Glucocorticoids and Relapse and Infection Rates in Anti-Neutrophil Cytoplasmic Antibody Disease

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Summary

Background and objectives The optimal course of glucocorticoid therapy in anti-neutrophil cytoplasmic autoantibody (ANCA) disease is unknown. This cohort study evaluates effects of glucocorticoid therapy duration on patient outcomes and adverse events.

Design, setting, participants, & measurements This study assessed 147 patients diagnosed between January 1, 2000 and January 1, 2009 who were treated with glucocorticoids and cyclophosphamide. Patients with end stage kidney disease at presentation, treatment resistance, or who had died within 6 months were excluded. Patients were divided into three groups: 0, 5, or >5 mg prednisone daily at 6 months after therapy initiation. The latter two groups were combined for assessment of adverse events. Wilcoxon rank sum, Kruskal–Wallis, or Fisher's exact tests were used for between-group comparisons. Time to relapse was evaluated by the Kaplan–Meier method with log-rank test for comparison.

Results There were no differences between groups in ANCA specificity, serum creatinine, frequency of risk factors for relapse, or length of therapy with immunosuppressants. Length of glucocorticoid therapy had no impact on time to relapse (hazard ratio, 0.69 [95% confidence interval (CI), 0.23−2.02]; 1.01, [95% CI, 0.57−1.81] for the 5-mg and >5-mg groups, respectively), relapse-free survival, end stage kidney disease, or death. Patients receiving glucocorticoids beyond 6 months had significantly higher incidence of infections (0.64 infections per person-year versus 0.39, $P<0.0001$) and a marginally significant higher frequency of new-onset diabetes mellitus (odds ratio, 2.03; 95% CI, 0.94−4.38).

Conclusions Glucocorticoid therapy beyond 6 months is associated with a significantly greater risk of infections but not a significantly decreased risk of relapse.

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Introduction

Glucocorticoids have been a component of treatment of anti-neutrophil cytoplasmic autoantibody (ANCA) disease for over 4 decades. Glucocorticoids initially were used alone in treating ANCA disease (1), but the addition of cyclophosphamide marked a significant outcome benefit (2–4). The optimal strategy for glucocorticoid use with cyclophosphamide is unknown, especially considering the associated adverse events. Our group attempts to limit adverse effects by discontinuing glucocorticoids within the first 16–24 weeks of treatment while maintaining immunosuppressive therapy with cyclophosphamide and/or other immunosuppression as required. Although limiting glucocorticoid exposure was presumed to be of benefit, there has not been an evaluation of disease outcomes or treatment-specific adverse effects in patients with ANCA disease receiving glucocorticoids for <6 months compared with those receiving a more prolonged course. In this inception cohort study, we compared outcomes of relapse, end stage kidney disease (ESKD), and mortality in three groups: (1) those receiving <6 months of glucocorticoids (0-mg group), (2) those taking 5 mg of prednisone at 6 months (5-mg group), and (3) those taking >5 mg of prednisone at 6 months (>5-mg group). The primary outcome was time to first relapse. We hypothesized that glucocorticoid use beyond 6 months is not beneficial in preventing or delaying relapses and is associated with more treatment complications.

Materials and Methods

Study Population

Patients enrolled in the ANCA disease registry of the Glomerular Disease Collaborative Network (GDCN) were included in this study by fulfilling six criteria. The GDCN ANCA small vessel vasculitis registry was previously described (3,5,6). Native kidney biopsy or biopsy of other tissue (predominantly lung, sinus, and skin) showing pauci-immune GN or small vessel vasculitis with or without granulomatous inflammation was required. All patients were ANCA positive as determined by immunofluorescence microscopy or antigen-specific ELISA. Signed informed consent for review of medical records was

required before screening for study inclusion. All included patients had induction therapy with glucocorticoids and cyclophosphamide, an initial diagnosis between January 1, 2000 to January 1, 2009, and remission on or off therapy attained for at least 1 month. Patient participation in the GDCN registry is approved by the University of North Carolina Committee on the Protection of Human Rights.

ANCA positivity was classified as cytoplasmic ANCA (cANCA) and/or proteinase 3-ANCA (PR3-ANCA), or perinuclear ANCA (pANCA) and/or myeloperoxidase-ANCA (MPO-ANCA). A result of pANCA alone required a concurrent negative antinuclear antibody test result. Renal biopsies were evaluated by the University of North Carolina Nephropathology Laboratory. Patients were followed by physicians participating in the GDCN.

