Intraoperative Surgical Complications in Transoral Laser CO₂ Microsurgery of the Larynx: An Observational, Prospective, Single-Center Study

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Abstract

Introduction: Despite good outcomes of CO₂ laser of the larynx, a lack of prospective data related to intraoperative complications in the indexed literature is evident. Materials and Methods: An observational, prospective, nonrandomized study. Results: One hundred and twenty-eight patients met the inclusion criteria. The total rate of intraoperative complications was 14.8% (19/128). The rate of complications according to anatomical location was 7 (38.8%) of 18 for supraglottic tumors and 11 (10.3%) of 107 for glottic tumors, and 1 (33.3%) of 3 for subglottic tumors. We do not find differences in complications according to severity (minor vs major complication). Conclusion: Previous studies reported good oncologic outcomes and low complication rates with CO₂ transoral laser microsurgery (TOLMS) compared to traditional open surgery. However, it is important to consider the different intraoperative surgical, major and minor complications related to CO₂ TOLMS and discuss this with our patients during the preoperative assessment, especially in those patients who need a supraglottic tumor resection.

Keywords
laser, complications, surgery

Introduction

Since the proposal of Strong and Jako in the 70s about the use of endoscopic laser surgery for the treatment of laryngeal lesions, different improvements have been developed, such as the magnification generated by the microscope, allowing us to make limited resections and differentiate healthy tissue from affected tissue, thereby preserving disease-free adjacent areas. Other advantages of this technique are the decrease in the number of tracheotomies and the need for nasogastric tubes compared to traditional approaches. These advantages and the similar oncologic outcomes obtained by open surgery in patients with early and suitably selected advanced tumor stages, all associated with relatively low rates of complications, support the rapid spread of CO₂ transoral laser microsurgery (TOLMS) around the world.

However, CO₂ TOLMS of the larynx is not a harmless technique. There are some papers that focus on perioperative or postoperative complications after laser surgery of tumors of the upper aerodigestive tract, most of them retrospective in nature and none of them related explicitly to intraoperative surgical complications during CO₂ TOLMS of the larynx. Therefore, this study aims to describe the intraoperative surgical complications in a group of patients treated for benign and malignant lesions of the larynx using CO₂ TOLMS in a tertiary university hospital.

Material and Methods

After the approval of the ethics committee of our institution, an observational, prospective, nonrandomized study including 128 patients diagnosed with a larynx lesion and treated with...
In most cases of large tumors (T2, T3), it was necessary to perform a piecemeal resection. Laser vestibulectomy was performed when a ventricular fold hid the lateral or anterior portion of a tumor. In all cases, the surgeons try to achieve a margin of healthy tissue of 2 to 3 mm, trying to preserve function without affecting the oncological radicality of the procedure.

Statistical analysis was performed using SPSS for Windows, version 20.0 (SPSS, Inc, Chicago, Illinois). Quantitative variables in the study were expressed as mean (standard deviation). Correlations between the rate of complications and anatomical location and correlation of complications according to anesthetic difficult (Mallampati, TMD, Cormack-Lehane) or surgical procedures were analyzed using the Student t test. A P value <.05 was considered significant.

Results
Of the 128 patients who met the inclusion criteria, 118 (92.2%) patients were male and 10 (7.8%) patients were female. The mean age of the study group was 65 (11) years (min: 34/max: 90). Of these, 22 (17.2%) were diabetic, 65 (50.8%) were hypertensive, 93 (94.9%) were smokers, and 41 (41.8%) consumed alcoholic beverages. The mean hospital stay was 2 (4) days (min: 0/max: 35) for all locations (Table 1).

According to the location, glottis was the most common location affecting 107 (83.7%) patients, the second most common location was the supraglottis affecting 18 (14%) patients, and finally, the subglottic region was affected in 3 (2.3%) patients. Data about the type of cordectomy are presented in Table 2: In glottic tumors, the type I was the most common type, performed in 42 patients, while for supraglottic tumors, the type IIIa was the most common one, performed in 3 patients. However, 19 (14.8%) resection cannot be classified (Table 2).

The total rate of intraoperative complications was 14.8% (19/128). The most common complication was severe bradycardia during laryngeal suspension 4.7% (6/128). The second and third most common surgical complications were tooth damage and cuff damage of the first cuff among others (Table 3). No ignition of the airway, no skin burns or eye injuries in any of the patients, and no laser injuries on the operating room staff were reported.

