ORIGINAL RESEARCH PAPER

Volume - 15 | Issue - 05 | May - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

A COMPARATIVE STUDY BETWEEN HOLMIUM AND PNEUMATIC LITHOTRIPSY WITH RESPECT TO OVERALL STONE CLEARANCE, LOCATION OF STONE, COMPLICATIONS, DURATION OF SURGERY AND ADDITIONAL PROCEDURES REQUIRED.

General Surgery

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ABSTRACT

Background: A variety of treatment options are available for ureteric calculi, with an increasing trend toward minimally invasive surgery. Improvements in procedural techniques and devices have enhanced ureteroscopic lithotripsy (URSL) effectiveness. The holmium laser, a versatile energy source, enables tissue incision, tumor ablation, and intracorporeal lithotripsy, challenging traditional methods like pneumatic lithotripsy. Aims and Objectives: To compare holmium and pneumatic lithotripsy regarding overall stone clearance, clearance by stone location and size, complications, duration of surgery, and need for additional procedures.**Materials and Methods:** This prospective comparative study included patients with ureteric calculi undergoing ureteroscopic removal between March 2013 and March 2015. Patients with anatomical abnormalities, severe comorbidities, or infection were excluded. Perioperative and follow-up data were recorded and statistically analysed.Observations and Results: Eighty-six patients were studied (44 holmium, 42 pneumatic), with comparable baseline characteristics. Complete stone clearance was significantly higher in the holmium group (95.5%) compared to the pneumatic group (81.0%, p=0.036). Holmium lithotripsy showed equal efficacy for proximal and distal stones, whereas pneumatic lithotripsy was less effective for proximal stones (p=0.018). Complication rates were low and not significantly different (9.1% vs 19.0%). Most complications were minor, with no major adverse events. Additional procedures and operative duration were similar between groups. Stone size did not significantly affect outcomes; lithotripsy type was the most significant predictor of clearance.**Conclusion:** Holmium laser lithotripsy is a safe and effective treatment for ureteric calculi, offering superior overall and proximal stone clearance compared to pneumatic lithotripsy, and should be considered the preferred modality.

KEYWORDS

INTRODUCTION

Ureteric calculi, commonly known as kidney stones lodged in the ureter, represent one of the most prevalent urological disorders worldwide, affecting millions annually. These stones can cause severe pain, urinary obstruction, and complications such as infections or renal damage if not treated promptly. Historically, open surgery was the primary method for stone removal, but advancements in medical technology have shifted the paradigm toward minimally invasive procedures, significantly improving patient outcomes, reducing hospital stays, and minimizing recovery times.

Among these innovations, ureterorenoscopic lithotripsy (URSL) has emerged as a cornerstone treatment. URSL involves inserting a thin, flexible scope through the urethra and bladder into the ureter to visualize and fragment stones. Two prominent energy sources for stone fragmentation in URSL are holmium:yttrium-aluminum-garnet (Ho:YAG) laser lithotripsy and pneumatic lithotripsy. The holmium laser, introduced in the 1990s, is a solid-state laser operating at a wavelength of 2100 nm, which is highly absorbed by water, allowing precise stone fragmentation with minimal thermal damage to surrounding tissues. It can vaporize stones into fine dust or small fragments easily passed or extracted, making it versatile for various stone compositions, including hard ones like calcium oxalate monohydrate.

In contrast, pneumatic lithotripsy, also known as ballistic or intracorporeal lithotripsy, uses a probe that delivers mechanical energy through compressed air pulses, akin to a jackhammer, to break stones into larger fragments. This method, popularized in the 1980s, is cost-effective and straightforward but can lead to stone retropulsion (migration upward into the kidney), requiring additional maneuvers.

The choice between these modalities often depends on factors like stone size, location (proximal vs. distal ureter), composition, and available equipment. Proximal stones, located closer to the kidney, are more challenging due to the ureter's anatomy and potential for retropulsion, while distal stones near the bladder are generally easier to access. Complications such as mucosal injury, perforation, hematuria, or residual fragments can occur in both, but their incidence and management differ. Surgical duration impacts operating room efficiency and patient anesthesia exposure, while additional procedures like extracorporeal shock wave lithotripsy (ESWL) or percutaneous nephrolithotomy (PCNL) add to costs and risks.

This comparative study draws from a single-center prospective analysis conducted between March 2013 and March 2015, involving 86 patients, to evaluate the efficacy and safety of holmium versus pneumatic lithotripsy. By examining overall stone clearance, location-specific outcomes, complications, operative time, and auxiliary interventions, the research provides evidence-based insights for urologists. Prior studies, such as those by Jeon et al. (2005), Razaghi et al. (2011), and Cimino et al. (2014), have suggested holmium's superiority in clearance rates, particularly for upper ureteral stones, but results vary with stone size and study design.

AIMS AND OBJECTIVES

The primary aim of this study was to compare the effectiveness of holmium laser lithotripsy and pneumatic lithotripsy in achieving overall stone clearance for ureteric calculi. Stone clearance is defined as the complete removal or fragmentation of stones to sizes passable without intervention, confirmed via postoperative imaging like X-rays or ultrasounds.

