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Do High-Power Lasers Reduce Operative Time for Ureterorenoscopy? A Comparison of Holmium Lasers in An Australian Tertiary Centre

Romy F. Mondschein[1], Caitlin Ying Ming Louey[2], Amanda Yun Yee Ng[2], Philip McCahy[1]

[1]*Monash Health, Department of Surgery (Urology), Berwick, VIC, Australia*
[2]*Monash University, Department of Medicine, Clayton, VIC, Australia*

What's known on the subject? and What does the study add?

There is some laboratory-based evidence that high-powered laser systems destroy stones more effectively than low-power laser systems. However, whether this translates clinically is unknown, as direct clinical comparisons are absent from the literature. This study provides a direct comparison of the two laser systems.

Abstract

Objective: Holmium lasers are an effective endoscopic treatment for renal stones. Although laboratory studies have demonstrated reduced destruction times for high-power lasers, clinical evidence is lacking. Operative times for ureterorenoscopy (URS) were investigated by comparing high- and low power lasers in a general hospital setting.

Materials and Methods: An audited review was conducted of 354 patients who underwent URS over a two-year period at two hospital sites using high- or low power laser. Operative time, stone characteristics, disposable equipment, s use of dusting, complications and stone-free rates were recorded. Linear regression was used to model the relationship between laser type and theater time. Univariate analysis was performed to determine other factors associated with increased operative time.

Results: Mean operative time was 61.9 minutes. No significant difference between sites [0.40, p=0.88, confidence interval (CI) -4.9-5.8] was found, including following the exclusion of large stones (>20 mm). Stone size categories analyzed separately showed reduced operative times for larger stones when using high-power laser. Basket use (8.4, p=0.002, CI 3.06-13.65) and increasing stone size (6.9, p<0.005, CI 3.4-10.4) were associated with increased operative time. Complications and stone-free rates did not vary between sites.

Conclusion: High-power laser was not associated with reduced total operative time in this cohort, although there was a trend toward this for larger renal calculi. Further delineation by surgeon expertise would be useful to determine whether high power laser is generally advantageous in the clinical setting. In training hospitals, any differences may be obscured by other factors.

Keywords: Ureterenoscopy, endoscopy, operative time

Introduction

Holmium lasers came into use in the 1990's and have proven to be cost effective, safe and effective treatment of ureteric and renal stones (1). Endoscopic interventions currently account for the largest proportion of stone procedures conducted in Australia (2). Renal stone disease in Australia, as in other western countries, is a significant and increasing financial burden (3) that will need to be managed across public and private sectors in coming years. The use of equipment associated with fewer complications, maximal stone clearance and efficient utilization of theater time will be key to minimizing the cost of endoscopic stone treatments in coming years (3).

Holmium lasers come in various guises with wattage (W) representing the main point of difference. Laser settings for stone destruction are relatively limited when using low-powered lasers (4). 10-20 W systems can be used to fragment stones, resulting in multiple particles (5). Large fragments often require basket retrieval and access sheath insertion, both of which add to operative time, procedure cost and potential complications including ureteric damage (6).

Correspondence: Romy F. Mondschein MD, Monash Health, Department of Surgery (Urology), Berwick, VIC, Australia
Phone: +614 76376456 **E-mail:** rmondschein2@gmail.com **ORCID-ID:** orcid.org/0000-0003-4231-414X
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High-power lasers can deliver more energy (up to 120 W) at higher frequencies. This allows more variation in laser settings, including the ability to dust stones with low-power high-frequency settings (1,7). Dusted stones may result in fewer large fragments, increasing the likelihood of spontaneous passage without the need for multiple procedures to clear a single stone (8). Additionally, resulting in smaller fragments may not require basket retrieval, reducing costs and complications associated with baskets and access sheaths (1). Finally, high-power lasers allow pulse width variation, which can reduce retropulsion. Resulting improved control of renal stones during procedures could reduce operative time (1).

These combined advantages of high-power lasers may result in reduced total operative time. Time in theater is costly and associated with increased complications (9,10). There is some laboratory-based evidence that high-powered laser systems destroy stones more effectively (11). However, whether this translates clinically is unknown, as direct clinical comparisons are absent from the literature. Operative time comparisons must date been based on the results of individual arms of separate studies, with no differences identified (12). In practice, many factors contribute to increased time in theater, encompassing patient, stone, surgeon and anesthetic attributes. Many of these influences are unmodifiable, particularly in a public hospital setting. Given the deficit of clinical evidence supporting the adoption of high-power laser technology, this study compares operative times for high and low-powered lasers within the public hospital system. Secondary aims were to identify other factors associated with increased operative time and compare complication rates between these devices.

