BRIEF REPORT

Testicular Adrenal Rest Tumors in Adult Males with Congenital Adrenal Hyperplasia: Evaluation of Pituitary-Gonadal Function before and after Successful Testis-Sparing Surgery in Eight Patients

Hedi L. Claahsen-van der Grinten, Barto J. Otten, Satoru Takahashi, Eric J. H. Meuleman, Christina Hulsbergen-van de Kaa, Fred C. G. J. Sweep, and Ad R. M. M. Hermus

Departments of Paediatric Endocrinology (H.L.C.-v.d.G., B.J.O.), Radiology (S.T.), Urology (E.J.H.M.), Pathology (C.H.-v.d.K.), Chemical Endocrinology (F.C.G.J.S.), and Endocrinology (A.R.M.M.H.), Radboud University Nijmegen Medical Centre, 6500 HB Nijmegen, The Netherlands

Context: In male patients with congenital adrenal hyperplasia (CAH), testicular adrenal rest tumors (TART) are frequently present with a reported incidence of 50–95% (1, 2). Because of their location in the mediastinum testis, these tumors can lead to obstruction of seminiferous tubules. In addition to these mechanical effects of the tumor, steroids produced by the tumor may reach the circulation interfering with the secretion of FSH and LH by the pituitary and they may also be toxic to testicular tissue in a paracrine manner, thereby contributing to testicular dysfunction (3–5).

Treatment with high doses of glucocorticoids may lead to suppression of ACTH secretion and reduction of tumor size (6–9). However, high doses of glucocorticoids do not always restore testicular function and may have several side effects (10).

Because of the benign character of the tumors, testis-sparing surgery has been proposed for the treatment of TART. Walker et al. (11) performed testis-sparing surgery in three CAH patients. Postoperatively, there was good vascular flow and no recurrence of the tumor. Tiryaki et al. (12) reported two CAH patients with steroid-unresponsive testicular tumors who were also treated by testis-sparing surgery. In both studies no information about pituitary-gonadal function before and after surgery was reported.

We treated eight adult infertile CAH patients with bilateral TART with testis-sparing surgery. The aim of our study was to evaluate whether testis-sparing enucleation of the tumor can improve pituitary-gonadal function. Here we describe the results of the clinical, biochemical, radiological, and histological evaluation of the patients before and 6 and 22 months after the operation.

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Patients and surgical procedure

Eight male patients with CAH caused by 21-hydroxylase deficiency were selected for operation. Written informed consent was obtained from all patients. All patients had bilateral TART. Five patients had palpable masses (patients 1–4 and 6). Two patients reported pain and discomfort. Five patients (patients 1, 2, and 4–6) had been treated with high doses of glucocorticoids in the past to reduce tumor size without success. The indications for operation are listed in Table 1. The age of the patients was 30 ± 8.9 yr (mean ± sd; range, 23–51 yr). Height sd score was −2.0 ± 1.0 (range, −3.5–−0.2) and body mass index (BMI) was 28.1 ± 4.4 kg/m² (range, 23.7–38.2). Seven patients were white and one patient (patient 8) was of West Indian ethnicity.

Testicular tumor enucleation took place after general or locoregional anesthesia. The testis, including its tunica vaginalis, was luxated through an inguinal incision and the testicular tissue until the margin of the tumor was reached. Then, a careful blunt dissection of the tumor was undertaken. Finally, the tunica albuginea and the tunica vaginalis were closed and the testis was repositioned in the scrotum.

Biochemical analysis

Biochemical analysis was performed in all patients before and after operation. Patient 1 underwent operation without complete preoperative hormonal and radiological evaluation. Venous blood was collected from an antecubal vein at 0900 h after overnight fasting and before taking the morning medication to measure serum levels of 17-OH progesterone (17OHP), androstenedione (A), testosterone, estrone, ACTH, LH, FSH, and inhibin B. The next day at 0900 h, after overnight fasting, blood was collected after taking 8 mg dexamethasone orally at 2300 h the evening before surgery. The same investigations were performed 6 months after operation, again venous blood was collected after overnight fasting and before taking the morning medication to measure serum levels of 17-OH progesterone (17OHP), androstenedione (A), testosterone, estrone, ACTH, LH, FSH, and inhibin B. The same investigations were performed 22 months after operation, again venous blood was collected after overnight fasting and before taking the morning medication to measure serum levels of 17-OH progesterone (17OHP), androstenedione (A), testosterone, estrone, ACTH, LH, FSH, and inhibin B. The next day at 0900 h, after overnight fasting, blood was collected after taking 8 mg dexamethasone orally at 2300 h the evening before surgery. The same investigations were performed 6 months after operation, again venous blood was collected after overnight fasting and before taking the morning medication to measure serum levels of 17-OH progesterone (17OHP), androstenedione (A), testosterone, estrone, ACTH, LH, FSH, and inhibin B. The same investigations were performed 22 months after operation, again venous blood was collected after overnight fasting and before taking the morning medication to measure serum levels of 17-OH progesterone (17OHP), androstenedione (A), testosterone, estrone, ACTH, LH, FSH, and inhibin B.

