High Levels of Interferon Gamma in the Plasma of Children With Complete Interferon Gamma Receptor Deficiency

Claire Fieschi, MD, MSc*; Stéphanie Dupuis, MSc*; Capucine Picard, MD, MSc*; C. I. Edvard Smith, MD, PhD‡; Steven M. Holland, MD§; and Jean-Laurent Casanova, MD, PhD||

ABSTRACT. We have found that children with complete interferon gamma (IFNγ) receptor deficiency, unlike patients with other genetic defects predisposing them to mycobacterial diseases, have very high levels of IFNγ in their plasma. This unexpected observation provides a simple and accurate diagnostic method for complete IFNγ receptor deficiency in children with clinical disease caused by bacille Calmette-Guérin vaccines or environmental nontuberculous mycobacteria. Pediatrics 2001;107(4). URL: http://www.pediatrics.org/cgi/content/full/107/4/e48; interferon gamma, mycobacteria, genetic susceptibility, immunodeficiency, plasma.

ABBR EV IATIONS. BCG, bacille Calmette-Guérin; NTM, nontuberculous mycobacteria; IFN, interferon; IL, interleukin; ELISA, enzyme-linked immunosorbent assay.

Mendelian susceptibility to mycobacterial infection (MIM 209950) is a rare and heterogeneous syndrome.1–5 Affected individuals develop severe clinical disease caused by weakly virulent mycobacterial species, such as bacille Calmette-Guérin (BCG) vaccines and environmental nontuberculous mycobacteria (NTM). The clinical phenotype ranges from fatal disseminated infection in early childhood to focal recurrent infection in adults. In the last 5 years, considerable genetic heterogeneity has been documented. Mutations have been found in 4 genes: IFNGRI, encoding the interferon gamma (IFNγ) receptor ligand-binding chain; IFNGR2, encoding the IFNγ receptor signal-transducing chain; IL12B, encoding the p40 subunit of interleukin (IL)-12; and IL12RB1 encoding the IL-12 receptor β1 chain. Different types of mutations define 8 inherited disorders: complete recessive IFNγR1 deficiency with4–6 or without7 receptor surface expression; partial, as opposed to complete, IFNγR1 deficiency with recessive8 or dominant inheritance9; recessive complete10 or partial11 IFNγR2 deficiency; complete recessive IL-12p4012; and IL-12Rβ1 deficiency.13,14 However, a molecular etiology is still lacking for a majority of the patients. Complete IFNγR11–7 and IFNγR29 deficiency are responsible for early-onset overwhelming mycobacterial disease. Partial IFNγR1 defects5,9 and partial IFNγR2 deficiency,11 like complete IL-12p4012 and IL-12Rβ1 deficiency,13,14 are responsible for milder clinical forms.1–3

The diversity of the genes and pathogenic mutations involved renders molecular diagnosis challenging. For example, complete IFNγR1 deficiency may be caused by mutations preventing expression of the receptor4–6 or binding of the surface receptor to IFNγ.7 Moreover, cells with complete IFNγR deficiency do not respond to IFNγ,4–7 whereas cells with partial IFNγR deficiency respond to IFNγ at high concentration.8,9,11 Finally, most patients display low levels of IFNγ production by peripheral blood cells.1–2 Cumbersome diagnostic investigations combining highly specialized functional, biochemical, and genetic assays are, therefore, required in most patients with the syndrome. An accurate and rapid molecular diagnosis is, however, essential for the rational and efficient treatment of the patient. Indeed, children with complete IFNγR deficiency do not achieve sustained remission with antibiotics alone and do not respond to exogenous IFNγ, resulting from a lack of functional receptors. The outcome seems to be often fatal and bone marrow transplantation should be considered.1–3,15 In contrast, the administration of subcutaneous IFNγ together with antibiotics is often beneficial in patients with other genetic defects, and full remission of mycobacterial disease has been achieved.1–3 The lack of a simple method for rapidly discriminating between patients with complete IFNγR deficiency and patients with other genetic etiologies greatly compromises the management of these patients.

We measured IFNγ by enzyme-linked immunosorbent assay (ELISA) in the plasma of healthy individuals and patients with various forms of Mendelian susceptibility to mycobacterial infection. IFNγ is undetectable (<5 pg/mL) in the serum and plasma of 6 healthy individuals tested (not shown). All patients had suffered from BCG and/or NTM clinical disease when the blood sample was taken. Patients with IL-12p40 (n = 3) and with IL-12-receptor β1 chain deficiency (n = 5)—like patients with partial dominant IFNγR1 deficiency (n = 7) and partial re-
Fig 1. Serum levels of IFNγ in patients with known genetic etiologies for Mendelian susceptibility to mycobacterial infection. Known genetic etiologies include complete recessive IFNγR1 deficiency (CR1), complete recessive IFNγR2 deficiency (CR2), and partial recessive IFNγR1 deficiency (PR1). Other cases (others) include partial dominant IFNγR1 deficiency (n = 7), partial recessive IFNγR2 deficiency (n = 1), complete IL-12p40 deficiency (n = 3), and complete IL-12Rβ1 deficiency (n = 5). The experiment was performed in a single laboratory using the IFNγ ELISA kit: PeliKine Compact, Human IFN γ ELISA kit (CLB, The Netherlands). Its sensitivity is 5 pg/mL and the linear range is 5 pg/mL to 500 pg/mL. Our study was performed in compliance with institutional requirements and an informed consent was obtained from each patient’s family.

In any event, plasma IFNγ determination by ELISA is a simple, cheap, rapid, and efficient way to guide molecular diagnosis and to provide a rational basis for the treatment of patients with Mendelian susceptibility to mycobacterial infection. High levels (our threshold of 80 pg/mL is >2 standard deviations above the mean level in patients with partial recessive IFNγR1 defects) of IFNγ in the serum of a patient with BCG and/or NTM clinical disease should lead to the consideration of bone marrow transplantation options while searching for and validating null mutations of IFNGR1 or IFNGR2. Undetectable or low levels of IFNγ should lead to the child being treated with subcutaneous IFNγ while searching for mild mutations of IFNGR1 and IFNGR2, or null mutations of IL12B and IL12RB1.

REFERENCES
High Levels of Interferon Gamma in the Plasma of Children With Complete Interferon Gamma Receptor Deficiency
Claire Fieschi, Stéphanie Dupuis, Capucine Picard, C. I. Edvard Smith, Steven M. Holland and Jean-Laurent Casanova

Pediatrics 2001;107;e48
DOI: 10.1542/peds.107.4.e48

Updated Information & Services
including high resolution figures, can be found at:
http://pediatrics.aappublications.org/content/107/4/e48

References
This article cites 14 articles, 2 of which you can access for free at:
http://pediatrics.aappublications.org/content/107/4/e48.full#ref-list-1

Subspecialty Collections
This article, along with others on similar topics, appears in the following collection(s):
Infectious Disease
http://classic.pediatrics.aappublications.org/cgi/collection/infectious_diseases_sub

Permissions & Licensing
Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at:
https://shop.aap.org/licensing-permissions/

Reprints
Information about ordering reprints can be found online:
http://classic.pediatrics.aappublications.org/content/reprints
High Levels of Interferon Gamma in the Plasma of Children With Complete Interferon Gamma Receptor Deficiency
Claire Fieschi, Stéphanie Dupuis, Capucine Picard, C. I. Edvard Smith, Steven M. Holland and Jean-Laurent Casanova

Pediatrics 2001;107;e48
DOI: 10.1542/peds.107.4.e48

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://pediatrics.aappublications.org/content/107/4/e48