Written by practising clinicians, this comprehensive full-colour atlas provides essential reading for all those who manage paediatric disorders. All the major disorders of paediatric gastroenterology are covered in this volume: diarrhoea and vomiting, coeliac disease, cow’s milk allergy, inflammatory disorders, short bowel syndrome, appendicitis, gastrointestinal bleeding, liver disease, and abdominal masses. More unusual and challenging aspects such as congenital gastrointestinal malformations, diagnosing abdominal pain, failure to thrive, and paediatric clinical dietetics are also addressed. There is a wealth of valuable information on how to make accurate diagnoses and effectively manage children with gastrointestinal disorders, presented in a logical clear way, taking the reader through clinical presentation, differential diagnosis, prognosis and treatment options.

Concisely written and with numerous illustrations, Paediatric Gastroenterology: an Atlas of Investigation and Management provides an easy and accessible format to quickly read and review material. Readers will find this an invaluable aid to identify disorders correctly through visual memory, create investigative strategies for diagnosis and determine appropriate management.

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An Atlas of Investigation and Management

PAEDIATRIC GASTROENTEROLOGY

José M Moreno-Villares, MD
Nutrition Unit
Department of Paediatrics
Hospital Universitario 12 de Octubre
Madrid, Spain

Isabel Polanco, MD, PhD
Professor of Paediatrics
Head of Department of Paediatric Gastroenterology and Nutrition
Hospital Infantil Univeritario La Paz
Facultad de Medicina, Universidad Autónoma
Madrid, Spain

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Preface

Paediatric gastroenterology emerged as a speciality in the 1960s. Since then it has become an essential component of major academic paediatric programmes throughout the world. The introduction of new diagnostic techniques that required special skills, as well as the development of complex new therapies for children with gastrointestinal disorders, were cornerstones in the development of the speciality. The recognition that appropriate nutrition during infancy and childhood is vital for health and the profound impact that many gastrointestinal diseases may have upon growth also contributed to the discipline’s development.

Many excellent paediatric gastroenterology texts have been published since the first textbook on the subject was published in the early 1970s, but there are not so many based on excellent figures and comprehensive tables. *Paediatric Gastroenterology, An Atlas of Investigation and Management,* provides concise and practical information for readers. Topics on the three main areas of the speciality – gastroenterology, hepatology, and nutrition – constitute the body of this book. The authors were carefully selected to provide a comprehensive and clear account of their assigned topics. All of them have been willing to dedicate their time, knowledge, and effort in preparing their chapters. Our most sincere thanks to them. It has been a pleasure to work with Clinical Publishing’s production team who have helped to produce a book of outstanding quality.

We hope and expect that this Atlas will be of benefit to all physicians dealing with gastrointestinal problems in children.

José M Moreno-Villares, MD
Isabel Polanco MD, PhD

Contributors

*Adolfo Bautista Casanovas,* MD, PhD
Head of Paediatric Surgery Section
University Hospital of Santiago de Compostela
Santiago de Compostela, Spain

*Mª Ángeles Calzado Agrasot,* MD
Paediatric Gastroenterology and Hepatology Unit
Hospital La Fe
Valencia, Spain

*Javier Blasco Alonso,* MD
Gastroenterology, Hepatology and Nutrition Division
Hospital Materno-Infantil
Málaga, Spain.

*Javier Bueno,* MD
Paediatric Liver Transplantation Unit
Paediatric Surgery Department
Hospital Valle de Hebrón
Barcelona, Spain

*Maria José Galíano Segovia,* MD
Centro de Salud Maria Montessori
Leganés
Madrid, Spain

*Anil Dhawan,* MD, FRCPCH
Paediatric Liver Centre
Institute of Liver Studies
Variety Club Children’s Hospital
King’s College Hospital
London, UK

*Iñaki Eizaguirre,* MD, PhD
Paediatric Surgery Department
Donostia Hospital
San Sebastian, Spain

