Use of Surgical Lasers in the Treatment of Pelvic Pain and Endometriosis
"What is a Laser?"

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Definition

Everyone has heard of lasers, but you might not know exactly what the term means. The term laser refers to a class of instruments that use light energy, not a specific device. Laser is an acronym: Light Amplification by Stimulated Emission of Radiation.

The common mechanism in lasers is that a particular substance (e.g. CO2 gas) is stimulated resulting in a single wavelength of light being emitted. This single wavelength of light is a very intense source of energy. The effect of this energy is dependent upon the specific wavelength and the power of the laser.

Lasers are found everywhere in our daily life, including such things as light pointers, laser printers, light shows at concerts, DVD players and tools for cutting metal in industry. There are many different types of lasers that have dramatically different purposes and diverse effects. Much as four rubber-wheeled vehicles can range from a Volkswagen to a truck. One is good for hauling large amounts of dirt while the other is not.

Medical lasers are one small subset of a larger group of lasers. There are many types of medical lasers including diode, argon, green light, eximer, Yag, Neodymium, KTP, Carbon 12 CO2, and Carbon 13 CO2 lasers. The only medical laser that truly cuts and vaporizes endometriosis during laparoscopy is the Carbon 13 CO2 laser.

Carbon 13 CO2 laser is the laser of choice for laparoscopic endometriosis surgery

Why is the Carbon 13 CO2 laser the only laser that should be used to surgically treat endometriosis laparoscopically? Simply put, it is the only laser that has the precision and power to cut and vaporize.

Vaporization is a process by which water is turned into water vapor. In the case of medical laser vaporization, when the water in a cell is turned into water vapor, the cell expands in volume over 1,000 times and the solid matter is suspended in the water vapor as a type of fog. The heat of the laser is carried away in the water vapor, thus there is practically no conduction of heat, leaving the surrounding cells undamaged. There is no burning of the tissue.

Let me explain why the Carbon 13 CO2 laser is the only laser that vaporizes during laparoscopy. When the regular Carbon 12 CO2 laser is used in the open air it works great, but when it is used laparoscopically, something unforeseen happens. You see, as the power is turned up on the Carbon 12 CO2 laser laparoscope, the diameter of the laser beam gets larger and the power directed at the tissue actually *decreases*. So much so that it actually can drop below the level of energy required to cut and vaporize and it can start to coagulate and leave charring behind. This problem has to do

with the CO2 gas that is used to insufflate the abdominal and pelvic cavity (the gas used to "blow up the balloon" so that we can see inside to operate).

Remember, each laser emits a specific wavelength of light (and energy). A Carbon 12 CO2 laser has a wavelength of 10,600 nanometers and a Carbon 13 CO2 laser has a wavelength of 11,100 nanometers.

When a Carbon 12 CO2 laser is used through Carbon 12 CO2 gas (as is the case during laparoscopy), it excites the gas, which expands and acts as a defocusing lens. As it increases the diameter of the laser beam the power density decreases. This is known as a "blooming effect".

Power density determines the amount of energy and effect on tissue. Power density (PD) and pounds per square inch (PSI) are similar concepts. A good example is the PSI of an elephant and a woman in high heels. The PSI on the high heel is greater that the PSI on an elephant's foot. It's the same concept for the laser beam. It needs to be pinpoint to cut and vaporize, not the size of a dime.

A certain level of power density is required to achieve cutting and vaporization. If the power density drops below this level, coagulation and charring occur. Since the Carbon 13 CO2 laser has a different wavelength than the Carbon 12 CO2 gas, the laser beam passes right through the Carbon 12 CO2 gas and keeps its pinpoint size. Use of the Carbon 13 CO2 laser eliminates the "blooming effect" and maintains a small beam.

As a result, the power density of a Carbon 13 CO2 laser is higher than that required for cutting and vaporization and thus is an ideal laser for laparoscopic treatment of endometriosis. Coagulation and cauterization do not occur with the Carbon 13 CO2 laser as demonstrated in the published scientific literature.

