

An exploration of factors associated with the use of glucocorticoids in the Systemic Lupus International Collaborating Clinics Inception Cohort.

Jayne Little ^{1,2}, Ben Parker ², Mark Lunt ¹, John G. Hanly³, Murray B. Urowitz⁴, Ann E. Clarke⁵, Juanita Romero-Diaz⁶, Caroline Gordon^{7,8}, Sang-Cheol Bae⁹, Sasha Bernatsky¹⁰, Daniel J Wallace¹¹, Joan T. Merrill¹², Jill Buyon¹³, David A. Isenberg¹⁴, Anisur Rahman¹⁴, Ellen M. Ginzler¹⁵ Michelle Petri¹⁶, M.A. Dooley¹⁷, Paul Fortin¹⁸, Dafna D. Gladman⁴, Kristjan Steinsson¹⁹, Rosalind Ramsey-Goldman²⁰, Munther A. Khamashta²¹, Cynthia Aranow²², Meggan Mackay²², Graciela S. Alarcón²³, Susan Manzi²⁴, Ola Nived²⁵, Andreas Jönsen²⁶, Asad A. Zoma²⁷, Ronald F. van Vollenhoven²⁷, Manuel Ramos-Casals²⁸, Guillermo Ruiz-Irastorza²⁹, S. Sam Lim³⁰, Kenneth C. Kalunian³¹, Murat Inanc³², Diane L. Kamen³³, Christine A. Peschken³⁴, Soren Jacobsen³⁵, Anca Askanase³⁶, Jorge Sanchez-Guerrero³⁷ Ian N. Bruce^{1,2}

¹Arthritis Research UK Centre for Epidemiology, Centre for Musculoskeletal Research, School of Biological Sciences, Faculty of Biology, Medicine and Health, The University of Manchester; ²NIHR Manchester Musculoskeletal Biomedical Research Unit, Central Manchester University Hospitals NHS Foundation Trust, Manchester Academic Health Science Centre, Manchester, UK; ³Division of Rheumatology, Department of Medicine and Department of Pathology, Queen Elizabeth II Health Sciences Centre and Dalhousie University, Halifax, Nova Scotia, Canada; ⁴Lupus Program, Centre for Prognosis Studies in The Rheumatic Disease and Krembil Research Institute, Toronto Western Hospital, University of Toronto, Toronto, Ontario, Canada; ⁵University of Calgary, Cumming School of Medicine; ⁶Instituto Nacional de Ciencias Médicas y Nutrición, Mexico City, Mexico; ⁷Rheumatology Research Group, Institute of Inflammation and Ageing, University of Birmingham, Birmingham, UK; ⁸Rheumatology department, City Hospital, Sandwell and West Birmingham Hospitals NHS Trust, Birmingham, UK; ⁹Department of Rheumatology, Hanyang University Hospital for Rheumatic Diseases, Seoul, Korea; ¹⁰Divisions of Rheumatology and Clinical Epidemiology, McGill University Health Centre; ¹¹Cedars-Sinai/David Geffen School of Medicine at UCLA, Los Angeles, CA, USA;

