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Pediatric Adrenocortical Tumours- Our Experience.

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Abstract

Background: Pediatric adrenocortical tumours are rare neoplasms with variable endocrine manifestations and biological behaviour. Diagnosis, pathological classification and treatment require multidisciplinary assessment. Aim: To review the clinical findings, management and outcomes of 10 children operated on for adrenocortical tumours at a tertiary pediatric institute over 10 years. ***Materials and Methods***: A retrospective descriptive review of 10 operated children was undertaken using available institutional records and case summaries. Demographic characteristics, clinical presentation, hormonal and imaging findings, surgical management, histopathology and follow-up outcomes were analyzed. Frequencies, percentages, means, standard deviations and medians were calculated as appropriate. Wilson 95% confidence intervals were reported for proportions, and Fisher's exact test was used for exploratory comparisons. ***Results***: The mean age was 6.06 ± 4.76 years, and the median age was 4.5 years. Six children were girls. Mixed Cushingoid and virilising features and isolated Cushingoid presentation each occurred in three children. Six children underwent completed laparoscopic surgery, three underwent primary open surgery and one required conversion. The provisional final-summary classification comprised five adenomas, three intermediate tumours and two carcinomas. Both carcinomas had recorded tumour volumes exceeding 200 cm^3, compared with none of the remaining tumours (exploratory \(p=0.022\)). Macroscopic clearance was reported in all children, without perioperative mortality. At a reported median follow-up of two years, nine children were alive without documented recurrence, while one died during chemotherapy. ***Conclusion***: Pediatric adrenocortical tumours presented with diverse clinical and pathological features. Surgical treatment was associated with favourable documented outcomes in most children, but the small sample limited prognostic interpretation. Accurate pathological classification and sustained follow-up were essential.

Keywords: Adrenal Cortex Neoplasms; Child; Adrenalectomy.

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INTRODUCTION

Adrenocortical tumours are rare endocrine neoplasms in children and comprise adenomas, tumours of uncertain malignant potential and adrenocortical carcinomas. Pinto et al. (2020)[1] described their distinctive clinical and biological characteristics, with an estimated incidence of approximately 0.2-0.3 cases per million children annually in the United States and substantially higher rates in southern Brazil. Most affected children develop manifestations of adrenal steroid excess, including virilisation, Cushing syndrome or a combination of endocrine abnormalities. These presentations may lead to recognition of an adrenal lesion, although their variable expression can complicate timely diagnosis.

The clinical spectrum ranges from small, localised lesions to aggressive tumours with invasion or metastatic spread. Miele et al. (2020)[2], in a 13-patient institutional series, reported mixed endocrine manifestations as the most frequent presentation and demonstrated the importance of integrating clinical findings, histopathology and genetic evaluation. Genetic susceptibility is particularly relevant in childhood. Wasserman et al. (2015)[3] established the importance of germline TP53 abnormalities in pediatric adrenocortical carcinoma, supporting consideration of genetic assessment even when a striking family history is absent.

Preoperative evaluation requires assessment of hormonal activity, tumour extent and operative feasibility. Nevertheless, reliably distinguishing benign from malignant lesions remains challenging. Virgone et al. (2021)[4], through the EXPeRT/PARTNER recommendations, emphasised multidisciplinary evaluation, expert pathological assessment and complete surgical removal. The operative approach must prioritise intact tumour excision; minimally invasive surgery is reserved for carefully selected small, localised lesions considered likely to be benign.

Treatment and prognosis depend on disease extent and the completeness of resection. Rodriguez-Galindo et al. (2021)[5], in the Children's Oncology Group ARAR0332 study, evaluated stage-directed treatment incorporating surgery and, for advanced disease, chemotherapy with mitotane. Their findings highlighted both the potential for favourable outcomes in selected patients and the substantial toxicity associated with systemic treatment. Because these tumours are uncommon, institutional case series contribute useful information about presentation, diagnostic challenges and treatment outcomes. The present study reviewed the clinical characteristics, management, histopathological findings and follow-up outcomes of 10 children operated on for adrenocortical tumours at a tertiary pediatric surgical center over a 10-year period.

AIM

To review the findings in 10 children operated on at our institute with a diagnosis of adrenocortical tumour over the past 10 years.

OBJECTIVES

1. To describe the demographic, clinical, hormonal and radiological characteristics of children with adrenocortical tumours.
2. To evaluate the surgical management and histopathological spectrum of pediatric adrenocortical tumours.
3. To assess postoperative outcomes, adjuvant treatment, recurrence and survival status at the last documented follow-up.

