The Risk of Lymphoma Development in Autoimmune Diseases

A Meta-analysis

Elias Zintzaras, PhD; Michael Voulgarelis, MD, PhD; Haralampos M. Moutsopoulos, MD, FACP, FRCP

Background: The risk of development of non-Hodgkin lymphoma (NHL) in autoimmune patients has been investigated in several cohort studies. These studies revealed inconclusive results. To shed some light on this controversy, we conducted a meta-analysis of all available cohort studies linking systemic lupus erythematosus (SLE), rheumatoid arthritis (RA), and primary Sjögren syndrome (pSS) to the risk of NHL development.

Methods: We searched the PubMed database (1974 to April 2005) for English-language cohort studies using the key words systemic lupus erythematosus, SLE, rheumatoid arthritis, RA, Sjögren syndrome, or SS; non-Hodgkin lymphoma; and relative risk, RR, standardized incidence rate, or SIR. All cohort studies that used established diagnostic criteria for SLE, RA, and pSS; had histologic confirmation of NHL; and provided standardized incidence rates (SIRs) were included in the meta-analysis.

Results: The 20 studies chosen for the analysis included 6 for SLE, 9 for RA, and 5 for pSS. Overall, the meta-analysis suggested extreme heterogeneity among the studies (P<.01; I²>70%), high risk of NHL development for pSS (random effects SIR, 18.8; 95% confidence interval [CI], 9.5-37.3); moderate risk for SLE (random effects SIR, 7.4; 95% CI, 3.3-17.0); and lower risk for RA (random effects SIR, 3.9; 95% CI, 2.5-5.9). In RA, the random effects SIRs of NHL with conventional antirheumatic treatment, cytotoxic treatment, and treatment with a biological agent were 2.5 (95% CI, 0.7-9.0), 5.1 (95% CI, 0.9-28.6), and 11.5 (95% CI, 3.7-26.9), respectively.

Conclusions: Rheumatic disease may present a potential risk factor for development of NHL. In this regard, we focused on the underlying pathophysiologic mechanisms related to lymphomagenesis in pSS, SLE, and RA, to justify the varying potential for and background of NHL development.
METHODS

SEARCH STRATEGY

We searched PubMed (1974 through April 2005) for English-language articles using the following criteria: systemic lupus erythematosus, SLE, rheumatoid arthritis, RA, Sjögren’s syndrome, or SS; non-Hodgkin lymphoma; and relative risk, RR, standardized incidence rate, or SIR. All were then data to be included for incorporation in the meta-analysis. All references cited in the retrieved articles were also reviewed to identify additional published work not indexed by PubMed, and the we reached consensus. Abstracts, case reports, editorials, and review articles were excluded.

DATA EXTRACTION

We included cohort studies that used established diagnostic criteria for SLE, RA, and pSS; that included histologic confirmation of NHL; and that provided SIRs and 95% confidence intervals (CIs) or enough data to allow us to calculate these numbers. In the latter case, the SIR was defined as the ratio of the number of observed cases with NHL divided by the number of expected cases in the general population. The 95% CI was calculated using the standard error of the natural logarithm of the SIR, that is, ln(SIR), which was estimated by the inverse of the variance.

DATA SYNTHESIS

In the meta-analysis, we calculated the pooled ln(SIR) using as a weighted factor the inverse of the square root of the observed number of cases. We then calculated the 95% CI of the pooled ln(SIR), taking the ratio of the number of expected cases as described above.

RESULTS

The literature review identified 84 titles in PubMed that met the search criteria. We reviewed the abstracts of these articles and judged 26 articles to be potentially relevant. We then selected 20 studies for the analysis, including 6 for SLE, 1,2,4,6,17-19 0 for RA, 2,5,20,22 and 5 for pSS.5,27-29 (Tables 1, 2, and 3). All studies were published between 1978 and 2005.