¹²Department of Clinical Pharmacology, Oklahoma Medical Research Foundation, Oklahoma City, OK, USA; ¹³New York School of Medicine, New York, US, ¹⁴Centre for Rheumatology, Department of Medicine, University College London, UK; ¹⁵Department of Medicine, SUNY Downstate Medical Center, Brooklyn, NY, USA; ¹⁶Division of Rheumatology, Johns Hopkins University School of Medicine, Baltimore, MD, USA; ¹⁷Thurston Arthritis Research Center, University of North Carolina, Chapel Hill, NC, USA; ¹⁸Division of Rheumatology, Centre Hospitalier Universitaire de Québec et Université Laval, Québec City, Canada; ¹⁹Center for Rheumatology Research, Landspítali University hospital, Reykjavik, Iceland; ²⁰Northwestern University and Feinberg School of Medicine, Chicago, IL, USA; ²¹Lupus Research Unit, The Rayne Institute, St Thomas' Hospital, King's College London School of Medicine, UK, London, UK; ²²Feinstein Institute for Medical Research, Manhasset, NY, USA; ²³Department of Medicine, University of Alabama at Birmingham, Birmingham, AL, USA; ²⁴Department of Clinical Sciences, Rheumatology, Lund University, Lund, Sweden; ²⁵Department of Rheumatology, University Hospital Lund, Lund, Sweden; ²⁶Lanarkshire Centre for Rheumatology, Hairmyres Hospital, East Kilbride, Scotland UK; ²⁷Unit for Clinical Therapy Research (ClinTRID), Karolinska Institute, Stockholm, Sweden; ²⁸Josep Font Autoimmune Diseases Laboratory, IDIBAPS, Department of Autoimmune Diseases, Hospital Clínic, Barcelona, Spain; ²⁹Autoimmune Diseases Research Unit, Department of Internal Medicine, BioCruces Health Research Institute, Hospital Universitario Cruces, University of the Basque Country, Barakaldo, Spain; ³⁰Emory University School of Medicine, Division of Rheumatology, Atlanta, Georgia, USA; ³¹UCSD School of Medicine, La Jolla, CA, USA; ³²Division of Rheumatology, Department of Internal Medicine, Istanbul Medical Faculty, Istanbul University, Istanbul, Turkey; ³³Medical University of South Carolina, Charleston, South Carolina, USA; ³⁴University of Manitoba, Winnipeg, Manitoba, Canada; ³⁵Department of Rheumatology, Rigshospitalet, Copenhagen University Hospital, Blegdamsvej 9, 2100, Copenhagen, Denmark; ³⁶Hospital for Joint Diseases, NYU, Seligman Centre for Advanced Therapeutics, New York NY; ³⁷Mount Sinai Hospital and University Health Network, University of Toronto, Canada.

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Corresponding author:

Professor Ian Bruce

Arthritis Research UK Centre for Epidemiology

Centre for Musculoskeletal Research

School of Biological Sciences

Manchester Academic Health Science Centre

The University of Manchester

Oxford Road

Manchester

UK

M13 9PT

ian.bruce@manchester.ac.uk

Abstract

Objective

To describe glucocorticoid (GC) use in the Systemic Lupus International Collaborating Clinics (SLICC) inception cohort and to explore factors associated with GC use. In particular we aimed to assess temporal trends in GC use and to what extent physician-related factors may influence use.

Methods

Patients were recruited within 15 months of diagnosis of SLE from 33 centres between 1999 – 2011 and continue to be reviewed annually. Descriptive statistics were used to detail oral and parenteral GC use. Cross sectional and longitudinal analyses were performed to explore factors associated with GC use at enrolment and over time.

Results

We studied 1700 patients with a mean (SD) follow-up duration of 7.26 (3.82) years. 1365 (81.3%) patients received oral GCs at some time during the study and parenteral GCs were received between assessments in 4.26% (458/10745) of cases. GC use was strongly associated with treatment centre, age, race/ethnicity, sex, disease duration and disease activity. There was no change in the proportion of patients on GCs or the average doses of GC used over time.

Conclusions

GCs remain a cornerstone in SLE management and there have been no significant changes in their use over the last 10-15 years. Whilst patient and disease factors contribute to the variation in GC use, between centre differences suggest that physician-related factors also contribute. Evidence based treatment algorithms are needed to inform GC use in SLE.

Introduction:

Glucocorticoids (GCs) have been used in the treatment of systemic lupus erythematosus (SLE) for more than 60 years. Despite their widespread use, there are only a limited number of small scale clinical trials (1-3) and observational studies (4-9) exploring the most effective mode, dose or regimen of administration. This limited evidence, combined with the inherent heterogeneity of the disease, means that guidelines for the use of GCs in SLE cannot be very specific (10-16). As such, there is significant variation in opinion with regards to the use of GCs in SLE (17-19). Most observational studies describing GC use in SLE are limited to single centres, small cohorts or SLE disease subgroups (20-23).

A number of factors are likely to influence GC use. These include patient related factors (e.g. disease phenotype/severity, comorbidities and personal preference) and patient independent factors (e.g. health care setting and opinions of the treating physician). Two survey-based studies suggest that prescribing may be more influenced by patient independent factors, such as geographical location (17, 18).

The aims of this study were to describe GC use in detail in a large international SLE inception cohort and to explore variations in GC practice between treatment centres. Finally we aimed to explore what other patient dependent and independent factors are associated with GC use in SLE and to determine whether there was any temporal trend towards more modest GCs use over the study period.