Materials and Methods

An audited review was undertaken of 354 consecutive patients who underwent ureterorenoscopy (URS) performed under general anesthetic for stone disease over a two-year period. Procedures were conducted at two hospital sites that utilized either the Lumenis Pulse 120 W (Lumenis, Israel) or 30 W laser (Dornier MedTech Gmbh, Germany) laser. Specific laser settings used for each procedure were not available. The two sites were training hospitals as part of the same metropolitan public hospital network and subject to similar operative conditions and patient population. Operative time was extracted from anesthetic records. Data describing stone burden, composition, location and use of disposable equipment (access sheath, baskets and stents) were collected, in addition to demographic data. Stone size was based on the maximum diameter from computed tomography scans and calculated cumulatively if there were multiple stones. Use of the dusting technique, the length of admission, complications and post-operative stone-free rates were recorded.

Statistical Analysis

Data were analyzed using Stata 16.0. Descriptive statistics of the cohort were obtained and compared to ensure no significant differences between sites. Linear regression was used to model the association between the mean operative time and laser type. Univariate logistic and linear regression analyzes were performed to determine other factors that may be associated with increased operative time. Logistic regression was used to model relationships between laser type and complications, use of baskets and dusting. The relationship between laser type and operative time was modeled for each category of stone size to assess for effect modification from stone burden, and the relationship between laser type and operative time for stones less than 2 cm in size only was modeled using linear regression.

This study was approved by the institution's Human Ethics and Research Committee (RES-19-0000-593Q).

Results

Cohort Characteristics

354 individual patients were identified Table 1. More procedures occurred at the high-power site (n=195, 55.08%) compared with the low power site (n=159, 44.92%). 81% (n=287) patients underwent one URS, 17% (n=6) went on to undergo a second procedure. There were no significant differences in baseline characteristics between the two sites other than an over-representation of large stones (>2 cm) at the high-power site (12.7% compared to 6.6%), although this difference was not statistically significant. Most stones were located intrarenally Table 2.

Table 1. Baseline characteristics of the cohort subdivided by laser

Baseline characteristics	High-power site		Low-power site	
	Mean	Range (standard deviation)	Mean	Range (standard deviation)
Age (n=354)	53.8	18.0-83.0 (14.9)	54.3	20.0-89.0 (6.9)
BMI (n=335)	30.1	18.8-58.4 (6.3)	28.4	17.2-65.8 (6.6)
Stone size (n=344)	10.7	3.0-65.0 (7.7)	11.2	4.0-37.0 (6.0)

BMI: Body mass index

Operative Time and Lasers

The mean operative time was 61.9 minutes. No significant difference in mean operative time was found between the two sites [difference 0.40 minutes, p=0.88, confidence interval (CI) -4.9 - 5.8]. Due to the over-representation of large stones (>2 cm) at the high-power site, mean time difference between sites was modeled excluding stones >2 cm; still, no significant difference was identified (0.03 minutes, p=0.99, CI -5.4 - 5.5). Across the cohort, stone size increased operative time, adding 7 minutes for each increase in size category (p<0.001, CI 3.4 - 10.4 minutes) (Table 3). The relationship between operative time and laser type was modeled for each stone size category separately, to assess for effect modification from varying stone burden. There was a trend toward high-power laser reducing operative time for large stones, but the relationship did not reach significance Table 4. Stone composition data were available for a third of the cohort. There was no relationship between operative time and stone composition. Calcium oxalate stones comprised 50% of stones for which composition data were available Table 5.

The reported use of dusting at the high-power site was associated with a reduction in operative time of almost 8 minutes (-7.8 minutes, p=0.05, CI -15.5 - -0.12). The reported use of dusting did not significantly affect operative time at the low-power site (1.05, p=0.80, CI -7.27 - 9.37). Dusting was reported more frequently in the high-power cohort [odds ratio (OR) 3.9, p<0.005, CI 2.5-6.1].