*George Gershman,* MD, PhD
Associate Professor of Pediatrics
David Geffen School of Medicine
Chief, Division of Pediatric Gastroenterology and Nutrition
Harbor-UCLA Medical Center
Torrance
California, USA

*Jerónimo González Piñera,* MD, PhD
Associated Professor of Paediatric Surgery
Department of Paediatric Surgery
University General Hospital
Albacete, Spain
Daniel González-Santana, MD  
Paediatric Gastroenterology Division  
Las Palmas de Gran Canaria University  
Hospital Universitario Materno-Infantil de Canarias  
Spain

Antonio Monica Guerra, MD, PhD  
Nutrition Unit  
University of Porto  
Porto, Portugal

Carolina Gutiérrez Junquera, MD, PhD  
Associated Professor of Paediatrics  
Department of Pediatric Gastroenterology  
University General Hospital Albacete  
Spain

Iñaki X. Irastorza Terradillos, MD  
Paediatric Gastroenterology Division  
Hospital de Cruces  
Bilbao, Spain

Angel Mazón, MD  
Paediatric Allergy Division  
Hospital Infantil La Fe  
Valencia, Spain

José M. Moreno-Villares, MD  
Nutrition Unit  
Department of Paediatrics  
University Hospital 12 de Octubre  
Madrid, Spain

Antonio Nieto, MD, PhD  
Paediatric Allergy Division  
Hospital Infantil La Fe  
Valencia, Spain

Agustín Nogués, MD  
Paediatric Radiology Department  
Donostia Hospital  
San Sebastian, Spain

Joanna Pawłowska, MD  
Department of Gastroenterology, Hepatology and Immunology  
The Children’s Memorial Health Institute  
Warsaw, Poland

Luis Peña-Quintana, MD  
Paediatric Gastroenterology, Hepatology and Nutrition Division  
University Hospital  
Universidad de Las Palmas de Gran Canaria  
Spain

Amaya Peñalva Arigita, RD  
University Hospital Valle de Hebrón  
Barcelona, Spain

Isabel Polanco, MD, PhD  
Professor of Paediatrics  
Head of Department of Paediatric Gastroenterology and Nutrition  
University Hospital La Paz  
Universidad Autónoma  
Madrid, Spain

Begoña Polo Miquel, MD  
Paediatric Gastroenterology and Hepatology Division  
Hospital La Fe  
Valencia, Spain

Carmen Ribes-Koninckx, MD, PhD  
Paediatric Gastroenterology and Hepatology Division  
Hospital La Fe  
Valencia, Spain

Enriqueta Román Riechmann, MD  
Department of Paediatrics  
Hospital de Fuenlabrada  
Madrid, Spain

Carlos Sierra Salinas, MD  
Gastroenterology, Hepatology and Nutrition Division  
Hospital Materno-Infantil  
Málaga, Spain

Piotr Socha, MD  
Department of Gastroenterology, Hepatology and Immunology  
The Children’s Memorial Health Institute  
Warsaw, Poland

Juan A. Tovar, MD, PhD  
Professor and Chief, Department of Paediatric Surgery  
University Hospital  
La Paz  
Madrid, Spain

Jorge Vargas, MD  
Division of Gastroenterology and Nutrition  
Department of Paediatrics  
Mattel Children’s Hospital at UCLA  
Los Angeles, USA

Juan C. Vitoria Cormenzana, MD, PhD  
Professor of Paediatrics  
Basque Country University  
Chief, Paediatric Gastroenterology Division  
Hospital de Cruces  
Bilbao, Spain

David Ziring, MD  
Division of Gastroenterology and Nutrition  
Department of Paediatrics  
Mattel Children’s Hospital at UCLA  
Los Angeles, USA
Abbreviations

