

# Comparative analysis of laparoscopic and open surgical techniques for nonparasitic splenic cyst management in children: a proposed prediction index

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**Abstract. – OBJECTIVE:** In this research, our goal is to carry out a retrospective assessment of patients who received surgical treatment for nonparasitic splenic cysts (NPSCs) and to propose an innovative index (Karakuz Index) for predicting the optimal surgical approach.

**PATIENTS AND METHODS:** This study is a retrospective analysis of 48 pediatric patients who underwent surgical treatment for nonparasitic splenic cysts. The patient population was divided into two groups based on the surgical approach: open surgery (n=37) and laparoscopic surgery (n=11).

**RESULTS:** Of the 256 patients with nonparasitic splenic cysts (NPSCs), 48 patients underwent surgical treatment (18.8%). The average age was  $11.4 \pm 4.2$  years, and the majority were female (52%). Surgical approaches included laparoscopic (23%) and open surgery (77%), with cystectomy, partial splenectomy, and total splenectomy performed (48%, 23%, and 29%, respectively). The Karakuz Index, a novel metric, also showed significant differences between the two groups. Histopathological findings and recurrence rates were similar between both approaches ( $p=0.335$  and  $p=0.229$ , respectively). The Karakuz Index demonstrated a sensitivity of 60% and a specificity of 91% at a cut-off value of 16.

**CONCLUSIONS:** The novel Karakuz Index demonstrated promising discriminatory capacity and requires further research in larger studies.

*Key Words:*

Splenic Cyst, Karakuz index, Nonparasitic Splenic cysts, Laparoscopy.

examinations or imaging studies. The growing use of imaging techniques in pediatric cases has resulted in an increase in the diagnosis of these cysts through methods such as ultrasound, computed tomography, and magnetic resonance imaging<sup>1</sup>. Splenic cysts generally remain asymptomatic until they grow large enough to exert pressure on nearby organs. The primary symptom experienced by patients is usually abdominal pain, predominantly in the left upper quadrant. Additional symptoms and signs may include a palpable mass, thrombocytopenia, a feeling of fullness after eating small amounts of food, and abdominal bloating or swelling<sup>2,3</sup>.

Recent technological advancements and improved surgical skill sets have led to the development of laparoscopic and open techniques as alternative treatment options for pediatric NPSCs. Laparoscopic procedures have gained momentum due to several advantages, including reduced postoperative pain, shorter hospital stays, and better cosmetic outcomes. Despite these benefits, open surgical techniques continue to be used in specific cases, particularly for the management of large or complex cysts<sup>4</sup>.

In this research, our goal is to carry out a retrospective assessment of patients who received surgical treatment for NPSCs and to propose an innovative index (Karakuz Index) for predicting the optimal surgical approach.

## Patients and Methods

### *Patients and Design*

This study is a retrospective analysis of 48 pediatric patients who underwent surgical treatment for nonparasitic splenic cysts. The patient

## Introduction

Nonparasitic splenic cysts (NPSCs) in children are an uncommon occurrence, and the majority of them are detected unintentionally during physical

population was divided into two groups based on the surgical approach: open surgery (n=37) and laparoscopic surgery (n=11). Various patient characteristics, including age, gender, standard spleen size, cyst diameter, cyst localization, procedure type, histopathology, operative time, and the novel Karakuz Index, were compared between the two groups.

### **Type of the Study**

This study is a type 3 retrospective descriptive study. Retrospective descriptive studies provide a detailed description and characterization of an event, situation, or health condition within a specific population, based on data from past events. These types of studies allow researchers to better understand a particular subject by examining existing data and identifying patterns or trends.

### **Definition of the Karakuz Index**

As is widely known, laparoscopic surgery is performed for smaller cysts, while open surgery is performed for larger cysts; however, a clear distinction between small and large cysts in children has not been defined. Similarly, there is no existing prediction index to guide the choice between open and laparoscopic surgery in children. In this study, we introduce the Karakuz Index. To calculate the Karakuz Index, the patient's estimated spleen size (ESS), based on age, is first determined using the previously reported formula in the literature:  $[5.8 + (\text{Age}/3)]$ . Next, the square of the patient's splenic cyst size is divided by this estimated spleen size to compute the Karakuz Index (Figure 1).