Patients and Methods

SLICC inception cohort

The SLICC consortium includes 33 centres across North America, Europe, and Asia. Patients were recruited to the Inception Cohort between 1999 and 2011. All patients were recruited within 15 months of confirming 4 American College of Rheumatology (ACR) Classification Criteria for SLE (24). Case report forms (including demographic, disease, treatment and co-morbidity details) were completed at enrolment and annually thereafter. Disease activity was quantified using the SLE Disease Activity Index 2000 (SLEDAI-2K)(25) and the 'classic' British Isles Lupus Assessment Group's (BILAG) disease activity index (26). Data were submitted to the co-ordinating centres at the University of Toronto, Toronto, Ontario, Canada and Dalhousie University, Halifax, Nova Scotia,

Canada. For this analysis, patients with a minimum of one follow up assessment (in addition to the enrolment assessment) were included.

Ethics

The study was approved by the Institutional Research Ethics Boards of participating centres in accordance with the Declaration of Helsinki's guidelines for research in humans.

Descriptive analyses of GC use

Information on GC use was recorded at enrolment (past and current use) and at each annual assessment visit, including the dose, duration and type of oral (PO) GC courses. From this data it was possible to calculate the average daily and total cumulative PO GC doses as well as the total time/proportion of time spent on PO GCs over each follow up interval (FUI - defined as the time from one assessment to the next). PO doses were transformed into prednisolone equivalents. The number and dose of parenteral GC pulses was also recorded at baseline and at each follow up assessment but transformation to prednisolone equivalents was not possible, as specific GC type was not collected for these episodes. Descriptive statistics were used to report the proportions of patients receiving GCs at enrolment (PO and parenteral), the proportion of FUIs where GC had been given and the average doses received at enrolment and within FUIs. Average dose descriptions exclude patients/FUIs where dose was zero and are reported as median (IQR).

Cross-sectional analyses of factors associated with GC use at enrolment

Potential factors that might influence the use of GCs were defined a priori from our review of the literature: Demographic details including age, sex and race/ethnicity (grouped into Caucasian, Asian, Hispanic, African ancestry & other), disease activity (SLEDAI-2K), disease phenotype including presence or absence of active renal disease (active nephritis or any renal manifestation of the SLEDAI-2K. We also included comorbidities including diabetes mellitus, hypertension, body mass index (BMI), concomitant medications (antimalarial yes/no and/or immunosuppressant yes/no), date of diagnosis and treatment centre. Univariable analyses were performed to explore the association between each of these predictor variables the following GC outcomes:

- 1) Taking PO GCs at enrolment (yes/no)
- 2) Average daily dose of PO GC at enrolment
- 3) Received parenteral GCs prior to enrolment (yes/no)
- 4) Total dose of parenteral GC received prior to enrolment

Logistic and linear regression models were used for binary outcomes (1 & 3) and continuous outcomes (2 & 4 – log transformed data) respectively. For each outcome, predictor variables significant at univariable analysis ($p < 0.20$) were entered into multivariable models using forwards stepwise selection to create the final models ($p < 0.05$). Linear regression results were back transformed and converted to percentage dose changes for ease of interpretation. Tests for interactions between sex and other independent variables were performed, as was quadratic transformation of BMI to explore a possible curvilinear relationship with GC use.

To illustrate differences in GC use between centres, we defined a hypothetical 'typical' patient and used the weightings generated by each model to describe the probable GC use by this 'typical' patient at each treatment centre. The 'typical' patient was defined (according to the median/modal values of the predictor variables in the cohort overall) as a 33 year old Caucasian female with disease duration of 0.4 years, no active renal disease, hypertension or diabetes, a SLEDAI2K score of 4 and taking an antimalarial but no immunosuppressive treatment.

Longitudinal analysis of factors associated with GC use over time

Random effect modelling was used to explore the relationship between the same predictor variables (age, sex, race/ethnicity, diagnosis date and treatment centre were fixed, all other predictor variables were time-variant) with the following outcome descriptions of GC use over time:

- 1) PO GCs received during preceding FUI (yes/no)
- 2) Average daily PO GC dose over preceding FUI
- 3) Parenteral GCs received during preceding FUI (yes/no)
- 4) Total dose of parenteral GC received over preceding FUI

The GC outcomes were calculated over individual FUIs, therefore a patient with an enrolment and 3 follow up assessments would contribute data from three FUIs to the longitudinal analysis.

