n = 141)	MMF (n = 163)	P overall	P^a (TAC vs CYC)	P^b (TAC vs MMF)	P^c (CYC vs MMF)
Duration of follow-up (months), median (range)	45.5 (12–122)	42 (12–130)	43 (12–134)	—	—	—	—
Renal outcome, n (%)				0.003	0.001	0.265	0.029
Class A	91 (85.8)	94 (66.7)	128 (78.5)	0.001	0.001	0.131	0.02
Class B	14 (13.2)	46 (32.6)	33 (20.2)	0.001	<0.001	0.137	0.014

Class C	1 (0.9)	1 (0.7)	2 (1.2)	1.00	1.00	1.00	1.00
Relapse (≥1 episode), n (%)	19 (17.9)	59 (41.8)	39 (23.9)	<0.001	<0.001	0.242	0.001

Pa compares TAC with CYC; Pb compares TAC with MMF; Pc compares CYC with MMF.

Additionally, 117 patients (28.5%) experienced relapse at least once over the disease course. The recurrence-free survival curves for TAC, CYC, and MMF are presented in **Figure 3**, showing a significant overall difference (p = 0.017). The TAC cohort had a considerably lower recurrence rate (17.9%) than the CYC cohort (41.8%), while no meaningful distinction was observed between TAC and MMF **(Table 5)**.

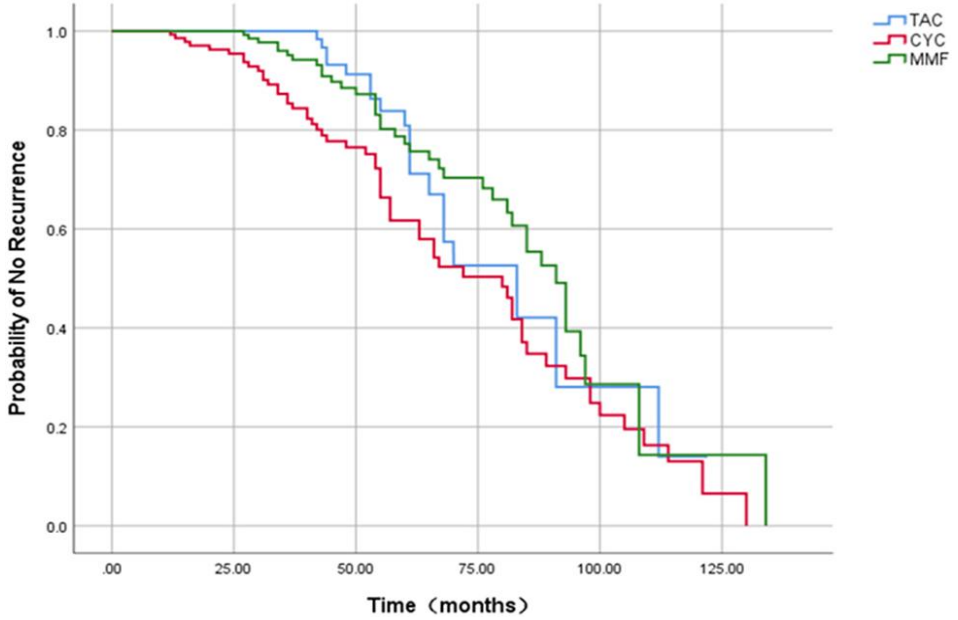


Figure 3. Kaplan–Meier curves depicting recurrence-free survival from diagnosis to last follow-up among patients treated with TAC (Blue), CYC (Red), and MMF (Green).

IgAVN is a frequent cause of secondary renal disease in pediatric populations. Although most patients achieve remission with appropriate therapy, 1%–7% may ultimately progress to ESKD [11]. Previous work has highlighted that nephrotic-range proteinuria and severe proteinuria are major predictors for ESKD in IgAVN [12]. Thus, prompt reduction of urinary protein remains essential in disease management. Calcineurin inhibitors such as TAC or CsA can produce rapid decreases in proteinuria and induce remission in multiple glomerular disorders, including hereditary podocytopathies [13–15]. Despite not being universally recommended, Chan *et al*. emphasize personalized use of TAC based on clinical and pathological characteristics [16]. Consequently, in our center, TAC combined with glucocorticoids is prioritized for patients presenting with heavier proteinuria and more advanced histologic lesions.