History of medical lasers in the treatment of endometriosis

My first exposure to the surgical treatment of endometriosis was in 1983 by my mentor and the grandfather of endometriosis treatment, Dr. Robert Franklin. He is a wonderful man who is truly a gentleman and scholar. He was recognized by the Endometriosis Association at their 25th annual conference last year for his lifetime achievement in the field of endometriosis. As a resident, I trained with Dr. Kelly who, in 1983, published the first scientific article on the surgical treatment of endometriosis with the CO2 laser and laparoscopy. Back then laparoscopic equipment, including the laser, was pretty basic and fairly crude. Remember in 1983, Apple computer released the Apple IIe and LISA, the predecessor to the Apple Machintosh computer that would be released the next year in 1984. Also in 1983, Microsoft announced that it would develop a Windows-oriented operating system for Intel-based microprocessor systems, but Windows 1.0 would not be shipped until 1985. So much has changed over the last 23 years! Almost every aspect of laparoscopic surgery has changed and improved dramatically since then. This includes the quality of the video cameras (we now perform surgery watching HDTV) and light sources, and insufflation devices (the instrument that fills the abdomen and pelvic area with CO2 gas during surgery), which are now 40 times as fast.

Much of the surgical technique for laparoscopic treatment of endometriosis was developed during the 1980s. Scissors cut, but result in too much bleeding to be the only method of excision. Prior to laparoscopy, scissors and monopolar electrosurgery were used at laparotomy (the big incision that allows the surgeon to put his or her hands inside of the body).

At first, many physicians felt that the use of monopolar electrosurgery was unsafe to use laparoscopically. The early electrosurgical generators had problems with arcing which meant that the electrical current would invisibly jump to other organs such as the bowel, leaving a burn that destroyed the tissue. This was a real problem when the patient developed a hole and a leak in the bowel a couple of days after surgery. To fix this problem, patients would potentially have to undergo a bowel resection, have a colostomy bag and could even die. The current electrosurgical generators have solved these problems and today, use of monopolar electrosurgery is safe laparoscopically.

The search was on to find a method to safely excise or coagulate endometriosis laparoscopically. The endocoagulator was initially introduced as a device to provide laparoscopic coagulation without the risks associated with electricity. The best way I can describe the endocoagulator is to envision cutting a 1/4" diameter piece out of the bottom of a clothes iron and gluing it on the end of a stick. The endocoagulator is a 1/4" diameter probe (usually about a foot and a half long) that is heated on the end much like an iron. It was used laparoscopically to coagulate the endometriosis. While safe, this approach was ineffective in the treatment of endometriosis as are all types of coagulation.

There was much excitement about surgical lasers when they arrived on the scene. They seemed to be safe and effective since they used light energy. Initially, the argon, KTP, YAG and CO2 lasers were all used in gynecology. The argon and KTP lasers were absorbed by pigmented lesions (remember in the 1980s most surgeons still thought that almost all endometriosis lesions were pigmented). Eventually, these lasers fell out of favor, as we better understood endometriosis and its effective surgical treatment. The YAG laser would ablate and coagulate tissue but was less precise and had other shortcomings that eventually caused its demise.

The early CO2 lasers were underpowered and difficult to use. The laser beam could not be used with a fiber and thus needed rigid arms and complex articulating mirror systems. One almost had to be a mechanic and a surgeon in order to get the laser beam properly aligned so that it would shine down the operating channel of the laparoscope. When working properly, the CO2 laser cut and vaporized tissue fairly well, but also resulted in charring and coagulation of the tissue.

By 1991, these problems had been corrected with better delivery systems and the introduction of the Coherent 5000L Carbon 13 CO2 laser. It is still by far and away the best instrument for the surgical treatment of endometriosis. This laser was truly way ahead of its time. The arms, mirror systems and coupling devices that attached the laser to the operative laparoscope were dramatically improved. Any technician could hook up the laser and have it work properly.

The laser is a powerful instrument and takes learning and quite a bit of skill to use effectively and safely. Many surgeons never took the time to learn how to use this amazing instrument. Those that did acquire the skills to use the laser have options available to them in surgical treatment of endometriosis not offered by other techniques.

Further reading on lasers

The following links contain good information on how lasers actually work for those of who want to better understand the details:

http://science.howstuffworks.com/laser1.htm
http://science.howstuffworks.com/laser2.htm
http://science.howstuffworks.com/laser3.htm
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