Outcomes 2 and 4 were again log transformed and final models were generated through the same process of initial univariable testing and forwards selection. Quadratic transformation of BMI was also tested, as were interaction terms. For descriptions of probable GC use in the hypothetical 'typical patient', the definition was adapted to a 37 year old female with disease duration of 4.7 years and SLEDAI2K score of 2, to reflect the median/modal values of these variables in the cohort over time.

Sensitivity analyses

To further explore the effect of disease activity and phenotype, sensitivity analyses were run on all final models: 1) Inclusion of the BILAG total score 2) Replacement of the total SLEDAI-2K score with individual components of the score (selected from arthritis, rash, myositis, serositis, active neurological disease, thrombocytopenia, low complement and increased dsDNA binding through univariable testing ($p < 0.20$) and forwards stepwise selection ($p < 0.05$)). We also examined the influence of body weight on all final models.

Missing data

Less than 5% of the data was missing for all variables apart from height and weight and blood pressure. These were replaced with the average from preceding and subsequent visits or alternatively the preceding or subsequent visit where possible. Complete case analysis was then performed, accepting the minimal remaining missing data.

Result

Patients

Of 1848 patients recruited to the SLICC Inception Cohort, 1700 (92%) had a minimum of one follow up visit and are included in these analyses. Patient characteristics are summarised in table 1. These 1700 patients provided data on 10745 FUIs with a mean (SD) total time in the study of 7.26 (3.82) years. The median (IQR) length of these FUIs was 372 (341, 427) days.

Descriptive analysis of GC prescribing

At enrolment, 1189 (69.98%) patients were taking PO GC at a median (IQR) daily dose of 20.0 (10.0-30.0) mg; 414 (24.4%) patients were receiving ≥ 30 mg/day. The proportion of patients receiving PO GC decreased in later FUIs. For example, by the 5th follow up assessment, 610/1076 patients (56.90%) had used PO GC over the preceding FUI, of whom 129 (12.0%) had taken GC for some, and 481 (44.7%) for all of the preceding FUI. Similarly the median (IQR) daily GC dose decreased from 10.0 (5.0-15.0) mg at follow-up 1 to 5.5 (4.6-10.0) mg at follow-up 5.

Of the 10732 (99.9%) FUIs in which the proportion of time on GCs could be calculated, all of the time had been spent on PO GC in 4946 (46.1%) and none of this time had been spent on PO GC in 4265 (39.7%); in 1521 (14.2%) FUIs a proportion of the period had been spent on PO GCs. Therefore, 558

(32.8%) patients spent their entire study period on PO GCs, 807 (47.5%) spent part of the entire study period on PO GC and 335 (19.7%) never received PO GC therapy.

Regarding parenteral GC, at enrolment 235 (13.8%) patients had received at least one dose at a median (IQR) total dose of 1.5 (0.7-3.0) g. Parenteral GCs were given between subsequent visits in 458 (4.26%) FUIs at a median (IQR) total dose of 0.5 (0.12-2.0) g. Patients who had parenteral GCs also received a median (IQR) total PO GC dose of 3.4 (0.5 -6.2) g in the same FUI. Overall more PO GC was received during those FUIs where higher doses of parenteral GC were also received (table 2). This was also true in the group who had <250mg of parenteral GC which are likely to have been intra-muscular and/or intra-articular GCs.

Factors associated with GC use at enrolment and over time

Treatment centre

There was a significant association between treatment centre and all four measures of GC use in multivariable analyses both at enrolment and over time ($p < 0.0001$) (table 5). There were a number of centres where GC use differed significantly from the overall cohort (table 6), for example there were 11 centres where the probability of a 'typical patient' being on PO GCs at enrolment was significantly lower and three where this probability was significantly higher. Significant variations were also seen in the longitudinal analyses; of note there was a centre in Korea where the probability (95% CI) of a 'typical patient' receiving PO GC between assessments was 0.97 (0.95, 1.00) compared to 0.39 (0.33, 0.46) in the cohort overall. Variations were also noted within countries, for example in the UK the probability (95% CI) of a 'typical patient' being on PO GC at enrolment ranged from 0.11 (-0.03, 0.25) at one centre to 0.58 (0.43, 0.72) at another. We also observed variability in pulsed GC use, however absolute numbers receiving parenteral GC in many centres were limited.

