Cureus
Part of SPRINGER NATURE

Open Access Case Report

Laparoscopic Adrenalectomy for Low-Grade Adrenocortical Carcinoma in a Three-Year-Old Female Patient Presenting With Virilization

Review began 11/17/2026
Review ended 11/20/2026
Published 11/24/2026

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DOI: 10.7759/cureus.120204

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Abstract

Adrenocortical carcinoma (ACC) is a rare endocrine malignancy in the pediatric population, with an estimated worldwide annual incidence of 0.3 to 0.4 cases per million children under 15 years of age. Unlike adult adrenal tumors, most pediatric cases present with clinical manifestations of autonomous hormone hypersecretion, predominantly peripheral precocious puberty and progressive virilization secondary to excess adrenal androgen synthesis. Complete surgical extirpation with microscopically negative margins (R0) and preservation of capsular integrity remains the single definitive curative modality. While open adrenalectomy has historically been the standard of care for suspected or confirmed adrenal malignancies, transperitoneal laparoscopic adrenalectomy has been explored as a minimally invasive option in carefully selected pediatric patients with small (<5 cm), well-circumscribed, localized tumors lacking radiological signs of local or vascular invasion. We describe the clinical presentation, surgical technique, histopathological assessment, and 12-month postoperative follow-up of a three-year-old female patient who presented with a one-year history of progressive virilization, clitoromegaly, labial hypertrophy (Prader stage II), and axillary bromhidrosis. Contrast-enhanced computed tomography demonstrated a well-circumscribed, heterogeneous right adrenal mass measuring 4.4 × 2.0 × 3.5 cm without local or inferior vena cava invasion. A four-port transperitoneal laparoscopic right adrenalectomy was completed without capsular breach or hemodynamic instability. Pathological examination revealed a 4.5 cm encapsulated low-grade adrenocortical neoplasm (Children's Oncology Group Stage I) with a pediatric Wieneke score of 0 points, negative chromogranin A staining, and a Ki-67 proliferation index of <5%, highlighting the diagnostic overlap between pediatric adenoma and low-grade carcinoma. Postoperative biochemical evaluation confirmed normalization of serum androgens, and surveillance imaging at 12 months showed no residual disease or recurrence. This case illustrates the technical feasibility, rapid postoperative recovery, and favorable short-term disease-free outcome of laparoscopic adrenalectomy in a carefully selected pediatric patient when strict oncological principles are maintained, though extended multidisciplinary surveillance remains mandatory.

Categories: Urology, Pediatric Surgery, Pediatrics
Keywords: adrenocortical carcinoma, endocrine oncology, laparoscopic adrenalectomy, minimally invasive surgery, pediatric adrenal tumor, pediatric urology, precocious puberty, virilization

Introduction

Pediatric adrenocortical carcinoma (ACC) is a rare endocrine malignancy, with an estimated annual incidence of 0.3 to 0.4 cases per million children under 15 years of age [1, 2]. Unlike adult adrenal tumors, which are frequently incidental and non-functioning, approximately 80% to 90% of pediatric adrenocortical tumors are hormonally active, most commonly presenting with virilization, Cushing syndrome, or mixed endocrine manifestations [2, 3]. Furthermore, pediatric ACC is strongly associated with genetic predisposition, particularly germline mutations in the TP53 tumor suppressor gene linked to Li-Fraumeni syndrome, including the low-penetrance R337H founder variant [1].

Distinguishing benign adrenocortical adenomas from malignant carcinomas in children remains a major histopathological challenge, as conventional adult scoring systems such as the Weiss criteria lack specificity and frequently overestimate malignancy in the pediatric population [4]. Consequently, the Wieneke (Armed Forces Institute of Pathology) index is preferred for pediatric cases, integrating macroscopic and microscopic parameters-including tumor weight, size, capsular or vascular invasion, necrosis, and mitotic activity-to predict clinical behavior more accurately [4].

