Clinical efficacy and safety of rituximab in lupus nephritis

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Background: Long-term treatment programs with low toxicity represent a therapeutic challenge in lupus nephritis (LN). Although a therapeutic benefit of rituximab (RTX) has been reported in LN patients who have failed conventional treatment, the results are controversial. We aimed to assess the clinical efficacy and safety of RTX as a new immunosuppressive medicine in the treatment of LN with a meta-analysis.

Methods: Based on predetermined criteria, PubMed, Embase, and Cochrane Library were used to identify the eligible studies. Cochrane Review Manager version 5.3 was applied to pool the data extracted from individual investigations and provide summary effect estimates.

Results: Twenty-four studies with 940 patients were analyzed. In case series trials with specific LN assessment, the complete remission (CR) rate at 12 months was 35.9% (95% CI: 24.2%–49.5%), and total remission (TR: CR plus partial remission) was 73.4% (95% CI: 66.0%–79.7%). In controlled trials, RTX was associated with a higher probability of TR (OR =2.02, 95% CI: 1.23–3.32, P < 0.01). The CR in the RTX group was higher than that in the control group, although there was no significant difference between the two groups (OR =1.98, 95% CI: 0.90–4.39, P =0.05). Additionally, RTX treatment significantly decreased proteinuria (mean difference: −2.79, 95% CI: −3.95 to −1.62, P < 0.01) as well as the renal activity index in patients with LN (mean difference: −3.46, 95% CI: −4.43 to −2.50, P < 0.01). In controlled trials, the relative risks of the adverse events of infection and infusion reaction were not notably different between the two groups.

Conclusion: RTX is a promising therapy for the treatment of LN due to significant clinical efficacy and a favorable safety profile. In future studies, larger study populations and longer-term time points may identify additional important patient-centered outcomes.

Keywords: systemic lupus erythematosus, lupus nephritis, rituximab, efficacy, safety, meta-analysis

Introduction

Systemic lupus erythematosus (SLE) is an autoimmune disease characterized by multiorgan damage and the production of autoantibodies directed against multiple cellular components.¹–³ Lupus nephritis (LN) occurs in up to 60% of adults with SLE, and up to 30% of LN patients progress to end-stage renal disease (ESRD).⁴–⁵ ESRD is the most severe manifestation of LN and often requires dialysis or transplantation. The “gold standard” treatment for LN includes mycophenolate mofetil (MMF) as well as corticosteroids and cyclophosphamide (CYC),⁶ which results in significant morbidity from infections and ovarian failure.⁷ As a relapsing/remitting autoimmune disease, long-term treatment programs with low levels of toxicity remain a major interventional objective.

Lupus B cells are characterized by various alterations in phenotype and clonal expansion, and hyperreactive B cells play a central role through the production of
autoantibodies and adverse regulatory effects on mediators of inflammation and general immune functions. Rituximab (RTX) is a chimeric antibody which binds specifically to the B-cell surface antigen CD20. CD20 protein is expressed on immature and mature B lymphocytes, but it is not found in early B-cell precursors or plasma cells. Targeting and transiently depleting B cells is an ideal therapeutic approach for LN. RTX was the first approved agent for the treatment of patients with relapsed or refractory lymphoma, and has subsequently been used for various autoimmune diseases, including LN.

Therapeutic benefit of RTX has been reported in LN patients where conventional treatment had failed, although the randomized controlled trials have failed to identify any superiority to placebo. The reasons for RTX failure may include too few patients, strong placebo effects, use of background therapies, heterogeneous outcome measures, heterogeneous patient population, and liberal steroid use. In this study, we aimed to evaluate the clinical efficacy and safety of RTX as a new immunosuppressive treatment for LN with a meta-analysis of the recent literature.

