Objective: To examine the prevalence of steatorrhea and exocrine pancreatic insufficiency (EPI) and their association with growth and immune status variables in children with perinatally acquired human immunodeficiency virus (HIV) infection.

Design: Cross-sectional study.

Setting: Tertiary care HIV subspecialty practice.

Participants: Children with perinatally acquired HIV infection. Exclusion criteria included being younger than 1 year and receiving mineral oil as a medication.

Methods: Weight, height, and upper arm anthropometric variables were measured. Spot stool samples were analyzed for steatorrhea using the Sudan III qualitative test and for EPI using fecal elastase-1 enzyme assay. Hormone-stimulated pancreatic function testing and 72-hour stool and dietary fat sample collection were performed when fecal elastase-1 enzyme was in the range of EPI, defined as less than 200 µg/g. HIV RNA viral load, CD4 status, type of antiretroviral therapy, and biochemical evidence of hepatobiliary disease were measured within 3 months of stool sample collection. z Scores were computed for height, weight, triceps skinfold, and upper arm muscle area.

Results: We enrolled 44 patients (23 girls [52%]) with a mean ± SD age of 7.4 ± 3.1 years. None had hepatobiliary disease. The prevalence of steatorrhea was 39% (95% confidence interval, 23%-56%). The prevalence of EPI was 0% (95% confidence interval, 0%-9%). There were no associations between steatorrhea and EPI, growth, HIV RNA viral load, CD4 status, or type of antiretroviral therapy. Older children had decreased z scores for height (r = −0.42; P = .006).

Conclusions: The clinical significance of steatorrhea in children with HIV infection is unclear. Furthermore, its evaluation should focus on nonpancreas-based conditions. Continual close monitoring of growth is essential in children with HIV infection.


STEATORRHEA, defined as malabsorbed fat in feces, is prevalent in adults with human immunodeficiency virus (HIV) infection even in the absence of gastrointestinal tract symptoms. The prevalence and impact of steatorrhea on growth and nutritional status in children with perinatally acquired HIV infection is not well defined. Impaired growth in HIV infection has multifactorial origins ranging from inadequate energy (caloric) intake to nutrient malabsorption, inefficient utilization, and increased losses. Because a goal of nutritional care in children with HIV infection is to achieve a positive energy balance and normal growth, knowledge of the prevalence of steatorrhea and its growth-related abnormalities can lead to optimized care. Pancreatic dysfunction has been suggested in children and adults with HIV infection. The aim of this study was to examine the prevalence of steatorrhea and exocrine pancreatic insufficiency (EPI) in children with perinatally acquired HIV infection. The hypothesis was that a significant proportion of children with HIV infection and steatorrhea has EPI. If true, this would merit consideration of pancreatic enzyme therapy.

RESULTS

Of 65 children within the age range of interest, 44 (23 girls [52%]) enrolled in the study. Participants were aged 7.4 ± 3.1 years, and their growth characteristics were as follows: HAZ, −0.70 ± 1.36; WAZ, −0.40 ± 1.20; WHZ, −0.17 ± 1.34; TSFZ, −0.19 ± 0.65; and UAMAZ, −0.05 ± 1.23. None of the study patients had hepatobiliary disease. Reasons for nonparticipation included disinterest in the study (n = 14) and foster care (n = 7). Nonparticipants were aged 6.7 ± 4.0 years, and...
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\[-0.36 \pm 1.28\; \text{WAZ}, 0.08 \pm 1.54; \text{and WHZ}, 0.23 \pm 1.23\] (not statistically significantly different from study patients). Two patients had chronic (>2 weeks) pathogen-negative diarrhea at the time of stool sample collection. One patient had Mycobacterium avium-intracellulare infection complicated by acute pancreatitis at the time of stool sample collection. Levels of HIV RNA ranged from less than 40 to 900,000 copies/mL. There were 11 patients with HIV RNA viral loads in the tertile range of less than 40 to 3000 copies/mL and 10 each with HIV RNA viral loads in the tertile ranges of 3001 to 30000 and greater than 30000 copies/mL. The CD4 status was normal in 17 patients (59%), moderately suppressed in 11 (35%), and severely suppressed in 3 (10%).

