SYSTEMATIC REVIEW

EFFICACY AND SAFETY OF PNEUMATIC LITHOTRIPSY WITH LASER LITHOTRIPSY IN THE TREATMENT OF URETERAL STONES <20 MILLIMETERS IN CHILDREN: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Background: Ureterorenoscopy (URS) in treating ureteral stones in children is preferred for >10 mm-sized stones. Pneumatic lithotripsy is often used, but laser lithotripsy is gaining more popularity over the years, as it is considered better in terms of safety and efficacy. However, no previous meta-analysis has discussed the comparison of these two modalities. This meta-analysis compared pneumatic and laser lithotripsy in children with ureteral stones. **Methods:** This meta-analytic study followed the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) guidelines. Inclusion studies were retrieved by thoroughly searching Pubmed, Scopus, ScienceDirect, Web of Science, and Embase databases, focusing on the comparative intervention of pneumatic and laser lithotripsy in the paediatric population. **Result**: Study analysis showed that laser lithotripsy had a significantly higher stone-free rate (OR: 2.06; 95% CI: 1.06 – 4.00; p=0.03) and lower stone retropulsion (OR: 0.37; 95% CI: 0.16–0.87; p=0.02) compared to pneumatic lithotripsy. However, mean operative time (MD: 2.33; 95% CI: -4.09–8.74; p=0.48), length of stay (MD: -0.17; 95% CI: -0.36–0.02; p=0.08), post-operative fever (OR: 1.50; 95% CI: 0.48–4.66; p=0.48), and ureteral injury (OR: 0.43; 95% CI: 0.08–2.48; p=0.35) was not different between the two groups. **Conclusion:** A higher stone-free rate (SFR) and a lower incidence of stone retropulsion can be achieved using laser lithotripsy instead of pneumatic lithotripsy for treating ureteral stones in children.

Keywords: Ureteral stones; Ho-YAG; Laser lithotripsy; Pneumatic lithotripsy; Paediatric urolithiasis

Citation: Irsayanto D, Setiawan MR, Salsabila S, Yatindra IBGTY, Renado J, Wirjopranoto S. Efficacy and Safety of Pneumatic Lithotripsy with Laser Lithotripsy in The Treatment of Ureteral Stones <20 Millimeters in Children: A Systematic Review and Meta-Analysis. J Ayub Med Coll Abbottabad 2024;36(1):202–9.

DOI: 10.55519/JAMC-01-12288

INTRODUCTION

Ureteral stones in children have recently been reported to be 50 cases per 100,000 children, which has increased in recent years.[1] The percentage of paediatric emergency department visits for ureteral stones from 1999 to 2008 has increased by 86%.[1–3] Several factors that should be considered in managing ureteral stones in children are the size of the stone, its location, its composition, and the anatomy of the urinary tract.[4]

Finding the most effective treatment option for ureteral stones in children is crucial, as stones that go untreated can cause significant morbidity. While medical expulsive therapy (MET) has shown promising results in increasing spontaneous stone expulsion and reducing the need for surgery,[5,6] there is a lack of consistent literature to support its sole use in children.[7] This is of concern because shock wave lithotripsy (SWL), the first-line treatment for most ureteral stones in children, is not as effective for stones larger than 10 mm.[8] In addition, open stone surgery is now rarely performed, leaving endoscopic techniques such as URS as the preferred method for larger stones.[9] Research is therefore urgently needed to determine the most effective treatment options for children with urinary tract stones, in particular those with larger ureteral stones.

Ureterorenoscopy in paediatric patients requires more endourological techniques and expertise but is increasingly preferred and becoming a first-line procedure for ureteral stones in children.[5] Pneumatic and laser devices are the two familiar energy sources of ureteral stone lithotripsy.[6,7] Pneumatic lithotripsy generates mechanical energy by transmitting air projectiles at a given frequency per minute.[6,8] The disadvantage of using a pneumatic lithotripter is the retrograde migration of stones into the kidney during fragmentation. There is also a risk of ureteral perforation.[9] On the other hand, the currently most developed lithotripsy device is laser; in terms of safety and efficacy, the holmium: yttrium-aluminum-garnet (Ho: YAG) laser is the intracorporeal lithotripter of choice.[4,10–12] Ureteral calculi are less common in paediatric patients, so the success rate of URS procedures is also less reported than in adult patients.[13] To date, a meta-analysis comparing pneumatic and laser lithotripsy use in paediatric patients with ureteral stones is yet to be conducted. This study aims to compare the two interventions in terms of their efficacy and safety. To date, a meta-analysis comparing pneumatic and laser lithotripsy use in paediatric patients with ureteral stones is yet to be conducted. This study aims to compare the two interventions in terms of their efficacy and safety.

MATERIAL AND METHODS

This review followed the Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA). The protocol of this review has been registered in PROSPERO (CRD42023402080).