Materials and methods
Data sources and search terms
The search strategy was designed to identify the full length of studies reporting outcomes of RTX treatment in LN patients. Two independent reviewers performed the searches in the following databases: PubMed, Embase, and Cochrane Library. PubMed was searched using Medical subheading using the terms “Rituximab” and “Lupus Nephritis” published from January 1, 2000, to October 31, 2018. As per this method, the entry terms for RTX were: Rituximab; Rituxan; CD20 Antibody, Rituximab CD20 Antibody; IDEC C2B8 Antibody; Mabthera; IDEC C2B8; IDEC-C2B8; IDEC-C2B8 Antibody; GP2013. The entry terms for LN were: Lupus Nephritis; Nephritis Lupus; Lupus Glomerulonephritis; Glomerulonephritis Lupus; Glomerulonephritis Lupus; Nephritis Lupus; Nephritis Lupus; Lupus Glomerulonephritis. Similarly, other database searches were conducted using a combination of rituximab and lupus nephritis terms. No language restrictions were applied. Reference lists of the research articles and reviews were screened to manually identify additional articles.

Inclusion and exclusion criteria
Inclusion criteria
Inclusion criteria were: 1) retrospective study, prospective study, or controlled trials (randomized controlled study [RCT], case-control study) indicating the outcomes of RTX therapy in at least seven LN patients; 2) presence of data on therapeutic efficacy and safety; and 3) enrolled patients with a diagnosis of LN disease based on the American College of Rheumatology criteria.

Exclusion criteria
Exclusion criteria were: 1) abstracts, case reports, reviews, and editorials; 2) studies with insufficient details; and 3) duplicate reports from the same study.

Study selection
Two independent investigators were responsible for determining whether the reports were eligible for inclusion in the meta-analysis. To resolve any inconsistencies, the investigators compared lists after reviewing the identified papers. A third investigator resolved any discrepancies to finalize the list of included studies.

Data extraction and data synthesis
A custom Excel sheet was used to collect all the relevant data on the surname of first author, publication year, patient, intervention, and outcome characteristics. Two investigators extracted the data independently. The results were compared and discussed when there was disagreement. The P(opulation) I(ntervention) C(omparison) O(utcome) of the study were defined as follows: P: Patients with LN; I: treated with RTX, MMF, CYC, or placebo/not treatment (P/NT); C: RTX vs MMF, RTX vs CYC, RTX vs P/NT; O: CR: complete remission, TR: total remission (CR plus partial remission), proteinuria, renal activity index (AI), adverse events.

Statistical analysis
All statistical analyses were conducted and Cochrane Review Manager version 5.3 (Cochrane Library, UK) was applied. Two meta-analysis models were constructed. Model 1: CR and TR of the patients to RTX therapy. TR was defined as CR plus partial remission. Model 2: mean change with statistical significance of AI and proteinuria after RTX therapy. The non-comparative percentages of response were pooled by using the method of the inverse of the variance with logit-transformed proportions. A fixed-effects model was used to calculate the pooled statistic, and the heterogeneity among the included investigations was detected using $I^2$. A random-effects model was constructed when the $P$-value from the heterogeneity test was $<0.1$. Statistical significance was defined as $P<0.05$. 
Results

Search results
Among the 940 publications identified, 24 studies met the inclusion criteria, with 19 case series and five comparative studies.13–36

Characteristics of included studies
The included studies consisted of 24 studies that investigated RTX therapy in 940 LN patients, detailed in Table 1. The studies were conducted between 2005 and 2018, and dose of RTX varied. Some investigators used 375 mg/m² qid., whereas others used 375 mg/m² at day 1 and day 15. Doses of 1,000 mg bid. 2 weeks apart, 1,000 mg at day 1 and day 15 every 6 months, and 600 mg qd were also infused in other cohorts.

Meta-analysis results
Case series with specific LN assessment
Nineteen case series trials12,15–32 in patients with LN met our inclusion criteria. All studies used renal values as criteria to assess clinical outcome and define CR and TR. Based on renal outcome, the pooled percentage using logit-transformed proportions of TR was 72.9% (95% CI: 67.3%–77.8%; Figure 1). The pooled percentage of CR at 12 months was 35.9% (95% CI: 24.2%–49.5%; Figure 1), and the pooled percentage of TR at 12 months was 73.4% (95% CI: 66.0%–79.7%; Figure 1).

