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EXTENDED REPORT

Consensus statement on blocking the effects of interleukin-6 and in particular by interleukin-6 receptor inhibition in rheumatoid arthritis and other inflammatory conditions

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ABSTRACT

Background Since approval of tocilizumab (TCZ) for treatment of rheumatoid arthritis (RA) and juvenile idiopathic arthritis (JIA), interleukin 6 (IL-6) pathway inhibition was evaluated in trials of TCZ and other agents targeting the IL-6 receptor and ligand in various RA populations and other inflammatory diseases. This consensus document informs on interference with the IL-6 pathway based on evidence and expert opinion.

Methods Preparation of this document involved international experts in RA treatment and RA patients. A systematic literature search was performed that focused on TCZ and other IL6-pathway inhibitors in RA and other diseases. Subsequently, incorporating available published evidence and expert opinion, the steering committee and a broader expert committee (both including RA patients) formulated the current consensus statement.

Results The consensus statement covers use of TCZ as combination- or monotherapy in various RA populations and includes clinical, functional and structural aspects. The statement also addresses the second approved indication in Europe JIA and non-approved indications. Also early phase trials involving additional agents that target the IL-6 receptor or IL-6 were evaluated. Safety concerns, including haematological, hepatic and metabolic issues as well as infections, are addressed likewise.

Conclusions The consensus statement identifies points to consider when using TCZ, regarding indications, contraindications, screening, dose, comedication, response evaluation and safety. The document is aimed at supporting clinicians and informing patients, administrators and payers on opportunities and limitations of IL-6 pathway inhibition.

SCOPE AND PURPOSE

The treatment of rheumatoid arthritis (RA) has significantly advanced over the past decade with the recent optimisation of the use of synthetic disease modifying anti-rheumatic drugs (sDMARDs), such as methotrexate (MTX),[1 2] newly developed sDMARDs, such as leflunomide,[3 4] and with the addition of biological DMARDs (bDMARDs) to the RA therapeutic armamentarium. The first bDMARDs studied and subsequently approved were inhibitors of tumour necrosis factor (TNFi),[5 6] followed by abatacept, an inhibitor of T-cell costimulation,[7] rituximab, an agent leading to B-cell depletion[8] and tocilizumab (TCZ), an interleukin 6 (IL-6) receptor blocker. Although there is little direct comparison data between the five currently approved TNFi (adalimumab, certolizumab pegol, etanercept, golimumab and infliximab) or other bDMARDs, reviews and meta-analyses of clinical trial data suggest these compounds have similar efficacy.[9–12] They differ in terms of molecular structures (chimeric, humanised or human monoclonal antibodies, or recombinant receptor constructs), route of application (intravenous or subcutaneous), and adverse event profiles, with these differences determined by the agents' modes of action. In contrast to bDMARDs, the modes of action of sDMARDs are generally not well-understood, their adverse event profiles are mostly different and their costs are substantially lower.

Given the variety of available therapies and in light of the variability discussed above, recommendations for the management of RA have been developed.[13 14] However, these recommendations, despite their sophisticated and quite comprehensive nature, capture only parts of the complexity of the application of individual drugs. Therefore, consensus statements on the use of groups of agents or individual classes of agents have been developed, providing pertinent information for various stakeholders.[15 16] Developing recommendations for individual classes of drugs may bear the value of

providing more detailed information on a particular agent than can usually be offered by more general presentations. This is especially true for describing the safety aspects of certain therapeutics, but can also be true for deliberations with regard to efficacy.

In the present manuscript, inhibition of the effects of IL-6 was the focal point of a consensus activity. Interference with IL-6 is currently possible by using TCZ, a humanised monoclonal antibody directed against the IL-6 receptor (IL-6-R), but other compounds, such as another antibody targeting the IL-6R and several agents focusing on the cytokine IL-6 itself, are currently in development.[17–20]

An international group of experts and patient representatives experienced in clinical research, the use of biological agents and the development of consensus statements and treatment recommendations, convened in Vienna in March 2012 to develop a consensus statement on the current use of IL-6 pathway inhibition in rheumatology. This statement targets primarily those health professionals who prescribe IL-6 inhibition related therapies, health professionals who do not primarily prescribe the agent but care for patients treated with TCZ, as well as patients interested in information on IL-6R or IL-6 inhibition. In addition, this document may also be informative to payers, hospital managers, administrators and other stakeholders interested in treating RA and other chronic inflammatory diseases.

The consensus statement will address the following areas:

- Background on IL-6 and mode of action of TCZ and other compounds
- Indication, considerations and screening for initiating TCZ in RA
  - Treatment dose algorithm and co-medication
  - Evaluation of response and management of response
  - Predictive factors of response
  - Contraindications and adverse events
  - Long-term exposure—efficacy and safety issues
- Patient perspectives
- Research agenda

To achieve these objectives, a systematic literature review (SLR) of the published literature on the efficacy and safety of TCZ and steering other biologicals inhibiting the IL-6 pathway in patients with RA was first undertaken to identify relevant data, which also included abstracts of recent international conferences, such as the European League Against Rheumatism (EULAR) and American College of Rheumatology (ACR) meetings of 2011 and abstracts known to be submitted to EULAR 2012 to be used and referenced if accepted for presentation. The results of this SLR[21] were presented to and discussed by the committee, providing the basis for the discussions of the large task force and the conclusions that will be presented herein. Levels of evidence will be indicated next to each recommendation, in line with published guidelines (see also online supplement).[22]

