

Carbon dioxide laser safety issues in blepharoplasty and eyelid surgery

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Abstract

Carbon dioxide laser blepharoplasty was first described in 1984. Given its advantages, in particular better hemostasis compared with traditional scalpel surgery, carbon dioxide laser has been increasingly used in various eyelid operations. Despite its benefits, carbon dioxide laser has potential hazards, not only to the patient, but also to the operating surgeon and the operating theater personnel. It is therefore important for ophthalmologists to have a better understanding of the basic laser safety principles. This article reviews the potential hazards associated with carbon dioxide laser use in blepharoplasty and provides suggestions on safety measures. Together with proper training and practical experience, carbon dioxide laser can be used safely and effectively in blepharoplasty and eyelid surgery.

Key words: Blepharoplasty; Carbon dioxide; Eyelids/surgery; Laser therapy

Introduction

Carbon dioxide (CO₂) laser blepharoplasty was first described by Baker et al in 1984.¹ In their series of 40 patients, these researchers used CO₂ laser for ablation of periorbital rhytids.¹ Various advantages compared with conventional scalpel blepharoplasty were reported, including improved control of intraoperative hemorrhage, minimal postoperative ecchymosis and edema, and early rehabilitation. Since then CO₂ laser has become popular for plastic and eyelid surgeries (Figure 1).

Subsequent experience in CO₂ laser blepharoplasty revealed further advantages compared with conventional surgery.

Bleeding was found to be minimal during incision because a narrow zone of thermal injury seals most small vessels.² The operating field is therefore relatively bloodless. Better hemostasis with the use of the laser enables better visualization of the operating field during surgery, thereby reducing the operating time.^{3,4} Postoperative lid swelling and edema are reduced as lymphatic vessels are sealed by the laser.³ It has been suggested that reduced edema and ecchymosis enable earlier social activity and therefore result in a high rate of satisfaction immediately following surgery.⁵ Long-term results of CO₂ laser blepharoplasty were shown to be similar to those with traditional surgery.⁶

The addition of periorbital resurfacing enables the correction of eyelid skin aging that is not addressed by traditional scalpel blepharoplasty.⁶ CO₂ laser periorbital resurfacing from the outside permits shrinkage of the entire thickness of the lid skin without removing skin and muscle. When used following skin incision, defocused application of CO₂ laser to the surface of the orbicularis oculi muscle and septum induced shrinkage of these structures, producing a significant tightening effect on the lid.⁶ In other words, periorbital resurfacing addresses problems that were not dealt with by traditional blepharoplasty.

Apart from blepharoplasty, CO₂ laser is also used extensively in other eyelid operations such as entropion, ectropion, and ptosis correction.^{7,8} As CO₂ laser may be used for various eyelid surgeries, it is important for ophthalmologists to consider the safety issues related to its use. CO₂ laser, as with any other laser, can be hazardous for the patient, the operating surgeon, and the operating theater personnel. CO₂ laser can be used safely with better understanding of the basic safety principles and with practical experience.

