Chapter 73
Advanced Approaches to Diagnose and Treat the Chronic Autoimmune Disorders:
Multimodal Molecular Imaging

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ABSTRACT

Pathology and dynamics of particular cells and the molecular components of immune system is still challenging to be traced within living organisms. The techniques of molecular imaging (MI) are promising tools to monitor the immune system at work, to improve or allow personalized diagnostics and treatment, especially of the autoimmune diseases. In this study some possible targets for MI and biosensing are discussed. The personalized medicine, in addition to bioinformatics-based systemic approach, requires extensive research and novel high-throughput technologies like next generation of imaging, biosensing experimental systems based on microfluidics, nanotechnology, femtochemistry, superresolution (STED, STORM, PALM, SOFI, etc.), label-free imaging, spectroscopy (including TCSPC), MRI, multimodal optical methods, accoustic imaging through ultrasonic waves, nuclear medicine methods like SPECT and PET. Moreover, dedicated designs of modular Lab-on-Chip solutions are of high demand to perform multipurpose cell measurement and give a possibility to flexibly interact with sensed objects.

INTRODUCTION

Chronic autoimmune disorders are the reason for serious complication or damage in functionality of human bodies (see fig. 1). They affect multiple parts of central nervous system (CNS); particular tissue like thyroid gland; blood cells or hematopoietic system leading often to unrecoverable damage of the target or its functionality (Betterle, Lazzarotto, & Presotto, 2004). Although some understanding of the reasons of pathology can be achieved throughout theoretical modeling using methods of bioinformatics, immunogenetics and immunomics, as recently pointed out by Brusic, Gottardo, Kleinstein, Davis and

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Human Immunology Project Consortium steering committee (2014) and Kidd, Peters, Schadt and Dudley (2014), the study of the dynamics of particular cells and the molecular components of immune system is still hard to perform in living organisms (Garber, 2014). Among others, the techniques of molecular imaging (MI) seem to be the most promising tool to monitor the immune system at work (Zaretsky et al., 2012). In this study a review of some currently used techniques is presented and their possible applications in particular autoimmune disorders, like idiopatic or immune thrombocytopenia purpura (ITP, abnormally low platelet counts) (Badalin, 2014; Bussel et al., 2007; Peñalver et al., 2006) are discussed.

This chapter pays special focus on some advances in techniques of molecular imaging adapted to improve or allow personalized diagnostics and treatment in immunology, especially autoimmune diseases. Some of MI techniques are suitable to investigate in precision already known immunosuppressive therapies leading to understanding the underlying processes responsible for their effectiveness or its lack. As discussed, for instance, in the notes of Lydyard and Whelan (2011), a number of successful treatment methods for ITP, including intravenous gamma globulin, corticosteroids, cytostatics and monoclonal antibodies, have been proven to be clinically useful (Peñalver et al., 2006; Conrad, 2009; Conrad and Fritzler, 2007; Conrad, 2011; Conrad, Schößler, Hiepe, & Fritzler, 2011). However, these therapies usually fail on long term scale. The molecular-cell interaction, responsible for development of autoimmune disorders of this kind are still rather poorly understood in vivo in humans and difficult or expensive to diagnose. Moreover, understanding of the complexity of epigenetic interactions leading to autoimmune disorders is still at its advent, although the epigenetics acts as a key factor in this domain (see fig. 2).

Figure 1. Organs and tissues under attack of autoimmune process, trigerred by external and internal factors