Diagnostic ANCA disease categories were defined according to the Chapel Hill Consensus Conference (7). A diagnosis of granulomatosis with polyangiitis (GPA) (8) (previously Wegener's granulomatosis) was defined by the histologic presence of necrotizing granulomatous inflammation, and/or imaging showing pulmonary nodules or cavities (noninfectious) and/or bony erosions, and/or subglottic stenosis. Microscopic polyangiitis was defined by systemic necrotizing small vessel vasculitis without evidence of granulomatous inflammation or asthma. ANCA GN was defined as pauci-immune necrotizing and/or crescentic GN without overt signs of systemic vasculitis.

Response to therapy was defined as improvement in vasculitic manifestations regardless of the extent of therapy. Remission was defined as the absence of hematuria, >10 red blood cells per high-powered field, for at least 1 month, absence of dysmorphic red blood cells on microscopic urinalysis, or findings of focal sclerosing glomerulopathy without active crescents or necrosis on kidney biopsy and absence of extrarenal manifestations of vasculitis. Proteinuria alone was not considered indicative of active GN. Disease relapse was defined by vasculitic manifestations in any organ deemed severe enough to warrant a change in therapy. Treatment resistance was defined as lack of improvement with at least 1 month of therapy or progression to ESKD due to active GN. Relapse was a potential outcome in all patients in this cohort because patients with treatment resistance were excluded.

Exclusion criteria included eosinophilic GPA (previously Churg Strauss Syndrome), those who presented with the need for and remained on renal replacement therapy, patients with <12 months of follow-up, and patients who died before 6 months (patients who died after 6 months met the criteria for 12 months of follow-up).

Organ involvement was defined by biopsy or by previously described criteria (3,6). Therapeutic interventions were recorded with start and stop dates for immunosuppressive medication. The use and dose of intravenous (IV) methylprednisolone were recorded. The total months of cyclophosphamide, glucocorticoid, and other immunosuppressant use were recorded. Patients who received at least one IV dose or daily oral dosing for at least 1 month were considered to have been treated with cyclophosphamide.

Outcomes of interest included time to relapse, ESKD, and death. To evaluate these outcomes, we separated our cohort into: (*1*) those receiving <6 months of glucocorticoids (0-mg group), (*2*) those taking 5 mg of prednisone at 6 months (5-mg group), and (*3*) those taking >5 mg of prednisone at 6 months (>5-mg group). Patients taking a low dose of prednisone at 6 months (5-mg group) were studied separately with respect to the primary outcome to avoid *a priori* grouping into one of the other two groups. Owing to the small size of the 5-mg group and the small number of certain adverse events, we combined these patients into the >5-mg group for evaluation of adverse events because the duration of glucocorticoid use was similar in patients in the 5-mg and >5-mg groups. In addition, because the lower dose of 5 mg of prednisone is expected to have lower risks of infections or other adverse events compared with higher doses, merging the 5-mg and >5-mg groups biases the results toward the null by diluting the effect of higher doses of steroids.

Noninfectious complications of glucocorticoids included the following: avascular necrosis (AVN), malignant hypertension, osteoporosis, cancer, neuropsychiatric events, cataracts, myocardial infarction, nonvasculitic gastrointestinal bleeding, new-onset diabetes mellitus (DM), stroke, steroid myopathy, and acne. Weight and body mass index were not consistently reported to allow for appropriate review. Infectious complications of immunosuppression and time to infection were defined as any infection treated with oral or IV antibiotics. Malignancies were assessed by the review of medical records. Deaths were documented from medical records or from the Social Security death index.

Statistical Analyses

Descriptive statistics included the number (*n*), percentage (%), mean, and SD. Demographic and clinical characteristic comparisons between groups used Fisher's exact tests for categorical measures and Wilcoxon rank sum tests or Kruskal–Wallis tests for continuous measures. Incidence rates were calculated accounting for varying follow-up times, reported as per patient-year of follow-up using all events for relapse, infection, malignancies, and mortality. Binomial principles were used to calculate 95% confidence intervals (95% CIs) and SDs for incidence rates. *P* values for comparing two incidence rates were calculated by testing the hypothesis that their difference was equal to zero. Kaplan–Meier estimators were used to plot the univariate probability of ESKD-free or relapse-free survival, with time "0" being the date of diagnosis of disease. Proportional hazards models were used for relapse, ESKD, and death, with hazards ratios (HRs) and 95% CIs presented. Analyses were conducted using SAS software (version 9.1; SAS Institute, Cary, NC). Exact *P* values are reported with a two-sided *P* value of <0.05 considered statistically significant.

