ECTRIMS/ EAN Guideline on the pharmacological treatment of people with Multiple Sclerosis.

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Abstract

Background. Multiple Sclerosis (MS) is a complex disease with new drugs becoming available in the past years. There is a need for a reference tool compiling current data to aid professionals in treatment decisions.

Objectives. To develop an evidence-based clinical practice guideline for the pharmacological treatment of people with MS.

Methods. This guideline has been developed using the GRADE methodology and following the updated EAN recommendations. Clinical questions were formulated in PICO format and outcomes were prioritized. The quality of evidence was rated into four categories according to the risk of bias. The recommendations with assigned strength (strong, weak) were formulated based on the quality of evidence and the risk-benefit balance. Consensus between the panelists was reached by use of the modified nominal group technique.

Results. A total of 10 questions were agreed, encompassing treatment efficacy, response criteria, strategies to address suboptimal response and safety concerns and treatment strategies in MS and pregnancy. The guideline takes into account all disease-modifying drugs approved by the EMA at the time of publication. A total of 21 recommendations were agreed by the guideline working group after three rounds of consensus.

Conclusion. The present guideline will enable homogeneity of treatment decisions across Europe.

1. Background and scope

Multiple sclerosis (MS) is an inflammatory-demyelinating disease of the central nervous system (CNS) that is characterized by inflammation, demyelination and degenerative changes. MS usually begins around the age between 20 and 40 and affects two to three times as many women as men; it also constitutes the most frequent cause of non-traumatic disability in the young adult population (1). The incidence of MS varies across regions, with rates as high as 8 to 10 new cases per 100,000 in high latitudinal regions (2, 3). Current estimates suggest that over 700,000 people are affected in Europe, with over 2.5 million cases worldwide (4), which represent a significant burden in terms of impact on quality of life, societal costs and personal expenses (5, 6). Most patients (85-90%) have a relapsing course from onset that is characterized by relapses and remissions of neurological symptoms associated with areas of CNS inflammation, and over the course of two decades, more than half of untreated patients transition to a phase of gradual worsening independent of acute attacks (7, 8). Progressive forms of MS can be present as the initial disease course (primary progressive MS) in approximately 10-15% of patients (9, 10).

There is no curative treatment available for MS, and the current therapeutic strategy is aimed at reducing the risk of relapses and potentially disability progression. The treatment era for MS began in 1993, when the first interferon became available, and recent years have seen a large expansion in the therapeutic options for MS, with 11 disease-modifying therapies approved by the European Medicine Agency (EMA) in both injectable and oral formulations by the beginning of 2017 (11). The growing armamentarium of therapies brings new opportunities for individualized therapy where patients and providers must balance considerations around efficacy, side effects and potential harm in a shared-decision process. However, the variety of mechanisms of action, monitoring requirements and risk profiles together with the existing knowledge gaps make individualized medicine a complex task (12, 13). There is still controversy about the relative efficacy of the drugs available, who should receive therapy and the optimum time to start. The heterogeneity of MS together with the changes in the diagnostic criteria over the years (14-16) and the recent redefinition of the clinical subtypes (17) hamper direct comparisons across studies for different drugs. Moreover, despite the identification of several prognostic factors (18-20), there is no accepted consensus definition that allows physicians to classify patients into "high-risk" and "low-risk" groups in order to prioritize treatment strategies.

A number of evidence-based guidelines and technology appraisal documents have been produced over the past five years (21-24) but there is no comprehensive document that incorporates recently approved drugs to help clinicians and patients in the decision-making process for those aspects that raise specific difficulties when facing everyday clinical practice.

These are questions such as how to select the initial therapy and choose subsequent therapies; how to best monitor treatment response; when to switch or discontinue treatment; and how to manage therapy in special situations such as pregnancy. In this context, the European Committee of Treatment and Research in Multiple Sclerosis (ECTRIMS) and the European Academy of Neurology (EAN) have joined forces to provide up-to-date, evidence-based recommendations for the treatment of patients with MS to assist physicians, patients, health-care providers and health-policy makers in Europe and worldwide in the decision-making process.

This guideline focuses on disease-modifying treatment for the adult population with MS, including all immunomodulatory and immunosuppressive drugs authorized by the EMA. It does not include recommendations concerning combination therapies or new active agents in the final stages of clinical evaluation that are not approved by the EMA at the time of publication. Nevertheless, the available evidence regarding these drugs has been analysed, and a regular update of the document is planned in order to incorporate new drugs in the recommendations as soon as they are approved. This guideline does not include treatments usually considered complementary and/or alternative medicine or aspects of symptomatic treatment and/or treatment of relapses.

Patients with clinically isolated syndrome (CIS) who do not fulfil the current MS 2010 diagnostic criteria and patients with confirmed MS have been considered, distinguishing between the different clinical subtypes of MS using previous and recent classification criteria (17, 25). Guidance relating to paediatric MS is not included in this guideline and can be found in recent documents (26-29).

The document is a joint venture of ECTRIMS and EAN and, as such, the recommendations have been drawn up considering its European scope, including both the outpatient and in-hospital setting, but it does not address specific organizational issues, management models or country-specific regulations required to implement the recommendations. Users of these guidelines should adapt the recommendations to be consistent with their local regulations and/or team capacities, infrastructure, and cost-benefit strategies.

2. Guideline questions

The guideline task force, on the basis of its large expertise in the field, has prioritized the key aspects to be covered in the guideline. These aspects are as follows: early treatment in CIS patients, treatment in patients with established disease (both relapsing and progressive), monitoring of treatment response, treatment strategies in case of inadequate treatment response,

treatment discontinuation and/or switch, as well as treatment in special situations such as pregnancy.

To address the previous topics, ten questions have been formulated and classified into the two following types: those involving a specific therapeutic intervention, formulated following the PICO framework (Patients, Intervention, Comparator, Outcome); and those covering aspects of clinical management, formulated considering population, management aspect and outcome.

An explicit list of outcomes for each question was proposed by the GL chairs and circulated to the rest of the working group who were invited to rate their relative importance for clinical decision-making and add new outcomes if needed. The outcome prioritization was performed via a two-round consensus exercise using a 9-point Likert scale and grouped into 3 categories (1–3: outcome of low importance; 4–6: outcome important but not critical for decision-making; 7–9: outcome critical for decision-making) . Only outcomes graded as critical or important according to expert opinion were analysed.

Therapeutic intervention questions

1. In patients with CIS (regardless of whether they fulfil criteria of definite MS (15)), what is the benefit of starting treatment with *a disease-modifying drug (DMD)* compared to no treatment?

2. In patients with relapsing-remitting MS and secondary progressive MS, what is the benefit of treating with *a DMD* compared to no treatment/another *DMD?*

3. In patients with primary progressive MS, what is the benefit of treating with *a DMD* compared to no treatment?

Clinical management questions

4. In patients with relapsing MS treated with DMDs, does the presence of early disease activity (relapses and/or disability progression and/or MRI activity at 6 months/12 months) predict an increased risk of future disability?

5. In MS patients treated with DMDs, should a follow-up MRI be performed within a pre-specified time frame to monitor treatment response and safety?

6. In patients with relapsing MS treated with interferon or glatiramer acetate and with evidence of early disease activity (relapses and/or disability progression and/or MRI activity at 6/12 months), what is the benefit of switching between interferon and glatiramer acetate versus moving to more efficacious drugs?

7. In patients with relapsing MS who stop taking a highly efficacious drug, is there a risk of return and/or rebound of their disease activity (increased risk of relapses, disability progression and/or MRI activity)?

8. In patients with relapsing MS who stop taking a highly efficacious drug, what is the benefit of further treatment?

9. In patients with relapsing MS treated with DMDs that remain stable over a long time period, what is the benefit of continuing treatment compared to stopping?

10. In women with MS treated with DMDs who wish to become pregnant or who have an unplanned pregnancy, what should the therapeutic approach be?

3. Methodology

This guideline was developed in accordance with the recommendations of the GRADE (Grading of Recommendations Assessment, Development and Evaluation) Working Group (30) and in line with the 2015 Practical recommendations for the process of proposing, planning and writing a neurological management guideline by EAN task forces (31).

3.1 Search strategy

Searches were performed following a predefined review protocol *(Appendix 1)* and conducted in the following databases: The Cochrane Central Register of Controlled Trials (Central), Excerpta Medica Database (Embase), Medical Literature Analysis and Retrieval System Online (MEDLINE)/MEDLINE In-Process, and Psychological Information Database (PsycINFO). All search terms for each search are listed in Appendix 2.

