Minimally Invasive Therapy 1993: 2: 23–26

The Verapulse holmium surgical laser in clinical urology: a pilot study

D.R. WEBB MS, FRACS, R. KOCKELBURGH MB, ChB, FRCS(Ed)* & W.F. JOHNSON FRACS

*Departments of Urology and *Surgery, Royal Melbourne Hospital, Parkville, Victoria, Australia*

Summary. Fifty-one cases of Verapulse holmium laser treatment of various urological conditions are presented. The laser was easy to use and was equally effective through fluid and carbon dioxide media for soft tissue ablation, lithotripsy and laparoscopic surgery. The laser demonstrated precision haemostatic cutting and was particularly suited to superficial ablation of lesions in the bladder and urethra and for the fragmentation of ureteric calculi. Its minimal depth of penetration (less than 0.5 mm) meant that conventional diathermy and lithotripsy techniques are still superior for the cutting of large volumes of tissue and for the fragmentation of large renal calculi. In three patients the holmium-YAG laser was able to ablate small superficial recurrent tumours using sedo-analgesia alone. We feel this laser warrants further investigation as an urological laser and may have applications in other fields of endoscopic surgery.

Keywords: holmium laser, laser lithotripsy, urethrotomy, endopyelotomy, flexible cystoscopy, interstitial cystitis

Introduction

Lasers have been applied in clinical urology for more than 12 years [1]. Despite this long period of time lasers have not achieved a definitive position in urological practice. The majority of lasers have been single purpose, expensive, not universally applicable across the urological spectrum or to other specialities, and in most instances have not demonstrated a distinct therapeutic advantage over conventional electro-diathermy or lithotripsy techniques.

It was of great interest therefore to observe the versatile characteristics of the Verapulse holmium laser in ENT, gynaecological and orthopaedic surgery, and also through the laparoscope in which the precise cutting, coagulation and lithotriptic energy could be applied along fine flexible quartz fibres or rigid probes through air and fluid. These properties suggested a potential application to urology and in this paper we present 51 patients who were treated by the Verapulse holmium laser between September 1991 and July 1992.

Correspondence: Mr D.R. Webb, Department of Urology, Royal Melbourne Hospital, Parkville, Victoria, Australia.

Materials and methods

All patients were treated with the Coherent Verapulse 2.1 Surgical Laser (Coherent, Palo Alto, California, USA), a holmium laser operating at a wave-length of 2.1 μm (near infra-red range). The laser has a maximum power of 32 watts (W) using different pulse rates (8 to 20 per second) and various energy settings (0.6 to 2.0 joules). These were varied depending on the treatment situation and tissues involved (Table 1). The energy was delivered through fine flexible quartz fibres of 3 F diameter or via the straight Lapratome (Coherent).

Fifty-one patients were treated; 33 were male and 18 female with a mean average age of 55 years old (age range 19 to 86). The conditions treated are detailed in Table 2. All patients were treated under general anaesthesia except three with known small recurrent superficial low grade transitional cell tumours who underwent laser ablation via a Pentax flexible cystourethroscope

Table 1. Parameters for Verapulse holmium laser.

Operation	Joules		Pulses/second		Examples
	From	To	From	To	
TURBT	1.2	1.6	12	16	1.2/12 (14.4 watts) 1.2/14 (16.8 watts)
Ureterolithiasis	0.6	1.0	8	20	0.6/12 (9.6 watts) (0.8/10 (12 watts)
Pyeloplasty	1.2	1.6	12	14	
Laparoscopic surgery	1.2	1.6	14	16	1.2/14 1.4/14 1.2/16
Meatotomy/ stricture	1.2	1.6	12	16	
Penile warts etc. (external)	1.0	1.4	10	14	

TURBT, trans-urethral resection of bladder tumours.

(16 F) using 1% topical xylocaine urethral jelly and midazolam sedation alone.

These fibres all cut directly ahead except in the last two cases of bladder neck incision and percutaneous pyeloplasty in which a prototype 70 degree deflecting quartz fibre was used. The laser energy was directed into the target with the aid of a red helium neon (HeNe) aiming beam either by direct contact or from a short distance. All treatments were performed entirely under vision using saline irrigation. As the procedures were endoscopic and the laser was optically safe, glasses and shielding were not required.

This laser is FDA approved as retina safe and can be used without safety goggles or glasses, at the discretion of the laser safety officer. This is due to the fact that it is fibre-optic delivered, has a 0.4 mm thermal penetration depth, is highly absorbed in water and has a divergent cone angle of 27 degrees. The operator would need to stand 10 cm or closer to the laser to receive any significant thermal penetration.