Results

Patient Groups

Of the 582 ANCA-positive patients with biopsy-proven disease in the registry, 230 patients were diagnosed between January 1, 2000 and January 1, 2009, received glucocorticoids, and were screened for inclusion in this study (Figure 1). Of the 230 patients, the following were excluded: 2 with eosinophilic GPA, 20 who did not receive cyclophosphamide, 1 treated only with IV methylprednisolone and

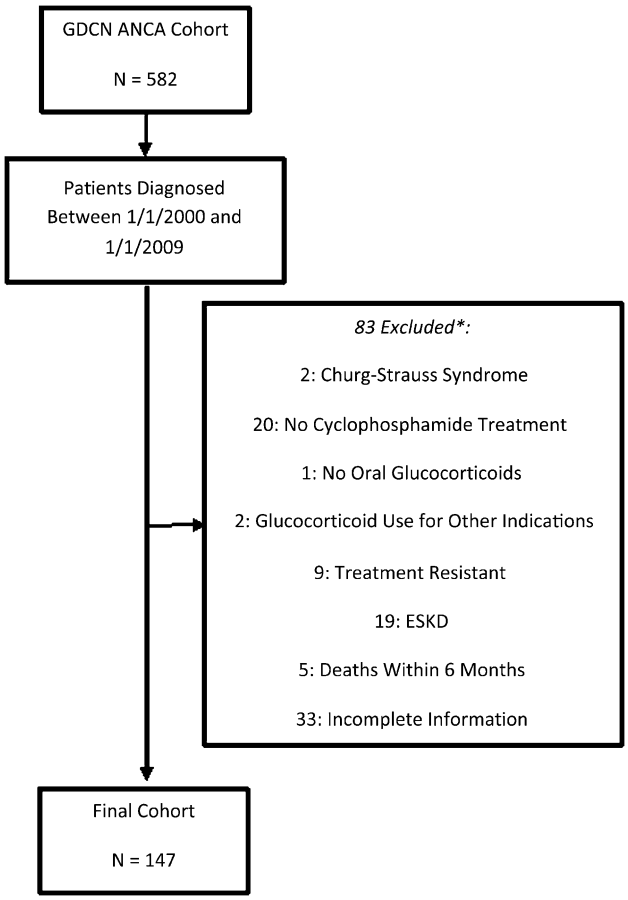

Figure 1. | Derivation of the Glomerular Disease Collaborative Network Anti-Neutrophil Cytoplasmic Antibody Disease Cohort (GDCN ANCA). *Some patients met more than one exclusion criterion.

cyclophosphamide but no oral glucocorticoids, 2 with prolonged glucocorticoid use for other indications, 33 with incomplete clinical information, 9 with treatment resistance, 19 with ESKD at presentation, and 5 who died within 6 months of diagnosis.

As shown in Table 1, 147 patients treated with cyclophosphamide and glucocorticoids were categorized into three groups based on the amount of prednisone used 6 months after therapy initiation. There were 69 patients in the 0-mg group, with a median duration of glucocorticoid use of 5 months; 17 patients were in the 5-mg group, with a median duration of glucocorticoid use of 15 months; 61 patients in the >5-mg group, with a median dose of prednisone of 17.5 mg at 6 months and a median duration of 13 months. The length of follow-up for the total cohort was 35±27 months.

Demographics and Disease Characteristics

The baseline demographic and disease characteristics of the three groups were similar, with some differences by race and age (Table 1). There was no difference among the groups with respect to disease categories of microscopic polyangiitis, GPA, and ANCA GN (P=0.23), the number of affected organ systems (P=0.22), or peak entry creatinine (P=0.85). There was no clinically significant difference in the duration of cyclophosphamide induction therapy or duration of maintenance immunosuppression (Table 1). The majority of patients in the three groups received IV methylprednisolone with induction therapy (P=0.22).

