

Preconceived Impressions Regarding Holmium: YAG Laser Safety in the Urology Operating Theatre

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Background: Since its introduction over two decades ago, the surgical laser has served in the lithotripsy of urinary calculi, resection of bladder tumours, bladder neck incisions, and prostate enucleation. Concerns regarding the safe use of holmium lasers have resulted in potentially excessive and overly precautionary theatre regulations. We aimed to evaluate the preconceived impressions and practice patterns at a single site surrounding laser use in endourology.

Methods: We designed a three-part online questionnaire that could be accessed using a smart device or computer. This survey was distributed to all theatre staff involved in laser surgery at our single site, including surgical, nursing, and anaesthetic staff of varying seniority. It asked questions regarding holmium laser safety, provided an up-to-date summary of published literature surrounding the safe use of lasers, and finally gave participants further option to alter the answers to several previously encountered questions.

Results: A total of 54 theatre staff completed the survey, including 17 theatre nurses (31.5%), 10 urology consultants (18.5%), 8 urology registrars (14.8%), 7 anaesthetic registrars (13%), 4 anaesthetic consultants (7.4%). About 51.9% of participants believed that current laser safety protocols were adequate, with 38.9% finding them excessive. After reading recently published information on laser safety, 22.2% thought current laser safety measures were adequate (57% decrease) and 77.8% found them to be excessive (100% increase). About 74.1% of participants found that laser safety goggles impair their vision and that 79.6% would choose not to wear them if they were optional.

Conclusion: Strict laser safety guidelines reflect an overestimated risk associated with using holmium laser in operating theatres. Laser safety regulations should be re-evaluated to align with current research and potential hazards inherent to the device. In doing so, a more effective distribution of staff could enable greater access to laser surgery, thereby reducing patient morbidity and hospital wait times.

Keywords: endourology, laser surgery, holmium laser

Background

Holmium:yttrium-aluminum-garnet (Ho:YAG) laser energy source is the cornerstone of endourology and minimally invasive interventions such as ureteroscopy, holmium enucleation of prostate (HoLEP), and transurethral resection of bladder tumours (TURBT).¹ The field of laser surgery is constantly evolving, incorporating different laser platforms, modifications such as pulse modulation and various energy sources such as holmium or thulium. With the incidence of stone disease increasing in recent years, there has been a shift towards primary ureteroscopy (URS) with laser lithotripsy in the acute setting. As the overall demand for primary laser surgery increases in the future, additional strain will be placed on the hospitals to provide emergency theatres that are deemed “laser safe” and staffed by laser qualified personnel. Despite the many benefits of laser use in urology, some disadvantages remain. Laser equipment is costly, the operating surgeon requires training, and strict safety precautions must be adhered to.²

The holmium laser is classified as a class 4 laser, meaning it can cause skin and eye damage from direct contact.¹ URS is regarded as a safe and effective procedure overall, however adverse events can occur and involve patients,

surgeons, and theatre staff alike. The majority of complications involve the patient, with ureteric injury, bleeding, thermal damage, and delayed ureteric stricturing being well reported and often correlate to user experience.^{2,3} Extracorporeal injury to the surgeon, patient, and theatre staff, however, is possible but less common.³ The majority of the literature on laser surgery focuses on outcomes and intra-operative complications. There is a scarcity of information on laser usage, practical considerations, and specific guidance on the correct set up and usage of the laser.⁴ This lack of discussion may contribute to the fear of laser usage in theatre and the strict safety measures that are implicated.

Concerns regarding the safety of holmium laser have recently been addressed and published as part of the Canadian Urological Association (CUA) best practice reports by Bhojani et al 2020,⁵ They report that in the last two decades, there have been no reported injuries associated with the use of Ho:YAG laser.^{2,3} Further, they refute the standardised mandatory wearing of laser safety goggles for all operating room staff, providing evidence that corneal injury from exposure to laser energy occurs at distances within 5cm and that prescription glasses are as protective as laser safety goggles.^{1,4} Here, we present a review of laser theatre staffs' opinions and preconceived notions regarding laser safety and protocols at our single site. Our goal was to characterise the preconceived impressions regarding laser safety held by all intraoperative staff, including anaesthetic and nursing staff. By advocating for an update to the stringent laser safety regulations, we aim to improve access to emergency and after-hours laser surgery to benefit both the patient and hospital system alike.

