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Review – Stone Disease

Role of Pediatric Ureteral Access Sheath and Outcomes Related to Flexible Ureteroscopy and Laser Stone Fragmentation: A Systematic Review of Literature

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Abstract

Context: Flexible ureteroscopy and laser lithotripsy (FURSL) represent a good treatment option for pediatric urolithiasis. Scarce evidence is available about the safety and efficacy of the concomitant use of a ureteral access sheath (UAS) in the setting of pediatric ureteroscopy (URS).
Objective: To acquire all the available evidence on UAS usage in pediatric FURSL, focusing on intra- and postoperative complications and stone-free rates (SFRs).
Evidence acquisition: We performed a systematic literature research using PubMed/MEDLINE, Embase, and Scopus databases. The inclusion criteria were cohorts of pediatric patients <18 yr old, submitted to URS for FURSL, reporting on more than ten cases of UAS placement. The primary outcomes were prestenting rates, operating time, ureteric stent placement rates after surgery, rates and grades of complications, ureteral injuries, and overall SFR. A total of 22 articles were selected.
Evidence synthesis: In total, 26 intraoperative and 130 postoperative complications following URS with UAS placement were reported (1.8% and 9.18% of the overall procedures, respectively). According to the Clavien-Dindo classification, 32 were classified as Clavien I, 29 as Clavien II, 43 as Clavien I or II, six as Clavien III, and one as Clavien IV. Twenty-one cases of ureteral injuries (1.59%) were noted in the whole cohort; most of them were ureteral perforation or extravasation, and were treated with a temporary indwelling ureteric stent. The overall SFR after a single URS procedure was 76.92%; after at least a second procedure, it was 84.9%.
Conclusions: FURSL is a safe and effective treatment option for pediatric urolithiasis. UAS use was associated with a low rate of ureteric injuries, mostly treated and resolved with a temporary indwelling ureteric stent.
Patient summary: We performed a systematic literature research on the utilization of a UAS during ureteroscopy for stone treatment in pediatric patients. We assessed

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the outcomes related to the rates of intra- and postoperative complications and the rates of efficacy of the procedure in the clearance of stones. The evidence shows a low rate and grade of complications associated with UAS placement and good stone-free outcomes. A ureteric injury may occur in 1.6% of cases, but it is usually managed and resolved with a temporary indwelling ureteric stent.

1. Introduction

Pediatric urolithiasis is an emerging issue among urological practice. Its incidence has risen over the past decades in Europe and North America [1–4], and consequently, its overall economic burden on both the emergency department and inpatient admissions [5]. Metabolic abnormalities that increase the risk of nephrolithiasis, especially hypercalciuria and hypocitraturia, can be identified in 75–84% of pediatric patients [6]. Anatomic or structural defects, such as pelvic-ureteric junction obstruction, are the most common predisposition to pediatric urolithiasis. Despite this, most patients with these abnormalities will not face stone formation, suggesting a more complex and multifactorial process involving genetic, dietary, and environmental factors [7].

As regards treatment, according to European Association of Urology (EAU) guidelines, shockwave lithotripsy (SWL) still represents the first choice for most pediatric renal stones, while percutaneous nephrolithotomy (PCNL) should be reserved for larger and complex stones [8]. However, the uptake of ureteroscopy (URS) as a safe and highly effective option in the pediatric population has markedly increased due to advancements related to optic systems, miniaturized equipment, and surgeon expertise [9]. Nowadays, flexible URS and laser lithotripsy (FURSL) in the management of pediatric renal stones allows surgeons to deal with stones safely and effectively even in lower pole location and in children from the age of 3 mo [10].

The use of a ureteral access sheath (UAS) during FURSL in the adult population is well established. The most relevant advantages in using a UAS are repeated entrance into the ureter and collecting system, lower intrapelvic pressure, as well as protection to both the ureteroscope and the ureter when extracting stone fragments [11]. Moreover, a UAS allows better visibility and decreased risks of postoperative sepsis and bleeding. However, little evidence is available regarding the utilization of a UAS in the setting of pediatric URS, and concerns have been raised on the risks of ureteral injuries, tissue ischemia related to overdilation, and risk of ureteric stricture.

The aim of this systematic review was to acquire all the available and most up-to-date evidence on UAS placement in pediatric FURSL, focusing on its outcomes such as peri- and postoperative complications and overall stone-free rate (SFR).