α1-ATD alpha-1-antitrypsin deficiency
AAP American Academy of Pediatrics
AFP alpha-fetoprotein
AIH autoimmune hepatitis
ALT alanine aminotransferase
AMA antimitochondrial antibodies
ANA antinuclear antibodies
APC antigen-presenting cell
ASCA anti-Saccharomyces cerevisiae antibodies
ASMA antismooth muscle antibody
AST aspartate aminotransferase
BA biliary atresia
BMI body mass index
BRIC benign recurrent intrahepatic cholestasis
Btl. bottle
BUN blood urea nitrogen
CD coeliac disease
CFU colony-forming units
CK creatine kinase
CM cow’s milk
CMA cow’s milk allergy
CMV cytomegalovirus
CNS central nervous system
CPM caloric–protein malnutrition
CrD Crohn’s disease
CT computed tomography
CTT colonic transit time
Da Dalton
DH dermatitis herpetiformis
DNA HBV hepatitis B virus DNA
EBV Epstein–Barr virus
EC endoscopic capsule
EF elemental formulas
EH extensively hydrolyzed (formula)
EIA enzyme immunoassay
ERCP endoscopic retrograde cholangiopancreatography
ESPGHAN European Society of Pediatric Gastroenterology, Hepatology, and Nutrition
FGID functional gastrointestinal disorders
FTT failure to thrive
GER gastro-oesophageal reflux
GERD gastro-oesophageal reflux disease
GFD gluten-free diet
GGT gamma glutamyl transpeptidase
GI gastrointestinal
GIST gastrointestinal stromal tumour
GN ganglioneuroma
Hb haemoglobin
HB hepatoblastoma
HC head circumference
Hct haematocrit
HD Hirschsprung’s disease
HIV human immunodeficiency virus
HP Helicobacter pylori
HPN home parenteral nutrition
HSP Henoch–Schönlein purpura
HUS haemolytic uraemic syndrome
IBD inflammatory bowel disease
IBS irritable bowel syndrome
IF infant formula
IDI intractable diarrhoea of infancy
IGF-1 intestinal growth factor
IL interleukin
INSS International Neuroblastoma Staging System
IQ intelligence quotient
LA laparoscopic appendectomy
LDH lactate dehydrogenase
LF lactose-free (formula)
LKM liver/kidney microsomal antibodies
MAC middle arm circumference
MCV mean cell volume
MBG meta-iodine-benzyl-guanidine
MRI magnetic resonance imaging
NAFLD nonalcoholic fatty liver disease
NASH nonalcoholic steatohepatitis
NB neuroblastoma
NEC necrotizing enterocolitis
NK natural killer cells
NKT natural killer T cells
NPD negative predictive value
NSAID nonsteroidal anti-inflammatory drug
OA open appendectomy
OCTN organic cation transporter gene
ORS oral rehydration solution
ORT oral rehydration therapy
pANCA anti-neutrophil cytoplasmic antibody with perinuclear staining pattern
PFIC progressive familial intrahepatic cholestasis
PH partially hydrolyzed (formula)
Pi protease inhibitor
PN parenteral nutrition
PPV positive predictive value
RAST radioallergosorbent test
RDA recommended dietary allowances
RDW red blood cell differentiation width
RNA HCV hepatitis C virus RNA
SBS short bowel syndrome
Sc scoop
SE semi-elemental (formula)
SGOT serum glutamic oxalacetic transaminase
SGPT serum glutamic pyruvic transaminase
SIOP Société Internationale d’Oncologie Pédiatrique
STEP serial transverse enteroplasty
TPN total parenteral nutrition
TNF tumour necrosis factor
TS tricipital skinfold
TSH thyroid stimulating hormone
UC ulcerative colitis
UPDG galactose-1-phosphate-uridyl transferase
US ultrasonography
WBC white blood count
WD Wilson’s disease
WI Waterloo index
WHO World Health Organization
Chapter 1

Failure to thrive in infants and children

José M Moreno-Villares, MD, and Antonio Monica Guerra, MD

Introduction

Evaluation of growth and development in the primary care setting is a cornerstone of pediatric care. Usually head circumference, weight, and length are measured at birth, and then on an intermittent basis throughout the rest of childhood. When a divergence from the standard growth curve occurs, in either direction, a careful assessment is required to determine the etiology.

