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The advantages and disadvantages of using a CO2 laser in endoscopic treatment of laryngeal cancer: a literature review

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Abstract

Introduction: The use of a carbon dioxide (CO_2) laser combined with a microscope has revolutionized the surgical approach in treating larynx lesions. This method is mainly used in malignant and premalignant lesions in the larynx. The CO_2 laser is also commonly used to widen the glottis and in palliative surgery.

Aim of study: The purpose of our study was to show advantages and disadvantages of using a CO2 laser in surgery for laryngeal cancer while analyzing available literature.

Material and methods: An unsystematic review of Polish and English-language scientific literature was carried out. Electronic databases: SCOPUS, Google Scholar and PubMed were searched using keywords: laser surgery, CO_2 laser, laryngeal cancer, larynx.

Description of the state of knowledge: CO_2 laser microsurgery is characterized by precision and a high safety profile. Low tracheotomy rate, preservation of the closed anatomical area of the neck, makes the operation lightly burdening, shortens the time of hospitalization and recovery. Moreover, it minimizes costs and has a positive impact on the quality of life. The disadvantages of using a CO_2 laser mainly relate to transient perioperative and postoperative complications. Disturbances in voice emission clearly have a negative impact on functioning in society. The use of a carbon dioxide laser in the presence of anesthetic gases creates the risk of ignition in the respiratory tract, tissue burns or attachment of the endotracheal tube.

Conclusions: The use of a CO_2 laser in the treatment of larynx lesions has advantages and disadvantages. The benefits of this technique outweigh the rare complications. Side effects are usually minor and transient but may lead to damage to health. It is worth remembering that only early neoplastic lesions are operated with the CO_2 laser, which emphasizes the essence of prevention.

Key words: laser surgery; CO_2 laser; laryngeal cancer; larynx

Introduction

The role of the larynx is significant and indisputable. Located in the upper part of the respiratory tract, the organ is responsible for ventilation and voice production, that is phonation. It protects the lower respiratory tract against food aspiration and choking (1, 2). Disease processes as well as reparatory operations within the larynx impair its efficient functioning in the scope of the abovementioned activities. Endoscopic surgery using a laryngoscope and microtools is one of the most commonly used surgical methods for this organ (3, 4, 5). It is characterized by low invasiveness, thanks to which strong attempts are made to maintain the function of the larynx to the largest extent possible (4, 5, 6, 7, 8). The development of anesthesiology associated with general anesthesia, advances in the technique of endoscopic access and the appearance of a carbon dioxide laser (CO_2) as well as its combination with an operating microscope and micromanipulator revolutionized the surgical approach in the treatment of larynx lesions (3, 4, 9, 10).

Aim of study

The aim of our study was to analyze available scientific materials in terms of the advantages and disadvantages of using a carbon dioxide laser in laryngeal cancer surgery.

Material and methods

An unsystematic review of Polish and English-language scientific literature was conducted. Electronic databases: SCOPUS, Google Scholar and PubMed were searched using the following keywords: laser surgery, CO_2 laser, laryngeal cancer, larynx. The research method was an analysis. Scientific articles constituted the research material.

Description of the state of knowledge

I. The advantages of using a CO_2 laser

I.I Operating principles and unique features

The CO_2 laser operating principle is based on the generation of monochrome, infrared, invisible, collimated and coherent light. The wavelength emitted is 10.6 μm. Water and surface layer cells absorb them well (3, 4, 6). A beam of light carries energy, which at the interface is converted into heat. Cells are heated up locally to a temperature of at least 100 ° C and isobaric evaporation of water takes place. Further tissue heating is inhibited. An increase in the volume of water contained in the cells leads to spatial separation of tissues or cutting. Such sudden evaporation, thanks to the high power of the laser, enables to reduce the risk of edema. This method is called photovaporation (3, 4, 6).

The combination of the suspension laryngoscope with the operating microscope and the cutting tool being the light generated by the laser, freed the operator's hands and allowed remote control with the use of a micromanipulator (4, 5, 10). Following Wójtowicz and Sztyfter, it should be noted that the image enlargement obtained by means of a surgical microscope allows the ENT specialist to assess and distinguish between the boundaries of healthy and diseased tissues during the surgery itself, which reduces the extent of resection (11).

Another advantage of the carbon dioxide laser as a microsurgical tool is its work in two modes: pulsed or continuous. Thanks to this, the doctor can separate tissues layer by layer or cut like a knife (4). The precision of this technique is based on a slight penetration force and the ability to adjust the appropriate diameter of the generated light beam, and focus it using the lens. This makes the laser a tool almost adapted to the patient. The CO_2 laser easily coagulates vessels with a diameter of up to 0.5mm, which facilitates care for asepsis. The use of high temperatures reduces the risk of hemorrhage. This results in better visibility in the operating field, less traumatization of surrounding tissues, accelerates healing and increases the chance of voice preservation (3, 4, 5, 6, 12).

I.II The use of a CO_2 laser in larynx lesions

A CO_2 laser has been used to treat precancerous conditions such as hyperplasia, pachydermia, keratosis and laryngeal papillomas in adults. It is possible to remove them entirely by evaporating to the depth of healthy tissue. This prevents malignancy. In addition, clinicians often use this method for benign tumors of the larynx including vocal fold polyps and juvenile papillomas (3, 4, 5, 12, 13). What is more, CO_2 laser microsurgery is the technique of choice for the treatment of early squamous cell carcinomas of the glottis and epiglottic region at the local advancement stage T1a and T1b and T2. In these cases the laser is used as a knife (5, 6, 7, 8, 9, 12, 13, 14).