2. Evidence acquisition

We searched PubMed/MEDLINE, Embase, and Scopus databases following the Preferred Reporting of Systematic Reviews and Meta-analyses (PRISMA) guidelines [12]. Search terms included the following: "paediatric/pediatric kidney stones," "paediatric/pediatric stones," "paediatric/pediatric urolithiasis," "ureteral access sheath," "UAS," "ureteric access sheath," "URS," "retrograde intrarenal surgery," "RIRS," and "ureteroscopy." The references of identified studies were examined to find any further potential studies for inclusion. Boolean operators (AND, OR) were employed. The research was limited to English-language articles without any restriction on the publishing year.

The inclusion criteria were as follows:

1. Cohorts of pediatric patients <18 yr old
2. Submitted to URS for FURSL
3. Studies reporting on more than ten cases of UAS placement

Patient characteristics, and intra- and postoperative variables were described. The primary outcomes were prestenting rates, operating time, ureteric stent placement after surgery, rates and grades of complications, ureteral injuries, and overall SFR. No randomized controlled trial (RCT) compared pediatric URS with versus without UAS placement. As the outcome measures and reporting were not standardized, a formal meta-analysis could not be performed.

3. Evidence synthesis

The literature search provided 468 results. After removing duplicates, a total of 202 abstracts were considered for eligibility. Review articles and conference abstracts were excluded from the analysis. Eventually, 48 full-text articles were assessed. Among these, five articles did not meet the inclusion criteria, eight were excluded because a UAS was not used during URS, seven did not specify the rate of UAS placement in the cohort of procedures, and six had a case series with fewer than ten patients. In the end, we selected 22 articles for our analysis (Table 1 and Fig. 1). All manuscripts were published between 2007 and 2022.

3.1. *Patients characteristics*

Overall, 1317 patients (693 males and 624 females) were included, and 1416 ureteroscopies with UAS placement were performed. Some patient cohorts were relatively small (eight patients with cystinuria submitted to multiple procedures [13]); conversely, one article gathered data from eight different centers globally in a multicentric study [14], collecting data from 314 pediatric patients. Two articles showed outcomes from large cohorts of patients in tertiary endourological referral centers (167 patients and 170 URS procedures

Table 1 – Descriptive characteristics of the studies included in the analysis

Author	Year	Patients (*n*)	Procedures (*n*)	Age, mean (range)	Age limit (yr)	Gender, *n* (%)	Stone size (mm), mean (range)	Operating time (min), mean (range)	Prestenting, *n* (%)
Quiroz Madarriaga [13]	2022	8	22	9.5 (4–18)	18	M 7 (87.5); F 1 (12.5)	7.7 (5–18)	120 (100–300)	5 (62.5)
Lim [14]	2022	314	314	9.54 (0.42–16)	18	M 185 (58.9); F 128 (41.1)	10.7 (8–12)	60 (45–90)	155 (49.4)
Ferretti [21]	2021	28	40	8 (2–16)	16	M 19 (67.8); F 9 (32.2)	9.5 (5–24)	77.7 (20–140)	17 (56.6)
Kahraman [34]	2021	46	46	5.87 (0.5–17.8)	17	M 29 (63); F 17 (37)	8.5 (3–20)	60 (45–120)	21 (45.6)
Chandramohan [19]	2021	62	67	3.51 (0.3–5)	5	M 40 (64.5); F 22 (35.5)	11.9 (7.3–18.2)	55.2 (36.4–80.5)	62 (100)
Mosquera [26]	2021	48	48	10.72 (1.1–16.9)	16	M 24 (50); F 24 (50)	10.41 (3–20)	NA	20 (41.7)
Ozkent [31]	2021	55	55	7.2 (0.6–17)	17	M 28 (50.9); F 27 (49.1)	13.9 (7.3–20.5)	61.8 (39.5–84.1)	29 (52.7)
Aljumaiah [22]	2020	14	15	9.5 (9–17)	17	M 9 (64.3); F 5 (35.7)	12.5 (10–20)	55.7 (24–120)	NA
Jones [16]	2020	81	102	8.8 (1.5–16)	16	M 39 (47); F 43 (53)	11.5 (4–46)	NA	35 (34.7)
Jones [33]	2020	55	55	9.3 (2–16)	16	M 26 (47); F 29 (53)	11.4 (5–46)	NA	NA
Sforza [32]	2020	15	15	11.8 (8–16)	NA	M 8 (53.3); F 7 (46.7)	9.48 (8.9–12)	70 (60–80)	8 (53.3)
Anbarasan [20]	2019	21	21	11.8 (2–16)	16	M 10 (48); F 11 (52)	15.4 (5–30)	NA	8 (38)
Berrettini [18]	2018	13	16	3.91 (0.75–6.5)	6	M 5 (38); F 8 (62)	15.5 (9–23)	98.2 (16–75)	16 (100)
Yuruk [24]	2017	14	14	10.9 (7–15)	NA	M 8 (57.1); F 6 (42.8)	13.6 (10–18)	38.2 (30–50)	1 (7.1)
Featherstone [25]	2017	18	35	10.4 (3.6–15)	NA	M 7 (39); F 11 (61)	13.3 (10–25)	NA	1 (5.5)
Erkurt [17]	2014	65	65	4.31 (0.5–7)	7	M 31(48); F 34 (52)	14.66 (7–30)	46.47 (20–95)	17 (26.1)
Wang [27]	2011	96	96	13 (1.5–20.9)	NA	M 34 (35); F 62 (65)	9.6 (0.8–54)	92 (23–218)	26 (27)
Yeow [23]	2009	26	26	8.2 (0.25–15)	NA	M 14 (54); F 12 (46)	10.3 (3–21)	NA	25 (96.1)
Tanaka [30]	2008	50	52	7.9 (1.2–13.6)	14	M 31 (62); F 19 (38)	8 (1–16)	NA	29 (56)
Kim [15]	2008	167	170	5.2 (0.25–18.1)	18	M 89 (53.3); F 78 (46.7)	6.12 (3–24)	107 (72–196)	95 (57)
Cannon [28]	2007	21	27	15.1 (1–20)	NA	M 8 (38); F 13 (62)	12.2 (6.3–18.1)	NA	8 (38)
Smaldone [29]	2007	100	115	13.2 (7.8–18.6)	NA	M 42 (42); F 58 (58)	8.3 (2.7–13.9)	NA	54 (54)