Age, sex and race/ethnicity

We found strong inverse associations between age and PO GC use in both univariable (Tables 3 & 4) and multivariable (table 5) analyses. Older age was associated with reduced odds of receiving PO GCs and lower PO GC dose. For example, in longitudinal analyses the odds of receiving PO GCs reduced with each additional year of age (OR: 95% CI = 0.98: 0.96, 0.99) and there was a small reduction in dose used (0.66 [0.31, 1.01] %). There was also a greater odds of men receiving PO GC (OR: 95%CI = 3.90: 2.19, 6.94) and men also took higher doses (16.85 [2.79, 32.83] %) in longitudinal analysis. When we added body weight to the final longitudinal models, the dose difference between

men and women was no longer significant (13.32 (-0.64, 29.24) %) but men were still more likely to be taking PO GC steroids (OR: 95%CI = 4.02: 2.24, 7.22). Hispanics, Asians and patients of African origin all had greater odds of receiving PO GCs than Caucasians both at enrolment and over time. Race/ethnicity was also associated with PO GC dose over time, for example, Hispanics had higher odds of using PO GCs (OR: 95%CI = 2.46 (0.87, 6.95) and at higher average doses than Caucasians (36.07 [1.65, 82.15] %). There were no significant associations between age, sex or race and parenteral GC use (frequency or dose) either at enrolment or over time, nor did we find any significant interactions between sex and other independent variables.

Other factors

Longer disease duration was associated with lower GC use by most of the measures used to assess PO and parenteral use (table 5). Overall disease activity (SLEDAI-2K score) was positively associated with the frequency and dose of PO GC and the frequency (but not dose) of parenteral GC in cross-sectional and longitudinal analyses. Active renal disease was also associated with PO GC use (frequency and dose) at enrolment (not over time) but had no associations with parenteral GC use. We also found a number of positive associations between hypertension and diabetes mellitus and GC use but no associations with BMI. Antimalarial use had a negative association with a number of GC measures whereas immunosuppressant use showed positive associations with all four measures at enrolment and over time. For example the OR (95%CI) for receiving parenteral GC at enrolment if on an antimalarial was 0.63 (0.46, 0.86) and 2.06 (1.52, 2.80) if on an immunosuppressant. Sensitivity analyses incorporating BILAG score (supplementary table 2) or significant SLEDAI 2K components (results available) supported our primary models.

Diagnosis date

When we examined GC use according to year of diagnosis, there were no significant associations between date of diagnosis and any of the four GC outcomes in either cross-sectional or longitudinal analysis (tables 3 & 4).

Discussion

There is growing evidence that lower doses of GCs may be as effective for the treatment of SLE whilst incurring fewer adverse events (6-9). As such, a number of review and guidance articles have advocated more judicious use of GC (27-31). We have observed that PO GCs were used frequently in

this international SLE cohort with 32.8% of patients spending their entire observation period on GC therapy. Also, 'high' doses (32) were commonly used with 24.4% of patients receiving ≥ 30 mg/day at enrolment. Of note, we found no association between date of diagnosis and any of the GC outcomes suggesting that the aspiration for more judicious use has not yet translated into changes in routine clinical practice over the past 10-15 years. It should however be noted that in this time period very few new therapies or therapeutic paradigms have gained widespread use, however recent results from a phase III trial of belimumab suggest this may have some GC-sparing effects(33).

Previous survey-based studies have found geographical variation in GC use (18) and have found associations between GC prescribing and physician-related factors such as specialty and years of experience (17). We found significant associations between all four GC measures and 'treatment centre' at enrolment and over time. A number of factors are likely to contribute to this between centre variability, for example the local health-care system (e.g. universal coverage vs insurance-based systems), socioeconomic status, availability of GC-sparing agents and cultural acceptance of GC use. Data on these factors was not collected therefore they were absent from our models, however even within countries or regions (e.g. Canada and Europe), where confounding from such factors should be less marked, there was still significant variation in GC use. This real-world variation between centres requires further exploration but lends support to the hypothesis that GC use is still driven by patient-independent factors to a significant degree. Such patient-independent heterogeneity in GC use will contribute to 'noise' in multicentre clinical trials and will increase the likelihood of type 2 errors occurring. Our observations suggest that in such multicentre trials some period of standardisation of GC use may be necessary to address such variation prior to randomisation.