Carbon dioxide laser safety

Authorized operators

The CO₂ laser system should only be used by personnel with

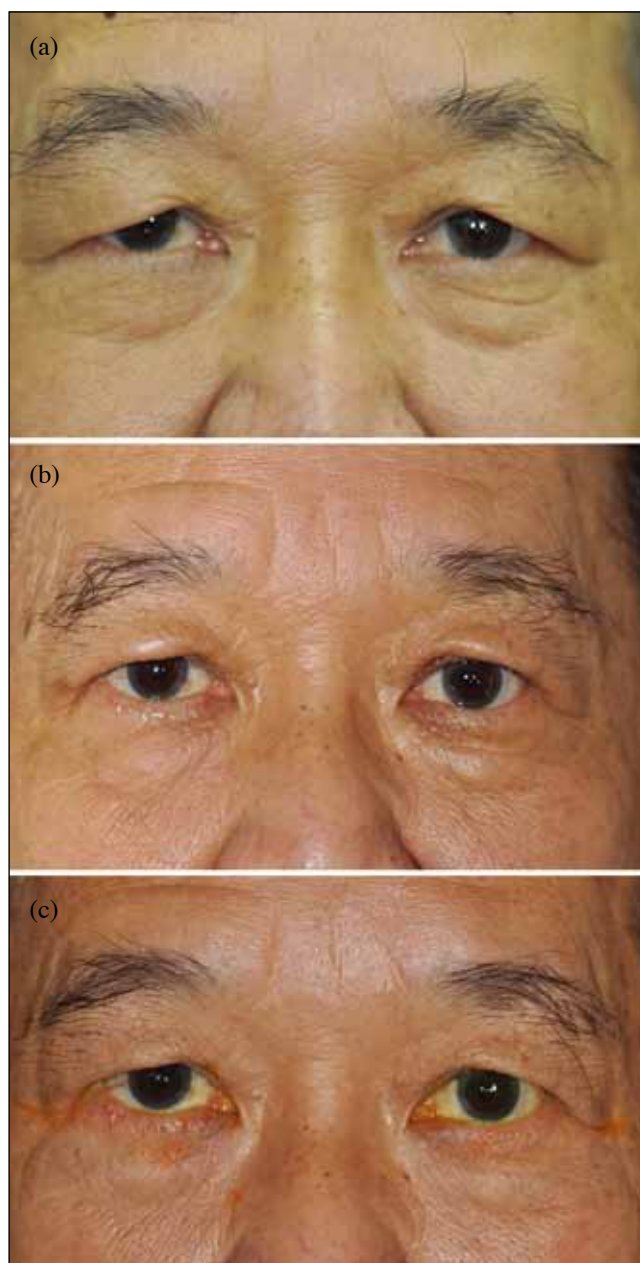


Figure 1. A 71-year-old man with bilateral upper eyelid dermatochalasis who underwent bilateral upper blepharoplasty using carbon dioxide laser: (a) preoperative, (b) 1 month postoperative and (c) 4 months postoperative.

sufficient training. A register of the names of all authorized operators should be maintained. A Laser Safety Officer or Laser Protection Supervisor should be designated from among the authorized operators. The supervisor will be responsible for maintenance of the register and for ensuring all operators have proper understanding of how the CO₂ laser works and adequate knowledge of laser safety.

Operating theater and carbon dioxide laser system setup

A Laser Treatment Controlled Area (LTCA) is the area where the procedure is performed and access is limited to authorized operators and trained personnel only. Laser

warning signs clearly marked for the wavelength of CO₂ laser should be posted on all LTCA doors (**Figure 2**). All reflective surfaces in the area, including windows, should be covered. No more than one laser should be switched on at any time, and no other procedure should be undertaken while the laser is in use. When the laser is in use, the number of persons in the operating theater should be kept to a minimum. The laser machine should comply with the local electrical safety regulations and be certified by the institution's engineer. The handpiece should be properly connected and fixed to the delivery system (**Figure 3**).

Eliminating fire hazard

The presence of oxygen while the CO₂ laser is in use results in flammability and may lead to fire. It is advisable to avoid giving patients supplemental oxygen during CO₂ laser eyelid operations. If supplemental oxygen is necessary, it should be delivered to patients through an intranasal tube covered by wet gauze or laser-impermeable material such as aluminum foil. It has been shown that there is no CO₂ laser reflection off wet gauze and no effect on the gauze itself.⁹ When CO₂ laser is in use, all oxygen should be turned off. No volatile agents should be used for anesthesia and skin preparation.



Figure 2. Clearly marked signs for the wavelength of the carbon dioxide laser should be posted on all operating theater doors.



Figure 3. The UltraPulse® carbon dioxide laser delivery system. The handpiece (inset) should be properly connected and fixed to the delivery system.

The CO₂ laser can start a fire if activated while in direct contact with dry material. Wet towels should be placed around the patient's face and neck to prevent ignition of the surrounding drapes. A study has shown that moist towels do not burn or catch flame when in contact with the CO₂ laser.¹⁰ A fire extinguisher should be readily available.

Eye protection

The CO₂ laser beam is largely absorbed by water. In addition, the CO₂ laser beam is absorbed within the upper 200 µm of tissue. The cornea, which is composed of more than 75% water and measures about 500–600 µm at its center, is therefore highly susceptible to injury by the CO₂ laser.¹¹ Apart from the cornea, the CO₂ laser may perforate the globe. It is therefore important to protect the eyes of the patient, the surgeon, and the operating theater personnel.