Disease Relapse and Renal and Patient Survival

No statistically significant difference in the rates of relapse (P=0.27) (Table 1) or in relapse-free survival (Figure 2) was found among the three groups. Compared with the 0-mg group, the HR for time to relapse was 0.69 for the 5-mg group (95% CI, 0.23−2.02) and 1.01 for the >5-mg group (95% CI, 0.57−1.81) (Table 2).

We investigated whether the three patient groups had differences in the use of maintenance immunosuppressive medications (azathioprine [AZA] or mycophenolate mofetil [MMF]), and whether their use affected the rate of relapse. The median duration of treatment with AZA varied between 9 and 16 months, with no significant difference among the three prednisone groups (P=0.7) (Table 1). Among patients receiving MMF for maintenance therapy, patients in the 0-mg prednisone group were treated for a median of 22 months, compared with 4 months in the 5-mg prednisone group and 7 months in the >5-mg prednisone group (P=0.03) (Table 1). Because of this difference in the duration of MMF therapy, we evaluated the effect of duration of AZA or MMF therapy on the risk of relapse by multivariate modeling, controlling for months of induction therapy, age at diagnosis, race, and PR3- versus MPO-ANCA. The duration in months of AZA or MMF use had no effect on time to relapse, and controlling for these had no effect on the time to relapse for each of the prednisone patient groups (Table 3). There was no difference in relapse rate between the group of patients who received pulse methylprednisolone (n=101) and those who did not (n=46) (P=0.15).

We evaluated the effect of previously identified risk factors for relapse (5,9), namely, the presence of upper respiratory tract disease, lung involvement, and/or PR3-ANCA. The only factor noted to have a statistically significant effect on time to relapse was the presence of PR3-ANCA versus MPO-ANCA, with a HR of 1.91 (95% CI, 1.1−3.3) (Table 2). This was true in all three groups and was not affected by the dose of prednisone at 6 months. We found no significant difference in relapse-free survival between patients with MPO- or PR3-ANCA across the three prednisone groups. There was a trend toward higher likelihood and earlier development of relapse in patients with lung involvement (HR, 1.34; 95% CI, 0.79−2.28) and upper respiratory involvement (HR, 1.53; 95% CI, 0.92−2.56) in the entire cohort that was not affected significantly by the length of glucocorticoid exposure.

There was no statistically significant difference between the three groups in the development of ESKD (P=0.53) or death (P=0.46) (Table 1).

Adverse Effects of Immunosuppression Including Glucocorticoid Therapy

We documented the presence of infections, new-onset DM, osteoporosis, cancer, cataracts, neuropsychiatric events,

Table 1. Demographics and clinical phenotype

Characteristic	0 mg Prednisone at 6 mo (n=69)	5 mg Prednisone at 6 mo (n=17)	>5 mg Prednisone at 6 mo (n=61)	P Value[a]
Age at diagnosis (yr)	56 (46, 67)	71 (58, 74)	63 (46, 70)	0.03
Sex, female	32 (46)	8 (47)	23 (38)	0.58
Race, Caucasian	50 (73)	16 (94)	53 (87)	0.04
PR3-ANCA or cANCA[b]	25 (36)	5 (29)	32 (52)	0.10
Disease category				
GPA (WG)	21 (30)	2 (12)	20 (33)	0.23
MPA	30 (43)	11 (65)	32 (52)	
ANCA GN	18 (26)	4 (24)	9 (15)	
Organ involvement				
lung	35 (51)	7 (41)	39 (64)	0.15
ear, nose, and throat	31 (45)	7 (41)	28 (46)	0.97
organ systems involved (mean)	3.0 (1.0, 3.0)	3.0 (2.0, 3.0)	3.0 (2.0, 4.0)	0.22
Peak creatinine at disease onset (mg/dl)	2.8 (1.6, 4.6)	2.8 (1.9, 3.7)	2.8 (1.4, 4.3)	0.85
Follow-up (mo)	30 (19, 64)	31 (15, 41)	26 (17, 40)	0.30
Treatment				
prednisone dose at 6 mo (mg)	0	5 (5, 5)	17.5 (10.0, 30.0)	<0.0001
duration of prednisone treatment (mo)	5 (4,6)	15 (9, 31)	13 (7, 19)	<0.0001
mean duration of prednisone treatment (mo)	5	20	20	<0.0001
methylprednisolone induction[c]	54 (78)	11 (65)	40 (66)	0.22
duration of cyclophosphamide induction (mo)	6 (6, 8)	6 (3, 7)	7 (6, 12)	0.05
total duration of cyclophosphamide (mo)[d]	6 (6, 10)	6 (3, 12)	8 (6, 12)	0.13
other immunosuppression[e] (mo)	68 (99) 18 (0, 24)	17 (100) 6 (0, 20)	60 (98) 5 (0, 16)	0.80
patients taking azathioprine	14 (20)	5 (29)	20 (33)	0.27
duration of azathioprine treatment (mo)	12 (7, 26)	9 (6, 32)	16 (7, 28)	0.70
patients taking mycophenolate mofetil	23 (33)	5 (29)	18 (30)	0.91
duration of mycophenolate mofetil treatment (mo)	22 (6, 46)	4 (3, 12)	7 (1, 17)	0.03
Outcomes				
relapse	31 (45)	13 (76)	35 (57)	0.27
ESKD[f]	7 (10)	0	5 (8)	0.53
death	6 (9)	3 (18)	8 (13)	0.46