BACKGROUND

IL-6 is a small polypeptide of approximately 26 kD molecular weight that is involved in the differentiation and growth of a variety of cells.[23 24] It has originally been described as B-cell stimulating factor, hepatocyte stimulating factor and interferon β2, before it was cloned[23 24] and shown that all these activities were attributable to a single molecule which did not convey antiviral actions. IL-6 binds to a receptor (IL-6R), which consists of the actual cytokine binding part, the IL-6Rα chain, and a second moiety, gp130, which transduces the respective signals into the cell. A number of recent reviews have covered its mode of action and related aspects in detail, and the reader is referred to these and similar publications.[23–27] More detailed insights are also summarised in the online supplementary files.

TCZ, a humanised anti-IL-6R antibody directed to the IL-6Rα chain, is currently the only IL-6 pathway inhibitor licensed for the treatment of RA, and the evidence available on safety and efficacy therefore rests almost exclusively on information related to this agent. However, other IL-6 inhibiting therapies are currently in development and phase 2 data already partly available; this information is also included in our analysis.

MODE OF ACTION

Inhibition of the effects of IL-6 has been primarily studied in a number of phase II and III clinical trials of TCZ. The original designation of the antibody was myeloma receptor antibody, since IL-6 is a growth factor for myeloma cells. TCZ showed initial clinical efficacy in collagen-induced arthritis in monkeys;[28] in a rare lymphoproliferative disorder, Castleman's disease;[29 30] and also in early phase evaluations in RA.[29 31–34] Its effects on acute phase reactant (APR) levels and other features of chronic inflammation are fully in line with inhibition of the above-mentioned modes of action of IL-6. However, it is currently unknown if cells to which an anti-IL-6R antibody binds, are lysed, undergo apoptosis, are ingested by phagocytes of the spleen or others, or simply circulate with their receptor being blocked. It is also unknown if binding of such antibodies to the receptors might lead to cap formation and subsequent ingestion of the IL-6R. These questions need to be addressed as part of the research agenda.

RECOMMENDATION FOR THE USE OF TCZ

Indication, considerations and screening for initiating TCZ in RA

Indication

Adult RA

In line with the current licensed indication in Europe, TCZ may be used in adult patients with active RA, normally with at least moderate disease activity according to a validated composite measure, who have had an inadequate response to, or intolerance of at least one synthetic DMARD and/or TNF-inhibitor.[35]

Before concluding that a patient has not sufficiently responded to a previous synthetic DMARD or a TNF-blocker, attempts should be made to improve the ongoing regimen by optimising the respective DMARD or TNF-blocker dose, if indicated, considering pertinent recommendations.[14]

TCZ fulfilled the requirements for the above indications as a consequence of the results of several clinical trials (level 1a, grade A). In table 1A, the response rates according to the ACR improvement criteria[36] as observed in phase III clinical trials are depicted, showing superiority to control arms in all studies. A significant decrease in the disease activity score using 28 joint counts (DAS28) and high proportions of EULAR moderate and good response as well as DAS28 remission (DAS28<2.6) rates have been observed. However, interpretation of the LATTER data is impeded by the high weight of the APR component in the DAS28 formula[37 38] and the prominent effect of IL-6 inhibition on the hepatic APR production, which can lead to exaggerated improvement or response rates when this measure is employed. Nevertheless, the pre-eminent requirement of improvement in both swollen and tender joints to fulfil ACR improvement criteria[36] and the published clinical trial data showing a decrease in disease activity across all variables studied as well as functional improvement and structural

Table 1A ACR20, 50 and 70% response rates (% of patients fulfilling improvement criteria) and percentage of HAQ change from baseline or fulfilment of HAQ-MCID (reduction of more than 0.22) in different clinical trials of TCZ