Methodology

We designed a short three-part questionnaire that could be accessed on smartphones or any computer (Table 1). The three-part survey was emailed to an institutional Email list comprising all doctors and nurses affiliated with urology surgery at our single site. Part one consisted of questions relating to laser safety. Part two allowed participants to view the summary and recommendations from the CUA best practice guidelines (Table 2). Finally, part three gave participants the option to re-evaluate their answers to part one (Table 1).

Data were collected anonymously through the survey application. Analysis of data and formulation of figures was performed by the lead investigator.

Results

Demographics

We had a total of 54 responses to our radiation safety quiz; the breakdown consisted of 17 theatre nurses (31.5%), 10 urology consultants (18.5%), 8 urology registrars (14.8%), 7 anaesthetic registrars (13%), 4 anaesthetic consultants (7.4%) (Supplementary Figure 1 in Supplementary File 1).

Institutional Laser Safety and Laser Utilisation

The majority of participants (57.4%) have undergone formal laser safety training (Supplementary Figure 2 in Supplementary File 1). About 61.1% of respondents had been involved in more than 20 procedures using Ho:YAG laser (Supplementary Figure 3 in Supplementary File 1).

Key Results

Just over half (55.6%) of responders answered true to the question – Eye damage can occur by looking into the “green light beam” even if the laser is not activated? (Figure 1). About 70.4% did not believe that normal prescription glasses would protect against laser-induced eye damage (Figure 2). Only 38.9% of respondents correctly answered <5cm for the question “If the laser fibre is activated and there is no intervening barrier (no fluid or solid), what is the minimum distance for the laser to cause damage? (Figure 3). About 74.1% of participants found that laser safety goggles impair their vision and that 79.6% would not choose to wear them if they were optional (Figure 4 + Figure 5). Prior to reading the CUA's best practice recommendations, approximately half (51.9%) of participants believed that current laser safety protocols were adequate, with 38.9% feeling they were excessive (Figure 6). After reading the findings, however, 22.2% thought current laser safety measures were adequate and 77.8% found them to be excessive (Figure 7).

Table 1 Laser Safety Survey Parts and Questions

	Question	Optional Answers
Part One	1 – Please select your role	<ul style="list-style-type: none"> ● Theatre nurse ● Anaesthetic consultant ● Anaesthetic registrar ● Anaesthetic technician ● Urology consultant ● Urology registrar ● Other with the option to specify role
	2 – Have you done laser safety training?	<ul style="list-style-type: none"> ● Yes ● No
	3 – How many urological procedures using Holmium laser have you participated in?	<ul style="list-style-type: none"> ● None ● 1–5 ● 6–20 ● More than 20
	4 – Eye damage can occur by looking into the “green light beam” even if the laser is not activated?	<ul style="list-style-type: none"> ● True ● False
	5 – Normal prescription glasses protect against eye damage?	<ul style="list-style-type: none"> ● True ● False
	6 – If the laser fibre is activated and there is no intervening barrier (no fluid or solid), what is the minimum distance to avoid injury?	<ul style="list-style-type: none"> ● 0.4cm ● 5cm ● 30cm ● 1m ● 5m
	7 – Do you find that laser safety glasses impair your vision?	<ul style="list-style-type: none"> ● Yes ● No
	8 – Based on the hazard posed by Holmium laser, how would you classify the current laser safety requirements?	<ul style="list-style-type: none"> ● Insufficient ● Adequate ● Excessive
Part two	Summary and Recommendations from CUA (Table 2)	
Part three	1 – After reading the summary and recommendations, how would you classify the current laser safety requirements?	<ul style="list-style-type: none"> ● Insufficient ● Adequate ● Excessive
	2 – If the use of laser safety glasses was optional would you choose to wear them?	<ul style="list-style-type: none"> ● Yes ● No

Table 2 Recommendations on Ho:YAG Laser Safety by the Canadian Urological Association

1	After over 20 years of extensive use, no eye injuries have ever been reported with the Ho:YAG laser.
2	Based on recent experimental data, it is evident that there is no damage to the unprotected eye unless the laser is fired very close to the eye (within 5 cm of the cornea).
3	Current evidence does not support mandatory safety eyewear for all personnel.
4	For operating surgeons who may already be wearing prescription glasses, laser goggles over glasses lead to significant visual impairment and could affect the surgeons ability to identify important visual cues.
5	Standard prescription eyeglasses are as protective as laser safety goggles.
6	Those who do not wear prescription glasses and may be in close proximity to the laser fibre (within 5cm) may wish to consider protective eyewear.

