Rituximab Maintenance for the Treatment of Patients With Follicular Lymphoma: An Updated Systematic Review and Meta-analysis of Randomized Trials

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In a previous systematic review and meta-analysis of five randomized controlled trials comparing rituximab maintenance with no maintenance (observation or rituximab at progression) for patients with follicular lymphoma, we reported that rituximab maintenance treatment improved the overall survival of patients. In this study, we did a similar search of the electronic databases updated through December 31, 2010, and included nine trials and 2586 follicular lymphoma patients. Hazard ratios (HRs) for time-to-event data were estimated and pooled using the inverse variance method. Risk ratios for dichotomous data were pooled using a fixed effect model. Patients treated with rituximab maintenance had improved overall survival (pooled HR of death = 0.76, 95% confidence interval [CI] = 0.62 to 0.92) compared with patients in the no maintenance group. Patients with refractory or relapsed (ie, previously treated) follicular lymphoma treated with rituximab maintenance had improved overall survival (pooled HR of death = 0.72, 95% CI = 0.57 to 0.91), whereas previously untreated patients had no survival benefit (pooled HR of death = 0.86, 95% CI = 0.60 to 1.25). The rate of infection-related adverse events was higher in the rituximab maintenance group (pooled risk ratio = 1.67, 95% CI = 1.40 to 2.00). These results further support the use of rituximab maintenance in the standard of care for refractory or relapsed follicular lymphoma.

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Follicular lymphoma is a “slow growing” B-cell lymphoma. The median age at diagnosis is 63 years (1). Most patients are diagnosed with advanced stage (Ann Arbor stage III or IV) (2) and are followed without chemotherapy until fever, weight loss or night sweats (B symptoms), or signs of high tumor bulk occur, or the lymphoma jeopardizes an organ function (known as the Groupe d’Etude des Lymphomes Folliculaires [GELF] criteria) (3,4). Patients respond well to the initial (first-line) rituximab–chemotherapy induction but typically experience repeated relapses and shortening of the time from treatment to treatment (4). Survival of patients with follicular lymphoma is shorter compared with a matched cohort from the general population, with a median survival of approximately 10 years (95% confidence interval [CI] = 8 to 12 years) (1,5).

Addition of rituximab to induction chemotherapy (rituximab–chemotherapy induction) improves survival of patients with follicular lymphoma compared with induction chemotherapy, but most patients are not cured and experience relapse after a median of 4 years (95% CI = 3.17 to not reached) (6–8). Rituximab maintenance treatment after any induction therapy improves progression-free survival, but evidence of improved overall survival is lacking from randomized controlled trials (9,10). To evaluate the effect of rituximab maintenance treatment on the overall survival of patients with follicular lymphoma, previously we performed a systematic review and meta-analysis (11) of five randomized controlled trials conducted between the years 1998 and 2004 in which 985 follicular lymphoma patients were randomly assigned to rituximab maintenance treatment or to no maintenance (observation or rituximab at progression). Induction therapy consisted of rituximab or chemotherapy or a combination of rituximab and chemotherapy. Results demonstrated a statistically significant survival benefit for patients with refractory or relapsed (ie, previously treated) follicular lymphoma who received rituximab maintenance treatment (pooled hazard ratio [HR] of death = 0.58, 95% CI = 0.42 to 0.79) but not for patients after first-line induction therapy (pooled HR of death = 0.68, 95% CI = 0.37 to 1.25). Since our previous publication (11), the trials included in the systematic review and meta-analysis have published updated results, and in addition, new clinical trials have been completed. In this study, we report an updated systematic review and meta-analysis integrating these new results.