In the kidney and bladder the quartz fibre tip was manipulated onto the tissue or calculus using the Storz (Tuttlingen, Germany) Laser Scope bridge through a 21 F panendoscopy sheath or 20 F visual urethrotomy sheath. For renal calculi, the fibre was passed along the channel of a Wolf (Knittlingen, Germany) operating nephroscope. Ureteric stones were treated by direct contact with the fine 400 μm fibre passed through the instrument channel of a 9.5 F Wolf ureteroscope.

Table 2. Conditions treated by the Verapulse holmium surgical laser.

Organ	Condition	Treatment	No.
Kidney	First degree PUJ obstruction	Percutaneous endopyelotomy	3
	Calculus Ca/oxolate cystine struvite	PCNL	3
Ureter	Calculus	Ureteroscopic lithotripsy	10
Bladder	TCC pTa pT_1	TURBT-ablation	1
		Flexible cystoscopic ablation LA	3
	Interstitial cystitis	TU-ablation	2
	Ureterocoele	TU-incision	1
	Impacted calculus	Ureteric meatotomy	1
	Bladder neck obstruction	TURBN-incision	1
			(23)
Urethra	HPV condylomata (20+)	TU-ablation	1
	Bulbar stricture	Visual urethrotomy	1
Abdomen (laparoscopic)	Stress urinary incontinence	Colpo suspension	3
	Cancer of the prostate	RPLND	3
	Large ureteric calculus	Trans-abdominal ureterolithotomy	3
	Huge renal cyst	Marsupialization	1
			(51)

PUJ, pelvi-ureteric junction. PCNL, percutaneous nephrolithotomy. TCC, carcinoma *in situ*. pTa, PT_1, superficial TCC on IUCC staging system. TURBN, trans-urethral bladder neck. TU, trans-urethral. HPV, herpes papovirus. RPLND, retroperitoneal lymph node dissection.

Laparoscopic procedures were performed using standard CO_2 insufflation. The laser energy was applied via the Laparatome inserted through a purpose built 'trumpet' irrigation/aspiration instrument to allow smoke aspiration through a 5 mm abdominal instrument port.

Results

The laser was applied using familiar urological instrumentation and irrigation medium with the added simplicity and comfort of not requiring safety eyewear. Those factors made its application both straightforward and comfortable. There was no significant tissue damage or other complications from the laser therapy. The specific observations for each condition were as follows.

Kidney

Endoscopic laser division of the pelvi-ureteric junction (PUJ) obstructions were precise, avascular and without charring. The layer by layer division through the PUJ enabled complete visualization during the cutting procedure. No incisions or energy were delivered outside the serosa of the collecting system, thereby avoiding potential segmental or major vessel damage. The 70 degree deflecting fibre further simplified and improved the ease of division with its ability to cut at an angle to the endoscope within the small confines of the PUJ and upper ureter.

Three renal calculi were treated. They were all particularly hard, one being dense struvite, the other calcium oxalate which had not fragmented after 2500 shock waves on the Dornier (Germering, Germany) MPL 9000 lithotripter and one pure cystine calculus. The 1.2 cm cystine stone fragmented rapidly and easily. The harder stones were both easily penetrated by the laser energy, the fibre drilling deep shafts into the depth of the stone but not actually fragmenting it into smaller pieces for extraction. Following laser penetration subsequent ultrasonic lithotripsy was straightforward. Despite extensive laser lithotripsy to these calculi for over 20 min, there was no observable bleeding, oozing or soft tissue damage.

Ureter

In contra-distinction to the larger renal calculi, all ureteric stones except the first stone treated, fragmented easily. This calculus was large (2.5 by 1.5 cm) and we had some difficulty applying the laser tip to the calculus. With experience this was overcome and we learnt that optimal lithotripsy in the ureter was obtained with lower energy settings (0.6 joules) and higher pulse frequency settings (up to 20 pulses per second). All other calculi fragmented into small particles for extraction or spontaneous passage. There was no tissue damage. The fine fibre (400 μm) allowed excellent irrigation via the smaller 9.5 F ureteroscope channel and this combined with no endothelial oozing or bleeding created an excellent visual field. The fibres were placed in contact but did not require pressure to fragment the stones. It was therefore quite unnecessary to immobilize the calculus and the minimal irrigation required resulted in no calculi being flushed out of the field of vision.