Data are expressed as n (%) or median (interquartile range). PR3, proteinase 3; cANCA, cytoplasmic anti-neutrophil cytoplasmic antibody; GPA, granulomatosis with polyangiitis; WG, Wegener's granulomatosis; MPA, microscopic polyangiitis; ESKD, end stage kidney disease.

[a]P values were calculated by Fisher exact test for categorical variables and Kruskal–Wallis test for continuous variables. A significant P value ($P<0.05$) indicates at least two of the groups are statistically different, but further pair-wise comparisons were not done because the 5-mg prednisone group is so small.

[b]All patients who were not PR3-ANCA or cANCA positive were MPO-ANCA or pANCA positive with a negative antineutrophil antibody. ANCA-negative patients and patients positive for both MPO-ANCA and PR3-ANCA were excluded from this study.

[c]Methylprednisolone intravenous injection given as a part of induction therapy at least once at a dose of at least 250 mg.

[d]Total months a patient took cyclophosphamide over the reviewed course, including induction, maintenance, and relapse treatment.

[e]Total months a patient received immunosuppression therapy, not including prednisone or cyclophosphamide, including induction, maintenance, and relapse treatment.

[f]Patients with ESRD on presentation were excluded from this study.

nonvasculitic gastrointestinal bleeding, steroid-induced myopathy, myocardial infarction, stroke, malignant hypertension, AVN, and acne as reported in patient records.

We combined the 5-mg and >5-mg groups to assess the effect of glucocorticoids on the frequency and incidence of adverse effects. Patients treated with glucocorticoids beyond 6 months had a significantly greater incidence of infections compared with patients in the 0-mg group (0.64 infections per person-year [95% CI, 0.56−0.73] versus 0.39 infections per person-year [95% CI, 0.35−0.43], respectively ($P<0.0001$)