Complete surgical resection with negative margins (R0) remains the cornerstone of curative treatment [2, 5]. Open adrenalectomy has historically been the standard of care to prevent capsular disruption and tumor spillage [5]. Although transperitoneal laparoscopic adrenalectomy has been reported in selected pediatric series for small, localized, well-circumscribed adrenal masses (<5 cm) without local invasion [6-8], its use in

suspected pediatric ACC remains controversial rather than an established standard. Notably, contrary evidence has demonstrated higher rates of incomplete resection and earlier, more frequent local recurrence following laparoscopic resection compared to open surgery [9, 10]. Because existing pediatric laparoscopic series often combine benign adenomas with malignant tumors and lack standardized oncological selection criteria-particularly in very young children-detailed clinical documentation remains essential to define the anatomical and surgical parameters that permit safe minimally invasive resection without compromising oncological principles [11, 12]. Here, we report the successful laparoscopic management of a localized right ACC in a three-year-old child, highlighting strict patient selection and adherence to oncological surgical techniques.

Case Presentation

A previously healthy three-year-old female patient presented to the pediatric outpatient clinic accompanied by her parents, who reported a one-year history of progressive virilization. The clinical picture was characterized by abnormal clitoral enlargement, hypertrophy, and hyperpigmentation of the labia majora (Prader stage II without labial fusion), pubic hair development (Tanner stage II; breast Tanner stage I with no thelarche or menarche), sporadic mild abdominal discomfort, and generalized malaise. Over the preceding three months, the parents had also noted the onset of adult-type axillary bromhidrosis. On physical examination, the patient was alert and active, with normal blood pressure for age and height, normal somatic proportions without Cushingoid features, and no abdominal mass or hepatosplenomegaly. Exact anthropometric percentiles, linear growth velocity, and wrist bone age radiographs were not available in the retrospective outpatient chart. There was no family history of early-onset malignancies or Li-Fraumeni syndrome; germline TP53 mutation testing was not performed because molecular genetic analysis was unavailable at our public tertiary care institution.

Preoperative endocrine evaluation confirmed autonomous adrenal androgen excess, demonstrating marked elevations in serum total testosterone and dehydroepiandrosterone sulfate (DHEA-S), alongside elevated urinary 17-ketosteroids (exact numerical values and institutional reference ranges were unavailable from the archived external laboratory reports; serum androstenedione and 17-hydroxyprogesterone assays were not performed at our institution). Serum electrolytes, adrenocorticotropic hormone (ACTH), and baseline 8:00 AM cortisol levels remained within standard reference limits, clinically excluding overt hypercortisolism and salt-wasting congenital adrenal hyperplasia.

Cross-sectional multiphasic contrast-enhanced computed tomography (CT) of the abdomen and pelvis revealed a well-defined, heterogeneous, encapsulated mass originating from the right adrenal gland, measuring 4.4 × 2.0 × 3.5 cm in maximum cross-sectional dimensions, with internal patchy contrast enhancement and absence of coarse intratumoral calcifications (Figure *1*).

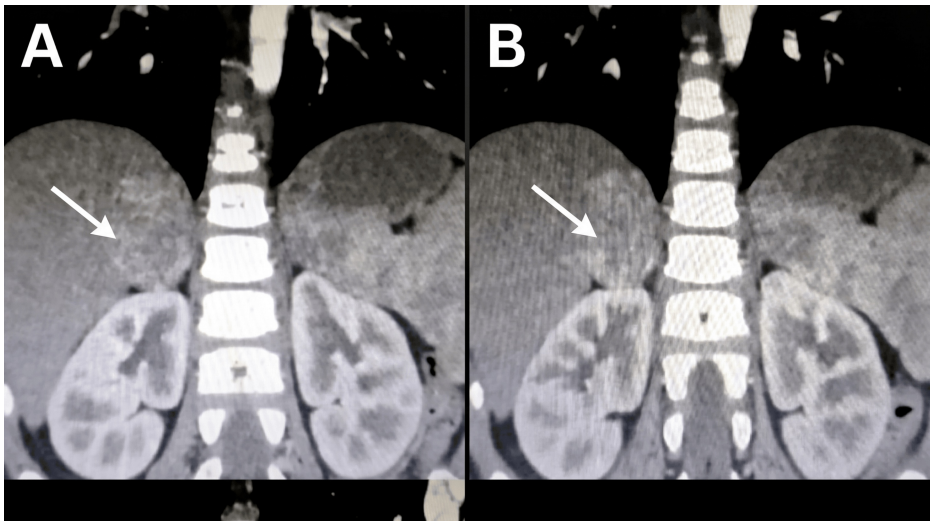


FIGURE 1: Coronal abdominopelvic computed tomography demonstrating the right adrenal mass

