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SYSTEMATIC REVIEW

Efficacy and safety of laparoscopic urethral anastomosis in the repair of congenital urethral stricture in children: a systematic review

Eficacia y seguridad de la anastomosis uretral laparoscópica en la reparación de la estenosis uretral congénita en niños: una revisión sistemática

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ABSTRACT

Introduction: congenital urethral strictures are rare but significant defects in pediatric urology, causing urinary system abnormalities. These defects are difficult to manage in children due to differences in anatomy and physiology. Laparoscopic urethral anastomosis, a minimally invasive surgery, has become a popular option in pediatric urology.
Objective: the research paper was aimed to assess the outcomes of laparoscopic urethral anastomosis in the pediatric patients with congenital urethral stricture
Method: this review article focuses on the effectiveness and safety of laparoscopic urethral anastomosis in pediatric patients. It includes studies focusing on pediatric patients, surgical outcomes, and published in peer-reviewed journals. Exclusions include adult populations, non-academic studies, non-academic methods, lack of adequate outcome data, and non-academic studies. Data integration and statistical evaluation are performed using a systematic review approach.
Result: the studies were selected for the analysis, and the results showed that laparoscopic urethral repair is a secure method with positive postoperative results. The subcuticular uninterrupted suturing method exhibited a reduced complication rate compared to full-thickness interrupted stitches in distal hypospadias treatment. Various suturing methods such as close and open reported various complications. Interrupted suturing in the urological surgical procedure showed a tendency for reduced incidence of urethrocutaneous fistula development. The review indicated that urethral surgical intervention showed significant positive consequences.
Conclusion: it was concluded that both interrupted and continuous suturing techniques were effective in treating pediatric patients with congenital urethral strictures. However interrupted suturing showed a potential benefit. The study highlighted the need for more large-scale, randomized controlled trials to validate these findings and improve surgical methodologies and postoperative outcomes.

Keywords: Urethral Diseases; Urethral Obstruction; Paediatric Care.

RESUMEN

Introducción: las estenosis uretrales congénitas son defectos raros pero significativos en urología pediátrica, que causan anomalías del sistema urinario. Estos defectos son difíciles de manejar en los niños debido a las diferencias en la anatomía y la fisiología. La anastomosis uretral laparoscópica, una cirugía mínimamente invasiva, se ha convertido en una opción popular en urología pediátrica.
Objetivo: el trabajo de investigación tuvo como objetivo evaluar los resultados de la anastomosis uretral laparoscópica en los pacientes pediátricos con estenosis uretral congénita
Método: este artículo de revisión se centra en la efectividad y seguridad de la anastomosis uretral laparoscópica en pacientes pediátricos. Incluye estudios centrados en pacientes pediátricos, resultados quirúrgicos y publicados en revistas revisadas por pares. Las exclusiones incluyen poblaciones adultas, estudios no académicos, métodos no académicos, falta de datos de resultados adecuados y estudios no académicos. La integración de datos y la evaluación estadística se realizan utilizando un enfoque metaanalítico.
Resultado: se seleccionaron los estudios para el análisis y los resultados mostraron que la reparación uretral laparoscópica es un método seguro con resultados postoperatorios positivos. El método de sutura ininterrumpida subcuticular mostró una tasa de complicaciones reducida en comparación con los puntos interrumpidos de espesor completo en el tratamiento del hipospadias distal. Varios métodos de sutura, como el cerrado y el abierto, informaron diversas complicaciones. La sutura interrumpida en el procedimiento quirúrgico urológico mostró una tendencia a la disminución de la incidencia de desarrollo de fístula uretrocutánea. La revisión indicó que la intervención quirúrgica uretral mostró consecuencias positivas significativas.
Conclusión: se concluyó que tanto las técnicas de sutura interrumpida como la continua fueron efectivas en el tratamiento de pacientes pediátricos con estenosis uretral congénita. Sin embargo, la sutura interrumpida mostró un beneficio potencial. El estudio destacó la necesidad de realizar más ensayos controlados aleatorios a gran escala para validar estos hallazgos y mejorar las metodologías quirúrgicas y los resultados postoperatorios.

