Autoimmune lymphoproliferative syndrome (ALPS) is a rare inherited disorder of apoptosis, most commonly due to mutations in the FAS (TNFRSF6) gene. It presents with chronic lymphadenopathy, splenomegaly, and symptomatic multilineage cytopenias in an otherwise healthy child. Unfortunately, these clinical findings are also noted in other childhood lymphoproliferative conditions, such as leukemia, lymphoma, and hemophagocytic lymphohistiocytosis, which can confound the diagnosis. This report describes a 6-year-old girl with symptoms misdiagnosed as hemophagocytic lymphohistiocytosis and treated with chemotherapy before the recognition that her symptoms and laboratory values were consistent with a somatic FAS mutation leading to ALPS. This case should alert pediatricians to include ALPS in the differential diagnosis of a child with lymphadenopathy, splenomegaly, and cytopenias; obtain discriminating screening laboratory biomarkers, such as serum vitamin B-12 and ferritin levels; and, in the setting of a highly suspicious clinical scenario for ALPS, pursue testing for somatic FAS mutations when germ-line mutation testing is negative. Pediatrics 2013;132:e1440–e1444
First recognized in the early 1990s, autoimmune lymphoproliferative syndrome (ALPS) is a rare inherited disorder of apoptosis leading to autoimmune cytopenias due to immune dysregulation and inappropriate accumulation of lymphocytes in the lymph nodes and spleen. Because the differential diagnosis for lymphadenopathy, splenomegaly, and cytopenias involves many conditions with overlapping features, diagnostic criteria for ALPS (Table 1) and other lymphoproliferative disorders, such as hemophagocytic lymphohistiocytosis (HLH) (Table 2), have been developed. By definition, ALPS patients have chronic nonmalignant lymphadenopathy and/or splenomegaly associated with an increased circulating population of pathognomonic CD3+ TCRab+ lymphocytes that do not express CD4 or CD8, which are referred to as double-negative T cells (DNTs). In addition, patients frequently have classically elevated biomarkers (eg, vitamin B-12). The most common cause of ALPS is an inherited germ-line heterozygous mutation in the FAS (TNFRSF6) gene, known as ALPS-FAS. Recently, an increasing cohort of patients with somatic FAS gene mutations that are mostly limited to the circulating DNTs (ALPS-sFAS) have been described with the same clinical and laboratory features as patients with germ-line mutations. In this case report, we describe a 6-year-old girl with ALPS-sFAS after a presumptive diagnosis of HLH was made in her first year of life.

**PATIENT PRESENTATION**

The patient was born at full term and was clinically well during the first months of life. However, routine laboratory testing at her 9-month well-child visit revealed pancytopenia (white blood cell count: 4700 cells per mm³; absolute neutrophil count (ANC): 1200 per mm³; hemoglobin: 6.3 g/dL; platelets: 87,000 per mm³), prompting a subspecialty referral and a hospital admission. Her spleen was palpable 5 cm below the left costal margin, her liver edge was palpable 4 cm below the right costal margin, and she had palpable cervical lymphadenopathy. After viral etiologies were ruled out, a diagnosis of HLH was considered because she met 4 of 8 criteria including the following: cytopenias involving at least 2 cell lineages, hypertriglyceridemia (292 mg/dL), increased serum or plasma vitamin B-12 levels (500 ng/mL), and increased plasma sFASL levels (20 pg/mL) or plasma IL-18 levels (<150 mg/dL). Hemophagocytosis in bone marrow, spleen, lymph nodes, or liver were not noted. The patient had persistent fever (≥38.5°C) and splenomegaly (her spleen edge was palpable 5 cm below the left costal margin, her liver edge was palpable 4 cm below the right costal margin, and her liver edge was palpable 4 cm below the right costal margin). Because the differential diagnosis of HLH includes familial HLH, no evidence of malignancy should be apparent. Therefore, a presumptive diagnosis of HLH was confirmed.