Achieving remission early is critical to preventing long-term renal decline. Combination therapy with glucocorticoids and CYC is a commonly employed option due to its relative effectiveness [17]. Nevertheless, certain patients fail to respond to this regimen [18]. Furthermore, because of the considerable adverse effects linked to CYC, alternative immunosuppressive strategies—such as pairing glucocorticoids with MMF or TAC—have been explored and have demonstrated good outcomes [19]. A meta-analysis indicates that MMF may offer superior efficacy and safety compared with CYC [20]. Retrospective data also suggest that TAC can be effective for IgAVN cases not responding to CYC or MMF combinations [21]. Yet, findings by Rohner *et al*. did not reveal major differences among TAC, MMF, or CYC regarding outcomes in IgAVN [22]. Because comparative evidence in children remains scarce, our center applies more intensive immunosuppression during acute presentations and evaluates the effectiveness of TAC, MMF, and CYC.

Although TAC showed higher complete remission rates than CYC at 3 and 6 months, it was mainly prescribed for patients with more severe proteinuria and advanced pathology, potentially affecting interpretation. After adjusting for confounders, TAC still demonstrated a better overall response than CYC. Meanwhile, MMF did not

appear significantly inferior to CYC in inducing remission. Furthermore, TAC provided a faster and more substantial reduction in proteinuria than CYC.

Several investigations have indicated that side effects related to TAC treatment are generally uncommon and mild in IgAVN patients [21, 23] Xu *et al*. reported that MMF resulted in fewer adverse reactions—such as gastrointestinal issues, hepatic dysfunction, myelosuppression, and hair loss—when compared with CYC [20]. In our analysis, both TAC and MMF were linked to reduced occurrences of leukopenia, digestive symptoms, and infections, along with a lower overall rate of adverse events relative to CYC. These observations imply that TAC and MMF offer safer therapeutic profiles for IgAVN. Although not statistically significant, TAC appeared to produce fewer cases of leukopenia, gastrointestinal upset, infection, and impaired liver function than MMF, suggesting the possibility that TAC may be better tolerated; further evidence is still needed.

Deng *et al*. noted that 97.8% of pediatric IgAVN cases had favorable outcomes, with no documented renal insufficiency during follow-up [24]. In contrast, another cohort found that 7.9% of IgAVN patients advanced to ESKD, concluding that clinical and pathological severity—rather than the type of immunosuppressive regimen—predicted poor prognosis [25]. Similarly, a prognostic study found no clear advantage for any specific immunosuppressive therapy [22]. Interestingly, none of the individuals in our cohort progressed to ESKD during extended observation. Additionally, our data showed that TAC outperformed CYC in achieving more complete renal remission.

Multiple factors contribute to remission and relapse patterns in IgAVN, yet research on recurrence remains limited. A Japanese pediatric cohort reported that 16% of children relapsed at least once following combination therapy [26]. A randomized controlled trial by Zhang *et al*. confirmed the long-term safety and effectiveness of TAC and documented a notable reduction in recurrence [27] A separate retrospective review reported that recurrence was influenced by age range, pathological classification, and treatment choice, and that MMF or MMF combined with TAC significantly lowered relapse frequency [28]. In our study, 28.5% of patients experienced one or more relapses—higher than previously described. Although we did not perform a detailed risk factor evaluation, our time-to-recurrence analysis showed that therapy selection influenced the likelihood of relapse. Furthermore, TAC and MMF used with glucocorticoids resulted in much lower relapse rates than CYC, implying that TAC not only induces remission quickly but may also help maintain long-term renal stability.

Naturally, this study has several limitations. First, as a retrospective design, it is subject to inherent bias and potential confounders. Being a single-center investigation also limits broader applicability. Larger prospective comparative studies are required to better address these issues. Additionally, baseline proteinuria varied among treatment groups, which could affect interpretations; for this reason, logistic regression was employed to adjust for confounding, improving the reliability of our conclusions. Finally, although long-term outcomes were compared across treatment regimens, no further bias correction methods were applied, and additional confirmation is necessary.

Conclusion

In summary, this retrospective study evaluated the effectiveness and safety of TAC, CYC, and MMF in managing pediatric IgAVN. TAC combined with glucocorticoids may serve as a suitable induction strategy for children presenting with more severe proteinuria and advanced pathology, providing rapid and meaningful reductions in proteinuria and promoting renal remission. In addition, TAC was associated with enhanced long-term kidney outcomes and decreased relapse frequency, supporting its role as a safe and beneficial option for treating pediatric IgAVN.

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Ethics Statement: None

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