Undernutrition or 'failure to thrive' (FTT) is a common nutritional problem in the infant and toddler pediatric population. The identification of patients with FTT is a routine part of residency training in pediatrics.

Inappropriate nutrient intake and growth parameters

FTT is a clinical label frequently used to describe infants and young children, generally under 3 years, who fail to grow as expected using established growth standards for age and gender along a period of time (usually longer than 3 months) (1.1).

Weight is a measure of the varying combination of height, body fat, and muscle bulk, which makes it a less straightforward measure of growth than height. Nevertheless, because of its widespread availability and ease of measurement, it is the most usual tool when growth measure is considered. What constitutes a normal rate of weight gain (Table 1.1)? It is often assumed that normal growth constitutes tracking along the birth centile. However, weight at birth is a reflection of the intrauterine environment and is of limited prognostic value. Many children deviate from their earlier centile position, and this divergence may not become pathological. Although the most commonly used definition of abnormality is that falling below a predetermined centile, usually the third (1.2), this would include a number of constitutionally small children. An alternative definition applies when a child has a weight curve that has fallen more than two standard deviations or

1.1 Eleven-month-old male, with growth faltering in the last 4–5 months, more severe in the last 2 weeks. Reduction in >2 major percentiles for weight.
2 Failure to thrive in infants and children

percentiles below a previously established rate of growth. However, up to 30% of healthy term infants cross one percentile line and 23% cross two percentile lines (in either direction) by the age of 2 years.

Table 1.1 Normal weight gain and frequency of monitoring

<table>
<thead>
<tr>
<th>Normal weight gain</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth to 5 months</td>
<td>15–30 g/day</td>
</tr>
<tr>
<td>6 to 12 months</td>
<td>15 g/day</td>
</tr>
<tr>
<td>12 months to 2 years</td>
<td>6–8 g/day</td>
</tr>
<tr>
<td>2 years to 6 years</td>
<td>38 g/month</td>
</tr>
</tbody>
</table>

Frequency of monitoring

Monthly for the first two months, every other month from 2 to 6 months; every 3rd month from 6 to 24 months, and yearly from 2 to 6 years old

Definition of FTT

FTT describes an infant or child whose current weight or rate of weight gain is significantly below that expected of similar children of the same age and sex. Most paediatricians diagnose FTT when a child’s weight for age falls below the fifth percentile of the standard growth charts or it crosses two major percentile lines (1.3). One problem arises from the use of different growth charts; misinterpretation may occur if different genetic backgrounds are not considered. This problem may be overcome if universal growth references could be used. The World Health Organization (WHO) has recently published charts resulting from the Multicenter Growth Reference Study, and are intended to substitute for the National Center for Health Statistics/WHO (NCHS/WHO) growth reference, which has been recommended for international use since the late 1970s (www.who.int/childgrowth/standards/curvas_por_indicadores/en/index.html) (1.4, 1.5).

FTT is not a final diagnosis but a description of a physical state; therefore, a cause must always be sought. Because the description itself is vague it has been proposed to use growth failure or undernutrition as a diagnostic replacement for FTT.

1.2 An 18-week-old female, with irritability and poor weight gain since birth. Weight below 3rd percentile.

1.3 Four-month-old male. Loss of >2 major percentiles since birth.
Until recently, the evaluation of a child with FTT focused on factors related to external environment or to medical causes. Currently, the child’s feeding behaviour and the interaction between the caregiver and the child has taken on greater importance. Feeding is an interactive process that depends upon abilities and characteristics of both the parents and the child.