Table 2. Stone location	
Location	**% (n)**
Ureteric	13.4 (47)
Pelviureteric junction	5.7 (20)
Intrarenal	63.1 (222)
Multiple locations	17.9 (63)

Operative Equipment and Lasers

Laser type did not significantly affect basket use (OR 1.16, p=0.48, CI 0.76 - 1.78). Basket use decreased by 35% for procedures that reported dusting compared to those that did not (OR 0.65, p=0.05, CI 0.42 - 0.99), however, subdivided by site, this was only significant for the low-power laser (OR 0.48 p=0.055, CI 0.23 - 1.02)

Operative Time and Adjunct Equipment Table 5

Stone Clearance and Complications Table 6

There was a trend toward higher likelihood of adequate stone clearance post-URS (no fragments >4 mm) at the high-power site, although the relationship did not reach significance. This assessment was based on post-operative CT or XR KUB conducted usually 6-12 weeks post URS. Overnight stays were more likely at the high-power site, although numbers were low across the cohort (7.4%). There were fewer complications at the high-power site although again the difference did not reach significance. Across the cohort, there were 30 complications, including post-operative sepsis (11), mucosal trauma (7), intra-operative bleeding affecting vision (10), one pseudoaneurysm and one post-operative myocardial infarction (8.55% complication rate).

Discussion

Urolithiasis represents an increasing burden on healthcare systems throughout the western world (2). With significant financial implications associated with efficient use of operative

Table 3. Operative time for high-power compared to low-power laser for increasing stone size

Stone size	Total % of stones	HP site minutes	LP site minutes	Difference (min)	p-value (CI)
<6 mm	11.3	49.6	51.7	2.08	0.73 (-14-4-10.8)
6-10 mm	53.8	61.6	61.2	0.40	0.92 (-7.06-7.87)
11-20 mm	28.8	60.6	64.2	-3.60	0.46 (-6.0-13.3)
>20 mm	6.1	49.5	65.0	-15.5	0.23 (-10.4-41.3)

CI: Confidence interval

Table 4. Adjunct equipment used

Item	HP site (%, n)	LP site (%, n)	Total (%)	Effect on operative time	p-value (CI)
Stent pre-ureterorenoscopy	61.0 (119)	78.6 (125)	68.9 (244)	-4.0 minutes	0.18 (-9.8-1.90)
Stent post-ureterorenoscopy	93.7 (178)	88.0 (140)	91.2	+8.3 minutes	0.09 (-1.2-17.90)
Basket	46.2 (90)	42.4 (67)	44.5 (157)	+8.4 minutes	0.002 (3.06-13.65)
Access sheath	82.6 (157)	82.4 (131)	82%	-1.6 minutes	0.66 (-8.7-5.54)

CI: Confidence interval

time (13), identifying equipment associated with efficiency in theater is of great benefit. With various Holmium lasers available for use in Australia, we assessed the potential time-benefits of upgrading to a high-power laser system in the public hospital setting. To our knowledge, this is the only comparison of laser type and operative times in a public hospital setting in Australia.

No significant difference in operative times because of using the high-power 120 W Holmium laser compared to the lower-power laser was noted in the public hospital setting, although there was a trend toward shorter times for larger calculi. Basket use and increasing stone size were independently associated with increased operative time. The reported use of dusting was significantly associated with shorter operative time at the high-power site. Complications and overnight admissions did not vary significantly between laser type. This study benefited from access to complete medical, anesthetic and operative records for patients who underwent ureterenoscopy with one of two commonly used lasers, within the environment of a single hospital network. However, the retrospective nature of this study was in some ways limiting.

Study Limitations

Sufficient data describing the training level of the primary operator in addition to contributions and level of supervision from senior surgeons could not be obtained. At the consultant level, it is possible that high-power laser techniques could consistently reduce operative time. However, in training hospitals where surgeons have varied levels of confidence and familiarity with not only lasers but also adjunct equipment, any advantage of high-powered lasers may be overshadowed. A prospective study could delineate the benefits of high-power lasers further by using either a single surgeon or collecting data on the level of training.

Table 5. Stone composition			
Composition	**HP site**	**LP site**	**Total %, n**
Data unavailable	68.3%	68.8%	68.8, 225
CaOx	13.9%	18.1%	15.6, 51
CaOxPhos	5.6%	7.6%	6.4, 21
CaOxPhosMg	4.4%	2.1%	3.4, 11
Uric acid	1.7%	1.4%	1.5, 5
CaOx + uric acid	3.3%	1.4%	2.5, 8
Other combination compositions including cysteine and ammonia	2.8%	0.7%	1.8, 6