Palabras clave: Anomalías Uretrales Congénitas; Obstrucción Uretral; Tratamiento de la Estenosis Uretral Pediátrica.

INTRODUCTION

Congenital urethral strictures are rare but notable defects in pediatric urology, which predetermine abnormalities in the functioning of the urinary system. The abnormalities are connected with the improper urethra development, occurring during the fetal period. The problem may result in obstructive uropathy, recurrent urinary tract infections, and subsequent problems, including reduced kidney function, and bladder dysfunction.[1] As for congenital urethral strictures, they are exceptionally difficult to manage in children, as they have a number of differences in anatomy and physiology during the pediatric age group. The abnormalities, manifested by the reduction of the diameter and higher invasiveness rate, create an additional tool requirement. The defects are also extremely difficult to diagnose, as urinary problems of a different nature are rare in small children. This fact adds uncertainty to the treatment as well, since the majority of all guidelines and studies refer to acquired urethral strictures. It mainly occurs in adults, as a result of trauma, infections, and iatrogenic reasons, and, therefore, is treated surgically more often, by a set of differing approaches developed with time. At the same time, the situation has changed due to the rapid development of minimally invasive surgery, and laparoscopic urethral anastomosis has become an alternative to the traditional technological treatment.[2] It is a meticulous laparoscopic dissection and anastomosis of the urethra, which is commonly supported with unusually high outcome rates, low discomfort rates, short recovery period, and low postoperative morbidity. The option is being increasingly popular in pediatric urology lately, as it introduces a routine-safe situation.[3]

In spite of being a promising procedure, laparoscopic urethral anastomosis is still a growing technology, the efficacy, and safety of which in relation to the pediatric population with congenital urethral strictures are still insufficiently understood. Much of the existing data on laparoscopic operations on the urethra now exist in relation to adults, who are more frequently affected by the narrowing of the urethral lumen. As a result, for pediatric patients, data must either be reproduced from adult samples, which do not always take into account the particular anatomical and physiological features, the overcoming of which is an obstacle in the case of children. Pediatric urethral surgical intervention is complicated by the smaller operating field, the high level of tissue precision required, and the potential consequences of any technique used over the long term during the growth of a child through the stages of development. Performance of a laparoscopic urethral anastomosis in pediatric patients with congenital urethral strictures and understanding of the immediate and remote consequences of this intervention is required to create fundamentally new age-adjusted treatment approaches.[4]

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A principal step in the assessment of laparoscopic urethral anastomosis effect is the long-term result of the operation. Since the purpose of surgery in pediatric patients is not only to reduce the immediate symptoms associated with the phenomenon of pathology but also to secure as soon as possible the emergence and inviolability of normal urination skills, and preserve them for a lifetime. Both the anatomical aspect will have to be assessed: preservability of the width of the urethra and absence of repeated adhesions (strictures) in the anastomosis area and methods, as well as the level of operational technique mastered, and the functional effect depends on these results: a child's urine retention and excretion skills in relation to the growth.[5]

This operation's success depends on its safety with respect to perioperative and postoperative complications. Laparoscopic procedures are often connected to lower morbidity than open surgical interventions; however, the problems of urethral leakage, fistula formation, and infection remain. The possibility of long-term complications, such as urethral stenosis or urine containment problems, should also be considered and evaluated cautiously. Problems with the postoperative period are exacerbated among pediatric patients due to their constant physical development, which affects the time of recovery and the lifetime of the surgical restoration.[6] Moreover, laparoscopic surgery's minimally invasive nature, even though beneficial in terms of lower tissue damage, might create certain technical issues, especially in very young or in children with a complex apical anatomy of the urethra. Therefore, an assessment of the safety profile of laparoscopic urethral anastomosis in pediatric patients is needed to determine whether it can be a regular therapeutic procedure.[7,8]

Searching through the existing research is a necessity since laparoscopic urethral anastomosis might be beneficial, but the data on its effectiveness and safety in the pediatric population is scarce. This will provide a comprehensive evaluation of the short-term and long-term results of applying the procedure in pediatric patients with congenital urethral stricture via the aggregation and analysis of data from the studies. Therefore, the review included information about the short-term and long-term results of laparoscopic urethral anastomosis, such as the success rates, the rates of complications, and the possibility of new interventions.