FU	Study	% of patients fulfilling ACR20	% of patients fulfilling ACR50	% of patients fulfilling ACR70	HAQ-decrease from baseline (%)	Comment
TCZ combination therapy						
16 weeks	CHARISMA[33] 7 arms, escalating doses of TCZ monotherapy (2 vs 4 vs 8 mg/kg) versus each dose in combination with MTX Results for 8 mg/kg combination therapy versus MTX	74/41	53/29	37/16		MTX-IR
24 weeks	OPTION[40] PL/TCZ 4/TCZ 8 mg/kg	26/48/59	11/31/44	2/12/22	21/33/34	MTX-IR
	TOWARD[41] PL/TCZ 8 mg/kg	25/61	9/38	3/21	13/33*	MTX/DMARD-IR†
	RADIATE[42] PL/TCZ 4/TCZ 8 mg/kg	10/30/50	4/17/29	1/5/12	0/18/23	Anti-TNF-IR
	ROSE[43] PL vs TCZ 8 mg/kg		11/30			DMARD-IR†
52 weeks	LITHE[44]‡ PL/TCZ 4/TCZ 8 mg/kg	25/47/56*	10/29/36*	4/16/20*	26/35/39*	MTX-IR
TCZ monotherapy						
12 weeks	Japanese[34] PL/TCZ 4 vs 8 mg/kg	11/57/78	2/26/40	0/20/16		DMARD-IR
16 weeks	CHARISMA 7 arms, escalating doses of TCZ monotherapy (2 vs 4 vs 8 mg/kg) versus each dose in combination with MTX Results for 8 mg/kg monotherapy vs MTX	63/41	41/29	16/16		MTX-IR
24 weeks	AMBITION[45] MTX/TCZ 8 mg/kg	53/70	34/44	15/28	33/44	
	ACT-RAY[46 47] TCZ 8 mg/kg/TCZ 8 mg/kg +MTX	70/72	40/46	25/25	33/33*,§	MTX-IR, switch to vs adding TCZ; LDA and DAS28-REM were more frequent on combination than TCZ mono-therapy
	SATORI[48] MTX/TCZ 8 mg/kg	25/80	11/49	6/30	25/50*	MTX-IR
	ADACTA,[49] TCZ 8 mg/kg/ adalimumab 40 mg	65/49	47/28	33/18	n.a.	Adalimumab monotherapy
52 weeks	SAMURAI[50] DMARDs/TCZ 8 mg/kg	34/78	13/64	6/44	10/50*	DMARD-IR
Other IL-6 or IL-6R inhibitors (phase II; week 12)						
12 weeks	*Anti-IL-6R*					
	Sarilumab[20 51] PL/150 mg	46/72	n.a.	n.a.	n.a.	
	Anti-IL-6					
	BMS945429[19] PL/active	36/82¶	15/50	6/43	29/39	
	Sirukumab[17] PL/active	30/63¶	3/27	n.a.	n.a.	
	Olokizumab[18]	n.a.	n.a.	n.a.	n.a.	

*Estimated values using baseline data and approximate values from respective curves, since exact data not provided in the publications.
†DMARDs aside from MTX: sulfasalazine, leflunomide, antimalarials and other.
‡1 year data.
§Differences between groups in ACT-RAY not significant; all other studies showed significant differences from control; where studied, 4 mg/kg dose was also significantly different from control; details see individual publications.
¶Highest response rate among several arms.
ACR, American College of Rheumatology; DMARDs, disease modifying antirheumatic drugs; DAS-28, disease activity score using 28 joint counts; FU, weeks of follow-up; HAQ, Health Assessment questionnaire disability index; IR, insufficient response; LDA, low disease activity; MCID, minimally clinically important difference; MTX, methotrexate; n.a., not available; PL, placebo; TCZ, tocilizumab; TNF, tumour necrosis factor; for trial acronyms see respective publications.

effects (table 1B), provide evidence that TCZ is an effective biological disease modifying drug. Indeed, when focusing on the clinical disease activity index (CDAI), a score that does not comprise an APR in its formula, TCZ remains significantly effective.[39] Its efficacy appears to be of similar magnitude as that of TNF-inhibitors, abatacept and rituximab.[9]

TCZ has shown superior efficacy compared with control groups in the treatment of RA manifestations in combination with MTX and other sDMARDs; TCZ was assessed mostly in combination with MTX, but in some studies up to 20% of the patients received other sDMARDs like leflunomide, sulfasalazine and/or chloroquine/hydroxychloroquine without noticeable differences in efficacy.[41 52] TCZ was also effective as monotherapy. Studies of other biologicals employed as monotherapy mostly revealed similar efficacy as MTX and had generally less efficacy than combination therapy.[10 12 14] By contrast, TCZ monotherapy has been shown in Japanese and an international trial to convey significantly better efficacy compared with MTX (in MTX naïve or MTX never failed patients) or other DMARDs in clinical, functional and, in the SAMURAI trial, also structural respects, although it should be borne in mind that in the Japanese studies MTX was dosed at only 8 mg weekly (level 1b, grade A; table 1A).[45 48 50] A recent trial comparing TCZ monotherapy with adalimumab monotherapy (ADACTA trial) revealed clinical superiority of TCZ.[49] While this finding is not surprising given the fact that adalimumab monotherapy was not shown to be clinically superior to MTX monotherapy in early RA[53] (and TCZ monotherapy was not compared with a combination of ADA+MTX), the data implicitly confirm the previous findings on the efficacy of TCZ monotherapy compared with DMARDs studied hitherto.[45 48 50] For monotherapy, the 8 mg/kg dose is the only one studied in phase 3 trials.

Adding TCZ to MTX (combination therapy) compared with switching from MTX to TCZ monotherapy (withdrawal of MTX) failed to convey superior clinical and structural effects in

Table 1B Radiographic changes in TCZ clinical trials assessing joint damage

Study	Placebo+MTX	4 mg/kg+MTX	8 mg/kg+MTX	8 mg/kg mono-therapy	DMARDs	Assessment
LITHE†[44]	1.13	0.34*	0.29*			GTSS, mean change from baseline
SAMURAI†[50]				2.3 (1.5–3.2)**	6.1 (4.2–8.0)	vdH-TSS, mean (95%CI) change from baseline
ACT-RAY†[46]			0.08 (1.88)	0.22*** (1.11)		Change of GTSS at 6 months; mean (SD)
ACT-RAY†[47]			92.4%	85.5%****		No radiographic progression at 1 year