Systematic Search Strategy

A systematic search using medical subject heading (MeSH) terms with the Boolean operator was performed in Scopus, Pubmed/Medline, Embase, Web of Science, Cochrane Library and ScienceDirect databases for studies published up to March 2023. The primary keywords used in the searching process were as follows: ((laser lithotripsy) OR (laser) OR (holmium)) AND ((pneumatic lithotripsy) OR (pneumatic) OR (ureterorenoscopy)) AND ((children) OR (paediatric).

Eligibility Criteria

This review included studies comparing two or more groups of patients aged <18 years with ureteral stones <20 mm in size, using holmium laser and pneumatic lithotripsy as treatment arms. This study includes observational studies. Studies reporting outcomes of stone-free rates (SFR), mean operative time, mean length of stay, the incidence of intraoperative and post-operative complications (perforation, stone retropulsion, fever). Articles of case series, in-vitro studies, reviews, single-arm studies, non-English language, and abstracts with incomplete data were omitted from the review.

Data Extraction and Quality Assessment

Data extraction was carried out by two independent authors. For the dichotomous variable analysis, Odds Ratio (OR) with a 95% Confidence Interval (CI) was used. The continuous variable was assessed using Standardize Mean Difference (SMD) 95% Confidence Interval (CI). The *p*-value below 0.05 was considered statistically significant. The SFRs, ureteral injury, stone retropulsion, post operative fever, mean operative time, and mean length of stay were the analyzed endpoints.

The quality assessment and the risk of bias were evaluated using The Newcastle-Ottawa Scale (NOS) scoring system for observational studies. Meta-analysis was performed by determining the heterogeneity of the included studies as indicated by the Chi-square p-value and the I^2 percentage. The fixed-effect models were used for pooled studies with low heterogeneity (I^2 <50%); otherwise, the random-effects model was applied (I^2 >50%). A complete analysis was done using the Review-Manager (RevMan) software version 5.4 from the Cochrane Collaboration.

RESULTS

Search Results and Study Characteristics

An initial 397 articles were found according to the used keywords. Complete eligibility assessment yielded five matched articles for further qualitative and quantitative analysis (Figure 1). All included studies were retrospective cohorts' studies. The characteristics of the included studies are outlined in Table 1. 370 patients aged 2–14 years were gathered from published articles between 2009 and 2020. SFRs for each procedure were reported to vary, as pneumatic lithotripsy had SFRs from 66.7–94.73%, while Ho:YAG lithotripsy had SFRs from 83.4–100%. Complication rates have been reported in 10.5–40% of patients undergoing pneumatic lithotripsy procedures and 0–41.2% of patients undergoing holmium: YAG laser lithotripsy procedures (Table 2).

Risk of bias among the included studies

Assessment of the study quality was carried out using the criteria of the Newcastle-Ottawa Scale (NOS). In the selection aspect, all included studies reported a good selection process, as the included populations were fairly representative of ureteral stones cases among pediatric population. In addition, a good comparative and exposure aspects were observed, with adequate follow-up duration and fairly low dropout rates. Based on the final assessment, all included studies had a mean NOS score of 8 which could be interpreted as excellent quality (Table 3).

Stone-free rate

Study analysis on SFR in laser and pneumatic lithotripsy was performed in five included studies, comprising 294 children. There was a significantly higher difference in the SFR of laser lithotripsy compared to pneumatic lithotripsy (OR: 2.06; 95% CI: 1.06–4.00; *p*=0.03), as depicted in Figure 2. Fixed effects models were used for meta-analysis, as a result of low heterogeneity between studies (*p*=0.08).

Mean Operative Time

Meta-analysis of the difference in mean operative times of laser and pneumatic lithotripsy was performed in three available studies. The pooled analysis found that the difference in operative time was not significant (Mean differences [MD]: 2.33; 95% CI: -4.09–8.74; *p*=0.48) as depicted in Figure 3. A random-effect model was used for this outcome, as the heterogeneity between studies was found to be high (*p*=0.002).

Length of Stay

Meta-analysis of differences in length of stay between the groups of laser and pneumatic lithotripsy was performed in three included studies. The pooled analysis showed that there was no significant difference in length of stay (MD: -0.17; 95% CI: -0.36–0.02; *p*=0.08). The forest plot is shown in Figure 4. Fixed effects models were used for analysis, as a result of low, heterogeneity between studies (*p*=0.11).

Post-operative Fever

In this meta-analysis, incidence of fever after laser lithotripsy and pneumatic lithotripsy was not significantly different (OR: 1.50; 95% CI: 0.48 – 4.66; *p*=0.48). The pooled analysis was done for three studies with 200 total patients as seen in Figure 5. Fixed effects models were generated for analysis of OR (*p*=0.92).