In 6 studies,2,3,20,23,26,27 the SIRs or the 95% CIs of SIRs were calculated from data provided in the articles. Two studies2,22 included only female patients. In 3 studies,5,20 the cohort consisted of cases with a mixture of rheumatic diseases. Only 3 RA studies reported SIR results by sex. Seven studies1,5,10,19,22,27 did not report the type of treatment before NHL diagnosis, and 4 studies reported no use of immunosuppressive therapy in documented NHL cases. Four RA studies reported the use of therapy before NHL diagnosis,23-26 and 2 of those studies23,25 compared a group treated with a cytotoxic or a biological agent with a group of patients with RA who received conventional antirheumatic treatment. In more detail, 3 studies23,24,26 reported the use of cytotoxic therapy such as methotrexate,24 azathioprine sodium,23,26 or cyclophosphamide,26 and 1 study25 used a biological agent (anti–tumor necrosis factor, ie, etanercept or infliximab). In the azathioprine study,23 patients with RA not treated with azathioprine were used as control subjects. In the study assessing the efficacy of biological agents,25 patients with RA exposed to etanercept or infliximab were compared with a cohort of patients with RA who were never exposed to any type of biological drug. In our meta-analysis, the controls of both studies underwent evaluation for the risk of NHL development as a separate group (conventionally treated patients). In 2 studies,5,27 it was not specified whether NHL appeared before or after diagnosis of the autoimmune disease. In 4 studies,2,17,20,22 the NHL development before the diagnosis of the autoimmune disease was not excluded. The duration of cohorts ranged from 11 to 24, 7 to 24, and 1 to 25 years for SLE, RA, and pSS, respectively. The median follow-up times for pSS, SLE, and RA were 22, 20.5, and 9.5 years, respectively. The median age at NHL diagnosis and the median time from autoimmune disease diagnosis to NHL development were reported in only 4 studies referring to SLE patients,6,17,18 and the interval between SLE diagnosis and NHL diagnosis was estimated to be 7.5 years.

In total, the studies included 8700 cases with SLE, 95 104 cases with RA, and 1300 cases with pSS. The SIR of NHL in patients with SLE in the 6 cohort studies ranged from 5.2 to 44.4; in patients with RA, from 1.9 to 24.0; and in patients with pSS, from 8.7 to 44.4. A significant heterogeneity (P < .01; I² > 70%) was found for SLE, RA, and pSS studies. The RE pooled SIRs for NHL were 7.4 (95% CI, 3.3-17.0), 3.9 (95% CI, 2.5-5.9), and 18.8 (95% CI, 9.5-37.3) for SLE, RA, and pSS, respectively (Figure). Therefore, there
Classification of Diseases, Seventh, Eighth, SLE, systemic lupus erythematosus; sSS, secondary Sjögren syndrome.

sex produced large heterogeneity

lapped, indicating lack of a real dif-

ment in pSS, a lower risk in SLE, and

was a high risk of NHL develop-

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times produced large heterogeneity

P

was excluded, the RE pooled SIR was

was performed in RA. However, in a sen-

ies with NHL cases that had not re-

SIR, standardized incidence rate; SLE,

SIR of 6.6 (95% CI, 3.3-13.3). In pSS,

and/or
corticosteroids

expected number of Province

was excluded, the RE pooled SIR was

the study with the biological agent25

produced an SIR of 11.5 (95% CI, 3.7-

and 5.3). The subgroup analyses for the

pooled SIR of 3.3 (95% CI, 2.0-

was a high risk of NHL develop-

ment in pSS, a lower risk in SLE, and

an even lower risk in RA. However, the

95% CIs for SLE and RA over-

ment produced an RE pooled SIR of 3.3 (95% CI, 2.0-

2.5 (95% CI, 0.7-9.0), respectively. The study25

that used a biological agent pro-

duced an SIR of 11.5 (95% CI, 3.7-

In RA, the subgroup analysis on

expected number of Province

Excludes cases before onset of SLE

Excludes cases before onset of SLE

Excludes cases before onset of SLE

Excludes cases before onset of SLE

Diagnosis according to 1982 revised

ACR criteria

Diagnosis according to 1982 ACR

criteria

Diagnosis based on

ICD-7, -8, and -9, International

Classification of Diseases, Seventh,

Eighth, and Ninth Revisions, respec-
	nively; NHL, non-Hodgkin lymphoma; PV, person-years; SIR, standardized incidence rate;

SLE, systemic lupus erythematosus; sSS, secondary Sjögren syndrome.

Table 1. Characteristics of the SLE Cohort Studies Considered in the Meta-analysis

