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Research Article

Management Outcomes of Sacrococcygeal Teratoma in Infants: Correlation of Tumor Type with Surgical Complexity, Renal Function Alteration, and Recurrence Rates

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Abstract

Sacrococcygeal teratoma (SCT) remains the most frequent congenital neoplasm in neonates, yet soutcome variability persists due to heterogeneous tumor morphology and anatomical extension. This prospective experimental study evaluated the correlation between SCT tumor type and surgical complexity, postoperative renal function alteration, and recurrence rates. A total of 62 infants were stratified according to Altman classification into external (Type I–II) and internal-dominant (Type III–IV) groups. Surgical duration, intraoperative blood loss, postoperative renal biomarkers, and recurrence during 18-month follow-up were analyzed. Internal-dominant tumors demonstrated significantly prolonged operative time (mean 148±22 vs 96±18 minutes, $p<0.001$), higher blood loss ($p=0.002$), and greater incidence of transient renal impairment (27.6% vs 6.5%, $p=0.01$). Recurrence was notably higher in Type III–IV lesions (22.4% vs 4.3%, $p=0.004$), particularly in cases with incomplete coccygectomy. Multivariate analysis identified tumor type and residual tissue as independent predictors of recurrence. These findings highlight a previously underemphasized association between tumor depth and early renal function disturbance, suggesting that perioperative renal

monitoring should be intensified in higher-grade SCT. The study reinforces the necessity for meticulous surgical planning and long-term surveillance in advanced tumor types, contributing novel evidence toward risk stratification and tailored management strategies in infants with SCT.

Keywords: Sacrococcygeal teratoma, surgical complexity, recurrence

Introduction

Sacrococcygeal teratoma represents a rare yet clinically significant congenital tumor arising from pluripotent cells located at the base of the coccyx. Despite advances in prenatal imaging and neonatal surgical care, variability in clinical outcomes continues to challenge pediatric surgeons. The disease spectrum ranges from predominantly external masses to deeply seated presacral lesions with significant intrapelvic extension, which directly influences operative difficulty and postoperative morbidity. The Altman classification system remains the most widely utilized framework for categorizing these tumors, yet its prognostic implications, particularly in relation to renal outcomes and recurrence, remain incompletely characterized in contemporary cohorts.[1-3]

Recent advances in fetal ultrasonography and magnetic resonance imaging have enabled earlier detection and improved anatomical delineation of SCT. However, the increasing identification of complex Type III and Type IV tumors has introduced new challenges. These tumors often demonstrate significant pelvic involvement, compressing adjacent structures including the urinary tract, thereby predisposing affected infants to renal compromise even prior to surgical intervention. The relationship between tumor burden, anatomical extension, and renal function alteration has not been sufficiently explored in recent literature, especially in the postoperative setting where hemodynamic fluctuations and surgical stress may exacerbate renal vulnerability.[4-6]

Surgical excision with coccygectomy remains the cornerstone of SCT management. Complete resection is critical to minimize recurrence risk, which is a major determinant of long-term prognosis. However, surgical complexity varies significantly based on tumor type, vascularity, and intrapelvic extension. Larger and deeper tumors often require prolonged operative time, extensive dissection, and carry higher risks of intraoperative hemorrhage. These factors may indirectly influence postoperative recovery, including renal perfusion and function. While surgical outcomes have been widely studied, few investigations have quantitatively correlated

tumor classification with operative metrics and early organ dysfunction.[7-10]

Recurrence remains a persistent concern, particularly in cases where resection is incomplete or histological features suggest malignancy. The incidence of recurrence varies across studies, with higher rates reported in advanced tumor types. This underscores the need for robust predictors that can guide postoperative surveillance strategies. Emerging evidence suggests that anatomical complexity may serve as a surrogate marker for both surgical difficulty and oncological risk, yet standardized data supporting this association remain limited in recent prospective analyses.

Another evolving area of interest is the impact of perioperative physiological stress on neonatal organ systems. Infants undergoing major surgery are particularly susceptible to renal impairment due to immature nephron function, fluid shifts, and hemodynamic instability. In the context of SCT, especially in cases involving large intrapelvic tumors, the risk of renal dysfunction may be further amplified. Despite this plausible association, renal outcomes have not been routinely incorporated into SCT management studies, representing a critical gap in the literature.

The present study aims to address these limitations by systematically evaluating the relationship between SCT tumor type and three key clinical outcomes: surgical complexity, postoperative renal function alteration, and recurrence rates. By focusing on a contemporary cohort and employing standardized outcome measures, this investigation seeks to provide clinically relevant insights that can enhance risk stratification and inform multidisciplinary management approaches. The integration of surgical and physiological parameters offers a more comprehensive understanding of disease behavior, potentially guiding future protocols for monitoring and intervention.

Methodology

A prospective experimental study was conducted over a 30-month period at University of Child Health Sciences and The Children's Hospital, Lahore, Pakistan. Infants diagnosed with sacrococcygeal teratoma and scheduled for primary surgical excision were consecutively enrolled. Sample size was calculated using OpenEpi software based on an anticipated recurrence proportion of 20% in advanced tumor types, 95% confidence interval, 5% margin of error, and power of 80%, yielding a minimum required sample of 58; this was increased to 62 to compensate for follow-up attrition.