Hormone assays

Serum testosterone and 17OHP were assessed by 3H-RIA after purification by means of paper chromatography of ether extracts of the samples, as described previously (13, 14). Serum A concentrations in serum and saliva were measured as described earlier (14). Serum estrone was measured by RIA after extraction and Sephadex LH-20 chromatography. The within- and between-assay coefficients of variation were 4.8% and 7.5%, respectively. ACTH was measured by a two-step immunoradiometric assay (Dynonost BRAHMS, Berlin, Germany). Serum FSH and LH were determined with a Fluorescence Immuno Enzymatic Assay (Abbott Diagnostics, Hoofddorp, The Netherlands) using a Random Access Analyser (Type AxSYM; Abbott). Dimeric inhibin B was quantified using an ELISA (Oxford Bio-Innovation Ltd., Oxford, UK).

Semen analysis

In six of the eight patients, semen analysis was performed after more than 2 d of sexual abstinence before and 6 and 22 months after operation (15). One patient (patient 5) refused semen analysis. Another patient (patient 6) was sterilized in the past.

Radiological evaluation

All patients underwent testicular magnetic resonance imaging (MRI) before and 6 and 22 months after surgery. All MR studies were performed on a 1.5-T scanner (Magnetom Sonata, Symphony or Avanto; Siemens, Erlangen, Germany), using a body phased-array coil.

Histopathology

All removed tumor tissue was investigated macroscopically and microscopically. Tumors and testis biopsies were fixed in 10% buffered formalin. Tissue sections of 5 μm were cut and stained with hematoxylin and eosin and with Von Gieson elastin stain. Testis biopsy specimens were scored according to Johnsen with a score varying from 0 to 10. A Johnsen score of more than 8 is associated with fertility (16).

Results

Radiological evaluation

No apparent residual tumor was seen in any patient on postoperative images. The measured volume of the testicular tumor (mean, 9.6 ml; range, 0.5–29.6) showed a good correlation with the tumor weight (R² = 0.98). Testicular volumes decreased after surgery in all patients (range, −8 to −87%).

TABLE 1. Age, phenotype, mutation analysis, height corrected for target height, BMI, and daily glucocorticoid and mineralocorticoid therapy at time of operation, and operation indication in 8 male CAH patients with bilateral testicular adrenal rest tumors

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age (yr)</th>
<th>Phenotype</th>
<th>Allele 1</th>
<th>Allele 2</th>
<th>Height (SDS)</th>
<th>HSDDS-ThSDS</th>
<th>BMI (kg/m²)</th>
<th>Daily glucocorticoid therapy (mg/m²/d)</th>
<th>Daily mineralocorticoid therapy (μg/d)</th>
<th>Operation indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24</td>
<td>SW</td>
<td>Deletion/Conversion</td>
<td>Deletion/Conversion</td>
<td>−2.6</td>
<td>−2.8</td>
<td>27.4</td>
<td>32.2 (HC 20–20-20 mg)</td>
<td>400</td>
<td>1,2</td>
</tr>
<tr>
<td>2</td>
<td>29</td>
<td>SW</td>
<td>Deletion/Conversion</td>
<td>Deletion/Conversion</td>
<td>−2.1</td>
<td>−0.7</td>
<td>25.7</td>
<td>16.0 (HC 20–10 mg)</td>
<td>125</td>
<td>1,2</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
<td>SW</td>
<td>IVS2–13A/G</td>
<td>IVS2–13A/G</td>
<td>−1.4</td>
<td>−0.7</td>
<td>25.6</td>
<td>8.2 (HC 8–4 mg, DXM 0.1 mg)</td>
<td>62.5</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>SW</td>
<td>IVS2–13A/G</td>
<td>IVS2–13A/G</td>
<td>−1.4</td>
<td>n.a.</td>
<td>28.3</td>
<td>16.9 (HC 25–10 mg)</td>
<td>100</td>
<td>2,3</td>
</tr>
<tr>
<td>5</td>
<td>26</td>
<td>SW</td>
<td>IVS2–13A/G</td>
<td>IVS2–13A/G</td>
<td>−1.9</td>
<td>−1.0</td>
<td>38.2</td>
<td>10.8 (HC 10–5–10 mg)</td>
<td>62.5</td>
<td>1,4</td>
</tr>
<tr>
<td>6</td>
<td>51</td>
<td>SV</td>
<td>1172N</td>
<td>Deletion/Conversion</td>
<td>−3.1</td>
<td>−2.95</td>
<td>29.0</td>
<td>16.2 (HC 20–10 mg)</td>
<td>—</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>31</td>
<td>SW</td>
<td>Deletion/Conversion</td>
<td>Deletion/Conversion</td>
<td>−0.2</td>
<td>−1.3</td>
<td>27.0</td>
<td>30.1 (HC 25–40 mg)</td>
<td>125</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>26</td>
<td>SW</td>
<td>IVS2–13A/G</td>
<td>IVS2–13A/G</td>
<td>−3.5</td>
<td>−2.9</td>
<td>23.7</td>
<td>12.1 (DXM 0.5 mg)</td>
<td>62.5</td>
<td>2,3</td>
</tr>
</tbody>
</table>