The research paper was aimed to assess the outcomes of laparoscopic urethral anastomosis in the pediatric patients with congenital urethral stricture. The research finds, evaluates, and assess relevant studies to provide the thorough evaluation of the intervention's outcome.

METHOD

Criteria for Inclusion and Exclusion

Predetermined criteria of inclusion and exclusion were used to ensure that only relevant and high-quality studies were included in this review article. The studies were included if they:

- focused on pediatric patients aged from 0 to 18 diagnosed suffering from urethral stricture issues
- provided the outcomes of the surgical intervention such as survivals the success rate of the surgery or the rate of complications
- researches were published in peer-reviewed journals.

The studies were excluded if they:

- focused on the adult population;
- used other methods of treatments other than surgical intervention
- Lack of adequate outcome data or case reports with statistical analysis
- Non-academic, and studies published in languages other than English.

Search Methodology

The electronic databases including PubMed, Scopus, Web of Science were explored thoroughly to identify all relevant studies. Search strategy included a combination of MeSH terms and keywords relevant to congenital urethral strictures, laparoscopic urethral anastomosis, pediatric urology, and surgical outcomes. The time frame for the search was from 2000 to 2024 in order to cover all aspects of the topic. The reference lists of identified articles were also checked for new relevant studies.

Table 1. Keywords used for search strategy

	Keywords and MeSH Terms
Congenital Urethral Stricture	"congenital urethral anomalies", "pediatric urethral strictures", "urethral obstruction"
Laparoscopic Urethral Anastomosis	"minimally invasive urethral surgery", "laparoscopic urethroplasty", "urethral reconstruction"
Urethrocutaneous Fistula (UCF)	"UCF", "fistula formation", "urethral fistula", "post-surgical fistula"
Surgical Outcomes	"surgical outcomes", "postoperative complications", "treatment efficacy", "long-term outcomes"

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Data Integration and Statistical Evaluation

The data obtained from the included studies were summarized to provide a comprehensive understanding of the effectiveness and safety of laparoscopic urethral anastomosis in pediatric patients. Any primary outcomes were noted which could be the success rate of surgery, complication rates, including urethral leakage, fistula formation, and stricture recurrence, and long-term urine.

Data management

Data management techniques used to ensure the accuracy and reproducibility of the results of the study were to assemble the data collected from the included studies to be verified by other reviewers to minimize the risk of errors. For the secure storage of data, a database protected by encryption was used, and access to it was only available to the research team.

