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Applications of CO_2 Laser in Endoscopic Surgery for Sinonasal Neoplasms

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Introduction

Endoscopic endonasal surgery revolutionized the classical external approach to sinonasal and skull base disease. Recently, new surgical devices have improved this technique. The introduction of lasers, due to their minimal invasiveness and high precision, opened new possible frontiers in this surgical technique. The aim of the present study is to assess safety, effectiveness, and potential advantages of CO_2 laser during endoscopic endonasal surgery for the resection of sinonasal neoplasms.

Material and Methods

The surgical procedures have been performed either with Diode laser (980 nm wavelength) or CO_2 laser (10.600 nm wavelength). Different characteristics of lasers depend on their different absorption coefficient in each kind of biological tissue. Diode laser is absorbed from both hemoglobin and water and has a continuous emission mode. CO_2 laser has a higher absorption coefficient mainly in water. In contrast with diode laser, CO_2 emission mode can be either continuous or pulsed. Emission mode is related to a different temperature increment in tissues. Continuous wave exponentially increases tissues temperature thus producing more lateral thermal damage: This characteristic guarantees good blood coagulation but a less precise cut. On the contrary, pulsed wave limits temperature increment and lateral thermal damage and guarantees a more precise and surgical cut with a worse coagulation. According to the frequency, pulsed emission mode can be Ultra-pulsed or High-pulsed, the lower lateral thermal damage is provided by the lower frequencies (Figure 1).

During the surgery we evaluated: Instrument ergonomics, quality in section on both health tissue and tumor, and coagulation and bleeding control from major vessels.

Results

From January to May 2021, six patients who underwent endoscopic endonasal surgery were eligible for the study. Three of them had a benign inverted papilloma and three had a malignant neoplasm which on histopathologic report revealed to be intestinal-type adenocarcinoma in two cases and sinonasal melanoma in one case.

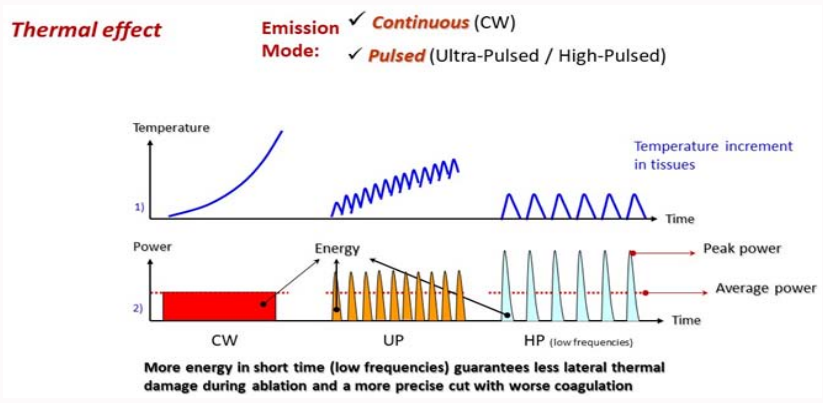

Figure 1: Thermal effect.

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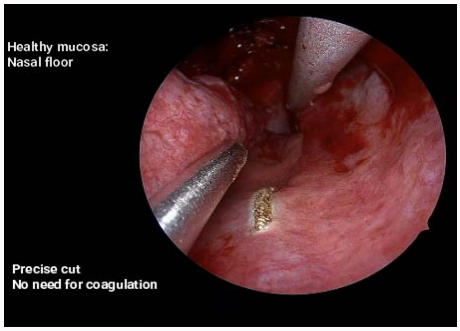

Figure 2: Healthy mucosa: Nasal floor.

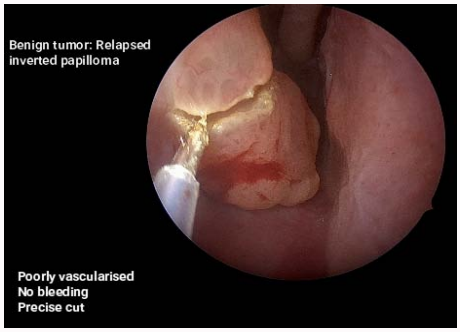

Figure 3: Benign tumor: Relapsed inverted papilloma.

Instrument ergonomics

Patient positioning follows surgical routine, and the machine can be placed behind the surgeon. The fiber is light and slim so that each anatomical site of nasal cavities resulted easily accessible. Due to the good handling, the first operator adequately performed complete endoscopic exploration of sinonasal cavities in each intervention.

Quality in section

High-pulsed emission mode delivers a controlled train of low frequency (50 Hz) high-power pulses. This modality produces the best quality cut but a worse cauterization and is ideal for poorly vascularized lesions or health mucosa resection, to guarantee free surgical margins. We tested CO_2 in the mucosa of nasal floor, septum, and lateral wall. Approach was conducted through 90° angulated probes. Perpendicular dissections produced a precise cut, a natural section of mucosa and avoided tissue carbonization often caused by straight probes (Figure 2).