Secondary objectives included assessing stone clearance rates in relation to stone location—specifically, proximal (upper) versus distal (lower) ureteric stones, as anatomical differences influence procedural success. Proximal stones often require more energy to fragment without migration, while distal ones benefit from easier access. Additionally, the study evaluated intraoperative and postoperative complications, such as retropulsion, residual fragments, mucosal injury, hematuria, and perforation, to gauge safety profiles.

Further, it compared the duration of surgery, encompassing the entire procedure from anesthesia induction to completion, to determine efficiency. Finally, the need for additional procedures, including ESWL for residual stones, repeat URSL, PCNL for migrated fragments, or prolonged double-J (DJ) stenting, was analyzed to understand overall treatment burden. These objectives address key clinical questions:Is holmium superior in challenging cases? Does it reduce complications or secondary interventions? By focusing on these metrics, the study aims to guide treatment selection, potentially favoring holmium for its precision in an era of rising minimally invasive preferences.

MATERIALS AND METHODS

This prospective comparative study was conducted at a single tertiary care center from March 2013 to March 2015. A total of 86 patients diagnosed with ureteric calculi who elected ureteroscopic stone removal were enrolled after informed consent. Patients were allocated to either the holmium laser group (n=44) or the pneumatic lithotripsy group (n=42), based on availability and surgeon preference, though groups were matched for comparability.

Inclusion criteria

Inclusion criteria encompassed adults with single or multiple ureteric stones suitable for URSL, confirmed by imaging (e.g., CT urography or intravenous pyelogram).

Exclusion criteria Exclusion criteria were stringent: anatomical abnormalities like duplex ureters, horseshoe kidneys, or bladder diverticula; severe comorbidities (e.g., uncontrolled diabetes, cardiac issues); active urinary tract infections; or pregnancy. This ensured homogeneity and minimized confounding variables.

Procedures were performed under spinal or general anesthesia using a semi-rigid ureteroscope (e.g., 8-9.5 Fr). For holmium lithotripsy, a 200-550 μm fiber delivered energy at 0.5-1.5 J/pulse and 5-15 Hz, fragmenting stones into dust. Pneumatic lithotripsy employed a LithoClast probe with 1-3 Hz pulses to break stones mechanically. Stones were basket-extracted or left to pass if <2 mm. DJ stents were placed routinely for 2-4 weeks.

Perioperative data included stone size (measured via imaging), location (proximal: above iliac vessels; distal: below), operative time, complications, and clearance (assessed intraoperatively and at 1-3 months follow-up via KUB X-ray/ultrasound). Statistical analysis used SPSS software: unpaired t-tests for continuous variables (age, stone size, duration); Mann-Whitney for non-normal data; chi-square/Fisher's exact tests for categorical outcomes (clearance, complications); and binary logistic regression to identify predictors of clearance, with p<0.05 as significant.

Ethical approval was obtained, and the study adhered to Helsinki Declaration principles, ensuring patient safety and data confidentiality.

RESULTS

The groups were demographically comparable, with no significant differences in age (holmium: mean 45.43 ± 14.71 years; pneumatic: 48.79 ± 13.28 years; p=0.271), sex (holmium: 70.5% male; pneumatic: 78.6% male; p=0.388), stone size (holmium: 9.75 ± 2.78 mm; pneumatic: 9.88 ± 3.20 mm; p=0.990), or location (holmium: 61.4% proximal; pneumatic: 50.0% proximal; p=0.289). These similarities validate direct comparisons.

Overall stone clearance was markedly higher in the holmium group at 95.5% (42/44 patients) compared to 81.0% (34/42) in the pneumatic group (chi-square p=0.036; Fisher's exact p=0.047), highlighting holmium's superiority. This aligns with the logistic regression, where lithotripsy type was the strongest predictor (B=-1.826, p=0.032, Exp(B)=0.161), indicating pneumatic use reduced clearance odds by 84%. Stone size (p=0.283) and location (p=0.077) were non-significant.

Location-specific clearance revealed holmium's consistency: 96.3% (26/27) for proximal and 94.1% (16/17) for distal stones (p=1.000, no difference). In pneumatic, proximal clearance was lower at 66.7% (14/21) versus 95.2% (20/21) distal (p=0.018; Fisher's p=0.045). Cross-tabulation confirmed holmium's advantage for proximal stones (p=0.006; Fisher's p=0.015) but equivalence for distal (p=0.878; Fisher's p=1.000). This suggests pneumatic's limitations in upper ureter due to retropulsion.

Complications occurred in 9.1% (4/44) holmium and 19.0% (8/42) pneumatic cases (p=0.183, not significant). Intraoperatively: holmium had retropulsion (1), mucosal injury (2), perforation (1); pneumatic: retropulsion (6), residual + retropulsion (1) (p=0.293). Postoperatively: holmium had hematuria (1); pneumatic: residual stone (1) (p=0.973). Retropulsion was predominant in pneumatic (7/8 cases), often leading to residuals. The minor perforation was managed conservatively with extended DJ stenting; no major issues like avulsion or urinoma arose.