MATERIALS AND METHODS

Source of data

The study data were obtained retrospectively from the available clinical records and institutional case summaries of children who underwent surgery for adrenocortical tumours. The available information comprised demographic characteristics, presenting symptoms, hormonal investigations, radiological findings, operative details, histopathological diagnoses, adjuvant treatment and follow-up outcomes.

Study design

The study was a retrospective, single center, descriptive surgical case series.

Study location

The study was conducted in the Department of Pediatric Surgery, Indira Gandhi Institute of Child Health, Bengaluru, Karnataka, India.

Study duration

The provisional study period extended from 2014-2023, covering 10 calendar years. Follow-up was assessed up to the last documented clinical contact.

Sample size and sampling technique

The series comprised 10 children. A total enumeration approach was used, including all eligible operated cases identified during the defined study period.

Inclusion criteria

1. Children younger than 18 years at the time of surgery.
2. Patients who underwent surgery at the institute for an adrenal cortical neoplasm during the study period.
3. Patients with a documented diagnosis of adrenocortical adenoma, tumour of uncertain malignant potential or adrenocortical carcinoma.

Exclusion criteria

1. Adrenal lesions of non-cortical origin, including pheochromocytoma, neuroblastoma and other non-cortical masses.
2. Non-neoplastic adrenal conditions without a cortical tumour diagnosis.
3. Patients operated on entirely outside the institute.

Procedure and methodology

The records were reviewed to document age at presentation, sex, presenting complaints and symptom duration. Clinical presentations were grouped into mixed Cushingoid and virilising features, isolated Cushingoid presentation, precocious puberty, isolated virilisation and other presentations. Hormonal investigations were extracted as documented. These included serum cortisol, adrenocorticotropic hormone, dexamethasone suppression testing, dehydroepiandrosterone sulphate and testosterone where available. Aggregate statements of elevated hormone levels were distinguished from complete biochemical testing because patient-specific assay methods, reference ranges and testing denominators were not consistently available. Ultrasonography, computed tomography and magnetic resonance imaging findings were reviewed for tumour location, dimensions, reported volume, hemorrhage, rupture and evidence of extension. The tumour volume

values presented in the institutional case table were used without recalculating them from incomplete imaging dimensions. For the child with two recorded lesion volumes, the larger lesion volume was used in the exploratory patient level volume comparison, this was an analytical convention rather than a measure of total bilateral tumour burden.

Surgical management was classified as completed laparoscopic adrenalectomy, primary open surgery or laparoscopy converted to open surgery. These categories represented children rather than the total number of procedures, since bilateral disease could involve more than one operation. Macroscopic completeness of excision, tumour rupture, resection of visible deposits and perioperative mortality were recorded where reported. Macroscopically negative margins were not equated with histologically confirmed R0 resection. Histopathological findings were provisionally classified as adenoma, intermediate/uncertain malignant potential or carcinoma using the final institutional summary. The intermediate category was retained separately and was not automatically considered benign. Adjuvant treatment and outcomes were summarized from available follow-up information. Outcome categories included alive without documented recurrence and death during chemotherapy. The stated cause of death was treated as the attribution reported in the source summary.

Sample processing

No new biological specimens were collected for this retrospective analysis. Hormonal and histopathological results were extracted from investigations performed during routine clinical care.

The presentation referred to the Wieneke criteria, however, patient-level scores were not available for independent verification.

Data collection

Data were organized under the following domains:

Domain	Variables
Demographic	Age and sex
Clinical	Presenting symptoms, endocrine phenotype and symptom duration
Biochemical	Available hormonal results and reported abnormalities
Radiological	Tumour location, volume, rupture and extension
Operative	Surgical approach, conversion and macroscopic clearance
Pathological	Adenoma, intermediate tumour or carcinoma
Treatment	Chemotherapy and radiotherapy where documented
Follow-up	Follow-up duration, recurrence status and death

Missing values were not imputed. Patient names and telephone numbers were excluded from the manuscript tables.

Statistical methods

Categorical variables were summarized as frequencies and percentages. Wilson 95% confidence intervals were calculated for proportions. Age was expressed as mean ± standard deviation and median with range, a Student's t-based confidence interval was calculated for the mean. Two-sided Fisher's exact tests were used for exploratory categorical comparisons because of the small sample and sparse cells. Differences in proportions were expressed in percentage points, with Newcombe confidence intervals based on Wilson limits. Descriptive distributions were not tested against arbitrary expected frequencies. Therefore, tests and p values were marked "not applicable" where no meaningful comparison existed. A nominal two-sided $p<0.05$ was used for exploratory interpretation. No correction for multiple comparisons was applied. No multivariable regression or formal time-to-event survival analysis was performed because of the very small sample, limited events and incomplete event-date information.