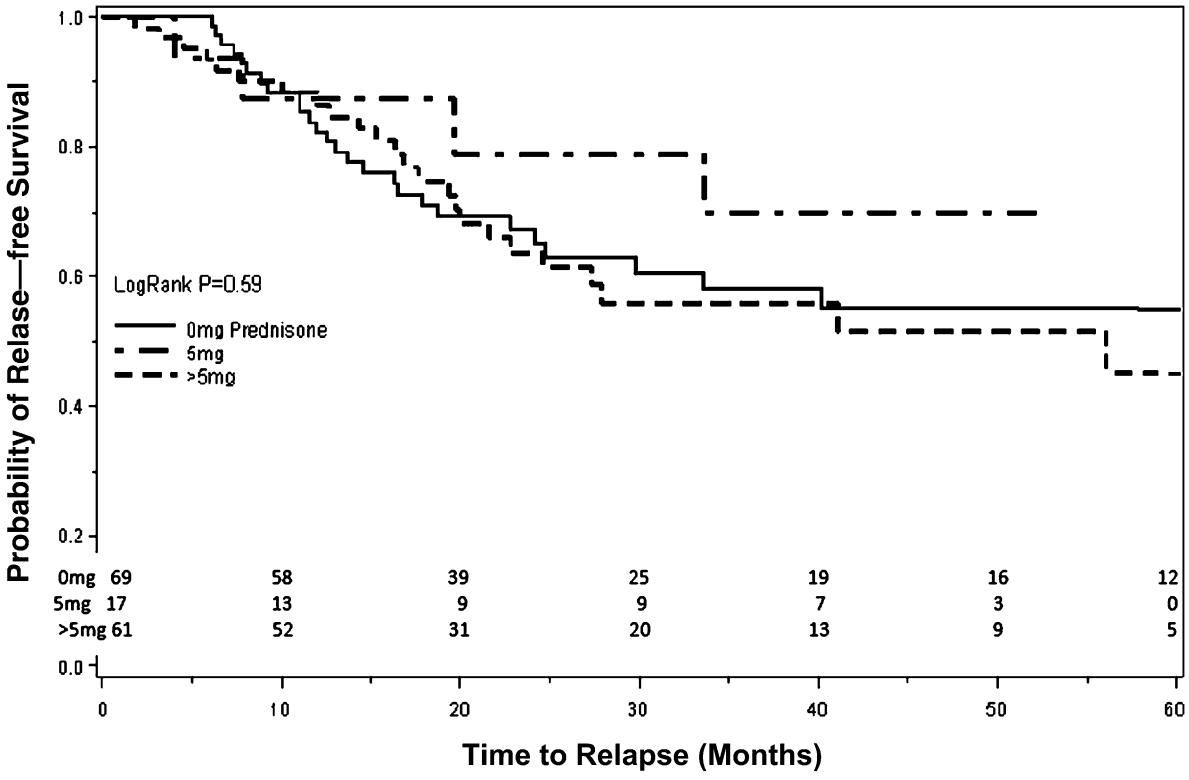

Figure 2. | **Relapse-free survival for the three groups of patients based on prednisone use at 6 months.**

Table 2. Model for time to relapse controlling for prednisone at 6 months, months of induction cyclophosphamide, age, race, PR3-ANCA, or use of any remission maintenance medication

Parameter	*P* Value	Hazard Ratio	95% Confidence Interval
Prednisone at 6 mo, 5 versus 0 mg	0.49	0.69	0.23–2.02
Prednisone at 6 mo, >5 versus 0 mg	0.97	1.01	0.57–1.81
Cyclophosphamide induction therapy (mo)	0.81	0.99	0.92–1.06
Age at diagnosis (yr)	0.39	0.99	0.98–1.01
Caucasian Race, Caucasian versus non-Caucasian	0.91	0.96	0.45–2.02
PR3-ANCA versus MPO-ANCA	0.02	1.91	1.1–3.3
Maintenance immunosuppression (mo)[a]	0.40	1.01	0.99–1.02

PR3-ANCA, proteinase 3 antineutrophil cytoplasmic antibody; MPO-ANCA, myeloperoxidase antineutrophil cytoplasmic antibody.
[a]Immunosuppression other than glucocorticoids or cyclophosphamide.

(Table 4). To more directly assess the effect of length of glucocorticoid therapy on infection risk, we compared the incidence of infections occurring after the 6-month time point (Table 4). The incidence of infections beyond 6 months remained significantly higher among those who continued receiving glucocorticoids (0.42 infections per person-year [95% CI, 0.39−0.46] versus 0.23 infections per person-year [95% CI, 0.21−0.25], respectively; $P<0.0001$). Of note, there was a statistically nonsignificant increased overall incidence of infection and the incidence of infection beyond 6 months in the 5-mg group compared with the 0-mg group. Because the duration of MMF was different across the three groups in contrast to AZA, in which duration was not different, we sought to determine if the dose of MMF was also different and could have contributed to the difference in infection rates between those not taking prednisone at 6 months and those who maintained prednisone treatment. The MMF dose was 583±123 mg (median 500 mg) in the 0-mg group and 569±448 mg (median 500 mg) in the ≥5-mg group ($P=0.92$).

There was a marginally significant higher frequency of new-onset DM among patients taking any amount of glucocorticoids at 6 months (32%) compared with the 0-mg group (19%) (OR, 2.03; 95% CI, 0.94−4.38; $P=0.09$) (Table 4).