F = female; M = male; NA = not available.

[15], and 81 patients and 102 URS procedures [16]). The mean age of patients was 8.9 yr. Most of the included studies set 18 yr as the age limit; three studies analyzed the outcomes and feasibility of URS in preschool children (Erkurt et al. [17] in children aged <7 yr, Berrettini et al. [18] in preschool children weighing <20 kg, and Chandramohan et al. [19] in patients <5 yr old). The pediatric population accounted for 693 males (52.6%) and 624 females (47.4%). The mean stone size was 11.1 mm across studies; it exceeded 15 mm in two studies [18,20] only. Stone size was usually defined as the largest linear diameter of a single stone or the sum of long axes in the case of multiple stones. Ferretti et al. [21] specified stone length range and stone surface area; others [22] subclassified stone burden in <10, 10–20, and >20 mm. There was great heterogeneity among studies regarding diagnostic investigations, with most groups using ultrasound for kidney, ureter, and bladder or x-rays, and occasional low-dose non-contrast computed tomography.

3.2. *Prestenting rates*

We report no broad agreement on the opportunity of prestenting in the setting of pediatric URS among the selected studies. Indeed, the mean rate of prestented patients was 50%, reflecting different clinical practices in the management of pediatric URS. Two groups [18,19] treating patients <5 yr old put a JJ stent in 100% of patients and one group [23] in 96.1% of patients. This action was performed 12 or 14 d before the procedure to obtain a passive dilatation of the ureter. On the contrary, a preoperative JJ stent was placed only in one out of 14 (7.1%) patients by Yuruk et al. [24] and in one out of 18 (5.5%) patients by Featherstone et al. [25], due to obstruction and urosepsis before the surgical treatment.

3.3. *UAS placement rates, calibers, and lengths*

Overall, a UAS was placed in 603 procedures in the cohort of selected studies (Table 2). Anbarasan et al. [20] analyzed a whole group of patients (21) who underwent FURSL with an access sheath; Mosquera et al. [26] reported one of the largest UAS cohorts in pediatric patients carried out in two high-volume endourology centers, including 48 cases. Most groups used a 9.5 or 11.5 Fr UAS (three used 9.5 Fr UAS, three 11–9.5 Fr UAS, seven 11.5–9.5 UAS, and one 10–12 Fr UAS). Seven groups [13–15,23,27–29] used different caliber access sheaths, depending on the surgeon's choice, with calibers varying from 8 to 15 Fr. One study [30] did not report UAS caliber. UAS length was specified only in nine out of 22 studies, with four groups using a 35 cm UAS [13,20,22,31], two using either a 20 or a 28 cm UAS [21,32], one using a 28 cm UAS only [19], one using either a 20 or a 35 cm UAS [18], and one using either a 28 or a 35 cm UAS [24].