The rate of complications according to the anatomical location was 7 (38.8%) of 18 for supraglottic tumors, 11 (10.3%) of 107 for glottic tumors, and 1 (33.3%) of 3 for subglottic tumors. When we compare complications according to location, we decide to exclude patients treated for subglottic tumors due to the small sample size (3 patients); comparing supraglottic and glottic tumor resection, we found a major significant rate of complications in supraglottic tumors surgery ($P = .001$). Specific complication according to every location is presented in Table 4. According to severity, 10 (7.8%) patients presented a minor complication, with mucosal bleeding or tooth damage the most common, and 9 (7%) patients presented a major complication, bradycardia being the most common one during
surgery. When we compared complications according to severity, we exclude bradycardia due to the risk of bias related to medical or pharmacological conditions (3% = 2.3%) and we could not find a significant statistical difference (P = .08; Table 5). Management of complication is described in Table 6. When we evaluate the airway, there was no correlation between Mallampati score (P = .315), Cormack-Lehane score (P = .198), or TMD (P = .990) with the appearance of intraoperative complications (Table 7).

**Discussion**

In this prospective study, we include 128 patients treated by primary intention using CO₂ TOLMS due to benign laryngeal lesions or malignant tumors (pT1, pT2, pT3), in which the presence of intraoperative complications was high compared to previous reports, with 14.8% of patients affected. None of the events turned out to be fatal. We found a higher rate of complications, a fact that can be related to the prospective nature of our study comparing with previous retrospective reports, and due to the risk of bias reporting complications in surgical procedures in University and non-University hospitals, probably influenced by the different definitions of complications.

To the best of our knowledge, this is the first study that focused exclusively on intraoperative surgical complications during CO₂ TOLMS of the larynx. As we mentioned above, complications of laser surgery have been previously classified as intraoperative and postoperative (immediate or delayed), also being divided into minor and major, with minor complications are those that resolve spontaneously or can be treated in

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**Table 1.** Demographic Data, Anatomical Location, and Type of Surgery Performed.

| Sex       | N   | %    |
|-----------|-----|------|
| Male      | 118 | 92.2 |
| Female    | 10  | 7.8  |
| Mean age  | 65  | (min: 34/max: 90) |

| ASA       |     |      |
|-----------|-----|------|
| 1         | 8   | 6.3  |
| 2         | 85  | 66.4 |
| 3         | 35  | 27.3 |
| 4         | 0   | 0    |

| Comorbidities |     |      |
|---------------|-----|------|
| DM            | 22  | 17.2 |
| HTA           | 65  | 50.8 |
| COPD          | 28  | 21.9 |
| Cardiopathy   | 32  | 32   |
| Smoker        | 81  | 63.3 |
| Exsmoker      | 32  | 25   |
| Alcohol       | 48  | 37.5 |
| Mean hospital stay | 2   | (min: 0/max: 35) |

| Anatomical location |     |      |
|---------------------|-----|------|
| Supraglottic        | 18  | 14   |
| Glottis             | 107 | 83.7 |
| Subglottic          | 3   | 2.3  |

| Type of surgery |     |      |
|-----------------|-----|------|
| TOLMS glottic lesion | 96 | 75   |
| TOLMS glottic + CND | 4  | 3.1  |
| Synechia treatment | 2  | 1.6  |
| Posterior cordotomy | 2  | 1.6  |
| TOLMS for glottic papilloma | 2  | 2.4  |
| TOLMS for a laryngoele | 1  | 0.8  |
| TOLMS for a supraglottic papilloma | 1  | 0.8  |
| TOLMS for supraglottic benign lesion | 4  | 3.1  |
| TOLMS for supraglottic tumor | 6  | 4.7  |
| TOLMS for supraglottic tumor + CND | 7  | 5.4  |
| Subglottic lesion | 3   | 2.3  |
| Total            | 128 | 100  |

| Abbreviations: ASA, American Society of Anesthesiologists; DM, diabetes mellitus; CND, cervical neck dissection; COPD, chronic obstructive pulmonary disease; max, maximum; min, minimum; HTA, arterial hypertension; TOLMS, transoral laser microsurgery. |

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**Table 2.** Type of Cordectomies According to the European Laryngological Society Proposal for Glottic and Supraglottic Endoscopic Resection.

