Autophagic Behavior of T Lymphocytes in Systemic Lupus Erythematosus

Elena Ortona1, Walter Malorni2 and Marina Pierdominici1

1Department of Cell Biology and Neurosciences, Istituto Superiore di Sanità, Rome, Italy
2Department of Therapeutic Research and Medicine Evaluation, Istituto Superiore di Sanità, Rome, Italy

Corresponding author: Walter Malorni, Department of Therapeutic Research and Medicine Evaluation, Section of Cell Aging andDegeneration, Istituto Superiore di Sanita’, Rome, Italy. Tel: 00390649903290; Fax: 00390649903691; E-mail: malorni@iss.it

Received date: February 01, 2016; Accepted date: February 27, 2016; Published date: February 29, 2016

Copyright: © 2016 Ortona E, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Keywords: Autophagy; T lymphocytes; Autoimmunity; Systemic lupus erythematosus; Autoantibodies; α-Synuclein; D4GDI

Commentary

The purpose herein is to provide an update on the role of autophagy dysregulation in systemic lupus erythematosus (SLE) focusing our attention on T lymphocytes.

Macroluautophagy (simply called ‘autophagy’ here) is a genetically programmed process that requires the activity of autophagy-related gene (Atg) proteins [1,2]. Autophagy is a lysosome-mediated catabolic process characterized by sequestration of cytoplasmic material in double-membraned vacuoles, the autophagosomes, which ultimately fuse with lysosomes forming autophagolysosomes. These peculiar organelles are specifically devoted to the degradation and recycling of wasted or altered proteins and organelles [1]. On these bases, autophagy was defined as a promoter of cell survival under stressful conditions (e.g., nutrient depletion and oxidative stress) providing an alternative source of nutrients to the cell. Autophagy thus represents an important role in various biological processes, particularly in the immune response [4,5]. It has diverse functions in innate immunity such as pathogen recognition, elimination of microorganisms, control of inflammation, and secretion of immune mediators [6]. Autophagy also contributes to adaptive immunity through diverse mechanisms, e.g., antigen processing for presentation by major histocompatibility complex (MHC) class II/ class I molecules and control of development and effector function of T and B lymphocytes [5,7]. Over recent years, perturbations in autophagy have been implicated in a number of diseases, including autoimmune diseases [8-10]. Systemic lupus erythematosus (SLE) is a prototypic autoimmune disease of unknown etiology, more frequently observed in women than in men (the ratio of women to men is 7:1-10:1), and characterized by polyclonal distribution of autoantibodies [1]. The activation processes, which modify lymphocyte function, and the peculiar, very high nuclear/cytoplasmic ratio (i.e., a very small cytoplasmic milieu which does not facilitate cytopathological analyses), clearly complicate the matter. Lymphocytes need a strictly regulated metabolic extracellular environment and their activation depend on a precise cell remodeling that involves key metabolism-associated organelles, such as mitochondria, so that autophagic evaluations are quite arduous. The data obtained so far by us and others, both ex vivo in freshly isolated lymphocytes (basal autophagy) and in vitro under autophagy stimulation (autophagy susceptibility), indicated an apparent disparity of autophagic behavior in lupus T cells versus normal T cells [13-16].

Basal Autophagy

A first study by Gros et al. [16] revealed that T cells from two distinct lupus-prone mouse models, i.e., MRL (lpr/lpr) and (NZB/NZW) F1, exhibited high loads of autophagic compartments compared with control mice. Autophagic vacuoles were also found to be significantly more frequent in T cells from a small cohort of lupus patients compared with healthy controls and patients with other autoimmune diseases. Interestingly, this elevated number of autophagic structures was not distributed homogeneously and was highly expressed in some T cells only. A further study carried out by our group [13] showed higher autophagy levels in naïve CD4+, but not CD8+, T cells from patients with SLE as compared with those from healthy donors. These results could explain the heterogeneous distribution of autophagic structures in lupus T cells, observed by Gros et al. [16]. Peripheral post-thymic expansion of naïve CD4+ T cells has been hypothesized to be driven by self-peptides for the maintenance of T-cell immunity in adults [17,18] and an unregulated expansion of these autoreactive T cells has been suggested to contribute to the pathogenesis of autoimmune diseases [17]. Hence, in SLE, proliferating, autoreactive naïve CD4+ T cells could undergo enhanced autophagy in order to supply their metabolic needs.

