

# BMJ Open Treatment and clinicopathological characteristics of lupus nephritis with anti-neutrophil cytoplasmic antibody positivity: a case-control study

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## ABSTRACT

**Objective** To assess the clinical features, pathological presentations, treatments and outcomes of lupus nephritis (LN) with anti-neutrophil cytoplasmic antibody (ANCA) positivity.

**Design** A case-control study.

**Methods** Patients (n=49) were retrospectively included from Jinling Hospital in China if presenting with biopsy-proven ANCA-positive LN between 1985 and 2008. Clinicopathological characteristics and outcomes were analysed and compared with those of a control group (n=1279). We further compared treatment responses and outcomes of ANCA-positive LN patients based on the treatment issued.

**Results** The study included 40 women and 9 men (median age 33 years at biopsy): 38 with myeloperoxidase (MPO)-ANCA, 7 with proteinase 3 (PR3)-ANCA and 4 with double positivity. ANCA-positive LN patients exhibited higher haematuria, serum creatinine levels and systemic lupus erythematosus disease activity index scores. On pathological evaluation, class IV LN was predominant, accounting for 61.22% of cases. Light microscopy revealed significantly higher activity index and chronicity index scores, including cellular crescents, interstitial inflammation, tubular atrophy and interstitial fibrosis. ANCA-positive LN patients receiving mycophenolate mofetil as induction therapy had a higher remission rate and better renal outcomes than those receiving cyclophosphamide. During follow-up, end-stage renal disease developed in seven (14.29%) ANCA-positive LN patients, all of them were MPO-ANCA positive.

**Conclusions** The characteristics of ANCA-positive LN were massive haematuria and advanced renal insufficiency. We observed a higher remission rate and better prognoses when using mycophenolate mofetil than when using cyclophosphamide as induction therapy.

## INTRODUCTION

Lupus nephritis (LN) is immune complex glomerular nephritis that develops as a frequent complication of systemic lupus erythematosus (SLE). Autoantibody production in SLE patients is a hallmark of the disease entity, as well as of its activity and prognosis.<sup>1</sup>

## Strengths and limitations of this study

- This study is the largest case-control study to retrospectively summarise the clinicopathological characteristics and outcomes of lupus nephritis (LN) patients with anti-neutrophil cytoplasmic antibody (ANCA) positivity (n=49) and ANCA negativity (n=1279) in China.
- This is the first comparison of intravenous cyclophosphamide with oral mycophenolate mofetil in the treatment of ANCA-positive LN.
- LN patients without biopsy were not included.
- A larger study is needed to describe the differences between MPO-ANCA-positive and PR3-ANCA-positive LN patients.

Intravenous cyclophosphamide (CYC) has been the traditional regimen for treating LN.<sup>2</sup> However, CYC is frequently associated with severe side effects, and infections contribute to the overall mortality associated with LN. Recent studies have established mycophenolate mofetil (MMF), a selective lymphocyte antiproliferative agent, as a safe and an effective alternative to CYC for treating LN.<sup>3</sup> Until now, steroids, CYC and MMF remain the first-line therapeutics for the treatment of LN.

Anti-neutrophil cytoplasmic antibody (ANCA) is the probable cause of a distinct form of vasculitis accompanied by necrotising granulomatosis. Based on ELISA results, the major target antigens of ANCA are proteinase 3 (PR3) and myeloperoxidase (MPO).<sup>4</sup> ANCA-positive LN patients have been described in case reports or small series over the last 25 years.<sup>5-22</sup>

However, due to the relatively small amount of research to date, the clinical features, pathological presentations and outcomes of ANCA-positive LN patients are not clear. Moreover, investigations that have addressed the treatment of this population

are rare. Therefore, we retrospectively summarised the clinicopathological characteristics and outcomes of ANCA-positive and ANCA-negative LN patients. Furthermore, we compared the efficacy, renal relapse rates, adverse events and outcomes between the use of MMF and CYC as induction therapies in ANCA-positive LN patients.