Stone retropulsion

In this meta-analysis, the difference in the incidence of stone retropulsion with the use of laser and pneumatic lithotripsy was gathered from five studies. A significantly lower stone retropulsion was found in the group of laser lithotripsy, as compared to pneumatic lithotripsy (OR: 0.37; 95% CI: 0.16 – 0.87; *p*=0.02). The forest plot in fixed effect model is shown in Figure 6. Heterogeneity between the pooled studies was low on this outcome (*p*=0.19).

Ureteral Injury

In this meta-analysis, the difference in the incidence of ureteral injury caused by laser and pneumatic lithotripsy in pediatric patients with ureteral stones was not significant (OR: 0.43; 95% CI: 0.08–2.48; *p*=0.35). Forest plot comprising three studies is shown in Figure 7. The heterogeneity between the pooled studies was low (*p*=0.44).

Table-1: Studies Characteristic

Authors	Country	Study design	N	Intervention	N	Age (year)		Sex (n)		Stone size (mm)		Stone burden (mm2)		Stone location		Follow up	
Yapanoğlu *et al*., 2009	Turkey	Retrospective Cohort	36	Pneumatic lithotripsy	11	Mean ±SD	8.0 ±4.3	NR	NR	Mean ±SD	7.9 ±3.1	NR	NR	NR	NR	Mean ±SD	13.2 ±13.2
				Holmium: YAG laser Lithotripsy	25	Mean ±SD	8.8 ±3.2	NR	NR	Mean ±SD	8.3 ±3.3	NR	NR	NR	NR	Mean ±SD	10.2 ±10.9
Atar *et al*., 2012	Turkey	Retrospective Cohort	100	Pneumatic lithotripsy	29	Mean ±SD	8.8 ±3.4	Male Female	10 19	Mean (range)	NR	55.6 (16-57)	NR NR	NR	NR	NR	1 month
				Holmium: YAG laser Lithotripsy	35	Mean ±SD	8.4 ±3.6	Male Female	13 22	Mean (range)	NR	47.6 (16-118)	NR	NR	NR		
Gurocak *et al*., 2015	Turkey	Retrospective Cohort	60	Pneumatic lithotripsy	36	Mean ±SD	9.11 ±4.21	Male Female	21 15	Mean ±SD	6.27 ±2.03	Mean ±SD	55,5 ±31,2	NR	NR	NR	NR
				Holmium: YAG laser Lithotripsy	24	Mean ±SD	7.04 ±4.92	Male Female	11 13	Mean ±SD	7.08 ±1.66	Mean ±SD	53 ±25.52	NR	NR		
Jhanwar *et al*., 2016	India	Retrospective Cohort	76	Pneumatic lithotripsy	38	Mean ±SD	12.5 ±2.49	Male Female	34 4	NR	NR	Mean ±SD	8 ±3.09	Right Left	26 12	NR	NR
				Holmium: YAG laser Lithotripsy	38	Mean ±SD	11.97 ±2.74	Male Female	32 6	NR	NR	Mean ±SD	8.2 ±3	Right Left	28 10		
Kizilay *et al*., 2020	Turkey	Retrospective Cohort	98	Pneumatic lithotripsy	30	Mean ±SD	8.1 ±2.1	Male Female	18 12	Mean ±SD	5.8 ±1.2	NR	NR	Right Left	17 13	Mean	6,4 months
				Holmium: YAG laser Lithotripsy	68	Mean ±SD	7.8 ±1.9	Male Female	38 30	Mean ±SD	6.2 ±2.3	NR	NR	Right Left	29 39		

SD, standard deviation; NR, not reported.