| Type of Cordectomy | Tx | Tis | pT1a | pT1b | pT2 | pT3 | Total (%) |
|--------------------|----|-----|------|------|-----|-----|----------|
| GLS type I         | 28 | 5   | 7    | 2    | 0   | 0   | 42       |
| GLS type II        | 1  | 0   | 0    | 0    | 9   | 0   | 10       |
| GLS type III       | 0  | 1   | 10   | 0    | 2   | 0   | 13       |
| GLS type IV        | 0  | 1   | 7    | 0    | 2   | 1   | 11       |
| GLS type Va        | 1  | 0   | 2    | 6    | 2   | 0   | 11       |
| GLS type Vb        | 0  | 0   | 0    | 0    | 0   | 2   | 2        |
| GLS type Vc        | 0  | 0   | 0    | 0    | 4   | 2   | 6        |
| GLS type Vd        | 0  | 0   | 0    | 0    | 2   | 1   | 3        |
| GLS type VI        | 0  | 0   | 2    | 0    | 0   | 0   | 2        |
| SGL type I         | 1  | 0   | 0    | 1    | 0   | 0   | 2        |
| SGL type Ia        | 0  | 0   | 0    | 0    | 0   | 0   | 0        |
| SGL type Ib        | 0  | 0   | 0    | 0    | 0   | 0   | 0        |
| SGL type Ila       | 0  | 0   | 2    | 1    | 0   | 0   | 3        |
| SGL type IIb       | 0  | 0   | 0    | 0    | 1   | 1   | 2        |
| SGL type IVa       | 0  | 0   | 0    | 0    | 0   | 1   | 1        |
| SGL type IVb       | 0  | 0   | 0    | 0    | 0   | 1   | 1        |
| Other type of resection | 0  | 0   | 0    | 0    | 0   | 0   | 19       |
| Total              | 128|     |      |      |     |     | 100      |

| Abbreviations: GLS, glottic; SGL, supraglottic. |

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**Table 3.** Type of Intraoperative Complications.

| Type of Complication | N  | %   |
|----------------------|----|-----|
| Severe bradycardia during surgery | 6  | 4.7 |
| Oral cavity bleeding secondary to intubation | 2  | 1.5 |
| Severe dyspnea after extubating | 2  | 1.5 |
| Cervical emphysema | 1  | 0.8 |
| Tooth damage during laryngoscopy | 3  | 2.3 |
| Oral cavity bleeding | 1  | 0.8 |
| Pharyngeal wall bleeding | 1  | 0.8 |
| Cuff damage during laser CO₂ excision (first balloon) | 2  | 1.5 |
| Inferior lip lesion | 1  | 0.8 |
| Total              | 19/128 | 14.8 |

| Abbreviations: ASA, American Society of Anesthesiologists; DM, diabetes mellitus; CND, cervical neck dissection; COPD, chronic obstructive pulmonary disease; max, maximum; min, minimum; HTA, arterial hypertension; TOLMS, transoral laser microsurgery. |
the office under local anesthesia without significant consequences for the patient, while major complications are those that need intensive medical treatment or even revision surgery. Finding an average global rate of complication (perioperative or postoperative) reported between 3% and 19% described for tumors of the glottis, supraglottic, and subglottic, including all stages operated by experienced surgeons. Reviewing the indexed literature, data regarding exclusively intraoperative major and minor complications rate from 0% to 6%. Endolaryngeal bleeding during supraglottic resection is the most common complication associated with CO₂ TOLMS. However, other complications described are cervical emphysema secondary to extensive resection of the anterior commissure, perforation of the cricothyroid membrane or tracheal injury, ignition of the airway secondary to cuff damage or prolonged surgery, and mucosal edema usually related to prolonged surgical time and surgical manipulation. No previous studies describe medical complications related to CO₂ TOLMS.

We found a statistical difference in the rate of complications according to the anatomical location, being more common in those patients operated for supraglottic tumors (P = .001). However, our results can be related to the small sample size of patients treated for supraglottic tumors compared to those treated for glottic tumors. Furthermore, we decide to exclude patients treated for subglottic tumors due to the small sample size (3 patients).

According to severity, in our cohort, 10 (7.8%) patients present a minor complication, being the most common the oral cavity bleeding or teeth damage and 9 (7%) patients present a major complication, being the most common bradycardia.