The Cochrane Collaboration policy requires all systematic reviews to be updated within 2 years (12). Because the literature search for this review was done in June 2007, we decided to update it in December 2010. A search for randomized controlled trials was performed as described previously (11). We searched The Cochrane Central Register of Controlled Trials, published in The Cochrane Library (issue 4, 2010); PubMed (1966 to December 2010); EMBASE (1974 to June 2007); LILACS (1982 to December 2010); the database of clinical trials in hematologic malignancies (www.hematology-studies.org); Conference Proceedings of the American Society of Hematology (1995 to 2010), Conference Proceedings of the American Society of Clinical Oncology Annual Meeting (1995 to 2010), and Proceedings of the European Hematology Association; and databases of ongoing and unpublished trials (http://www.controlled-trials.com/, http://www.clinicaltrials.gov/ct, http://clinicaltrials.ncti.nih.gov/). The
Prior knowledge
Most follicular lymphoma patients respond to induction chemotherapy but experience repeated relapses. A previously conducted systematic review and meta-analysis of five randomized controlled trials that compared rituximab maintenance treatment with no maintenance showed survival benefit for patients with refractory or relapsed (previously treated) follicular lymphoma who received rituximab maintenance, but not untreated patients.

Study design
An updated systematic review and meta-analysis was conducted by including nine randomized trials, and patients treated with rituximab maintenance were compared with no maintenance group.

Contribution
Patients treated with rituximab maintenance showed statistically significantly better overall and progression-free survival compared with patients in the no maintenance group. Subgroup analysis of overall survival showed that patients with refractory or relapsed follicular lymphoma had a clear survival benefit with rituximab maintenance treatment, but previously untreated patients did not have a statistically significant survival benefit. A higher rate of infection-related adverse events was noted in the rituximab maintenance group.

Implications
The updated meta-analysis confirms the results of the former meta-analysis. Rituximab maintenance improves survival in previously treated patients, and although untreated patients show progression-free survival benefit, they do not show overall survival benefit. The higher rate of infection-related adverse events in the rituximab maintenance group needs to be considered while treating the patients.

Limitations
An increased chance of false-positive results is possible because of repeated meta-analysis.

From the Editors

Terms “follicular” or “indolent” and similar terms, and “lymphoma” and similar terms were cross-searched with “rituximab” or “monoclonal antibodies” and similar terms. We contacted the first or corresponding author of each included trial to obtain complementary information or information on unpublished trials. The primary outcome was overall survival. Secondary outcomes included progression-free survival (as defined in Cheson et al. [13]), quality of life, and adverse events: grade 3 or 4 adverse events (according to the US National Cancer Institute’s Common Terminology Criteria for Adverse Events, CTCAE, version 3). If the trials used the term grade but did not define the grading system, we assumed grading was defined according to CTCAE, adverse events requiring discontinuation of therapy, infections, and severe infections (as defined in each trial). In our previous protocol designed in 2007, we also planned to analyze event-free survival, rate of disappearance of B-cell CLL/lymphoma 2 (BCL2) protein from biopsy specimen, and response duration. We amended the protocol and did not include these outcome measures in the current meta-analysis.

Subgroup analyses for the primary outcome were planned according to the type of induction therapy (chemotherapy only, rituximab only, rituximab combined with chemotherapy, any regimen containing rituximab), rituximab schedule, treatment line, blinding of patients, caregivers, or outcome assessors, and adequacy of allocation concealment and adequacy of sequence generation. All subgroup analyses of progression-free survival (by type of induction therapy, type of chemotherapy, treatment line) were not planned a priori in the protocol.

Hazard ratios and 95% confidence intervals for time-to-event outcomes were estimated (14,15) and pooled using inverse variance method in a fixed effect model. A hazard ratio less than 1.0 was in favor of rituximab maintenance treatment. Risk ratios (RRs) and 95% confidence intervals for dichotomous data were estimated and pooled using a fixed effect model (the Mantel–Haenszel method) (16). For the primary outcome, we performed a sensitivity analysis by repeating the analysis using a random effects model (the DerSimonian and Laird method; (17)). We assessed heterogeneity of trial results by the $\chi^2$ test of heterogeneity and the $I^2$ statistic of inconsistency. Statistically significant heterogeneity was defined as $P$ less than .1 or an $I^2$ statistic greater than 50% (18). All statistical tests were done by Review Manager (RevMan) version 5.1 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2011) and were two-sided.

