The Versatility of using Carbon Dioxide (CO_2) Laser in Minimally Invasive Gynecologic Surgery

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Introduction

Minimally invasive gynecologic surgery (MIGS)

The use of minimally invasive gynecologic surgery (MIGS) to diagnose and treat a multitude of female pelvic conditions has become common practice over the last several decades (Cho et al., 2010) and is continuing to be refined and expanded. The main therapeutic modality in MIGS is laparoscopy, in which very small incisions (usually 0.2–1.5 cm) are utilized to access the abdomen and pelvis, introducing a working channel with the aid of a camera and designated surgical tools (Vecchio et al., 2000). Laparoscopy is one of the most common surgical procedures performed in many parts of the world today and has demonstrated significant advantages over laparotomy including reduced hemorrhage and infection rates, shortened recovery time and length of hospital stays, and less post-operative scarring (Modlin et al., 2004).

Use of Carbon dioxide (CO_2) laser in MIGS

One of the surgical tools available to the MIGS surgeon is the carbon dioxide (CO_2) laser. The CO_2 laser has been used extensively during laparoscopic gynecologic procedures since the early 1980's, mostly for the surgical treatment of endometriosis (Adelman et al., 2013). The CO_2 laser energy is used for vaporization, excision and coagulation of tissue. And, since it is highly absorbed by water, this laser can be used very effectively in soft tissues where water is ubiquitous. The unique features of CO_2 laser are precision, low penetration depth (0.1 mm), and low collateral thermal damage. These features enable the gynecologic surgeon to use the CO_2 laser in an efficient and safe manner inside the pelvic cavity (Schipper & Nezhat, 2012). Recent studies have pointed out the important role of the CO_2 laser in fertility preservation in cases of ovarian endometriosis, due to the minimal damage caused by this modality to the adjacent healthy ovarian tissue (Candiani et al., 2018, Ottolina et al., 2017).

Common indications for using CO_2 laser in MIGS

There are several indications in minimally invasive gynecologic surgery, in which the CO_2 laser can be used in an efficient and safe manner. In this paper we present a short overview on some of these indications.

Lysis of adhesions

Pelvic adhesions can form as a result of prior infection (such as a ruptured appendix or pelvic inflammatory disease), endometriosis, or previous surgery (Vrijland et al., 2003) and may contribute to infertility and chronic pelvic pain (van den Beukel et al., 2017). Natural conception rates in women suffering from severe pelvic adhesions are relatively low and ectopic pregnancy rates can be high. Therefore, adhesiolysis procedures may improve the chances of conception and normal pregnancy in such women (Milingos et al., 2000). Since adhesions tend to reform after open laparotomy or extensive lysis of tissue, the use of laparoscopy with the CO_2 laser with its precision cutting characteristics and minimal collateral tissue damage can provide advantages during adhesiolysis.

Treatment of endometriosis

Laparoscopy is the most common procedure used to diagnose and treat endometriosis (Duffy et al., 2014). Endometriotic lesions may be excised or ablated, and, as discussed above, several studies have demonstrated the safety and efficiency of CO_2 laser in achieving good post-operative results and fertility rates following laparoscopic treatment of endometriosis (Tsolakidis et al., 2010, Donnez et al., 2010, Meuleman et al., 2009).

Ovarian cystectomy

Surgical cystectomy is often indicated for simple ovarian cysts sized 6 cm or larger that are persistent over 2 or more menstrual cycles in premenopausal, non-pregnant women. Indications for surgical intervention with complex masses or postmenopausal women suggest even earlier diagnosis and treatment. This can often be achieved using laparoscopy, carefully dissecting the cyst from surrounding normal ovarian tissue while attempting to remove the cyst intact when possible (Sagiv et al., 2005). Due to the precision of the CO_2 laser, as well as its ability to minimize collateral cortical ovarian tissue damage, the CO_2 laser can be used as a good choice of surgical instrumentation for ovarian cystectomy (Alammari et al., 2017).

Uterine fibroids removal – Myomectomy

Laparoscopic myomectomy is a surgical approach to treat symptomatic uterine fibroids in women desiring fertility-sparing procedures. The uterine fibroid can be removed by performing a transverse or longitudinal incision just above the myoma, followed by enucleation of the myoma using a combination of mechanical instruments for traction and counter-traction.

Energy devices can be used as needed for aiding in dissection and controlling bleeding (Donnez & Dolmans, 2016). Once all myomas are removed, the uterine defects are repaired. Several studies have demonstrated the advantages of using CO_2 laser during laparoscopic myomectomy (Choussein et al., 2015, Barton & Gargiulo, 2013). The CO_2 laser is a useful tool during myomectomy for making the uterine incision, in aiding during the dissection of the fibroid, and ensuring efficient hemostasis.