Note: Reprinted with permission from Bhojani N, Andonian S, Watterson JD, et al. Canadian urological association best practice report: holmium:YAG laser eye safety. *Can Urol Assoc J.* 2020;14(12):380–382.⁵

Eye damage can occur by looking into the “green light beam” even if the laser is not activated

54 responses

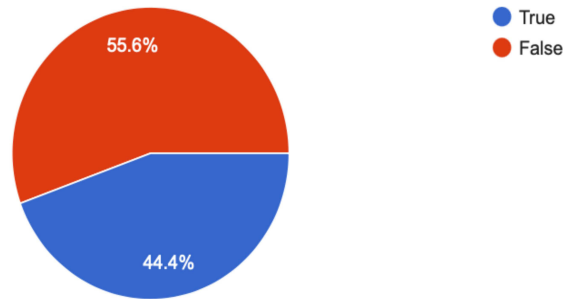


Figure 1 Responses to the above question “Eye damage can occur by looking into the green light beam even if the laser is not activated” expressed as a percentage of True/False.

Normal prescription glasses protect against laser induced eye damage

54 responses

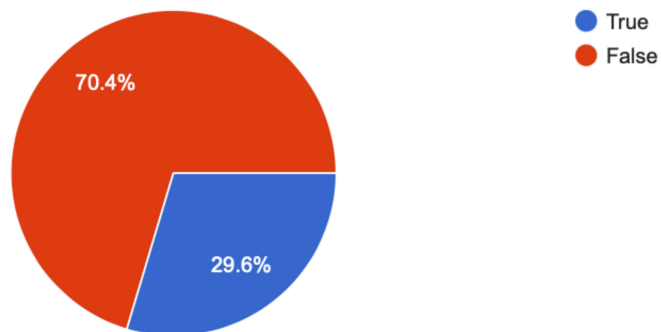


Figure 2 Responses to the above question “Normal prescription glasses protect against laser induced eye damage” expressed as a percentage of True/False.

If the laser fibre is activated and there is no intervening barrier (no fluid or solid), what is the minimum distance to avoid injury?

54 responses

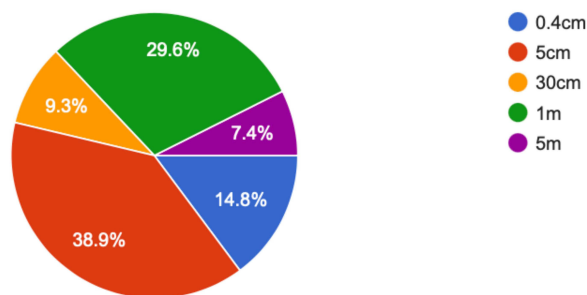


Figure 3 Responses to the above question “If the laser fibre is activated and there is no intervening barrier (no fluid or solid) what is the minimum distance to avoid injury?” represented as a percentage of total answers.

Do you find that the laser protection glasses impair your vision ?

54 responses

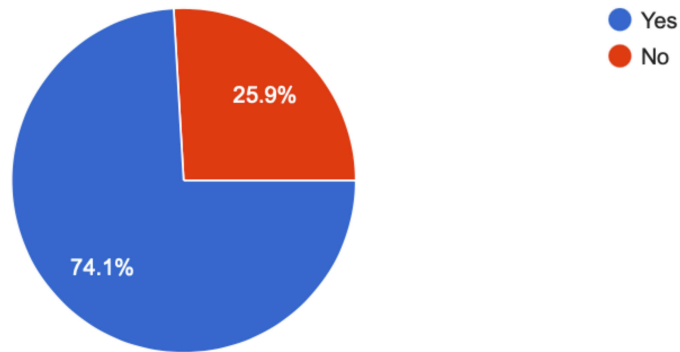


Figure 4 Responses to the above question “Do you find that the laser protection glasses impair your vision?” represented as a percentage of Yes/No answers.