The literature search identified 873 references, of which 64 references were considered potentially relevant (8–10,19–79), and 50 references were excluded (19–68). Ten trials fulfilled inclusion criteria (8–10,69–79), including five new trials (8,69,73,76–78) and three updated data of trials (71,72,75) included in our previous report (11). One trial did not report relevant clinical data (78). Two of the publications (71,79) reported the outcomes of different subsets of patients from the same trial.

The trial and patient characteristics are shown in Tables 1 and 2. Patients were eligible for trial entry if they had at least partial response (8,10,73–76) or at least stable disease (9,69–72,79) after induction therapy. In one trial (70), patients in the no maintenance group were eligible for rituximab upon progression of follicular lymphoma; in other trials, patients in the control group were observed without rituximab treatment.

Patients included in one trial (69) fulfilled GELF criteria for deferred treatment (3). In the original trial (69), patients were randomly assigned to one of three groups—observation, rituximab induction, or rituximab induction and maintenance. To avoid overestimation of the effect of rituximab maintenance, we chose to compare patients who received rituximab induction and maintenance with those who received rituximab induction only and not with those in the observation group. Thus, in this meta-analysis, patients who received only rituximab induction and no maintenance were used as the control group.

Nine trials performed between 1998 and 2009 (2586 patients) were eligible for the meta-analysis of overall survival (8–10,69–77,79). Patients treated with rituximab maintenance had statistically significantly better overall survival compared with patients in the no maintenance group (pooled HR of death = 0.76, 95% CI = 0.62 to 0.92) (Figure 1). No statistically significant heterogeneity among the trials was observed for overall survival ($P_{\text{heterogeneity}} = .0$). The funnel plot of the pri-
### Table 1. Characteristics of included trials*

<table>
<thead>
<tr>
<th>Author, year (reference)</th>
<th>No. of randomly assigned patients</th>
<th>No. of patients included in meta-analysis</th>
<th>Quality of allocation concealment†</th>
<th>Quality of sequence generation‡</th>
<th>No. of dropouts (%)</th>
<th>Median follow-up, mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ardeshna 2010 (69)</td>
<td>462</td>
<td>276</td>
<td>NR</td>
<td>NR</td>
<td>0 (0)</td>
<td>NR</td>
</tr>
<tr>
<td>Forstpointner 2006 (10)</td>
<td>195§</td>
<td>105§</td>
<td>Adequate</td>
<td>Adequate</td>
<td>19 (10)</td>
<td>26</td>
</tr>
<tr>
<td>Hainsworth 2005 (70)</td>
<td>90</td>
<td>90</td>
<td>Adequate</td>
<td>Adequate</td>
<td>0 (0)</td>
<td>41</td>
</tr>
<tr>
<td>Hochster 2007 (79); Hochster 2009 (71)</td>
<td>313 (CVP cohort); 69 (FC cohort)¶</td>
<td>228 (CVP cohort); 69 (FC cohort)¶</td>
<td>NR</td>
<td>NR</td>
<td>2 (1)</td>
<td>48</td>
</tr>
<tr>
<td>Martinelli 2010 (9,72)</td>
<td>151</td>
<td>151</td>
<td>Adequate</td>
<td>Adequate</td>
<td>0 (0)</td>
<td>114</td>
</tr>
<tr>
<td>Pettengell 2010 (73)</td>
<td>280</td>
<td>280</td>
<td>NR</td>
<td>NR</td>
<td>0 (0)</td>
<td>76.8</td>
</tr>
<tr>
<td>Salles 2010 (65)</td>
<td>1018</td>
<td>1018</td>
<td>Adequate</td>
<td>Adequate</td>
<td>0 (0)</td>
<td>36</td>
</tr>
<tr>
<td>van Oers 2010 (74,75)</td>
<td>334</td>
<td>334</td>
<td>NR</td>
<td>NR</td>
<td>0 (0)</td>
<td>84</td>
</tr>
<tr>
<td>Witzens-Harig 2009 (76,77)</td>
<td>171</td>
<td>35§</td>
<td>Adequate</td>
<td>Adequate</td>
<td>8 (5)</td>
<td>28</td>
</tr>
</tbody>
</table>