Additional procedures were needed in 9.1% holmium (ESWL:1, repeat URS:1, prolonged DJ:2) versus 19.0% pneumatic (ESWL:5, PCNL:1, repeat URS:1, ESWL+repeat URS+PCNL:1; p=0.183, not significant). Though not statistically different, pneumatic required more interventions, often for migrated fragments.

Surgical duration averaged 37.59 ± 8.87 minutes for holmium and 39.05 ± 8.57 for pneumatic (p=0.394, not significant). Stone size did not correlate with clearance in either group.

These results echo comparative studies. Jeon et al. (2005) reported 96.0% holmium vs. 73.1% pneumatic clearance (p<0.05), with shorter times (49.8 vs. 76.9 min). Razaghi et al. (2011) found 100% holmium vs. 85.7% pneumatic (p=0.003), with no complication differences. Cimino et al. (2014) noted 86.1% laser vs. 80.7% pneumatic (p=0.002). Bapat et al. (2006) showed 97.01% holmium vs. 86.01% pneumatic for upper stones, with fewer auxiliaries in holmium. However, Kassem et al. (2012) found no differences for large stones. Meta-analyses like Yin et al. (2013) confirmed holmium's benefits in clearance and reduced migration (OR=0.26, p=0.003), though operative times varied.

Tipu et al. (2007) reported 92% holmium vs. 82% pneumatic overall, with 90.9% vs. 71.4% for proximal. Razzaghi et al. (2013) noted similar safety, with perforations in 2-3 cases per group. Salman et al. also highlighted fewer re-treatments in holmium (4% vs. 14%).

In discussion, the study interprets these as holmium's precision reducing retropulsion, especially proximally, without increasing complications or time. Logistic regression underscores lithotripsy type over size/location.

Table no 1: Comparison of age

Variables	Type of Lithotripsy	No.	Mean	SD	Median	IQR	t-value	P-value
Age (years)	Holmium	44	45.43	14.71	43	24	-1.108	0.271
	Pneumatic	42	48.79	13.28	48	19	Difference is not significant	

Unpaired t-test applied

Table no 2: Comparison of size of stone

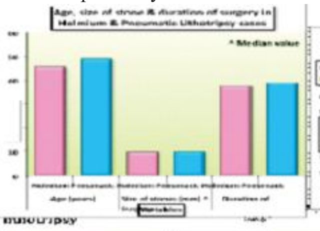
Variables	Type of Lithotripsy	No.	Mean	SD	Median	IQR	z-value	P-value
Size of stones (mm) ^	Holmium	44	9.75	2.78	10	5	-0.013	0.990
	Pneumatic	42	9.88	3.20	10	5	Difference is not significant	

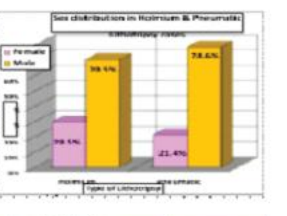
Data failed Normality test. Hence Mannwhitney test applied. T value replaced by z value.

Table no 3: Comparison of Duration of surgery(min)

Variables	Type of Lithotripsy	No.	Mean	SD	Median	IQR	z-value	P-value
Duration of Surgery (min) ^	Holmium	44	37.59	8.87	35	15	-0.852	0.394
	Pneumatic	42	39.05	8.57	40	10	Difference is not significant	

Data failed Normality test. Hence Mannwhitney test applied. T value replaced by z value.





Sex		Type of Lithotripsy: Holmium	Type of Lithotripsy: Pneumatic	Total
Female	No.	13	9	22
	%	29.5%	21.4%	25.6%
Male	No.	31	33	64
	%	70.5%	78.6%	74.4%
Total	No.	44	42	86
	%	100.0%	100.0%	100.0%

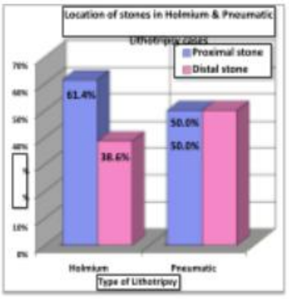
Chi-Square Tests	Value	df	p-value	Association is-
Pearson Chi-Square	0.744	1	0.388	Not significant
Continuity Correction	0.378	1	0.538	Not significant

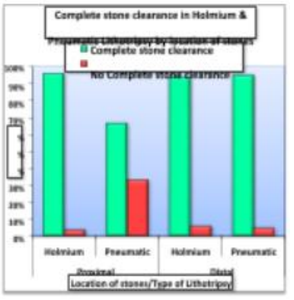
Table no 5: Association among cases between location of stones * type of lithotripsy

Location of stones		Type of Lithotripsy: Holmium	Type of Lithotripsy: Pneumatic	Total
Proximal	No.	27	21	48
	%	61.4%	50.0%	55.8%
Distal	No.	17	21	38
	%	38.6%	50.0%	44.2%
Total	No.	44	42	86
	%	100.0%	100.0%	100.0%