Thirty-three patients provided fecal specimens for analysis, and their clinical characteristics are shown in Table 1. The prevalence of steatorrhea by Sudan III qualitative stain was 39% (95% CI, 23%-56%). There were no significant associations between presence of steatorrhea and any of the growth variables (HAZ, WAZ, WHZ, TFSZ, and UAMAZ), HIV RNA viral load, and CD4 status (Table 1). No patient had both steatorrhea and decreased FE-1 levels in the range for EPI. Only 2 patients had FE-1 levels in the range for EPI. One was a 9-year-old girl with chronic pathogen-negative diarrhea (negative for Giardia, Clostridium difficile, Cryptosporidium, Salmonella, Shigella, Yersinia, Campylobacter, Plesiomonas, and Aeromonas), impaired growth (HAZ, –4.06; WAZ, –2.50; and WHZ, 0.38), and an FE-1 level of 174 µg/g. Her %CoA was 96% (normal, ≥93%). The hormone-stimulated pancreatic test results showed normal pancreatic enzyme and electrolyte output, and, therefore, EPI was excluded. The second patient was an 8-year-old boy with Mycobacterium avium-intracellulare infection complicated by acute pancreatitis with an FE-1 level of 170 µg/g. His FE-1 level after recovery from the Mycobacterium avium-intracellularure infection was normal (593 µg/g), and further testing for EPI was not performed. Therefore, in this sample of children with perinatally acquired HIV infection, the prevalence of EPI was 0% (95% CI, 0%-9%).

Older patients had significantly lower HAZ than younger patients (Figure). There was a significant trend for HAZ to decline with advancing chronological age (r = –0.42; P = .006). No similar trend was observed with the other growth variables: WAZ, P = .2; WHZ, P = .3; TFSZ, P = .8; and UAMAZ, P = .5.

In this sample of children with perinatally acquired HIV infection, steatorrhea was prevalent but had no consistent association with EPI, growth variables, HIV RNA vi-

**Table 1**

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**COMMENT**

In this sample of children with perinatally acquired HIV infection, steatorrhea was prevalent but had no consistent association with EPI, growth variables, HIV RNA vi-
STOOL STUDIES AND HORMONE-STIMULATED PANCREATIC FUNCTION TEST

Spot fecal specimens were collected, aliquoted, and stored at –70°C before measurement of qualitative steatorrhea and FE-1 analysis. Qualitative steatorrhea was assessed using the Sudan III qualitative stain (Mayo Clinic Laboratories, Rochester, Minn), which is specific for detecting triacylglycerides and fatty acids in the stool matrix and reliable for excluding steatorrhea. The FE-1 content of the spot stool specimen was measured using enzyme-linked immunosorbent assay (Schell-Bo-Tech, Wettenberg, Germany). After age 1 month, normal FE-1 levels are greater than 200 µg/g. Thereafter, levels of 100 to 200 µg/g indicate moderate EPI. Levels less than 100 µg/g indicate severe EPI. Fecal elastase-1 enzyme has high stability at room and cold storage temperatures and has demonstrated high specificity (96%) and sensitivity (100%) for the detection of EPI in children with cystic fibrosis.

Patients were admitted to the inpatient General Clinical Research Center at The Children’s Hospital of Philadelphia for the 72-hour stool and dietary fat sample collections, which were performed while the patient consumed a diet containing 3 g of fat per kilogram of body weight (maximum, 100 g). Percent coefficient of fat absorption (%CoA) was calculated according to the following formula:

\[
%\text{CoA} = (\frac{\text{Fat Intake (g)} - \text{Stool Fat (g)}}{\text{Fat Intake (g)}}) \times 100
\]

The normal range of %CoA is 93% or greater. The stool analysis was conducted using the method of Jeejeebhoy et al (Mayo Clinic Laboratories).