### **Inclusion Criteria**

Patients (0-18 years) who were surgically treated due to NPSCs in the pediatric surgery clinic of Başakşehir Çam and Sakura Training Hospital, and patients whose file records and data were adequate and regular in retrospective scanning were included in our study.

### **Exclusion Criteria**

Patients whose patient records and data were insufficient and irregular in the retrospective

screening were excluded from the study. Additionally, patients with a diagnosis of hydatid cysts and those managed conservatively were excluded.

### **Ethical Approval**

The ethics committee of this study was obtained from the Ethics Committee of Başakşehir Çam and Sakura Training Hospital (number: KAEK/26.07.2023.332). Informed consent was obtained from all patients.

### **Statistical Analysis**

Statistical analysis of patient data, including descriptive statistics, frequencies, and other characteristics across all categories, was performed. Continuous data were presented as mean  $\pm$  standard deviation. To determine whether the data followed a normal distribution, the Shapiro-Wilk and Kolmogorov-Smirnov tests were employed to assess continuous variables. The Student's *t*-test was used for comparing continuous variables with a normal distribution, while non-parametric tests were chosen for data that did not follow a normal distribution. Categorical variables were compared using the Chi-square test. Cut-off analysis and the proposed new index were evaluated using ROC analysis. All analyses were conducted using SPSS Statistics for Windows, Version 24.0 (IBM Corp., Armonk, NY, USA). The *p*-values were two-sided, and a *p*-value  $\leq 0.05$  was deemed statistically significant.

## **Results**

In a patient population of 256 individuals with nonparasitic splenic cysts (NPSCs), surgical treatment was performed on 48 of them. This indicates that approximately 18.8% of the patients with NPSCs underwent surgery. The patient population consisted of 48 individuals, with various characteristics and outcomes, as described below. The average age of the patients was  $11.4 \pm 4.2$  years. The cohort was predominantly female, constituting 52% of the patients. The estimated spleen size (ESS) was measured as the mean with a standard deviation of  $9.6 \pm 1.4$ . The average cyst diameter was  $11.95 \pm 5.8$ . Regarding the localization of the cysts within the spleen, 46% were found in the upper pole, 21% in the hilus, and 33% in the lower pole. In terms of the surgical approach, 23% of the patients underwent laparoscopic surgery, while the remaining 77% were treated with open surgery. The procedures performed during the

$$\begin{aligned} \text{Estimated Spleen Size (ESS)} &= 5.8 + (\text{Age} / 3) \\ \text{Karakuz Index} &= (\text{Splenic Cyst Size})^2 / \text{ESS} \end{aligned}$$

**Figure 1.** Definition of the Karakuz Index.

**Table I.** General characteristics.

Characteristics	N	%
Age*	11.4	4.2
Gender (F)	25	52%
Estimated splenic size*	9.6	1.4
Cyst diameter*	11.95	5.8
Localization		
Upper pole	22	46%
Hilus	10	21%
Lower pole	16	33%
Approach		
Laparoscopic	11	23%
Open	37	77%
Procedures		
Cystectomy	23	48%
Partial splenectomy	11	23%
Total splenectomy	14	29%
Histopathology		
Epithelial	25	52%
Mesothelial	13	27%
Pseudocyst	10	21%
Recurrence	1	2%
Follow-up	4	1.5
Karakuz index*	17.56	14.68

\*Mean SD deviation.

surgeries included cystectomy (48%), partial splenectomy (23%), and total splenectomy (29%). Histopathological examination of the cysts revealed 52% to be of epithelial origin, 27% mesothelial, and 21% pseudocysts. The Karakuz Index, a novel metric proposed in this study, was calculated for each patient with a mean value of  $17.56 \pm 14.68$ . During the  $4 \pm 1.5$ -year follow-up period, recurrence occurred in one patient. This patient, who developed recurrence, had undergone laparoscopic cystectomy (Table I).