3.4. *Postoperative stent placement*

Eighteen articles reported data on the postoperative placement of a ureteric stent. Great heterogeneity emerged, with three groups [18,19,32] choosing to insert a stent in every patient (either a ureteral catheter or a JJ stent) and two groups [13,30] in >90% of patients, compared with three groups [15,31,33] that put a stent in <50% of patients. Four studies [14,17,23,34] did not report data on postoperative stent placement. Stent removal was achieved after a mean of 21.5 d, with most of the groups leaving it for 10–14 d [15,18,19,21,23], others for 21–28 d [13,24,32] or up to 6–8 wk [16,20].

3.5. *Complication rates*

Regarding surgical complications, a total of 26 intraoperative and 130 postoperative complications were reported among the 22 selected articles, accounting for 1.8% and 9.18% of the overall procedures, respectively. Intraoperative complications included: rupture of the laser fiber during lithotripsy, intrarenal bleeding, ureteral injury [13], pelvicalyceal system

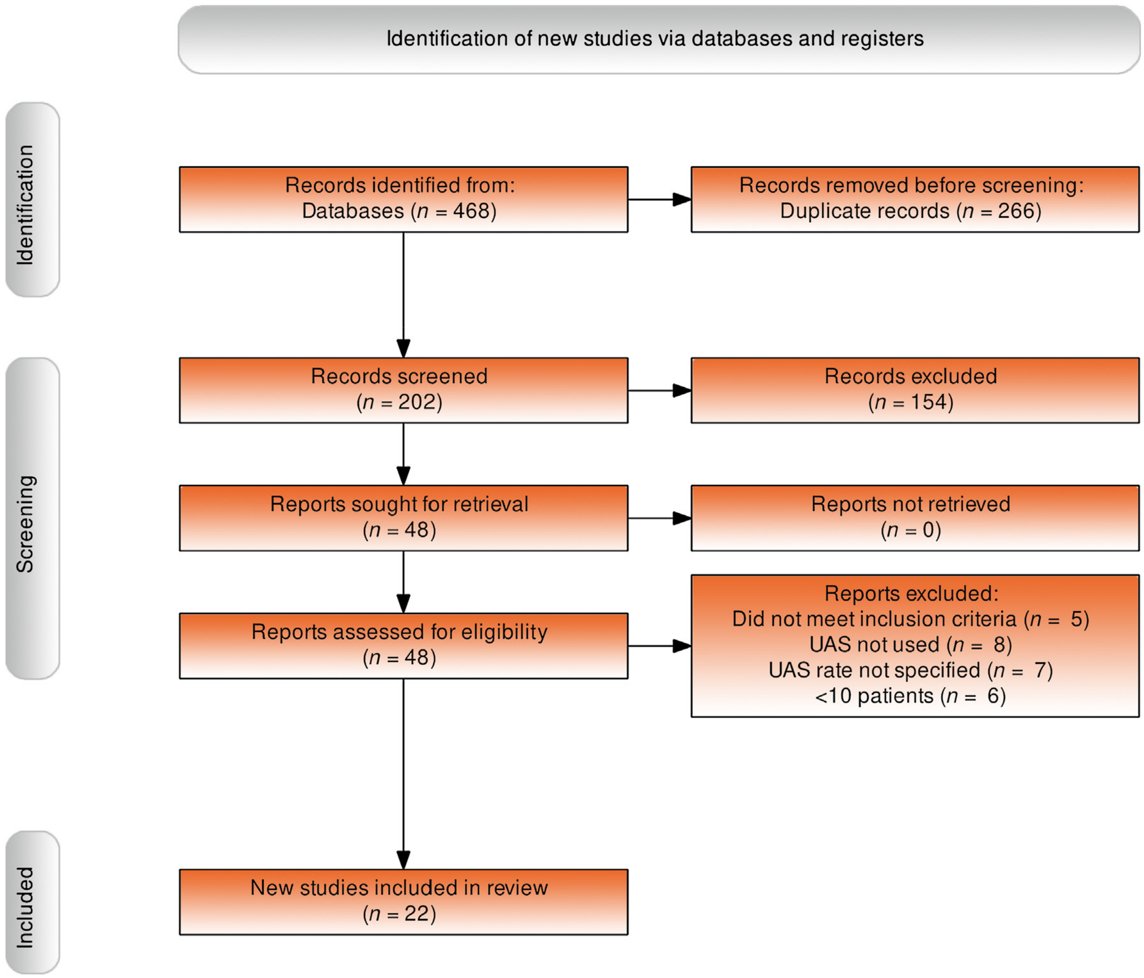

Fig. 1 – PRISMA flowchart of the included studies. PRISMA = Preferred Reporting of Systematic Reviews and Meta-analyses; UAS = ureteral access sheath.