Controlled trials
Five controlled trials13,33–36 analyzed clinical remission as an outcome. RTX was associated with a higher probability of TR (OR =2.02, 95% CI: 1.23–3.32, P<0.01; Figure 2). The CR in the RTX group was higher than that in control group, although there was no significant difference between the two groups (OR =1.98, 95% CI: 0.90–4.39, P>0.05; Figure 2). The CR and TR at 12 months were calculated and the pooled ORs for CR and TR were 2.03 (95% CI: 0.54–7.64, P>0.05; Figure 2) and 2.09 (95% CI: 1.23–3.57, P<0.01; Figure 2), respectively. This result indicates that treatment with RTX was associated with a higher TR.

Change in proteinuria
Proteinuria was used to evaluate renal injury in five studies.19,21,22,27,38 RTX treatment decreased proteinuria (mean difference =−2.79, 95% CI: −3.95 to −1.62, P<0.01; Figure 3).

Change in renal activity index
Renal AI is determined by morphologic alteration in renal biopsy, and the maximum score is 24 points. Four studies17,21,28,29 used AI to evaluate pathological renal changes (Figure 4). These trials mostly included patients with active LN despite treatment, WHO or International Society of Nephrology/Renal Pathology Association class III (eight patients), IV (33 patients), III–V (one patient), IV–V (seven patients). Twelve patients had class V LN. In all patients, there was a significant reduction in AI following RTX treatment (mean difference =−3.46; 95% CI: −4.43 to −2.50, P<0.01).

Adverse events
In the case series trials,12,15–32 97 (24.7%) patients suffered adverse events. Sixty-two (15.8%) patients had a total of 69 infections: 14 respiratory infections, ten urinary tract infections, three osteoarticular infections, four sepsis, ten herpes zoster, and one pneumococcal meningitis. Fifteen (3.8%) patients developed an infusion reaction. Two posterior reversible leukoencephalopathies and eight cases of neutropenia were observed. Three patients died during the follow-up period (due to invasive histoplasmosis, complications of surgery, and disease progression). In the controlled trials,13,33,35,36 the relative risks of the following adverse events were not significantly different between RTX and other immunosuppressive agents (CYC/MMF): infection, 0.81 (95% CI: 0.46–1.43, P>0.05) and infusion reaction, 2.18 (95% CI: 0.43–10.98, P>0.05).

Discussion
The renal injury associated with SLE gradually progresses from early mild lesions to glomerular sclerosis and is a major cause of morbidity and mortality in the affected individuals.37 Therefore, it is critical to initiate induction therapy with the best possible clinical efficacy at a very early stage of LN. The primary goals of LN management are renal remission with minimal toxic effects.38

In LN, B cells, attracted by the accumulative of immune complexes, migrate from the circulation into the renal tubule.39 These B cells then undergo clonal expansion in response to local antigens, which perpetuates a cycle of interstitial inflammation and damage.40 B-cell depletion therapies reduce immune complexes in both serum and kidney, and RTX has been of interest for use in LN as a chimeric anti-CD20 monoclonal antibody. Li et al39 found that RTX monotherapy appeared to be effective in the induction therapy of patients with LN, and the addition of CYC had no additional beneficial effect.

Our findings indicate therapeutic efficacy of RTX in LN patients. RTX resulted in a higher TR than the control group.
Table 1 Summary of available information for each study included in the analysis