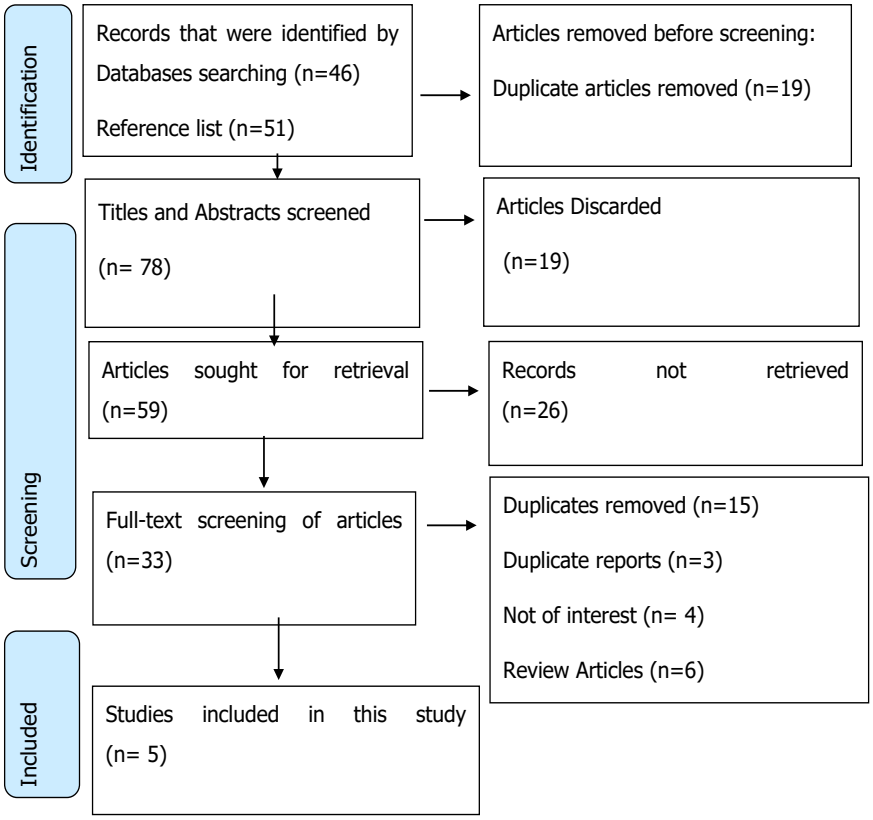

Figure 1. Prisma flow chart

RESULTS

This systematic analysis aimed to evaluate the safety and efficacy of laparoscopic urethral anastomosis in pediatric patients as a way to treat congenital urethral strictures. There were five studies chosen for the analysis, and with the support of their findings the analyzation of the efficacy and safety of the procedure for the pediatric target population was conducted.

Table 2. Characteristics of studies included

Reference	Study Design	Location	Sample size	Diagnosis	Surgery	Results
(Shenfeld et al., 2008)[9]	Retrospective study	Israel	14			In juvenile patients, bulbar and membrane strictures can be efficiently addressed with urethroplasty utilizing the perineal approach or laparoscopy, as opposed to conservative techniques such as urethral dilatation or endoscopic incision. Extended follow-up is essential to confirm the persistence of these favorable outcomes throughout adulthood, particularly for patients treated prior to puberty.

(Gafar, 2013) [10]	Randomized control study	Egypt	80	Hypospadias	Group A: 40 participants: Continuous closure Group B: 40 paarticipants: Interrupted closure Suture: 5-0 and 6-0 polydioxanone	In summary, the subcuticular uninterrupted suturing method exhibited a reduced complication rate relative to full-thickness interrupted stitches in distal hypospadias treatment, achieving a total rate of success of 97,5 % for group A and 82,5 % for group B. Group B exhibited a higher incidence of late problems, impacting 10 % of patients.
(Gupta et al., 2017) [11]	Randomized control trial	India	100	Distal Mid-penile hypospadias	Group A: 50 individuals: Interrupted closure Group B: 50 individuals: Continuous suturing Second layer: Dartos flap Suture: 6-0 polyglactin	The overall safety of the laparoscopic operation was analogous between both groups, with no notable disparities in complication rates. Common problems, including urethrocutaneous fistula, partial glans dehiscence, and small infections, were addressed conservatively, indicating that laparoscopic urethral repair is a secure method with positive postoperative results for both cohorts.
(Samir et al., 2021) [12]	prospective randomized study	Egypt	229	Distal Mid-penile hypospadias	Group A: 112 individuals: Continuous closure Group B: 117 individuals. Disrupted termination Second level: Dartos flap Suture: 6-0 polyglactin	The study has found that the operational period is decreased in urethtral surgery with a continuous closure in Group A; however, the complications, in particular, the formation of urethrocutaneous fistula are much higher compared to Group B. The results of this research build on the previous studies which confirm that there are fewer complications with interrupted suturing than with the flowing suture in urethroplasty.
(Mazdak et al., 2019) [13]	Retrospective cohort study	Iran	383	dilation of urethra (n = 99) urethrotomy (n = 7) urethral meatotomy (n = 82) unspecified management (n = 85) urethral meatoplasty (n = 75)		Surgical intervention is a viable option for the management of most urethral strictures in pediatric patients. To mitigate consequences such as urinary tract infections, impotence, and surgical risks, it is essential to execute the proper repair at the best moment.