Tabel 2. Evaluated parameters

Authors	Intervensi	N	Mean Operative Time		Length of Stay		Stone free rate (N (%))	Ureter drainage (%)	Fever (N (%))	Stone Displacement (N (%))	Ureteral injury (N (%))	Complication rate (N (%))
Yapanoğlu *et al*., 2009	Pneumatic lithotripsy	11	Mean ± SD	42.3 ± 15.2	Mean ± SD	33.6 ± 23.0	9 (81.8)	NR	0 (0.0)	1 (9.1)	NR	4 (36.4)
	Holmium:YAG laser Lithotripsy	25	Mean ± SD	32.4 ± 12.5	Mean ± SD	17.4 ± 17.2	25 (100.0)	NR	1 (4.0)	0 (0.0)	NR	1 (4)
Atar *et al*., 2012	Pneumatic lithotripsy	29	Mean	20.5	Mean	1.13	23 (79.0)	8 (27.6)	NR	6 (20.7)	0 (0.0)	10 (34.5)
	Holmium:YAG laser Lithotripsy	35	Mean	25.2	Mean	1.14	34 (97.0)	14 (40.0)	NR	1 (2.9)	0 (0.0)	2 (5.7)
Gurocak *et al*., 2015	Pneumatic lithotripsy	36	NR	NR	NR	NR	30 (84.0)	NR	NR	5 (13.9)	NR	6 (16.7)
	Holmium:YAG laser Lithotripsy	24	NR	NR	NR	NR	20 (83.4)	NR	NR	0 (0.0)	NR	0 (0.0)
Jhanwar *et al*., 2016	Pneumatic lithotripsy	38	Mean ± SD	37.13 ± 5.9	Mean ± SD	2.45 ± 0.49	36 (94.73)	NR	2 (5.2)	2 (5.2)	2 (5.2)	4 (10.5)
	Holmium:YAG laser Lithotripsy	38	Mean ± SD	40.15 ± 5.5	Mean ± SD	2.27 ± 0.43	38 (100.0)	NR	3(7.89)	0 (0.0)	0 (0.0)	3 (7.9)
Kizilay *et al*., 2020	Pneumatic lithotripsy	30	Mean ± SD	14.6 ± 7.8	Mean ± SD	1.23 ± 1.2	20 (66.7)	7 (23.3)	2 (6.7)	4 (13.3)	1 (3.3)	12 (40.0)
	Holmium:YAG laser Lithotripsy	68	Mean ± SD	22.8 ± 10.2	Mean ± SD	1.12 ± 0.7	59 (86.8)	11 (16.2)	8 (11.8)	3 (4.4)	2 (2.9)	28 (41.2)

SD, standard deviation; NR, not reported.

Tabel-3: Risk of bias assessment of observational studies using Newcastle Ottawa Scale

Authors	Selection	Compatibility	Exposure	Total Score
Yapanoglu *et al*. 2009	***	**	***	8
Atar *et al*. 2012	***	**	***	8
Gurocak *et al*. 2015	***	**	**	7
Jhanwar *et al*. 2016	***	**	**	7
Kizilay *et al*. 2020	****	**	**	8

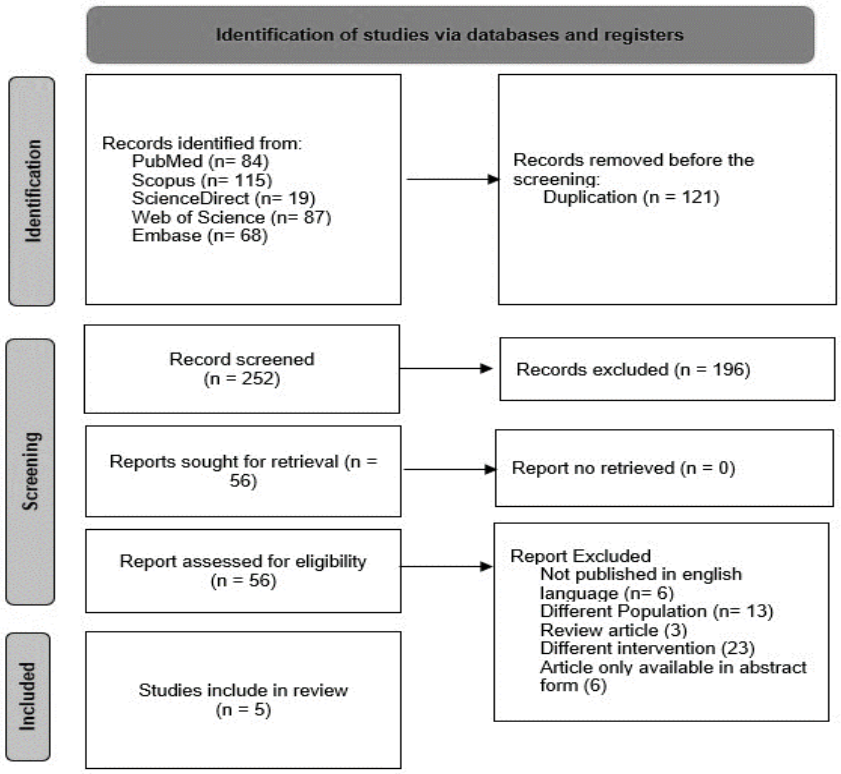


Figure-1: PRISMA flowchart guide in search and screening studies

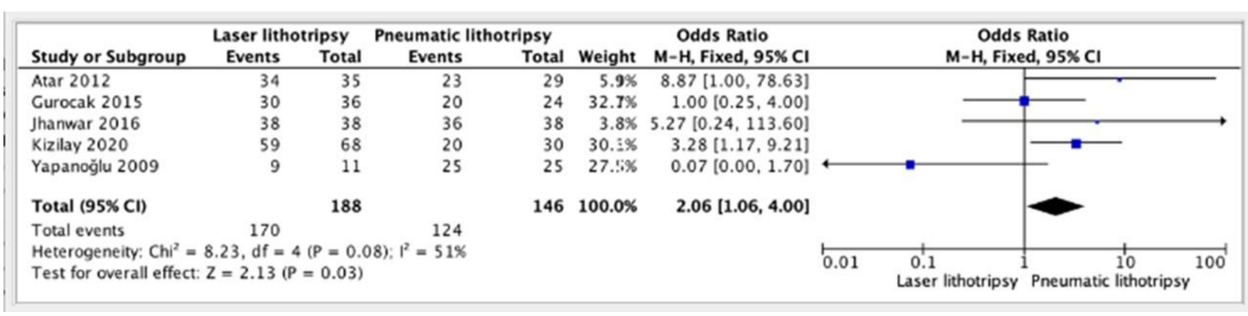


Figure-2: Forest plot of stone-free rate laser lithotripsy compared to pneumatic lithotripsy