## METHODS

### Patients

Chinese patients (n=1814) with biopsy-proven LN at Jinling Hospital treated between January 1985 and December 2008 were retrospectively reviewed.<sup>23</sup> Patients who fulfilled the following criteria were included in this study: (1) age  $\geq 18$  years, (2) met the American Rheumatologic Association criteria for the diagnosis of SLE,<sup>24</sup> (3) biopsy-proven LN, (4) presence of ANCA positivity, (5) duration of follow-up  $\geq 6$  months and (6) complete baseline and follow-up data. Simultaneously, ANCA-negative LN patients during the same period were included as the control group and compared with the ANCA-positive LN patients.

### Renal morphology

For light microscopy, we processed biopsy specimens for H&E, periodic acid-Schiff, Masson trichrome and Jones methenamine silver staining. Pathological parameters such as the activity index (AI) and chronicity index (CI) were determined using a modification of a previously reported system involving the semi-quantitative scoring of specific biopsy features.<sup>25 26</sup> Vasculopathy was defined according to renal vascular complications of SLE.<sup>27</sup> Biopsy specimens were reviewed and reclassified according to the 2003 International Society of Nephrology/Renal Pathology Society criteria.<sup>28</sup> Two renal pathologists examined biopsy specimens. Differences in classifications and scores between the two were resolved by reviewing the biopsies.

### Data collection

The following data were collected retrospectively at biopsy: gender, age, duration of LN, SLE disease activity index (SLEDAI), hypertension, extrarenal manifestations, 24-hour urinary protein excretion, urinary sediment inspection, serum albumin (SAlb) and serum creatinine (SCr), estimated glomerular filtration rate (eGFR), C3 and C4 levels, and ANCA specificity (tested by ELISA).

MMF was prescribed at doses of 1–2 g/day for 6 months, while CYC was administered at 0.5–0.75 g/m<sup>2</sup> body surface area once a month for 6 months. The total dose of CYC was less than 9 g. Patients who were given less CYC or MMF, *Tripterygium wilfordii* (TW) or other immunosuppressors were assigned to the other-regimens group. All patients received three methylprednisolone injections of 500 mg per day for 3 days followed by oral corticosteroids at doses of 0.6–0.8 mg per kilogram of body weight per day. Maintenance therapy was started at the end of induction therapy with low doses of prednisone

and immunosuppressors, including azathioprine, leflunomide and TW. The primary efficacy endpoint was the total remission (TR) rate at 6 months, and the endpoint for renal outcome was end-stage renal disease (ESRD). When patients were at the end of the follow-up period, we recorded their laboratory findings at the last visit.

The following definitions were used: duration of LN, the time from LN diagnosis to the first renal biopsy; hypertension, blood pressure  $>140/90$  mm Hg; complete remission (CR), proteinuria  $\leq 0.4$  g/24 hours with a normal SAlb level ( $\geq 35$  g/L) and SCr level ( $<109.6$   $\mu\text{mol/L}$ ); partial remission (PR), decline in proteinuria excretion by  $>50\%$  of the baseline value and proteinuria  $>0.4$  g/24 hours but  $<3.5$  g/24 hours, with a normal SCr level or an elevation of  $<15\%$  above the baseline value, without extrarenal activity; TR, CR or PR; renal relapse, proteinuria  $\geq 1.0$  g/24 hours in patients with CR or proteinuria  $\geq 2.0$  g/24 hours in patients with PR, with or without active urine sediment or an increase in SCr by  $\geq 30\%$ ; ESRD, eGFR  $<15$  mL/min/per 1.73 m<sup>2</sup>, initiation of dialysis therapy continued for  $>3$  months or kidney transplantation.<sup>29</sup> eGFR was calculated using the Chronic Kidney Disease Epidemiology Collaboration 2009 creatinine equation.<sup>30</sup> Disease activity was assessed based on the SLEDAI.<sup>31</sup>

### Statistical analysis

All data were analysed using the statistical software SPSS V.17.0 (IBM). Quantitative data are presented as the mean $\pm$ SD or median with the IQR. All parameters were compared using a  $\chi^2$  test or Fisher's test for categorical data and a t-test, Mann-Whitney U, Kruskal-Wallis or one-way analysis of variance tests were used for continuous data. Kaplan-Meier curves and log-rank tests were used to analyse renal survival.  $p < 0.05$  was considered significant.