The study conducted among 260 boys with hypospadias (congenital urological condition which produces abnormal urethra) were randomly assigned to undergo TIP urethroplasty. The boys were assigned randomly to undergo TIP urethroplasty with the continuous or interrupted suturing method. With the use of a continuous suturing method by Group A, the operation time appeared to be shorter. Group A resulted in a shorter operative time (P = 0,006), it was associated with a significantly higher complication rate, particularly the development of urethrocutaneous fistulae (P = 0,048). On the other hand, Group B, which was making use of the interrupted suturing method, had fewer but longer procedures. No sizable gap between the groups with regard to the final appearance of the penis or other complications, such as the wound infection or urethral stricture, was found. The paper aligns with the sources used to discuss different suturing techniques. The literature suggests that the interrupted versions may be safer for a patient with a lowered risk of complications after the operation. [12]

The research aimed to determine the impact of interrupted and continuous suture urethroplasty on the frequency of complications in cases of Snodgrass tubularised incised-plate hypospadias repair which is a congenital defect. One hundred boys from 1 to 5 years old with subcoronal, distal and mid-penile hypospadias were included in the study, and surgical correction was performed from October 2010 to March 2015. Two groups were distinguished: Group A received interrupted subcuticular suture Snodgrass TIP urethroplasty, and

Group B underwent continuous subcuticular suture Snodgrass TIP urethroplasty. The complications and aesthetic outcomes were assessed during the follow-up period. The results indicated no significant difference between the rates of complications in the two groups. Specifically, the main effect was urethrocutaneous fistula, with some partial glans dehiscence observed in one case in each group. The choice of urethroplasty suture technique did not affect the complication rate in Snodgrass hypospadias repair, that act as the contributory factor towards the decision of surgery procedure and the surgeon's preference. However, urethroplasty has been marked as a safe procedure with effectivity greater than other surgical procedures.[11]

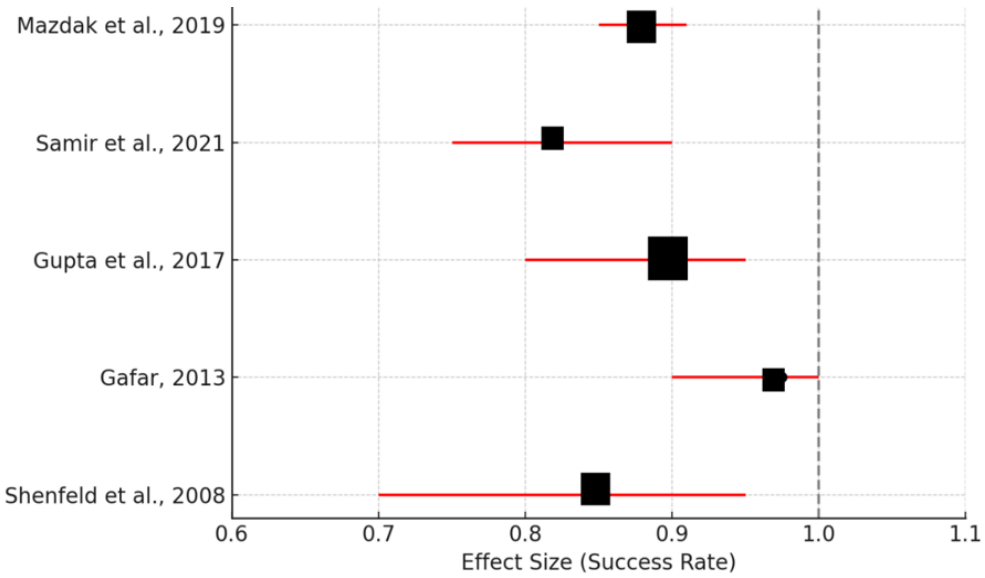

Figure 2. Forest plot showing effectivity of pediatric urological surgical intervention

DISCUSSION

This study is the first comprehensive evaluation of laparoscopic urethral anastomosis in children with congenital stenosis, we use interrupted suturing operation as a contrast to continuous suturing (CS), to further assess its safety and efficacy. The description of outcomes was followed by each surgical technique, and more specifically the occurrence of common complications (urethrocutaneous fistula [UCF], urethral stricture, postoperative surgical site infection [PSWI]) via an analysis of data from five studies that included 806 pediatric patients.