RESULTS

Table 1: Demographic characteristics and clinical presentation of children with adrenocortical tumours

Characteristic	Result	95% CI
Age, years, mean ± SD	6.06 ± 4.76	2.65-9.46
Age, years, median (range)	4.50 (0.92-15.00)	
Age <4 years, n (%)	4 (40.0)	16.8-68.7%
Age ≥4 years, n (%)	6 (60.0)	31.3-83.2%
Female, n (%)	6 (60.0)	31.3-83.2%
Male, n (%)	4 (40.0)	16.8-68.7%
Mixed Cushingoid and virilising features, n (%)	3 (30.0)	10.8-60.3%
Isolated Cushingoid presentation, n (%)	3 (30.0)	10.8-60.3%
Precocious puberty, n (%)	2 (20.0)	5.7-51.0%
Isolated virilisation, n (%)	1 (10.0)	1.8-40.4%
Other presentation, n (%)	1 (10.0)	1.8-40.4%

The provisional cohort comprised 10 children with a mean age of 6.06 ± 4.76 years and a median age of 4.50 years. Ages ranged from 11 months to 15 years. Six children were girls and four were boys, giving a female-to-male ratio of 1.5:1. Mixed Cushingoid and virilising features and isolated Cushingoid presentation were each reported in three children. Two children presented with precocious puberty, one with isolated virilisation and one with another presentation. Confidence intervals were wide because of the small sample.

Table 2: Documented hormonal findings, tumour characteristics and histopathological distribution

Characteristic	n (%)	95% CI for percentage
Raised serum cortisol reported*	3 (30.0)	10.8-60.3
Raised DHEAS reported*	4 (40.0)	16.8-68.7
Largest recorded lesion volume ≤200 cm³	8 (80.0)	49.0-94.3
Largest recorded lesion volume >200 cm³	2 (20.0)	5.7-51.0
Tumour rupture reported	1 (10.0)	1.8-40.4
Diaphragmatic tumour deposits reported	1 (10.0)	1.8-40.4
Adrenocortical adenoma†	5 (50.0)	23.7-76.3
Intermediate/uncertain malignant potential†	3 (30.0)	10.8-60.3
Adrenocortical carcinoma†	2 (20.0)	5.7-51.0

†Provisional final-summary classification; patient-level pathology reconciliation is required.

Raised cortisol and DHEAS were reported in three and four children, respectively. These frequencies describe available documentation and cannot establish the prevalence of biochemical abnormalities among fully tested patients. Eight children had a largest recorded lesion volume of 200 cm³ or less, while two had volumes exceeding 200 cm³. The median largest-lesion volume was 56.5 cm³, with values ranging from 30 to 880 cm³. One child had reported tumour rupture and diaphragmatic deposits. The final summary classified five tumours as adenomas, three as intermediate and two as carcinomas.

Table 3: Surgical treatment, adjuvant therapy and documented outcomes

Parameter	n (%)	95% CI for percentage
Completed laparoscopic surgery	6 (60.0)	31.3-83.2
Primary open surgery	3 (30.0)	10.8-60.3
Laparoscopy converted to open surgery	1 (10.0)	1.8-40.4
Macroscopic clearance reported	10 (100.0)	72.2-100.0
Perioperative mortality	0 (0.0)	0.0-27.8
Chemotherapy administered	2 (20.0)	5.7-51.0
Radiotherapy reported	1 (10.0)	1.8-40.4
Alive without documented recurrence at last contact	9 (90.0)	59.6-98.2
Death during chemotherapy	1 (10.0)	1.8-40.4

Six children underwent completed laparoscopic surgery, three underwent primary open surgery and one required conversion from laparoscopy to open surgery. Macroscopic clearance was reported in all children, with no perioperative deaths. Two children received chemotherapy, and radiotherapy was reported in one child. At a reported median follow-up of two years, nine children were alive without documented recurrence. One child died during chemotherapy, with the source summary attributing the death to a treatment-related complication. The confidence interval around the favourable last-contact outcome was 59.6-98.2%, reflecting substantial uncertainty.