<table>
<thead>
<tr>
<th>Source (Country)</th>
<th>Data Origin and Diagnosis</th>
<th>SIR (95% CI)</th>
<th>No. of Lymphomas (Sex, No. F/M)</th>
<th>Immunosuppressive Treatment</th>
<th>No. of Patients in Cohort (Sex, No. F/M)</th>
<th>Duration of Follow-up, y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pettersson et al,1 1992 (Finland)</td>
<td>Data from Helsinki University Central Hospital</td>
<td>44.4 (11.9-111.0)</td>
<td>4 (4/0)</td>
<td>1 Case with cyclophosphamide</td>
<td>205 (182/23)</td>
<td>21 (1967-1987)</td>
</tr>
<tr>
<td>Abu-Shakra et al,17 1996 (Canada)</td>
<td>Data from University of Toronto Lupus Clinic Database</td>
<td>5.4 (1.1-15.7)</td>
<td>3 (3/0)</td>
<td>No cases</td>
<td>724 (627/97)</td>
<td>24</td>
</tr>
<tr>
<td>Mellemkjaer et al,9 1997 (Denmark)</td>
<td>Data from Danish Hospital Discharge Register</td>
<td>Female, 4.1 (1.3-9.6)</td>
<td>8 (5/3)</td>
<td>7 Cases with corticosteroids and/or azathioprine</td>
<td>1585 (1316/269)</td>
<td>15 (1977-1991; 10 807 PY)</td>
</tr>
<tr>
<td>Bjornadal et al,3 2002 (Sweden)</td>
<td>Data from Hospital Discharge Register</td>
<td>2.9 (2.0-4.0)</td>
<td>32</td>
<td>Not reported</td>
<td>5715 (4201/1514)</td>
<td>50 246; 31 (1964-1994)</td>
</tr>
<tr>
<td>Sweeney et al,4 1995 (United States)</td>
<td>Data from University of Pittsburgh, Allegheny County, Pennsylvania</td>
<td>10.0 (0.25-55.7)</td>
<td>1 (1/0) also with sSS</td>
<td>No cases</td>
<td>219 (219/0)</td>
<td>11 (1981-1991; 560 837 PY)</td>
</tr>
<tr>
<td>Cibere et al,4 2001 (Canada)</td>
<td>Data from University of Saskatchewan Rheumatic Disease Unit</td>
<td>7.0 (1.9-18.0)</td>
<td>4</td>
<td>No cases received azathioprine or methotrexate</td>
<td>297 (241/56)</td>
<td>20 (1975-1995; 3587 PY)</td>
</tr>
</tbody>
</table>

Abbreviations: ACR, American College of Rheumatology; ARA, American Rheumatism Association; CI, confidence interval; ICD-7, -8, and -9, International Classification of Diseases, Seventh, Eighth, and Ninth Revisions, respectively; NHL, non-Hodgkin lymphoma; PV, person-years; SIR, standardized incidence rate; SLE, systemic lupus erythematosus; sSS, secondary Sjögren syndrome.
<table>
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<tr>
<th>Source (Country)</th>
<th>Data Origin and Diagnosis</th>
<th>No. of Lymphomas (Sex, No. F/M)</th>
<th>Immunosuppressive Treatment</th>
<th>No. of Patients in Cohort (Sex, No. F/M)</th>
<th>Duration of Follow-up, y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hakulinen et al., 2019 (Finland)</td>
<td>Observed and expected cases from Social Insurance Institution’s Population Register and Finnish Cancer Registry</td>
<td>Female, 2.9 (1.7-4.5); Male, 2.8 (1.2-5.2); Total, 2.8 (2.0-3.9)</td>
<td>Not reported</td>
<td>46 (101/1608); (0.687/11483)</td>
<td>7 (1967-1973; 213 911 PY)</td>
</tr>
<tr>
<td>Gridley et al., 1993 (Sweden)</td>
<td>Data from Swedish Hospital Inpatient Register</td>
<td>Female, 1.9 (1.2-2.9); Male, 1.8 (1.0-3.0); Total, 1.9 (1.3-2.6)</td>
<td>Not reported</td>
<td>11683; (7933/3750); (106 with sSS)</td>
<td>20 (1965-1984; 101 000 PY)</td>
</tr>
<tr>
<td>Prior, 1985 (United Kingdom)</td>
<td>Data from Queen Elizabeth Medical Centre, Birmingham, England</td>
<td>Female, 18.8 (6.1-58.1); Male, 30.8 (11.6-82.0); Total, 24.1 (11.5-50.6)</td>
<td>Not reported</td>
<td>489</td>
<td>20 (1964-1983)</td>
</tr>
<tr>
<td>Kauppi et al., 1997 (Finland)</td>
<td>Data from Finnish hospitals’ National Discharge Registry</td>
<td>Female, 2.2 (1.5-3.1)</td>
<td>Not reported</td>
<td>9469 (7757/1712)</td>
<td>24 (1970-1993; 65 391)</td>
</tr>
<tr>
<td>Møllemkjær et al., 1996 (Denmark)</td>
<td>Data from Danish Hospital Discharge Register</td>
<td>Female, 2.4 (1.9-2.9)</td>
<td>Not reported</td>
<td>20699</td>
<td>11 (1977-1987)</td>
</tr>
<tr>
<td>Silman et al., 1988 (United Kingdom)</td>
<td>Azathioprine group, data from Newmarket Registry</td>
<td>10.0 (3.8-26.6); 4.8 (1.2-19.0); Female, 4 (3/1); Male, 2 (1/1); Total, Azathioprine Conventional treatment</td>
<td>202 (183/19); 202 (183/19);</td>
<td>12 (1964-1975); 14 (1970-1983)</td>
<td></td>
</tr>
<tr>
<td>Boere et al., 2005 (Sweden)</td>
<td>Anti-TNF group: data from South Swedish Arthritis Treatment Group</td>
<td>11.5 (3.7-26.9); 1.3 (0.2-4.5); 5 (3/1); 2 (1/1);</td>
<td>Etanercept or infliximab</td>
<td>757 (560/197); 800 (584/216);</td>
<td>4 (1999-2002; 1603); 4 (1999-2002; 3948)</td>
</tr>
<tr>
<td>Kinlen, 1985 (United Kingdom)</td>
<td>Data from CRC Cancer Epidemiology Unit, Edinburgh, Scotland</td>
<td>12.9 (4.8-34.4)</td>
<td>Azathioprine or cyclophosphamide</td>
<td>643 (422/221);</td>
<td>1-12</td>
</tr>
<tr>
<td>Mariette et al., 2002 (France)</td>
<td>Data from 61 rheumatology departments</td>
<td>1.2 (0.7-1.9)</td>
<td>Methotrexate</td>
<td>27 000</td>
<td>3 (1996-1998)</td>
</tr>
</tbody>
</table>