The present study compares patient characteristics and outcomes between open surgery ( $n=37$ ) and laparoscopic surgery ( $n=11$ ) for the treatment of nonparasitic splenic cysts in children. Patients who underwent open surgery were older ( $12.51 \pm 3.33$  years) than those who underwent laparoscopic surgery ( $7.64 \pm 4.81$  years) ( $p=0.008$ ). The standard spleen size differed significantly between the two groups, with open surgery patients having a larger average size ( $9.97 \pm 1.1$  cm) than laparoscopic surgery patients ( $8.34 \pm 1.61$  cm) ( $p=0.008$ ). Cyst diameter also showed a substantial difference between the groups, with larger cysts ( $13.37 \pm 5.55$  cm) treated with open surgery and smaller cysts ( $7.18 \pm 3.84$  cm) treated with laparoscopy ( $p<0.001$ ). No significant differences were observed in terms of gender and cyst localization between the two surgical approaches

( $p>0.05$ ). However, the type of procedure performed showed a significant difference between the open and laparoscopic groups ( $p=0.004$ ). In the open surgery group, cystectomy was performed in 13 patients, partial splenectomy in 10, and total splenectomy in 14. In contrast, the laparoscopic group had 10 patients undergoing cystectomy and only 1 patient receiving partial splenectomy, while no total splenectomies were performed. Operative time was significantly different between the groups ( $p<0.05$ ). Histopathological findings did not show a significant difference between the two groups ( $p=0.335$ ). The Karakuz Index, a novel metric proposed in this study, showed a significant difference between the open ( $20.71 \pm 15.06$  cm) and laparoscopic ( $7.03 \pm 6.2$  cm) groups ( $p=0.005$ ). No difference was observed in terms of recurrence during the follow-up period ( $p>0.05$ ) (Table II).

In our study, a ROC analysis was performed for the Karakuz Index. According to the analysis, the index cut-off value was determined to be 16, with a sensitivity of 60%, a specificity of 91%, and AUC 0.84 (Figure 2).

## Discussion

The present study aimed to compare patient characteristics and outcomes between open surgery and laparoscopic surgery for the treatment of nonparasitic splenic cysts in children. In our cohort of 48 patients, we observed significant differences in age, spleen size, cyst diameter, type of procedure performed, and operative time between the two surgical approaches. The Karakuz Index, a novel metric proposed in this study, demonstrated a significant difference between the open and laparoscopic groups, suggesting its potential usefulness in clinical decision-making.

This study's patient population, consisting of 48 individuals, can be compared to other studies<sup>5,6</sup> in the literature. In the study by Czauderna et al<sup>5</sup> the patient population comprised 26 male and 24 female patients, with ages ranging from 1 to 17 years (mean 11.9 years). Al-Salem<sup>6</sup> conducted a study with 103 patients (61 boys and 42 girls), with a mean age of 7.6 years (range, 1.8-13 years). In our study, the average age of the patients was  $11.4 \pm 4.2$  years, with a predominantly female cohort constituting 52% of the patients. In our research, the average age was 11.4 years, which is closely aligned with the 11.9 years reported in the study of Czauderna et al<sup>5</sup>. However, the mean age

**Table II.** Comparison open and laparoscopic approaches for the NPSCs treatment.

Characteristics	Open (n=37)	Laparoscopy (n=11)	p-value
Age*	12.51±3.33	7.64±4.81	0.008
Gender (F)	18	7	0.382
Estimated splenic size*	9.97±1.1	8.34±1.61	0.008
Cyst diameter*	13.37±5.55	7.18±3.84	<0.001
Localization			0.802
Upper pole	16	6,00	
Hilus	8	2,00	
Lower pole	13	3,00	
Procedures			0.004
Cystectomy	13	10.00	
Partial splenectomy	10	1.00	
Total splenectomy	14	0.00	
Operative time*	75±45	140±65	<0.05
Histopathology			0.335
Epithelial	20	5.00	
Mesothelial	11	2.00	
Pseudocyst	6	4.00	
Recurrence	0	1	0.229
Follow-up*	4±1.5	4±1.5	1.000
Karakuz index*	20.71±15.06	7.03±6.2	0.005