Chi-Square Tests	Value	df	p-value	Association is-
Pearson Chi-Square	1.125	1	0.289	Not significant
Continuity Correction	0.712	1	0.399	Not significant

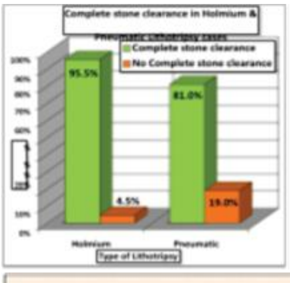
Table no 5: Association among cases between Complete stone clearance * type of lithotripsy

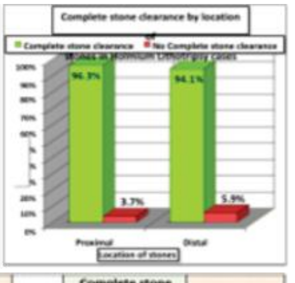




Complete stone clearance		Type of Lithotripsy		Total
		Holmium	Pneumatic	
Yes	No.	42	34	76
	%	95.5%	81.0%	88.4%
No	No.	2	8	10
	%	4.5%	19.0%	11.6%
Total	No.	44	42	86
	%	100.0%	100.0%	100.0%

Chi-Square Tests	Value	df	p-value	Association is-
Pearson Chi-Square $	4.398	1	0.036	Significant
Continuity Correction $	3.100	1	0.078	Not significant
Fisher's Exact Test			0.047	Significant
$ 1 cells (25.0%) have expected count less than 5. P-value of Fisher's Exact Test will be used.				





Location of stones		Complete stone clearance		Total
		Yes	No	
Proximal	No.	26	1	27
	%	96.3%	3.7%	100.0%
Distal	No.	16	1	17
	%	94.1%	5.9%	100.0%
Total	No.	42	2	44
	%	95.5%	4.5%	100.0%

Chi-Square Tests	Value	df	p-value	Association is-
Pearson Chi-Square $	0.114	1	0.736	Not significant
Continuity Correction $	0.000	1	1.000	Not significant
Fisher's Exact Test			1.000	Not significant
$ 2 cells (50.0%) have expected count less than 5. P-value of Fisher's Exact Test will be used.				

Association among Pneumatic cases between Complete stone clearance location stones

Location of stones		Complete stone clearance		Total
		Yes	No	
Proximal	No.	14	7	21
	%	66.7%	33.3%	100.0%
Distal	No.	20	1	21
	%	95.2%	4.8%	100.0%
Total	No.	34	8	42
	%	81.0%	19.0%	100.0%

Chi-Square Tests	Value	df	p-value	Association is-
Pearson Chi-Square $	5.559	1	0.018	Significant
Continuity Correction $	3.860	1	0.049	Significant
Fisher's Exact Test			0.045	Significant

Table no 6: Association among cases between Complications * type of lithotripsy

Table no 7: Association among cases between Intra-op Complications * type of li

Intra-op complication		Type of Lithotripsy		Total
		Holmium	Pneumatic	
Yes	No.	4	7	11
	%	9.1%	16.7%	12.8%
No	No.	40	35	75
	%	90.9%	83.3%	87.2%
Total	No.	44	42	86
	%	100.0%	100.0%	100.0%

Chi-Square Tests	Value	df	p-value	Association is-
Pearson Chi-Square	1.106	1	0.293	Not significant
Continuity Correction	0.531	1	0.466	Not significant

Table8:Association among casesbetween Post-opComplications type of lithotripsy

Additional procedure required		Type of Lithotripsy		Total
		Holmium	Pneumatic	
Yes	No.	4	8	12
	%	9.1%	19.0%	14.0%
No	No.	40	34	74
	%	90.9%	81.0%	86.0%
Total	No.	44	42	86
	%	100.0%	100.0%	100.0%

Chi-Square Tests	Value	df	p-value	Association is-
Pearson Chi-Square	1.774	1	0.183	Not significant
Continuity Correction	1.042	1	0.307	Not significant

Table no 9: Association among cases betweenvarious Intra-op Complications type of lithotripsy

Additional procedure required		Type of Lithotripsy		Total
		Holmium	Pneumatic	
ESWL ^	No.	1	5	6
	%	2.3%	11.9%	7.0%
Prolonged DJ ^	No.	2	0	2
	%	4.5%	0.0%	2.3%
Repeat URS ^	No.	1	1	2
	%	2.3%	2.4%	2.3%
ESWL+Repeat URS ^	No.	0	1	1
	%	0.0%	2.4%	1.2%
PCNL ^	No.	0	1	1
	%	0.0%	2.4%	1.2%
None	No.	40	34	74
	%	90.9%	81.0%	86.0%
Total	No.	44	42	86
	%	100.0%	100.0%	100.0%

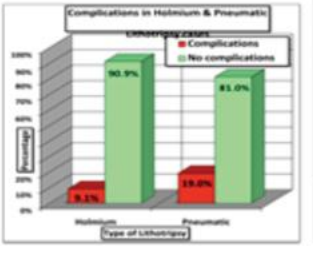
Chi-Square Tests	Value	df	p-value	Association is-
Pearson Chi-Square $	7.110	5	0.213	Not significant
Pearson Chi-Square ^	1.042	1	0.307	Not significant
$ 10 cells (83.3%) have expected count less than 5. ^ Row data pooled & Chi-Square Test reapplied.				