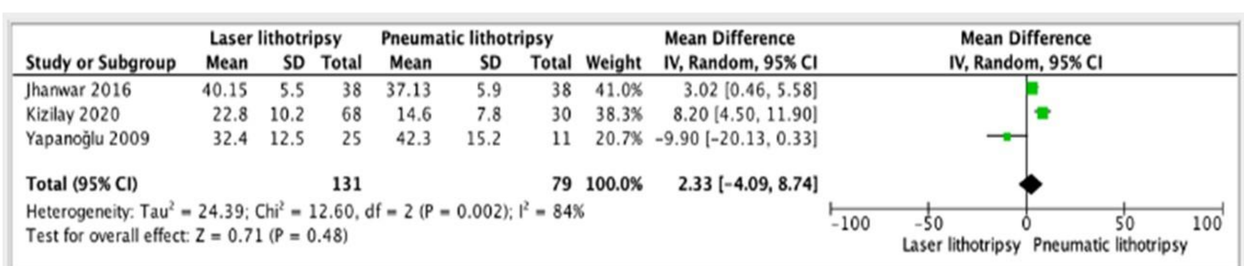
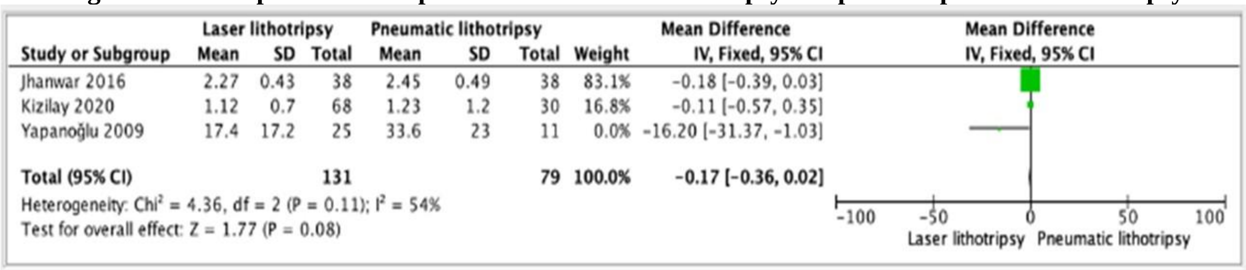


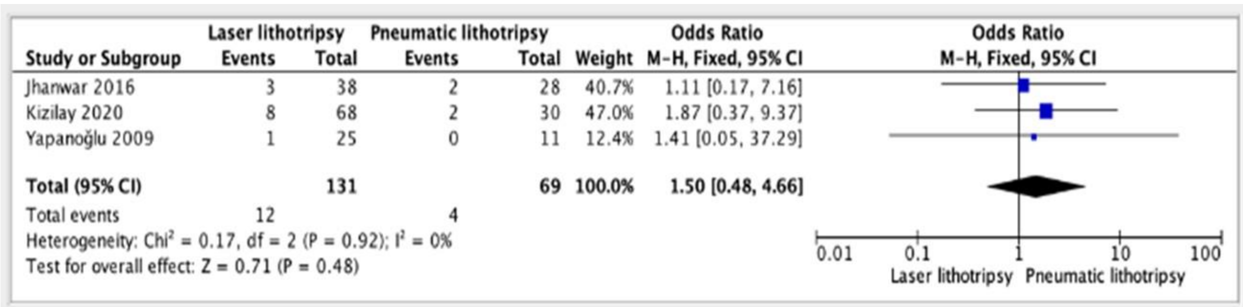
Figure-3: Forest plot of mean operative time of laser lithotripsy compared to pneumatic lithotripsy



Study or Subgroup	Laser lithotripsy Mean	SD	Total	Pneumatic lithotripsy Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Jhanwar 2016	2.27	0.43	38	2.45	0.49	38	83.1%	−0.18 [−0.39, 0.03]
Kizilay 2020	1.12	0.7	68	1.23	1.2	30	16.8%	−0.11 [−0.57, 0.35]
Yapanoğlu 2009	17.4	17.2	25	33.6	23	11	0.0%	−16.20 [−31.37, −1.03]
Total (95% CI)			**131**			**79**	**100.0%**	**−0.17 [−0.36, 0.02]**