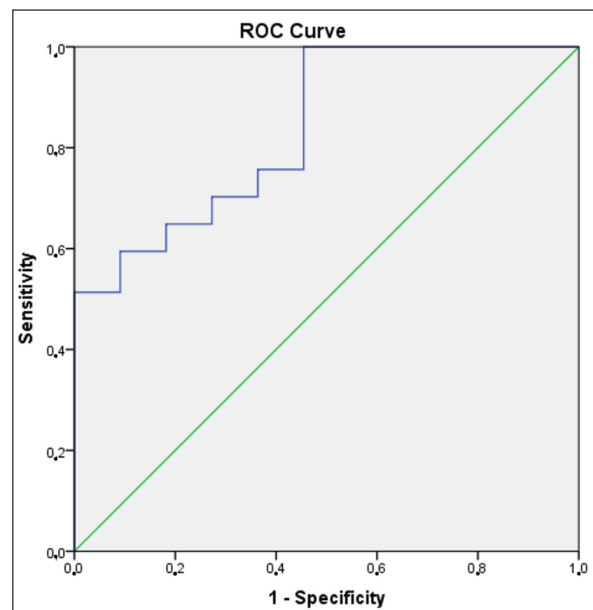
\*Mean SD deviation.

of patients in the study of Al-Salem<sup>6</sup> study was lower, at 7.6 years, compared to both our study and Czauderna et al<sup>5</sup>. This variation in the age distribution among the studies could be attributed to differences in the inclusion criteria, patient populations, and the prevalence of splenic cysts across various age groups.

In our study, the average cyst diameter was found to be 11.95±5.8. As for the localization of the cysts within the spleen, 46% were identified in the upper pole, 21% in the hilus, and 33% in the lower pole. These findings can be compared with existing literature to provide a broader context for understanding the characteristics of nonparasitic splenic cysts. Morgenstern<sup>7</sup> reported an average cyst diameter of 9.7±4.9 cm in their study, which is smaller than the average diameter observed in our study. The differences in cyst diameters between the studies might be attributed to variations in patient populations, sample sizes, and the natural progression of cysts at the time of diagnosis. Concerning the localization of cysts, the study by Czauderna et al<sup>5</sup> found that 54% of cysts were located in the upper pole, 31% in the lower pole, and 15% in the hilus. These findings show similarities and differences when compared to our study. While both studies found a higher prevalence of cysts in the upper pole, the distribution of cysts in the hilus and lower pole differed between the two studies. The variations in cyst localization

might be due to differences in patient populations, the study design, or random variations in the localization of nonparasitic splenic cysts.

In our study, the surgical procedures performed for nonparasitic splenic cysts (NPSCs) included cystectomy (48%), partial splenectomy (23%), and total splenectomy (29%). Histopathological examination of the cysts revealed

**Figure 2.** ROC analysis for Karakuz Index.



52% to be of epithelial origin, 27% mesothelial, and 21% pseudocysts. We can compare our findings with the following relevant literature to better understand the surgical management and histopathological characteristics of NPSCs: Zhang et al<sup>8</sup> described a novel therapeutic approach to nonparasitic splenic cysts, involving laparoscopic fenestration and endothelium obliteration. In contrast, our study utilized cystectomy, partial splenectomy, and total splenectomy as the primary surgical procedures. The differences in treatment approaches could be attributed to various factors such as cyst size, location, and the surgeons' expertise. Czauderna et al<sup>5</sup> conducted a multicentric study on nonparasitic splenic cysts in children, reporting a diverse range of surgical procedures. Their study aligns with our findings, showcasing the variability in the surgical management of NPSCs. Morgenstern<sup>7</sup> discussed the pathogenesis, classification, and treatment of nonparasitic splenic cysts. Sinha and Agrawal<sup>9</sup> reviewed the current status of nonparasitic splenic cysts in children. They highlighted various surgical techniques, including cystectomy, and partial splenectomy, which were also employed in our study. This similarity emphasizes the consistency of surgical approaches for managing NPSCs across different studies. Schier et al<sup>10</sup> found that laparoscopic unroofing of splenic cysts resulted in a high rate of recurrences in their study. Czauderna et al<sup>5</sup> reported a 16% recurrence rate, and all of their recurrences occurred in patients who had undergone laparoscopic procedures. While our study specifically addresses 2% of the recurrence rate, it is important to consider the possibility of recurrence in the long-term management of NPSCs.