There was significant race/ethnic variation in PO GC use, with higher use amongst non-Caucasians. Race/ethnicity may reflect socioeconomic status at the individual or population level and PO GC may be a favoured treatment option for uninsured individuals or in poorer countries due to its relatively low cost. There was also significantly higher frequency and dosing of GCs amongst male patients. Gender differences in the SLE phenotype are well recognised (34) e.g. lower incidence of musculoskeletal features, Raynaud's phenomenon, alopecia and photosensitivity but more nephritis, serositis and discoid lupus in men. However, whether men experience higher disease activity, damage accrual or mortality is more contentious with inconsistent findings across several studies

(35-42). In the SLICC cohort we found no difference in disease activity between men and women (data on file) although more men had active renal disease at enrolment (OR (95% CI) (age/race adjusted logistic regression) = 1.80 (1.49, 2.90)). Our analyses adjusted for such confounding however despite this, a gender difference in GC use persisted. This may therefore reflect differences due to patient choices or physicians' therapeutic strategies in men and women. For example, men may be less concerned about weight gain and physicians may have more concerns about osteoporosis in women. Similarly physicians may hold a perception that males with SLE require more aggressive treatment or men may choose to stay on GCs if they are working in manual occupations.

Our study has some strengths and limitations which are worth consideration. As far as we are aware, this is the first time that the use of GCs and factors associated with their use has been described in a large international SLE cohort. The large cohort size and long follow-up from early in the disease course allowed us to adjust for a range of potential confounders and also explore variations related to between and within centre differences in a real world setting for several different measures of GC use. We were limited in not being able to include factors related to socioeconomic status, as this data was not routinely collected. As such we recognise that unmeasured confounding may account for some of the inter-centre variation observed. Another major strength is the low level of missing data in the cohort although we also recognise that the annual data collection may introduce some recall bias on the part of the patient and physician when completing details of steroid courses.

We have therefore found significant between-centre variation across a range of different measures of GC use in SLE patients. Several patient-related factors such as age, gender, race/ethnicity, disease activity and renal involvement explain part of this variation however our models suggest that physician-dependent factors still have a major influence in determining GC use. We also found no major change in GC use over the past 15 years and so current standard of care remains dependent on GC use. New therapies will be needed to provide better, GC sparing/avoiding approaches to SLE management. Taken together, the challenge now will be to develop better evidence based treatment algorithms to optimize GC use, reduce variation and minimize GC harm in SLE. Such an approach will also likely contribute to a more consistent 'standard of care' and thus improve the likelihood of success in future clinical trials.

References

1. Edwards JCW, Snaith ML, Isenberg DA. A Double-Blind Controlled Trial of Methylprednisolone Infusions in Systemic Lupus-Erythematosus Using Individualized Outcome Assessment. *Annals of the rheumatic diseases*. 1987;46(10):773-6.
2. Danowski A, Magder L, Petri M. Flares in lupus: Outcome assessment trial (FLOAT), a comparison between oral methylprednisolone and intramuscular triamcinolone. *Journal of Rheumatology*. 2006;33(1):57-60.
3. Zeher M, Doria A, Lan J, Aroca G, Jayne D, Boletis I, et al. Efficacy and safety of enteric-coated mycophenolate sodium in combination with two glucocorticoid regimens for the treatment of active lupus nephritis. *Lupus*. 2011;20(14):1484-93.
4. Badsha H, Kong KO, Lian TY, Chan SP, Edwards CJ, Chng HH. Low-dose pulse methylprednisolone for systemic lupus erythematosus flares is efficacious and has a decreased risk of infectious complications. *Lupus*. 2002;11(8):508-13.
5. Kong KO, Badsha H, Lian TY, Edwards CJ, Chng HH. Low-dose pulse methylprednisolone is an effective therapy for severe SLE flares. *Lupus*. 2004;13(3):212-3.
6. Ruiz-Arruza I, Barbosa C, Ugarte A, Ruiz-Lratorza G. Comparison of high versus low-medium prednisone doses for the treatment of systemic lupus erythematosus patients with high activity at diagnosis. *Autoimmunity reviews*. 2015;14(10):875-9.
7. Ruiz-Iratorza G, Danza A, Perales I, Villar I, Garcia M, Delgado S, et al. Prednisone in lupus nephritis: How much is enough? *Autoimmunity reviews*. 2014;13(2):206-14.
8. Condon MB, Ashby D, Pepper RJ, Cook HT, Levy JB, Griffith M, et al. Prospective observational single-centre cohort study to evaluate the effectiveness of treating lupus nephritis with rituximab and mycophenolate mofetil but no oral steroids. *Annals of the rheumatic diseases*. 2013;72(8):1280-6.
9. Fischer-Betz R, Chehab G, Sander O, Vordenbaumen S, Voiculescu A, Brinks R, et al. Renal Outcome in Patients with Lupus Nephritis Using a Steroid-free Regimen of Monthly Intravenous Cyclophosphamide: A Prospective Observational Study. *Journal of Rheumatology*. 2012;39(11):2111-7.
10. Guidelines for referral and management of systemic lupus erythematosus in adults. American College of Rheumatology Ad Hoc Committee on Systemic Lupus Erythematosus Guidelines. *Arthritis and rheumatism*. 1999;42(9):1785-96.
11. Bertsias G, Ioannidis JP, Boletis J, Bombardieri S, Cervera R, Dostal C, et al. EULAR recommendations for the management of systemic lupus erythematosus. Report of a Task Force of the EULAR Standing Committee for International Clinical Studies Including Therapeutics. *Annals of the rheumatic diseases*. 2008;67(2):195-205.
12. Bertsias GK, Tektonidou M, Amoura Z, Aringer M, Bajema I, Berden JH, et al. Joint European League Against Rheumatism and European Renal Association-European Dialysis and Transplant Association (EULAR/ERA-EDTA) recommendations for the management of adult and paediatric lupus nephritis. *Annals of the rheumatic diseases*. 2012;71(11):1771-82.