Serial coronal contrast-enhanced computed tomography (CT) projections demonstrating a well-circumscribed, heterogeneous, encapsulated right adrenal mass measuring 4.4 × 2.0 × 3.5 cm (white arrows) located superior to the upper pole of the right kidney, showing internal patchy enhancement with smooth, well-defined peripheral margins and no evidence of direct vascular or renal parenchymal invasion.

Specific quantitative attenuation values in Hounsfield units (HU) and delayed washout percentages were not documented in the archived radiology report. Importantly, fat planes between the mass, the superior pole of

the right kidney, and the inferior vena cava (IVC) were preserved, with no evidence of local invasion or tumor thrombus in the IVC or right adrenal vein. Chest CT revealed an isolated, non-specific calcified subpleural nodule in the right lower hemithorax, which was deemed non-metastatic upon subsequent multidisciplinary oncological evaluation.

Following pre-anesthetic optimization and endocrine consultation-which determined that routine perioperative stress-dose corticosteroid supplementation was unnecessary given normal baseline cortisol and ACTH levels-the patient underwent an elective laparoscopic right adrenalectomy. Under general endotracheal anesthesia, the patient was positioned in a modified left lateral decubitus position, and pneumoperitoneum was established to an intra-abdominal pressure of 10 mmHg. Four laparoscopic trocars were placed: a 10-mm transumbilical camera port, a 5-mm working port positioned in the right anterior axillary line at the level of the right lumbar flank, and two 3-mm ancillary working ports placed in the subxiphoid region for liver retraction and precision dissection. Surgical dissection began with mobilization of the right hepatic lobe by incising the right triangular and coronary ligaments, allowing gentle cephalad retraction of the liver (Figure *2A*).

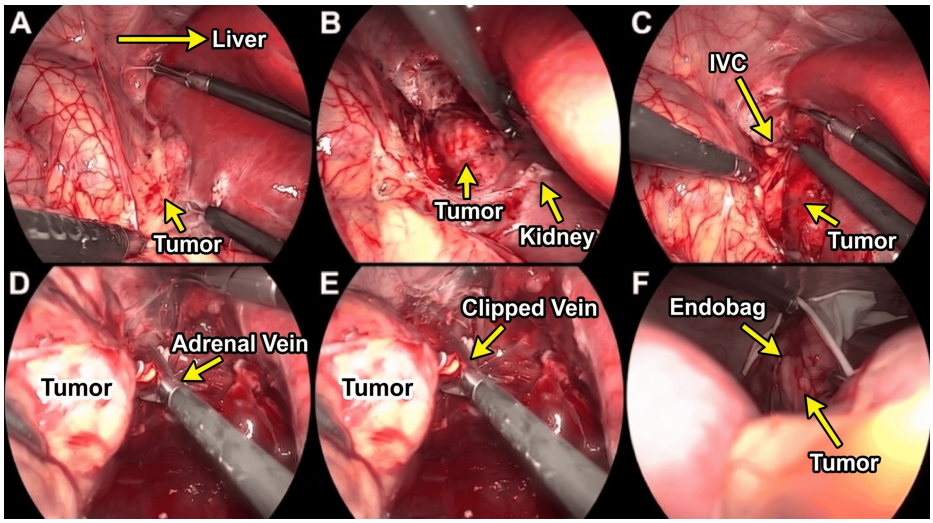


FIGURE 2: Intraoperative views of the transperitoneal laparoscopic right adrenalectomy