Titles and abstracts of identified studies were screened for inclusion against agreed criteria. Eligibility criteria for therapeutic intervention questions included: SR, RCTs with at least 1 year follow-up (48 weeks acceptable) and long term extensions on included RCTs. Studies on pediatric population, studies evaluating combination of drugs, unlicensed doses, those published in non-english language and those with <10 participants per arm were excluded. For clinical management questions we included SR, RCTs and observational studies. Exclusion criteria varied between the different clinical managment questions and details can be found in Appendix 1.

All primary-level studies included after the first scan of citations were acquired in full and re-evaluated for eligibility at the time they were entered into a study database (standardized template created in Microsoft Excel). The full-text papers were screened by 2 reviewers using the inclusion criteria for reference. Study characteristics, aspects of methodological quality, and

outcome data were extracted from all eligible studies using an Excel-based form and Review Manager Version 5.3 (Cochrane Collaboration, 2014).

3.2 Quality appraisal and data synthesis

The quality appraisal process was conducted depending on the study design using available standardized tools. For the evidence coming from RCTs, the quality of individual studies was assessed using the Cochrane Collaboration's tool for assessing risk of bias in randomized trials (Higgins & Green, 2011). For cohort studies, the Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I; Cochrane Bias Methods Group)(32) was used, whereas for before-and-after studies, the "Quality Assessment of Before-After (Pre-Post) Studies With No Control Group" tool developed by the National Heart, Lung, and Blood Institute and the Research Triangle Institute International was used. Systematic reviews were assessed using the 'Assessing the Methodological Quality of Systematic Reviews (AMSTAR)' tool. For RCTs, meta-analysis using a random-effects model was used to combine results from similar studies using Review Manager Version 5.3. Where application of this analysis was not possible, a narrative synthesis was used. Observational studies were analysed separately from the RCTs and synthesized narratively. Dichotomous outcomes were analysed as relative risks (RR; also called a risk ratio), and continuous outcomes were analysed using the mean difference (MD) with the associated 95% confidence interval.

3.3 Grading the quality of the evidence

The process for grading the quality of the evidence followed two different approaches according to the type of question.

    a.   Therapeutic intervention

For questions about the effectiveness of interventions, the GRADE approach was used to assess the quality of evidence for each outcome (33) taking into account the following items: study design, risk of bias, inconsistency, indirectness and imprecision. GRADE evidence profiles, including both the quality of the evidence and the results of the evidence synthesis for each 'critical and important' outcome, were created using GRADEprofiler (GRADEpro) software (Version 3.6).

    b.   Clinical management

For the clinical management questions, the risk of bias was assessed using different tools depending on study design as detailed previously, and this information was presented in an narratively and in summary tables.

3.4 Method for reaching consensus

The panel formulated practice recommendations on the basis of the quality of the evidence and the balance between health benefits and harms for both therapueutic and clinical management questions. Consensus was reached by use of the modified nominal group technique following a two-stage process (34). In the first stage, participants received a summary of the available evidence and its quality as detailed previously, an overview of the modified nominal group technique, and a ranking excel sheet containing the proposed list of statements and instructions on its use. The proposed list of statements and their assigned strength (strong, weak) was iniatially drafted by the GL chairs during a face to face meeting with participation of the methodologists in charge of the evidence analysis. For those aspects for which there was not sufficient evidence to suppport a formal recommendation, consensus statements were formulated.

The panel members were asked to indicate their agreement with the set of statements by taking into account the available evidence and their expertise and to provide written comment on their reason for any disagreement and possible modifications. The statements were rated on a 9-point Likert scale and grouped into 3 categories (1–3: inappropriate strategy; 4–6: uncertain; 7–9: appropriate strategy). In the second stage, panellists met during a face-to-face consensus meeting, and anonymized distributions of responses to each statement were presented to all members, together with the additional comments and a ranking of statements. Those statements with less than 80% agreement were redrafted, and a second round of voting using show of hands was conducted. If agreement of 80% or above was achieved, then the rerated statements were adopted (35). Those statements that could not be approved during the face-to-face meeting due to time limitations were evaluated in a 3rd round via e-mail.

4. Results

4.1 Efficacy of DMDs

Review question 1: In patients with CIS (regardless of whether they fulfil the criteria of definite MS (15)) what is the benefit of starting treatment with a DMD compared to no treatment?

An electronic database search was performed for questions 1-3 simultaneously and identified 4,416 records. Of these, 4,266 studies were excluded based on their title/abstract and 150 studies were subjected to a full-text appraisal. Information about the excluded studies can be found in *Appendix 3*. Five trials (36-40) and their extensions (41-46) met the eligibility criteria for question number one. They were all placebo-controlled trials testing interferon, glatiramer acetate and teriflunomide. Sample sizes of the pivotal trials varied from 383 to 618 participants

(mean=493), with a follow-up ranging from 104 to 156 weeks (mean: 125 weeks). All trials included participants who had not received any prior disease-modifying therapy before study entry, and the mean EDSS scores at baseline ranged from 1 to 1.67 (mean: 1.42). Further details about the characteristics of the included studies can be found in ***Appendix 4 - Tables 1 to 5.***

Three trials (36, 38, 39) (N=1,368) comparing interferon with placebo showed a reduced time to conversion to clinically definite multiple sclerosis (CDMS) at two years (high-quality meta-analysis, 2 trials (36, 39) n=808; HR=0.49, 95% CI, 0.38 to 0.64) and a reduced number of participants converting to CDMS at follow-ups ranging from two to three years (moderate quality meta-analysis, 2 trials (36, 38) n=723; RR=0.71, 95% CI, 0.61 to 0.82). Treatment with interferon also showed a benefit in a number of participants free from new or newly enlarging T2 lesions and gadolinium (GAD) enhanced lesions but MRI results could not be combined into meta-analyses due to the variability of MRI outcomes reported across the three trials. The interferon group resulted in a higher but not significant discontinuation risk due to any reason (moderate quality meta-analysis, 3 trials (36, 38, 39) n=1,193; RR=1.11, 95% CI, 0.80 to 1.54) and a higher discontinuation risk due to side effects (low quality meta-analysis, 2 trials (38, 39); n=810; RR=2.17, 95% CI, 0.16-28.82). In the extension studies, patients on placebo were offered interferon. The early-intervention group showed a greater time to conversion to CDMS than the delayed-treatment group at three years' follow-up (45), and this difference was maintained at five (43, 46), eight (44) and 11 years' follow-up (42).

There is only one available trial of glatiramer acetate compared with placebo (n=481) in CIS patients showing a delayed conversion to CDMS at three years' (moderate quality; HR=0.55, 95% CI, 0.40 to 0.76), with a higher number of discontinuations in the glatiramer acetate group due to any reason (moderate quality, RR=1.66, 95% CI, 1.02 to 2.69) and due to side effects (moderate quality, RR=3.43, 95% CI, 1.14 to 10.26) (37). According to a single extension study, there was a beneficial effect of early treatment with glatiramer acetate on the time to CDMS, number of new or newly enlarging T2 lesions, number of GAD lesions and brain volume change, with no significant differences in adverse events at five years' follow-up (41).

According to a single placebo-controlled trial (N=413), treatment of CIS patients with teriflunomide resulted in a delayed time to conversion to CDMS (low quality HR=0.57, 95% CI, 0.38 to 0.87) and a reduced number of participants converting to CDMS at two years' follow-up (low quality, RR=0.64, 95% CI, 0.44 to 0.92). MRI outcomes showed a lower number of GAD lesions (low quality, MD=-0.56, 95% CI, -1.04 to -0.08), a beneficial effect on the change in T2 lesion volume (low quality, MD=-0.07, 95% CI, -0.18 to 0.03), with no difference between groups in brain atrophy. The study reported a higher number of non-significant discontinuations in the placebo group due to any reason (RR=0.83, 95% CI, 0.60 to 1.15) and due to side effects

(RR=0.91, 95% CI, 0.49 to 1.70) (40). GRADE tables and Forest plots are presented in *Appendix 5* and *Appendix 6.* Further details about the safety issues of these drugs are shown in *Appendix 7.*

Review question 2: In patients with relapsing-remitting MS and secondary progressive MS, what is the benefit of treating with *a DMD* compared to no treatment/another *DMD?*

Thirty-three RCTs met the eligibility criteria for question number two and, of these, 28 RCTs included patients with relapsing-remitting forms of MS (some of which included patients with and without progression) and 5 RTCs were restricted to patients with secondary progressive MS.