or ureteric injury [14], ureteric damage [19], ureteral perforation with extravasation, submucosal wire, and proximal stent migration [27], and one case of distal ureteral stricture requiring ureteral reimplantation [29]. Postoperative complications reported were the following: fever, obstructive pyelonephritis [13], hematuria [17,18,32], sepsis [14,16], vomiting, urinary tract infection [17,18,21,26], pain, urinary retention [16], hydrocalyx [18], ureteral wall injury [17], postoperative hydronephrosis [27], voiding symptoms, and rehospitalization [30]. Six studies reported no postoperative complications [15,20,22,23,25,28].

3.6. *Complication types*

Twelve articles reported surgical complications according to the Clavien-Dindo classification [35]. Thirty-two complications were classified as Clavien I, 29 as Clavien II, and 43 as Clavien I or II. One patient with obstructive pyelonephritis that required nephrostomy placement was classified as having IIIa [13] and two patients with ureteral wall injuries were classified as having III complications [17]; two cases in the cohort of Chandramohan et al. [19] (IIIb) were readmitted with pain and fever due to ureteric stone fragments and required URS for the clearance of *steinstrasse*. One hydrocalyx surgical correction [18] was considered Clavien IIIb. Finally, one case of postoperative sepsis requiring admission to the intensive care unit [16] was classified as having Clavien IV.

3.7. *Ureteral injuries*

Twenty-one cases of ureteral injuries (1.59%) were noted in the whole cohort of pediatric patients. Smaldone et al. [29] reported five cases of ureteral perforation or extravasation during surgical procedures treated with ureteric stent placement and one case of distal ureteral stricture requiring subsequent ureteral reimplantation. Wang et al. [27] observed four ureteral perforations with extravasation; 85.7% of these intraoperative complications occurred in the group of patients with UAS use. Erkurt et al. [17] noted two ureteral wall injuries, treated with stent insertion. One grade 1 intraoperative ureteral laceration was assessed by Yuruk et al. [24] during a procedure carried out with a UAS. One grade 1 ureteric lesion was detected in the cohort of Mosquera et al. [26] and described using the classification for ureteric injuries provided by Traxer and Thomas [36]. This classification was also applied in the study by Chandramohan et al. [19] to one case of grade 1 (mucosal damage) and one case of grade 2 (submucosal damage) ureteric injuries during URS with UAS placement; both