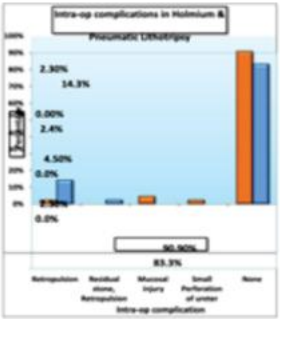
\Table no 10: Association among cases between various Post-op Complications * type of lithotripsy

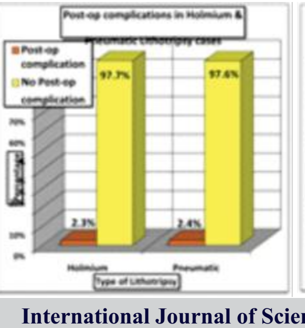
Post-op complication		Type of Lithotripsy		Total
		Holmium	Pneumatic	
Residual stone ^	No.	0	1	1
	%	0.0%	2.4%	1.2%
Significant hematuria ^	No.	1	0	1
	%	2.3%	0.0%	1.2%
None	No.	43	41	84
	%	97.7%	97.6%	97.7%
Total	No.	44	42	86
	%	100.0%	100.0%	100.0%

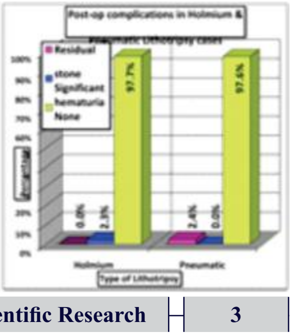
Chi-Square Tests	Value	df	p-value	Association is-
Pearson Chi-Square $	2.002	2	0.367	Not significant
Pearson Chi-Square ^	0.000	1	1.000	Not significant
Fisher's Exact Test ^			1.000	Not significant
$ 4 cells (66.7%) have expected count less than 5. ^ Row data pooled & Chi-Square Test reapplied with Continuity Correction.				
^ 2 cells (50.0%) have expected count less than 5. P-value of Fisher's Exact Test will be used.				

$ 2 cells (50.0%) have expected count less than 5. P-value of Fisher's Exact Test will be used.









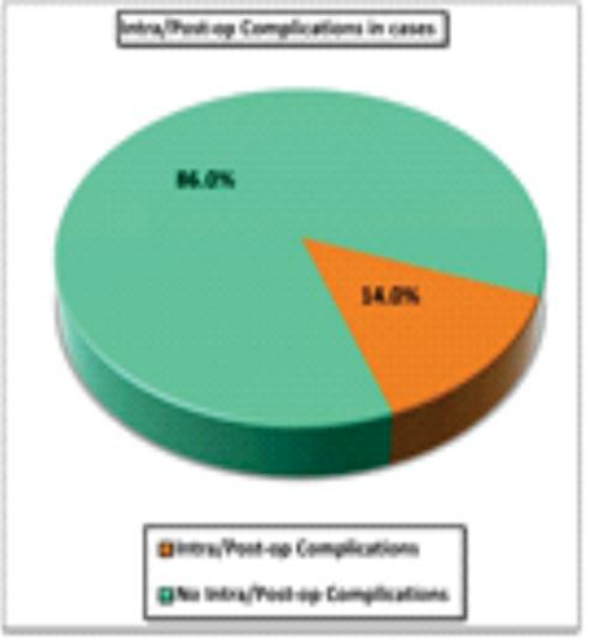


Table no 11: Association among cases between Additional procedure required * type of lithotripsy

Additional procedure required		Type of Lithotripsy		Total
		Holmium	Pneumatic	
Yes	No.	4	8	12
	%	9.1%	19.0%	14.0%
No	No.	40	34	74
	%	90.9%	81.0%	86.0%
Total	No.	44	42	86
	%	100.0%	100.0%	100.0%

Chi-Square Tests	Value	df	p-value	Association is-
Pearson Chi-Square	1.774	1	0.183	Not significant
Continuity Correction	1.042	1	0.307	Not significant

Table no 12: Association among cases between Additional procedure required * type of lithotripsy

Additional procedure required		Type of Lithotripsy		Total
		Holmium	Pneumatic	
ESWL ^	No.	1	5	6
	%	2.3%	11.9%	7.0%
Prolonged DJ ^	No.	2	0	2
	%	4.5%	0.0%	2.3%
Repeat URS ^	No.	1	1	2
	%	2.3%	2.4%	2.3%
ESWL+Repeat URS ^	No.	0	1	1
	%	0.0%	2.4%	1.2%
PCNL ^	No.	0	1	1
	%	0.0%	2.4%	1.2%
None	No.	40	34	74
	%	90.9%	81.0%	86.0%
Total	No.	44	42	86
	%	100.0%	100.0%	100.0%

Chi-Square Tests	Value	df	p-value	Association is-
Pearson Chi-Square $	7.110	5	0.213	Not significant
Pearson Chi-Square ^	1.042	1	0.307	Not significant

$ 10 cells (83.3%) have expected count less than 5. ^ Row data pooled & Chi-Square Test reapplied.