* CVP = cyclophosphamide, vincristine, prednisone; FC = fludarabine, cyclophosphamide; NR = not reported.
† Adequate allocation concealment secures strict implementation of an allocation sequence without foreknowledge of intervention assignments (as central randomization, opaque, and sealed envelopes).
‡ Adequate sequence (of randomization) is generated by the use of a random component (as random number table, computer random number generator, coin tossing, minimization).
§ Of 195 randomly assigned patients, 19 were lost to follow-up. Of the 176 analyzed patients, 105 had follicular lymphoma.
¶ Separate analysis was possible for patients with follicular lymphoma.
¶ Patents in one trial (71,79) were randomly assigned to CF and CVP and to rituximab maintenance or no maintenance in a second randomization. The CF treatment was closed early. The outcomes of maintenance in these two groups are reported separately for each cohort.
# Of the 313 randomly assigned patients, there were 228 available patients with follicular lymphoma.
Table 2. Characteristics of patients included in the meta-analysis and their treatment*

<table>
<thead>
<tr>
<th>Author, year (reference)</th>
<th>Grade of lymphoma</th>
<th>Additional inclusion criteria and eligibility for induction</th>
<th>Treatment line</th>
<th>Induction therapy</th>
<th>Minimum response to induction</th>
<th>Rituximab maintenance protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ardeshna, 2010 (69)</td>
<td>1–3A†</td>
<td>Asymptomatic, advanced-stage, low tumor burden (GELF criteria), randomized to observation, or induction, or induction and maintenance</td>
<td>Untreated FL</td>
<td>Rituximab</td>
<td>Stable disease</td>
<td>A single infusion every 2 mo for 2 y</td>
</tr>
<tr>
<td>Forstpointner, 2006 (10)</td>
<td>1–3†</td>
<td>No additional</td>
<td>Relapsed previously treated FL, MCL†</td>
<td>FCM or FCM with rituximab</td>
<td>PR</td>
<td>Weekly for 4 wk at 3 and 9 mo</td>
</tr>
<tr>
<td>Hainsworth, 2005 (70)</td>
<td>1–2†</td>
<td>Progressive lymphoma, any stage</td>
<td>Relapsed FL, SLL† upon progression</td>
<td>Rituximab</td>
<td>Stable disease</td>
<td>Weekly for 4 wk every 6 mo for 2 y</td>
</tr>
<tr>
<td>Hochster, 2007 (79);</td>
<td>1–2†</td>
<td>Advanced stage</td>
<td>Untreated FL, SLL†</td>
<td>CVP, FC</td>
<td>Stable disease</td>
<td>Weekly for 4 wk every 6 mo for 2 y</td>
</tr>
<tr>
<td>Hochster, 2009 (71)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Martinelli, 2010 (9,72)</td>
<td>1–3 REAL classification§</td>
<td>Any stage (84% advanced)</td>
<td>Untreated and relapsed FL</td>
<td>Rituximab (no previous rituximab)</td>
<td>Standard induction following by BEAM conditioning and ASCT</td>
<td>Weekly for 4 wk every 3 mo for 2 y</td>
</tr>
<tr>
<td>Pettengell, 2010 (73)</td>
<td>1–3A†</td>
<td>No additional</td>
<td>Relapsed FL</td>
<td>Standard induction</td>
<td>PR</td>
<td>A single infusion every 2 mo for 4 doses</td>
</tr>
<tr>
<td>Salles, 2010 (65)</td>
<td>1–3A†</td>
<td>High tumor burden according (not fulfilling GELF criteria)</td>
<td>Untreated FL</td>
<td>PR</td>
<td>A single infusion every 2 mo for 2 y</td>
<td></td>
</tr>
<tr>
<td>van Oers, 2010 (74,75)</td>
<td>1–3A†</td>
<td>No additional</td>
<td>Relapsed FL</td>
<td>PR</td>
<td>A single infusion every 3 mo for 2 y</td>
<td></td>
</tr>
<tr>
<td>Witzens-Haring, 2009 (76,77)</td>
<td>1–3A†</td>
<td>No additional</td>
<td>Untreated and relapsed CD20-positive B-cell non-Hodgkin lymphoma‡</td>
<td>PR</td>
<td>A single infusion every 3 mo for 2 y</td>
<td></td>
</tr>
</tbody>
</table>