*p<0.0001; **p<0.001; ***p=0.26; ****p=0.007; using as a cutoff the smallest detectable change of the Genant modified Sharp score of 1.5 (a relatively high value as a cutoff for non-progression; data on lower values, such as 0 or 0.25 are awaited).
†The LITHE and SAMURAI data, including p values, relate to 1 year study results; for ACT-RAY, data shown reflect 6-month analyses which showed no significant differences between TCZ monotherapy and combination with MTX.
DMARDs, disease modifying antirheumatic drugs; GTSS, Genant-modified total Sharp score; MTX, methotrexate; TCZ, tocilizumab; vdH-TSS, van der Heijde modified total Sharp score.

patients with established RA and active disease despite MTX treatment for most endpoints (ACT-RAY trial; table 1A).[46] Thus, these data further imply that monotherapy is effective and is not significantly inferior to combination therapy. However, many of the assessments showed better numerical outcomes in the combination therapy; moreover, at 6 months and 12 months, significantly more patients achieved DAS28 low disease activity or remission, respectively, and less patients had progression of joint damage on combination therapy compared with monotherapy.[47] Thus, while TCZ monotherapy is superior to MTX monotherapy, a number of patients may benefit from the combination more than from switching to monotherapy. However, if combination with MTX or other DMARDs is contraindicated and monotherapy with a biological agent is mandated, TCZ should be considered. In light of all of the above aspects, a 3-arm trial comparing MTX, TCZ and the combination in early RA is still awaited to clarify these questions.

Throughout all studies assessing a 4 mg/kg and an 8 mg/kg dose in combination with MTX, both doses had significantly better efficacy than control regarding clinical functional and structural outcomes,[44 40 42] but there was a consistent (though statistically not significant) clinical superiority of the higher dose (table 1A), which was particularly prominent for more profound levels of efficacy (eg, ACR70) and in patients who have failed TNFi; these data suggest that many patients receiving TCZ at 4 mg/kg will have only a limited, inadequate response and a majority no profound response (level 1c, grade A). Trials investigating an increase to 8 mg/kg after a starting dose of 4 mg/kg, as currently recommended in the US, have not been systematically performed, although in the clinical trials evaluating the 4 mg/kg dose, rescue therapy with 8 mg/kg had been implemented in patients who did not achieve at least 20% improvement in tender and swollen joint counts by week 16;[44 40 42] moreover, in a post-hoc analysis TNFi-insufficient responders (IR) and MTX-IR patients not achieving an adequate response to TCZ 4 mg/kg by week 16 showed improvement after escalation to 8 mg/kg.[54] Importantly, the rate of anaphylactic reactions appears to be several fold higher at the 4 mg/kg than at the 8 mg dose of TCZ (see below).[55] A lower dose than 4 mg/kg is not recommended because of its insufficient efficacy and even higher risk of immunogenicity.[33] In general, based on the available data, the task force felt that starting combination therapy with a dose of 8 mg/kg and possibly decreasing the dose when necessitated by adverse events may be more appropriate than starting at 4 mg/kg due to the better efficacy and lesser immunogenicity of the higher dose; clinical and laboratory monitoring is necessary at either dose.

TCZ has also shown significant effects on retarding progression of joint damage, both in combination as well as monotherapy;[50 46 44] structural efficacy was observed at both 4 mg/kg and 8 mg/kg, where studied (table 1B). Moreover, TCZ inhibited x-ray progression in patients with low as well as persistent high clinical disease activity, thus dissociating the tight link between disease activity and joint damage, as also seen with TNF-blockers.[56] TCZ is effective across all populations investigated, that is, established and early RA; MTX-naïve,[45] DMARD-IR[33 41 52 48 46 44 40] and TNFi-IR[42] patients (level 1a to 1b, grade A). No differences in efficacy were seen between patients positive or negative for rheumatoid factor.[52 57]

In line with its mode of action, TCZ leads to a rapid reduction in APR, including C-reactive protein (CRP) levels, which is sustained at the 8 mg/kg dose; in contrast, with 4 mg/kg CRP decreases are not maintained throughout the 4 week time course and this saw tooth pattern suggests an inadequate suppression of the pathway at this dose.[41 44 40 42] Further, TCZ leads to an increase in haemoglobin levels, especially in RA patients with anaemia, presumably by inhibiting the production of hepcidin, a molecule stimulated by IL-6 and involved in the pathways to anaemia of chronic disease;[58] it may be thus useful in RA patients with otherwise refractory anaemia of chronic disease. The adverse event profile will be discussed in detail in subsequent sections.

Considerations for initiating treatment

Before starting any treatment for RA in general and thus also TCZ, an individual therapeutic goal should be determined as a shared decision between the patient and the treating physician, who should be experienced in the diagnosis and treatment of RA as well as the use of biological therapies and their complications[14 59] (level 5, grade D). Several studies have shown that RA patients cared for by physicians experienced in the management of their disease, thus primarily rheumatologists, have better outcomes than those followed by less specialised physicians.[60 61] Patients to whom the rheumatologist suggests treatment with TCZ should have at least moderate disease activity by composite scores, such as the DAS28 (>3.2), the Simplified or CDAI (SDAI>11; CDAI>10) or similar scores[62] (level 5, grade D). A raised CRP is also preferable.