Heterogeneity: $Chi^2 = 4.36$, df = 2 (P = 0.11); $I^2 = 54\%$
Test for overall effect: Z = 1.77 (P = 0.08)

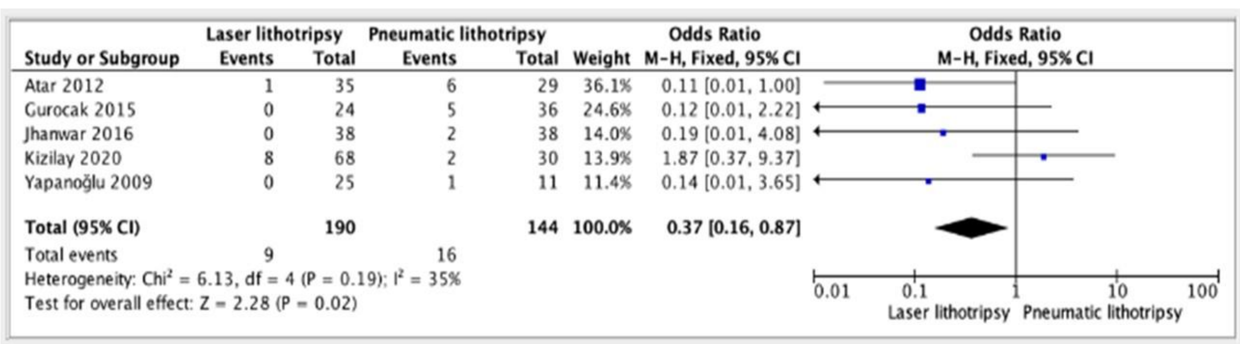
Figure-4: Forest plot of length of stay of laser lithotripsy compared to pneumatic lithotripsy



Study or Subgroup	Laser lithotripsy Events	Total	Pneumatic lithotripsy Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Jhanwar 2016	3	38	2	28	40.7%	1.11 [0.17, 7.16]
Kizilay 2020	8	68	2	30	47.0%	1.87 [0.37, 9.37]
Yapanoğlu 2009	1	25	0	11	12.4%	1.41 [0.05, 37.29]
Total (95% CI)		**131**		**69**	**100.0%**	**1.50 [0.48, 4.66]**
Total events	12		4			

Heterogeneity: $Chi^2 = 0.17$, df = 2 (P = 0.92); $I^2 = 0\%$
Test for overall effect: Z = 0.71 (P = 0.48)

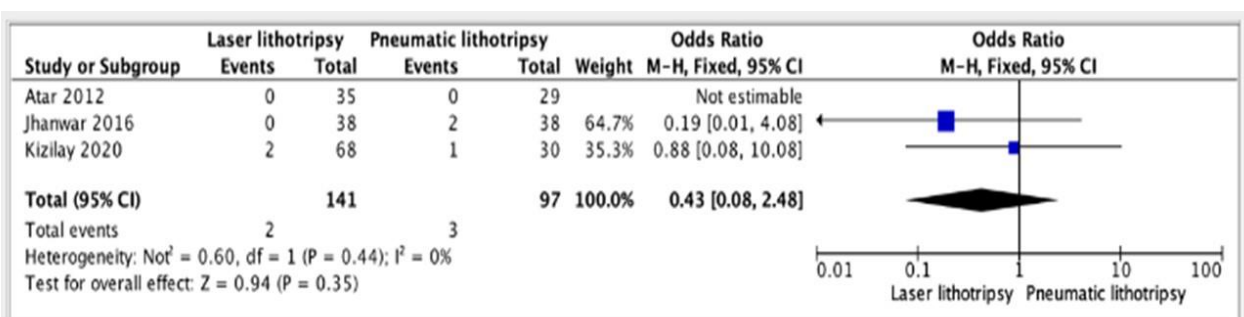
Figure-5: Forest plot of the incidence of post-operative fever in laser lithotripsy compared to pneumatic lithotripsy



Study or Subgroup	Laser lithotripsy Events	Total	Pneumatic lithotripsy Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Atar 2012	1	35	6	29	36.1%	0.11 [0.01, 1.00]
Gurocak 2015	0	24	5	36	24.6%	0.12 [0.01, 2.22]
Jhanwar 2016	0	38	2	38	14.0%	0.19 [0.01, 4.08]
Kizilay 2020	8	68	2	30	13.9%	1.87 [0.37, 9.37]
Yapanoğlu 2009	0	25	1	11	11.4%	0.14 [0.01, 3.65]
Total (95% CI)		**190**		**144**	**100.0%**	**0.37 [0.16, 0.87]**
Total events	9		16			

Heterogeneity: $Chi^2 = 6.13$, df = 4 (P = 0.19); $I^2 = 35\%$
Test for overall effect: Z = 2.28 (P = 0.02)