Relapsing-remitting MS

The trials on relapsing-remitting MS comprised 16 placebo-controlled trials, including interferon, glatiramer acetate, teriflunomide, dimethyl fumarate, fingolimod, natalizumab and daclizumab, and 12 head to head trials involving many of these agents and including alemtuzamab. Sample sizes ranged from 75 to 2244 participants (mean: 879), and the length of study follow-up ranged from 48 to 260 weeks (mean: 98 weeks). Overall, participants were predominantly female (mean of means: 70%) in their late thirties (mean of means: 36 years) who had been diagnosed with MS for an average of 5.3 years (range: 1.1-10.6 years). Twenty-two studies reported the number of participants who had received any DMD prior to study entry, which was 0% in five studies, 100% in one study, and ranged from 7.6% to 75% in the remaining 16 studies (mean of means: 32%). At baseline, the EDSS scores ranged from 1.9 to 2.9 (mean of means: 2.5), and the number of relapses in the previous year ranged from 1 to 1.8 (mean of means: 1.4). Further details about the characteristics of the included studies can be found in *Appendix 4 - Tables 6 to 25.*

All the evaluated drugs showed a significant treatment effect compared with placebo. Interferon resulted in a lower annualized relapse rate at follow-up ranging from 48 to 104 weeks (moderate quality meta-analysis, 2 trials (47, 48); N=1909; mean difference (MD)=-0.10, 95% CI, -0.16 to -0.04) and a beneficial effect on the number of participants free from relapse at 48 weeks' follow-up (moderate quality evidence; RR=1.15, 95% CI, 1.08 to 1.23) (47) and at 104 weeks' follow-up (low quality meta-analysis; 3 trials (49-51) (N=960) (RR=1.73, 95% CI, 1.35 to 2.21). Interferon had an impact on disability worsening confirmed at three months over 48 weeks' follow-up (low quality evidence, RR=0.61, 95% CI, 0.39 to 0.93; n=1,012) (47) and on disability worsening confirmed at six months over two years' follow-up (low quality evidence meta-analysis; 2 trials (48, 51); RR=0.71, 95% CI, 0.51 to 0.98; k=2; n=1069). Interferon also showed an impact on MRI parameters, according to moderate quality evidence, with fewer new

or newly enlarging T2 lesions (MD=-7.30, 95% CI, -8.85 to -5.75) (47) and a change in brain volume at 48 weeks' follow-up (MD=-0.10, 95% CI, -0.20 to 0.00) (47) and at 2 years' follow-up (MD=-0.11, 95% CI, -0.28 to 0.06) (48). Similarly, low quality evidence suggested a larger proportion of participants free from T2 active lesions (RR=2.80, 95% CI, 1.69 to 4.63) and free from combined unique active lesions (RR=2.97, 95% CI, 1.49 to 5.92) at 2 years (50). The evidence suggested an increased risk of trial discontinuation due to side effects and due to any reason in the interferon group compared with that in the placebo group at 48 weeks' (47) and at 2 years' follow-up (low quality evidence meta-analysis; 3 trials (48, 50, 51); N=1630; RR=1.72, 95% CI, 1.04 to 2.86).

Extension studies available for four of the interferon pivotal trials concluded that the early-intervention group had a lower annualized relapse rate and fewer new or newly enlarging T2 lesions at two and four years' follow-up (52, 53), as well as a lower proportion of participants with disability worsening at two and 8 years' follow-up (53, 54). At 16 years' follow-up, there was little difference between the early- and delayed-treatment groups in the number of participants reaching an EDSS score of 6, and those converting to secondary progressive MS (55). Further details about the study outcomes can be found in *Appendix 8*.

Three trials (N=3,217) compared glatiramer acetate with placebo with length of follow-up ranging from 52 to 104 weeks (56-58). Glatiramer acetate resulted in a lower annualized relapse rate at follow-ups ranging from 52 to 96 weeks (moderate quality evidence meta-analysis of 2 trials (56, 58); n=2,117; MD=-0.14, 95% CI, -0.21 to -0.06) and a higher proportion of participants free from relapse at follow-ups ranging from one to two years (moderate quality evidence meta-analysis of three trials (56-58); n=2,360; RR=1.17, 95% CI, 1.10 to 1.24). There was a non-statistically significant evidence effect on disability at 96 to 104 weeks' follow-up (low quality evidence meta-analysis of 2 trials (56, 57); n=964; RR=0.86, 95% CI, 0.66 to 1.11) and 128 weeks' follow-up (low quality evidence meta-analysis of 2 trials (56, 57); n=964; RR=0.79, 95% CI, 0.52 to 1.20). Glatiramer acetate resulted in a lower number of cumulative GAD lesions (MD=-0.73, 95% CI, -1.15 to -0.31) and cumulative new or newly enlarging T2 lesions at six and 12 months' follow-up (56, 58) as well as a beneficial (but non-statistically significant) effect on the percent change in brain volume at one year, according to high-quality evidence (MD=-0.06, 95% CI, -0.19 to 0.06) (58). According to the only available extension study, there was little difference between groups in the proportion of participants discontinuing the trial for any reason during the extension phase. The early-treatment group had a higher proportion of injection site reactions (2.4% vs 0.9%) (59).

Two trials compared teriflunomide with placebo with length of follow-up ranging from 104 to 108 weeks (60, 61). According to moderate quality evidence meta-analysis of the two trials

(n=1,479), teriflunomide reduced the risk of relapses (RR=1.25, 95% CI, 1.16 to 1.36), resulted in a decreased annualized relapse rate (MD=-0.18, 95% CI, -0.24 to -0.11) and reduced disability worsening compared with those associated with placebo (RR=0.76, 95% CI, 0.62 to 0.93) at 48 to 108 weeks' follow-up. Only one of the trials reported MRI data that showed a beneficial effect on the mean number of GAD lesions (MD=-1.07, 95% CI, -1.40 to -0.74) and on the number of patients free from enhanced lesions (moderate quality evidence, RR=1.62, 95% CI, 1.39 to 1.87)(61). In the single extension study available, there was little difference up to 9 years' follow-up between the early- and delayed-treatment groups for the annualized relapse rate and a lower proportion of participants with disability worsening in the early-treatment group (62).

Two trials (n=2,667) compared dimethyl fumarate with placebo with length of follow-up ranging from 96 to 104 weeks (56, 63). A moderate quality meta-analysis of both trials (n=1,479) showed a beneficial effect of dimethyl fumarate at 2 years' follow-up on the number of participants free from relapses (RR=1.28, 95% CI, 1.14 to 1.43), the annualized relapse rate (MD=-0.19, 95% CI, -0.25 to -0.13), the risk of disability worsening (RR=0.66; 95% CI, 0.51 to 0.85) and the presence of new or newly enlarging T2 lesions (MD=-13.36, 95% CI, -16.63 to -10.9) and GAD lesions (MD=-1.64, 95% CI, -2.17 to -1.10). One extension study reported outcomes at five years with the previous trials combined, where participants receiving placebo were re-randomized to one of the two doses of dimethyl fumarate. The results indicated little difference between the early- and delayed-treatment groups for the annualized relapse rate during the extension phase and a lower proportion of participants with disability worsening in the early-treatment group (64).

Two trials compared fingolimod with placebo with 104 weeks' follow-up (65, 66). According to a meta-analysis of both trials (n=2,355), moderate quality evidence showed that fingolimod was associated with a larger proportion of participants free from relapse (RR=1.44, 95% CI, 1.28 to 1.63), a lower annualized relapse rate (MD=-0.21, 95% CI, -0.25 to -0.16), lower risk of disability worsening (RR=0.71, 95% CI, 0.56 to 0.90) and a trend in favour of fingolimod for all MRI outcomes. The extension studies available for both trials show a beneficial effect in the early-treatment group compared with that in the delayed-treatment group with a lower annualized relapse rate, a higher proportion of participants free from disability worsening and a beneficial effect of early fingolimod on the number of new T2 lesions, GAD lesions and the percent change in brain volume at 4-6 years' and 4.5 years' follow-up (67).

One trial (n=942) compared natalizumab with placebo for 104 weeks (68). High-quality evidence from a single trial indicated a higher number of participants free from relapse (RR=1.59, 95% CI, 1.40 to 1.81), a lower annualized relapse rate (MD=-0.50, 95% CI, -0.63 to

-0.37), fewer GAD lesions (RR=-1.10, 95% CI, -1.54 to -0.66) and new or newly enlarging T2 lesions (RR=-9.10, 95% CI, -10.98 to -7.22) in the natalizumab group. Moderate quality evidence suggested a beneficial effect on the number of participants with disability worsening (RR=0.59, 95% CI, 0.46 to 0.75).