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Study design</th>
<th>N</th>
<th>RTX dose</th>
<th>Affecting immune drugs added</th>
<th>P dose (mean)</th>
<th>F/U</th>
<th>Clinical outcome</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sfikakis et al, 2005</td>
<td>Greece</td>
<td>PCS</td>
<td>10</td>
<td>4×375 mg/m²</td>
<td>P</td>
<td>0.5 mg/kg/d for 10 w, tapered by 4 mg every 2 w thereafter</td>
<td>12</td>
<td>CR: 50% TR: 80%</td>
<td>CR: normal serum creatinine and albumin, inactive urine sediment, urinary protein/24 h &lt; 500 mg</td>
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<tr>
<td>Vigna-Perez et al, 2005</td>
<td>Mexico</td>
<td>PCS</td>
<td>22</td>
<td>2×0.5–1 g</td>
<td>NM</td>
<td>NM</td>
<td>3</td>
<td>CR: 23% TR: 55%</td>
<td>CR: normal serum creatinine, inactive urine sediment, urinary protein/24 h &lt; 500 mg</td>
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<tr>
<td>Gunnarsson et al, 2007</td>
<td>Sweden</td>
<td>PCS</td>
<td>7</td>
<td>4×375 mg/m²</td>
<td>CYC: 2×0.5 mg/m², MTP: 4×100–250 mg, P</td>
<td>1 mg/kg/d at first week, 0.75 mg/kg/d at second week, 0.5 mg/kg/d at third week then tapered</td>
<td>6</td>
<td>CR: 43% TR: 86%</td>
<td></td>
</tr>
<tr>
<td>Lindholm et al, 2008</td>
<td>Sweden</td>
<td>RCS</td>
<td>17</td>
<td>4×375 mg/m²</td>
<td>NM</td>
<td>NM</td>
<td>12</td>
<td>CR: 12% TR: 65%</td>
<td></td>
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<tr>
<td>Boletis et al, 2009</td>
<td>Greece</td>
<td>PCS</td>
<td>10</td>
<td>4×375 mg/m²</td>
<td>MMF: 2 g/d, P</td>
<td>0.5 mg/kg/d for 4 w, tapered by 5 mg, either every 2 or 4 w thereafter</td>
<td>38</td>
<td>CR: 70% TR: 80%</td>
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<tr>
<td>Melander et al, 2009</td>
<td>UK</td>
<td>RCS</td>
<td>20</td>
<td>4×375 mg/m²</td>
<td>None (but CYC 3 pts)</td>
<td>0.7 mg/kg/d at entrance</td>
<td>22</td>
<td>CR: 35% TR: 60%</td>
<td>CR: urinary protein/24 h &lt; 500 mg, no hematuria, normal GFR or &gt; 50% improvement in GFR</td>
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<tr>
<td>Pepper et al, 2009</td>
<td>UK</td>
<td>PCS</td>
<td>18</td>
<td>2×1 g</td>
<td>MMF: 1 g/d, MTP: 2×500 mg, P</td>
<td>10 mg/d at entrance</td>
<td>12</td>
<td>CR: 33% TR: 67%</td>
<td>CR: normal serum creatinine and albumin, minimal proteinuria (protein: creatinine ratio &lt; 50)</td>
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<tr>
<td>Garcia-Carrasco et al, 2010</td>
<td>Mexico</td>
<td>RCS</td>
<td>13</td>
<td>2×1 g</td>
<td>MTP: 2×500 mg</td>
<td>16 mg/d at entrance (dose adjusted during trial)</td>
<td>6</td>
<td>CR: 38% TR: 76%</td>
<td>CR: normal serum creatinine and albumin, inactive urine sediment, urinary protein/24 h &lt; 500 mg</td>
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<tr>
<td>Ramos-Casals et al, 2010</td>
<td>Spain</td>
<td>RCS</td>
<td>49</td>
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<td>NM</td>
<td>NM</td>
<td>26</td>
<td>CR: 80%</td>
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<tr>
<td>Study</td>
<td>Country</td>
<td>Intervention</td>
<td>Dose</td>
<td>Therapies</td>
<td>Duration</td>
<td>CR</td>
<td>TR</td>
<td>Outcome</td>
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<tr>
<td>Catapano et al, 2010&lt;sup&gt;33&lt;/sup&gt;</td>
<td>UK</td>
<td>RCS</td>
<td>11</td>
<td>CYC: 500 mg MTP: 500–1,000 mg</td>
<td>10 mg/d at entrance</td>
<td>4</td>
<td>CR: 36% TR: 91%</td>