In the phase III trials, TCZ was started in patients with an inadequate response to sDMARDs[41 44 40] or also TNFi.[42] TCZ was used in combination with sDMARDs, primarily MTX, or as monotherapy.[33 45 50 46 44] When TNFi preceded TCZ therapy, requirements for time of discontinuation were different among prior agents: for etanercept it was at least 2 weeks, while for adalimumab and infliximab at least 8 weeks.[42] In an open label phase IV study, TCZ therapy was used within 1 month of stopping TNFi without any increases in serious infections or other safety signals.[63] In clinical practice it is likely that TCZ will be frequently applied earlier than after such intervals; however there are no available data supporting the safety of TCZ in such cases.[64] Of note, TCZ has not yet

been studied in patients who had been previously exposed to rituximab or abatacept, although data from an observational study of small cohorts suggest some risk of infections in its use after rituximab. Thus, more information will have to be obtained from further trials or soon become available from registries. Data from registries of patients receiving TCZ are currently limited,[65] but the registries will provide additional information on the use of co-medications or patients treated in the presence of comorbidities that were excluded from clinical trials, as patients in clinical practice are usually more heterogeneous in these respects compared with trial populations.

Screening before initiating TCZ

In general, patients should be well informed about the risks and benefits of TCZ therapy (level 5, grade D).

Initiation of TCZ should be preceded by obtaining a detailed history regarding chronic or recent co-morbidity, such as cardiovascular, liver and pulmonary diseases, recurrent infections, allergies, gastrointestinal perforations or diverticulitis, pregnancy or plans to become pregnant, and a complete physical examination to consider possible contraindications in all patients, especially the elderly. Special attention should be paid to vaccinations which should be performed in accordance with respective recommendations ideally before the administration of TCZ.[66] During TCZ therapy vaccination with live vaccines (which includes rubella and shingles vaccines) should be avoided (level 5, grade D).

A history of diverticulitis (note, not diverticulosis) should alert the patient and treating physician, to a heightened risk of gastrointestinal perforations during TCZ therapy. Gastrointestinel (GI) perforations have been reported (incidence 0.1–0.2%), especially in patients with such history[35 55 67] (level 4, grade C), although most were on glucocorticoids or non-steroidal antirheumatic drugs (NSAIDs). Indeed, recent data indicate that RA patients, regardless of DMARD therapy, have a generally increased rate of GI perforation including both the upper and lower GI tract, and the risk factors for this complication are glucocorticoid therapy, NSAIDs, and diverticulitis history among others.[68] At this time, further information is needed to understand whether TCZ or other IL-6 inhibitors further increase the risk of this complication beyond that observed in the general RA population. Until then, however, when IL-6 blocking therapy is prescribed in such patients, efforts to eliminate or mitigate known risk factors for perforation should be undertaken where possible, and vigilance for this potential complication should be maintained.

In clinical trials of TCZ, patients with RA were screened for hepatitis B and C and excluded if testing positive. Likewise, patients were excluded if they had active liver disease, indicated by screening and baseline concentrations of alanine or aspartate aminotransferase of 1.5 times the upper limit of normal (ULN) or more. Of note, hepatic transaminase increases occurred more frequently when TCZ was used in combination with MTX as compared to monotherapy. The safety of TCZ in patients with active hepatitis B or C virus (HBV, HCV) infections is currently unknown. Clearly, in the presence of acute viral hepatitis TCZ therapy is contraindicated. Also, in patients with chronic hepatitis B with poor liver function, TCZ therapy is not recommended. In Japan, several case reports have been published in which two HBV patients, in the context of concomitant antiviral therapy, and one HCV patient were successfully treated with TCZ,[69–72] and in a postmarketing surveillance report no hepatobiliary disorders due to reactivation of hepatitis B or C have been seen[73] (level 4, grade C). Thus, in patients with chronic hepatitis B and moderate to good liver function, treatment with antiviral agents should be performed before considering TCZ therapy. In HBV carriers or in patients with latent HBV infection (ie, HBs antigen negative, HBc or HBs antibody positive) who show positive HBV DNA in peripheral blood, prophylaxis should be considered before starting TCZ. Thus, until further safety data are collected, TCZ treatment in patients with chronic viral hepatitis can currently not be recommended without antiviral prophylaxis in case of hepatitis B,[71] especially since reactivation of viral hepatitis has been reported for other biological agents, such as TNF-inhibitors, abatacept and rituximab[74–77] (level 5, grade D).

While preclinical studies have not clearly defined the role of IL-6 in the defence against *Mycobacterium tuberculosis*,[78] the occurrence of tuberculosis has been reported in clinical trials and postmarketing surveillance studies of TCZ[73 79] (level 4, grade C) and, therefore, patients should be screened for latent tuberculosis according to local recommendations in the same manner as for other biologicals; in the pivotal clinical trials patients had been screened for tuberculosis. Chemoprophylaxis prior to TCZ initiation should be given in patients diagnosed with latent tuberculosis infection (level 5, grade D). Patients with active tuberculosis are contraindicated for treatment with TCZ.

Glucocorticoid therapy should be recorded and minimised or tapered as rapidly as possible, since there are indications that the risk of serious infections including opportunistic infections is higher in TCZ treated patients with concomitant glucocorticoid therapy than in those without[73] (level 4, grade C).

Regarding safety during and after pregnancy, currently only limited data exist;[80 81] there is no apparent evidence that IL-6 plays a role in fertility or gestation or TCZ leads to malformations, though IgG antibody transmission across the placenta has been demonstrated with other biological agents. Nevertheless, women of childbearing potential should use effective contraception during and until 3 months after cessation of therapy. Currently it cannot be suggested to continue TCZ therapy in women who become pregnant because only insufficient safety data exist; on the other hand, therapeutic abortion relies on a thorough discussion between the physician and the mother. Also, breast-feeding should not be done during TCZ therapy (level 5, grade D).