One trial (n=621) compared daclizumab with placebo for 52 weeks (69) and indicated a lower annualized relapse rate (high-quality evidence, MD=-0.25, 95% CI, -0.37 to -0.13), a higher proportion of patients free from relapse (high-quality evidence, RR=1.25, 95% CI, 1.11 to 1.42), and a lower mean number of GAD lesions (moderate quality evidence, MD=-1.10, 95% CI, -1.45 to -0.75) and new or newly enlarging T2 lesions in the daclizumab group. Low quality evidence from the same trial indicated a reduced risk of disability worsening (RR=0.43, 95% CI, 0.22 to 0.85). In the extension study, the participants receiving placebo were re-randomized at two years' post-randomization of the SELECT trial to receive 150 or 300 mg of daclizumab, whilst those already receiving the investigational drug were re-randomized to continue with their present dose or undergo a 20-week wash-out and subsequent reinitiation of the drug (70). The results indicated a lower annualized relapse rate and fewer new T2 lesions in the continuous, wash-out and reinitiation groups than in the delayed-treatment group at two years' follow-up.

One trial (n=1326) compared cladribine with placebo for 96 weeks (71). High-quality evidence from a single trial indicated a higher number of participants free from relapse (RR=1.31, 95% CI, 1.20 to 1.42) and a lower annualized relapse rate (MD=-0.19, 95% CI, -0.23 to -0.14) in the intervention group. The authors reported statistically significant reductions in GAD lesions, active T2 lesions and combined unique lesions in the intervention group compared with placebo (p<0.0001).

Head to head comparisons

These are available only for interferon, glatiramer acetate and natalizumab. Head to head comparisons between glatiramer acetate and interferon are available from four trials (72-75), with the length of follow-up ranging from 52 to 104 weeks. There was no difference in the number of participants free from relapse at 2 years' follow-up (moderate quality evidence meta-analysis of 3 trials (72, 74, 75); n=2,175; RR=0.98, 95% CI, 0.90 to 1.06) or disability worsening (RR=1.07, 95% CI, 0.83 to 1.31), according to moderate quality evidence from a single trial (75). At 2 years' follow-up, a low quality meta-analysis of the four trials (n=2,341) (72-75) indicated that fewer people in the glatiramer acetate group discontinued due to any reason (RR=1.30, 95% CI, 0.68to 2.47) and due to side effects (RR=1.15, 95% CI, 0.75 to 1.77) than in the interferon group, although the data were imprecise and the differences were not significant.

Teriflunomide, fingolimod and daclizumab were compared with interferon in single trials. There was a higher proportion of participants free from relapse in the interferon group (N=342; RR=0.68, 95% CI, 0.57 to 0.82) than in the teriflunomide group, with little difference between groups in the annualized relapse rate at 48 weeks' follow-up, according to low quality evidence (76). Moderate quality evidence showed more participants free from relapse (N=1292; RR=1.19, 95% CI, 1.11 to 1.29), a lower annualized relapse rate (MD=-0.17, 95% CI, -0.26 to -0.08), and fewer participants with disability worsening in the fingolimod group than in the placebo group at 1 year; however, the estimate was imprecise and not significant. MRI outcomes consistently favoured the fingolimod group (77). Two extension studies at two (78) and 4.5 years (79) after the start of the original trial reported that early treatment showed a significant effect on the annualized relapse at 2 years with no significant differences for the annualized relapse or for disability worsening and little difference in the number of new T2 lesions, GAD lesions and percent change in brain volume at 4.5 years' follow-up. Compared with interferon, daclizumab resulted in more participants free from relapse (n=1,841; RR=1.31, 95% CI, 1.22 to 1.42), a lower annualized relapse rate (MD=-0.17, 95% CI, -0.22 to -0.12), a reduced risk of disability worsening (RR=0.80, 95% CI, 0.66 to 0.98) and a lower mean number of new or newly enlarging T2 lesions (MD=-5.20, 95% CI, -6.30 to -4.10) at 144 weeks' follow-up, according to moderate quality evidence (80).

Three trials (n=1,755) compared alemtuzumab with interferon, with follow-ups ranging from 104 to 260 weeks (81-83). There was a higher proportion of participants free from relapse (moderate quality evidence meta-analysis of 3 trials (81-83); n=1,414; RR=1.38, 95% CI, 1.26 to 1.51) and a lower annualized relapse rate (moderate quality evidence meta-analysis of 2 trials (82, 83); n=851) MD=-0.25, 95% CI, -0.33 to -0.18) in the alemtuzumab group at follow-ups ranging from two to three years. The effect on the annualized relapse in the alemtuzumab group (MD=-0.23, 95% CI, -0.30 to -0.16) was maintained at 5 years according to low quality evidence from a single study (82). Moreover, fewer participants in the alemtuzumab group had disability worsening at two to three years' (low quality evidence meta-analysis of 3 trials (81-83); n=1,414; RR=0.59, 95% CI, 0.40 to 0.86) and at five years' follow-up (RR=0.43, 95% CI, 0.24 to 0.78)(82). Meta-analysis of the MRI data reported in two of the trials (82, 83) showed a substantial and significant heterogeneity in the findings (I^2=81%, p=0.02) due to the different proportion of participants in the interferon group with new or newly enlarging T2 lesions. Considering each study individually, there was moderate evidence of a lower proportion of participants with a new or newly enlarging T2 in the alemtuzumab group, which was not statistically significant in one of the trials (81).

Two trials (n=1,656) compared ocrelizumab with interferon for 96 weeks (84). The annualized relapse rate was significantly lower in participants receiving ocrelizumab than in those receiving

interferon (high-quality evidence, meta-analysis of 2 trials (84); n=1,656) MD=-0.13, 95% CI, -0.18 to -0.08), and a higher proportion of participants with ocrelizumab showed disability improvement at the end of the trial when confirmed at 12 weeks (moderate quality evidence, RR=1.32, 95% CI, 1.04 to 1.68) and at 24 weeks (moderate quality evidence, RR=1.35, 95% CI, 1.02 to 1.79).

Secondary Progressive MS

Considering specifically those trials addressing secondary progressive MS patients, five studies met the eligibility criteria (reported across seven papers) with sample sizes ranging from 194 to 939 participants and a 156-week follow-up for all trials. Overall, there was a higher proportion of women (58%) than men, the average age was 43 years, and the participants had been diagnosed with MS for approximately 13 years (range: 10-14.7 years). At baseline, the EDSS scores ranged from 4.8 to 5.4 (mean of means: 5.1). Interferon and mitoxantrone were the only DMDs studied. Further details about the characteristics of the included studies can be found in *Appendix 4 - Tables 26 to 28.*

Four trials (N=2,646) compared interferon with placebo (85-88). At three years, there was a significant effect on disability worsening confirmed at three months (RR=0.78, 95% CI, 0.66 to 0.92) (85) and a smaller effect on disability confirmed at six months (moderate quality evidence meta-analysis of three trials (85, 87, 88); n=1,707; RR=0.92, 95% CI, 0.80, 1.06). These studies reported a higher proportion of participants free from combined unique active lesions in the interferon group than in the placebo group (meta-analysis of 2 trials (85, 86); n=970 RR=1.71, 95% CI, 1.17 to 2.49). The only available extension study reported outcomes at 10 years after randomization in the core trial (89). Patients who completed the core trial were offered interferon in an open-label extension for 18 months. Thereafter, treatment decisions were at the discretion of the treating physicians and the patient. Fewer participants in the early-treatment group (29%) had progressed to an EDSS score of 8 or higher than in the delayed-treatment group (36.4%).

One trial (N=194) (90) compared mitoxantrone with placebo and reported a reduced risk of disability worsening (RR=0.38, 95% CI, 0.15 to 0.99) at 104 weeks. A small non-randomized subgroup of participants in the trial underwent MRI scanning that showed no significant difference between the groups in the number of participants with positive gadolinium enhancement or in the number of GAD lesions at one or two years. The mean change from baseline of new T2-weighted lesions was significant at 2 years but not at 1 year.

GRADE tables and Forest plots are presented in *Appendix 5* and *Appendix 6.* Further details about the safety issues of these drugs are detailed in *Appendix 7.*

Review question 3: In patients with primary progressive MS, what is the benefit of treating with *a DMD* compared to no treatment?

Five RCTs met the eligibility criteria for this review (reported across six papers) (91-95), and all compared active drugs against placebo, with sample sizes ranging from 50 to 970 participants (mean: 553) and a length of study follow-up ranging from 104 to 156 weeks. Overall, just over half of the participants were male, and the average age was 47 years. Participants had been diagnosed with primary progressive MS for an average of 6 years (range: 2.9 to 11.4 years) and at baseline, the EDSS scores ranged from 4.7 to 5.2 (mean of means: 4.9). Further details about the characteristics of the included studies can be found in *Appendix 4 - Tables 29 to 33*.