**Aetiology**

FTT has been historically dichotomized as organic versus nonorganic (1.6). Organic FTT results from a major organ system illness or dysfunction, while nonorganic FTT is generally a diagnosis of exclusion. A third category has been added, mixed FTT, to recognize the fact that many organic FTT often have a psychological component. This approach is quite simplistic and inadequate for patient management. There is growing evidence that feeding difficulties are central to the development of the disorder. Family stressors, psychiatric disorders of parents, and disturbances in the infant–parent relationship may interfere with the development of an adequate feeding relationship.
4 Failure to thrive in infants and children

It is important to note that an infant presenting with presumed FTT may have a normal variant of growth. Specific infant populations with growth variations also need to be considered when making the diagnosis of FTT, for instance, infants with intrauterine growth retardation or premature infants.

<table>
<thead>
<tr>
<th>Table 1.2 Normal variants of growth presenting as FTT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Birth weight</strong></td>
</tr>
<tr>
<td>Low to normal</td>
</tr>
<tr>
<td><strong>Parental percentiles</strong></td>
</tr>
<tr>
<td><strong>Progress along percentiles</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 1.3. Classification of FTT by pathological causes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inadequate caloric intake</strong></td>
</tr>
<tr>
<td>• Food not available</td>
</tr>
<tr>
<td>– Type or volume of food not appropriate (e.g. too diluted formula)</td>
</tr>
<tr>
<td>– Poverty and food shortages</td>
</tr>
<tr>
<td>– Neglect</td>
</tr>
<tr>
<td>– Feeding technique, parent–infant interaction problems</td>
</tr>
<tr>
<td>• Lack of appetite</td>
</tr>
<tr>
<td>– Chronic illness</td>
</tr>
<tr>
<td>– Psychosocial disorder</td>
</tr>
<tr>
<td>• Mechanical feeding difficulties, e.g. oral-motor dysfunction or malformation</td>
</tr>
</tbody>
</table>

| **Reduced absorption or digestion of nutrients** | **Defective utilization** |
|-----------------------------------------------|
| • Pancreatic insufficiency: cystic fibrosis | • Chromosomal or genetic abnormality |
| • Loss or damage to villous surface | • Metabolic disorder |
| – Coeliac disease | • Endocrine disorder |
| – Cow’s milk protein allergy | • Congenital infections |
| – Vitamin or mineral deficiencies | **Increased metabolism** |
| • Cholestasis | • Chronic infection or inflammation |
| | • Hypoxaemia (congenital heart disease, chronic lung disease) |
| | • Hyperthyroidism |
| | • Malignancy |
Within the group of normal variants of growth presenting as FTT, four main patterns occur (Table 1.2). There are also growth curves available for syndromes with abnormal growth (e.g. Down syndrome, Noonan syndrome, Prader–Willi syndrome) (1.7, 1.8). There are many reasons why an infant does not take on adequate nutrition. A more useful classification of FTT is then based on pathophysiology, as shown in Table 1.3.

### Evaluation

#### History and examination

The history is essential in defining the underlying cause of growth failure in children (1.9). The evaluation should include an assessment of the diet and eating behaviours, past and current medical, social, and family history, and should include a complete physical examination (Table 1.4). A

---

1.7 Patients with special conditions, e.g. Down syndrome, chromosomopathies and other genetic conditions, have their own growth rate and deserve specific growth curves.

1.8 Patient with a Silver–Russell syndrome.

1.9 Algorithm of management of FTT in primary care.
Failure to thrive in infants and children

Table 1.4 Evaluation of medical history in FTT

Dietary history
- Amount of food and/or formula
- Is the formula prepared correctly?
- Food patterns: types of foods, especially beverage consumption (milk, juices, sodas)

Feeding history
- When does the child eat? Where? With whom?
- Breastfed?
- Positioning of the child
- Feeding battles
- Snacking

Past and current medical history
- Obstetric history
- Birth history, including weight and height
- Neonatal period
- Recent acute illness especially upper airway infections, otitis, gastroenteritis

- Are they recurrent?
- Chronic medical conditions
- Past hospitalizations, injuries, accidents
- Vomiting?