## RESULTS

### Patient information

Among the 1814 cases, 486 were not tested for ANCA specificity, 1279 showed ANCA negativity and 49 (3.69%) showed ANCA positivity, including 38 with MPO-ANCA positivity, 7 with PR3-ANCA positivity and 4 with double positivity. Of the 49 ANCA-positive LN patients, 40 (81.63%) were women, and nine (18.37%) were men, and their median age was 33 (IQR 26–40) years. The median duration of LN was 3.77 (IQR 1.18–15.97) months, and 15 (30.61%) patients had hypertension (table 1).

ANCA-positive LN patients had higher haematuria (median 101 (IQR 25–525) vs 43 (IQR 5–176)  $\times 10^4$ /mL;  $p=0.006$ ), higher levels of SCr (median 91.05 (IQR 74.26–147.63) vs 73.37 (IQR 54.81–101.66)  $\mu\text{mol/L}$ ;  $p < 0.001$ ) and higher SLEDAI scores (median 14 (IQR 12–18) vs 12 (IQR 10–16);  $p < 0.001$ ) than the controls. Conversely, there were no significant differences in the incidence of hypertension, duration of LN, sex, age, proteinuria, SAlb or serum C3 and C4 levels between the two groups (table 1).

**Table 1** Clinical and laboratory features based on ANCA specificity

	ANCA (+) (n=49)	ANCA (-) (n=1279)	p Value
Men	9 (18.37)	181 (14.15)	0.408
Age, years	33 (26–40)	30 (22–37)	0.116
Duration of LN, months	3.77 (1.18–15.97)	5.27 (1.80–22.20)	0.186
SLEDAI, score	14 (12–18)	12 (10–16)	<0.001
Hypertension	15 (30.61)	363 (28.38)	0.734
Proteinuria, g/24 hours	2.81 (1.11–5.04)	2.29 (1.12–4.35)	0.247
Urinary RBC count, $\times 10^4$ /mL	101 (25–525)	43 (5–176)	0.006
SAIb, g/L	27.40 (21.55–32.65)	27.90 (22.40–33.40)	0.492
SCr, $\mu$ mol/L	91.05 (74.26–147.63)	73.37 (54.81–101.66)	<0.001
eGFR, mL/min/per 1.73 m <sup>2</sup>	68.67 (44.01–96.86)	98.36 (65.48–122.60)	<0.001
<60 mL/min/per 1.73 m <sup>2</sup>	21 (42.86)	284 (22.20)	0.001
<30 mL/min/per 1.73 m <sup>2</sup>	4 (8.16)	112 (8.76)	0.900
C3, g/L	0.42 (0.34–0.66)	0.47 (0.36–0.68)	0.181
C4, g/L	0.09 (0.06–0.16)	0.11 (0.06–0.17)	0.457

Values are given as n (%) or median (IQR).

ANCA, anti-neutrophil cytoplasmic antibody; C3, complement 3; C4, complement 4; eGFR, estimated glomerular filtration rate; LN, lupus nephritis; RBC, red blood cell; SAIb, serum albumin; SCr, serum creatinine; SLEDAI, systemic lupus erythematosus disease activity index.

The observed extrarenal manifestations are summarised in [table 2](#). We did not note any differences when comparing LN patients with and without ANCA positivity.

#### Renal morphology

The renal biopsy findings are shown in [table 3](#). Among the 49 ANCA-positive LN patients, 30 (61.22%) presented with class IV (including 20 (40.82%) with class IV-G and 10 with (20.41%) class IV-S), 9 (18.37%) with class III, 4 (8.16%) with class IV+V, 3 (6.12%) with class V, 2 (4.08%) with class III+V and only 1 (2.04%) with class II.

On renal pathological evaluation, the scores for cellular crescents, interstitial inflammation, tubular atrophy and interstitial fibrosis among the

ANCA-positive LN patients were higher than those for the control group ( $p=0.001$ ,  $p=0.002$ ,  $p=0.005$  and  $p=0.005$ , respectively). Furthermore, the ANCA-positive LN patients had higher AI and CI scores ( $p=0.023$  and  $p=0.010$ , respectively).