Delivery modes of CO_2 laser during MIGS

Currently, the gynecologic surgeon has several options to deliver the CO_2 laser energy through the laparoscopic working channel. In the first decades of using CO_2 laser, the beam was delivered directly through the laparoscope, so that there was a “line-of-sight” of the laser, delivered from the laser system to an articulated arm, and then through the laparoscopic channel (Figure 1). More recently, a flexible CO_2 laser fiber was developed, so that the surgeon can hold an ergonomic handpiece in her or his hand (Figure 2).
With this system, a flexible fiber is inserted through the channel in the operating scope or an accessory laparoscopic port to deliver the laser beam. Recent studies presented the advantages of using a flexible fiber (FiberLase, Lumenis), especially in the learning curve of the training time for novice users. Such users accommodated to using the fiber more rapidly and effectively than the articulated arm (Vanni et al., 2017). Today, there are several CO_2 laser systems in the market that enable the use of both delivery systems (AcuPulse DUO, UltraPulse DUO, Lumenis). In these systems, there is an easy-to-use option to alternate between the two modes of laser delivery, thus providing more accessibility to the desired tissue (Figure 3).
The use of innovative robotic surgical systems such as the DaVinci (Intuitive Surgical) is now commonplace worldwide, and the CO_2 laser flexible fiber can now also be used in robotically-assisted gynecologic surgery. In a robotically-assisted surgery, the surgeon is using a designated console with a visual display of the laparoscopic camera, controlling different surgical tools with the arms of the robot as needed. The development of the Lumenis Drop-in Guide, an instrument through which the flexible CO_2 laser fiber is passed that is then grasped by a needle driver controlled by the robotic arm, allows for precise cutting and vaporization of the tissue using the CO_2 laser (Figure 4) with all the inherent surgical advantages of the robotically-assisted procedure.

Our experience in using CO_2 laser for MIGS

In our surgical practice at The Christ Hospital (Cincinnati, OH), we use the CO_2 laser as a primary surgical tool of choice in minimally invasive surgery for many varied gynecologic indications (e.g. adhesiolysis, ovarian cystectomy, myomectomy and ablation/excision of endometriosis).
During the time period of 1996-2019, our practice has performed more than 1,500 cases in which the CO_2 laser was utilized during various minimally invasive gynecologic surgical procedures. We have used several generations of CO_2 laser, but currently use the AcuPulse DUO (Lumenis), both with an operative laparoscope as well as in combination with the DaVinci robotic system (Intuitive Surgical). Our personal experience shows that using the CO_2 laser with a robotic drop-in guide during gynecologic surgery provides us with an easily reproducible technique with excellent clinical outcomes. The Drop-in Guide has simplified our robotically assisted procedures since it allows us to take significant advantage of the degrees of freedom of movement of the robotic “wrists”, allowing easy access to locations that would be almost impossible with a straight port or the freebeam.
Finally, compared to electrical energy, the CO_2 laser allows us to minimize potential collateral thermal injury to the ovaries and surrounding delicate tissues, thereby possibly increasing the chances of successful fertility preservation during extensive surgery.

Figure 1
CO_2 laser beam delivered through an articulated arm

Figure 2
GYN Surgeon uses a hand-held ergonomic handpiece with a flexible CO_2 fiber

Figure 3
Lumenis AcuPulse DUO (left) and UltraPulse DUO (right) CO_2 laser systems. These novel laser devices enable the use of both fiber and free beam delivery methods

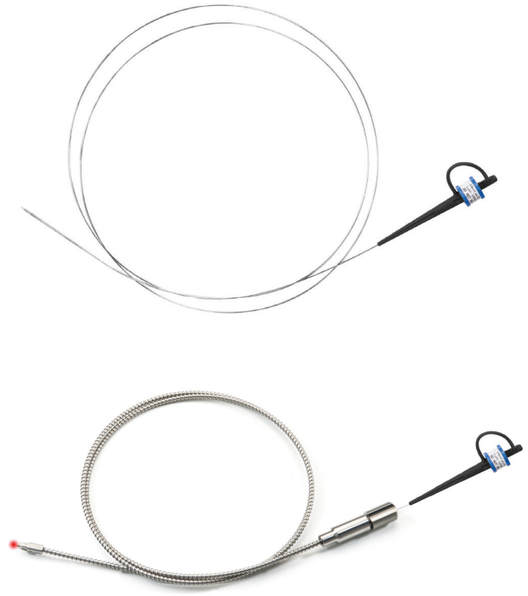

Figure 4
CO_2 flexible FiberLase™ (upper image) can be inserted through Drop-in Guide™ (below image) for GYN robotic-assisted surgery

Conclusions

The CO_2 laser is a useful, precise, and versatile part of the gynecologic surgeon's utility kit. Use of the CO_2 laser is associated with excellent clinical outcomes and may reduce collateral thermal damage, thereby possibly reducing adhesion formation and enhancing future fertility. The ability to choose from several different forms of delivering the laser energy (direct line-of-sight, through a handheld flexible fiber, or via robotic-assisted systems) allows the surgeon to optimize individual surgical therapy. The advantages of CO_2 laser in the maximization of fertility outcomes and ovarian preservation may become more and more evident as the technologic development of minimally invasive surgery continues.

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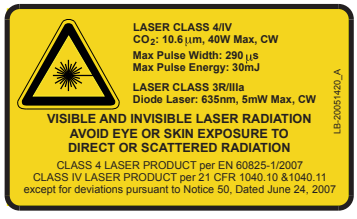
Risk Information

CO_2 lasers (10.6 µm wavelength) are intended solely for use by trained physicians. Incorrect treatment settings or misuse of the technology can present risk of serious injury to patient and operating personnel. The use of Lumenis CO_2 laser is contraindicated where a clinical procedure is limited by anesthesia requirements, site access, or other general operative considerations. The use of Lumenis CO_2 laser is contraindicated for patients who are not candidates for general surgery, or when local or spinal epidural anesthesia is inappropriate, laparoscopic applications where laparoscopy is contraindicated. Risks may include excessive thermal injury and infection. Read and understand the CO_2 systems and accessories operator manuals for a complete list of intended use, contraindications and risks.



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