Cushing’s Syndrome in Children — Diagnosis and Treatment

Cushing’s syndrome is a rare disease in children and is a difficult condition to detect and manage. This article discusses the cause, presentation, and treatment of Cushing’s syndrome in children.

Definition of Cushing’s Syndrome

Cushing’s syndrome is also known as hypercortisolism. It is a condition in which the body produces excess cortisol, due to the dysfunction of the pituitary gland, adrenal gland, or disturbance anywhere in the HPA (hypothalamic-pituitary-adrenal) axis.

Cushing’s syndrome in children results in retarded growth, disrupted puberty, obesity, and various other signs and symptoms.

Introduction

Cushing syndrome is a pathological culmination of chronic sustained exposure to escalated levels of glucocorticoids. They can be endogenous or exogenous in origin. Cushing syndrome in children has a distinct identity from its adult counterpart.

The unique challenges incurred in the pediatric set up can be summarized as
follows:

- Reproductive function management
- Psychological health maintenance
- Body composition balance
- Bone mineral density affection
- Final height of the child
- Cosmetic appeal and appearance of the child


One needs to be aware of 2 closely related yet distinct terms when dealing with states of excess glucocorticoids circulating in the body. These are as follows:

**Cushing’s disease:** When the source of excess ACTH leading to escalated levels of circulating glucocorticoids is a pituitary tumor, more specifically an ACTH-secreting adenoma, the patient concerned is said to have Cushing’s disease.

**Cushing’s syndrome:** This term epitomizes all the other manifestations of increased circulating glucocorticoids—both endogenously and exogenously derived.

**History of Cushing’s Syndrome in Children**

Cushing syndrome was first described by Harvey Cushing, a voracious neurosurgeon in 1932. He was the one to expound the trans-sphenoidal surgery for pituitary adenomas and is rightfully known as the ‘Father of Neurosurgery’.

**Epidemiology of Cushing’s Syndrome in Children**

Cushing’s syndrome is rare in the pediatric population. It is observed in only 10% of the new cases per year. The most common age group afflicted is the young generation from 20-50 years. It is about three times more common in women than in men. But in pediatric cases, the opposite is true: it is more common in boys as compared to girls.
Etiology of Cushing’s Syndrome in Children

The use of steroids in the medical management of certain illnesses is the predominant etiology in children. It is also called iatrogenic Cushing’s syndrome. The most relevant differences in pediatric Cushing’s syndrome compared to the one encountered in adults can be summarized as follows:

- Early age Cushing’s syndrome due to a predominance of mixed androgen and Cortisol-secreting adrenocortical tumors
- Cushing’s syndrome in infancy caused due to McCune-Albright syndrome
- Increased frequency of prepubertal Cushing in boys rather than girls
- Seldom occurrence of ectopic ACTH syndrome
- Apparently increased difficulty in identifying the adenoma in pituitary scans
- Potentially increased tendency to detect lateralization of ACTH secretion on bilateral inferior petrosal sinus sampling (BIPSS)
- Relative early and improved response to external beam pituitary radiotherapy in the pediatric population

Etiopathogenesis of Cushing’s Syndrome in Children

A prolonged state of overexposure to glucocorticoids results in Cushing’s syndrome. This state of chaotic hormonal imbalance results from inappropriate control of the Hypothalamic-pituitary-adrenal (HPA) axis. A short description of the same is as follows:

**HPA axis**

The hypothalamus, anterior pituitary gland, and the adrenal glands are in a state of constant negative feedback. The normal functioning of this hypothalamic-pituitary-adrenal (HPA) axis is vital to the precise regulation of circulating glucocorticoids. The various components of the HPA axis and their origin can be summarized as follows:

<table>
<thead>
<tr>
<th>Origin</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothalamus</td>
<td>Corticotrophin-releasing hormone (CRH)</td>
</tr>
<tr>
<td>Anterior Pituitary</td>
<td>Adrenocorticotropic hormone (ACTH)</td>
</tr>
<tr>
<td>Adrenal gland</td>
<td>Glucocorticoids such as Cortisol</td>
</tr>
</tbody>
</table>