13. Hahn BH, McMahon MA, Wilkinson A, Wallace WD, Daikh DI, Fitzgerald JD, et al. American College of Rheumatology guidelines for screening, treatment, and management of lupus nephritis. *Arthritis care & research*. 2012;64(6):797-808.
14. Hoes JN, Jacobs JW, Boers M, Boumpas D, Buttgerit F, Caeyers N, et al. EULAR evidence-based recommendations on the management of systemic glucocorticoid therapy in rheumatic diseases. *Annals of the rheumatic diseases*. 2007;66(12):1560-7.
15. van der Goes MC, Jacobs JW, Boers M, Andrews T, Blom-Bakkers MA, Buttgerit F, et al. Monitoring adverse events of low-dose glucocorticoid therapy: EULAR recommendations for clinical trials and daily practice. *Annals of the rheumatic diseases*. 2010;69(11):1913-9.
16. Duru N, van der Goes MC, Jacobs JW, Andrews T, Boers M, Buttgerit F, et al. EULAR evidence-based and consensus-based recommendations on the management of medium to high-dose glucocorticoid therapy in rheumatic diseases. *Annals of the rheumatic diseases*. 2013;72(12):1905-13.
17. Walsh M, Jayne D, Moist L, Tonelli M, Pannu N, Manns B. Practice pattern variation in oral glucocorticoid therapy after the induction of response in proliferative lupus nephritis. *Lupus*. 2010;19(5):628-33.
18. Ngamjanyaporn P, Bruce I, Parker B, Sergeant J. Clinicians Approaches to the Management of Background Therapy in SLE Patients in Clinical Remission: Results of an International Survey. *Arthritis & rheumatology*. 2014;66:S300-S.
19. Ad Hoc Working Group on Steroid-Sparing Criteria in L. Criteria for steroid-sparing ability of interventions in systemic lupus erythematosus: report of a consensus meeting. *Arthritis and rheumatism*. 2004;50(11):3427-31.
20. Ribi C, Trendelenburg M, Gayet-Ageron A, Cohen C, Dayer E, Eisenberger U, et al. The Swiss Systemic lupus erythematosus Cohort Study (SSCS) - cross-sectional analysis of clinical characteristics and treatments across different medical disciplines in Switzerland. *Swiss medical weekly*. 2014;144:w13990.
21. Strand V, Galateanu C, Pushparajah DS, Nikai E, Sayers J, Wood R, et al. Limitations of current treatments for systemic lupus erythematosus: a patient and physician survey. *Lupus*. 2013;22(8):819-26.
22. Brunner HI, Klein-Gitelman MS, Ying J, Tucker LB, Silverman ED. Corticosteroid use in childhood-onset systemic lupus erythematosus - practice patterns at four pediatric rheumatology centers. *Clinical and experimental rheumatology*. 2009;27(1):155-62.
23. Tomic-Lucic A, Petrovic R, Radak-Perovic M, Milovanovic D, Milovanovic J, Zivanovic S, et al. Late-onset systemic lupus erythematosus: clinical features, course, and prognosis. *Clinical rheumatology*. 2013;32(7):1053-8.
24. Hochberg MC. Updating the American College of Rheumatology revised criteria for the classification of systemic lupus erythematosus. *Arthritis and rheumatism*. 1997;40(9):1725.
25. Gladman DD, Ibanez D, Urowitz MB. Systemic lupus erythematosus disease activity index 2000. *The Journal of rheumatology*. 2002;29(2):288-91.
26. Isenberg DA, Rahman A, Allen E, Farewell V, Akil M, Bruce IN, et al. BILAG 2004. Development and initial validation of an updated version of the British Isles Lupus Assessment Group's disease activity index for patients with systemic lupus erythematosus. *Rheumatology*. 2005;44(7):902-6.
27. Bose B, Silverman ED, Bargman JM. Ten Common Mistakes in the Management of Lupus Nephritis. *Am J Kidney Dis*. 2014;63(4):667-76.
28. Fangtham M, Petri M. 2013 Update: Hopkins Lupus Cohort. *Current rheumatology reports*. 2013;15(9).
29. Houssiau FA, Lauwerys BR. Current management of lupus nephritis. *Best Pract Res Cl Rh*. 2013;27(3):319-28.
30. Franchin G, Diamond B. Pulse steroids: How much is enough? *Autoimmunity reviews*. 2006;5(2):111-3.