Two available trials comparing interferon with placebo indicated little difference in the number of participants with disability worsening (confirmed at 3 months) at two years' follow-up (low quality evidence meta-analysis of two trials (91, 93); n=108; RR=0.97, 95% CI, 0.62 to 1.52). In the single available extension study, patients who completed the core trial were eligible to enter the five-year extension phase with no treatment (96). There was no significant difference between early- and delayed-treatment in the proportion of participants with disability worsening, in their cognitive performance (as measured with the PASAT 3) or in the change in T2 lesion volume. The authors reported a beneficial effect of early treatment on the change in brain parenchymal fraction.

Moderate quality evidence of a single trial of glatiramer acetate compared with placebo (N=2,646) suggested a non-significant effect on the number of participants with disability worsening (RR=0.87, 95% CI, 0.75 to 1.02) and a longer time to disability worsening (HR=0.87, 95% CI, 0.71 to 1.07) in the active treatment group at 156 weeks (95).

Moderate quality evidence of a single trial of fingolimod compared with placebo (n=970) indicated little difference between groups in the proportion of participants with disability worsening (92).

Finally, a recently published trial (n=732) compared ocrelizumab with placebo and showed high-quality evidence of greater time to disability worsening in the ocrelizumab group than in the placebo group at 120 weeks' follow-up, when confirmed at 12 weeks (HR=0.76, 95% CI, 0.59 to 0.98) and 24 weeks (HR=0.75, 95% CI, 0.58 to 0.97). The authors also reported evidence of benefit with ocrelizumab compared with placebo for the volume of hyperintense lesions on T2-weighted images (HR=0.90, 95% CI, 0.88 to 0.92) and change in brain volume at 120 weeks' follow-up (HR=17.5, 95% CI, 3.2 to 29.3) (94).

GRADE tables and Forest plots are presented in *Appendix 5* and *Appendix 6.* Further details about the safety issues of these drugs are detailed in *Appendix 7.*

Quality assessment

All included studies in questions one to three were assessed for risk of bias. Sequence generation and allocation concealment were issues in most of the trials either because it was improperly conducted (causing high risk of bias) or because it was unclear according to the published information. Participants, personnel and outcome assessors were blind in most of the trials, with few exceptions that posed a high risk of bias (48, 56, 71, 74, 76, 81-83, 88). When considering incomplete outcome data, a few trials had a high risk of bias due to missing data for more than 20% of the study sample or due to unequal drop-out between intervention groups (40, 60, 63, 65, 66, 73, 75, 76, 80, 85-88, 90, 92, 94, 97). Outcome assessor bias and selective outcome reporting were also a problem in some trials, either due to not meeting requirements with a high risk of bias (69, 74, 75, 77) or because there was not enough information to make a judgement as no study protocols were available (49-51, 57, 73, 91, 93, 95, 97). See *Appendix 5* for further details on quality assessment.

Recommendations

R1. The entire spectrum of DMDs should be prescribed only in centres with adequate infrastructure to provide:
- Proper monitoring of patients
- Comprehensive assessment
- Detection of side effects and capacity to address them promptly.
[consensus statement]

R2. Offer interferon or glatiramer acetate to patients with CIS and an abnormal MRI with lesions suggestive of MS who do not fulfil criteria for MS.
[strong]

R3. Offer early treatment with DMDs to patients with active relapsing-remitting MS as defined by clinical relapses and/or MRI activity (active lesions -contrast-enhancing lesions; new or unequivocally enlarging T2 lesions assessed at least annually). Also includes CIS fulfilling current diagnostic criteria for MS.
[strong]

R4. For active relapsing-remitting MS, choosing between the wide range of available drugs (interferon beta-1b, interferon beta-1a -sc, im-, peginterferon beta-1a, glatiramer acetate, teriflunomide, dimethyl fumarate, cladribine, fingolimod, daclizumab, natalizumab, ocrelizumab and alemtuzumab), from the modestly effective to the highly efficacious, will depend on the following factors, in discussion with the patient:

- Patient characteristics and comorbidities

- Disease severity/activity

- Drug safety profile

- Accessibility of the drug

[consensus statement]

R5. Consider treatment with interferon-1a (sc) or -1b for patients with active secondary-progressive MS taking into account, in discussion with the patient, the dubious efficacy, as well as the safety and tolerability profile of these drugs.

[weak]

R6. Consider treatment with mitoxantrone for patients with active secondary progressive MS taking into account, in discussion with the patient, the efficacy, and specifically the safety and tolerability profile of this agent.

[weak]

R7. Consider treatment with ocrelizumab or cladribine for patients with active secondary-progressive MS.

[weak]

R8. Consider treatment with ocrelizumab for patients with primary-progressive MS.

[weak]

R9. Always consult the Summary of Product Characteristics (SPC) for dosage, special warnings and precautions for use, contraindications, and monitoring of side effects and potential harms.

[consensus statement]

4.2 Monitoring treatment response

Review question 4. In patients with relapsing MS treated with DMDs, does the presence of early disease activity (relapses and/or disability progression and/or MRI activity at 6 months/12 months) predict an increased risk of future disability?

One systematic review (SR) with the literature search up to 2014 met the inclusion criteria for this review (98). An updated electronic database search from January 2014 to December 2016 identified 1,653 records, and 1,464 studies were excluded based on the title/abstract. After full-text appraisal of five studies, three met the eligibility criteria (99-101), and two were excluded (102, 103). An additional targeted electronic database search assessing the predictive value of early 'no evidence of disease activity' on disability progression (criterion was not included in the previous SR) identified 244 records, but only one study met the inclusion criteria (104) (see *Appendix 3).*

The available SR (98) described the criteria used in the literature to define long-term (≥2 years from start of treatment) and short-term (≤2 years from treatment initiation) non-response to interferon or glatiramer acetate and examined the predictive value of short-term suboptimal response criteria (including EDSS score and/or an MRI parameter and/or relapse rate) for long-term non-response, at least 24 months after the start of treatment. Two additional studies not included in the previous SR used the *Rio Score* and the *Modified Rio Score* at one year to predict responses at three (101) and five years (105) in MS patients treated with interferon beta for at least one year. Sormani *et al.* pooled data from nine European MS centres that evaluated response to treatment at three years or more (99). The "no evidence of disease activity" (NEDA) criteria were assessed yearly in a prospective cohort of CIS and RRMS patients to predict absence of disability worsening (104). Further details about the study characteristics and assessed criteria can be found in *Appendix 4 - Tables 34 to 36.*

Overall, criteria that included MRI or MRI combined with clinical measures had a higher predictive value than clinical criteria alone. When considering only MRI criteria, measures of new/newly enlarging T2 lesions outperformed those of GAD lesions. Of the 16 criteria evaluated in the SR by Rio *et al.*, the following three were determined to have the best predictive value:

1) one or more new/newly enlarging T2 lesions;
2) two or more new/newly enlarging T2 lesions;
3) two or more criteria from the modified Rio score.

The presence of one or more new/newly enlarging T2 lesions for predicting EDSS worsening at 4-4.8 years' follow-up resulted in a specificity of 70.2% and sensitivity of 85.5% for one or

more lesions and a specificity of 83.6% and sensitivity of 62.4% for two or more lesions, according to a meta-analysis of two studies (102, 106) (n=764). The presence of two or more criteria from the modified Rio score had a specificity of 89.1% and sensitivity of 26.4% in predicting EDSS worsening at four years' follow-up, according to a meta-analysis of two studies (102, 107) (n=957). This result was confirmed in the study by Romero and colleagues; however, in the study by Hyun et al., the values for specificity and sensitivity appeared to be much higher. Rottstein 2015 (n=219) reported only the positive and negative predictive value of NEDA. The positive predictive value suggested that 71.7% of participants with NEDA at one year also had an absence of disability worsening at seven years' follow-up. The authors reported only the lowest (40.7%) and highest (43.1%) negative predictive value of NEDA between years' two to six. Tables with descriptive results corresponding to this question are presented in *Appendix 9.*

Quality assessment

Using criteria from the AMSTAR tool, the SR was rated as *low quality*. This was due to the absence of reported information, namely, the study characteristics of included studies, an excluded studies list and a quality assessment of included studies. The primary studies were assessed with the Cochrane tool for 'Risk Of Bias In Non-randomized Studies of - Interventions (ROBINS-I)'. All four studies were judged as having a *moderate risk* of bias. This was mainly due to a lack of information about missing data and potential confounding factors.

Review question 5. In MS patients treated with DMDs, should a follow-up MRI be performed in a pre-specified time scheme to monitor treatment response and safety?