Based on the hazard posed by holmium laser, how would you classify the current laser safety requirements?

54 responses

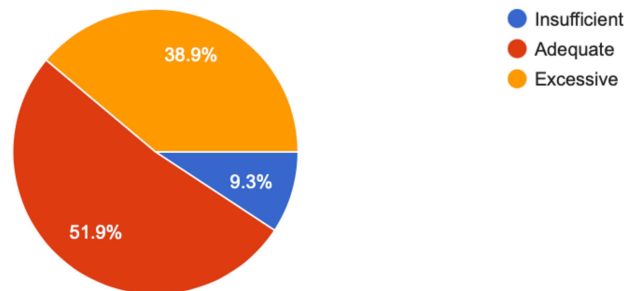


Figure 5 Responses to the above question “Based on the hazard posed by the holmium laser, how would you classify the current laser safety requirements?” represented as a percentage of Yes/No answers.

After reading the summary and recommendations, how would you classify the current laser safety requirements?

54 responses

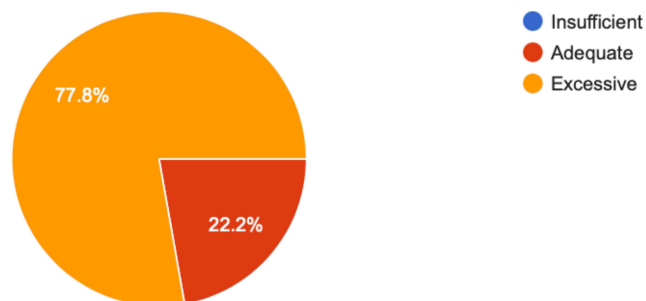


Figure 6 Responses to the above question “After reading the summary and recommendations, how would you classify the current laser safety requirements?” represented as a percentage.

If the use of laser safety goggles was optional would you choose to wear them?

54 responses

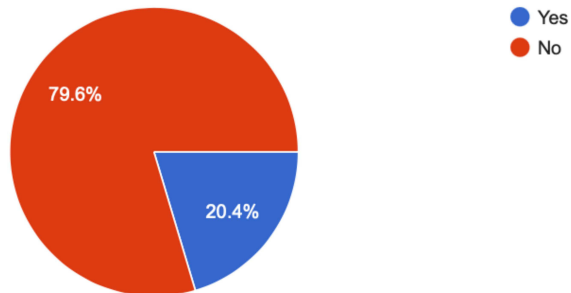


Figure 7 Responses to the above question "If the use of laser safety goggles was optional would you choose to wear them?" represented as a percentage.

Discussion

Laser technology has improved significantly in the last two decades, with holmium laser forming a cornerstone for a variety of endourological procedures.⁶ Risk factors for holmium laser adverse effects have been well described, relating to energy, pulse energy, and distance from the target to the laser fibre tip.⁷ Despite current data and recommendations for the update of laser safety protocols, outdated blanket laser safety policies remain. The occupational health and safety of staff and patients remains paramount, however modern policies need to reflect current evidence-based research to ensure that scarce hospital resources can be allocated effectively.

Despite the majority of staff completing laser safety training and having been involved in >20 laser cases, the vast majority of questions were answered incorrectly. This further highlights the limited understanding staff have on how lasers work in surgery and the safety measures needed to facilitate their usage. This lack of education and scarcity of up-to-date knowledge only perpetuates outdated notions on laser safety.

