CO_2 Laser Surgery in Otorhinolaryngology-Site and Complications: A 10-year Experience at Ramathibodi Hospital

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Abstract

Objective : To present data on ten years' experience in CO_2 laser surgery and associated complications among otorhinolayngologic patients.

Material and Method : The study involved examining records of otorhinolaryngologic patients who underwent CO_2 laser operations during a 10-year period (July 1, 1986 – June 30, 1996). The sample consisted of 733 patients: 370 male and 363 female patients. CO_2 laser surgery in otorhinolaryngology was first used in Ramathibodi Hospital on July 10, 1986.

Results : These patients were aged 2 months to 93 years with the mean age of 24.3 years (median = 16 years). Among 1,725 operations, 1,570 operations (91%) were performed under general anesthesia and 155 operations (9%) were performed under local anesthesia. In our series, the most frequent sites for laser surgery were as follows: larynx (77.22%), oral cavity and oropharynx (12.64%), skin (5.04%) and nose and paranasal sinuses (3.31%). Intra-operative complications occurred in 18 out of 1,725 (intra-operative complication rate of 1%). Laser-related complications were found in 13 out of 1,725 operations (0.75%) and non laser-related complications were found in 5 out of 1,725 operations (0.25%). There was no mortality.

Conclusion : CO_2 laser is a useful modality of treatment in otorhinolaryngologic surgery especially in the larynx. Our experience demonstrates the relative low incidence of complications (1%) and no mortality in otorhinolaryngology head and neck surgery.

Key word : CO_2 Laser Surgery, Laser Complication

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The development of LASER (Light Amplification by the Stimulated Emission of Radiation) began in 1917 when Einstein published his paper "Zur Quaanten Theorie der Strahlung", which was a turning point in history for discussion of stimulated emission[1]. In 1954, Townes and Gordon built "MASER" (Microwave Amplification by the Stimulated Emission of Radiation), a pioneering microwave laser[2]. In 1958, Townes and Schawlow published the first theoretic calculation for a visible light MASER and defined the term "Optical MASERS"[3]. Nine months later, Gould defined the term "LASER" as mentioned earlier[4].

In May 1960, Theodore Maimen at Hughes Aircraft Company made the first laser. The light in the red region of the spectrum at 694 nm was produced by the application of a ruby as the laser medium[5]. The neodynium-doped (Nd): glass laser was developed in 1961[6]. In 1964, the argon ion (Ar) and the neodynium-doped ytrium-aluminum-garnet (Nd:YAG) lasers were developed[7].

In 1965, continuous CO_2 laser was discovered. Within five years, there was a rapid development of basic surgical laser with the handpieces containing lenses of various focal lengths [8], laser endoscope and stereomicroscope laser attachment[9]. In 1968, Polanyi[10] developed the articulated arm to deliver the CO_2 laser to remote targets. He worked with Jako to use the articulated arm to deliver the CO_2 laser to ablate vocal fold papillomatosis[11,12]. In Thailand, the continuous CO_2 laser was first used in Ramathibodi Hospital on July 10,1986; it provided an alternative mode of therapy in otorhinolaryngology.

Objective

To present data on ten years experience in CO_2 laser surgery and associated complications among otorhinolayngologic patients.

MATERIAL AND METHOD

The study involved examining records of otorhinolaryngologic patients who underwent CO_2 laser operations during a 10-year period (July 1, 1986 – June 30, 1996). The sample consisted of 733 patients: 370 male and 363 female patients.

Sharplan 1060 equipment was used for the CO_2 laser generator. Safety precautions (listed by ANSI for class IV laser use)[13] included:

-Direct supervision by individual knowledge in laser technology and safety.

-Location so that access to the area by spectators required approval.

-Appropriate warning signs "The word *DANGER* shall be on all signs and labels associated with class IIIb and class IV laser systems. For class IV, an appropriate sign word would read –Laser Radiation, avoid eye or skin exposure to direct or scattered radiation."

-Have any potentially hazardous beam terminated in a beam stop of an appropriate material that is highly absorbent, nonspecular (nonreflecting), and fire resistant such as a dull metal.

-Have only diffusely reflective materials, such as dull-surfaced instruments, in or near the beam path where feasible.

-Use safety latches or interlocks to prevent unexpected entry of personnel into laser controlled areas.

-Everyone in the room including the patient should have eye protection in place while the laser is being operated.

-Cover or restrict all windows to reduce laser radiation to levels of or below the ocular maximum permissible exposure by installing blinds.

During intralaryngeal operation under general anesthesia, the endotracheal tube should be covered with aluminum foil to protect the tube from the laser beam because such a laser beam could penetrate the tube and cause burn injuries to the respiratory tract. For operations within the oral cavity or the nose, the endotracheal tube should be covered with damp compresses. The cuff of the endotracheal tube should be inflated with saline instead of air.