Administration of TCZ in combination therapy and monotherapy

TCZ is administered as a monthly intravenous infusion, usually over 1 hour. The approved initial dose in Europe and most other regions of the world is 8 mg/kg, while in the USA it is 4 mg/kg. The maximum recommended dose is 800 mg for people with ≥100 kg bodyweight.[35 55] A subcutaneous formula is currently under investigation. Other IL-6 blockers that are currently in phase 2 or 3 studies (see table 1A) are also applied by the subcutaneous route.

TCZ is approved for use in combination with MTX and as monotherapy if MTX is not tolerated or inappropriate. However, TCZ has also been used in combination with a variety of other sDMARDs.[52 82]

While it is recommended to lower the dose of TCZ when certain adverse effects occur (see below), it is not clear at present how one should proceed once patients reach the treatment target, such as clinical remission or sustained low disease activity: can the dose be reduced, the interval between infusions expanded, or should full treatment be continued? In a Japanese study, only 13% of the patients maintained low disease activity over 1 year after cessation of TCZ without use of any

DMARDs. If the patients normalised MMP-3 and had low IL-6 levels, the retention rate reached 38%.[83] Further study will need to assess the impact of disease duration and DMARDs use on the duration of response after TCZ is discontinued. It is also unknown whether there will be a difference in the duration of sustained efficacy between early and established RA.

Evaluation of response and management of non-response

Response assessment should be done using composite measures of disease activity, such as DAS, DAS28, SDAI and CDAI. However, it should be borne in mind that APR are included in all of these except for the CDAI. Because the effect of IL-6 inhibition on CRP levels or ESR may be profound despite lack of clinical improvement, the actual response may be obscured (see above). Therefore measures that do not comprise an APR, such as the CDAI, are preferred (level 5, grade D). For the future, treatment goals based on modern imaging modalities that assess inflammatory activity, such as sonography or MRI, if shown to be associated with important outcomes, may be particularly relevant for patients using TCZ.

In line with respective recommendations,[13 14 59] disease activity assessment should be done initially monthly to every 3 months, aiming at a significant improvement within 3 months and attaining low disease activity (CDAI≤10, SDAI≤11, DAS28<3.2) or remission (using ACR-EULAR remission criteria[84]) within 6 months (level 5, grade D). Clinical trial data suggest that clinical efficacy is already seen within a few weeks[41 45 40] and, therefore, support the validity of the above recommendations for response expectations.

If a patient does not achieve low disease activity within 6 months at an adequate dose (or does not experience a significant improvement of disease activity within 3 months) another treatment option should be considered (level 5, grade D).

However, in the USA, where a starting dose of 4 mg/kg is licensed (and which may convey more immunogenicity and lower response rates as discussed above), a dose escalation may have to be considered much earlier if significant improvement is not attained. Specific data to guide such dose escalation are not well elaborated yet, since in clinical trials a dose increase from 4 to 8 mg was usually done only after 16 weeks and only in patients failing to achieve 20% reduction in tender and swollen joint counts, a quite minimalistic requirement given the baseline disease activity and length of time. Thus, in the case of dose escalation, judging response adequacy may be more appropriate after 3 and 6 months at the generally accepted therapeutic dose of 8 mg/kg.

Cost-effectiveness

Despite the relatively limited time since approval, some economic analyses on the use of TCZ have been published and, with all reservations regarding such analyses at a relatively early stage of use, revealed cost-effectiveness.[85 86] More data will be needed for full appreciation of the health economic aspects of TCZ use.

Contraindications, adverse effects and long-term exposure

TCZ has been studied in several international and Japanese trials, and most of these trials had long-term extension phases. The long-term safety in Japanese patients as well as in the international studies has been reported,[87 88] and also the SLR informing the present recommendations has focused partly on safety;[21] the reader is referred to these publications as well as the package insert.[35 55 87–89] A brief summary of adverse events as derived from the above-mentioned studies and the package insert is also provided in the online supplementary files, and some have been discussed above under "Screening before initiating TCZ". The items primarily addressed in the online supplement are hypersensitivity, infections including hepatitis, malignancies, changes of blood counts, lipids, gastrointestinal perforations, hepatic manifestations and cardiovascular risk.

Dose adaptation or discontinuation in case of adverse events and monitoring recommendations

While it is evident that in patients with infections, especially serious ones, TCZ therapy has to be interrupted or sometimes discontinued and therapy has to be withdrawn in the event of infusion reactions, there are also specific laboratory abnormalities that may require dose reductions or discontinuation. Thus if transaminase elevations in the range of 1–3×ULN persist, the dose should be reduced to 4 mg/kg or interrupted until normalisation; if transaminases increase to >3×ULN, therapy should be interrupted and can be resumed at lower dose when levels are <3×ULN, and resumed at 8 mg/kg after transaminase normalisation. For persistent (ie, seen at least twice) increases >3×ULN or for any elevation >5×ULN, TCZ should be permanently discontinued (level 5, grade D).