31. Parker BJ, Bruce IN. High dose methylprednisolone therapy for the treatment of severe systemic lupus erythematosus. *Lupus*. 2007;16(6):387-93.
32. Buttgereit F, da Silva JA, Boers M, Burmester GR, Cutolo M, Jacobs J, et al. Standardised nomenclature for glucocorticoid dosages and glucocorticoid treatment regimens: current questions and tentative answers in rheumatology. *Annals of the rheumatic diseases*. 2002;61(8):718-22.
33. van Vollenhoven RF, Petri M, Wallace DJ, Roth DA, Molta CT, Hammer AE, et al. Cumulative Corticosteroid Dose Over Fifty-Two Weeks in Patients With Systemic Lupus Erythematosus: Pooled Analyses From the Phase III Belimumab Trials. *Arthritis & rheumatology*. 2016;68(9):2184-92.
34. Murphy G, Isenberg D. Effect of gender on clinical presentation in systemic lupus erythematosus. *Rheumatology*. 2013;52(12):2108-15.
35. Mok MY, Li WL. Do Asian patients have worse lupus? *Lupus*. 2010;19(12):1384-90.
36. Mongkoltanatus J, Wangkaew S, Kasitanon N, Louthrenoo W. Clinical features of Thai male lupus: an age-matched controlled study. *Rheumatology international*. 2008;28(4):339-44.
37. Voulgari PV, Katsimbri P, Alamanos Y, Drosos AA. Gender and age differences in systemic lupus erythematosus. A study of 489 Greek patients with a review of the literature. *Lupus*. 2002;11(11):722-9.
38. Garcia MA, Marcos JC, Marcos AI, Pons-Estel BA, Wojdyla D, Arturi A, et al. Male systemic lupus erythematosus in a Latin-American inception cohort of 1214 patients. *Lupus*. 2005;14(12):938-46.
39. Ward MM, Studenski S. Systemic lupus erythematosus in men: a multivariate analysis of gender differences in clinical manifestations. *The Journal of rheumatology*. 1990;17(2):220-4.
40. Munoz-Grajales C, Gonzalez LA, Alarcon GS, Acosta-Reyes J. Gender differences in disease activity and clinical features in newly diagnosed systemic lupus erythematosus patients. *Lupus*. 2016;25(11):1217-23.
41. Ding Y, He J, Guo JP, Dai YJ, Li C, Feng M, et al. Gender differences are associated with the clinical features of systemic lupus erythematosus. *Chinese medical journal*. 2012;125(14):2477-81.
42. Andrade RM, Alarcon GS, Fernandez M, Apte M, Vila LM, Reveille JD. Accelerated damage accrual among men with systemic lupus erythematosus XLIV. Results from a multiethnic US cohort. *Arthritis and rheumatism*. 2007;56(2):622-30.