<td>CR: stable or reduced serum creatinine, inactive urine sediment, urinary protein/24 h &lt; 500 mg PR: stable or reduced serum creatinine, &lt; 30 RBC/hpf, urinary protein/24 h 50% reduction</td>
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<tr>
<td>Jónsdóttir et al, 2013&lt;sup&gt;25&lt;/sup&gt;</td>
<td>Sweden</td>
<td>PCS</td>
<td>25</td>
<td>CYC: 2–0.5 g, MMF (2 pts), P</td>
<td>0.5 mg/kg/d during the treatment weeks then tapered rapidly thereafter</td>
<td>12</td>
<td>CR: 16% TR: 56% (6 m) CR: 20% TR: 80% (12 m)</td>
<td>CR: inactive urinary sediment, decrease in proteinuria to ≤0.2 g/d, normal, or stable renal function PR: inactive sediment proteinuria ≤0.5 g/day, normal or stable renal function</td>
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<tr>
<td>Davies et al, 2013&lt;sup&gt;27&lt;/sup&gt;</td>
<td>UK</td>
<td>PCS</td>
<td>18</td>
<td>CYC: 2–0.5 g, MTP: 2–500 mg</td>
<td>NM</td>
<td>6</td>
<td>CR: 61% TR: 72%</td>
<td></td>
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<tr>
<td>Condon et al, 2013&lt;sup&gt;26&lt;/sup&gt;</td>
<td>UK</td>
<td>PCS</td>
<td>50</td>
<td>MTP: 2–500 mg, MMF: 0.5–1.5 g/d</td>
<td>NM</td>
<td>12</td>
<td>CR: 52% TR: 86%</td>
<td>CR: UPC ratio &lt; 50 mg/mmol, serum creatinine level ≤115% of baseline PR: UPC ratio &lt; 300 mg/mmol with &gt;50% reduction from baseline, serum creatinine level ≤115% of baseline</td>
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<tr>
<td>Tsanyan et al, 2014&lt;sup&gt;29&lt;/sup&gt;</td>
<td>Russia</td>
<td>PCS</td>
<td>45</td>
<td>MTP: 6–250–1,000 mg</td>
<td>NM</td>
<td>6</td>
<td>CR: 81% TR: 86%</td>
<td>According to the SLICC RA/RE CR: baseline activity score &gt;0 and follow-up score =0 PR: baseline activity score &gt; follow-up score and follow-up score ≠0</td>
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<td>Contis et al, 2016&lt;sup&gt;30&lt;/sup&gt;</td>
<td>France</td>
<td>RCS</td>
<td>17</td>
<td>MTP: 100–750 mg</td>
<td>NM</td>
<td>12</td>
<td>CR: 24% TR: 53%</td>
<td>CR: normal serum creatinine, inactive urinary sediment, urinary protein/24 h &lt; 500 mg PR: &gt;50% improvement in renal parameters</td>
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<td>Kotagiri et al, 2016&lt;sup&gt;21&lt;/sup&gt;</td>
<td>Australia</td>
<td>PCS</td>
<td>14</td>
<td>AZA (6 pts), MMF (7 pts), CYC (1 pts)</td>
<td>NM</td>
<td>6</td>
<td>CR: 14% TR: 79%</td>
<td>CR: normalization of creatinine, albumin, proteinuria, and urinary RBCs PR: &gt;50% improvement in at least 1 parameter, without deterioration in others</td>
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<tr>
<td>Chavarot et al, 2017&lt;sup&gt;32&lt;/sup&gt;</td>
<td>France</td>
<td>RCS</td>
<td>15</td>
<td>P</td>
<td>Background steroids ≤20 mg/d</td>
<td>6</td>
<td>CR: 27% TR: 80% (6 m) CR: 47% TR: 60% (12 m)</td>
<td>CR: UPC ratio &lt; 0.5 g/g, normal, or near-normal GFR PR: ≥50% reduction in proteinuria to subnephrotic levels, normal or near-normal GFR</td>
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<table>
<thead>
<tr>
<th>Study</th>
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<th>P dose (mean)</th>
<th>F/U</th>
<th>Clinical outcome</th>
<th>Definition</th>
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<tr>
<td>Hogan et al, 2018[23]</td>
<td>France</td>
<td>RCS</td>
<td>12</td>
<td>2×1 g</td>
<td>MTP: 500 mg, MMF: 1,200 mg/m²/d</td>
<td>0.3, 0.10, 0.0 mg/kg/d at 3, 6, and 12 m</td>
<td>6</td>