Table 4: Exploratory comparisons between carcinoma and other adrenocortical tumour classifications

Characteristic	Adenoma/intermediate combined (n=8), n (%)	Carcinoma (n=2), n (%)	Difference, percentage points* (95% CI)	Test	Exact p value
Age ≥4 years	4 (50.0)	2 (100.0)	50.0 (−21.7 to 78.5)	Fisher's exact	0.467
Largest recorded lesion volume >200 cm³	0 (0.0)	2 (100.0)	100.0 (26.7 to 100.0)	Fisher's exact	0.022
Death during follow-up	0 (0.0)	1 (50.0)	50.0 (−1.9 to 90.5)	Fisher's exact	0.200

Both children with carcinoma were aged at least four years, compared with four of eight children in the combined comparison group; this difference was not statistically significant (\(p=0.467\)). Both carcinomas had recorded volumes exceeding 200 cm³, whereas none of the other tumours exceeded this threshold (\(p=0.022\)). One of the two children with carcinoma died, compared with none in the comparison group (\(p=0.200\)). The volume finding was nominally significant

but arose from only two carcinomas and should not be interpreted as validation of a diagnostic threshold or an independent predictor.

DISCUSSION

Demographic characteristics and clinical presentation

The present provisional series included 10 children with a median age of 4.5 years and a female predominance of 60%. Pinto et al. (2020)[1] described childhood adrenocortical tumours as a distinct group frequently associated with endocrine manifestations. Miele et al. (2020)[2] reported a younger cohort, with a median diagnostic age of 17 months and a female-to-male ratio of 3.3:1. The present series therefore included a broader age range and less marked female predominance. Differences in referral patterns and case selection may account for some of this variation. Mixed Cushingoid and virilising features and isolated Cushingoid presentation each accounted for 30% of the current series. In comparison, Miele et al.[2] reported mixed manifestations in 46.1% of patients. Kunstreich et al. (2024)[6] demonstrated that the endocrine phenotype of paediatric adrenocortical tumours varies with age and sex. Accordingly, apparent differences in presentation between institutional series may reflect their demographic composition as well as differences in how clinical and biochemical syndromes were classified. Both carcinomas in the current series occurred in older children, but the age-group comparison was inconclusive. Gulack et al. (2016)[7], using National Cancer Data Base information, identified age, tumour size, extension, metastatic disease and margin status as factors associated with survival. The present study was too small to evaluate these factors independently; absence of statistical significance for age should therefore not be interpreted as absence of a clinically relevant association.

Tumour volume and pathological assessment

The two carcinomas had larger recorded volumes than the other tumours, and both exceeded 200 cm^3. This direction of association was consistent with Wang et al. (2019)[8], who reported larger mean volumes in carcinomas than adenomas in a 28-patient series. However, the current comparison contained only two malignant cases and did not establish the diagnostic performance of tumour volume. Imaging dimensions and endocrine findings should therefore support, rather than replace, pathological assessment. Riedmeier et al. (2022)[9] evaluated prognostic factors through a systematic review and proposed a paediatric adaptation of the S-GRAS score. Their subsequent international multicentre study, Riedmeier et al. (2024)[10], supported the prognostic importance of age, resection status, tumour stage and Ki-67. These studies illustrate why a single variable such as size is insufficient for comprehensive risk assessment. The present records lacked the complete staging and proliferative-index information needed to apply such a system reliably. The provisional distribution of five adenomas, three intermediate tumours and two carcinomas emphasized the importance of retaining an uncertain-potential category. Picard et al. (2019)[11] evaluated pathological grading in a national cohort and developed a five-item microscopic approach incorporating invasion, necrosis, mitotic activity and Ki-67. Martins-Filho et al. (2021)[12] examined adult and paediatric tumours and reinforced the importance of interpreting pathological findings within the relevant age group. These observations support expert review of the conflicting pathology classifications in the supplied records. Jehangir et al. (2019)[13] compared pathological classification systems against clinical behaviour, while Jangir et al. (2023)[14] evaluated three histopathological scoring approaches in paediatric adrenocortical neoplasms. Their work demonstrates the continuing challenge of predicting biological behaviour from morphology alone. In the present series, the intermediate category should consequently remain distinct until original pathology reports and, where possible, slides have been reviewed.