Table 2 – Intra- and postoperative outcomes of stone treatment and UAS placement

Author	Patients (*n*)	UAS *n* (%)	UAS caliber (%)	UAS length (cm)	DJ placement, *n* (%)	Intraoperative complications *n* (%)	Postoperative complication rate, *n* (%)	Clavien-Dindo grade (*n*)	Ureteral injuries, *n* (%)	Ureteral injuries connected to UAS	SFR I (%)	SFR II (%)
Quiroz Madarriaga [13]	8	15 (68)	10–12 Fr (60); 12–14 Fr (40)	35	7 (90.9)	4 (18.2)	6 (27)	II (5); IIIa (1)	1 (0.04)	NA	59.00	
Lim [14]	314	171 (54.5)	>8 Fr (78)	NA	NA	5 (0.02)	43 (13.7)	I–II (43)	5 (1.6)	NA	75.40	
Ferretti [21]	28	12 (50)	9.5 Fr	20/28	37 (75.5)	NA	4 (10.8)	I (2); II (2)	NA	NA	76.60	93.30
Kahraman [34]	46	16 (34.8)	11–9.5 Fr	NA	NA	NA	2 (4.3)	I (2)	0	0	61.00	
Chandramohan [19]	62	40 (63.5)	11.5–9.5 Fr	28	67 (100)	2 (3)	24 (38)	I (18); II (2); IIIb (4)	2 (1 grade I; 1 grade II)	2/2 (100%)	76.30	
Mosquera [26]	48	48 (100)	11.5–9.5 Fr	NA	27 (56.3)	NA	1 (2.1)	II (1)	1 (2.1, grade I)	1/1 (100%)	66.60	100.00
Ozkent [31]	55	19 (34.5)	11–9.5 Fr	35	23 (41.8)	1 (1.8)	9 (16.3)	NA	NA	NA	81.80	
Aljumaiah [22]	14	14 (100)	10–12 Fr	35	14 (100)	0	0	NA	0	0	78.60	
Jones [16]	81	21 (20.5)	11.5–9.5 Fr	NA	61 (60)	0	3 (3)	I (1); II (1); IV (1)	0	0	73.00	99.00
Jones [33]	55	15 (27)	11.5–9.5 Fr	NA	24 (44)	NA	3 (5.4)	II (2); IV (1)	0	0	85.00	100.00
Sforza [32]	15	15 (100)	9.5 Fr	20/28	15 (100)	NA	2 (13.3)	II (2)	0	0	86.70	
Anbarasan [20]	21	21 (100)	11–9.5 Fr	35	14 (67)	0	0	NA	0	0	95.00	
Berrettini [18]	13	15 (93.8)	11.5–9.5 Fr	20/35	16 (100)	NA	6 (37.5)	I (3); II (2); IIIb (1)	0	0	81.30	
Yuruk [24]	14	12 (85.7)	11.5–9.5 Fr	28/35	12 (85.7)	1 (7.1)	1 (7.1)	II (2)	1 (7.1, grade I)	1/1 (100%)	100.00	
Featherstone [25]	18	17 (49)	9.5 Fr	NA	21 (60)	0	0	NA	0	0	33.30	89.00
Erkurt [17]	65	40 (61.5)	11.5–9.5 Fr	NA	NA	NA	18 (27.7)	I (6); II (10); III (2)	2 (3)	NA	87.07	92.30
Wang [27]	96	40 (42)	11–13 Fr (37); 12–14 Fr (52); 13–15 Fr (11)	NA	75 (78)	7 (7.3)	7 (7.3)	NA	4	6/7 (85.7%)	70.00	
Yeow [23]	26	12 (46.2)	11.5–9.5 Fr/12–10 Fr	NA	NA	0	0	NA	0	0	88.50	
Tanaka [30]	50	25 (48)	NA	NA	51 (98)	0	1 (1.9)	NA	0	0	50.00	58.00
Kim [15]	167	NA	9.5 Fr/10 Fr	NA	72 (42.4)	0	0	NA	0	0	100.00	
Cannon [28]	21	11 (43)	12 Fr/9.5 Fr	NA	15 (71)	0	0	NA	0	0	76.00	
Smaldone [29]	100	24 (24)	11–9.5 Fr (14); 14–12 Fr (10)	NA	76 (76)	6 (5.2)	NA	NA	5	NA	91.00	

NA = not available; SFR I = stone-free rate after first ureteroscopy; SFR II = stone-free rate after >1 ureteroscopy; UAS = ureteral access sheath.

these patients required prolonged stenting for 4 wk. Lim et al. [14], in their global study of 314 pediatric patients from eight centers, reported five ureteric injuries (1.6%, three in the cohort of patients <5 yr old and two in the group of patients >10 yr old) and five cases of pelvicalyceal system injury (1.6%), all of them in patients <5 yr old. These were all noted postoperatively on retrograde pyelography and managed with a postoperative stent. Authors hypothesized that they might be explained by the minimal pelvicalyceal space of these younger patients. Finally, one grade 2 ureteral injury was reported in a cohort of eight cystinuric patients [13].

3.8. Stone-free rates

SFRs were evaluated in all the studies included in the analysis, even though significant heterogeneity emerged regarding follow-up timing schemes and diagnostic means. The definition of stone-free status varied among the studies. The overall SFR after a single URS procedure was 76.92%; after the second procedure, it went up to a mean of 84.9%. Six articles [16,17,21,25,26,33] reported an SFR after a first and at least a second session of URS. These results are concordant with reported outcomes varying from 84% to 100% after a single ureteroscopic procedure [10,37,38].

3.9. Discussion

One of the first applications of UAS in a pediatric cohort for the management of renal and ureteral stones was described by Singh et al. [39] on eight patients with a mean age of 9.3 yr. The authors did not report any ureteral perforation or stricture, with a mean follow-up of 10 mo. However, only a few studies on relatively small cohorts exist investigating the role of the UAS placement in endoscopic treatment of pediatric renal stones. This is due to persistent concerns about the potential risk of intra- and postoperative complications associated with it, even though its high efficiency, minimal invasiveness, and repeatability are increasingly recognized [40]. Studies focusing on analyzing the outcomes of UAS placement reported different conclusions. In the whole cohort including 1417 cases of pediatric URS with UAS placement, we reported 26 intraoperative and 130 postoperative complications, accounting for 1.8% and 9.18% of the overall procedures, respectively. Nevertheless, the use of a UAS did not cause any significant short- or long-term complication, as reported by the majority of these groups [18,20,22,26,39].