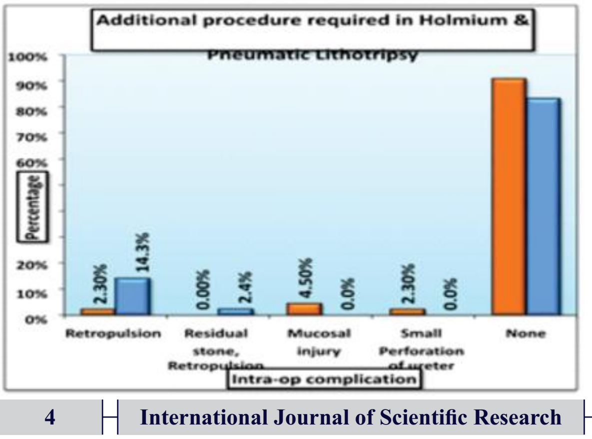


Table no 13: Binary logistic regression with complete stone clearance as dependent variable and set of independent (predictor) variables

Dependent Variable Encoding

Complete stone clearance	Internal Value
Yes	1
No	0

Categorical Variables Codings

Variables		Frequency	Parameter coding
			1
Type of Lithotripsy	Pneumatic	42	1
	Holmium	44	0
Location of stones	Distal	38	1
	Proximal	48	0

Variables	B	S.E.	Wald	df	Sig.	Exp (B)
Size of stones (mm)	-0.133	0.124	1.151	1	0.283	0.875
Location of stones (Distal)	1.53	0.864	3.137	1	0.077	4.619
Type of Lithotripsy (Pneumatic)	-1.826	0.851	4.602	1	0.032	0.161
Constant	4.067	1.536	7.013	1	0.008	58.36

Thus Type of Lithotripsy is the only statistically significant predictor of Complete stone clearance; more of Pneumatic Lithotripsy, less is the clearance.

DISCUSSSION

The study is a single centre prospective comparative study involving 86 patients, 44 patients were in holmium lithotripsy group and 42 patients in pneumatic lithotripsy group.

1) Comparabilty: In our study comparing between holmium and pneumatic lithotripsy, both our groups were comparable with each other and there was no statistically significant difference in the groups with respect to age, sex, size of the stones and location of the stones.(Table 1-4 and charts 1 and 2)

2) Complete stone clearance: Out of the 44 patients in holmium (HO) group complete stone clearance was observed in 42 patients i.e. in 95.5 % of patients. In the pneumatic (PL) group out of 42 patients, 32 patients had complete stone clearance i.e. 81.0%. This difference was found to be statistically significant and p value of 0.036 ($p<0.05$) was observed suggesting that holmium laser was superior to pneumatic lithoclast in complete stone clearance. Similar results have been obtained by other studies as well: In a study done by Jeon SS, Hyun JH, Lee KS. Ivolving 51 patients (26 PL and 25 Ho), the immediate stone-free rates were 96.0% in the holmium:YAG group and 73.1% in the Lithoclast group ($P < 0.05$). This data suggested that holmium:YAG lithotripsy is more effective than Lithoclast lithotripsy in the aspect of immediate stone free rate.comparison of holmium:YAG laser with Lithoclast lithotripsy in ureteral calculi fragmentation. Jeon SS, Hyun JH, Lee KS. - Int. J. Urol. - June 1, 2005; 12 (6); 544-7) In another study involving 112 patient (56 PL and 56 Ho) the success rate was 85.7% in pneumatic group and 100% in holmium: YAG laser group ($p = 0.003$). Another prospective single-blinded study was done to analyze the stone-free (SF, stone clearance) rates between pneumatic lithotripsy (PL) and laser lithotripsy (LL) for the treatment of single and primary ureteral stones and to evaluate potentially predictive factors of a SF status. In this study 133 consecutive patients with single and primary ureteral stones were prospectively enrolled. The SF rate in the PL group was 80.7 and 86.1% in the LL group ($p = 0.002$). Success rates with regard of stone position were not significantly different between groups. The study concluded that LL(Holmium laser lithotipsy) significantly influences the SF(stone clearance rate) status after ureteroscopy, allowing a higher SF rate when compared to PL(Pneumatic lithotripsy).(Pneumatic lithotripsy versus holmium:YAG laser lithotripsy for the treatment of single ureteral stones: a prospective, single-blinded study.