### Table 4. Complications According to Anatomical Locations.³

| Anatomical Location and Type of Complications | N | %  | P   |
|---------------------------------------------|---|----|-----|
| Supraglottic                                 |   |     |     |
| Severe bradycardia during surgery            | 3 | 2.4 | .001|
| Oral cavity bleeding secondary to intubation | 1 | 0.8 |     |
| Tooth damage during intubation               | 1 | 0.8 |     |
| Severe dyspnea after extubating              | 2 | 1.5 |     |
| Glottic                                      |   |     |     |
| Severe bradycardia during surgery            | 3 | 2.4 |     |
| Oral cavity bleeding secondary to intubation | 1 | 0.8 |     |
| Oral cavity bleeding during laryngoscope     | 1 | 0.8 |     |
| Tooth damage during intubation               | 2 | 1.5 |     |
| Pharyngeal wall bleeding during laryngoscope | 1 | 0.8 |     |
| Cuff damage during laser CO₂ excision (first balloon) | 2 | 1.5 |     |
| Inferior lip lesion                          | 1 | 0.8 |     |
| Subglottic                                   |   |     |     |
| Cervical emphysema                           | 1 | 0.8 |     |
| Total                                       | 19/128 | 14.8 |

*P value calculation compares supraglottic and glottic complications.

### Table 5. Intraoperative Minor and Major Complications in TOLMS.³

| Type of Complications                          | N | %  | P  |
|-----------------------------------------------|---|----|----|
| Minor                                         |   |     |    |
| Oral cavity bleeding secondary to intubation  | 3 | 2.3 | .08|
| Tooth damage during intubation                | 3 | 2.3 |     |
| Inferior lip lesion                           | 1 | 0.8 |     |
| Pharyngeal wall bleeding during laryngoscope  | 1 | 0.8 |     |
| Cuff damage during laser CO₂ excision (first balloon) | 2 | 1.5 |     |
| Total                                        | 10 | 7.8 |     |
| Major                                         |   |     |    |
| Severe bradycardia during surgery             | 6 | 4.6 |     |
| Severe dyspnea after extubating               | 2 | 1.5 |     |
| Cervical Emphysema                            | 1 | 0.8 |     |
| Total                                        | 9  | 7   |     |

*Abbreviation: TOLMS, transoral laser microsurgery.

*In comparison based on severity, we exclude bradycardia due to the risk of bias related to medical or pharmacological conditions.

### Table 6. Management of Complications According to Severity.

| Complication          | Management                        |
|-----------------------|-----------------------------------|
| Minor                 |                                   |
| Oral cavity bleeding  | Compression                       |
| secondary to intubation| Tooth prosthesis in the postop    |
| Tooth damage during   | Compression                       |
| intubation            | intubation                        |
| Inferior lip lesion   | Cauterization of the bleeding     |
| Pharyngeal wall       | Stop TOLMS and tube change        |
| bleeding during       | laryngoscope                      |
| laryngoscope          | Cuff damage during laser CO₂ excision (first balloon) | |
| Total                 |                                   |
| Major                 |                                   |
| Severe bradycardia    | Release laryngoscope support      |
| during surgery        | or remove laryngoscope            |
| Severe dyspnea after  | Tracheotomy                       |
| extubating            | Conservative management           |
| Cervical Emphysema    |                                   |

*Abbreviation: TOLMS, transoral laser microsurgery.*

### Table 7. Airway Characteristics According to Cormack-Lehane, Mallampati, and Thyromental Distance With the Appearance of Intraoperative Complications.

| Variable                  | N | %   | Patients Affected |
|---------------------------|---|-----|-------------------|
| Cormack-Lehane            |   |     |                   |
| I                         | 44 | 34.4| 6                 |
| II                        | 70 | 54.7| 11                |
| III                       | 14 | 10.9| 2                 |
| Mallampati                |   |     |                   |
| I                         | 27 | 21.1| 3                 |
| II                        | 58 | 45.3| 9                 |
| III                       | 43 | 33.6| 7                 |
| Thyromental distance      |   |     |                   |
| I = >6.5 cm               | 36 | 28.1| 5                 |
| II = 6-6.5 cm             | 64 | 50  | 10                |
| III = <6 cm               | 28 | 21.9| 4                 |