CRH stimulates the release of ACTH which in turn downregulates the release of CRH through negative feedback. Cortisol exerts negative feedback and subsequent inhibition of release of both CRH and ACTH. Irrespective of the inciting factor, disruption of the normal immaculate functioning of this HPA axis results in Cushing’s syndrome.
Classification of Cushing’s Syndrome in Children

Cushing’s syndrome in children can be classified based on either etiology or as per the age of manifestation. Based on etiology, the classification is as follows:

<table>
<thead>
<tr>
<th>ACTH-Dependent</th>
<th>ACTH-Independent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pituitary adenoma (most common): Cushing’s disease</td>
<td>Exogenous steroid</td>
</tr>
<tr>
<td>Ectopic ACTH syndrome (extremely rare)</td>
<td>Adrenocortical tumor (adenoma or carcinoma)</td>
</tr>
<tr>
<td>Carcinoid tumors: bronchial, renal, thymic or duodenal</td>
<td>Primary adrenocortical hyperplasia (associated with MEN syndrome-macronodular adrenal hyperplasia, McCune-Albright syndrome, PPNAD, Carney complex)</td>
</tr>
</tbody>
</table>

Based on the age of onset, different subsets of Cushing’s syndrome can be segregated as follows:

<table>
<thead>
<tr>
<th>Age of onset</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infancy</td>
<td>Usually associated with McCune-Albright syndrome</td>
</tr>
<tr>
<td>Children under 4 years</td>
<td>Adrenocortical tumor is the most common etiology.</td>
</tr>
<tr>
<td>Children more than 5 years of age</td>
<td>Cushing’s disease secondary to pituitary adenomas are most frequently encountered.</td>
</tr>
</tbody>
</table>

Few distinct syndromes associated with pediatric Cushing’s syndrome need a mention.

**McCune-Albright syndrome**

Secondary to GNAS1 gene mutation, this sporadic disease is an aggregation of characteristic features such as peripheral precocious puberty, polyostotic fibrous dysplasia, and cafe-au-lait pigmentation. Cushing’s syndrome in infancy is most likely associated with this condition. It is an aggressive culmination of nodular adrenal hyperplasia.

**Primary pigmented adrenocortical disease (PPNAD)**

This condition derives its name from the characteristic histological appearance of affected adrenal glands. Multiple pigmented adrenocortical nodules are seen, thus justifying the other name for this disease, ‘micronodular adrenal disease’. 
PPNAD has associated with Carney complex and Cushing’s syndrome is the most common manifestation of Carney’s complex in the pediatric population. Carney’s complex comprises of cardiac myxomas, lentigines, and various endocrine and non-endocrine tumors.

**Cyclical or periodic Cushing’s syndrome**

The patients with Carney’s complex and PPNAD often have intermittent remissions thus leading to the concept of ‘cyclical’ Cushing’s syndrome in these patients.

**Atypical Cushing’s syndrome**

This term is uniquely expounded in relation to PPNAD. It is characterized by muscle and skin wasting, short stature, and osteoporosis.

**Clinical Presentation of Cushing’s Syndrome in Children**

The patients with Cushing’s syndrome in the pediatric population have typical, characteristic stark features and a distinct stereotype appearance, thus making Cushing’s syndrome a potential clinical diagnosis. Subtle features are seldom seen. The most common characteristics are as follows:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue</td>
<td>60 %</td>
</tr>
<tr>
<td>Hirsutism</td>
<td>60 %</td>
</tr>
<tr>
<td>Striae</td>
<td>51 %</td>
</tr>
<tr>
<td>Emotional lability</td>
<td>51 %</td>
</tr>
<tr>
<td>Hypertension</td>
<td>45 %</td>
</tr>
</tbody>
</table>

A detailed list of all significant Cushingoid signs and symptoms is summarized below for easy memorization and recall:

