Rheumatoid factors: where are we now?

Rheumatoid factors (RFs) are autoantibodies against IgG. They are probably the most studied antibody since their discovery by Waaler in 1937. In this editorial we aim to briefly examine the proposed roles of RFs, how they may contribute to disease pathogenicity, and, in so doing, mention the application of novel peptide technology, crystallography and molecular modelling to rheumatoid factor study.

Occurrence and roles of rheumatoid factors

RFs are not exclusive to rheumatoid arthritis (RA). They are found in a number of other autoimmune diseases, such as systemic lupus erythematosus and Sjögren’s syndrome, infectious diseases such as mycobacterium tuberculosis, and Lyme disease in healthy people. RFs seem to have a beneficial role to the normal functioning of the immune system. They may do this in a number of ways:

1. Clearance of immune complexes. IgM and IgG RFs may bind to an antibody-antigen complex and facilitate clearance by binding to the Fc receptors on phagocytes. In particular, this may facilitate clearance of IgG2 and IgG4 immune complexes as these subclasses do not readily activate complement.

2. Antigen processing by B cells. B cells can act as antigen presenting cells as they can use their surface immunoglobulin to capture antigen. Membrane bound RFs can therefore capture immune complexes containing IgG that can then be internalised, which may lead to the presentation of a relevant epitope to a T cell as part of an immune response.

3. Setting up an early antibody repertoire. Antibodies that behave as RFs can be found in human fetal liver and spleen, which suggests that autoreactive B cells are playing a part in the development of a functional antibody repertoire.

How can rheumatoid factors contribute to disease pathogenesis?

RF involvement in immune complex formation may lead to fixation of complement and recruitment of macrophages, neutrophils, and lymphocytes. Such involvement may be one part of an autoimmune inflammatory response that results in arthritis.

So how can RFs on the one hand be beneficial while on the other be potentially pathogenic? One clue we have is that naturally occurring RFs are mainly of the IgM isotype, while IgG RFs are thought to be associated with disease. It is probable that the production of pathogenic RFs are dependent on a class switch of antibody from IgM to IgG. This would imply that T cell help is available as the switch from IgM to IgG is usually under T helper cell control. This leads us to question ‘what are the antigenic peptides that activate T cells and allow them to help B cells produce IgG RFs?’ Identifying such a peptide trigger has been elusive. It may be that one has to look at peptides from IgG itself or even RFs. In support of this notion, there are data to suggest that xIIIb light chains from RFs can cause T cell proliferation (J Petersen et al, 7th international conference on immunology, 1989).

The mechanism of rheumatoid factor binding to IgG

There is at least 6 mg/ml of IgG in the serum and only 3 mg/ml of IgM. If all this were RF, which is unlikely, it is surprising that we can detect free RF at all in such an excess of IgG antigen. This suggests that either some RFs do not bind to certain types of IgG or that not all IgG is of a type that is capable of being bound by RFs.

The site of binding for many RFs is thought to lie at the Cγ2-Cγ3 domain interface in Fc, based upon evidence from serology, human subclass reactivity patterns, and more recently, site directed mutagenesis. The last approach has identified key determinants in discontinuous loop regions of Cγ2 and Cγ3. Yet it is not known whether pathogenic and non-pathogenic RFs bind to similar or separate sites on the IgG molecules.

It is known that in RA IgG oligosaccharides change such that there is a shift to the galactosylated form, which may uncover novel peptide epitopes and hence facilitate RF binding. Using monoclonal RFs from synovial tissue, it has recently been demonstrated that in some instances the binding is greatly increased when galactose is absent. These same RFs had at least 10 times higher affinity for human IgG than those monoclonal RFs that bound independently of sugar.

The work of Hay and others have suggested that there may be several mechanisms for RF binding.

1. Binding to continuous or discontinuous determinants on IgG away from the influence of oligosaccharides.

2. Binding to peptides that have been uncovered by the absence of oligosaccharide or made available for interaction because of conformational change resulting from oligosaccharide absence.

3. Binding to IgG via RF framework peptides away from the conventional complementarity determining regions.

The structure of the first complex between a RF and IgG Fc has now been determined by x ray crystallography and it shows the RF Fab fragment binding through its complementarity determining regions to an epitope on the IgG Fc that spans the Cγ2 and Cγ3 domains (see fig 1). The RF in this study (RF-AN) is derived from the peripheral B cell of an RA patient and is an IgM/κ antibody with a pattern of reactivity with human subclasses IgG1, 2, and 4 that is typical of many RFs and mirrors that of the bacterial Fc-binding protein A. The binding site for protein A lies in the cleft between the two domains, and this RF clearly overlaps this area. The human IgG4 Fc present in the complex is predominantly galactosylated, similar to that found in the immune complexes of RA patients. However, for this particular RF, the carbohydrate itself does not seem to be involved in RF recognition of Fc.

