# Adalimumab concentration-based tapering strategy: as good as the recommended dosage

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Drug monitoring consists of observing, recording or detecting the effects of a substance administered to an individual. Therapeutic drug monitoring (TDM) aims at improving patient care based on drug concentration measurement in order to adjust the dose or time interval individually.[1] TDM is based on the assumption of a definable relation between dose and plasma/blood drug concentration and between concentration and therapeutic effects.

In *ARD*, l'Ami *et al* conducted an open-label randomised trial comparing an increasing dosing interval of adalimumab from 2 to 3 weeks with a standard-dose conservative strategy in patients with rheumatoid arthritis (RA) with an adalimumab trough concentration >8 mg/L.[2] The authors concluded that the dose tapering strategy was not inferior to the conservative strategy over 26 weeks. This important contribution is a step towards implementation of TDM in clinical practice. Prior to this work, the same group found that a drug concentration between 5 and 8 mg/L was associated with a good clinical response and strongly suggested that no additional improvement could be expected by increasing the dose (ie, by reducing the time interval) in patients with trough concentration >8 mg/L.[3] A similar range has been described for adalimumab in psoriatic arthritis, which validates these findings.[4] In the economic context, this tapering strategy can be seen as an opportunity to alleviate the burden for society.

However, in the l'Ami *et al*'s study, the target sample size was not reached, which somehow minimises the strength of the conclusion and raises the question of acceptability by patients to participate in the study. Indeed, some patients could have feared a flare or, more probably, because they wanted to taper the dose, did not want to be allocated to the conservative arm. Whatever this limitation, tapering adalimumab seems to perform as good as the recommended dose in patients with RA with serum drug concentration above the recommended range, who represent more than one-third of the patients in the authors' experience.[2]

There are three principal arguments to support TDM of a tumour necrosis factor inhibitor (TNFi) in rheumatic diseases (table 1). The first is the variability in drug concentration among patients, which has been largely observed with all biologicals, and with adalimumab concentration ranging from undetectable to 28 mg/L in clinical practice.[5] The second is the observation of a relation between drug concentration and clinical response, but only in responding patients, as this association is lacking in primary non-responders. For adalimumab, clinical improvement was greater for patients with a trough concentration between 5 and 8 mg/L than below this range.[3] The third is the fact that low dosage/concentration may result in decreased efficacy and in increased risk of immunisation[6 7] and high dosage/concentration may increase the risk of side effects.[8 10]

There are three requirements for rheumatologists to implement TDM in clinical practice (table 1). First, we need a reliable method to quantify the drug and anti-drug antibodies (ADA).[11] Second, we need to establish guidelines or algorithms, supported by the best clinical evidence possible, to define therapeutic options in different clinical situations, such as prediction of response, biological failure or tapering,[12] and finally, we need to follow personalised medicine, to define for each patient the optimal dosing schedule by using pharmacokinetic-pharmacodynamic (PK-PD) modelling, either what it is called proactive TDM, the dosing schedule at initiation is based on the patients' characteristics (disease activity in particular) and the reactive TDM in which the dosing schedule is adjusted upon clinical response and drug concentration.[13]

Because TDM of a TNFi is based on serum trough concentrations, we need to understand the PK of biopharmaceuticals. Biopharmaceuticals are large proteins that need to be administered parenterally. Because of their high molecular mass and hydrophilicity, their volume of distribution is low (3-4 L).[14] These proteins do not undergo renal elimination or metabolism by hepatic enzymes, and proteolytic catabolism within the cells of the reticuloendothelial system (RES) is the primary route of elimination.[15] Recycling of proteins with Fc domains is mediated by the Brambell receptor (FcRn), which plays a critical role in protecting IgG antibodies against catabolic activities.[16] Elimination is also driven by binding to its antigenic target and irreversible binding by ADAs, when a patient develops immunogenicity.

Factors that may affect the PK and hence PD of biopharmaceuticals are complex, but the two most important are the development of ADAs and antigenic burden (disease activity). Other factors are concomitant immunosuppressive therapy, like methotrexate; disease severity, which may also increase non-immune elimination through RES-mediated mechanisms; disease type, such as inflammatory bowel disease, responsible for loss of the drug into faeces; and finally, patient-related factors such as body mass index and gender.[14]

One of the most important factors that affect the efficacy of biologicals is their potential for the development of ADA. ADAs bind to the biological agent, preventing it from binding to its target and forming immune complexes that accelerate the clearance of the drug.[17] Clinically

**Table 1** Arguments for therapeutic drug monitoring of a tumour necrosis factor inhibitor in rheumatic diseases and requirements

| Rationale | Requirement |
|---|---|
| Pharmacokinetic interindividual variability | Valid assay for drug concentration measurement and anti-drug antibody detection |
| Dose–concentration relationship | Algorithm based on clinical and biological assessment |
| Risk of adverse events, outside the target concentration range* | Personalised dosing-schedule modelling tool, to achieve the target concentration and response |

*Immunogenicity with low concentrations and infection with high concentrations.