Sequential laparoscopic views illustrating key anatomical landmarks and surgical steps: (A) Cephalad retraction of the right hepatic lobe (liver) exposing the retroperitoneal operative field and the encapsulated right adrenal mass (tumor); (B) dissection along the avascular cleavage plane separating the inferior border of the adrenal mass from the upper pole of the right kidney (kidney); (C) medial mobilization exposing the right lateral wall of the inferior vena cava (IVC); (D) skeletonization and hemostatic clipping of the right adrenal vascular pedicle/vein (adrenal vein) using polymer Hem-o-lok clips; (E) complete division of the clipped adrenal vessels; (F) intact placement of the resected tumor within an impermeable endobag for safe retrieval without spillage.

The posterior retroperitoneum was opened lateral to the IVC, and careful dissection using advanced bipolar energy was conducted within the avascular plane separating the medial border of the tumor from the right lateral wall of the IVC (Figure *2C*) and the upper pole of the right kidney (Figure *2B*). The short right adrenal vein was cleanly skeletonized, secured with polymer Hem-o-lok clips (Figure *2D*), and divided without hemorrhage (Figure *2E*). The mass was excised en bloc with its intact fibrous capsule, avoiding direct grasping or compression of the tumor body. The intact specimen was placed into a sterile impermeable laparoscopic extraction bag and retrieved intact through the transumbilical port site after extending the fascial incision to approximately 2.5 cm to accommodate the specimen without rupture (Figure *2F*). Total operative time was 115 minutes, with minimal blood loss (<15 mL) and no intraoperative hemodynamic instability.

The postoperative recovery was uneventful. The patient commenced enteral liquids on postoperative day one, tolerated normal feeding on postoperative day two, and was discharged home on postoperative day three in stable condition.

Macroscopic pathological examination revealed a discrete, encapsulated, yellowish-brown fleshy tumor measuring 4.5 × 2.2 × 3.5 cm (slightly larger in maximal dimension than the 4.4 × 2.0 × 3.5 cm measured on preoperative CT due to specimen processing; exact specimen weight was not recorded in the archived pathology report). Histopathological evaluation demonstrated diffuse architectural growth with round-to-oval nuclei, moderate eosinophilic cytoplasm, absence of confluent tumor necrosis, absence of capsular or vascular invasion, and low mitotic activity (<5 mitoses per 20 high-power fields (HPF)) without atypical

mitotic figures. When evaluated against the pediatric Wieneke (Armed Forces Institute of Pathology) criteria, the tumor exhibited a low-risk score (0 points based on available morphological parameters: tumor size <10.5 cm, absence of necrosis, absence of capsular or vascular invasion, and absence of atypical mitoses), underscoring the well-recognized diagnostic overlap between pediatric adrenocortical adenoma and low-grade adrenocortical carcinoma on routine histology. Immunohistochemical staining was negative for chromogranin A (excluding neuroblastoma and pheochromocytoma) and revealed a low Ki-67 proliferation index of <5% (exact integer percentage and additional adrenocortical markers such as SF-1, inhibin-alpha, and Melan-A were unavailable due to reagent limitations at our tertiary center). Surgical resection margins were microscopically negative (R0), corresponding to Children's Oncology Group (COG) Stage I.

Postoperative recovery was uneventful; the patient commenced enteral liquids on postoperative day one, tolerated a normal diet on day two, and was discharged home on postoperative day three in stable condition. Structured postoperative surveillance included clinical and serum androgen evaluations at three, six, and 12 months, demonstrating biochemical normalization of serum androgen concentrations by three months and progressive regression of clitoromegaly (Table *1*). Whole-body radiological surveillance at six and 12 months - comprising contrast-enhanced thoracoabdominal CT and technetium-99m methylene diphosphonate (Tc-99m MDP) bone scintigraphy - showed no abnormal tracer uptake, residual retroperitoneal tumor bed enhancement, or distant metastatic spread. Given the potential for late recurrence in pediatric adrenocortical neoplasms, a structured multidisciplinary follow-up protocol combining clinical, hormonal, and cross-sectional imaging assessments is planned for at least five years postoperatively.