The numbers of events for osteoporosis-related pathologic fractures ($n=3$), myocardial infarction ($n=1$), stroke ($n=0$), cataracts ($n=7$), and AVN ($n=2$) were too small for statistical analysis. Use of pulse methylprednisolone with

Table 3. Model for time to relapse controlling for prednisone at 6 months, months of cyclophosphamide induction, age, race, PR3-ANCA, or use of AZA or MMF specifically

Parameter	*P* Value	Hazard Ratio	95% Confidence Interval
Prednisone at 6 mo, 5 versus 0 mg	0.54	0.71	0.24–2.12
Prednisone at 6 mo, >5 versus 0 mg	0.87	1.05	0.57–1.94
Cyclophosphamide induction therapy (mo)	0.70	0.99	0.92–1.06
Age at diagnosis (yr)	0.36	0.99	0.98–1.01
Race, Caucasian versus non-Caucasian	0.73	0.86	0.39–1.94
PR3-ANCA versus MPO-ANCA	0.04	1.80	1.02–3.17
AZA (mo)	0.19	0.98	0.96–1.01
MMF (mo)	0.87	1.00	0.99–1.02

PR3-ANCA, proteinase 3 antineutrophil cytoplasmic antibody; AZA, azathioprine; MMF, mycophenolate mofetil; MPO-ANCA, myeloperoxidase antineutrophil cytoplasmic antibody.

Table 4. Adverse events

	Adverse Event from Biopsy Date to the End of Follow-Up			Adverse Event from 6 mo to the End of Follow-Up		
	0 mg Prednisone 6 Mo (*n*=69)	Prednisone >6 Mo[a] (*n*=78)	*P* Value[b]	0 mg Prednisone 6 Mo (*n*=69)	Prednisone >6 Mo[a] (*n*=78)	*P* Value[b]
At least 1 infection	38 (55)	49 (63)	0.40	22 (32)	31 (40)	0.39
Absolute no. of infections/patient	1.25±1.62	1.56±2.42	0.46	0.82±1.38	1.15±2.29	0.47
Incidence of infection (per person-year) (95% CI)	0.39 (0.35–0.43)	0.64 (0.56–0.73)	<0.0001	0.23 (0.21–0.25)	0.42 (0.39–0.46)	<0.0001
New-onset DM	13 (19)	25 (32)	0.09	2 (3)	3 (4)	1.00
Osteoporosis	5 (7)	6 (8)	1.00	2 (3)	2 (3)	1.00
Cancer	7 (10)	6 (8)	0.77	5 (7)	4 (5)	0.73
Neuropsychiatric event	8 (12)	8 (10)	0.80	0	0	N/A
Cataracts	2 (3)	5 (6)	0.45	1 (1)	4 (5)	0.37
Myopathy	6 (9)	11 (14)	0.44	3 (4)	1 (1)	0.34
GI bleeding[c]	5 (7)	6 (8)	1.00	1 (1)	1 (1)	1.00
Acne	5 (7)	8 (10)	0.57	0	2 (3)	0.50

Data are expressed as *n* (%) or median (interquartile range). CI, confidence interval; DM, diabetes mellitus; GI, gastrointestinal.
[a]Includes patients taking ≥5 mg prednisone.
[b]*P* values were calculated by Fisher exact test.
[c]Gastrointestinal bleeding deemed not to be vasculitic in origin.

induction was not associated with a significant difference in frequency of new-onset DM (*P*=0.69), infection (*P*=0.69), or nonvasculitic gastrointestinal bleeding (*P*=1.00).

Discussion

Although glucocorticoids are almost uniformly used in the induction treatment of ANCA disease, the optimal duration of their use remains debated. Limiting the use of glucocorticoids to the first 4–6 months of therapy is not uniformly accepted. A recent systematic review and meta-analysis of five prospective observational studies and eight randomized control trials detected a higher incidence of relapse in studies or study arms in which glucocorticoid discontinuation was attempted within 12 months compared with studies or study arms in which glucocorticoid withdrawal was not attempted (43% [95% CI, 33–52] versus 14% [95% CI, 10–19], respectively) (10). There was no difference in relapse between studies or study arms in which glucocorticoids were discontinued after 12 months or were not discontinued. However, this analysis suffers from several limitations. There was significant heterogeneity among the studies included for meta-regression and meta-analysis, the duration of glucocorticoid dosing was not the primary treatment variable in any of the controlled trials, the frequency of relapse was the primary outcome in only a subset of studies (11–15), this analysis was not based on patient-level data, and the duration of glucocorticoid therapy was not recorded directly but was estimated from the described protocols.