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relevant ADAs are those that are present at high titters, since they bind to all or most of the circulating drug producing a significant reduction in serum drug concentrations.[18] However, in most patients ADA titters increase slowly, and before they are present in sufficient amounts to completely block therapeutic drugs, there is a period of several months during which patients may present low drug concentrations in serum, or only absent in the last days of the cycle, with a satisfactory or slightly worse clinical condition, which is gradually lost as the amount of ADA increases and completely blocks the drug during most of the treatment period.[19]

Disease activity is an important factor affecting the PK-PD. A high inflammatory burden expressed by high expression of TNF in the inflamed tissue will lead to tissue retention of the TNFi, thereby increasing drug concentration in the joint and reducing it in the blood, with less available drug.[14 20] Hence, patients with high disease activity may require greater amounts of drug to neutralise this high amount of TNF than those with moderate or low disease activity, so disease activity is a key factor in determining the target tissue concentration to achieve a clinical response.[21] This phenomenon, called the antigenic sink,[14] is a dynamic process because the drug reduces inflammation with consequently less TNF production, less binding to TNFi, thereby leading to increased drug concentration in the blood.[22] Accordingly, an inverse correlation is found between peripheral blood TNFi concentration and disease activity in all inflammatory diseases.[23]

Biopharmaceuticals need to be available in sufficient quantity in blood and target tissues to exert their effect; however, the optimal drug concentration range for therapeutic efficacy may differ depending on the disease activity, high for very active disease or even very low when the disease is in remission or with low disease activity.[21] Because the correlation between drug blood concentration and outcome is stronger than between the dose and outcome, measuring drug concentrations in terms of a disease activity state allows clinicians to understand the reasons for the failure or the efficacy of the treatment, and allows for optimising the therapeutic dosage regimen and thus improving the response.

The different clinical situations in which TDM can be useful have been recently reviewed, and dose tapering may be considered in some instances.[24 25] The lingering question is still when can the clinician consider dose tapering or dose intensification? Some authors have tried to decrease the dose in patients with low disease activity regardless of the concentrations, showing this strategy to be feasible in most patients, although with loss of response in some cases. The question is, while tapering, can we avoid the occurrence of flares? The study by l'Ami *et al* shows that dose tapering is efficient when selecting patients based on their drug concentration.

Rheumatologists have been primarily concerned with patients with refractory disease or adverse events, which requires a rapid therapeutic decision. Patients in remission or with good response have not drawn much attention so far. With the article by l'Ami *et al*, rheumatologists should now realise that some of their patients have high serum drug concentration when receiving the recommended dose and that dose reduction is feasible, and also has a major implication for rheumatologists and society, because TDM may reduce costs while maintaining the clinical response. A striking observation is that some proposed algorithms have focused on only patients with poor response. Recently, the Monitoring of Antibodies Group in Europe proposed a generalised therapeutic algorithm for biopharmaceutical treatment of inflammatory diseases that considers non-responders and responders.[12]

The unanswered question which remains is the clinical utility of TDM; in other words, what does TDM add in comparison to the experience-based decision? The article by l'Ami *et al* provides some new and important insights into the potential benefit of TDM, in the situation of low disease activity/remission, but still there are some unresolved questions. Is this strategy cost-effective in patients in remission with serum through concentrations within the optimum adalimumab range of 5–8 mg/mL? Some arguments favour TDM of TNFi agents in RA.[24] However, the strength of studies is insufficient to support TDM in clinical practice.[2628] Still, no large prospective study comparing TDM versus usual care has been published. The present article favours TDM of a TNFi in RA. Prior to this, some authors found that dose reduction of adalimumab was feasible, particularly with high trough concentration.[29] Finally, we remind that the decision is based on both clinical opinion and biological information. In addition, although this is the first randomised trial of TDM of a TNFi, we need to reconfirm this finding in further works before implementing TDM of biopharmaceuticals in clinical practice of RA.

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