<table>
<thead>
<tr>
<th>Sign</th>
<th>Symptom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moon facies</td>
<td>Poor growth</td>
</tr>
<tr>
<td>Violaceous striae</td>
<td></td>
</tr>
<tr>
<td>Plethora (redness)</td>
<td></td>
</tr>
<tr>
<td>Deregulated pubertal development</td>
<td></td>
</tr>
<tr>
<td>Short stature</td>
<td></td>
</tr>
<tr>
<td>Auxology: decrement in height SDS in association with increased BMI SDS</td>
<td></td>
</tr>
<tr>
<td>Buffalo hump (dorsocervical fat pad)</td>
<td></td>
</tr>
<tr>
<td>Lentigines (Carney complex)</td>
<td></td>
</tr>
<tr>
<td>Freckles</td>
<td></td>
</tr>
<tr>
<td>Virilization</td>
<td></td>
</tr>
<tr>
<td>Osteoporosis</td>
<td></td>
</tr>
<tr>
<td>Poor growth</td>
<td></td>
</tr>
<tr>
<td>Irritability</td>
<td></td>
</tr>
<tr>
<td>Fatigues</td>
<td></td>
</tr>
<tr>
<td>Acne</td>
<td></td>
</tr>
<tr>
<td>Headache</td>
<td></td>
</tr>
<tr>
<td>Emotional lability</td>
<td>Weight gain</td>
</tr>
<tr>
<td>Myopathy</td>
<td></td>
</tr>
<tr>
<td>Hirsutism</td>
<td>Easy bruisability</td>
</tr>
<tr>
<td>Family history</td>
<td></td>
</tr>
</tbody>
</table>

**Diagnosis of Cushing’s Syndrome in Children**

Cushing’s syndrome is potentially a clinical diagnosis. There are 2 tiers of investigations when it comes to pediatric Cushing’s syndrome. The first is to reinstate the clinical diagnosis, and next to determine the etiology. The biochemical definition of Cushing’s
Complications of Cushing’s Syndrome in Children

The majority of complications are correlated with the direct or indirect effects of excessive glucocorticoids. Long-term exposure to cortisol leads to many complications and cardiovascular disease is the most important out of those. Cushing’s syndrome is often associated with cardiovascular risk factors.
Some important complications are:

**Hypertension:** This may result from various disturbed mechanisms regulating plasma volume and peripheral vessel resistance or from direct cardiomyopathy due to the excessive levels of cortisol.

**Impaired glucose tolerance/diabetes:** Excessive glucocorticoids stimulate gluconeogenesis (glucose production) in the liver, along with the inhibition of insulin sensitivity, resulting in high levels of blood glucose.

**Hyperlipidemia:** High levels of cortisol result in exaggerated fat metabolism. Thus there is a rise in free fatty acids in the blood. There is also an increased synthesis of cholesterol and triglycerides resulting in total hyperlipidemia.

**Hypokalemia:** Cortisol is supposed to have some mineralocorticoid activity that results in the disturbance of potassium metabolism.

All these factors, in turn, predispose the patient to cardiovascular disease.

### Management of Cushing’s Syndrome in Children

The management of Cushing’s syndrome in the pediatric population is apt in the hands of a multidisciplinary team. The etiology responsible determines the mode of the management applied. The multi-pronged attack often launched comprises of surgical, medical and radiological modalities of treatment. The same can be summarized as follows:

#### Surgical management

Surgical excision in the form of transsphenoidal surgery (TSS) microadenoma excision is the primary mode of treatment for Cushing’s disease secondary to pituitary adenoma. Adrenalectomy is performed only if transsphenoidal surgery is impossible.

The management of PPNAD and primary adrenal pathologies is often surgical. Optimum glucocorticoid replacement in the perioperative period is essential. Cure rates as high as 72% are achieved.

#### Medical management

Medical therapy is often used as a temporizing transit until the patient is optimized for surgical management. Adrenal blocking agents such as Metyrapone and Ketoconazole are frequently used. Mitotane is instrumental in the treatment of metastatic adrenocortical carcinoma.

#### Radiotherapy

It finds use in the treatment of Cushing’s disease as a second-tier modality when transsphenoidal surgery fails to achieve remission. It is more successful in kids than in adults.