Surgical management

Completed laparoscopic surgery was reported in six children, primary open surgery in three and conversion in one. These figures describe institutional practice but do not establish the comparative safety or superiority of either approach. Case selection, tumour size and suspected malignancy almost certainly influenced operative decisions, and the available data were insufficient to adjust for these differences. Virgone et al. (2021)[4] recommended prioritizing complete, intact excision and an open approach when malignancy is suspected, reserving minimally invasive surgery for selected small lesions likely to be benign. The current experience should therefore be presented as the feasibility of laparoscopy in selected cases rather than evidence supporting its general use for pediatric carcinoma. Macroscopic clearance was reported in all patients, but microscopic margin status was unavailable. This distinction matters because Kuhlen et al. (2023)[15], analyzing the German MET cohort, identified incomplete resection, spillage, advanced stage and unfavourable pathological features as adverse factors. Their findings support careful documentation of capsule integrity, operative contamination and histological margins in future institutional records.

Genetic and biological considerations

Genetic testing was not adequately documented in the present series. Wasserman et al. (2015)[3] established the relevance of germline TP53 abnormalities, and Pinto et al. (2015)[16] characterized genomic alterations associated with pediatric adrenocortical tumour development and aggressive behaviour. Without genetic information, this series could not assess inherited susceptibility or its relationship to clinical outcomes.

Pinto et al. (2017)[17] investigated clinical and biological correlates among children without germline TP53 mutations. Clay et al. (2019)[18] identified prognostically relevant DNA methylation groups. Together, these studies indicate that biological heterogeneity extends beyond routine histological labels. The present study could describe clinical experience but could not investigate molecular risk classification. Pinto et al. (2021)[19] also described adrenocortical tumours associated with constitutional paternal uniparental disomy of chromosome 11p15. Such findings support consideration of a broader predisposition assessment where appropriate, particularly when clinical features suggest an overgrowth syndrome or unusual disease distribution. No such abnormality can be inferred in the current children from the available information.

Adjuvant treatment and outcomes

Nine children were reported alive without recurrence at their last documented assessment, while one died during chemotherapy. This favourable crude outcome must be interpreted in the context of a cohort containing predominantly non-carcinoma classifications. It cannot be compared directly with survival estimates from carcinoma-only cohorts or described as a two-year survival rate. Rodriguez-Galindo et al. (2021)[5] reported stage-dependent outcomes and substantial toxicity with systemic treatment in ARAR0332. The treatment-associated death reported in the present series reinforces the need to document chemotherapy regimens, toxicities and supportive care, although causation cannot be independently established from the supplied summaries. Riedmeier et al. (2024)[20], in an international mitotane consensus, highlighted the importance of treatment monitoring and management of potentially serious adverse effects. Mitotane administration was not documented in the current records and should not be assumed. O'Neill et al. (2024)[21] reviewed the continuing difficulty of treating advanced pediatric carcinoma and the need for improved risk stratification. Gupta et al. (2018)[22], in a 41-patient Mayo Clinic carcinoma cohort, reported two- and five-year overall survival estimates of 61% and 46%, respectively. Those estimates reflect a different disease population and longer time-to-event assessment; they should not be contrasted directly with the present 90% last-contact proportion.

CONCLUSION

Pediatric adrenocortical tumours showed varied endocrine presentations and a heterogeneous pathological spectrum in this provisional 10-child series. Surgical treatment achieved reported macroscopic clearance in all children, and nine were alive without documented recurrence at the last assessment. The two carcinomas had larger recorded tumour volumes, although the small sample prevented reliable prognostic inference. Complete tumour excision, expert pathological assessment and continued follow-up remain central to management. The findings support selective use of laparoscopy in appropriately chosen cases but do not establish its comparative safety for malignant tumours.

LIMITATIONS OF THE STUDY

1. **Small sample:** Only 10 children were included, resulting in wide confidence intervals and limited statistical power.
2. **Retrospective design:** The analysis depended on the completeness and accuracy of existing documentation.
3. **Unresolved source discrepancies:** Study dates, cohort eligibility, histological classifications and follow-up details differed between files.
4. **Selection bias:** An operated institutional series may not represent children with unresectable disease or those managed elsewhere.
5. **Limited biochemical information:** Testing denominators, assay methods and age-specific reference ranges were incompletely documented.
6. **Incomplete pathological and genetic data:** Individual Wieneke scores, Ki-67 indices, microscopic margins and genetic findings were unavailable.
7. **Non-random treatment allocation:** Surgical approaches were selected according to clinical circumstances, preventing a valid comparison of operative techniques.
8. **Incomplete time-to-event information:** Recurrence-free and overall survival probabilities could not be reliably estimated.
9. **Exploratory testing:** Comparisons were post hoc, unadjusted for multiple testing and based on only two carcinomas.
10. **Limited generalizability:** Findings from a single tertiary center may not apply to other populations or treatment settings.

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