Treatment of pediatric stone includes a wide range of therapeutic options that should be evaluated and tailored to single patient needs. The goals of intervention in the pediatric population should always be to achieve a high SFR, preservation of renal function with minimally invasive approaches, and prevention of recurrence. Recent advancements in equipment technology and miniaturization, and the broader availability and application of holmium YAG laser to lithotripsy have rendered URS a valuable and attractive treatment modality in pediatric urolithiasis since its first description in 1988 by Ritchey et al. [41]. URS can be proposed as first-line therapy in most pediatric cases, particularly with associated ureteral stones or lower pole stones present, or in patients with cystinuria, who are less likely to benefit from SWL treatment [42].

Despite this, EAU guidelines on pediatric urology [8] still present SWL as the first choice for treating most pediatric renal stones, although addressing concerns about SFRs and retreatment rates, both affected by the stone size, localization, type of lithotripter used, and Hounsfield units of the stone. Indeed, SWL often results in the need for multiple sessions of treatment, which in turn, require additional general anesthesia and extra radiation exposure. Therefore, PCNL is a better treatment option for larger and more complex stones, especially >20 mm in the renal pelvis or >10 mm in lower pole locations. PCNL is considered safe and effective in pediatric patients, with reported SFRs between 86.9% and 98.5% after a single session. However, it represents an invasive procedure that could result in significant complications, mostly bleeding, postoperative fever or infection, and persistent urinary leakage, thus exposing patients to the risk of blood transfusions, renal parenchymal loss, and longer inpatient stays. In this scenario, pediatric URS has been demonstrated to offer lower morbidity than PCNL and higher SFRs than SWL. Despite its minimally invasive nature, retrograde intrarenal surgery (RIRS) is not exempt from complications, even though in the cohorts analyzed, they were mostly low grade and transient [9,42].

The use of UAS in the adult population has been well established: when placed into the proximal ureter or renal pelvis, it allows a safe, easy, and efficient passage of the flexible ureteroscope back and forth into the kidney. Therefore, using a UAS results in decreased operative time, costs, and morbidities related to ureteral injuries due to the ureteroscope [43]. A decrease in renal pelvic pressure during URS is considered one of the most beneficial effects of UAS placement, resulting in a reduced risk of postoperative septic complications in the treatment of complex cases and better visibility inside the pyelocalyceal system [44]. However, concerns have been raised about ureteral injuries due to UAS placement, with an acute ischemic effect on ureteral tissue and a subsequent onset of ureteral stricture [45]. Delvecchio et al. [46] investigated the long-term safety of UAS placement concerning ischemia-induced stricture formation, assessing a stricture rate of 1.4%, which was considered consistent with flexible URS without the assistance of the access sheath. Specific risk factors for stricture onset were identified; prior ureteral or retroperitoneal surgery, retroperitoneal radiotherapy, peripheral vascular disease, and collagen vascular disorders were demonstrated to affect the ureteral wall integrity. On the contrary, a review of the literature found no significant difference in SFRs, complication rates, and the number of procedures per patient either with or without a UAS for the treatment of large stones (>2 cm) [47].

With this systematic review of literature, we analyzed all case series reporting at least ten UAS cases in pediatric patients, and we aimed to gather all available evidence on its indications and outcomes. First, no clear indications on UAS usage emerge from the analyzed articles. None of them justified the choice of UAS placement based on a stone size threshold, stone location, age, or clinical characteristics of patients (weight, height, and comorbidities). Three studies were explicitly focused on the use of UAS [20,22,26]. Most of the studies attempted the placement of UAS in all cases. However, in case of failure, surgeons either proceeded with flexible URS or put a temporary ureteric stent for passive dilatation of the ureter and postponed stone treatment. Regarding UAS calibers and lengths, 14 out of 22 (63.6%) studies showed a single-measure UAS positioned in every patient; five of 22 (22.7%) chose between two different calibers of UAS. This reveals that there is usually no planning based on preoperative variables and that, in most cases, surgeons decide the optimal strategy intraoperatively, considering the anatomy and wideness of the ureter.