No studies assessing the value of different MRI monitoring schemes for treatment response and safety were found. The use of MRI in the routine follow-up of patients with MS is, to date, less straightforward than in the diagnostic process. In the studies that assessed treatment response criteria (described in question 4), the MRI evaluation was performed at 6-12 months after treatment initiation and compared with a baseline MRI carried out at or prior to treatment onset.

Currently, there are several guidelines that aim to define the indications and frequency of MRI for monitoring the disease course in patients with an established diagnosis of MS (108, 109). Only the most recent guideline, developed by the MAGNIMS group, covers specific aspects regarding the use of MRI for monitoring treatment response and safety (110). The GL Steering Committee has referred to the *MAGNIMS consensus guidelines on the use of MRI in multiple*

sclerosis for establishing disease prognosis and monitoring patients to generate recommendations for this review question.

Recommendations

R10. Consider combining MRI with clinical measures when evaluating disease evolution in treated patients.

[weak]

R11. When monitoring treatment response in patients treated with DMDs, perform a standardized reference brain MRI usually within six months of treatment onset and compare it with a further brain MRI performed typically 12 months after starting treatment. Adjust the timing of both MRIs, taking into account the following aspects:

- the drug's mechanism of action (particularly the speed of action)

- disease activity (including clinical and MRI measures)

[consensus statement]

R12. When monitoring treatment response in patients treated with DMDs, the measurement of new or unequivocally enlarging T2 lesions is the preferred MRI method supplemented by gadolinium enhancing lesions for monitoring treatment response. Evaluation of these parameters requires:

- high-quality, standardized MRI scans

- interpretation by highly qualified readers with experience in MS

[consensus statement]

R13. When monitoring treatment safety in patients treated with DMDs, perform a standardized reference brain MRI:

- every year in low risk PML patients

- more frequent MRIs (on a 3 to 6 monthly basis) in high risk PML patients (JCV positive, natalizumab treatment duration over 18 months)

- in patients with high risk of PML who switch drugs, at the time that the current treatment is discontinued and after the new treatment is started.

[consensus statement]

4.3 Treatment strategy if inadequate treatment response

Review question 6. In patients with relapsing MS treated with interferon or glatiramer acetate and evidence of early disease activity (relapses and/or disability progression and/or

MRI activity at 6/12 months), what is the benefit of switching between interferon and glatiramer acetate versus moving to more efficacious drugs?

For review questions 6-8, the electronic database search identified 3,856 records. Of these, 3,853 studies were excluded based on their title/abstract and 82 studies were subjected to a full-text appraisal. After a full-text review and removal of duplicates, 9 studies met the eligibility criteria for this review. Due to differences in study design and included populations, the results could not be meta-analysed and are reported narratively. Three of the studies were RCTs (83, 111, 112); five were retrospective cohorts (113-117); and one was a prospective cohort (118). Before switching drugs, all participants had been receiving interferon beta-1a, interferon beta-1b or glatiramer acetate and were described as having had a treatment failure, although this term was not always defined (114, 116) or was assessed subjectively by the neurologist (117). Two studies included specific treatment failure definitions combining relapses (more than one or more than two) and sustained disability worsening (defined as increase in at least 0.5 points or increase in at least 1 point in the EDSS score compared with the year prior to therapy) (113, 118). In four studies, participants who switched drugs received fingolimod (111-115); in two studies, participants switched to natalizumab (117, 118); in one study, participants switched to natalizumab (116); and in one trial, participants switched to alemtuzumab (83). Further study characteristics are presented in *Appendix 4 - Tables 37 and 38.*

All analysed studies were consistent in showing a benefit in switching to alemtuzumab, fingolimod or natalizumab compared with interferon or glatiramer acetate, depending on specific study comparators. Switching to alemtuzumab resulted in better outcomes in terms of relapses, with a lower annualized relapse rate (0.26 vs 0.52; p=0.0002) and a higher proportion of participants free from relapse (66% vs 47%; p<0.0001). Switching to alemtuzumab also resulted in a lower proportion of participants with disability worsening (13% vs 20%; p=0.02) and fewer participants with new or newly enlarging T2 lesions (46% vs 68%; p<0.00001) at 2 years after the switch, according to evidence with a moderate risk of bias (83). Moreover, a larger proportion of participants in the interferon group dropped out of the study due to any reason (8% vs 32%; p< 0.00001) and due to side effects (3% vs 7%, p=0.02).

Switching to fingolimod resulted in a 61% reduction in the annualized relapse rate, a 46-48% reduction in GAD lesion count and a 21-27% reduction in new or newly enlarged T2 lesions at 52 weeks in a study with a low risk of bias (111). Further evidence with a serious risk of bias, reported a longer time to relapse (360 vs 274 median days; p=0.006) and a lower annualized relapse rate (0.19 vs 0.51; p=0.0013) in the group that switched to fingolimod at 51 weeks (113). Finally, evidence from two studies with a moderate risk of bias showed consistent findings, with a greater time to relapse, a lower annualized relapse rate and a greater time to

EDSS progression at two years after the switch (114, 115). All these studies reported consistent results of a higher proportion of participants discontinuing the study due to any reason in the interferon/glatiramer acetate group than in the fingolimod group (112-115).

Switching to natalizumab resulted in a longer time to relapse and to disability worsening (HR=0.42, 95% CI, 0.24 to 0.71; HR=0.38, 95% CI, 0.20 to 0.71) at two years' post-switch, according to evidence with a serious risk of bias (118). The impact on annualized relapse rate, which held at two, three and four years, was confirmed by a later study with a moderate risk of bias (annualized relapse rate of 0.20 vs 0.58), but there was a disproportionately higher drop-out rate in the natalizumab group, which warrants caution when interpreting findings (117). Other studies with a serious risk of bias could not confirm the positive results on the annualized relapse rate (116) or on time to disability worsening (117). These studies reported little difference in the proportion of participants discontinuing due to adverse events (7% vs 5.8%) (118) or a longer time to treatment discontinuation in the natalizumab group (HR=0.40, 95% CI, 0.34 to 0.47) (117).

Quality assessment

Evidence obtained by RCTs was assessed for risk of bias using the 'Cochrane Risk of Bias tool'. There was a low risk of bias for sequence generation, allocation concealment, attrition and selective outcome reporting for all included trials. In two of the trials, there was a high risk of performance and detection bias since all patients, providers and assessors were aware of treatment allocation (83, 112), whereas in the third trial (111), the risk of bias was low since all participants, providers and assessors were blinded to treatment allocation. See *Appendix 4-Table 37* for further details on the quality assessment.

The cohort studies were assessed using the Cochrane tool for 'Risk Of Bias In Non-randomized Studies of - Interventions (ROBINS-I)', three were judged as having a moderate risk of bias (114, 115, 117) and three as having a serious risk of bias (113, 116, 118). The domain that most commonly had a high risk of bias was in the measurement of outcomes, as outcome assessors were not blinded to participant treatment. In two studies (113, 116), the authors did not report all outcomes specified in the paper and were therefore at a high risk of bias for selective outcome reporting. Five out of the six cohort studies (113-115, 117, 118) used propensity score matching to account for potential confounders, and one of them (118) reported differences at baseline between participants who switched to a second-line drug and those who switched to a different first-line drug. See *Appendix 4 - Table 38* for further details on the quality assessment.

Recommendations

R14. Offer a more efficacious drug to patients treated with interferon or glatiramer acetate who show evidence of disease activity assessed as recommended in questions 4-5 of this guideline. [strong]

R15. When deciding on which drug to switch to, in consultation with the patient, consider the following factors:
- Patient characteristics and comorbidities
- Drug safety profile
- Disease severity/activity
[consensus statement]

4.4 Treatment strategies if safety issues

Review question 7. In patients with relapsing MS who stop taking a highly efficacious drug, is there a risk of return and/or rebound of their disease activity (increased risk of relapses, disability progression and/or MRI activity)?