Figure-6: Forest plot of stone migration in laser lithotripsy compared to pneumatic lithotripsy



Study or Subgroup	Laser lithotripsy Events	Total	Pneumatic lithotripsy Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Atar 2012	0	35	0	29		Not estimable
Jhanwar 2016	0	38	2	38	64.7%	0.19 [0.01, 4.08]
Kizilay 2020	2	68	1	30	35.3%	0.88 [0.08, 10.08]
Total (95% CI)		**141**		**97**	**100.0%**	**0.43 [0.08, 2.48]**
Total events	2		3			

Heterogeneity: $Not^2 = 0.60$, df = 1 (P = 0.44); $I^2 = 0\%$
Test for overall effect: Z = 0.94 (P = 0.35)

Figure-7: Forest plot of ureteral injury in laser lithotripsy compared to pneumatic lithotripsy

DISCUSSION

The modality of ureteral stone management has been an interest for ongoing research in recent years. New techniques and modifications of conventional procedures for treating ureteral stones have been widely proposed and researched, especially in pediatric patients suffering from ureteral stones. The main target for development is to find the procedure with the best efficacy and the lowest risk of morbidity. Management strategies are based on the patient's clinical profile, and the stone burden. The prevalence of ureteral stone size is often less than 20 mm, with multiple and recurrent stones often requiring active elimination of stones. Advances in endourological procedures have significantly minimized open stone surgery and laparoscopic approaches. However, the selection of alternative therapies depends mainly on the size, composition, location, patient demographic characteristics, facilities, and physician expertise. In pediatric patients, conservative therapy is not an option for ureteral stones because the size of the child's ureters tends to be smaller. URS is the preferred option for treating ureteral stones that are less than 20 mm in size, and the success rate of URS was found to be unaffected by the location of the stone.[14] URS can be used with various lithotriptors, including electro hydrolysis, pneumatic, ultrasonic, or laser.[15,16] The use of pneumatic lithotriptors is preferred because of their advantages in the level of durability of the instrument and can be used repeatedly.[16] The main disadvantage of pneumatic lithotriptor is that the remaining stones must be extracted one by one after the stones are fragmented, and enabling retropulsion into the kidneys. While laser has the advantage of better SFR and directly fragments stones into particles that are less than one millimeter in size, it is relatively more costly, especially in developing countries.[15,16]

Current literature shows several studies comparing laser utilization with more conventional pneumatic lithotriptors, each conducted to treat ureteral stones less than twenty millimeters in size. A total of five retrospective cohort studies were included in this systematic review and meta-analysis. The primary output of all studies included was a comparison of SFR results, length of surgery time, length of hospitalization, intraoperative and post-operative complications between the two procedures. URS measures using pneumatic lithotriptors for ureteral stones in adult patients have been reported to have an SFR of 90% in distal ureteral stones and 93% in proximal ureteral stones among studies with a sample size of 84 people. Meanwhile, another study reported 95% SFR in the lithotriptor laser group and was statistically more significant than pneumatic lithotriptor.[9,16]

This study showed a significant difference between the laser and the pneumatic lithotriptor groups for the outcome of SFR, which favors the laser lithotripsy group. This result is in line with previous research by Zyczkowski *et al.*, which showed 100% total disintegration of ureteral stones in the group of pediatric patients using laser lithotripters compared to 87% SFR in the group of pediatric patients using pneumatic lithotriptors.[17] Gurocak *et al*. in his research mentioned that between laser and pneumatic lithotripter has similarities in terms of effectiveness but differs quite significantly in terms of complications, which is lower in the laser group. Moreover, pneumatic lithotripters tend to push stones toward the kidneys, requiring further action.[18]

From the analysis of mean operative time between laser and pneumatic lithotripsy in this study, no significant differences were found between the two groups. In a meta-analysis study of 1555 adult patients comparing laser and pneumatic lithotripsy, it was found that the laser group had a shorter operating time and better SFR. However, the post-operative ureteral stricture rate was higher in the laser lithotripsy group. Previous literature also mentioned that the use of Ho:YAG laser showed operating time advantages over pneumatic lithotripsy in the pediatric population. This could be due to repeated fragmentation into several parts before stone extraction in pneumatic lithotripsy.[5] However, the fragments produced by Ho:YAG laser fragmentation are smaller and easier to clean during and after the procedure. With pneumatic lithotripsy, the operator must manipulate the device in search of moving stones. In addition, the need for additional extraction procedures is significantly higher in pneumatic lithotripsy. These factors may explain the longer operating time on pneumatic lithotripsy compared to Ho:YAG laser lithotripsy. Other studies have shown the pneumatic lithotripsy group to have a shorter operating time. The operators in the study rarely used forceps or basket catheters for the extraction of small fragments in their patients for safety purposes.[14]