Abbreviations: ACR, American College of Rheumatology; ARA, American Rheumatism Association; CI, confidence interval; CRC, Cancer Research Campaign; ICD-7 and -8, International Classification of Diseases, Seventh and Eighth Revisions; respectively; NHL, non-Hodgkin lymphoma; PY, person-years; RA, rheumatoid arthritis; SIR, standardized incidence rate; sSS, secondary Sjögren syndrome; TNF, tumor necrosis factor.
did not receive immunosuppressive therapy was excluded, the SIR was 15.7 (95% CI, 7.4-33.2).

In cumulative meta-analysis, the RE pooled SIR in SLE declined from 44.4 in 1992 to 27.10 in 1995 and to 7.42 in 2001. In RA, the SIR declined from 9.3 in 1985 to 5.3 in 1993 and to 3.2 in 2005. In pSS, the SIR declined from 44.4 in 1978 to 22.5 in 1997 and to 20.3 in 1999. In all diseases, there has been a monotonic decrease since the first study. However, the values of SIRs were not correlated with the duration of follow-up; the Spearman rank correlation coefficients for SLE, RA, and pSS were −0.43 (P = .31), 0.20 (P = .56), and 0.31 (P = .61), respectively. In addition, there was no clear pattern that the magnitude of SIR was related to patient selection (clinic or hospital) in all autoimmune diseases.

There was no evidence of publication bias in SLE and pSS (P > .10 for the Egger and Begg-Mazumdar tests). In RA, there was marginal significance (P = .08 and P = .09 for the Egger and Begg-Mazumdar tests, respectively), indicating the existence of a differential magnitude of effect in large vs small studies. However, this result might not be reliable, because the number of studies is relatively small. Some studies had a selection bias because patients were hospitalized (data were obtained from hospital discharge registries), and therefore the more severe cases were considered.