A study by Althunayan et al reviewed all adverse events attributed to laser surgery by utilising both the Rockwell Laser Industries Laser Accident Database from 1992 to 2012 and the mandatory reporting systems of adverse events developed by the US Food and Drug Administration.² With regard to operator/staff injuries attributable to the Ho:YAG laser, only 11 cases of minor skin burns have been reported and occurred due to firing a broken laser fibre. Importantly, no eye injuries have been reported during the 20-year history of the two databases. Furthermore, a study conducted by Villa et al used ex-vivo porcine eyes to establish at what distance a Ho:YAG laser would cause eye damage when conducted through room air. The study compared no protection to prescription eyeglasses and laser safety goggles at a variety of commonly used laser settings. This study determined that without eye protection, a Ho:YAG laser must be activated within 5cm of the eye to cause damage.⁸ Additionally, it was shown that prescription glasses and laser goggles were equally efficacious at preventing eye injury at all distances and all laser power settings.⁸ It is important to recognise that these findings are specific to Ho:YAG laser and does not apply to other laser platforms such as Thulium Fibre Laser (TFL) which have been shown to cause eye damage and distances up to 10cm.⁹

About 74.1% of staff found laser goggles to impair their vision. This is significant as endourology utilises expensive and difficult to handle equipments such as 200nm laser fibres and hydrophilic guide wires. Vision and dexterity are paramount to safely handling these devices while maintaining sterility. Similarly, the operating surgeon requires optimal vision throughout the case to ensure patient safety while performing an effective operation. These results mirror those presented by Paterson et al, where 264 Urologists who regularly perform laser surgery were asked to complete a survey. This survey revealed that 40% of urologists routinely wore laser safety goggles and that 70% of respondents reporting that laser goggles impaired their vision during surgery.¹⁰

With this in mind, and after reading the best practice recommendations from the CUA- 77.8% of participants found the current laser safety requirements to be excessive. If the option of wearing laser safety goggles was given to the participating staff members, nearly 80% would choose not to wear them. Therefore, by mandating a compulsory use of

laser safety goggles, a competing risk is created, as the majority of staff reported a significant reduction in their vision. Reducing the vision of the operating surgeon may impair their ability to complete a surgical case and increase the risk of adverse events to themselves, the patient, and surrounding staff. Interestingly, drug administration errors by anaesthetic staff have also been attributed to impaired vision while wearing laser safety goggles.¹¹

At our tertiary hospital, institutional laser safety includes a formal laser safety policy, a dedicated on-duty laser safety officer, and a laser safety committee. Mandated safety measures for the operating theatre include “in use” laser signs, laser warning barriers, window shades, mandatory laser goggles, and a dedicated extra numerary laser safety nurse. All laser nursing staff are required to complete their laser safety education before working in a laser theatre; however, this is not compulsory for urology or anaesthetic staff. Because of these staffing and theatre requirements, the access and ability to staff a laser safe theatre after hours is incredibly limited. This means patients who would otherwise be offered a primary ureteroscopy and laser within hours are instead offered a temporising surgery in the form of ureteric stent placement. Ureteric stenting is associated with significant patient morbidity, with patients having to wait an additional 3–4 weeks before their definitive surgery.¹² This means another hospital stay, another general anaesthetic, and another surgical procedure with additional surgical risks. By rationalising these strict and outdated blanket rules, more patients would receive definitive laser surgery as a primary procedure, reducing morbidity, hospital length of stay, and abolishing the need for subsequent surgeries. With rising pressures surrounding hospital bed availability, theatre staff shortages, and emergency theatre availability after hours, strict, potentially unnecessary/excessive laser safety guidelines can delay surgical timelines, contribute to bed shortages, and may impair patient outcomes.

Conclusion

Evidence to support mandatory eye protection and stringent laser theatre safety rules is not contemporary. The continued implementation of mandatory laser safety goggles in laser specific operating theatres overestimates the inherent risk associated with modern Ho:YAG laser systems. With current laser platforms being significantly safer compared to their predecessors, institutional safety standards must be updated to reflect current research and technology. In doing so, we aim to see improved access to laser surgery with the ultimate goal of reducing patient morbidity and improving patient turnover, particularly after hours. The current study was limited by the sample size of the single site surveyed. We aim to reproduce this study at the national level in the near future.

Data Sharing Statement

Anonymised data are provided in [supplementary file 2](#).

Ethics Statement

As this research survey involves low/negligible risk and only uses existing non-identifiable data, it is exempt from the Australian Human Resource Ethics Committee (HREC) review. This is in accordance with the Australian National Statement on Ethical Conduct in Human Research (2007) laws.

Consent

All participants gave informed consent prior to participation in the study.

Acknowledgments

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Disclosure

The authors have no conflicts of interest to declare for this work.

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