Our study also assessed the comparison of pneumatic and laser lithotripsy regarding the length of stay in the hospital. The three studies involved showed no significant difference between the two groups. This result is in line with the study conducted by Atar *et al.*, who also found that the length of stay for pneumatic lithotripsy group was 1.13 days, while those using laser were 1.14 days ($p>0.05$).[19] The meta-analysis of the 5 included studies showed no statistically significant difference in the additional DJ stents requirement between laser and pneumatic lithotripsy in pediatric patients with ureteral stones (OR: 0.48; 95% CI: 0.13–1.83 $p=0.28$). There was no significant difference for the placement of DJ stents reported by Jhanwar *et al*. and Atar *et al*.[19,20] Different results were found in studies by Yapanoglu *et al*. and Kizilay *et al.*, where significant results were obtained on the need for a DJ stent after the procedure. In both studies, it was stated that the need for a DJ stent was higher in pneumatic lithotripsy procedures. Our results align with this study that the insertion of DJ stents was higher in pneumatic lithotripsy, although not statistically significant.[5,14] In the study by Tan *et al.*, stents were placed in 20 of 36 patients if there were conditions of inadequate stone dissolution, ureteral trauma, impaction, and edema of the ureteral orifice.

Stents are mainly used in pediatric patients routinely, but these stents can cause discomfort or 'stent syndrome' and migration of stones and require additional anesthesia for stent removal.[21] A study by Jhanwar *et al*. reported that the use of stents could prevent the occurrence of post-operative sepsis and ureteral mucosal edema.[20]

Post-operative fever in the analysis of the three studies included in this study found no significant difference between laser and pneumatic lithotripsy in pediatric patients with ureteral stones (OR: 1.50; 95% CI: 0.48–4.66; *p*=0.48). The studies by Jhanwar *et al*. and Kizilay *et al*. found no significant differences in post-operative febrile complications (Grade I Clavien-Dindo System).[14,20] In contrast, the results of Yapanoglu *et al*. showed significant differences in complications between the pneumatic and laser lithotripsy groups, although they did not specifically mention the comparison in post-operative fever operation.[5] Infection after lithotripsy is one of the most common complications. Most infectious complications characterized by post-operative fever begin 24 hours after surgery. In a study by Lockhart *et al*., the most common causative organisms were Escherichia coli and Enterococcus. These complications can be avoided with the appropriate use of prophylactic antibiotics.[22] Other complication also reported such as stone repulsion, mild hematuria, failure of stone fragmentation, perforation, flank pain.[22]

From our meta-analysis, stone migration in laser and pneumatic lithotripsy had a significant difference, which was more frequent in patients treated with pneumatic lithotripsy, according to a study conducted by Jeon *et. al* that stone migration occurred in 19.2% (5/26) of the pneumatic lithotripsy group, compared to 4% (1/25) of the laser lithotripsy.[23] Conditions that often result in ureteral stones migrating cephalad are patients with proximal ureteral stones and patients operated on using a 7.5-Fr ureteroscope.[24] Of the three studies examining ureteral injury in laser and pneumatic lithotripsy in our study (Grade III Clavien-Dindo System), no significant difference was found between the two groups, consistent with a study conducted by Jeon *et al* that no complications were found in both study groups. However, URS with laser lithotripter could injure the ureter. The risk of ureteral wall injury can be prevented with careful handling.[23]

The present review study had several weaknesses, all the included studies had a retrospective cohort study due to the limited number of studies with a clinical trial design, this would affect the quality of the study because of the nature on the data obtain were not strictly controlled and there were no randomization process in observational study. The are some factors that was not controlled in this study such as type of stone, the specific location of the stone in the ureter, type of machinery was used for the intervention, the size of stone that are varies. More large-scale multicenter RCT studies are needed regarding the efficacy and safety of laser lithotripsy therapy compared to pneumatic lithotripsy in pediatric patients to strengthen the results of this study. Alson, systematic searches were performed directly on the two modalities, not using studies with multiple modalities that contained the selected modality

CONCLUSION

There was a significantly higher stone-free rate (SFR) and a significantly lower incidence of stone retropulsion in the laser lithotripsy group than in the pneumatic lithotripsy group. There were insignificant differences in operating time, length of stay, additional DJ stent procedures, post-operative fever, and ureteral injury incidence between groups. Unfortunately, the conclusions of this meta-analysis did not take into account stone location, stone size, stone composition, any anatomical abnormalities in the urinary tract, laser settings, and the size of the scope used, which are factors that may affect the outcome of lithotripsy and were not all reported in the included studies. A large-scale RCT is needed for future systematic review and meta-analysis, especially regarding comparing laser to pneumatic lithotripsy in paediatric patients.

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Submitted: July 19, 2023	*Revised: January 6, 2024*	*Accepted: January 6, 2024*

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