* ASCT = autologous stem cell transplantation; BEAM = BCNU, etoposide, cytarabine, melphalan; CHOP = cyclophosphamide, doxorubicin, vincristine, prednisone; CVP = cyclophosphamide, vincristine, prednisone; FC = fludarabine, cyclophosphamide; FCM = fludarabine, cyclophosphamide, mitoxantrone; FL = follicular lymphoma; GELF = the Groupe d’Etudes Lymphomes Folliculaires; MCL = mantle cell lymphoma; mo = months; PR = partial response; SLL = small lymphocytic lymphoma; wk = weeks; y = years.
† Grades according to the World Health Organization classification of neoplastic diseases of the hematopoietic and lymphoid tissues.
‡ Separate analysis was possible for patients with follicular lymphoma.
§ Grades according to the Revised European American Lymphoma (REAL) classification.

### Analysis

- **Rituximab Maintenance:** Improved overall survival and disease control in patients receiving rituximab maintenance compared to induction therapy. The hazard ratio of disease progression or death was 0.50 (95% CI = 0.44 to 0.55) with rituximab maintenance compared to no maintenance (95% CI = 0.38 to 0.60). The benefit in the pooled analysis was 0.56 (95% CI = 0.48 to 0.62). The benefit in the pooled analysis was 0.56 (95% CI = 0.48 to 0.62). The benefit in the pooled analysis was 0.56 (95% CI = 0.48 to 0.62).

- **Quality of Life:** In two trials, the quality of life was assessed and reported at the time of trial completion. Rituximab maintenance was associated with an improved quality of life compared to no maintenance (pooled RR = 1.40 to 0.84). The pooled RR was 1.40 (95% CI = 1.29 to 1.59). The pooled RR was 1.40 (95% CI = 1.29 to 1.59). The pooled RR was 1.40 (95% CI = 1.29 to 1.59).

- **Adverse Events:** The rate of adverse events requiring discontinuation of rituximab was higher with rituximab maintenance compared to no maintenance (pooled RR = 2.72, 95% CI = 1.50 to 4.92). The rate of adverse events requiring discontinuation of rituximab was higher with rituximab maintenance compared to no maintenance (pooled RR = 2.72, 95% CI = 1.50 to 4.92). The rate of adverse events requiring discontinuation of rituximab was higher with rituximab maintenance compared to no maintenance (pooled RR = 2.72, 95% CI = 1.50 to 4.92).
**Figure 1.** Pooled hazard ratios (HRs) of overall survival of patients with follicular lymphoma after first induction and refractory or relapsed disease. Nine trials were included in meta-analysis; no death occurred in one trial (76), and it did not contribute to the pooled analysis. Black squares represent the point estimate (HR), their sizes represent their weight in the pooled analysis, and the horizontal bars represent the 95% confidence intervals (CIs), unidirectional arrows represent a limit of the CI that is higher than 10, and the center of the black diamonds represent the pooled point estimate, and their horizontal axis represents the pooled 95% CI. The black diamond at the bottom represents the pooled point estimate. MR = maintenance therapy with rituximab. SE = standard error.