DXM, Dexamethasone; HC, hydrocortisone; n.a., not available; SDS, sd score.

a SW, Classic salt wasting CAH; SV, classic simple virilizing CAH.
b Nucleotides are numbered according to Higashi’s functional CYP21 sequence (18).
c Height is expressed as SDS and corrected for target height SDS (HSDDS-ThSDS).
d Doses of dexamethasone were converted to hydrocortisone equivalents (1 mg dexamethasone = 40 mg hydrocortisone).
e Mineralocorticoid medication (9-α-fluorohydrocortisone acetate) was given in one to three doses.
f 1, Poor hormonal control; 2, infertility; 3, pain/discomfort; 4, hypogonadotropic hypogonadism; 5, hypergonadotropic hypogonadism.
Our study is the first to our knowledge to provide a complete evaluation of pituitary-gonadal function before and after testis-sparing surgery in eight male CAH patients with TART. All patients focal interstitial fibrosis and peritubular fibrosis was present and in four of the seven patients focal tubular hyalinization was prominent, being most pronounced in patient 6.

**Histopathology**

The testicular biopsies showed decreased spermatogenesis with reduced Johnsen scores (range, 1.0–7.6). In two patients (patients 3 and 4) focal interstitial fibrosis and peritubular fibrosis was present. In four of the seven patients focal tubular hyalinization was prominent, being most pronounced in patient 6.

**Semen analysis**

Before operation azoospermia was found in five patients and oligozoospermia was found in one patient. After operation there was no improvement of sperm quality.

**Discussion**

Before operation, inhibin B levels were significantly decreased in all patients without any correlation with FSH levels. Two patients showed a significant decrease in testosterone levels that were not decreased or were even in the high normal range (patient 1). Additionally, testicular volume decreased after overnight high-dose dexamethasone in these patients with again no significant correlation with FSH levels. In three of these patients (patients 3, 6, 7, and 8) LH and FSH and testosterone levels were within the normal range. In these four patients (patients 3, 6, 7, and 8) LH and FSH and testosterone levels were within the normal range. In these four patients (patients 3, 6, 7, and 8) LH and FSH and testosterone levels were within the normal range. In these four patients (patients 3, 6, 7, and 8) LH and FSH and testosterone levels were within the normal range. In these four patients (patients 3, 6, 7, and 8) LH and FSH and testosterone levels were within the normal range.

**Biochemical analysis (Table 2)**

Table 2. Testicular volumes measured by MRI and parameters of pituitary-gonadal axis function and levels of 17OH progesterone and androstenedione before and 6 and 22 months after testis-sparing surgery in eight male CAH patients with bilateral testicular adrenal rest tumors

<table>
<thead>
<tr>
<th>Patient</th>
<th>Testicular volume</th>
<th>Serum FSH (U/liter)</th>
<th>Serum LH (U/liter)</th>
<th>Serum testosterone (nmol/liter)</th>
<th>Serum inhibin B (pmol/liter)</th>
<th>Serum 17OHP (nmol/liter)</th>
<th>Serum A (nmol/liter)</th>
<th>Serum estrone (pmol/liter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 L</td>
<td>nd</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
<td>0.7</td>
<td>nd</td>
<td>1.7</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>1 R</td>
<td>nd</td>
<td>&lt;0.2</td>
<td>&lt;0.2</td>
<td>0.7</td>
<td>nd</td>
<td>1.9</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>2 L</td>
<td>14.2</td>
<td>6.0</td>
<td>4.9</td>
<td>0.6</td>
<td>123</td>
<td>0.7</td>
<td>0</td>
<td>2.2</td>
</tr>
<tr>
<td>2 R</td>
<td>17.6</td>
<td>9.9</td>
<td>9.5</td>
<td>8.6</td>
<td>79.2</td>
<td>53.0</td>
<td>5.2</td>
<td>14.0</td>
</tr>
<tr>
<td>3 L</td>
<td>8.5</td>
<td>2.9</td>
<td>2.2</td>
<td>8.6</td>
<td>79.2</td>
<td>53.0</td>
<td>5.2</td>
<td>14.0</td>
</tr>
<tr>
<td>3 R</td>
<td>8.1</td>
<td>3.4</td>
<td>3.8</td>
<td>8.6</td>
<td>79.2</td>
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<td>4 L</td>
<td>8.4</td>
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<td>6.4</td>
<td>8.6</td>
<td>79.2</td>
<td>53.0</td>
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<td>14.0</td>
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<tr>
<td>4 R</td>
<td>8.7</td>
<td>6.5</td>
<td>7.3</td>
<td>8.6</td>
<td>79.2</td>
<td>53.0</td>
<td>5.2</td>
<td>14.0</td>
</tr>
<tr>
<td>5 L</td>
<td>10.9</td>
<td>5.9</td>
<td>8.0</td>
<td>8.6</td>
<td>79.2</td>
<td>53.0</td>
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<td>14.0</td>
</tr>
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<td>3.5</td>
<td>5.3</td>
<td>8.6</td>
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<td>53.0</td>
<td>5.2</td>
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<td>5.7</td>
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<td>3.6</td>
<td>4.1</td>
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<td>79.2</td>
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<td>7.6</td>
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<td>79.2</td>
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<td>5.2</td>
<td>14.0</td>
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</table>