We tested CO_2 with low frequency settings even for the removal of poorly vascularized lesions. We present the case of a relapsed Inverted Papilloma of the right nasal fossa. Radiological characteristics in T1 weighted with contrast showed its poor vascularization and STIR sequences, revealed its main water content. Due to its high absorption coefficient in water, CO_2 laser is an ideal tool for the removal of this kind of lesion. High pulsed emission mode was used because no high coagulation was needed due to the scarce vascularization of the lesion. With these settings we performed a precise cut, and no bleeding was observed during the procedure (Figure 3).

Ultra-pulsed mode emits CO_2 laser with higher frequencies producing slightly more thermal effect in lateral tissues. This sill guarantees a precise cut but a better coagulation and is ideal for the removal of vascularized lesions. We present the case of a highly aggressive Intestinal-type Adenocarcinoma of the right nasal fossa.

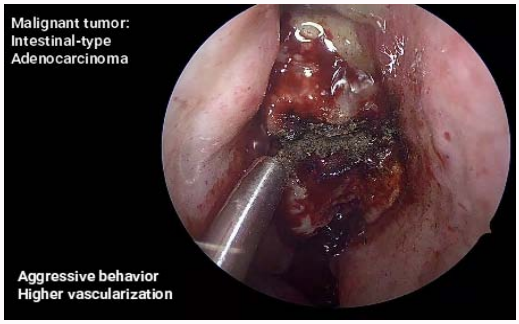

Figure 4: Malignant tumor: Intestinal-type adenocarcinoma.

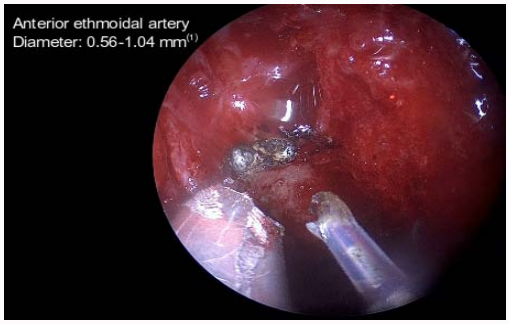

Figure 5: Anterior ethmoidal artery.

From T1 weighted with contrast sequences we observed a major blood content than the relapsed inverted papilloma of the previous clinical case. The endonasal vegetating portion was approached with a straight probe by ultra-pulsed emission mode (300 Hz) which proved better coagulation, necessary in such a highly vascularized disease (Figure 4). First steps of the debulking phase were conducted by vaporization of the mass. Subsequently, removal of the vegetating endonasal portion of the neoplasm was completed by cutting its base of implant, aided by gentle traction. Even though the high aggressive behavior and vascularization of this disease, no significant bleeding was observed during this phase.

Bleeding control from major vessels

We tested CO_2 in major vessels. To test bleeding control, we used continuous-wave emission mode. This modality emits a continuous wavelength that maximizes thermal damage to lateral tissues, thus producing a worse quality cut but optimizing cauterization and is ideal for bleeding control.

First, we tested CO_2 laser in the anterior ethmoidal artery (0.56 mm to 1.04 mm average diameter according to Yang et al. [1]). Even though CO_2 wavelength absorption is scarce by hemoglobin, this size of vessel showed to optimally be cauterized by our tool in continuous wave emission mode (Figure 5).

Secondarily, we tested CO_2 laser in Sphenopalatine artery (1.5 mm to 2.4 mm average diameter according to Lee et al. [2]). Due to the larger dimensions of this vessel, cauterization was yet possible, but results were suboptimal. Lots of steam was observed in this phase and this increased the duration of the procedure (Figure 6). Further aid with electrosurgical forceps was needed to obtain a complete result.

Discussion

In our test, ergonomics resulted good and positioning easy to perform. CO_2 laser resulted a helpful tool to obtain a bloodless

Figure 6: Sphenopalatine artery.

surgical field during the debulking phase of benign and malignant tumors and sections were high quality in both healthy and neoplastic tissue. Coagulation and vessels cauterization resulted effective until an average diameter of approximately 1 cm. We observed that 90 degrees angulated probes gave the possibility to obtain perpendicular dissections of the healthy mucosa, which guarantees more precise and natural sections and avoids tissue carbonization rather than classical tangential tools.

Possible drawbacks of CO_2 laser are its cost and time-consuming characteristics, mainly due to the necessity of expertise and learning curve. We observed that the first procedures conducted with CO_2 laser have been those who generally lasted more. It is possible that, with repeated usage of the tool, time-dependability will decrease.

Conclusion

CO_2 laser demonstrated good ergonomics, significant advantages in tumor debulking and health mucosa sectioning, and the possibility to obtain an effective cauterization of nasal vessels smaller than 1cm in diameter. Despite these advantages, this tool is potentially more-time consuming and more expensive. Further studies are needed to directly compare effectiveness of CO_2 laser over other lasers and cold instruments.

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