Bladder and urethra

Twenty-five of the 41 endoscopic (non-laparoscopic) or 61% of all laser applications were to the bladder, prostate and urethra, the majority (18 out of 25) for transitional cell carcinoma of the bladder. There were no complications such as perforation, bleeding or obturator spasm, and the application with the cystoscope deflector was accurate and simple. Small, flat and non-bulky tumours were easily ablated over quite large areas. Conversely, large bulky tumours (two) were coagulated slowly and lasering was abandoned in favour of resection by diathermy loop. However, all small tumours were quickly and adequately ablated, even over quite large areas. Of particular interest was the ability to ablate three small known low grade superficial tumours using only urethral local anaesthetic (1% xylocaine) and midazolam sedation with little or no patient discomfort through the flexible cystoscope.

Ablation of Hunner's ulcers was particularly effective, as minimal irrigation was required to perform the ablation, obviating the need for early distention of the bladder. This meant that the field was not complicated by bleeding or oozing and the entire area of ulcers, even in these thin bladders, was completely sealed. There were no perforations, even in one patient in whom nearly 40% of the total bladder area was lasered. Hydrodilatation following laser ablation caused little bleeding and chronic sufferers treated achieved an excellent symptomatic response.

The 70 degree prototype fibre performed a deep bloodless bladder neck incision quickly and simply. However, the fibre proved inadequate for incision of a fibrous, thick (4 mm) walled ureterocoele. The shallow tissue penetration meant the division was possible but lengthy and so was abandoned and conventional electro-cautery loop resection performed.

Placement of the fibre tip on small lesions in the urethra such as condylomata was accurate and particularly suitable for pinpoint ablation of these viral lesions. The laser easily divided a dense, collagenous bulbar urethral stricture with no tissue charring or bleeding.

Laparoscopy

The Verapulse holmium laser cut both peritoneum and tissues with precision and provided haemostasis through carbon dioxide without difficulty. Initially some smoke production was a problem but this was overcome using the sheath smoke aspirator. The ability to precisely cut and coagulate tissue by light touch only or by close apposition was particularly useful for division of the peritoneum and dissection of structures such as the ureter, as these qualities obviated the need to lift up or immobilize the organ involved. The combination of cut and coagulation is of particular importance for laparoscopic surgery where even minimal oozing is tedious. The tip of the Laparatome does not heat and therefore char. Hence there is no tissue adherance and no need to remove the tip for

cleaning. These factors combined with the constant cutting and coagulation effect enhance the ease of use.

Discussion

Our early experience with the Verapulse holmium laser suggests that it is particularly suited to urology owing to its ease of use, wide range of applications, precision haemostatic cutting and ablation, and lack of morbidity. This pilot study highlights the areas of potential application of the Verapulse holmium laser, including the management of small volume low grade bladder and urethral lesions and the ablation of large areas of bladder mucosa. The Verapulse holmium laser was particularly effective for the management of ureteric calculi. This is not surprising, given the good results of the single purpose pulsed dye laser previously reported for that purpose [2]. Also, of particular interest is a limited experience of local anaesthetic outpatient ablation of recurrent transitional cell tumours at the time of flexible check cystoscopy thus avoiding a subsequent inpatient admission, anaesthetic and duplicate endoscopy.

In general terms our initial experiences suggest that the place for the Verapulse holmium laser in urology is for conditions requiring fine touch, accurate cutting and small volume lithotripsy. These include recurrent superficial transitional cell tumours, superficial bladder and urethral lesions, PUJ incision, ureteric calculi and laparoscopy. Large calculi and bulky volumes of tissue at this stage appear to be better treated by conventional methods.

The Verapulse holmium laser is particularly suited to the bladder. Small volume pulses of irrigation prevent distention and bladder thinning thus decreasing the risk of perforation and bladder ooze. Normal saline is a safer medium than water and the absence of electrical current avoids obturator spasm, so large areas of bladder can be safely treated in the lateral wall peri-ureteric orifice areas without spasm or perforation. The fine fibre allows excellent irrigation through the flexible cystoscope and the narrow ureteroscope, and vision is further enhanced by the haemostatic-coagulative effect of Verapulse holmium ablation. All the small stones treated, no matter what composition or hardness, could be broken.

From this early experience we feel that the Verapulse holmium laser has potential advantages over conventional therapy in ureteric lithotripsy, small urethral lesions and superficial bladder lesions and requires further investigation for the out-patient treatment of recurrent superficial bladder tumours.

Acknowledgements

We wish to thank Messrs L. Harewood, L. Cleeve, A. Crosthwaite, D. Travis and Drs J. Goad and N. Redgrave for contributing patients to this series.

References

1 Staehler G, Hofstetter A. Transurethral laser irradiation of urinary bladder tumours. *Eur Urol* 1979; **5:** 64–9
2 Watson GM, Wickham JEA. Initial experience with a pulse dye laser for ureteric calculi. *Lancet* 1986; **1:** 1359–8