However, Kassem A et al29, In their prospective randomized trial, 'Laser and pneumatic lithotripsy in the endoscopic management of large ureteric stones: a comparative study'; they could not find significant difference in safety and efficacy between pneumatic and laser lithotripsy in treating large ureteric calculi.

3) Stone clearance with respect to location of stones: In the holmium

group there were 27 cases with proximal ureteric stones out of which complete stone clearance was seen in 26 cases, and out of 17 patients with distal ureteric stones complete stone clearance was seen in 16 cases. We applied the chi square test and could not find any significant difference in stone clearance with respect to location of stones and stone clearance in the holmium group. However, in Pneumatic group; out of the 21 proximal stones complete stone clearance was seen only in 14 patients and in 21 cases with distal ureteric stones complete stone clearance was seen in 20 cases. The chi square test in pneumatic group showed a significant difference p=0.018 (p<0.05). Thus it was observed that pneumatic lithotripsy was less effective in clearing proximal ureteric calculi than distal ureteric calculi. We cross tabulated the above data and compared the type of lithotipsy and location of stone. There was significant statistical difference p=0.005 (p<0.05 is significant) suggesting holmium laser is better for complete clearance of proximal ureteric calculi than pneumatic lithotripsy. However both the groups were equally efficacious for clearing distal ureteric calculi. In the study, 'Comparison of holmium laser and pneumatic lithotripsy in managing upper ureteral stones'. Bapat SS et al retrospectively analyzed the records of 394 patients with upper ureteral stone who underwent ureteroscopic lithotripsy from January 2000 to December 2005. Complete stone clearance was seen in 166/193 (86.01%) patients in the Lithoclast group and in 195/201 (97.01%) in the laser group. The study observed that, the fragmentation rates of holmium laser-assisted ureteroscopy were significantly better in the upper ureter. Similarly in the study,' Safety and efficacy of pneumatic lithotripters versus holmium laser in management of ureteral calculi: a randomized clinical trial.' Stone pushing back occurred in 10 (17.9%) patients in pneumatic group while none occurred in holmium laser group. Thus the authors concluded that; Laser lithotripsy is a superior approach for the management of upper ureteral stones of 1 to 2 cm in size due to its higher rate of stone clearance.The comparative cross sectional study 'Treatment of Ureteric Calculi - Use of Holmium: YAG Laser Lithotripsy versus Pneumatic Lithoclast' found similar results. In this study of 100 patients overall stone clearance was 92% in holmium laser group as compared to 82% in Pneumatic lithotripsy group. This difference was marked in proximal ureter; where stone clearance rate of 90.9% was seen in Holmium Laser (LL or Ho) group as compared to 71.4% in pneumatic (PL) group. (Salman Ahmed Tipu, Hammad Afzal Malik, Nazim Mohhayuddin, Gauhar Sultan, Manzoor Hussain, Altaf Hashmi, Syed Ali Anwar Naqvi, Syed Adibul Hasan Rizvi. Treatment of Ureteric Calculi - Use of Holmium: YAG Laser Lithotripsy versus Pneumatic Lithoclast. *Journal of Pakistan Medical Association* 2007; 57(9): . http://www.jpma.org.pk/full_article_text.php?article_id=1203 (accessed 16/5/2015).

4) Complications of Surgery: Intraoperatively noticed complications like retropulsion of stones, residual stones, mucosal injury, and perforation of ureter were taken together with post operatively noticed complications like hematuria and residual stones. This was done as most of the complications were noticed intraoperatively . Persistent hematuria seen in 1 case was actually a manifestation of mucosal injury noticed intraoperatively, while in only 1 case residual stones was noticed post operatively. Rest all the cases of retropulsion and residual stones were noticed intraoperatively. Complications following intracorporeal lithotripsy were infrequent and included Retropulsion of stones in kidney seen most commonly in 8 cases, residual stones in 2 cases (this includes 1 case where retropulsion of a fragment of stone was seen along with residual stone in kidney), while , mucosal injury , significant hematuria, perforation of ureter were seen in 1 case each. This data was then cross tabulated with the type of lithotripsy, and no statistically significant difference was observed. Thus we observed that overall complications were similar in both the groups. However as seen previously in discussion, when complications concerning stone clearance (retropulsion and residual stones) were separately analysed; holmium laser was more efficacious than pneumatic lithotripsy. Similar results were seen in other studies. Yin x et al, in their meta-analysis found Holmium: YAG LL conveyed significant benefits compared with PL in terms of early stone-free rate [odds ratio (OR)=4.42, 95% confidence interval (CI) (1.14, 17.16), p=0.03], delayed stone-free rate [OR=4.42, 95%CI (1.58, 12.37), p=0.005] and stone migration incidence [OR=0.26, 95%CI (0.11, 0.62), p=0.003], but not yet in the postoperative hematuria rate and the ureteral perforation rate.(Holmium: YAG laser lithotripsy versus pneumatic lithotripsy for treatment of distal ureteral calculi: a meta-analysis. Yin X, Tang Z, Yu B, Wang Y, Li Y, Yang Q, Tang W. - J. Endourol. - April 1, 2013; 27 (4); 408-14) Razzagi MR et al,found that in terms of complications, such as perforation, mucosal injury, and bleeding, there were no differences between the two groups.(*Safety and efficacy of pneumatic lithotripters versus holmium laser in management of ureteral calculi: a randomized clinical trial.* Razzaghi MR, Razi A, Mazloomfard MM, Golmohammadi Taklimi A, Valipour R, Razzaghi Z - Urol J - January 1, 2013; 10 (1); 762-6)Kaseem A et al in their comparative study involving 80 patients found that stone migration occurred in 12 PL (Pneumatic lithotripsy) cases and in 5 LL(Holmium Laser Lithotripsy) cases. Ureteric perforation occurred in 3 LL cases and in 2 PL cases. Ureteric stricture occurred in 1 case following LL. Both PL and LL are effective and safe modalities in treating large ureteric stones with minor insignificant differences. Jeon SS et al in their comparative study of 51 patients reported ureteric perforation in only 2 cases of lithoclast group (*A comparison of holmium:YAG laser with Lithoclast lithotripsy in ureteral calculi fragmentation.* Jeon SS, Hyun JH, Lee KS - Int. J. Urol. - June 1, 2005; 12 (6); 544-7) Bapat SS et al in their retrospective analysis of 394 cases found Ureteral perforations were nine in the Lithoclast group and six in the laser group.