The alternative method for general anesthesia in intralaryngeal laser surgery is the use of jet ventilation with a small metallic tube. With this tube, a wider operative field is attained and the explosive risk is lessened. When a non-explosive-anesthetic gas i.e. halogen is used with the oxygen; the proportion of inhaled air should not exceed 30 per cent[14]. For the protection from the plume derived from laser surgery, everybody in the operative room should wear a mask, and high-volume flow rate suction (20-40 ft^3 /min)[15] with ULPA filter during the operation should be used. Although in 1991, studies by Kashima et al[16]. demonstrated that the laser plume contained the

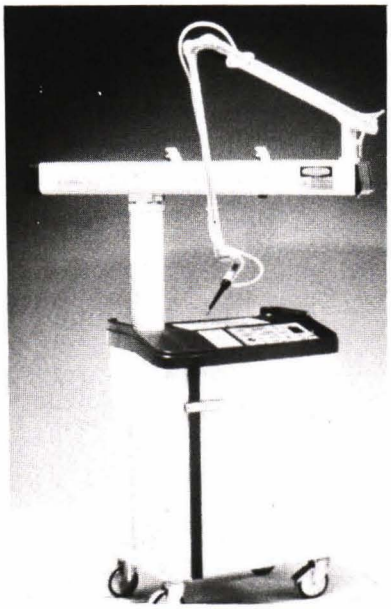

Fig. 1. CO_2 laser unit with fitted hand unit.

HPV-DNA virus, from our study in 1996 the plume derived from laryngeal papilloma tissue being lased by a continuous mode carbondioxide laser was void of viable cells and infectious DNA or viral particles[17].

RESULTS

The age range of the patients varied from 2 months to 93 years with the mean age 24.3 years (median = 16 years). Among 1,725 operations, 1,570 operations (91%) were performed under general anesthesia and 155 operations (9%) were performed under local anesthesia. The frequency of various treatments according to the anatomical locations of the diseases are shown in Table 1. The top twenty diseases according to number of treatments are shown in Table 2; other diagnoses are shown in Table 3.

In this study, intra-operative complications occurred in 18 out of 1,725 operations (intra-operative complication rate of 1%). Laser-related complications were found in 13 out of 1,725 operations (0.75%) and non laser-related complications were found in 5 out of 1,725 operations (0.25%). There was no mortality as shown in Tables 4 and 5.

DISCUSSION

The carbondioxide laser is the most commonly used laser in otolaryngology. One of the advantages of this wavelength (10,600 μm) is its predictable laser-tissue interaction as seen by visible tissue vaporization. The microcirculation is also coagulated, allowing precise visualization of the operative field with less tissue manipulated and less postoperative edema[18].

During the early period of laser surgery in Thailand, early reports on CO_2 laser surgery at Ramathibodi Hospital included laryngeal surgery (19-22), tracheobronchial surgery[19-21], palatal surgery (UPPP)[23], and rhinologic surgery[19].

In our series, more frequent sites for laser surgery were as follows: larynx (77.22%), oral

Table 1. Anatomical distribution and number of treatments.

Anatomical locations	Cases	Operations	%
Larynx	374	1,332	77.22
Oral cavity and oropharynx	194	218	12.64
Skin	83	87	5.04
Nose and Paranasal sinuses	55	57	3.31
Ear	10	13	0.75
Tracheobronchial	8	8	0.46
Esophagus	2	2	0.12
Others*	7	8	0.46
Total	733	1,725	100

* Others included elongated styloid process, neck mass, cystic hygroma, nasopharyngeal carcinoma, lacrimal duct obstruction.

Table 2. The top twenty diseases according to number of treatments.

Diseases	Case(s)	Operation(s)	%
1. Papillomas	89	814	47.19
2. Subglottic stenosis	63	114	6.61
3. Benign vocal cord tumor (Polyps, nodules, granuloma, tumor)	105	112	6.49
4. Laryngotracheal stenosis	54	111	6.43
5. Vocal cord paralysis	26	37	2.14
6. Benign buccal mucosa lesion (squamous papilloma, leucoplakia)	18	26	1.51
7. Laryngeal stenosis	28	32	1.86
8. Carcinoma of larynx	27	28	1.62
9. Snoring problem	10	14	0.81
10. Nasal hemangioma	3	14	0.81
11. Vallecular cyst	13	14	0.81
12. Tongue hemangioma	10	14	0.81
13. Tongue tie	14	14	0.81
14. Nasal papilloma	10	13	0.75
15. Facial nevus	12	12	0.7
16. Tongue carcinoma	11	12	0.7
17. Buccal mass	10	10	0.58
18. Chronic tonsillitis	10	10	0.58
19. Facial mole	10	10	0.58
20. Tongue mass	9	9	0.52
21. Others	201	305	17.68
Total	733	1,725	100

cavity and oropharynx (12.64%), skin (5.04%) and nose and paranasal sinuses (3.31%). This pattern is similar to that reported by Ossoff et al[24] and by Haug[25] (Table 6).