Parameter	Preoperative assessment	12-month postoperative follow-up	Clinical interpretation/notes
Clinical virilization	Clitoromegaly, labial hypertrophy (Prader II), Tanner II pubarche, bromhidrosis	Regression of clitoromegaly; resolution of bromhidrosis	Complete clinical remission of androgen excess
Serum total testosterone	Markedly elevated (exact numerical value unavailable in archived chart)	Normalized within age-appropriate female reference range	Confirmed autonomous androgen secretion and surgical cure
Serum DHEA-S	Markedly elevated (exact numerical value unavailable in archived chart)	Normalized within age-appropriate reference range	Confirmed adrenal origin of hyperandrogenism
Urinary 17-ketosteroids	Elevated (qualitative/archived report; quantitative assay unavailable)	Not repeated (clinical and serum androgen normalization achieved)	Consistent with excess adrenal androgen metabolites
Serum androstenedione and 17-OHP	Not performed (assays unavailable at tertiary institution)	Not performed	Congenital adrenal hyperplasia excluded clinically and biochemically
Morning (8:00 AM) cortisol and ACTH	Within normal age-appropriate reference limits	Preserved normal adrenal axis function	Excluded overt Cushing syndrome and adrenal insufficiency
Cross-sectional and nuclear imaging	Contrast CT: 4.4 × 2.0 × 3.5 cm well-circumscribed right adrenal mass; no IVC thrombus	Contrast CT & Tc-99m MDP bone scan: no residual mass, local recurrence, or metastasis	Confirmed complete R0 resection and disease-free survival

TABLE 1: Summary of preoperative and 12-month postoperative clinical, endocrine, and radiological findings

ACTH, adrenocorticotropic hormone; CT, computed tomography; DHEA-S, dehydroepiandrosterone sulfate; IVC, inferior vena cava; MDP, methylene diphosphonate; 17-OHP, 17-hydroxyprogesterone; R0, microscopically margin-negative resection

Discussion

Adrenocortical tumors are uncommon in early childhood, making timely diagnostic differentiation between benign adrenocortical adenomas and malignant adrenocortical carcinomas a critical clinical challenge [2, 4]. In the pediatric population, clinical presentation is predominantly governed by endocrine hypersecretion. Unlike adult patients who frequently present with non-functioning, incidentally discovered large retroperitoneal masses, pediatric patients frequently develop signs of virilization-such as rapid somatic growth, accelerated bone age, pubic hair development, and clitoromegaly-within the first four years of life [3, 9]. In our patient, the classic combination of progressive clitoromegaly, labial hypertrophy, and adult-type body odor prompted an endocrine evaluation that identified marked androgen excess and a

corresponding right suprarenal lesion.

The definitive management of localized adrenocortical tumors is complete surgical excision with an intact capsule (R0) [4, 5]. Capsular violation during operative dissection is widely recognized as an adverse prognostic factor, substantially elevating the risk of local retroperitoneal recurrence, peritoneal tumor seeding, and impaired overall survival [5, 6]. Consequently, open transabdominal or thoracoabdominal approaches have historically been the standard of care for suspected adrenocortical carcinomas [5, 8]. While transperitoneal laparoscopic adrenalectomy has been increasingly reported for benign and select localized adrenal lesions in specialized pediatric centers [6, 7, 10], its oncological safety in malignant tumors remains debated. Notably, Miller et al. reported less complete resection and earlier, more frequent local recurrence following laparoscopic adrenalectomy for adrenocortical carcinoma compared to open surgery [8], underscoring that minimally invasive resection must be restricted to strictly selected patients.

Criteria for considering a laparoscopic approach in pediatric adrenocortical tumors center around three main parameters: small lesion size (<5 cm), clear anatomical margins on cross-sectional imaging, and the absence of macroscopic invasion into adjacent organs or major vascular structures such as the renal vein and inferior vena cava (IVC) [6, 7, 10]. In our patient, the right adrenal lesion measured 4.4 cm in greatest dimension on preoperative CT, displayed distinct anatomical fat planes without renal or caval infiltration, and allowed clear, unhindered dissection along retroperitoneal planes.

