Comparative study between Laser lithotripsy and pneumatic lithotripsy in endoscopic management of ureteric stones

Thesis Submitted In Fulfilment for the Master Degree in Urology

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Abstract

Objective: This study compares the results of Holmium laser and pneumatic intracorporeal lithotripsy for ureteric calculi in terms of efficacy, safety and complications.

Methods: The study included 40 patients divided into two equal groups of laser lithotripsy (LL) and pneumatic lithotripsy. The study was conducted between April and December 2009. Inclusion criteria were patients with a ureteric stone 0.5-2 cm. and negative urine culture. KUB and ultrasound were mandatory. IVU or non contrast CT when required. Procedures were done under spinal or general anaesthesia. Rigid ureteroscope was used in all cases. Holmium laser with 550 µm wide fibre was employed in laser group with pulse energies of 0.6 to 1.2 J and pulse rates of 5 to 15 Hz. Swiss Lithoclast was used in PL group. Post operatively patients underwent KUB or spiral CT to assess stone free rate.

Results: The mean stone size was comparable in both groups 1.3 cm. the stone free rate was 95% in LL and 85% in PL. Stone migration occurred in 3 cases in PL and in 1 case in LL. Ureteric perforation occurred in 1 case in each group.

Conclusion: LL is a superior technology compared to PL in term of stone clearance and complications.

Key words: ureter, ureteroscopy, lithotripsy and calculi

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List of abbreviation

CT	Computed tomography
EHL	Electro hydrolic lithotripsy
ESWL	Extra corporeal Shock Wave Lithotripsy
Fr	French
g/day	Gram/day
Holmium YAG	Holmium: yttrium Aluminum Garnet
Hz	Hertz
IVP	Intra venous pyelography
J	Joule
N/A	Not available
PNL	Percutaneous Nephrolithotomy
RNA	Ribo Nucleic Acid
URS	Ureteroscopy
US	United States
USA	United States of America
UTI	Urinary tract infection
V	Volt
SWL	Shock wave lithotripsy

Introduction

Urolithiasis is a health problem of worldwide importance. A variety of treatment options are available for ureteric calculi but there is increasing trend towards minimal invasive surgery.The introduction of Extracorporeal Shock Wave Lithotripsy (ESWL) in 1980 has revolutionized the treatment of both renal and ureteric calculi ***(Chaussy et al, 1984).***

In context of ureteric calculi, the combination of ureteroscopy and intra corporeal lithotripsy has proven to be a viable alternative to ESWL ***(Segura et al, 1997).***

The advancement of ureteroscopy and related working instruments to manipulate or fragment ureteral calculi has significantly increased treatment options for urologists ***(Singal & Denstedt , 1997).***
For stone fragmentation, a variety of lithotriptors can be used, including

- Ultrasonic lithotriptors
- Electrohydraulic lithotriptors
- Pneumatic lithotriptors
- Laser lithotriptors

Pneumatic lithotripsy and holmium: YAG lithotripsy have reported favourable outcomes. A rather simple principle of the jackhammer has enabled Lithoclast lithotripsy to be a safe and effective method of stone treatment ***(Denstedt et al, 1995)*** .Thus the lithoclast has become a wide spread tool for fragmentation of urinary stones. However it has some disadvantages. Semirigid probe requires a rigid or at least semirigid ureteroscope and there is a high possibility of undesired retrograde displacement of the calculus ***(Vorreuther et al, 1998).***

Recent development of a flexible nitinol probe offers the potential for combining lithoclast with flexible ureteroscopy ***(Delvecchio et al, 2000).***

The holmium: YAG laser has excellent stone fragmenting properties and as a result, it is now a well established modality of intracorporeal lithotripsy ***(Teichman et al, 1998)***. Holmium laser light can be transmitted through a thin, flexible fibre compared with instruments for mechanical stone fragmentation. Holmium: YAG lithotripsy depends on photothermal mechanism for stone fragmentation`, thus the risk of retrograde stone propulsion could be minimized but it may cause thermal injury to the ureter if used carelessly ***(Vassar et al, 1999).***