With respect to leukocytopenia, TCZ should be discontinued if neutrophil counts are <500/mm^3; at counts of 500–1000/mm^3, TCZ should be interrupted and resumed at 4 mg/kg once neutrophil counts increase to >1000/mm^3 (level 5, grade D).

Liver enzymes and bilirubin, complete blood count with differential and lipid levels should be assessed every 4 to 8 weeks for the first 6 months and every 3 months thereafter (level 5, grade D).

Patient perspectives

TCZ not only improves clinical signs and symptoms and joint damage, but also all pertinent patient reported outcomes, such as pain, physical function and quality of life; moreover, fatigue, an important symptom identified by patients with RA, is significantly improved with TCZ.[90] Patients should be fully informed by their rheumatologist about the benefits and risks of TCZ therapy. Treatment initiation as well as the treatment target should be based on a shared decision between the patient and physician and appropriately recorded (level 5, grade D).

Other indications and experiences

While the focus of the present statement is on adult RA, several other indications should be mentioned. TCZ is also licensed in Europe and Japan for systemic juvenile idiopathic arthritis (sJIA).[55] In Japan, TCZ is also approved for use in polyarticular JIA and Castleman's disease. These data are supported by respective publications[30 91 92] (level 1b to 2b, grade B). The specific indications and licensing may differ among other countries.

There are also a number of other diseases in which TCZ has been employed with or without success. According to several case reports, TCZ has been effective in patients with secondary amyloidosis, polymyalgia rheumatica, adult onset Still's disease, polymyositis, systemic sclerosis, large vessel vasculitis (such as giant cell arteritis), and it has also been used in Lupus with indications of some mild improvement.[92–101] However, none of these conditions are licensed indications and more information will have to be obtained from formal clinical trials. In part, these findings are in line with data on IL-6 inhibition in experimental models of these diseases.[102] In patients with Castleman's disease who frequently experience an interstitial pneumonitis, lung disease has improved upon TCZ therapy.[103 104] In contrast, TCZ has revealed negative results in case series and clinical trial of axial spondyloarthritis/

ankylosing spondylitis,[105–107] and this was also the case for a study on sarilumab, another IL-6R inhibitor.[108] Likewise, case reports in psoriatic arthritis showed no clinical effect of TCZ despite reduction in CRP,[109] although these were small studies in refractory patients. Nevertheless, the potential efficacy of antibodies to IL-6 rather than the IL-6R is currently unknown, and the potential efficacy of IL-6R blockade in patients with peripheral spondyloarthritis remains to be investigated.

Finally, TCZ has also been evaluated in a small pilot controlled study of Crohn's disease and showed limited efficacy (20% clinical remission without effects on endoscopic and histological changes) at doses of 8 mg/kg every other week.[110]

Research Agenda

The committee felt that many questions remained open and needed to be addressed in future research in both adult and paediatric populations. Some of these questions are presented herein; they focus on TCZ but would equally be pertinent for other compounds targeting the IL-6R or IL-6 and might be addressed in the course of planned clinical trials.

Dose of TCZ and concomitant therapies

- Can TCZ be withdrawn, its dose reduced or the interval of its administration expanded successfully in patients who have attained low disease activity or remission?
- In the USA: when is it ideal to increase the TCZ dose from 4 to 8 mg/kg and what are the indicators that should lead to this dose increase?
- Is TCZ monotherapy similarly effective as combination therapy with MTX in early and established RA?
- What is the effect of other IL-6i when used as monotherapy?

Efficacy and assessment aspects

- What is the most suitable remission or low disease activity target for TCZ, taking into account the specific effect on APR (CDAI and/or a newer imaging modality with assessment of synovitis activity?)
- Is IL-6 pathway inhibition efficacious in patients with active disease but normal CRP levels?
- What are predictors of response to IL-6-blockers?
- What are the effects of IL-6 inhibition on systemic osteoporosis?
- Is the use of IL-6 inhibitors economically sound?
- What is the comparative efficacy and safety profile of TCZ compared to other biological agents?

Safety in relation to other targeted therapies

- What are the efficacy and safety when IL-6 pathway inhibitors are given to patients previously treated with rituximab (with or without persistent B-cell depletion) or abatacept?
- How safe are TNFi, abatacept and rituximab after IL-6i therapy and vice versa?
- How safe are IL-6 inhibitors when combined with other sDMARDs besides MTX?
- Are IL-6 inhibitors safe when used with or immediately after Jak inhibitors, once these are licensed?
- Is there a need for a washout period after other biologicals have been employed or can IL-6 inhibition be applied when the next dose of the other biological is scheduled? And vice versa, is there a need for a washout period for TCZ before another biological can be used?