Operative time was significantly longer in the laparoscopic group compared to the open surgery group, which may be attributed to the technical challenges and learning curve associated with laparoscopic surgery<sup>8,10,11</sup>. However, it is important to note that laparoscopic surgery has been associated with shorter hospital stays and reduced postoperative pain compared to open surgery<sup>10</sup>. Our study did not assess these outcomes, and further research is needed to evaluate the overall impact of the surgical approach on postoperative recovery and quality of life.

In our study, the Karakuz Index was introduced as a novel metric to differentiate between open and laparoscopic surgery for nonparasitic splenic cysts in children. The index demonstrated

a promising discriminatory capacity, with a sensitivity of 60%, specificity of 91%, and AUC of 0.84. To the best of our knowledge, this is the first study to propose and evaluate such an index, and further research is needed to validate its clinical utility in larger and more diverse patient populations.

### ***Strength of the Study***

The study introduces the Karakuz Index, a new metric that may provide additional insights into the management of nonparasitic splenic cysts. The significant difference between the open and laparoscopic groups with respect to the Karakuz Index could contribute to the development of better treatment strategies.

The study identified several significant differences between the open surgery and laparoscopic surgery groups, including age, spleen size, cyst diameter, type of procedure, and operative time. These findings can help guide clinicians in selecting the most appropriate surgical approach for their patients. By directly comparing open surgery and laparoscopic surgery, the study provides valuable insights into the advantages and disadvantages of each approach. This information can aid in the decision-making process when determining the most suitable treatment option for children with nonparasitic splenic cysts.

### ***Limitations***

The retrospective nature of this study may introduce potential biases, including selection bias and information bias, which could impact the accuracy of the results. Prospective, randomized controlled trials would offer more robust evidence and better control for confounding factors. The small sample size is also a limitation. With only 48 patients included in the study, the sample size is relatively small, which may limit the generalizability of the findings. Larger-scale studies with more diverse patient populations are needed to confirm the results. Moreover, the study was conducted at a single institution, which may not accurately represent the experience and outcomes of other centers. Multi-center studies would provide a more comprehensive view of the subject and enhance the external validity of the findings. In addition, the study primarily focused on immediate outcomes following surgery, without considering long-term postoperative complications, recurrence rates, or patient quality of life. Future studies should include long-term follow-up data to provide a more complete understanding of the

benefits and drawbacks of each surgical approach.

In conclusion, the Karakuz Index, introduced in this study as a novel metric, has not yet been validated in other studies or patient populations. Further research is needed to evaluate its reliability and generalizability in assessing the most appropriate surgical approach for treating non-parasitic splenic cysts in children. The study did not account for all potential confounding factors, such as surgeon experience, the use of different surgical techniques, or patient comorbidities, which could impact the outcomes and comparisons between the two surgical approaches. Future studies should attempt to control for these factors to obtain more accurate results.

## Conclusions

Our study demonstrated significant differences in patient characteristics and outcomes between open surgery and laparoscopic surgery for non-parasitic splenic cysts in children. The Karakuz Index, a novel metric proposed in this study, showed promising discriminatory capacity and warrants further investigation in larger, prospective studies. Our findings contribute to the growing body of literature on the management of non-parasitic splenic cysts in pediatric patients and may help inform clinical decision-making and surgical planning.

## Conflicts of Interest

The author declares no conflict of interest.

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No external funding was received for this study.

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## Ethics Approval

The Ethics Committee of this study was obtained from the Local Ethical Committee of Başakşehir Çam and Sakura Training Hospital (number: KAEK/26.07.2023.332).

## Informed Consent

Informed consent was obtained from all patients' guardians.

## Data Availability

Data is available on request from the author.

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