Complications

Complications that we found included postoperative airway obstruction due to glottic edema following removal of a papilloma in 2 cases (1 time and 4 times) and secretion block after bronchoscopic laser surgery of tracheal granulation tissue in 1 case. Cases which required endotracheal tube intubation could have the tubes removed without sequelae.

Rupture of the surgical glove during microlaryngoscopic surgery occurred during 3 operations; this might be underestimated and the actual figure may be higher as some surgeons admitted to not having recorded this.

Perforation of the endotracheal cuff was found in 2 early cases of endoscopic laryngeal surgery. This complication can be prevented by using normal saline to inflate the cuff instead of air and covering the balloon with saline soaked neurosurgical cottonoids, or by using the jet ventilation system instead of an endotracheal tube.

Rupture of the anterior tracheal wall was found in bronchoscopic laser removal with extensive tracheal papilloma around the tracheostomy stoma. The small perforated site was located just above the stoma and needed no specific treatment in the postoperative period.

Dental (tooth) trauma was found in 2 cases during endoscopic laser surgery; preoperatively, maxillary incisors were loose. Intra-operative arrhythmia occurred in 2 cases and lead to termination of the operation. This might have been associated with intra-operative hypoxia or carbon-dioxide retention.

Serious complications were found in 2 cases. Pneumothorax was detected during endoscopic laryngeal laser surgery with jet ventilation in a young girl with laryngeal papilloma. The operation was terminated and intercostal drainage (ICD) was done in the affected side; conservative management was complimented with radiologic

Table 3. Other diagnoses.

Diagnosis	Operations in each item n (%)
- Laryngotracheal granulation tissue	9 (0.5)
- Buccal mucosa carcinoma	8 (0.4)
- Facial papilloma, EAC stenosis	7 (0.4)
- Nasal synechiae	6 (0.3)
- Subglottic mass, tumor, soft palate carcinoma, OSA,	5 (0.3)
- Floor of mouth carcinoma, skin nevus, nasal nevus	
- Subglottic hemangioma, epiglottic cyst, Reinke's edema	4 (0.2)
- Buccal mucosa hemangioma, skin papilloma, tongue base mass	
- Ear pinna papilloma, papilloma at neck, lingual tonsil hypertrophy,	3 (0.2)
- Buccal mucosa lymphangioma, subglottic granulation tissue,	
- Skin tattoo, glottic leukoplakia, vocal edema, epiglottic mass,	
- False cord mass, floor of mouth cyst, oral cavity squamous papilloma,	
- Tongue leukoplakia, plica ventricularis.	
- Conjunctival papilloma, ear inclusion cyst, ear pinna keloid,	2 (0.1)
- Ear keloid, tracheobronchial carcinoma, ear carcinoma,	
- Tracheostomy stoma granulation tissue, allergic rhinitis,	
- Otosclerosis, elongated styloid process, facial mass,	
- Nasal inverted papilloma, buccal mucosa erythroplakia,	
- Oral cavity erythroplakia, laryngotracheal carcinoma,	
- Laryngotracheal hemorrhage, tongue ulcer, tongue hyperkeratosis	
- Skin malignant melanoma, tongue lichen planus, soft palate papilloma,	
- Gum hemangioma, gum carcinoma, uvular carcinoma, tonsil mass,	
- Lip mass, lip carcinoma, tonsil crypt, nasal polyps, lip mucocele,	
- Retromolar carcinoma, nasal granuloma, facial freckle,	
- Nasal malignant melanoma, tongue lymphangioma,	
- Floor of mouth ulcer, supraglottic mass, neck mass,	1 (0.1)
- Supraglottic stenosis, transglottic stenosis, laryngeal leukoplakia,	
- Cricoarytenoid fixation, subglottic obstruction, subglottic edema,	
- Supraglottic web, supraglottic granuloma, ventricular mass,	
- Epiglottic hemangioma, false cord prolapse, oral cavity granuloma	
- False cord granulation tissue, aryepiglottic fold cyst, cystic hygroma,	
- Hypopharynx mass, pyriform mass, vallecular mass,	
- Oral cavity leukoplakia, tongue papilloma, tongue erythroplakia,	
- Hard palate leukoplakia, hard palate squamous papilloma,	
- Soft palate mass, hard palate granuloma, hard palate ulcer,	
- Buccal mucosa mucocele, buccal mucosa fibrosis, buccal mucosa cyst,	
- Buccal mucosa verrucous carcinoma, alveolar pigmented lesion,	
- Uvular papilloma, tonsil papilloma, tonsil cyst, tonsil carcinoma,	
- Tongue base hemangioma, tongue base carcinoma, tongue base varicose vein,	
- Lip ulcer, lip squamous papilloma, lip keloid, posterior pillar papilloma,	
- Nasal angiofibroma, post pillar cyst, lip papilloma, nasal stenosis, nasal mass,	
- Nasal cyst, nasal basal cell carcinoma, nasal lymphangioma,	
- Neck squamous papilloma, post auricular senile keratosis, ear nevus,	
- Epistaxis, nasal septum papilloma, nasal septum mass,	
- Nasal septum granuloma, nasal septum inverted papilloma,	
- Turbinate hypertrophy, maxillary carcinoma, secretory otitis media,	
- Skin hemangioma, facial melanoma, skin seborrheic keratosis, elbow keloid,	
- Ear canal mole, skin inclusion cyst, skin keloid, eyelid hemangioma,	
- Skin osteosarcoma, lacrimal duct obstruction, eye lid osteosarcoma,	
- Ear canal mass, keloid at mandible, tracheotomy stoma granuloma,	
- Ear canal nevus, ear pinna nevus, ear pinna granulation tissue tissue,	
- Rhinophyma, preauricular granulation tissue, nasal keloid,	
- Esophageal stenosis, esophagus verrucus carcinoma,	
- Tracheobronchial adenoma, bronchial mass, bronchial foreign body.	