#### Treatment regimens and response

Among the 49 ANCA-positive LN patients, 20 received MMF as induction therapy, 18 received CYC and 11 were in the other-regimens group. (Details of the therapies are described in the online supplementary file 1.) We further compared data for baseline characteristics, efficacy, renal relapse rates and adverse events between the MMF and CYC groups.

**Table 2** Extrarenal manifestations based on ANCA specificity

	ANCA (+) (n=49)	ANCA (-) (n=1279)	p Value
Fever (non-infectious)	13 (26.53)	465 (36.36)	0.160
Malar rash	21 (42.86)	711 (55.59)	0.079
Photosensitivity	3 (6.12)	39 (3.05)	0.199
Mouth ulcer	6 (12.24)	129 (10.09)	0.624
Alopecia	8 (16.33)	233 (18.22)	0.736
Arthritis	26 (53.06)	814 (63.64)	0.132
Serositis	8 (16.33)	245 (19.16)	0.621
Neurological disorder	3 (6.12)	52 (4.07)	0.452
Raynaud phenomenon	4 (8.16)	142 (11.10)	0.646
Anaemia	36 (73.47)	775 (60.59)	0.070
Leucopenia	9 (18.37)	245 (19.16)	0.890
Thrombocytopenia	14 (28.57)	336 (26.27)	0.720

Values are given as n (%).

ANCA, anti-neutrophil cytoplasmic antibody.

**Table 3** Pathological findings based on ANCA specificity

	ANCA (+) (n=49)	ANCA (-) (n=1279)	p Value
Number of glomeruli	25 (20–31)	23 (17–30)	0.250
AI score	8.31±4.36	6.83±4.67	0.023
Endocapillary hypercellularity	1.61±1.17	1.62±1.26	0.972
Karyorrhexis/fibrinoid necrosis	0.57±0.54	0.44±0.50	0.097
Cellular crescents	1.31±1.03	0.85±0.85	0.001
Subendothelial hyaline deposits	0.57±0.94	0.73±0.97	0.221
Glomerular leucocyte infiltration	1.00±1.10	0.83±0.99	0.302
Interstitial inflammation	1.37±0.70	1.08±0.67	0.002
CI score	2.92±2.23	2.12±1.96	0.010
Glomerular sclerosis	0.69±0.77	0.55±0.68	0.207
Tubular atrophy	1.00±0.74	0.71±0.67	0.005
Fibrous crescents	0.22±0.42	0.15±0.37	0.110
Interstitial fibrosis	1.00±0.74	0.71±0.67	0.005
Vasculopathy			
Hyaline degeneration of artery	5 (10.20)	151 (11.81)	0.900
Noninflammatory necrotising vasculopathy	2 (4.08)	69 (5.39)	0.900
Inflammatory necrotising vasculopathy	1 (2.04)	2 (0.16)	0.107
Thrombotic microangiopathy	1 (2.04)	73 (5.71)	0.518
Atherosclerosis	11 (22.45)	434 (33.93)	0.095

Values are given as n (%) or mean±SD.

AI, activity index; ANCA, anti-neutrophil cytoplasmic antibody; CI, chronicity index.

The baseline characteristics of the study population are summarised in online supplementary table S1. All the baseline characteristics were comparable between the two groups with the exception of cellular crescent scores, which were significantly higher in the MMF group ( $p=0.007$ ).

Patients receiving MMF had a higher TR rate (15 (75.00%) vs 6 (33.33%);  $p=0.021$ ) and CR rate (13 (65.00%) vs 3 (16.67%);  $p=0.004$ ) than those receiving CYC, as shown in table 4. Furthermore, patients receiving MMF exhibited lower levels of proteinuria ( $p=0.001$ ), haematuria ( $p=0.083$ ) and SCr ( $p=0.011$ ) and had lower SLEDAI scores ( $p=0.015$ ) and higher levels of SAlb ( $p=0.013$ ) at the last follow-up. We noticed that the two groups had similar renal relapse rates.