For review questions 6-8, the electronic database search identified 3,853 records. Of these, 3,771 studies were excluded based on their title/abstract and 82 studies were subjected to a full-text appraisal. After a full-text review and removal of duplicates, 19 studies met the eligibility criteria for this review. One study was an RCT (119); 12 were prospective cohort studies (120-131); and six were retrospective cohorts (132-137). In 15 studies, participants were receiving natalizumab before discontinuing treatment due to safety issues, whereas in one study, (126) participants were receiving fingolimod. The number of included participants ranged from 18 to 333 (mean: 83). Treatment strategies after discontinuation of the drug varied and mainly included the following: no treatment, corticosteroids, interferon/glatiramer acetate and fingolimod. There was also great variation in the length of wash-out, which ranged from one month to six months. The mean/median number of natalizumab doses received prior to the switch ranged from 19 to 41. Further study characteristics are presented in ***Appendix 4 - Table 39.***

Rebound

Rebound was generally described as a return of disease activity beyond that seen in the pre-treatment period; however, there were differences in definitions across the included studies, ranging from the general "change in the disease course with worsening of the disease activity beyond the pre-treatment levels" to the more specific "increase in disease activity following natalizumab interruption defined as at least four T1 GAD lesions more than in pre-natalizumab scans". Across 11 studies, two reported no evidence of rebound (122, 134), and one reported no

evidence of immune reconstitution inflammatory syndrome (127). The proportion of participants showing evidence of rebound ranged, in most of the studies, from 9-12% (125, 126, 130, 131, 136), whereas other authors reported higher rebounds, including 14% (135), 21.2% (133) and 38.3% (137).

Relapse outcomes

At 24 weeks after natalizumab cessation, there was a significant reduction in the annualized relapse rate between the pre-natalizumab period and the post-natalizumab period (2 vs 0.3; p=0.009), (127) and a reduction in the mean number of relapses (1.1 vs 0.07), although no p-values were reported (119), according to fair quality evidence. At 52 weeks after natalizumab discontinuation, several studies of fair to poor quality reported a statistically significant reduction in the annualized relapse rate compared with that during the pre-natalizumab period (130, 134, 136, 137) or described a reduction without statistical calculations (122, 125). However, other studies of fair quality reported no change in the annualized relapse rate and mean number of relapses between the two time periods (119, 133).

Treatment after natalizumab varied across these studies. Patients treated with fingolimod approximately 3 months after natalizumab cessation showed a significantly reduced annualized relapse rate, whereas those who received no treatment showed a return to the same relapse rate observed in the pre-natalizumab period, according to fair quality evidence (132). The length of wash-out prior to switching to fingolimod was described to have an impact on the proportion of participants relapsing, with 19.9% in wash-out up to three months, 31.1% for three to six months and 59.1% if wash-out was longer than six months (123). In some studies (123, 128, 131, 135), relapse was reported as a continuous outcome for the pre-natalizumab/fingolimod period and as a dichotomous outcome for the post-natalizumab/fingolimod period, so it was not possible to make a direct comparison between the two time periods.

MRI outcomes

Only 6 studies reported MRI outcomes in the pre-natalizumab and post-natalizumab period (120, 122, 125, 127, 130, 137), and the results were less consistent than those for relapses. The presence of any new or enlarging T2-weighted lesion or any GAD lesion at 52 weeks after discontinuation was described in 48% of participants who had interrupted natalizumab, compared with 54% in the pre-natalizumab period (122). Similarly, a small study (n=23) reported a reduction in the proportion of participants who had an active MRI scan in the post-natalizumab period (30%) at 15 weeks compared with that during the pre-natalizumab period (70%)(120). Various studies reported an increase in the mean number of GAD lesions in all

participants as a group during the pre-natalizumab period compared to that during the post-natalizumab period (125, 127, 130, 137).

Quality assessment

The study quality was assessed with the "Quality Assessment of Before-After (Pre-Post) Studies With No Control Group" tool developed by the National Heart, Lung, and Blood Institute and the Research Triangle Institute International. One study (122) was rated 'good'; 11 were rated 'fair', indicating some susceptibility to bias (119, 120, 123, 125, 127, 128, 130, 133, 134, 136, 137); and four were rated 'poor', indicating a significant risk of bias (126, 131, 132, 135). The main reasons for the 'fair' and 'poor' ratings were a lack of outcome assessor blinding, a lack of definition of outcomes, no power calculations and no statistical analyses for the pre- and post-drug periods. See *Appendix 4-Table 39* for further details on the quality assessment.

Review question 8. In patients with relapsing MS who stop taking a highly efficacious drug, what is the benefit of further treatment?

For review questions 6-8, the electronic database search identified 3,853 records. Of these, 3,771 studies were excluded based on their title/abstract and 82 studies were subjected to a full-text appraisal. After a full-text review and removal of duplicates, four studies met the eligibility criteria; three were prospective cohorts (130, 138, 139) (Alping 2016, Iaffaldano 2014, Sangalli 2014); one was an RCT (140) (Fox 2014); and participants in all the studies were receiving natalizumab before switching to other DMTs. The number of included participants ranged from 110 to 214 (mean: 166), and the length of the follow-up post-switch ranged from 28 to 52 weeks (mean: 44 weeks). Due to differences in study design and treatment groups post-switch, it was not possible to meta-analyse the data, and the results are reported narratively. Further details on the study characteristics are presented in *Appendix 4 - Table 40.*

Evidence from a single RCT with a high risk of bias indicated that fewer participants who stayed on natalizumab had relapses (4%) as compared to those who switched to placebo (17%) or to other therapies (20%) (interferon, glatiramer acetate, methylprednisolone) at 24 weeks' post-switch. Similarly, in the natalizumab group, no participants had disease recurrence (one new GAD lesion of >0.8 cm^3 or 2 or more GAD lesions of any size), compared with 46% in the placebo group and 37% in the other therapies group (140). Evidence from an observational study with a moderate risk of bias compared patients switching from natalizumab to fingolimod or to interferon/glatiramer acetate. The results showed a reduced risk of relapse (IRR=0.52, 95% CI, 0.37-0.74) and a lower proportion of patients showing disability worsening (11.4% vs 22.5%) in the fingolimod group at one year post-switch, with no significant difference between

groups in the time to disability worsening (HR=0.58, 95% CI, 0.26 to 1.31) (139). Additional evidence with a serious risk of bias indicated no significant difference between switching to fingolimod or to interferon/glatiramer acetate in the number of participants who were free from relapse (130). Finally, switching from natalizumab to rituximab resulted in a reduced risk of relapse compared to that associated with switching to fingolimod (1.8% vs 17.6%; HR=0.10, 95% CI, 0.02-0.43) and a lower proportion of participants with contrast-enhancing lesions (1.4% vs 24.2%; OR=0.05, 95% CI, 0.0-0.22), according to evidence with a moderate risk of bias (138).

Quality assessment

According to the Cochrane tool for 'Risk Of Bias In Non-randomized Studies of - Interventions (ROBINS-I)', two of the observational studies (139) [Alping 2016 and Iaffaldano 2015] were judged as having a moderate risk of bias, and the third one (130) was judged as having a serious risk of bias. All three observational cohort studies had a high risk of bias for outcome measurements, as outcome assessors were not blinded to participant treatment. There was no clear evidence of selection bias, and it was unclear how many participants dropped out of the studies. Only Apling 2016 and Iaffaldano 2015 used propensity score matching to account for potential confounders. The RCT (140) was judged as having a high risk of bias. There was a high risk of performance and detection bias since all patients, providers and assessors were aware of treatment allocation. There was an unclear risk of bias for missing outcome data, as the authors reported study drop-out only for 52 weeks' follow-up, and outcomes were reported only at 24 weeks. There was a low risk of bias for sequence generation and allocation concealment. See *Appendix 4-Table 40* for further details on the quality assessment.

Recommendations

R16. When treatment with a highly efficacious drug is stopped, either due to inefficacy or safety concerns, consider starting another highly efficacious drug. When starting the new drug, take into account the following factors:
- disease activity (clinical and MRI), the greater the activity, the higher the urgency to start new treatment
- half life and biological activity of the previous drug
- the potential for resumed disease activity or even rebound (particularly with natalizumab)
[consensus statement]

R17. In treatment decisions, consider the possibility of resumed disease activity or even rebound when stopping treatment, particularly with natalizumab.

[weak]

4.5 Long-term treatment

Review question 9. In patients with relapsing MS treated with a DMD that remain stable over a long time period, what is the benefit of continuing treatment compared to stopping?

The electronic database search for this question identified 3,066 records. After removal of duplicates, 3,014 studies were excluded based on their title/abstract. After a full-text review, one study was excluded, and only one prospective cohort study met the eligibility criteria (141). It included patients treated with interferon or glatiramer acetate for at least three years without relapses for at least five years and compared those patients who stopped versus those who continued treatment using propensity score matching. At the study baseline, the mean age was 44 years, and the mean EDSS score was 3.5. The reason for treatment discontinuation was recorded only in 40% of the group (26.2% medication intolerance, 23.8% lack of improvement, 13% adverse event, and 11% disease progression). There was little difference between the groups in the proportion of participants who relapsed (36% vs 37.8%) and in the time to relapse (HR=1.07, 95% CI, 0.84-1.37; p=0.584), according to evidence with a moderate risk of bias. There was a longer time to disability progression in the group of participants who continued treatment than in those who discontinued (HR=1.47, 95% CI, 1.18-1.84; p=0.001) (141).