We evaluated the effect of the duration of glucocorticoid therapy on patient outcomes, focusing on time to relapse, frequency, and incidence of adverse events. Our group has typically initiated glucocorticoid therapy with three daily dosages of methylprednisolone 500 mg IV and daily prednisone 60 mg orally for 4 weeks, followed by a taper to 0 mg by 16–20 weeks. Despite this guideline, almost half of the patients in our cohort remained on prednisone beyond 6 months. We investigated whether glucocorticoid use beyond 6 months occurred in patients with more severe or persistently active vasculitis. We found no clinical difference between patients who took glucocorticoids beyond 6 months and those in the 0-mg group with respect to induction cyclophosphamide, total cyclophosphamide or maintenance immunosuppression use, or with respect to risk factors for relapse. It is difficult to determine how one decides on the duration of prednisone therapy. Despite a relative cohesiveness among clinicians in the GDCN, not all physicians discontinue prednisone by 6 months. It is difficult to appreciate how a treating physician perceives risk for complications such as DM, weight gain, or osteoporosis for a patient or how an individual's tolerance of certain side effects influences duration of the treatment. On the basis of all of the measures that could be evaluated in this inception cohort, there was no discernible clinical difference between the patients in the three groups.

We divided our cohort into three groups based on the dose of prednisone at 6 months. In previous studies, we considered patients taking 5 mg daily of prednisone or less to be "off prednisone." In this study, we compared the patients in the 5-mg group to those in the 0-mg and >5-mg prednisone groups, rather than *a priori* ascribing them to one group or the other. We found that the 5-mg group was similar to the >5-mg group with respect to the duration of glucocorticoid therapy and was different only in the duration of induction cyclophosphamide, although this was not clinically different due to an overlap of SDs.

We found no statistically significant difference in time to relapse among the three groups of patients based on the duration of glucocorticoid therapy. Patients in the 5-mg and >5-mg prednisone groups had a mean length of glucocorticoid therapy of 20 months in both groups and median duration of 15 and 13 months in the 5- and >5-mg groups, respectively, indicating that therapy for >12 months was not associated with a reduced frequency of relapse compared with patients receiving glucocorticoids for ≤6 months. These results differ from those of the recent systematic review and meta-analysis (10). However, in contradistinction to that meta-analysis, our study offers direct patient-level data, relative homogeneity of treatments, and allows for analysis of possible confounders on the frequency of and time to relapse. We demonstrate that, even when controlling for risk factors for relapse, duration of glucocorticoid therapy had no effect on time to relapse.

Evaluation of Adverse Events

Although glucocorticoid therapy is thought to play a pivotal role in halting the inflammatory vasculitic process related to ANCA disease (16), it is associated with significant short- and long-term adverse effects, including infections, DM, bone disease, hypertension, obesity, cancer, psychosis, cataracts, cardiovascular disease, and gastrointestinal bleeding. These and other transient adverse effects, such as disrupted sleep, agitation, anxiety, and volume expansion, may negatively affect quality of life but were not addressed in our analysis.

To assess adverse events, the 5-mg and >5-mg groups were combined because the duration of steroid use between the two groups was similar. We detected a significantly higher incidence of infections among patients remaining on glucocorticoids beyond 6 months, and the difference was confirmed when the analysis was limited to the period beyond 6 months. The latter result provides a more direct assessment of the effect of glucocorticoid use beyond 6 months by eliminating from the analysis the infections occurring during the months of induction therapy, which are common to the two groups of patients.

We also detected a two-fold increased frequency of new-onset DM in patients who were treated with glucocorticoids for longer than 6 months, although this difference did not reach statistical significance. Whether a statistically significant difference would have been detected in a larger cohort is difficult to conjecture. We were unable to assess the effect of possible contributors such as baseline body mass index or weight gain on the occurrence of diabetes because of incomplete data on these variables.

There are limitations to our study. The patient number was not large enough to detect differences in many of the recorded adverse events that can be related to glucocorticoid use, nor were we able to assess certain patient characteristics such as body weight. In addition, the 5-mg group had far fewer patients than the other two groups, thus limiting the conclusions that can be drawn from this specific treatment strategy.

Our study provides patient-level data showing that in patients treated with cyclophosphamide for induction therapy who reach remission, the withdrawal of glucocorticoids before 6 months is not associated with a statistically significantly increased risk of relapse. Additionally, we show that prolonged glucocorticoid exposure is associated with a significantly increased risk of infection.

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Disclosures

None.

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