All persons in the operating theater should wear protective goggles or eyewear with side shields for protection against the CO₂ laser beam (Figure 4). Such eyewear should be clearly

marked for the wavelength of CO₂ laser, i.e. 10,600 nm. It is important that correct goggles are used. Although it has been reported that the CO₂ laser beam does not penetrate glass or liquids,¹⁰ it should be noted that protective eyewear does not guarantee protection against direct laser contact.

Protective corneal shields should be applied for all patients. Plastic corneal shields have been shown to melt or even burn or ignite a fire after repeated passes of the CO₂ laser beam. However, metallic shields remain intact without damage and the temperature change is small because of the high reflectivity.¹² Therefore, it is important to ensure that metallic corneal shields, such as stainless steel shields, are used for all patients to protect their eyes from laser beam injury (Figure 5).

Laser smoke plume evacuation and safety masks

The CO₂ laser ablates tissue by cell vaporization. The laser energy disrupts cells, which consist predominantly of water, resulting in water vaporization and steam formation. The residual cell material undergoes carbonization and the



Figure 4. Protective goggles and eyewear with side shields for protection against the carbon dioxide laser beam.



Figure 5. Metallic corneal shield to be used by patients for protection against carbon dioxide laser ocular injury. A shield is placed in each eye with a rubber suction cup applicator.

carbonized cell materials mix with the steam forming a smoke plume. It has been shown in animal models that the particulates generated can deposit in the lower respiratory tract causing pathological changes, which may be fatal in immunocompromised patients.^{13,14} In addition, aerosolized blood may contain bacteria, viruses or DNA particles that may be infectious and could transmit diseases.^{15,16}

Laser smoke plume evacuators should be used to protect the respiratory system of the patient, the surgeon, and the operating theater personnel (**Figure 6a**). It has been suggested that a smoke evacuator within 1 cm of the laser site could capture 99% of the laser plume. However, only 50% of the laser plume would be captured if the evacuator was held 2 cm away.¹⁰ Usual surgical masks are not sufficient for filtering laser smoke. Special laser filtration masks should be used (**Figure 6b**).

Laser beam alignment check and test shots

A laser beam alignment check should be performed to verify that the laser treatment beam is of an acceptable quality, and to verify that the aiming and treatment beams are coincident. A marker pen can be used to mark an X on a moist wooden tongue depressor. Then the laser can be turned on and the desired laser mode set, including spot size and pattern, energy, and exposure time. The handpiece is positioned so that the laser aiming beam, usually red, is centered at the

intersection of the X on the tongue depressor. The tip of the handpiece spatula should touch the tongue depressor. After ensuring the aiming beam is at the intersection of the X, the laser is fired and verified that the burn lies at the area of the aiming beam. Once correct alignment is confirmed, the laser spot size, pattern and power should be tested and verified by firing further test shots on the tongue depressor. In between laser shots, it is important to keep the laser in standby mode.

Surgical technique in upper blepharoplasty

This author currently uses the UltraPulse® CO₂ laser (Encore; Lumenis Ltd, Yokneam, Israel). In upper blepharoplasty, the author's preference is for a 0.2 mm handpiece. The author uses the continuous wave mode, power 4 W, for incision and tissue dissection. This mode produces a continuous laser beam with no variation over time. Alternatively, some surgeons use the ultrapulse mode, which produces short pulses of laser at very high energy levels that are sustained over the entire duration of the pulse. When skin resurfacing is desired, a computer pattern generator handpiece should be attached (**Figure 7**).

Non-reflective instruments should be used during the operation. Following skin incision, a cut penetrating the skin and orbicularis oculi should be made. This skin-muscle tissue flap is then lifted with a pair of forceps and further excision is completed using the CO₂ laser. Traditionally, the excision is done with proper backing from a Jaeger eyelid plate to prevent inadvertent injury to the adjacent or underlying tissues and structures. However, a recent study showed that at 5 cm from the laser-safe reflective surface of a Jaeger eyelid plate, the reflected beam burned a hole in a surgical glove in less than 2 seconds of CO₂ laser firing.⁹ A possible explanation is that the curved surface of the Jaeger eyelid plate created unpredictable diffuse reflections. However, no damage to or reflection from wet gauze was noted after more than 30 seconds of continuous laser firing. Therefore, it was suggested that the Jaeger eyelid plate should be replaced with a wooden tongue blade wrapped in damp gauze.