During follow-up, 12 (60%) subjects in the MMF group and 12 (66.67%) in the CYC group reported at least one adverse event ( $p=0.671$ ). Both groups had equal occurrence rates of infections, arthralgia, arthrosis necrosis, menstrual disorders or menolipsis, cardiac vascular diseases, tumours and epilepsy. (table 4)

### Outcomes

During follow-up (median 100.17 (IQR 51.82–186.20) months), ESRD developed in 7 (14.29%) ANCA-positive LN patients, all of those were MPO-ANCA positive, including six with class IV and one with class III LN. The renal survival rates for ANCA-positive LN patients were 97.90% at 1 year, 95.70% at 5 years and 92.30% at 10 years;

these values were similar to those of the ANCA-negative LN patients, which were 97.30%, 92.50% and 87.00%, respectively (figure 1A).

The renal survival rate for ANCA-positive LN patients receiving MMF as induction therapy was 100% at 1 year, 100% at 5 years and 100% at 10 years; these values were higher than for those receiving CYC, which were 94.40%, 88.10% and 78.40%, respectively ( $p=0.039$ ) (figure 1B).

### DISCUSSION

ANCA positivity rates range from 0% to 30% in LN.<sup>5–22</sup> In this study, we found that ANCA positivity was rare in LN patients and accounted for only 3.69% of the total number of biopsy-proven LN cases, which is lower than shown in other studies. This may be explained by the fact that only the biopsy-proven LN patients were included and those without a biopsy were excluded.

This study shows that ANCA-positive LN presents with unique features. First, childbearing women were predominant, with ANCA-positive LN characterised by massive haematuria and advanced renal insufficiency, similar to what has been shown in previous studies.<sup>5–7–10</sup> Second, it was not surprising that ANCA-positive LN patients had significantly higher proportions of crescents and higher AI and CI scores. These results were partly in accordance with a previous report.<sup>8</sup> Nasr found that all biopsies from 10 ANCA-positive LN patients exhibited prominent

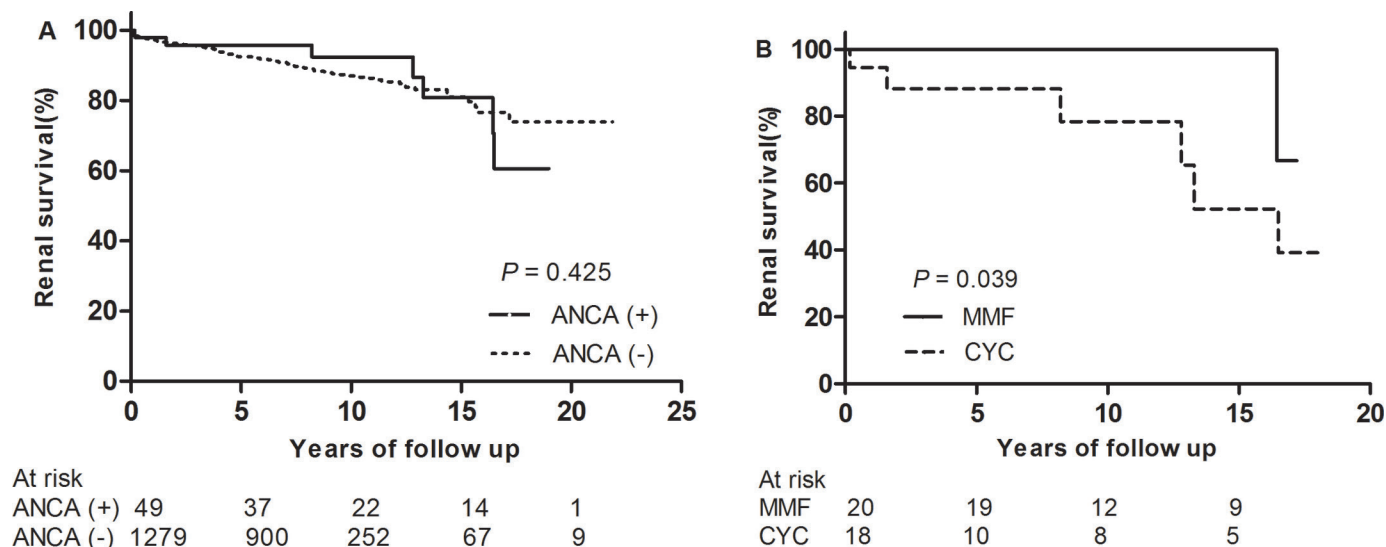
**Table 4** Treatment responses and follow-up data based on induction therapies