Quality assessment

According to the Cochrane tool for 'Risk Of Bias In Non-randomized Studies of - Interventions (ROBINS-I)', the study was judged to have a moderate risk of bias overall. This was due to an unclear risk of attrition because the authors did not report whether any data were missing. There was a moderate risk of detection bias as it was not possible to blind treatment discontinuation.

Recommendations

R18. Consider continuing a DMD if a patient is stable (clinically and on MRI) and shows no safety or tolerability issues.
[weak]

4.5 Treatment in special situations: pregnancy

Review question 10. In women with MS treated with DMDs who wish to start a pregnancy or who have an unplanned pregnancy, what should be the therapeutic approach?

For this question, an existing systematic review (142) was used to locate studies published prior to 2012, and eight studies met the eligibility criteria. These studies were supplemented by an electronic database search, which identified 808 records published between January 2012 and December 2016, and of these, 787 studies were excluded based on their title/abstract and 21 studies were subjected to a full-text appraisal. After a full-text review and removal of duplicates, 14 studies met the eligibility criteria for this review, resulting in a total of 19 available studies. Due to differences in study design and included populations, it was not possible to meta-analyse any data, and the results are reported narratively. Further study characteristics are presented in *Appendix 4 - Table 41.*

Several studies investigated the impact of exposure to interferon beta and/or glatiramer acetate (143-157), while fewer and more recent ones explored the effect of natalizumab (158-160), dimethyl fumarate (161), teriflunomide (162) and fingolimod (163). In most studies, women were classified as being exposed to a DMT, provided the last dose/injection of drug was administered after the last menstrual period before conception. Participants were recruited through patient registries, MS centres and clinical trials and from pharmaceutical companies' global pharmacovigilance databases. The number of included pregnancies ranged from 35 to 445 (mean: 206).

Exposure to interferon and/or glatiramer acetate

Regarding exposure to interferon, a study with a moderate risk of bias indicated no significant difference between groups (exposed vs non-exposed) in the proportion of infants born with low birth weight (OR=1.14, 95% CI 0.41 to 3.15, p=0.803) (164). This was confirmed in two additional studies with a serious risk of bias (144, 154). For spontaneous abortion, evidence with a serious risk of bias due to low numbers indicated a higher proportion of women with spontaneous abortion in the exposed group (143, 144, 154, 164). The proportion of infants with congenital malformations was higher in the exposed group (9% vs 5%)(144) but was not confirmed in a later study showing a higher risk in the unexposed group (3.1% vs 5.5%) (164). These comparisons were based on a small number of participants and should be interpreted with caution. For glatiramer acetate, evidence with a moderate risk of bias (n=246) indicated a higher number of spontaneous abortions in the exposed group than in the unexposed group (8.6% vs 6.3%); however congenital malformations were reported to be higher in the unexposed group (6.7% vs 2.2%)(152). Seven additional studies included women who were exposed to interferon or glatiramer acetate; in three of these studies, the exposure groups were combined (142, 146, 148), whereas in four they were separated, resulting in three armed studies (149-151, 157). There are inconsistent findings between the different studies regarding low birth weight,

spontaneous abortion and congenital malformations. Further details of the study results are presented in *Appendix 9 - Table 4.*

Exposure to natalizumab

One study with a serious risk of bias compared exposure to natalizumab with interferon or glatiramer acetate and suggested little difference between the groups in the proportion of infants born with low birth weight but a higher risk of spontaneous abortion in the group exposed to interferon or glatiramer acetate (21.1% vs 17.4%) and a higher proportion of infants with congenital malformations in the group exposed to natalizumab (3.9% vs 1.4%) (158). Compared to women who were not exposed to DMDs, evidence with a serious risk of bias indicated a higher proportion of women experiencing a spontaneous abortion in those exposed to natalizumab but a higher proportion of infants born with a congenital malformation in the unexposed group (160). Further details of the study results are presented in *Appendix 9 - Table 4.*

Exposure to other disease-modifying treatments

Three studies with a serious risk of bias compared pregnancy outcomes in women who had unplanned conceptions whilst receiving dimethyl fumarate (161), fingolimod (163) and teriflunomide (162) during clinical trials with those who had received placebo. In both the fingolimod and teriflunomide studies (162, 163), the placebo groups could not be considered, as there were very few participants. Among the women receiving fingolimod, 24% experienced a spontaneous abortion, and 5% of live births resulted in infants with a congenital malformation. For the women exposed to teriflunomide, 18.8% had a spontaneous abortion, and out of 27 live births, there were no malformations. The only study with a control group suggested a higher proportion of pregnancies resulting in spontaneous abortion in the placebo group (15.4%) than in the dimethyl fumarate-exposed group (7.7%)(161). Further details of study results are presented *Appendix 9 - Table 4.*

Quality assessment

According to the Cochrane tool for 'Risk Of Bias In Non-randomized Studies of - Interventions (ROBINS-I), all cohort studies that included an exposed and unexposed group, except four (152, 153, 157, 164), were judged as having a serious risk of bias. Confounding and outcome measurement were the domains that most commonly had a high risk of bias, as outcome assessors may have been aware of participants' exposure to DMTs. The risk of selective outcome reporting could not be assessed because no study protocols were available. The classification of participants as exposed or unexposed was not a problem in several studies (148,

149, 152-154, 157, 158, 160-164) as exposed status was clearly defined, and classification was unlikely to have been affected by knowledge of the outcomes as they were measured prospectively. However, in some studies, information used to define DMT exposure was recorded retrospectively after delivery and, therefore, infant outcomes may have biased recall of prior exposure. This issue resulted in a serious risk of bias (143, 146, 150, 154) or a moderate risk of bias (144, 151) in this domain. For the five cohort studies that included only an exposed group, three were rated as moderate quality (145, 147, 159) and two as poor quality (155, 156) according to the NIH Quality Assessment Tool for Before-After (Pre-Post) Studies With No Control Group.

Recommendations

R19. Advise all women of childbearing potential that DMDs are not licensed during pregnancy, except glatiramer acetate 20 mg/ml.

[consensus statement]

R20. For women planning a pregnancy, if there is a high risk of disease reactivation, consider using interferon or glatiramer acetate until pregnancy is confirmed. In some very specific (active) cases, continuing this treatment during pregnancy could also be considered.

[weak]

R21. For women with persistent high disease activity, it would generally be advised to delay pregnancy. For those who, despite this advice, still decide to become pregnant or have an unplanned pregnancy:

- treatment with natalizumab throughout pregnancy may be considered after full discussion of potential implications.

- treatment with alemtuzumab could be an alternative therapeutic option for planned pregnancy in very active cases, provided that a 4-month interval is strictly observed from the latest infusion until conception.

[weak]

Guideline update

The present guideline will be updated in five years. In the case of major changes in the evidence on the existing benefits and harms of included interventions or if new interventions become available this update could be approached earlier.

Conflicts of interest *(Appendix 11)*

Author contributions

XM, RG and AT had a leading role in the inception process with key involvement in the following tasks: production of an initial proposal of the guideline scope, aim and questions to be included; outcome prioritization process; revision of the evidence analysis results provided by the analysts; proposal of a first draft of recommendations to be agreed by the whole working group and writing the final manuscript.

SO coordinated the methodological process, the flow of materials and communications to ensure that all tasks were accomplished. She had a supervision role over the literature search, trial selection, data extraction and evidence analysis. She participated in writing the final manuscript.

EM perfomed the literature search, trial selection and data extraction, assessment of the risk of study bias and production of summary and GRADE tables.

SP has directed the literature search, study selection and data extraction as well as the evidence analysis process and participated in the consensus reaching process.

MPA, DC, MC, GC, TD, FF, HPH, EH, BH, LK, RL, CL, DHM, TO, KS, AS, PSS, MPS, CT, HW, FZ participated in the planning of the guideline, formulation of guideline questions and outcome prioritization. They reviewed the study selection and the analized evidence, and participated in the consensus finding process.

All authors reviewed the manuscript prior to submission.

Online material (Appendix 1 to 10)

Appendix 1 - Review protocols

Appendix 2 - Search Strategies

Appendix 3 - Excluded studies

Appendix 4 - Characteristics of included studies

Appendix 5 - GRADE tables

Appendix 6 - Forest plots

Appendix 7 - Additional safety data

Appendix 8 - Results of the extension studies

Appendix 9 - Descriptive results tables

Appendix 10 – Results of the consensus process

Appendix 11 – Register of interest forms

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