Social history
- Who lives in the home?
- Who are the caregivers?
- Who helps to support the family?
- What is the child’s temperament?
- Any family problems?

Family history
- Medical conditions or FTT in siblings
- Growth pattern in other members of the family, especially parents and siblings
- Mental illness

Table 1.5 Classification of undernutrition in children

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Mild risk</th>
<th>Moderate risk</th>
<th>High risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight for age (%)</td>
<td>&gt;90</td>
<td>75–89</td>
<td>60–74</td>
<td>&lt;60%</td>
</tr>
<tr>
<td>Weight for height (%)</td>
<td>&gt;90</td>
<td>80–90</td>
<td>70–79</td>
<td>70%</td>
</tr>
<tr>
<td>Height for age (%)</td>
<td>&gt;95</td>
<td>95–90</td>
<td>89–85</td>
<td>&lt;85%</td>
</tr>
</tbody>
</table>

A thorough psychosocial history is mandatory. An accurate assessment of growth requires the evaluation of current and past parameters including height or length, weight, and head circumference. Occasionally further assessments are performed such as mid-upper arm circumference, various skin fold thicknesses, body proportions and, if indicated, puberal assessment. The severity of a child’s undernutrition can be classified most easily using the Waterlow and Gomez criteria (Table 1.5), as a percentage of the median for age. Further examination beyond growth should include physical examination (1.10), including inspection of any physical sign of neglect or abuse, stigmas of underlying syndromes, dysmorphic features, skin rashes, and observation of feeding if possible.
Observing or videotaping the interaction between a parent and a child, especially during a feeding session in the office, may provide valuable information about the aetiology of FTT.

**Investigations**

Laboratory evaluation should be guided by history and physical examination findings only. A well-targeted battery of investigations may provide guidance. There are no routine laboratory tests that should be performed on every child, because the majority of children with FTT have no laboratory abnormalities. In those requiring investigation, a simple initial sequence can be performed (*Table 1.6*).

*Table 1.6 Investigations in failure to thrive*

<table>
<thead>
<tr>
<th>Initial evaluation</th>
<th>Third step (if clinically indicated or abnormal data from the initial investigations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Full blood examination/erythrocyte sedimentation rate or C-reactive protein</td>
<td>• Coeliac screen</td>
</tr>
<tr>
<td>• Chemistry panel: urea, creatinine, lytes</td>
<td>• Thyroid function test</td>
</tr>
<tr>
<td>• Iron status: iron, ferritin, transferrin, % saturation</td>
<td>• Bone age</td>
</tr>
<tr>
<td>• Blood glucose</td>
<td>• Stool microscopy and culture</td>
</tr>
<tr>
<td>• Liver function tests: GGT, SGPT, SGOT, alkaline phosphatase, bilirubin</td>
<td></td>
</tr>
<tr>
<td>• Urinalysis</td>
<td></td>
</tr>
<tr>
<td>• Urine culture</td>
<td></td>
</tr>
<tr>
<td><strong>Second step</strong></td>
<td></td>
</tr>
<tr>
<td>• Acid–base balance</td>
<td></td>
</tr>
<tr>
<td>• Immunoglobulins</td>
<td></td>
</tr>
</tbody>
</table>
Treatment

Medical intervention is dictated by the disease diagnosed. Addressing identified issues of attachment and other psychosocial issues is crucial and often requires input from a multidisciplinary team. Most cases can be managed by nutrition intervention or feeding behaviour modification. Evaluation and treatment is generally accomplished in outpatient settings rather than in the hospital.

Nutritional rehabilitation by means of increased caloric intake is often best supervised with the advice of an experienced dietician, allowing exact caloric requirements to be calculated. Asking the parent to write down the type of food and amounts a child eats over a 3-day period is one way of quantifying caloric intake.