The technical principles observed during this laparoscopic resection ensured strict compliance with oncological tenets. Utilization of four ports provided sufficient mechanical triangulation, stable cephalad liver retraction, and direct visualization of the short right adrenal vein draining into the IVC [10, 12]. Avoiding direct mechanical traction on the tumor parenchyma, utilizing atraumatic handling of peripheral margins, and employing an impermeable endobag for specimen extraction were instrumental in preserving capsular integrity and avoiding port-site contamination [12, 13].

Distinguishing benign adenomas from malignant carcinomas in pediatric adrenocortical neoplasms cannot be resolved using standard adult histopathological criteria, such as the classic Weiss system [4, 14]. Pediatric tumors often demonstrate atypical microscopic features that would classify as malignant in adults but exhibit benign clinical trajectories in children [14]. Therefore, pediatric-specific classification schemes, such as the Wieneke (Armed Forces Institute of Pathology) criteria, alongside molecular markers including the Ki-67 proliferation index and TP53 mutations, are essential for determining biological risk [4, 12, 14]. In the present case, although the lesion was locally classified and managed as a low-grade adrenocortical carcinoma based on clinical presentation and overall tumor size (4.5 cm), application of the pediatric Wieneke criteria yielded a score of 0 points (tumor size <10.5 cm, absence of necrosis, absence of capsular or vascular invasion, and absence of atypical mitoses), accompanied by a Ki-67 proliferation index of <5%. This finding highlights the well-recognized diagnostic gray zone between pediatric adrenocortical adenoma and low-grade adrenocortical carcinoma on routine histology and accounts for the patient's favorable biological behavior.

This report has several inherent limitations that warrant cautious interpretation. First, as a single-case observation with 12 months of postoperative follow-up, it cannot establish long-term oncological equivalence or superiority over open adrenalectomy, particularly given that pediatric adrenocortical neoplasms can recur several years after primary resection. Second, germline TP53 mutation analysis, quantitative urinary steroid profiling, and extended adrenocortical immunohistochemical panels (such as SF-1, inhibin-alpha, and Melan-A) were unavailable at our public tertiary center, and certain archived external laboratory values and specimen weight could not be retrieved retrospectively. Consequently, extended multidisciplinary surveillance-comprising periodic physical examinations, serum androgen panels, and cross-sectional imaging-is mandatory and planned for at least five years postoperatively [2].

Conclusions

Pediatric adrenocortical carcinoma is a rare endocrine malignancy that requires prompt diagnosis, multidisciplinary evaluation, and complete surgical excision with negative margins (R0) and preservation of capsular integrity.

In carefully selected pediatric patients with small (<5 cm), well-circumscribed, localized adrenal tumors showing no radiological evidence of vascular or adjacent organ invasion, transperitoneal laparoscopic adrenalectomy appears to be a technically feasible and safe minimally invasive option when performed by experienced surgeons adhering strictly to oncological principles. While our patient demonstrated rapid recovery, biochemical normalization, and disease-free survival at 12 months, single-case observations with short-to-intermediate follow-up cannot definitively establish long-term oncological equivalence to open resection; therefore, extended multidisciplinary surveillance remains mandatory.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. **AI use statement:** The authors used Gemini (Google LLC, Mountain View, CA, USA) as follows: language polishing, structure or formatting, translation, extensive copy editing or writing support in Abstract, Introduction, Case presentation, Discussion, Conclusions, References formatting. All AI-assisted outputs were meticulously reviewed and verified by the authors. The clinical details, surgical operative steps, histopathological findings, and patient outcomes were cross-referenced against original medical records and surgical reports. All cited literature and references were independently retrieved, checked for accuracy, and validated against primary sources. The authors take full responsibility for the data integrity and scientific conclusions of the manuscript. The authors confirm that they have reviewed and verified all AI-assisted content and take full responsibility for the work. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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