Autophagic Susceptibility

A significant disparity in autophagic propensity between lupus and control T lymphocytes has been revealed by in vitro studies. T lymphocytes from lupus-prone mouse models, i.e., MRL (lpr/lpr) and (NZB/NZW) F1, under phorbol myristate acetate/ionomycin stimulation, showed higher levels of autophagy as compared to those from control mice [16]. This result is at variance with what observed in patients with SLE in which T lymphocytes, under different autophagic stimulations, showed a resistance to autophagy induction as compared to healthy controls [13-15]. In particular, in vitro unresponsiveness to
autophagy induction was observed in SLE T lymphocytes cultured under growth factor deficiency [13], a condition that is known to induce metabolic impairment and trigger autophagy [19]. A mechanism contributing to autophagy resistance of SLE T lymphocytes has been revealed by the overexpression, at both mRNA and protein levels, of α-synuclein [15]. In fact, α-synuclein has been demonstrated to inhibit autophagy by reducing autophagosome formation at a very early stage [20]. On one hand, autophagy defect in SLE T cells appeared to be associated to an accumulation of α-synuclein aggregates, which require functional autophagy to be degraded; on the other hand, increased α-synuclein protein burden may impair autophagy, generating thus a bidirectional positive feedback loop. Even more interesting from a clinical point of view is the significant inverse correlation we found between α-synuclein and autophagy levels in T cells. This suggests that this molecule, representing an autophagy-related marker of peripheral blood T lymphocytes, could be taken into account as predictive biomarker for autophagy-modulating drug response [15]. In fact, drugs that are potentially modulate autophagy, such as the mTOR inhibitors (e.g., rapamycin and derivatives), are increasingly being used for therapeutic purposes in immune-mediated diseases, including clinical trials on patients with SLE [21-23]. There is therefore a growing need for identifying predictive biomarkers for the efficacy of these drugs. Another important mechanism in autophagy resistance of T cells in SLE could be the chronic exposure to autophagic stimuli leading to selection of autophagy refractory T lymphocytes. Interestingly, serum autoantibodies purified from SLE patients were able to induce autophagy in T cells from healthy controls [13]. These autoantibodies were found to react with the small GTPase family inhibitor D4GDI expressed at the lymphocyte surface [14]. Anti-D4GDI autoantibodies were present in about 50% of sera from SLE patients and, binding to their antigenic target, were suggested to trigger a series of intracellular changes, e.g. cytoskeleton remodeling, and induce autophagy. This autophagy ignition was apparent in T cells from healthy donors as well as from SLE patients lacking of serum anti-D4GDI autoantibodies whereas it was undetectable in T lymphocytes from patients displaying anti-D4GDI autoantibodies in their sera [14]. Hence, it was hypothesized that the chronic exposure to these autoantibodies could lead to the selection of autophagy-resistant T cell clones in certain patients [14] whose clinical features are nowadays under characterization in our laboratory. This autophagic defect could result in an overload of damaged mitochondria that release apoptogenic factors, generate reactive oxygen species, and increase apoptosis, commonly observed events in lymphocytes from SLE patients [12], in few words; it could exert a critical pathogenetic role. In particular, this autophagy/apoptosis imbalance could contribute to hematologic manifestations, such as lymphopenia and leukopenia, which were more frequently observed in patients exhibiting serum anti-D4GDI autoantibodies [14].

Accordingly, available literature data, summarized in figure 1, strongly support the role of autophagy as pathogenic determinant in SLE. As depicted above, constitutively higher levels of autophagy were detected in naive CD4+ T cells from SLE patients as compared to healthy donors. Conversely, autophagy resistance was found in T cells from patients with SLE. In this regard, differential in vitro responses of human and mouse T cells to autophagic stimuli should be underscored as a paradigmatic example of the difficulties occurring in the translation of preclinical studies into clinical testing. A further difficulty in translating these new findings to the bedside, is the fact that autophagy is a double-edge sword allowing on the one hand the maintenance of cellular homeostasis, but on the other hand the survival of autoreactive cells. Thus, further studies are mandatory to better understand the actual role of autophagy in the onset and in the progression of the disease. Finally, gender-based evidence suggesting a role for sex hormones in modulating autophagy and a different propensity of cells from males and females to autophagy induction [24-29] opens new paths for a better comprehension of SLE pathogenesis and for the optimization of clinical management of this disease.

![Figure 1: Defective autophagy in T lymphocytes from both lupus-prone mouse models and SLE patients are described both in freshly isolated lymphocytes (basal autophagy) and under autophagy stimulation (autophagy susceptibility).](image)

**References**

1. Klionsky DJ (2007) Autophagy: from phenomenology to molecular understanding in less than a decade. Nat Rev Mol Cell Biol 8: 931-937.
2. Mizushima N, Levine B (2010) Autophagy in mammalian development and differentiation. Nat Cell Biol 12: 823-830.
3. Scarlatti F, Granata R, Meijer AJ, Codogno P (2009) Does autophagy have a license to kill mammalian cells? Cell Death Differ 16: 12-20.
4. Virgin HW, Levine B (2009) Autophagy genes in immunity. Nat Immunol 10: 461-470.
5. Shibutani ST, Saitoh T, Nowag H, Münz C, et al. (2015) Autophagy and autophagy-related proteins in the immune system. Nat Immunol 16: 1014-1024.
6. Deretic V, Kimura T, Timmins G, Moseley P, Chauhan S, et al. (2015) Immunologic manifestations of autophagy. J Clin Invest 125: 1014-1024.
7. McLeod IX, Jia W, He YW (2012) The contribution of autophagy to lymphocyte survival and homeostasis. Immunol Rev 249: 195-204.
8. Giancicchi E, Delfino DV, Pierdominici M (2014) Recent insights on the putative role of autophagy in autoimmune diseases. Autoimmun Rev 13: 231-241.
9. Zhou XJ, Zhang H (2012) Autophagy in immunity: implications in etiology of autoimmune/autoinflammatory diseases. Autophagy 8: 1286-1299.
10. Pierdominici M, Vomero M, Barbati C, Colasanti T, Maselli A, et al. (2012) Role of autophagy in immunity and autoimmunity, with a special focus on systemic lupus erythematosus. FASEB J 26: 1400-1412.