Adverse incident reporting

Should a near-miss or an actual laser accident happen,

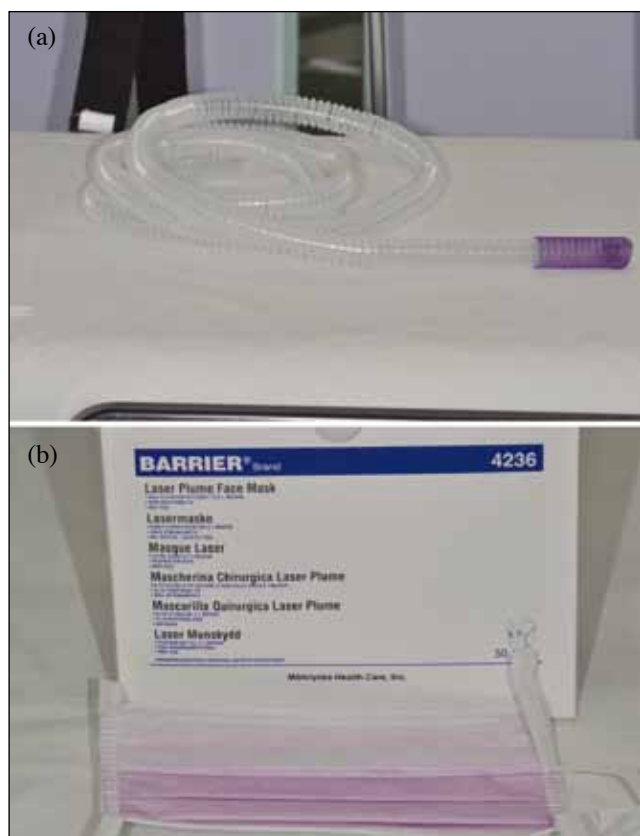


Figure 6. Carbon dioxide laser smoke protection for operating theater personnel. (a) Carbon dioxide laser smoke plume evacuator tubing and (b) carbon dioxide laser smoke plume masks with filtration efficiency to 0.1 µm.



Figure 7. Computer pattern generator handpiece (UltraPulse®).

appropriate eye or relevant physical examination must be carried out as soon as possible. The incident should be reported to the Laser Safety Officer for investigation and follow-up action. If the incident involves a worker's unsafe act, the worker must undergo proper training before resuming work involving use of the laser.

Possible complications of carbon dioxide laser in blepharoplasty

Many of the most common and most serious complications of blepharoplasty are attributable to hemorrhage and hematoma. These complications are eliminated by using CO₂ laser as the only cutting tool owing to its improved hemostasis.^{16,17} In a series of 196 patients receiving CO₂ laser blepharoplasty and periocular laser skin resurfacing, 4.1% developed dry eyes or exposure keratitis that required eye drops, punctal plugs, and night time lubrication with taping.⁶ Complications of visual loss, retrobulbar hemorrhage, globe or corneal injury, diplopia, hypertrophic scarring, permanent ectropion or ptosis, eyelid buttonhole, and singed eyelashes did not occur in any of the patients.⁶

When CO₂ laser is used for skin resurfacing, the most frequent complications are pigmentary disturbances, erythema, infection, and scarring.¹⁸ It is postulated that hyperpigmentation occurs when re-epithelialization after

cutaneous laser resurfacing includes follicular melanocytes,¹⁹ and this complication is more common in patients with darker skin phototypes.²⁰ Other possible complications include milia formation, acne flares, and ectropion.^{20,21} Postoperative infection with herpes simplex virus (HSV) may also occur regardless of prior HSV history.²⁰ Special attention to preoperative skin preparation and postoperative wound care help to reduce the frequency and severity of these complications.

Conclusion

CO₂ laser has a number of advantages when compared with a conventional scalpel for performing eyelid operations. Apart from the eyelid, CO₂ laser has also been used in other ocular surgeries such as enucleation, evisceration, squint correction⁷ and, recently, sclerectomy glaucoma surgery.^{22,23} While CO₂ laser is being used more extensively in ophthalmology, it is associated with potential hazards. It is important for ophthalmologists to keep in mind the safety issues related to its use.

Declaration

The author has no financial or proprietary interest in any product mentioned in this article.

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