The hormone-stimulated pancreatic test was performed using a modified technique. After a 6-hour fast, a double-lumen nasoduodenal tube was inserted through the nose and positioned in the duodenum with fluoroscopic guidance. Pancreatic and duodenal secretions mixed with infused marker was aspirated by low-pressure suction before, during, and after infusing intravenous secretin and cholecystokinin at doses known to cause maximal pancreatic secretion (secretin, 0.033 µg/kg per dose, and cholecystokinin, 0.2 µg/kg per dose). No sedation was required.

STATISTICAL ANALYSIS

To compare growth of children of different sexes and ages, the weight, height, and upper arm anthropometry data are expressed in means ± SD z scores. z Scores for height for age (HAZ), weight for age (WAZ), and weight for height (WHZ) were computed using an anthropometric software program (version 3.1; Division of Nutrition, Centers for Disease Control and Prevention, Atlanta, Ga). z Scores for triceps skinfold (TSFZ) and upper arm muscle area (UAMAZ) were computed using US reference data. Patients were grouped according to HIV RNA viral load tertile ranges of less than 40 to 3000, 3001 to 30000, and greater than 30000 copies/mL. A descriptive analysis was performed to assess the prevalence and 95% confidence intervals (CIs) of steatorrhea and EPI. Differences in growth variables (WAZ, HAZ, WHZ, TSFZ, and UAMAZ) between patients with and without steatorrhea were examined using the t test. The χ² test was used to test associations between steatorrhea and HIV RNA viral load tertile and CD4 status (normal, moderately suppressed, and severely suppressed). Pearson correlation was used to examine associations between age and growth variables. Statistical significance was defined as P≤.05. All analyses were performed using statistical software (Stata 5.0; Stata Corp, College Station, Tex).
paired growth in our sample of children with HIV infection. Mean z scores for height and weight were less than zero, thereby documenting that growth was generally impaired compared with the National Center for Health Statistics reference population. There was a significant trend of declining HAZ with advancing chronological age, but a similar trend was not observed with WAZ, WHZ, TSFZ, and UAMAZ. The decline in HAZ with advancing chronological age in study patients was not explained by delayed pubertal growth because most patients (>90%) were younger than the average age for progression into puberty. Two possible explanations for this significant trend are (1) a direct impact of chronic HIV infection on growth, leading to a cumulative decline in HAZ as infected children get older, or (2) unavailability of highly active antiretroviral therapy (HAART) during infancy and early childhood in patients born before 1996. In general, patients with decreased HAZ were older children born before HAART become widely available. Therefore, less effective control of HIV viral load during the critical growth periods of infancy and early childhood may have contributed to stunted growth patterns. Conversely, better control of HIV viral load using HAART initiated early in infancy may have led to a decreased impact of the disease on the linear growth patterns of patients born after 1996. Therefore, availability and use of HAART may be heralding a positive change from the impaired growth patterns and devastating clinical manifestations previously commonly observed in children with perinatally acquired HIV infection.

The main limitations of this study are related to its cross-sectional design. The duration and impact of steatorrhea on individual growth patterns was not specifically examined. The degree of steatorrhea was also not quantified; however, a positive Sudan III qualitative fecal fat test result generally corresponds to a %CoA of less than 94% and quantitative steatorrhea in the range of 4 or more to 10 g of stool fat per 24 hours. These data suggest that although the Sudan III qualitative test provides convenient, rapid, and noninvasive screening, a positive result represents broad ranges of quantitative steatorrhea. Therefore, the wide sensitivity range of the Sudan III qualitative test may have limited our ability to detect any associations between steatorrhea and growth patterns in this sample of children with perinatally acquired HIV infection. Finally, inferring a trend of impaired linear growth with advancing chronological age using cross-sectional data, and in the absence of information about genetic input to linear growth (biological parental heights) has limitations. Nonetheless, comparisons with the National Center for Health Statistics reference data indicated that the linear growth in this sample of children with perinatally acquired HIV infection was decreased.