Citation: Ortona E, Malorni W, Pierdominici M (2016) Autophagic Behavior of T Lymphocytes in Systemic Lupus Erythematosus. J Clin Cell Immunol 7: 397. doi:10.4172/2155-9899.1000397
11. Crispin JC1, Liossis SN, Kis-Toth K, Lieberman LA, Kyttaris VC, et al. (2010) Pathogenesis of human systemic lupus erythematosus: recent advances. Trends Mol Med 16: 47-57.
12. Moulton VR, Tsokos GC (2015) T cell signaling abnormalities contribute to aberrant immune cell function and autoimmunity. J Clin Invest 125: 2220-2227.
13. Alessandri C, Barbati C, Vacirca D, Piscopo P, Confaloni A, et al. (2012) T lymphocytes from patients with systemic lupus erythematosus are resistant to induction of autophagy. FASEB J 26: 4722-4732.
14. Barbati C, Alessandri C, Vomero M, Vona R, Colasanti T, et al. (2015) Autoantibodies specific to D4GDI modulate Rho GTPase mediated cytoskeleton remodeling and induce autophagy in T lymphocytes. J Autoimmun 58: 78-89.
15. Colasanti T, Vomero M, Alessandri C, Barbati C, Maselli A, et al. (2014) Role of alpha-synuclein in autophagy modulation of primary human T lymphocytes. Cell Death Dis 5: e1265.
16. Gros F, Arnold J, Page N, Décossas M, Korganow AS, et al. (2012) Macroautophagy is deregulated in murine and human lupus T lymphocytes. Autophagy 8: 1113-1123.
17. Kohler S, Thiel A (2009) Life after the thymus: CD31+ and CD31- human naive CD4+ T-cell subsets. Blood 113: 769-774.
18. Viret C, Wong FS, Janeway CA Jr (1999) Designing and maintaining the mature TCR repertoire: the continuum of self-peptide:self-MHC complex recognition. Immunity 10: 559-568.
19. Klionsky DJ, Abdelmohsen K, Abe A, Abedin MJ, Abeliovich H, et al. (2016) Guidelines for the use and interpretation of assays for monitoring autophagy (3rd edition). Autophagy 12: 1-222.
20. Winslow AR, Chen CW, Corrochano S, Acevedo-Arozena S, Gordon DE, et al. (2010) Ix-Synuclein impairs macroautophagy: implications for Parkinson's disease. J Cell Biol 190: 1023-1037.
21. Levine B, Packer M, Codogno P (2015) Development of autophagy inducers in clinical medicine. J Clin Invest 125: 14-24.
22. Zimmer R, Scherbarth HR, Rillo OL, Gomez-Reino JJ, Muller S (2013) Lupuzor/P140 peptide in patients with systemic lupus erythematosus: a randomised, double-blind, placebo-controlled phase IIb clinical trial. Ann Rheum Dis 72: 1830-1835.
23. Pan Q, Gao C, Chen Y, Feng Y, Liu WJ, et al. (2015) Update on the role of autophagy in systemic lupus erythematosus: A novel therapeutic target. Biomed Pharmacother 71: 190-193.
24. Barbati C, Pierdominici M, Gambardella L, Malchiodi Albedi F, Karas RH, et al. (2012) Cell surface estrogen receptor alpha is upregulated during subchronic metabolic stress and inhibits neuronal cell degeneration. PLoS One 7: e42339.
25. Lista P, Straface E, Brunelleschi S, Fraconi F, Malorni W (2011) On the role of autophagy in human diseases: a gender perspective. J Cell Mol Med 15: 1443-1457.
26. Straface E, Gambardella L, Brandani M, Malorni W (2012) Sex differences at cellular level: "cells have a sex". Handb Exp Pharmacol : 49-65.
27. Zeng M, Chen B, Qing Y, Xie W, Dang W, et al. (2014) Estrogen receptor β signaling induces autophagy and downregulates Glut9 expression. Nucleosides Nucleotides Nucleic Acids 33: 455-465.
28. Cook KL, Clarke PA, Parmar J, Hu R, Schwartz-Roberts JL, et al. (2014) Knockdown of estrogen receptor-β induces autophagy and inhibits antiestrogen-mediated unfolded protein response activation, promoting ROS-induced breast cancer cell death. FASEB J 28: 3891-3905.
29. Ruddy SC, Lau R, Cabrita MA, McGregor C, McKay BC et al. (2014) Preferential estrogen receptor beta ligands reduce Bcl-2 expression in hormone-resistant breast cancer cells to increase autophagy. Mol Cancer Ther 13: 1882-1893.