**TABLE 1 Revised Diagnostic Criteria for ALPS According to the First International ALPS Workshop 2009**

<table>
<thead>
<tr>
<th>Criteria to Determine a Diagnosis of ALPS</th>
</tr>
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<tbody>
<tr>
<td>Required criteria</td>
</tr>
<tr>
<td>1. Fever (≧38.5°C)</td>
</tr>
<tr>
<td>2. Splenomegaly</td>
</tr>
<tr>
<td>3. Cytopenias (affecting at least 2 of 3 lineages in the peripheral blood)</td>
</tr>
<tr>
<td>- Hemoglobin &lt;9 g/dL (in infants &lt;4 weeks: hemoglobin &lt;0 g/dL)</td>
</tr>
<tr>
<td>- Platelets &lt;100 × 10³ per mL</td>
</tr>
<tr>
<td>- Neutrophils &lt;1 × 10³ per mL</td>
</tr>
<tr>
<td>4. Hypertriglyceridemia (fasting: &gt;265 mg/dL) and/or hypocholesterolemia (&lt;150 mg/dL)</td>
</tr>
<tr>
<td>5. Hemophagocytosis in bone marrow, spleen, lymph nodes, or liver</td>
</tr>
<tr>
<td>6. Low or absent NK-cell activity</td>
</tr>
<tr>
<td>7. Ferritin &gt;500 ng/mLb</td>
</tr>
<tr>
<td>8. Elevated sCD25 (α-chain of sIL-2 receptor)c</td>
</tr>
</tbody>
</table>


**TABLE 2 Diagnostic Criteria for HLH Used in the HLH-2004 Trial**

<table>
<thead>
<tr>
<th>Criteria to Determine a Diagnosis of HLHb</th>
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<tbody>
<tr>
<td>(A) A molecular diagnosis consistent with HLH: pathologic mutations of PRF1, UNC13D, Munc18-2, Rab27a, STX11, SH2D1A, or BIRC4</td>
</tr>
<tr>
<td>Or</td>
</tr>
<tr>
<td>(B) If 5 of the 8 criteria listed below are fulfilled:</td>
</tr>
<tr>
<td>1. Fever ≥38.5°C</td>
</tr>
<tr>
<td>2. Splenomegaly</td>
</tr>
<tr>
<td>3. Cytopenias (affecting at least 2 of 3 lineages in the peripheral blood)</td>
</tr>
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</tbody>
</table>

Reprinted with permission from Jordan MB, Allen DE, Weitzman SM, et al. Blood. 2011;118:4041–4052. NK, natural killer; sCD25, Soluble CD25 (a term sometimes used for alpha-chain of soluble IL-2 receptor).b Although the HLH-2004 protocol uses ferritin >500 ng/mL, we generally view ferritin levels >3000 ng/mL as concerning for HLH and ferritin levels >10,000 as highly suspicious. In addition, in the case of familial HLH, no evidence of malignancy should be apparent. In addition, in the case of familial HLH, no evidence of malignancy should be apparent. In addition, in the case of familial HLH, no evidence of malignancy should be apparent.
HLH. Genetic evaluation for familial HLH revealed a variant of uncertain significance in the gene encoding perforin (c.272C>T, p.A91V). Treatment of HLH was initiated per the HLH-2004 Therapeutic Guidelines for Hemophagocytic Lymphohistiocytosis, consisting of etoposide, dexamethasone, and cyclosporine due to persistent and worsening lymphoproliferation and transfusion-dependent cytopenias. Because she remained treatment refractory, a search for a matched unrelated donor for allogeneic bone marrow transplantation was initiated, but transplant efforts were significantly delayed due to her complex social situation. Chemotherapy was stopped in October 2008 after 22 consecutive months of treatment. To obtain a more definitive tissue diagnosis and because the patient was experiencing discomfort from her significantly enlarged spleen, a splenectomy was performed in January 2009, both for therapeutic and diagnostic purposes. The pathology report after splenectomy revealed an enlarged spleen showing hypersplenism with widened splenic cords and rare to absent hemophagocytic activity. A second opinion noted that the spleen also had atypical T-cell hyperplasia with DNTs, consistent with ALPS. Mutation analyses for the ALPS-related genes (FAS, FASL, CASP10) were then obtained; however, no mutations were detected in genomic DNA obtained from peripheral blood mononuclear cells. Other screening tests for ALPS (Table 1), including serum vitamin B-12 levels, DNT percentage, and apoptosis assays, were not obtained. She was subsequently referred to the National Institutes of Health for further workup to evaluate for somatic ALPS. Peripheral blood immunophenotyping revealed an increased percentage of circulating DNTs (25.9%). In addition, she was determined to have an elevated serum vitamin B-12 level (>6000 pg/mL), high serum IL-10 (592 pg/mL), and high soluble FASL (5448 pg/mL). These serum biomarkers together with the elevated DNTs supported the diagnosis of ALPS caused by a FAS mutation.

A diagnosis of ALPS-sFAS was confirmed by detecting a somatic FAS mutation (c.913delTinsGA, p.M224RfsX7) in genomic DNA extracted from isolated DNTs.