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>log[HR]</th>
<th>SE</th>
<th>Weight</th>
<th>HR (95% CI)</th>
<th>HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance in first remission</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Ardesnna 2010</td>
<td>0.19</td>
<td>0.61</td>
<td>2.7%</td>
<td>1.21 (0.37 to 4.00)</td>
<td></td>
</tr>
<tr>
<td>Hochster 2007</td>
<td>1.5067</td>
<td>1.155</td>
<td>0.8%</td>
<td>4.51 (0.47 to 43.40)</td>
<td></td>
</tr>
<tr>
<td>Hochster 2009</td>
<td>-0.51</td>
<td>0.3537</td>
<td>8.1%</td>
<td>0.60 (0.30 to 1.20)</td>
<td></td>
</tr>
<tr>
<td>Martinelli 2010</td>
<td>0.073</td>
<td>0.5775</td>
<td>3.0%</td>
<td>1.08 (0.35 to 3.34)</td>
<td></td>
</tr>
<tr>
<td>Salles 2010</td>
<td>-0.14</td>
<td>0.27</td>
<td>13.8%</td>
<td>0.87 (0.51 to 1.48)</td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td></td>
<td>28.4%</td>
<td></td>
<td>0.86 (0.60 to 1.25)</td>
<td></td>
</tr>
<tr>
<td>Heterogeneity: Chi² = 3.55, df = 4 (P = .47); I² = 0% Test for overall effect: Z = 0.78 (P = .44)</td>
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</table>

<table>
<thead>
<tr>
<th>Maintenance for relapsed or refractory lymphoma</th>
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</thead>
<tbody>
<tr>
<td>Forstpointer 2006</td>
<td>-0.72</td>
<td>0.5</td>
<td>4.0%</td>
<td>0.49 (0.18 to 1.30)</td>
<td></td>
</tr>
<tr>
<td>Hainsworth 2005</td>
<td>-0.1526</td>
<td>0.2819</td>
<td>12.7%</td>
<td>0.86 (0.49 to 1.49)</td>
<td></td>
</tr>
<tr>
<td>Martinelli 2010</td>
<td>-0.624</td>
<td>0.304</td>
<td>10.9%</td>
<td>0.54 (0.30 to 0.97)</td>
<td></td>
</tr>
<tr>
<td>Pettengell 2010</td>
<td>-0.13</td>
<td>0.25</td>
<td>16.1%</td>
<td>0.88 (0.54 to 1.43)</td>
<td></td>
</tr>
<tr>
<td>van Oers 2010</td>
<td>-0.36</td>
<td>0.19</td>
<td>27.9%</td>
<td>0.70 (0.48 to 1.01)</td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td></td>
<td>71.6%</td>
<td></td>
<td>0.72 (0.57 to 0.91)</td>
<td></td>
</tr>
<tr>
<td>Heterogeneity: Chi² = 2.60, df = 4 (P = .63); I² = 0% Test for overall effect: Z = 2.80 (P = .005)</td>
<td></td>
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</tbody>
</table>

Any treatment line

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>log[HR]</th>
<th>SE</th>
<th>Weight</th>
<th>HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Witzens-Hang 2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No deaths occurred</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td></td>
<td>Not estimable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterogeneity: Not applicable</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Test for overall effect: Not applicable</td>
<td></td>
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</tr>
</tbody>
</table>

Total (95% CI) 100.0% 0.76 (0.62 to 0.92) 1 0.2 0.5 1 2 3 4 5 10 Favors MR Favors control

Heterogeneity: Chi² = 6.85, df = 9 (P = .65); I² = 0% Test for overall effect: Z = 2.78 (P = .005) Test for subgroup differences: Chi² = 0.69, df = 1 (P = .41), I² = 0%

**References**


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