Dietary recommendations

Children with FTT will need 150% of the recommended daily caloric intake, based on their expected, not actual, weight for height if tolerated. As most of these children lack the normal responses to internal hunger/satiation cues, high energy snacks may improve their nutritional status. In infants this increased caloric intake may be accomplished by concentrating the infant formula or adding carbohydrates or lipids to the formula or the puréed foods (1.11). Toddlers can receive more calories by adding cheese, butter, and so on to common toddler foods. In toddlers and older children we can also use high-calorie milk drinks, that provide 1.0–1.5 kcal/ml. Vitamin and mineral supplementation is also sometimes required. If all these attempts fail it may be necessary to consider nasogastric tube feedings as a last resort (1.12). The advantages are ensuring adequate caloric intake and decreasing or eliminating some of the emotional stress and frustrations with feeding times. However, there are also disadvantages, including the suppression of appetite and sometimes the modification of feeding behaviour.

1.11 There are two ways to increase the caloric intake in an infant: to increase the strength of the regular formula or to add caloric modules (carbohydrates or lipids or both) to the regular formula.
**Feeding or eating behaviours**

Parental anxiety about a child's FTT can be helped by reassurance. Paediatricians can intervene effectively in many feeding problems, providing useful guidance for parents (*Table 1.7*). Hospitalization is rarely required and may be counterproductive. It may be necessary when the safety of a child is a concern, outpatient management has failed, or if the FTT is severe.

**Outcomes**

It is ascertained that children with FTT are at risk of adverse outcomes such as short stature, behaviour problems, and developmental delay. However, there are only a limited number of outcome studies on children with FTT, with different definitions and designs, so it is difficult to make an assessment on long-term results of FTT. Rudolph and Logan found only a small difference in intelligence quotient (IQ) (equivalent to 3 IQ points) in children with FTT compared to their peers. This small difference is of questionable clinical significance. The height and weight differences in their analysis were larger, but few children were below the 3rd percentile at follow-up. In the light of these results, the aggressive approach to the identification and management of FTT needs reassessing.

In addition, it is often difficult to disentangle the effects of FTT from those of the high-risk environments in which FTT often occurs (poverty, family stress, and poor parental coping skills). Nevertheless, to decrease the risk of adverse effects, it is important to recognize and treat FTT promptly. Sometimes this necessitates the intervention of community-based resources.

Failure to thrive in infants and children

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**Table 1.7 Useful guidance for parents. Tips for preventing food hassles**

1. Make mealtimes pleasant
2. Avoid battles over eating. Encourage your child. Food should be used as nourishment, not as a reward or punishment
3. You are responsible for deciding what food your child is offered; your child decides how much to eat
4. Offer a variety of healthy and tasty foods
5. Establish a routine of meals and snacks and set times
6. Recognize your child’s cues indicating hunger, satiety, and food preferences
7. Accept your child’s wish to feed him- or herself
8. Try to eat together as a family
9. Establish a maximum time to finish a meal (for instance 30 minutes)
10. Limit possible distractions during meals

---

1.12 In some severe FTT cases, especially if an organic condition is underlying, it is necessary to provide enteral nutrition through a nasogastric tube. This patient has biliary atresia and FTT.
10 Failure to thrive in infants and children

Conclusion

It is common to confuse the description of poor growth with a diagnosis. The term ‘failure to thrive’, although firmly entrenched in the medical lexicon, adds little to our understanding of this condition and does not guide our approach. Many have suggested it should be abandoned. It represents a nonspecific description of symptoms rather than a specific condition. Paediatricians and other healthcare workers must come to a better understanding of the complex dynamics of feeding normal children. When feeding and caloric issues have been ruled out, other considerations should be taken into account. It is not a question of referring a child who is not growing well to the feeding expert, the gastroenterologist, or the endocrinologist, but rather the recognition that a rational, sequential approach needs to be followed, to allow for investigation of all the possible explanations of why a child is not growing.

References


General reading