DISCUSSION

ALPS and HLH have many overlapping clinical and laboratory features. Both are lymphoproliferative syndromes that present in childhood and are characterized by persistent lymphadenopathy/splenomegaly with evidence of immune dysregulation that includes hyperinflammation and cytopenias. Although underappreciated, ALPS-FAS and ALPS-sFAS patients often have significantly elevated sIL-2Rα and can occasionally have evidence of hemophagocytes in the bone marrow, making the distinction between ALPS and HLH even more nebulous.

However, distinguishing between ALPS and HLH is crucial because the management paradigms are very different. ALPS patients often require long-term immunosuppressive therapies with corticosteroids and steroid-sparing measures, including mycophenolate mofetil.
or sirolimus for managing chronic, refractory cytopenias and hypersplenism, respectively. ALPS patients with germ-line FAS mutations also require regular vigilance for possible hematopoietic malignancies because their risk of developing Hodgkin and non-Hodgkin lymphoma is 50- and 14-fold greater, respectively, than in the general population. Although splenectomy provided the tissue diagnosis of ALPS in this patient, it is neither necessary nor desirable for the diagnosis and management of most patients with ALPS. In contrast, the current standard of care is to treat HLH patients with chemotherapy, including etoposide and dexamethasone plus or minus cyclosporine. If the patient has a family history of HLH, has one of the genetic mutations, relapses while on chemotherapy for HLH, and/or has central nervous system disease, allogeeneic bone marrow transplantation is required for an effective cure.

In this case, the initial presumptive diagnosis of HLH delayed the identification of her actual diagnosis for almost 2 years. In the interim, she was exposed to 22 months of chemotherapy and underwent splenectomy before a definitive diagnosis of ALPS-sFAS was established. Although, she currently requires no specific treatment of her ALPS, there is now a need to carefully monitor her long term for risk of pneumococcal sepsis due to her surgical asplenia and the possibility of secondary leukemia associated with exposure to etoposide therapy. Both of these risks could have been avoided had the diagnosis of ALPS been considered and recognized sooner.

To distinguish the 2 disorders, it is essential to obtain discriminating data early as indicated in the diagnostic criteria for ALPS (Table 1) and HLH (Table 2). Elevated serum biomarkers (vitamin B-12, sFASL, IL-10, IL-18) in combination with evidence of autoimmune cytopenias and elevated immunoglobulin G levels can point toward a diagnosis of ALPS. However, recent reports also note elevated IL-10 levels in some HLH patients. In the case of germ-line mutations, a family history of chronic lymphoproliferation can support the diagnosis of ALPS. Importantly, the ferritin level can help differentiate ALPS from HLH, because the ferritin elevation in ALPS patients is generally lower than 3000 ng/mL, which is reportedly more specific for HLH. In our cohort of patients with ALPS-FAS and ALPS-sFAS who were ≤26 years old, only 1 patient, who notably had received numerous blood transfusions, had a ferritin level >3000 ng/mL. The remaining patients had serum ferritin levels ranging from 18 to 2951 ng/mL (median: 138 ng/mL), with 67 out of the 78 samples tested for ferritin found to be <500 ng/mL. Patient samples were also remarkable for very high median sIL-2Ra (5645 units/mL) and serum vitamin B-12 (3444 pg/mL) levels (Fig 1). We have highlighted this case to emphasize the importance of considering rare disorders, particularly ALPS, in the differential diagnosis of patients presenting with lymphadenopathy, splenomegaly, and cytopenias. Additionally, simple biomarkers should always be sought early in evaluation before obtaining more expensive, and potentially confounding, genetic testing. Readily attainable ALPS-related biomarkers (Table 1, Fig 1) can be used to determine the likelihood of ALPS and the need for sending confirmatory genetic testing. Last, it is critical to recognize that the clinical features of ALPS-FAS/ALPS-sFAS are similar, but Sanger sequencing using genomic DNA from unseparated peripheral blood mononuclear cells can lead to false-negative results in ALPS-sFAS. When there is a strong clinical likelihood of ALPS, but mutation analysis using genomic DNA has failed to reveal a FAS mutation, the analysis should be repeated by using DNA extracted from isolated peripheral blood DNTs to establish a diagnosis of ALPS-sFAS.

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REFERENCES


(Continued from first page)

This study has undergone annual review by the NIAID Institutional Review Board, and all participants whose data are included in this article were enrolled in the study after undergoing the informed consent process. This manuscript was developed after a presentation and discussion of this patient at the weekly grand rounds of the NIAID, NIH, in Bethesda, Maryland, in 2012.

This trial has been registered at www.clinicaltrials.gov (identifier: NCT00001350).

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Autoimmune Lymphoproliferative Syndrome Misdiagnosed as Hemophagocytic Lymphohistiocytosis

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