	<b>Total (n=49)</b>	<b>MMF group (n=20)</b>	<b>CYC group (n=18)</b>	<b>The other-regimens group (n=11)</b>	<b>p Value*</b>
Follow-up time, months	100.17 (51.82–186.20)	149.88 (97.47–191.53)	96.35 (25.36–169.06)	81.60 (34.90–119.90)	0.114
Treatment response					
Complete remission	22 (44.90)	13 (65.00)	3 (16.67)	6 (54.55)	0.004
Partial remission	27 (55.10)	15 (75.00)	6 (33.33)	6 (54.55)	0.021
Total remission	27 (55.10)	15 (75.00)	6 (33.33)	6 (54.55)	0.021
Renal relapse	8 (29.63)	5 (33.33)	2 (33.33)	1 (16.67)	0.900
Clinical data at the last follow-up					
SLEDAI, score	2 (0–6)	2 (0–4)	4 (2–11)	2 (0–5)	0.015
Proteinuria, g/24 hours	0.39 (0.79–1.06)	0.28 (0.13–0.49)	1.06 (0.43–3.53)	0.25 (0.18–0.49)	0.001
Urinary RBC count, ×10 <sup>6</sup> /mL	1 (1–6)	1 (1–5)	5 (1–51)	1 (1–2)	0.083
SALb, g/L	41.00 (36.00–44.10)	43.50 (39.18–45.10)	35.75 (33.13–42.05)	43.1 (40.75–45.25)	0.013
SCr, μmol/L	76.02 (54.80–113.15)	68.95 (53.26–91.72)	109.17 (74.92–260.12)	50.39 (42.43–71.16)	0.011
Adverse events					
Infection	29 (59.18)	12 (60.00)	12 (66.67)	5 (45.45)	0.671
Arthralgia	9 (18.37)	3 (15.00)	3 (16.67)	3 (27.27)	0.900
Arthritis necrosis	2 (4.08)	0 (0.00)	2 (11.11)	0 (0.00)	0.218
Menstrual disorder or menolipsis	10 (20.41)	6 (30.00)	3 (16.67)	1 (9.09)	0.454
Cardiac vascular disease	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0.900
Tumour	1 (2.04)	0 (0.00)	0 (0.00)	1 (9.09)	0.900
Epilepsy	2 (4.08)	1 (5.00)	1 (5.56)	0 (0.00)	0.900

Values are given as n (%) or median (IQR).

\*Comparison of MMF with CYC in the treatment of ANCA-positive LN patients.

CYC, cyclophosphamide; MMF, mycophenolate mofetil; RBC, red blood cell; SALb, serum albumin; SCr, serum creatinine; SLEDAI, systemic lupus erythematosus disease activity index.



**Figure 1** Comparison of renal survival based on (A) ANCA specificity and (B) induction therapies. ANCA, anti-neutrophil cytoplasmic antibody; CYC, cyclophosphamide; MMF, mycophenolate mofetil.

necrosis and crescents, with rare endocapillary proliferation and subendothelial deposits.<sup>8</sup> In our study, the scores for endocapillary hypercellularity and subendothelial deposits in ANCA-positive LN patients were lower than the scores in the control group. This difference, however, was not statistically significant. ANCA-positive LN included all types of proliferative LN, and classes IV and III were predominant, similar to results shown in previous studies.<sup>6-8 10 12 13 17 19 21 32 33</sup>

Opinions differ about whether ANCA positivity has any association with SLEDAI scores.<sup>7 10 12 17 19-21</sup> In our study, ANCA-positive LN patients had higher SLEDAI scores, which might be associated with higher haematuria owing to aggravated kidney injuries caused by ANCA. However, we did not observe any differences in extrarenal manifestations between cases of LN with and without ANCA positivity.

