The Role of Natural Killer Receptors in Celiac Disease

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Abstract

Celiac disease (CD) is a chronic enteropathy that develops in genetically-predisposed individuals after the ingestion of gluten. The small intestinal damage observed in CD patients is characterized by villous atrophy, crypt hyperplasia and massive infiltration of the mucosa with inflammatory cells. The molecular mechanisms that trigger and amplify inflammatory signals in CD are not fully understood. There is evidence that excessive activation of some subsets of Natural Killer (NK) cells occurs in CD and can contribute to the perpetuation of gluten-driven immune response and intestinal damage. On the other hand, the active phases of the disease are also marked by reduced mucosal presence of a specific subpopulation of NK cells expressing activating receptors and producing IL-22, a cytokine involved in the maintenance of intestinal barrier and immune homeostasis. In this article, we shortly revise the current literature on the role of NK cells in CD.

Keywords: Chronic inflammatory; Hyperplasia; Viral infections

Introduction

Celiac disease (CD) is a T cell-dependent chronic inflammatory disorder of the small intestine that affects approximately 1% of the population [1]. CD is triggered by ingestion of gluten, a mixture of proteins found in wheat, barley and rye, which leads to villous atrophy, crypt hyperplasia, massive infiltration of the mucosa with inflammatory cells and consequent malabsorption-related symptoms and signs [2]. The only current treatment of CD is a lifelong exclusion of gluten from the diet [2]. CD almost exclusively develops in HLA-DQ2 and/or HLA-DQ8 positive individuals, which are the restriction elements for CD4+ T cells recognizing gluten peptides [3]. The mechanisms underlying the breakdown of tolerance to gluten and the exact sequence of events leading to tissue damage in CD are not clear. Viruses could act as environmental factors promoting the development and/or propagation of CD-associated detrimental immune response. This relationship is based on the frequent observation that viral infections may precede the onset of CD [4], CD-associated inflammation is associated with increased production of interferon (IFN)-α [5], a cytokine over-produced during viral infections, and \textit{in vivo} treatment of fetal gut explants with IFN-α induces CD-like intestinal damage [6]. Support to the above hypothesis comes also from the demonstration that activation of various subsets of Natural Killer (NK) cells, a class of innate immune cells that protect host against a variety of viruses by killing infected cells, is either up-regulated or reduced in the active phases of CD [7]. NK cells exert several biological functions, including production of cytotoxic granules (i.e. granzyme B and perforin) and inflammatory or regulatory cytokines and induction antibody dependent cellular cytotoxicity [8]. Cytotoxic functions of NK cells are mainly regulated by the cell surface expression of activating and inhibitory receptors, which interact with ligands on target cells [9]. NKp46, double-positive NK cells also produce IL-22, a cytokine involved in the maintenance of intestinal barrier and immune homeostasis, it is conceivable that this defect could contribute to perpetuate the detrimental immune response in CD. At the same time, the fact that exclusion of gluten from diet reverts NKp44/NKp46-deficient NK cell deficiency suggests that such an abnormality is not primarily involved in the initiation of the inflammatory process.

On the other hand, excessive activation of NK cells could kill epithelial cells through the perforin/granzyme pathway further contributing to the small intestinal damage [14,15]. Indeed, the active phases of the disease are characterized by increased induction of activating receptors (i.e. NKp44/NKp30 or NKG2D2) on NK cells [16]. These observations are in line with the demonstration that human major histocompatibility complex class I chain related A and B (MICA and MICB) proteins, nonconventional HLA class I molecules that serve as ligands for the activating NKG2D receptor, are over-expressed in CD patients with villous atrophy [17,18]. MICA/NKG2D interaction is supposed to mediate also killing of epithelial cells in refractory CD, a rare complication of the disease that is resistant to the gluten-free diet.
and can associate with the development intestinal T cell lymphoma [18].

The factors leading to upregulation of MICA proteins to the surface of enterocytes in active CD remain to be clarified. ex vivo studies with duodenal explants of CD patients on gluten-free diet show that gliadin induces MICA expression in epithelial cells through a mechanism that is dependent on interleukin (IL)-15 [14,18], a cytokine produced in excess by innate immune cells in this disorder. Consistently, the MICA-inducing effect of gliadin is reproducible by the p31-49 gliadin-derived peptide, which is able to directly activate innate immune response in CD and to induce enterocyte apoptosis, the latter effect being inhibited by a blocking IL-15 antibody [19].

Finally, CD-associated mucosal inflammation is marked by reduced levels of the inhibitory receptor NKG2A [16], which could further contribute to the NK cell-mediated intestinal epithelial injury in this disorder.

Taken together the available literature indicate that NK cells can play a major role in CD pathogenesis. While the abundance of NK cells expressing activating receptors and their ability of kill target cells support their involvement in CD-associated villous atrophy, the defective presence of NKP44/NKP46-double positive NK cells could sustain the expansion of the gluten-induced mucosal inflammation. Further studies are needed to support these hypotheses. At the moment, the limited availability of biological samples (e.g., small number of cells purified from endoscopic biopsy samples) and the lack of a valid animal model of CD-like gluten-driven tissue damage represent the major obstacles to such studies.

References