<td>CR: 75% TR: 100% (6 m)</td>
<td>CR: UPC ratio &lt;5 mg/mg, normal serum creatinine (6 m)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CR: 75% TR: 100% (12 m)</td>
<td>PR: UPC ratio &lt;30 mg/mg, serum creatinine level ≤115% of baseline (12 m)</td>
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<td>Li et al, 2009[20]</td>
<td>China</td>
<td>PCS</td>
<td>19</td>
<td>Group 1: 2×1 g (9 pts)</td>
<td>MTP: 250 mg, P</td>
<td>30 mg/d for 4 d, 0.5 mg/kg/d for 4 w, then a reduction of 5 mg every 2 w to 5 mg/d for the rest of the study</td>
<td>12</td>
<td>CR: 21% TR: 79%</td>
<td>According to the SLICC RARE (48 w)</td>
</tr>
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<td>Moroni et al, 2014[13]</td>
<td>Italy</td>
<td>CS</td>
<td>54</td>
<td>Group 1: 2×1 g (17 pts)</td>
<td>MTP: 3×500–1,000 mg, P</td>
<td>0.5–1.75 mg/kg/d for 1 m, then tapered</td>
<td>12</td>
<td>CR: 71% TR: 100%</td>
<td>CR: serum creatinine &lt;1.2 mg/dl or return to the baseline value, urinary protein/24 h &lt;500 mg, &lt;5 RBC/hpf (48 w)</td>
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<td></td>
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<td></td>
<td>None (37 pts)</td>
<td>MTP: 3×500–1,000 mg, P, MMF (17 pts), CYC (20 pts)</td>
<td></td>
<td></td>
<td>CR: 59% TR: 92%</td>
<td>PR: serum creatinine &lt;1.2 mg/dl or return to the baseline value, urinary protein/24 h 0.5–2 g (48 w)</td>
</tr>
<tr>
<td>Basu et al, 2017[10]</td>
<td>India</td>
<td>CS</td>
<td>44</td>
<td>Group 1: 2×375 mg/m² (17 pts)</td>
<td>MTP: 3×15 mg/kg/d, P</td>
<td>2 mg/kg/d for 1 m, then tapered</td>
<td>3</td>
<td>CR: 71% TR: 94%</td>
<td>CR: urinary protein/24 h &gt;0.5 g, inactive urinary sediment, improvement in kidney function determined by GFR (48 w)</td>
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<td></td>
<td>None (27 pts)</td>
<td>MTP: 3×15 mg/kg/d, P, MMF (12 pts), CYC (15 pts)</td>
<td></td>
<td></td>
<td>CR: 32% TR: 70%</td>
<td>PR: ≥50% decrease in baseline proteinuria or proteinuria &lt;1 g/24 h, ≥25% decrease in baseline GFR (48 w)</td>
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<tr>
<td>Goswami et al, 2018[8a]</td>
<td>India</td>
<td>CS</td>
<td>222</td>
<td>Group 1: 1.9±0.25 g (22 pts)</td>
<td>MMF (4 pts), CYC (12 pts)</td>
<td>NM</td>
<td>6</td>
<td>CR: 73% TR: 91%</td>
<td>CR: serum creatinine &lt;1.3 mg/dl, normal urinalysis, urinary protein/24 h &lt;500 mg (48 w)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None (200 pts)</td>
<td>MMF: 1.5–3 g/d (61 pts), LDCYC: 6×500 mg (26 pts), HDCYC: 6×750–1,200 mg (113 pts)</td>
<td>NM</td>
<td></td>
<td>CR: 66% TR: 83%</td>
<td>PR: serum creatinine &lt;1.3 mg/dl, normal urinalysis, ≥50% decrease in baseline proteinuria (48 w)</td>
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<td>Country</td>
<td>Design</td>
<td>Patients</td>
<td>Placebo</td>
<td>Group 1</td>
<td>MTP</td>
<td>CYC</td>
<td>MMF</td>
<td>CR: 26% TR: 57%</td>
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<td>Rovin et al, 2012</td>
<td>America</td>
<td>RCT</td>
<td>144</td>
<td>72 pts</td>
<td>4×1 g</td>
<td>MTP</td>
<td>CYC</td>
<td>MMF</td>
<td>0.75 mg/kg/d for 16 d and tapered to ≤10 mg/d by 16 w</td>
</tr>
<tr>
<td>Zhang et al, 2015</td>
<td>China</td>
<td>RCT</td>
<td>84</td>
<td>4×375 mg/m²</td>
<td>1 g</td>
<td>MTP</td>
<td>CYC</td>
<td>MMF</td>
<td>0.6 mg/kg/d for 4 w, then reduced at 5 mg every week till reached 10 mg/d</td>
</tr>
</tbody>
</table>