*Abbreviation: TOLMS, transoral laser microsurgery.*

*In comparison based on severity, we exclude bradycardia due to the risk of bias related to medical or pharmacological conditions.
during surgery. Although bradycardia was excluded from the statistical analysis, to avoid the risk of bias, we consider necessary to take it into account during CO₂ TOLMS. In fact, we can divide complications into medical or surgical complication (those related to the technique). In the first group, we want to include bradycardia and severe respiratory insufficiency. Also, to try to understand the occurrence of bradycardia during surgery, Watterson et al performed a study and showed that bradycardia occurred during all phases of anesthesia, but most commonly during the maintenance phase. The most common causes of bradycardia are drug events (28%), problems with the airway or ventilation (16%), autonomic reflexes (14%), and epidural and spinal anesthesia (9%). An accepted definition of bradycardia is a heart rate <60 beats/min for >5 minutes. However, there are other factors related to bradycardia such as the use of remifentanil (vagus-related bradycardia), patients older than 50 years, and ear, nose, throat/maxillofacial surgery, with particular attention to ear surgery. However, it is challenging to determine precisely the cause of these episodes during the surgery. In our cohort, those 6 patients affected were older than 50 years. Three cases presented a glottic tumor and 3 cases a supraglottic tumor. In 4 of them, heart rate came back to normal after releasing the suspension laryngoscopy, one needed pharmacological support, and the other one had a cardiac arrest, being necessary to use pharmacological support and chest massage. Another life-threatening complication related to airway during this kind of surgery is severe respiratory insufficiency. In this situation, a decrease in the oxygen saturation level is the primary symptom and can occur during the surgery or after the surgery, being necessary to reintubate the patient as occur in 2 patients in our group. Related to specific surgical complications, the most common one was tooth damage (both prosthetic and cuff damage during CO₂ TOLMS excision (first cuff), each representing 2.3% and 1.5% of complications, respectively. One patient with a subglottic malignant lesion presented cervical emphysema due to penetration of the cri-thyroid membrane during CO₂ TOLMS. Mucosal bleeding was evident in 4 patients, 3 of them due to a laceration in the oral cavity mucosa and other secondary to a laceration in the lateral pharyngeal wall mucosa, finally 1 patient had a traumatic lip mucosal lesion during suspension laryngoscopy.

In our sample, ignition of the air was absent in all cases, even after cuff damage (first balloon), demonstrating the security of the use of a special orotracheal tube for laser surgery with a double-cuff system and methylene blue in the first one. In this way, it is important to understand the role of the anesthetists for reducing O₂ levels during surgery, also precautions such as how to place a cottonoid sponge with saline covering the cuff to avoid his damage, as well as understand that even when every precaution is taken ignition risk is always present.

Although some of these complications such as tooth injury, lips or gums lesion, or mucosal bleeding can be related to suspension laryngoscopy, it would be a mistake not to consider them as real complications related to CO₂ TOLMS, because this is an elementary part of the technique.

In our sample, we do not found any correlation between Mallampati score (P = .315), Cormack-Lehane score (P = .198), or TMD (P = .990) with the appearance of intraoperative complications. However, to improve the preoperative assessment of patient before CO₂ TOLMS, in 2014, Piazza et al presented an instrument called “The Laryngoscore,” including 11 parameters: interincisors gap, TMD, upper jaw dental status, trismus, mandibular prognathism, macroglossia, micrognathia, degree of neck flexion extension, history of previous open neck and/or RT of the head and neck, Mallampati modified score, and body mass index, demonstrating its reliability and reproducibility and allowing surgeons to identify good laryngeal exposure with a high confidence, while alarming about possible difficult laryngeal exposure.

After analyzing our results, a fact that perioperative complications related to CO₂ TOLMS are well-known, some of them from proper CO₂ TOLMS studies and other from suspension laryngoscopy studies. However, prospective data and the evidence-based medicine represent an option to support medical decision and patients counsel before surgical procedures. During this study and after the final analysis, all of our patient receive information in the clinic about all the complications that can they suffer during the surgery, and therefore, in some specific cases, dentist care is recommended before surgery and, in the operative room, we reinforce our checkpoint control during laryngoscopy and during the procedure (tooth evaluation, a more meticulous laryngoscopy, confirmation of balloon protection, and improved communication with the anesthetist team) to try to reduce the rate of complication. Also, we start to apply the Laryngoscore in our patients.

Finally, it is important to emphasize that this report is only related to specific intraoperative complications. However, when a surgeon performs this kind of procedures, it is important to remember the different short- and long-term postoperative complications as well as the functional results related to CO₂ TOLMS. Limitations in our study can be the limited number of patients included, the fact that most of them are treated for small lesions, and the absence or Laryngoscore application in the protocol.

Conclusion

Previous studies showed good oncologic results and low complication rates with CO₂ TOLMS compared to traditional open surgery. However, it is important to consider the different intraoperative surgical, major and minor complications, related to CO₂ TOLMS and discuss this with our patients during the preoperative assessment, especially in those patients who need a supraglottic tumor resection.

Declaration of Conflicting Interests

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