In conclusion, in this sample of children with perinatally acquired HIV infection, there was a high prevalence of steatorrhea (39%) that was neither secondary to EPI nor consistently associated with impaired growth, HIV RNA viral load, CD4 status, or type of antiretroviral therapy. Therefore, the clinical significance of steatorrhea in children with HIV infection is unclear. Furthermore, its evaluation should focus on nonpancreatic-based causes. Even with improved HAART, continual close monitoring of growth is essential for optimal care of children with HIV infection.

Accepted for publication September 26, 2000.

This study was supported in part by grant RR00240 from the General Clinical Research Center and by the Nutrition Center at The Children’s Hospital of Philadelphia.

Table 1. Clinical Characteristics of 33 Patients Who Provided Fecal Specimens for Analysis

<table>
<thead>
<tr>
<th>Qualitative Steatorrhea</th>
<th>Present (n = 14)</th>
<th>Absent (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD, y</td>
<td>7.8 ± 3.1</td>
<td>7.7 ± 3.0</td>
</tr>
<tr>
<td>FE-1, mean ± SD, µg/g</td>
<td>631 ± 167</td>
<td>533 ± 170</td>
</tr>
<tr>
<td>CD4 status (n = 31)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>8 9</td>
<td></td>
</tr>
<tr>
<td>Moderate suppression</td>
<td>4 7</td>
<td></td>
</tr>
<tr>
<td>Severe suppression</td>
<td>2 1</td>
<td></td>
</tr>
<tr>
<td>HIV RNA viral load, copies/mL (n = 31)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;40-3000</td>
<td>5 6</td>
<td></td>
</tr>
<tr>
<td>3001-30000</td>
<td>5 5</td>
<td></td>
</tr>
<tr>
<td>&gt;30000</td>
<td>4 6</td>
<td></td>
</tr>
<tr>
<td>z Score, mean ± SD (n = 33)</td>
<td></td>
<td></td>
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<tr>
<td>Height</td>
<td>−0.47 ± 1.04</td>
<td>−0.81 ± 1.63</td>
</tr>
<tr>
<td>Weight</td>
<td>−0.43 ± 0.86</td>
<td>−0.58 ± 1.27</td>
</tr>
<tr>
<td>Weight for height</td>
<td>−0.08 ± 1.01</td>
<td>−0.10 ± 1.06</td>
</tr>
<tr>
<td>Triceps skinfold</td>
<td>−0.38 ± 0.66</td>
<td>−0.02 ± 0.61</td>
</tr>
<tr>
<td>Upper arm muscle area</td>
<td>−0.11 ± 0.86</td>
<td>0.11 ± 1.62</td>
</tr>
</tbody>
</table>

*Data are given as number of patients except where indicated otherwise. FE-1 indicates fecal elastase-1 enzyme; HIV, human immunodeficiency virus. No comparisons reached statistical significance.

Table 2. Test Results in 33 Patients Who Provided Fecal Specimens for Analysis

<table>
<thead>
<tr>
<th>Patients, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative FE-1 and negative qualitative fecal fat</td>
</tr>
<tr>
<td>Negative FE-1 and positive qualitative fecal fat</td>
</tr>
<tr>
<td>Positive FE-1 and negative qualitative fecal fat</td>
</tr>
<tr>
<td>Positive FE-1 and positive qualitative fecal fat</td>
</tr>
<tr>
<td>Pancreatic stimulation test and quantitative steatorrhea</td>
</tr>
</tbody>
</table>

*FE-1 indicates fecal elastase-1 enzyme.
We thank Hans Scheefers, PhD, at ScheBo-Tech for conducting all the fecal elastase-1 enzyme assays; the children and families participating in this study; and the staff of the General Clinical Research Center at The Children's Hospital of Philadelphia for processing and triaging the fecal specimens.

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