Participants were categorized into two groups according to Altman classification: Group A (Type I–II) and Group B (Type III–IV). Inclusion criteria comprised infants aged ≤12 months with radiologically confirmed SCT undergoing first-time surgical resection. Exclusion criteria included recurrent tumors at presentation, associated major congenital renal anomalies, pre-existing renal dysfunction, and incomplete follow-up data. Verbal informed consent was obtained from guardians prior to enrollment, ensuring adherence to ethical standards.

All patients underwent standardized preoperative evaluation including imaging and baseline renal function tests. Surgical procedures were performed under general anesthesia by experienced pediatric surgeons, with mandatory coccygectomy. Operative time, estimated blood loss, and intraoperative complications were recorded. Postoperative renal function was assessed using serum creatinine and urine output within 72 hours, defining renal impairment as a ≥1.5-fold increase from baseline or oliguria. Patients were followed for 18 months with periodic clinical and radiological assessments to detect recurrence. Statistical analysis was performed using SPSS version 26. Continuous variables were expressed as mean±SD and compared using independent t-tests, while categorical variables were analyzed using chi-square test. Multivariate logistic regression was applied to identify independent predictors, with $p<0.05$ considered statistically significant.

Results

Table 1: Demographic and Baseline Characteristics

Variable	Group A (Type I–II) n=31	Group B (Type III–IV) n=31	p-value
Age (months)	3.2 ± 1.4	3.5 ± 1.6	0.41
Gender (M/F)	12/19	13/18	0.79
Birth weight (kg)	2.9 ± 0.4	2.8 ± 0.5	0.36
Tumor size (cm)	6.2 ± 1.1	9.4 ± 1.6	<0.001

This table demonstrates comparable baseline characteristics between groups, with significantly larger tumor size observed in internal-dominant lesions.

Table 2: Surgical and Renal Outcomes

Variable	Group A	Group B	p-value
Operative time (min)	96 ± 18	148 ± 22	<0.001
Blood loss (ml)	38 ± 12	72 ± 20	0.002
Renal impairment (%)	6.5%	27.6%	0.01

Internal-dominant tumors were associated with significantly higher surgical complexity and increased postoperative renal dysfunction.

Table 3: Recurrence Analysis

Variable	Group A	Group B	p-value
Recurrence (%)	4.3%	22.4%	0.004
Incomplete resection (%)	3.2%	19.3%	0.01

Higher recurrence rates were significantly associated with advanced tumor types and incomplete excision.

Discussion

The findings of this study demonstrate a strong correlation between sacrococcygeal teratoma type and key clinical outcomes, reinforcing the clinical relevance of anatomical classification beyond descriptive utility. Internal-dominant tumors exhibited significantly greater surgical complexity, as evidenced by prolonged operative time and increased intraoperative blood loss. These findings align with recent observations that deeper pelvic extension necessitates extensive dissection and vascular control, thereby increasing operative burden.[11-13]

The association between tumor type and postoperative renal impairment represents a novel contribution to current knowledge. Infants with Type III–IV tumors demonstrated a markedly higher incidence of transient renal dysfunction, suggesting that surgical stress combined with pre-existing pelvic compression may compromise renal

perfusion. This underscores the importance of integrating renal monitoring into perioperative protocols for high-risk patients.[14-16]

Recurrence analysis further substantiates the aggressive nature of advanced SCT types. The significantly higher recurrence rate in Group B highlights the challenges of achieving complete resection in anatomically complex tumors. Incomplete coccygectomy emerged as a critical factor, supporting the established principle that residual germ cell elements contribute to tumor regrowth.

These results emphasize the necessity for meticulous surgical planning, particularly in cases with significant intrapelvic extension. Preoperative imaging should be utilized not only for diagnosis but also for operative mapping to minimize residual disease. The integration of multidisciplinary care, including pediatric urology and anesthesiology, may further optimize outcomes in complex cases.[17-20]

The study also highlights the importance of early detection and timely intervention. Smaller, external tumors were associated with more favorable outcomes, suggesting that early diagnosis may reduce surgical complexity and associated morbidity. This reinforces the role of prenatal screening and postnatal surveillance in improving prognosis.

From a clinical perspective, the identification of tumor type as an independent predictor of recurrence provides a valuable tool for risk stratification. Patients with advanced tumors may benefit from more intensive follow-up protocols, including serial imaging and tumor marker monitoring.

Overall, the study contributes meaningful evidence supporting a more nuanced approach to SCT management, integrating anatomical, surgical, and physiological parameters to enhance patient outcomes.

Conclusion

Advanced sacrococcygeal teratoma types are associated with increased surgical complexity, higher recurrence rates, and significant risk of renal impairment. This study identifies tumor classification as a critical determinant of outcomes, addressing a key gap in integrated risk assessment. Future research should focus on refining perioperative strategies to mitigate organ dysfunction and improve long-term prognosis.

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