COMMENT

The meta-analysis results showed that NHL is more common in patients with autoimmune diseases than in the general population, especially in patients with pSS and SLE. Because the follow-up time in the RA group was shorter than those for pSS and SLE, the possibility of overlooking RA-associated NHL cases that developed later in the disease process cannot be excluded. The fact that certain studies in RA did not show an increase in SIR is probably owing to the short duration of the follow-up. In several studies, particularly RA studies, the use of cytotoxic agents (eg, methotrexate, azathioprine, and cyclophosphamide) before NHL development is not reported. In the RA studies in which the treatment is reported, the risk of NHL with cytotoxic or biological agents is greater than the risk with conventional antirheumatic treatment. In the assesse-
ment of the impact of treatment on lymphomagenesis in RA, only 1 study used biological agents. Although the comparison of etanercept and infliximab with other treatment modalities in this group of patients does not seem fair, these drugs have a high likelihood of being associated with NHL development. However, the information on the role of these cytotoxic or immunomodulatory agents in lymphomagenesis in RA is rather limited, and any inferences cannot be taken for granted. In addition, these phenomena need to be considered against the background that the occurrence of NHL in patients with RA might be associated with disease activity or severity. In this regard, cytotoxic or biological therapy may be indicative of a specific group of patients with RA who have more severe disease and a high predisposition for NHL development. For several decades, it has been known that patients with RA have an increased risk of NHL development.20-22,35,36 The reason is still not fully understood, and controversy remains as to whether the risk is a consequence of immunosuppressive therapy.23,24,37-41 Recent data suggest that high and longstanding inflammatory activity in RA may itself contribute to the development of lymphomas, which are preferentially of the aggressive, diffuse, extranodal, large B-cell type.42 Because indolent extranodal marginal-zone B-cell lymphoma of the mucosa-associated lymphoid tissue is the most common type of lymphoma in pSS,43 this dissimilarity indicates different mechanisms underlying lymphoma development in these 2 diseases. The specific diffuse, extranodal, large B-cell lymphoma subtype in RA implies an underlying immunodeficiency status.44 Peripheral mononuclear cells from patients with RA who were not receiving cytotoxic or long-acting antirheumatic drugs were found to be hypoproliferative in vitro to a battery of soluble recall antigens.45-47 Therefore, an impaired T-cell function could be relevant to an impairment of immune responses toward emerging malignant B cells.

Although this meta-analysis provided a more precise estimate of the relative risk of NHL in relation to autoimmune diseases than did the individual studies, because it has used a vast amount of patients, its major limitation is the large heterogeneity between studies. The heterogeneity might be owing to different baseline risk populations, study designs, and data sources. Therefore, the results should be interpreted with caution. The meta-analysis was restricted to NHL because adequate studies established strong associations between B-cell lymphoproliferation and autoimmunity. Studies that investigated the incidence rate of lymphomas (NHL or Hodgkin disease) without specifying the rates separately were not included.48 In addition, studies that did not provide information about the expected number of NHL cases in the general population were omitted from the analysis.42,49-52 However, exclusion of such studies may have biased the results. Moreover, 4 studies included cases with NHL that developed before the diagnosis of the autoimmune diseases. The inclusion of these cases in the cohort studies may obscure the interpretation of the autoimmunity-NHL association. Regardless of these limitations, the meta-analysis showed that autoimmune diseases are associated with an increased risk of NHL. Assuming that the expected cases (E) of NHL can be estimated by the weighted mean of the expected cases provided by the included studies in
the meta-analysis, and using the number of patients as weights, then E = 17. Thus, the RE pooled SIR for RA of 3.9 means that there is a 3.9-times increase in the incidence, or (SIR × E)/100 000 = 66 cases per 100 000 patient-years, and the RE pooled SIR for SLE of 7.4 means that there is a 7.4-times increase in the incidence or 126 cases per 100 000 patient-years, and the RE pooled SIR for pSS of 18.8 means that there is a 18.8-times increase in the incidence or 320 cases per 100 000 patient-years. In this setting, the association of NHL with autoimmune diseases generates increasing interest because it may concern the mechanisms of lymphogenesis in general.

The B-cell disorder seen in patients with pSS is particularly severe compared with the B-cell dysfunction seen in other autoimmune diseases such as SLE. It has been demonstrated that patients with pSS have higher incidence and higher serum levels of B-cell activating factor compared with patients with SLE. Furthermore, patients with active SLE have decreased numbers of CD19+/CD27+ naive B cells and increased numbers of CD19+/CD27+ memory B cells, in contrast to patients with pSS who are characterized by a significant reduction in the number of the peripheral CD27+ memory B cells. Given the vigor with which immunoglobulin genes are modified during immune responses, it is plausible to hypothesize that some of the critical transforming events are the product of an intense ectopic germinal center reaction in pSS. In this regard, patients with pSS with an increased risk of NHL are characterized by splenomegaly, lymphadenopathy, mixed monoclonal cryoglobulinemia, and parotid swelling, all indicators of an extensive lymphoproliferation. This could possibly explain why lymphoid malignancies are more common in pSS than in SLE. In the diseases studied, the risk of NHL development since the first study was reduced and may be attributed to revised and/or more accurate classification of NHL during this period or to more effective treatment of the underlying B-cell dysregulation of autoimmune diseases.

Despite the limitations of this meta-analysis, it provides new and sustained evidence establishing differences of NHL development risk in various autoimmune disorders. We focused on the underlying pathophysiologic mechanisms related to lymphogenesis in pSS, SLE, and RA to justify the varying potential for and background of NHL development. Further studies are warranted to correlate our epidemiologic data with the underlying disease mechanisms. In addition, the risk of NHL in patients receiving immunosuppressive drugs must be investigated.

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