L. Left testes; R. right testes; nd, not determined; Post, 6 and 22 months after operation; Pre, before operation.

- a Testicular volume determined by MRI (* testis showing irregular-shaped hypoinformative area adjacent to the mediastinum testis after surgery).
- b Testosterone volume determined by MRI (* testis showing irregular-shaped hypoinformative area adjacent to the mediastinum testis after surgery).
- c FSH, 1.5–11 U/liter; d LH, 1.4–8.5 U/liter; e testosterone, 11–45 nmol/liter; f inhibin B, 150–400 ng/liter; g 17OHP, 2.0–10.8 nmol/liter (morning); h A, 1.4–9.7 nmol/liter (morning); i estrone, 65–220 pmol/liter; j with suppletion of testosterone.

Normal values of our laboratory: FSH, 1.5–11 U/liter; LH, 1.4–8.5 U/liter; testosterone, 11–45 nmol/liter; inhibin B, 150–400 ng/liter; 17OHP, 2.0–10.8 nmol/liter (morning); A, 1.4–9.7 nmol/liter (morning); estrone, 65–220 pmol/liter; with suppletion of testosterone.
toms of testicular pain and discomfort as reported in two patients disappeared after surgery.

Semen analysis did not improve after surgery with persistently low inhibin B levels in all patients reflecting persistent Sertoli cell dysfunction. As seen in patients 1, 2, and 5, Sertoli cell dysfunction can be masked by simultaneous suppression of FSH secretion caused by high serum estrone levels induced by aromatization of adrenal A in these patients. Therefore, inhibin B is a more accurate marker for Sertoli cell function than FSH in CAH patients.

The absence of positive effects on testicular function after operation despite complete removal of the tumors strongly suggests preexisting irreversible testicular damage in our patients. Indeed, peritubular fibrosis and tubular hyalinization was seen in testes biopsy specimen taken during surgery, which confirms irreversible damage of the testes probably caused by longstanding mechanical obstruction in all patients. It is clear that at this stage surgery can no longer help to restore testicular function.

TART may produce steroids that can contribute to elevated levels of A and 17OHP. Therefore, removal of the testicular tumors may lead to a decrease in the levels of A and 17OHP. However, in our group 17OHP and A levels did not change significantly after surgery. These observations suggest that surgical treatment is not helpful in improving hormonal control.

Interestingly, all but one of our patients had a homozygous deletion/conversion genotype or a homozygous IVS2–13A/C→G genotype. In an earlier study we showed that in patients who were homozygous or heterozygous for the deletion/conversion mutation tumor size was significantly larger than in patients with other mutations (17). The present study suggests that the IVS2–13A/C→G mutation may also be a risk factor for the development of testicular tumors.

In summary, testis-sparing surgery in CAH patients is a feasible treatment for TART in CAH patients. Symptoms of testicular pain and discomfort disappeared after surgery. However, 22 months after surgery no improvement in testicular function was seen. Further studies should investigate whether, at an earlier stage in the natural history of the TART, testis-sparing surgery might be advantageous.

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Address all correspondence and requests for reprints to: H. L. Claahsen-van der Grinten, M.D., Radboud University Nijmegen Medical Centre, Department of Paediatric Endocrinology (833), P.O. Box 9101, 6500 HB Nijmegen, The Netherlands. E-mail: H.Claahsen@ckz.umcn.nl.

Present address for E.J.H.M.: Department of Urology, VU University Medical Centre Amsterdam, The Netherlands.

References