Surgical margins are already assessed during surgery under a surgical microscope, which ensures a precise incision (13). A high percentage of local control is achieved due to the possibility of separating the affected tissues from healthy ones by photovaporation of the margins. The results of local control tend to be similar to those after radiotherapy and partial open resection (7).

In palliative medicine, the CO_2 laser is designed to reduce bleeding from cancerous lesions and allows the tumor mass to be removed so that the airways remain unobstructed (3).

I.III Benefits for the patient

In addition to the results of oncological surgery of the larynx with the use of a CO_2 laser, what remains to be of significant importance is the patient’s quality of life. Doctors should pay attention to four aspects when deciding which technique to use: postoperative voice quality, length of hospitalization, the necessity of nasogastric tube feeding and tracheostomy.

Any intervention within the larynx carries the risk of deteriorating the quality of voice. Based on Remmelts' study, it can be concluded that voice effects after laser treatment are comparable to those after radiation therapy (5, 6). According to van Gogh et al. voice recovery after surgery is faster when a CO_2 laser rather than radiotherapy is used, and after 3 months after the surgery no difference is recorded when comparing the patient's voice quality to the one before surgery. Only the fundamental frequency remains higher. Long-term results are similar after the use of both radiotherapy and CO_2 laser (14, 15). In the study of Lao et al., patients after transoral laryngeal microsurgery showed better communication skills than after radiotherapy (15). According to Aaltonen, patients with laryngeal cancer treated with a CO_2 laser speak louder (5).

Lachowska et al. compared the hospitalization time of patients with glottis cancer Tis and T1N0M0 treated with traditional chordectomy through external access and endoscopic one using a CO_2 laser. Patients from the latter group spent less time in the hospital than patients from the former one, which was statistically significant (5). It is worth noting that the recovery time after laser treatment of cancerous lesions of the larynx is shorter when compared to the one with the use of radiation therapy. This generates lower costs, positively affects the patient's well-being and their mental condition. There are few publications available in the literature based on patients' opinions concerning the impact of the disease and its treatment on their quality of life (5, 6, 8, 10, 13, 14, 15, 16).

Researchers emphasize that patients treated with a CO_2 laser are rarely ordered nasogastric tube feeding and tracheostomy (5, 7).

II. The disadvantages of using a CO2 laser

Despite the indisputable benefits of using CO2 laser, it is vital to notice disadvantages and complications resulting from this technology. Minor procedure-related complications are common in this kind of surgery. Those that can resolve spontaneously or can be treated under local anesthesia, without any major consequences for the patient (6). Erosion of the mucosa is frequently observed, but usually heals within a few days. The most common location for these lesions are oral cavity and throat. Slightly more severe are hematoma on the tongue. The healing process of these may last longer (3). Major complications are defined as those that need extended medical therapies, blood transfusions, early surgical revision, or intensive care unit recovery. According to different classification the complications can be divided into early and late.

Early postoperative complications generally include subcutaneous emphysema, bleeding, dyspnoea, dysphagia, aspiration pneumonia (17). Laser microsurgery is also associated with a risk of hemorrhages and pneumothorax. These may require endoscopic coagulation or thoracostomy drainage (10). Some patients may require nasogastric tube insertion to avoid inhalation or tracheostomy (17). If an oral intubation is impossible to perform due to a tumor of the larynx, tracheostomy is made. It may be considered as a salvage therapy to protect the airway during the extensive surgery or a massive bleeding.

Tracheostomy makes it impossible to swallow normally which can result in delayed healing. Fortunately, it is usually just temporary (6). In some way, it creates a conflict between laser microsurgery and safe anesthesia that fully eliminates reflexes from the throat and larynx and immobilizes the vocal folds. It needs to be easily reversible and keep the patient in a state of respiratory efficiency after surgery. On the other hand good visibility and access to the larynx is required to effective and precise treatment.

Late postoperative complications consist of glottic synechia, vocal cord granulomas and arytenoid edema. Glottic synechiae may narrow the larynx, which leads to reduction of the laryngeal respiratory space. If dyspnoea occurs, it may require excision (17).

The disadvantage of the technique that the surgeon should remember about is that laser generates the temperature over 100C even up to 300C, which leads to tissue carbonization. Carbonized margins are difficult to evaluate if they are positive or suspicious. In addition to small sample size, it creates a problem for pathologists (6, 18).

There are studies that prove both deterioration and improvement of the quality of voice after laser microsurgery. Other authors state that the voice outcome is similar after surgery and radiotherapy. That is why, it is supposed that the voice outcome may depend not only on the way of treatment but also the type of resection (19, 20, 21).

It is vital to emphasize that CO2 laser is a tool which requires experience and developed manual skills. There are analyzes showing there is a relation between physician experience and a relapse rate. More experienced doctors achieved better results than the younger ones (18). The doctors should remember while performing the surgery about the potential risk of ignition. Reflection of the laser beam may cause the damage of the healthy tissue, intubation tube, decomposition and combustion of non-flammable anesthetics when mixed with oxygen, production of harmful gases and can hurt the surgeon as well. Cost of using the laser are significantly lower than radiotherapy, but purchasing the device is extremely expensive which makes it impossible to acquire by some of the health facilities.

Conclusions

There are both advantages and disadvantages of the use of CO_2 laser in endoscopic treatment of cancerous and precancerous laryngeal lesions. Undoubtedly, the benefits of using this technique outweigh the rare complications. Adverse reactions, despite their mild and transient nature, lead to health damage in patients. It is worth remembering that only early cancerous lesions are operated with a carbon dioxide laser, which emphasizes the essence of oncological prevention. Treatment decisions should be based on both oncological and functional outcomes, including patient preferences.

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