General safety aspects

- Is there a risk in patients with solid malignancies in the previous 5 years upon IL6 inhibition?
- Can patients with past/recent lymphoma or myeloma be safely treated with TCZ?
- How safe are IL-6 inhibitors in patients with diabetes?
- What is the net effect of IL-6-blockers on cardiovascular risk?
- What is the mechanism for the change in lipids seen with IL-6-blocking treatment?
- What is the involvement of IL-6 in defence against *Mycobacterium tuberculosis*? Is the risk of reactivation of latent tuberculosis truly increased among patients who receive TCZ or other IL-6 inhibitors?
- Is the response to vaccines impaired during IL-6-blocker therapy as it is during rituximab treatment?
- Is the risk of herpes zoster (shingles) increased with IL-6 inhibition?
- What are the predictors of anaphylactic reactions?
- How safe is the use of IL-6i in patients with hepatitis B or C, treated with or without antiviral agents?
- Does the use of isoniazid lead to significant increases in liver function tests in patients with IL-6 inhibitor mono- and combination therapy?
- What is the risk of GI perforations in patients treated with IL-6-blockers? Is there any specific GI perforation associated with these compounds, in the upper or lower gastrointestinal tract? Is it related or unrelated to concomitant use of other drugs?
- Is there a risk to exacerbate or trigger demyelinating disorders during treatment with IL-6 inhibitors?
- Are some forms of autoimmunity triggered upon the use of IL-6 inhibiting therapy?
- Is there a need to stop therapy with IL-6-blockers before fathering a child?
- What is the molecular effect of TCZ on target cells?

Other indications and aspects

- Larger trials should be performed for diseases like vasculitis (including giant cell vasculitis), polymyalgia rheumatica, poly- and dermatomyositis, systemic sclerosis, systemic lupus erythematosus, adult onset Still's disease, amyloidosis, and others.
- How should treatment with TCZ be approached in obese people?
- What is the efficacy and safety of using IL-6 inhibitors to treat extra-articular manifestations of RA, including interstitial lung disease and vasculitis?

CONCLUSION

In this consensus statement we provide recommendations for the use of IL-6 pathway inhibition in clinical practice. The data are primarily based on evidence assembled from clinical trials on TCZ, currently the only approved agent targeting this pathway, but also data of early phase clinical trials on other compounds that target both the IL-6 receptor and ligand have been considered. As far as available, these data confirm the efficacy and safety profile of IL-6 pathway blockade. Currently approved indications are adult rheumatoid and juvenile inflammatory arthritis. While other indications may follow with more available data, axial spondyloarthritis appears to be refractory to this therapy. The recommendations have been developed to provide guidance for rheumatologists and other physicians engaged in the treatment of inflammatory diseases as well as information for patients, payors and other stakeholders. They are summarised in the 'Points to Consider' (box 1). which provide only a synopsis of the discussions for purposes of general information. The details presented in the previous sections should be regarded as part and parcel of these points.

Additional data will be needed to fully understand the value of this treatment approach. Pertinent research question addressing

Box 1 Points to consider for the treatment of adult rheumatoid arthritis (RA) with tocilizumab (TCZ)*

Indication (level 1a, Grade A)

- RA with inadequate response to (or intolerance of) at least one synthetic disease modifying antirheumatic drug (sDMARDs) or tumour necrosis factor (TNF) inhibitor
  - Active RA (at least moderate disease activity according to a validated composite measure)

Contraindications (level 5, grade D)

- Allergy to TCZ
- Clinically relevant co-morbidities, particularly active infections

Pre-treatment screening (level 5, grade D)

- History and physical examination
  - Consider possible contraindications
  - Consider radiograph of the chest
  - Assess history of infections, diverticulitis and malignancies
- Routine laboratory testing, including lipid levels
- Testing for hepatitis B and hepatitis C viral infections
- Screening for tuberculosis
- Assess necessity of vaccination

Treatment dose and co-medication (level 1a, grade A)

- 8 mg/kg every 4 weeks as intravenous infusion, usually over 1 h
  - While the approved starting dose in the US is 4 mg/kg, this is not recommended by the task force.
  - A reduction from 8 to 4 mg/kg may be needed upon occurrence of certain adverse events.
- TCZ can be used in combination with methotrexate (MTX) (alternatively in combination with other sDMARDs) or as monotherapy, if MTX is inappropriate.
- Evaluation and definition of response (level 5, grade D)
- Apply validated composite indices to assess treatment response
  - Assess disease activity frequently especially during the first months after initiation of TCZ
  - Aim for remission (American College of Rheumatology-European League Against Rheumatism remission definition) or low disease activity state (LDA: disease activity score using 28 joint counts $\leq$ 3.2, simplified disease activity index $\leq$ 11, Clinical disease activity index $\leq$ 10)
  - A significant improvement should be achieved after 12 weeks and the treatment target should usually be reached after 24 weeks; insufficient response should normally lead to switching to an alternative therapy.
- Aim for improvement in function and quality of life
- Progression of structural changes should be prevented

Adverse events

- Infusion reactions (~7%)
  - Severe infusion (hypersensitivity) reactions may occur but are rare (0.3%); they are more frequent with the 4 mg/kg than the 8 mg/kg dose
- Serious infections occurred about twice as frequently with TCZ compared to placebo population
- Hepatic transaminase elevations
- Gastrointestinal perforations, primarily in patients with a history of diverticulitis
- Neutropenia and rarely thrombocytopenia
- Effects of uncertain relevance
  - Lipid increases (should be treated according to local guidelines)

*These points are a short abbreviation of the items discussed and presented in detail in the body of the text or in the online supplement. They should not be applied independently of the information provided there in more detail, but present only an overview of the general scope of the recommendations.

open issues on safety, efficacy and optimised use have been formulated. The expected advancements will allow for a more refined use of TCZ and other IL-6 inhibitors in the future. However, the already available information and the development of many additional biologicals targeting IL-6 or its receptor reveal the importance of this treatment option to improve the outcome in patients with RA, JIA and possibly other inflammatory diseases.

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