Similarly, there is no clear recommendation [8] regarding passive dilatation with a preoperative stent prior to URS with or without UAS placement. The benefit of prestenting in the adult population has been elucidated comparing a cohort of prestented versus non-prestented patients undergoing a ureteroscopic stone intervention for significant stone burden (>1 cm) [48]. Their findings assessed that prestenting reduced operative time significantly during first URS and total operative time in case multiple sessions were required. Corcoran et al. [49] analyzed preoperative variables to predict the likelihood of successful primary ureteroscopic access to the upper urinary tract without previous stent placement in prepubertal children. Authors obtained a successful primary ureteroscopic access in 18/30 patients (60%), using an 8/10 Fr coaxial ureteral dilator in 29/30 (97%) and placing a 9.5 Fr UAS in 13 of these patients at the first attempt. Among the reasons for failed primary access to the upper urinary tract were a narrow ureteral orifice in three (25%), difficulty passing the iliac vessels in four (33%), a narrow ureteropelvic junction in three (25%), and anatomical anomalies in two (17%). After 1–2 wk of passive ureteral dilation with a ureteral stent, placement of a UAS was still unsuccessful in seven of 12 patients with unsuccessful primary ureteroscopic access. Interestingly, no age, weight, height, or body mass index differences was found between cases of successful and unsuccessful primary access to the upper urinary tract and between successful and unsuccessful placement of a UAS. Therefore, the authors suggested that ureteroscopic access to the upper tract without prior stent placement is achievable even in young children. The decision to place a stent and plan for subsequent URS after passive dilation represents a safe and effective approach, and should be stressed and shared with parents in preoperative counseling.

Significant heterogeneity was found regarding the postoperative placement of a ureteral stent. A recent consensus statement on adult RIRS [50] recommended placing an internal ureteral stent after the procedure in most cases. Among the studies included in the analysis, this choice was based mainly on the duration of the procedure, number of passes with the ureteroscope, degree of ureteral trauma or edema visible after the procedure, and presence of residual calculi. Moreover, an indwelling ureteral stent was left in situ in patients at an increased risk of complications (eg, ureteral trauma, bleeding, or perforation) based on the surgeon's discretion. The use of strings on ureteral stents to avoid the need for additional general anesthesia was usually decided according to the surgeon's assessment of the family's ability to comply [15].

Despite the efficacy and good outcomes of URS, with increasing stone size, SFR decreases and the number of procedures required to achieve stone-free status increases. Few articles directly compared SFRs after URS with or without UAS placement. Wang et al. [27] found that UAS use was not associated with an improved SFR; likewise, other few studies noted similar outcomes with and without a UAS [51,52]. By contrast, UAS placement was associated with a better SFR [53]. However, none of these studies was conducted in a pediatric cohort of patients, and the absence of randomized trials makes it impossible to quantify the effect of UAS placement on SFR.

3.10. Limitations

We collected all evidence from literature regarding UAS use during URS in the pediatric population, focusing on the rate of pre- and postoperative stenting, operative time, intra- and postoperative complications, and rate of stone-free status. Additionally, cases of ureteral injuries were reported and analyzed. Despite this, the most significant part of the articles showed general data on the outcomes of URS in the pediatric population and was not explicitly tailored on assessing the impact of a UAS on intra- and postoperative variables. Moreover, we found no RCT comparing the outcomes of URS with versus without a UAS. Therefore, trends and evidence of UAS usage might be derived only from data described within these cohorts.

We could relate complications and ureteral injuries to UAS placement only when reported explicitly by authors. For this reason, the association between UAS use and outcomes and complications is difficult to quantify, and prospective clinical trials of larger sample sizes with standardized outcomes and longer follow-up durations are warranted to obtain more robust evidence on UAS. With newer, more powerful laser and advanced techniques, larger stones are now treated via URS, although in the absence of the type of power laser in all studies; this was difficult to compare [53]. The assessment of SFRs and other variables was also not standardized, and perhaps there is a need for this in the future to compare and contrast techniques and outcomes.

4. Conclusions

Flexible URS and laser lithotripsy is a safe and effective treatment option for pediatric urolithiasis. So far, no recommendation on UAS placement in pediatric URS exists, and it is not clear whether it improves SFRs. UAS use was associated with a low rate of ureteric injuries, mostly treated and resolved with a temporary indwelling ureteric stent. Further prospective and comparative studies on a larger cohort are warranted to assess the outcomes of UAS placement.

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Study concept and design: Somani.
Acquisition of data: Ripa.

Analysis and interpretation of data: Ripa.
Drafting of the manuscript: Ripa, Somani.
Critical revision of the manuscript for important intellectual content: Tokas, Griffin, Ferretti, Tur, Somani.
Statistical analysis: Ripa.
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