Knowledge of laser settings would have improved accuracy and allowed more definite conclusions to be drawn from the results. It was assumed that those at the high-power site utilized settings unique to the 120 W laser when appropriate, but this may not have always been the case. Deciding factors on whether to "dust" or fragment were not recorded by surgeons. Use of "dusting" was more commonly reported at the high-power site, however it was also reported at the low power site suggesting some subjectivity in the use of the technique and term (1). Some definitions of dusting in the literature refer to the laser settings used to achieve "dust", typically low energy, and high pulse rate (7). Others refer to "dusting" in terms of the result -fine fragments able to be passed spontaneously (8). Both are variable in the literature with reference to the exact settings that will best achieve dusting and the acceptable size of residual fragments (1). This may explain why dusting was associated with decreased basket use at the low-power site only -perhaps views differed on acceptable size of residual fragments between sites. At the high-power site, reported use of dusting was less than 50%. The high-power laser capability of dusting stones may have been under-utilised, potentially increasing operative time in this group. Surgeon experience and confidence with the high -power laser and associated dusting techniques may have influenced this finding. In the training hospital settings where 120 W lasers are less commonly available, laser-specific training may be needed to ensure high-power laser settings are utilized where appropriate. A prospective study design ensuring appropriate utilization of high-power technology features could alleviate this issue in future studies.

Utilizing anesthetic time as a proxy for operative time, rather than directly recording lasering time, was a necessity of our retrospective study design that could also have potentially obscured time benefits of high-powered lasers in stone destruction. Although direct collection of lasering time would provide a more accurate comparison of the effects of high-powered lasers *in vivo*, our results show that even if this benefit exists, it is still obscured (and over-all operative time unaffected) by other factors. Some prospective studies have recorded operative time only until fragmentation was complete,

Table 6. Admission, stone clearance and complications				
	Cohort (%, n)	**HP site (%, n)**	**LP site (%, n)**	**Difference between sites**
Overnight admission	7.4 (26)	8.8 (17)	5.7 (9)	OR 1.60, p=0.270, CI 0.69-3.70
Stone clearance*	41.6 (79)	43.6 (51)	38.4 (28)	OR 1.24, p=0.48, CI 0.68-2.26
Complications	8.55 (30)	6.7 (13)	10.8 (17)	OR 0.59, p=0.17, CI 0.28-1.26
*Data available for 54% of patients, OR: Odds ratio, CI: Confidence interval				

or focused on time spent lasering (14). The absence of this data does not detract from the result that in the training setting, any time saving still does not significantly influence total operative time. This is important because the time spent in theater is the largest contributor to the cost of treating renal stone (15). Total theater time is the target of reduction. A reduction in lasering time that does not result in decreased operative time is arguably not particularly valuable.

Finally, confidence in conclusions drawn regarding stone-free rates was low due to a significant amount of missing data. No follow-up imaging was available for around 46% of the cohort. Despite this, data on repeat ureteroscopy was complete and reassuringly showed that 81% of the cohort had one procedure alone. Subdivided by stone size, 61% of those who had more than one procedure had stones in the larger two size categories. Assuming stone-free rates correlate with repeat procedures, this is consistent with stone-free rates for single stage URS procedures quoted in the literature (1).

Importantly, missing follow-up data did not vary significantly between sites, nor was the reason for attrition expected to vary between sites. Complications appeared to occur more frequently at the low powered site although again the relationship did not reach significance. This supports at least comparable safety of high-powered lasers with low powered technology, even if no safety advantage resulting from shorter operative time was demonstrable.

Conclusion

High-power Holmium laser was not associated with reduced operative times in this patient cohort, although there was a trend toward this for larger renal calculi. High-powered lasers allow more confidence when utilizing “dusting” settings, which was reflected in the shorter operative times observed in the high-power laser arm when dusting was used. Prospective research assessing laser settings associated with optimal stone fragmentation and dusting is required in order to maximally utilization high-powered lasers. Further delineation by surgeon expertise would be useful to determine whether using a high-power laser is advantageous in the clinical setting generally. However, in training hospitals, our results suggest that any time advantage gained using a high-power Holmium laser may be obscured by other factors.

Ethics

Ethics Committee Approval: This study was approved by the institution’s Human Ethics and Research Committee (RES-19-0000-593Q).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: P.M., Concept: P.M., Design: P.M., Data Collection or Processing: R.F.M., C.Y.M.L., A.Y.Y.N., Analysis or Interpretation: R.F.M., C.Y.M.L., A.Y.Y.N., Literature Search: R.F.M., C.Y.M.L., A.Y.Y.N., Writing: R.F.M., C.Y.M.L., A.Y.Y.N., P.M.

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