The mechanism of Holmium: YAG lithotripsy is photothermal ***(Vassar et a, 1999)***. Holmium :YAG energy heats the stone to a critical thermal threshold at which the stone composition is altered yielding a stone crater and small fragment ***(Teichman et al, 1998)*** therefore ,undesired upward migration of stone or fragments can be minimized ***(Teichman et al, 1997)***

Pneumatic lithotripsy fragments calculi with a mechanism similar to that of a pneumatic jackhammer ***(Denstedt et al, 1992).***Compressed air propels a small projectile against the probe ,causing the probe to oscillate back and forth at a frequency of 12 cycles per second .fragmentation occurs as the probe tip repeatedly impacts the stone ***(Vorreuther et al, 1998)***

Chapter (I)

Anatomy of the ureter

Anatomic Relationships

The ureter begins at the ureteropelvic junction, which lies posterior to the renal artery and vein. It then progresses inferiorly along the anterior edge of the psoas muscle. Anteriorly, the right ureter is related to the ascending colon, caecum, colonic mesentery, and appendix. The left ureter is closely related to the descending and sigmoid colon and their accompanying mesenteries. Approximately a third of the way to the bladder the ureter is crossed anteriorly by the gonadal vessels. As it enters the pelvis the ureter crosses anterior to the iliac vessels. This crossover point is usually at the bifurcation of the common iliac into the internal and external iliac, thus making this a useful landmark for pelvic procedures.

Given the proximity of the ureters to several bowel segments, malignant and inflammatory processes of the terminal ileum, appendix, right or left colon, and sigmoid colon may involve the ureter. Effects can range from microhematuria to fistula or total obstruction. Within the female pelvis, the ureters are crossed anteriorly by the uterine arteries and are closely related to the uterine cervix. This location places the ureters at risk during hysterectomy. Pathologic processes of the fallopian tube and ovary may also encroach on the ureter at the pelvic brim***.(Anderson et al, 2007)***

Normal Variations in Ureteral Calibre

The normal ureter is not of uniform calibre, with three distinct narrowings classically described: the ureteropelvic junction, crossing of the iliac vessels, and the ureterovesical junction. At the ureteropelvic junction, the renal pelvis tapers into the proximal ureter. In many cases, this perceived narrowing may be more apparent than real, with no evidence of obstruction evident on radiographic or endoscopic investigation. The second region of narrowing occurs as the ureter crosses the iliac vessels. This is due to a combination of extrinsic compression of the ureter by the iliac vessels and the necessary anterior angulation of the ureter as it crosses the iliac vessels to enter into the pelvis. There is also no intrinsic change in the ureteral caliber at this location. The third site of narrowing observed in the normal ureter is the ureterovesical junction. There is a true physical restriction of the ureter as it makes the intramural passage through the bladder wall to the ureteral orifice. These three sites of ureteral narrowing are clinically significant because they are common locations for urinary calculi to lodge during passage. In addition, the angulation of the ureter, first anteriorly as it passes over the iliac vessels, then posteromedially as it enters the pelvis and courses behind the bladder, may restrict successful passage of rigid endoscopes. Appreciation of this normal angulation and the three-dimensional course of the ureter is critical for safe and successful ureteral endoscopy. ***(Anderson et al, 2007)***

Ureteral Segmentation and Nomenclature

The ureter is often arbitrarily divided into segments to facilitate ureteral description. The simplest system divides the ureter into the abdominal ureter extending from renal pelvis to the iliac vessels and the pelvic ureter extending from the iliac vessels to the bladder. Alternatively, the ureter can be divided into upper, middle, and lower segments. The upper ureter extends from the renal pelvis to the upper border of the sacrum. The middle ureter comprises the segment from the upper to the lower border of the sacrum. The lower (distal or pelvic) ureter extends from the lower border of the sacrum to the bladder ***(Drake et al, 2005.)***