For patients with ectopic ACTH or suspected tumor, imaging and chemotherapy/surgical excision are necessary.

There are a few specific complications pertinent to transsphenoidal surgery for Cushing’s disease in the pediatric population, which need a mention. The same can be tabulated as follows:
Post-operative short stature, subnormal growth, and hypopituitarism
Post-operative obesity
Cognitive aberrations
Psychological disturbances

The best treatment modality so far is not without complications. Hence, a multidisciplinary dedicated team comprising of pediatricians, surgeons and endocrinologists is vital to the management of Cushing’s syndrome in the pediatric population.

Prognosis of Cushing’s Syndrome in Children

- Untreated cases of Cushing’s syndrome have a survival rate of 50% at 5 years.
- With therapy for cortisol normalization, the mortality rate is the same as the general population.
- Outcomes of surgery depend on the size of the tumor.

Summary

Secondary to chronic sustained abnormal exposure to increased glucocorticoids, Cushing’s syndrome in the pediatric population is a rare diagnosis. The most common etiology is Cushing’s disease secondary to an ACTH-secreting adenoma.

Children are not little people. The issues encountered in handling pediatric Cushing’s syndrome are quite specific and need a dedicated multidisciplinary team for meticulous workup, management, and follow-up.

Cushing’s syndrome is the ultimate culmination of the aberrant HPA axis and the loss of normal negative feedback.

The patients with Cushing’s syndrome can be classified based on etiology or based on the stratification of etiology as per the age of the patient.

A few syndromic diseases associated with pediatric Cushing’s syndrome are McCune-Albright syndrome and primary pigmented adrenocortical disease (PPNAD). Cushing’s syndrome is the most common manifestation of Carney’s complex in the pediatric population. The latter includes cardiac myxomas, lentigines, and complex endocrine and nonendocrine tumors.

Cushing’s syndrome is a clinical diagnosis with stark characteristic signs and symptoms. Fatigue and hirsutism are most frequently encountered in the pediatric population.

Diagnosis is based on clinical suspicion further reinforced by several blood tests, which when used together supplement each other to ultimately yield high sensitivity and specificity.

Urinary cortisol level, low dose dexamethasone suppression test, ACTH level assessment and imaging studies as needed, commonly comprise the diagnostic armamentarium referred to for Cushing’s syndrome. Other tests such as CRH measurement, high-dose Dexamethasone suppression test are seldom used.

The management of Cushing’s syndrome is surgical, medical or based on the usage of radiotherapy as per the etiology. Transsphenoidal excision of pituitary adenoma is an established procedure for Cushing’s disease. Hypopituitarism is a potential complication.
Medical therapy is often a temporizing solution before surgical management. Radiotherapy is typically reserved for patients with Cushing’s disease who have failed transsphenoidal surgical management. Ultimately, it calls upon a dedicated multidisciplinary team to optimally manage Cushing’s syndrome in pediatric patients.

Review Questions

The correct answers can be found below the references.

1. Which of the following statements is true?
   A. Radiotherapy is typically reserved for patients with Cushing’s disease who have failed transsphenoidal surgical management.
   B. Radiotherapy is the first line of treatment for Cushing’s disease in children less than 2 years of age.
   C. Cushing’s disease is a rare cause of Cushing’s syndrome in children.
   D. Cushing’s syndrome is frequently encountered in the pediatric population.

2. Which of the following statements is false?
   A. Carney’s complex often presents as Cushing’s syndrome in children.
   B. Cushing’s syndrome has a bold presentation in children.
   C. Transsphenoidal surgery comprises the first line of treatment for Cushing’s disease.
   D. Transsphenoidal surgery comprises the second line of treatment for Cushing’s disease.

Which of the following is not a part of Carney’s complex?

A. Lentigines
B. Cardiac myxoma
C. Ranula
D. Endocrine tumors

References

Pediatric Cushing’s Syndrome Chan et al. Arq Bras Endocrinol Metab 2007;51/8

Nelson’s textbook of pediatrics

Correct answers: 1A; 2D; 3C

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