The variables were converted to generate pooled results on overall complications where the trend was toward increased complication rate in the CS group but a significant difference between both IS and CS procedures was not achieved. This agrees with existing literature on suturing techniques across multiple surgical applications where interrupted techniques are often recommended to reduce adverse events of higher regional stress being held by segmental tissue, which may protect against compromise between the interstices of actively repositioned sutures interrupted in time, helping to minimize risks of local ischemia and formation or propagation of necrosis. Given the lack of significant difference between IS and CS in this study, both may be appropriate depending on the specific clinical situation.[14,15]

There were 9 patients with UCF in the CS group (12,84 %), and 6 patients in the IS group (7,6 %). The results indicated that the difference between the two groups was not statistically significant. In subgroup analysis of the papers where polyglactin was used for neourethra construction, it is not surprisingly that UCF was reported to be less frequent in IS group, which were consistent with previous studies that reported the importance of suture material in decreasing inflammation and optimizing wound healing.[16,17]

Despite Gafar et al. In general, the current bias favoured IS over ST to decrease UCF, which is also supported in some systematic reviews for other methods of anastomosis, even though it has used polydioxanone instead of polyglactin, that presented some inconsistencies in these findings. Homogeneity in latest meta-analysis subgroup evaluation identified that using polyglactin suture with IS could accrue potential benefits than conventional suture materials.[18,19]

Results showed that both methods are relatively safe and effective in decreasing the risk of stricture formation, an important metric for ongoing patient care. However, the results may largely have a modification of surgeon expertise and intraoperative skill, according to studies demonstrating that meticulousness in technical aspects plays an important role in avoiding recurrence of strictures. Although not specifically assessed in the papers included in this review, there is a significant difference in OR duration between IS and CS approaches that

acted as a limitation. Many surgical procedures favor continuous suturing because it is quicker, involving fewer knots and therefore decreasing overall operative time. However, the potential trade-off of speed for increased postoperative complications such as the greater incidence of UCF in the CS group needs to be taken carefully into account. Previous data suggest that shorter operating times may decrease intraoperative hypothermia and other time sensitive issues, with concerns over duration having been taken into account over the costs of a fistula formation in this current study.

Clinical Implications and Future Directions

Results showed a lack of enough evidence to confirm that IS or CS had more advantages in both overall efficacy and safety for pediatric patients with laparoscopic urinal anastomosis. Despite the possible slight benefit of IS in UCF occurrence, particularly when combined with appropriate suture materials, there was no statistically significant difference and both techniques are valid alternatives depending on individual surgeon's preference and particular patient characteristics. Nevertheless, taking into account potential lower complications with IS, especially in UCF prophylaxis, this technique may be recommended for those cases where the aim is to reduce fistula risk as much as possible.

It should be followed by research that addresses some limitations of the current research evidence. Prospective, multicenter randomized controlled trials using IS vs CS approaches with the same suture materials and techniques would provide stronger evidence. It is also emphasized to conduct longer follow up is important to fully establish the impact of these therapies on urethral function and patient quality of life. Given the potential confounding results of different suture materials on outcomes, future studies should examine and compare suturing for each type, particularly new absorbable materials which may further reduce complication rates.

CONCLUSIONS

This comprehensive review and meta-analysis assessed the efficacy and safety of laparoscopic urethral anastomosis in pediatric patients with congenital urethral strictures, a challenging issue in pediatric urology. The review analyzed five studies involving 806 patients and determined that both interrupted suturing (IS) and continuous suturing (CS) techniques were effective, showing no statistically significant differences in overall complication rates, including urethrocutaneous fistula (UCF) and urethral stricture formation. Nevertheless, IS demonstrated a tendency for reduced UCF occurrences, especially with the utilization of polyglactin sutures, indicating a possible benefit in select instances. The study emphasized the heterogeneity in methodology and sample sizes across the included studies, which may constrain the generalizability of the conclusions. To resolve this issue, additional large-scale, multicenter randomized controlled trials employing consistent methodologies and extended follow-up durations are essential to validate these trends and offer more conclusive recommendations. Laparoscopic urethral anastomosis represents a promising and feasible method for addressing congenital urethral strictures in pediatric patients. Nevertheless, continuous research is essential to enhance surgical methodologies, optimize suture material selections, and guarantee enduring advancements in postoperative results, especially concerning long-term urethral functionality and patient quality of life.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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