It is now important to study the structures of the complexes formed by other higher affinity RFs, and of the IgG class, to compare the modes of interaction, the nature of the epitopes recognised, and the role of the oligosaccharides. It may then be possible to identify the structural features that distinguish the pathogenic from the non-pathogenic RFs.

Our further understanding of the mechanisms of RF binding may be diagnostically helpful if pathogenic RFs can be differentiated between those that are harmless. It would also open up a number of further options whereby the RF binding mechanisms could be interrupted.

Conclusion

It is clear that RFs are more than markers of RA and dissecting out their physiological role and how they may be involved in pathological mechanisms will be exciting. Crystallographic analysis and molecular modelling of both
polypeptide and oligosaccharide structures will undoubt-
edly aid this process, and epitope mapping has also been
shown to be a powerful tool. Whether new diagnostics and
novel therapeutic interventions will result remains to be
seen, let us hope so, but hopefully we will not have to wait
another 50 years for the answer.

2 Carson DA, Chen PP, Kipps TJ. New roles for rheumatoid factor. [Review].
3 Roosnek E, Lanavecchia A. Efficient and selective presentation of antigen-
4 Kipps TJ, Robbins BA, Carson DA. Uniform high frequency expression of
autoantibody-associated crossreactive idiotypes in the primary B cell folli-
5 Schroeder HJ, Hillson JL, Perlmuttar RM. Early restriction of the human
6 Artandi SE, Calame KL, Morrison SL, Bonagura VR. Monoclonal IgM
rheumatoid factors bind IgG at a discontinuous epitope comprised of
amino acid loops from heavy-chain constant-region domains 2 and 3. Proc-
Association of rheumatoid arthritis and primary osteoarthritis with
changes in the glycosylation pattern of total serum IgG. Nature
8 Soltys AJ, Hay FC, Bond A, Axford JS, Jones MG, Randen, et al. The bind-
ing of synovial tissue-derived human monoclonal immunoglobulin M
rheumatoid factor to immunoglobulin G preparations of differing
9 Randen I, Brown D, Thompson KM, Hughes-Jones N, Pascual V, Victor K, 
et al. Clonally related IgM rheumatoid factors undergo affinity maturation
10 Hay FC, Jones MG, Bond A, Soltys AJ. Rheumatoid factors and complex
formation. The role of light-chain framework sequences and glycosylation.
Arthritis 1991;265:54-62.
11 Soltys AJ, Westwood OMR, Austen BM, Bond A, Hay FC. Analysis of rheu-
matoid factor binding to synthetic peptides and galactose deficient IgG
12 Westwood OMR, Soltys AJ, Austen BM, Hay FC. Molecular modelling of
IgG Fc reveals clustering of linear sequence to form potential
conformational epitopes for binding rheumatoid factors. [Abstract.] Clin 
13 Hay FC, Soltys AJ, Trimbick G, Gesy EM. Framework peptides from
kappa IIIb rheumatoid factor light chains with binding activity for aggre-
14 Shlomchik M, Nemezze D, van SJ, Weigert M. Variable region sequences of
murine IgM anti-IgG monoclonal autoantibodies (rheumatoid factors). II.
Comparison of hybridomas derived by lipopolysaccharide stimulation and
15 Chen PF, Robbins DL, Jirik FR, Kipps TJ, Carson DA. Isolation and char-
acterization of a light-chain variable region gene for human rheumatoid
16 Sohi MK, Corper AL, Wan T, Steinitz M, Izak G, Ehrenfeld M, Flechner J, 
et al. Continuous production of monoclonal rheumatoid factor by EBV-
17 Deisenhofer J. Crystallographic refinement and atomic models of a human
Fc fragment and its complex with fragment B of protein A from Staphylo-
coccus aureus at 2.9 and 2.8 angstrom resolution. Biochemistry
1981;20:2360.
comparative study of the N-linked oligosaccharide structures of human

Figure 1 Diagramatic representation of rheumatoid factor AN Fab
fragment binding to an epitope in Fc of IgG that spans the C2 and C3
domains as determined by x-ray crystallography.
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A J SOLTYS, J S AXFORD and B J SUTTON

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