Because of the low frequency of ANCA-positive LN, there are no well-established treatment methods for patients with this disease.<sup>5 8 9 18</sup> Nasr showed that 6 of 10 patients reached complete or near-complete remission with CYC treatment.<sup>8</sup> In patients who did not respond well to CYC, rituximab was administered and provided satisfactory results.<sup>5</sup> Most authors, including us, have suggested aggressive immunosuppressive therapy.<sup>5 8</sup> In our study, patients receiving MMF as induction therapy had higher remission rates than those receiving CYC. The relative specificity for activated lymphocytes, as well as antiproliferative and antifibrotic actions, may be responsible for the beneficial effects of MMF in treating ANCA-positive LN.<sup>34-36</sup>

ESRD developed in seven ANCA-positive LN patients, all of whom were MPO-ANCA positive; this phenomenon can be explained by the following two factors: first, MPO-ANCA is more common in Asia, including China.<sup>37 38</sup> Second, several recent studies have reported worse renal survival in ANCA-associated vasculitis (AAV) patients

positive for MPO-ANCA,<sup>39-41</sup> and MPO-ANCA positivity is most likely related to smouldering disease, which causes ESRD.<sup>42</sup> Overall, LN patients with MPO-ANCA positivity need more attention, and a larger study is needed to find the differences between MPO-ANCA- and PR3-ANCA-positive LN patients. We believed that ANCA-positive LN patients would have worse renal outcomes; however, we could not draw this conclusion from this study.

Further detailed analysis of ANCA-positive LN patients revealed that only four had a history of taking propylthiouracil (PTU). It has been reported that 15%–64% of patients with PTU develop serum ANCA positivity, of whom 4%–6.5% have clinical symptoms of vasculitis.<sup>43 44</sup> Of note, one patient in our study had a history of silicon exposure, which has been associated with AAV. Hogan proposed that high levels of exposure to silica dust are associated with ANCA-associated small vessel vasculitis.<sup>45</sup> However, ANCA-positive LN was rarely induced in patients by silica exposure or PTU. Additionally, ANCA positivity in LN could result from inflammatory bowel disease and the use of levamisole and hydralazine.<sup>10</sup> Separate analysis is needed of all the possible causes of ANCA positivity related to conditions such as inflammatory bowel disease, silicon exposure and the use of levamisole, hydralazine and PTU. We will continue this research and analyse more patients in future studies.

A putative pathogenic mechanism for vascular inflammation begins with ANCA-induced activation of primed neutrophils and monocytes, leading to the activation of the alternative complement pathway.<sup>46</sup> Based on a deeper understanding of the pathogenesis of SLE, the increased cell death and enhanced extracellular trap formation observed in SLE-derived neutrophils might play key roles in the induction of autoimmunity and the development of organ damage.<sup>47</sup> It has been suggested that LN might facilitate the process of ANCA formation by promoting neutrophil degranulation and priming neutrophils,

increasing the surface expression of ANCA, including that of MPO-ANCA and PR3-ANCA. We observed that 28.57% of ANCA-positive LN patients did not exhibit crescents, and we concluded ANCA might participate in the development of crescents in LN as a major pathogenic mechanism in a gradual process and that the ANCA titre and duration of ANCA positivity would affect the formation of crescents.

There are some limitations to the findings of this report. First, all patients included in this study were of Chinese Han ethnicity; therefore, our results may not completely apply to non-Asians. Second, due to the limitations of a retrospective study, our conclusions require further validation.

In conclusion, the characteristics of ANCA-positive LN were massive haematuria and advanced renal insufficiency. We observed a higher remission rate and better prognoses when using MMF than when using CYC as induction therapy.

**Contributors** All authors contributed significantly to this manuscript, including contributions in the study design (CL and HTZ), chart reviews (CL, MLZ, DDL, ZHL and HTZ), interpretation of the data (CL, MLZ, DDL and HTZ) and preparation of the manuscript (CL, MLZ, DDL, JJW, JY, CHZ, ZHL and HTZ).

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**Competing interests** None declared.

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