Ureteral Blood Supply and Lymphatic Drainage

The ureter receives its blood supply from multiple arterial branches along its course. Of greatest importance to the surgeon is that arterial branches to the abdominal ureter approach from a medial direction whereas arterial branches to the pelvic ureter approach from a lateral direction. For the upper ureter these branches originate from the renal artery, gonadal artery, abdominal aorta, and common iliac artery. After entering the pelvis, additional small arterial branches to the distal ureter may arise from the internal iliac artery or its branches, especially the vesical and uterine arteries, but also from the middle rectal and vaginal arteries. After reaching the ureter, the arterial vessels course longitudinally within the periureteral adventitia in an extensive anastomosing plexus. It is this longitudinal vascularity that allows the ureter to be safely mobilized from the surrounding retroperitoneal tissues without compromising the vascular supply, provided that the periureteral adventitia is not stripped. The venous and lymphatic drainage of the ureter parallels the arterial supply. Thus, ureteral lymphatic drainage varies by ureteral level. In the pelvis, ureteral lymphatics drain to internal, external, and common iliac nodes. In the abdomen, the left para-aortic lymph nodes are the primary drainage site for the left ureter whereas the abdominal portion of the right ureter is drained primarily to right paracaval and interaortocaval lymph nodes. The lymphatic drainage of the upper ureter and renal pelvis tends to join the renal lymphatics and is identical to that of the ipsilateral kidney ***(Anderson et al, 2007)***

Ureteral Innervation

The exact role of the ureteral autonomic input is unclear. Normal ureteral peristalsis does not require outside autonomic input but, rather, originates and is propagated from intrinsic smooth muscle pacemaker sites located in the minor calyces of the renal collecting system. The autonomic nervous system may exert some modulating effect on this process, but the exact role is unclear. The ureter receives preganglionic sympathetic input from the 10th thoracic through 2nd lumbar spinal segments. Postganglionic fibers arise from several ganglia in the aorticorenal, superior, and inferior hypogastric autonomic plexuses. Parasympathetic input is received from the 2nd through 4th sacral spinal segments ***(Hinman et al, 1993).***

Pain Perception and Somatic Referral

Renal pain fibres are stimulated by tension (distension) in the renal capsule, renal collecting system, or ureter. Direct mucosal irritation in the upper urinary tract may also stimulate nociceptors. Signals travel with the sympathetic nerves and result in a visceral-type pain referred to the sympathetic distribution of the kidney and ureter (eighth thoracic through second lumbar**).** Pain and reflex muscle spasm are typically produced over the distributions of the subcostal, iliohypogastric, ilioinguinal, and/or genitofemoral nerves, resulting in flank, groin, or scrotal (or labial) pain and hyperalgesia, depending on the location of the noxious visceral stimulus ***(Anderson et al, 2007)***

Chapter (II)

Urinary Lithiasis

Classification of Nephrolithiasis

The most common component of urinary calculi is calcium, which is a major constituent in nearly 75% of stones. Calcium oxalate makes up about 60% of all stones; mixed calcium oxalate and hydroxyapatite, 20%; and brushite stones, 2%. Both uric acid and struvite (magnesium ammonium phosphate) stones occur approximately 10% of the time, whereas cystine stones are rare (1%) ***(Wilson, 1989).*** Stones associated with medications and their by-products such as triamterene, adenosine, silica, indinavir, and ephedrine are very uncommon and usually preventable.

Table (I): Stone Composition and Relative Occurrence

Stone Composition	Occurrence (%)
Calcium-Containing Stones	
Calcium oxalate	60
Hydroxyapatite	20
Brushite	2
Non–Calcium-Containing Stones	
Uric acid	7
Struvite	7
Cystine	1–3
Triamterene	<1
Silica	<1
2,8-Dihyroxyadenine	<1

(Pearle et al, 2005)