**Note:** The definition of CR and PR as per Sfikakis et al, 2005.

**Abbreviations:** AZA, azathioprine; CR, complete remission; CS, controlled studies; CYC, cyclophosphamide; d, day; FAU, follow-up in months; GFR, glomerular filtration rate; h, hour; HDCYC, high-dose cyclophosphamide; hpf, high-power field; IS, immunosuppressive agents; LDCYC, low-dose cyclophosphamide; m, month; MMF, mycophenolate mophetil; MTP, methylprednisolone (intravenous infusion); N, number of patients with available data for analysis; NM, not mentioned; P, prednisolone; PCS, prospective case series; PR, partial remission; pts, patients; RBC, red blood cells; RCS, retrospective case series; RcT, randomized controlled trial; RTX, rituxinab; SLICC RA/RE, systemic lupus international collaborating clinics renal activity/response exercise; TR, total remission; CR:PR, ; UPc, urine protein-to-creatinine; w, week.

It significantly decreased renal AI as well as proteinuria, suggesting that RTX therapy may prevent the development of organ damage, at least over the short term. The findings of this meta-analysis were consistent with a previous meta-analysis of high B-cell activating factor (BAFF), such as kidney biopsy-proven LN. In that meta-analysis, RTX was ranked as the most effective therapy for LN patients, especially for refractory patients when compared to standard immunosuppressive treatment or patients who experience a new flare-up after intensive treatment.

In our present study, several strengths, including the larger size of the sample and the new follow-up assessment of LN, allowed for a more accurate interpretation of this meta-analysis.
Figure 1 Results of the meta-analysis of remission in LN patients treated with rituximab in case series trials.

Abbreviation: LN, lupus nephritis.
Limitations

There were some limitations in this study. Only two RCTs and three case-control studies with various baseline regimens (MMF+ steroids or CYC+ steroids or steroids alone) were included in the meta-analysis, and these different regimens were not analyzed separately. Furthermore, the definition of complete and partial response used in each of the controlled trials was not same, and this could have introduced heterogeneity.

Figure 2 Results of the meta-analysis of remission in LN patients treated with rituximab in controlled trials.

Abbreviations: LN, lupus nephritis; RTX, rituximab.
geneity among the included studies. While some trials lasted several years, most were 6–12 months long, and this has led to considerable uncertainty in the impact of treatment on the outcomes of these patients and has prevented patients and clinicians from evaluating the relative balance of treatment benefits and risk.

Conclusion
RTX is a promising therapeutic agent for LN treatment. However, in future studies, larger study populations and longer-term end points should be assessed to identify additional important patient-centered outcomes.

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Disclosure
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References