4)Additional procedure required: In Pneumatic Lithotripsy (PL) group; 5 patients required ESWL , 1 case required PCNL , 1 case required repeat URS and 1 case required repeat URS with PCNL. In Pneumatic lithotripsy group 1 case required required ESWL, 1 case required repeat URS and 2 cases had prolonged DJ stents. This data was then analysed using chi square test and no statistical difference was found in either groups for additional procedure required. However Bapat SS et al found that the need for auxiliary procedures were significantly less for holmium laser-assisted ureteroscopy when compared with pneumatic lithotripsy. In their retrospective analysis of 394 patients, auxiliary procedures included SWL (27/193 [13.98%] patients in the Lithoclast group and 4/201 [1.99%] patients in the laser group) or repeated URS (two in the Lithoclast group). Salman Ahmed Tipu et al also report similar results. Only 2 (4%) patients required re-treatment or any ancillary procedure in laser group as compared to 7 (14%) patients who required more than one session in Pneumatic lithptripsy group.

5) Duration of surgery: We calculated the duration of surgery from start to finish of anesthesia, thus it includes the scopy time as well as the lithotripsy time. The mean duration of surgery was 37.59 minutes in holmium lithotripsy group while it was 39.05 minutes in Pneumatic lithotripsy group. There was no statistical difference between these groups with respect to the duration of surgery. However in meta-analysis done by Yin X et al; they found mean operative time [WMD=-16.86, 95%CI (-21.33, -12.39), p<0.00001], thus concluding that holmium laser lithotripsy required lesser time as compared to pneumatic lithotripsy group Jeon SS et al also found holmium laser superior requiring lesser time than pneumatic group. In their study the mean operation time in the holmium:YAG group (49.8 min) was shorter than that of the Lithoclast counterpart (76.9 min). However Razagghi MR et al found lithoclast took lesser time to fragment the stone as compared to laser group. They calculated only the duration of lithotripsy and found that, mean duration of lithotripsy was 13.7 ± 12.6 minutes in laser group and 7.9 ± 4.2 minutes in pneumatic lithotripsy group.

6)Size of stones: The width of the stone is the most significant measurement affecting the likelihood of spontaneous stone passage (Ueno et al, 1977). The 5-mm reference size has emerged as a breakpoint; when evaluating for passage, ureteral stones are generally categorized as greater than or less than 5 mm in greatest diameter. Hence we tried to find out whether size of stone affects stone clearance in either of groups following lithotripsy. The mean size of stone in Pneumatic group was 9.88 mm and in holmium group was 9.75 mm. There was no statistical difference with respect to size of stone in either groups. We then compared the stone size with stone clearance in both Pneumatic group and Holmium group and found no significant difference in either groups with respect to stone clearance. Logistical regression: We did logistical regression of stone location, stone size and type of lithotripsy and found that out of these 3, type of lithotripsy was most significant factor contributing to stone clearance.

CONCLUSION

Holmium laser lithotripsy emerges as a safe, efficacious modality for ureteric calculi management, outperforming pneumatic lithotripsy in overall stone clearance (95.5% vs. 81.0%) and particularly for proximal stones (96.3% vs. 66.7%), where retropulsion hampers

PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

pneumatic efficacy. Complications, surgical durations, and additional procedures showed no significant differences, though trends favor holmium with fewer interventions and migrations.

These findings, supported by logistic regression identifying lithotripsy type as the key clearance predictor, recommend holmium as the preferred method, especially for upper ureteral calculi. Comparative studies reinforce this, suggesting broader adoption could enhance outcomes in urological practice. Future research should explore cost-effectiveness and long-term follow-up to refine guideline

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