Table 4. The incidence of intraoperative complications (N=1,725 operations).

Complication(s)	number	(%)
Laser-related complications	13	0.75
Non laser-related complications	5	0.25
Total	18	1

Table 5. Complications of CO_2 laser surgery in otorhinolaryngology (n=18, or 100%).

Laser related complications:			13	72.22%
(Postoperative airway obstruction	6	33.33%)		
(Ruptured surgical glove	3	16.66%)		
(Ruptured endotracheal cuff	2	11.11%)		
(Silicone tracheal T-tube burn	1	5.56%)		
(Perforated anterior tracheal wall in the suprastomal area	1	5.56%)		
Non laser-related complications			5	27.78%
(Intra-operative arrhythmia	2	11.11%)		
(Tooth extraction during bronchoscope	2	11.11%)		
(Pneumothorax from jet ventilation	1	5.56%)		
Total			18	100%

Fig. 2. The T tube that was burnt during the operation.

Fig. 3. The surgical glove that was perforated by the laser beam during the operation.

study of the chest. The ICD was removed on the fifth postoperative day. The cause of the pneumothorax was probably due to positive pressure ventilation which was too high during the operation. The other serious complication was the silicone T-tube burn during the bronchoscopic laser removal of the granulation tissue in a 64-year-old woman who had asthmatic bronchitis and tracheal stenosis[26].

The incidence of risk of complications in our series was 0.73 per cent of all operations, slightly higher than that the 0.2 per cent reported by Healy[27]. No mortality was reported in our series and others[24,25,27-31]. The CO_2 laser is still regarded as a useful modality for treatment of otorhinolaryngologic disorders. The good results achieved are compatible with its widespread use. In order to avoid iatrogenic complications, surgeons, anesthesiologists and operative room staff should be knowledgeable about the basic principles of the laser and its application, as well as laser hazards and their management.

Complications of CO_2 laser surgery composed of a) exposure hazards to patients or operating room personnel i.e. corneal burns, skin exposure, postoperative dysgeusia b) anesthetic hazards i.e. endotracheal tube ignition, inadequate ventilation (tube kink, balloon rupture, increased CO_2 gas escape), intraoperative airway obstruction secondary to foreign body(aluminum foil, cottonoids) c) complications of microlaryngoscopy i.e. tooth trauma, temporomandibular joint dislocation, arrhythmia or acute myocardial infarction, airway obstruction secondary to swelling of the oropharynx or oral cavity d) complication of inadvertent CO_2

Table 6. Comparison of the operative sites of CO_2 laser surgery.

	Our series (1,725 ops) (%)	Haug et al (1993) (479 ops) (%)	Ossoff et al (1983) (204 cases) (%)
Larynx	77.22	68.1	62.25
Oral cavity and oropharynx	12.64	13.36 (oral cavity)	26.96
Skin	5.04	2.3	-
Nose and paranasal sinuses	3.31	7.3	3.35
Ear	0.75	-	-
Tracheobronchial lumen	0.46	8.98	3.4
Esophagus	0.12	-	-
Others*	0.46*	-	3.92
Total	100	100	100

* Others included elongated styloid process, neck mass, cystic hygroma, nasopharyngeal carcinoma, lacrimal duct obstruction.

laser irradiation i.e. misdirected burns from direct or reflected energy, tracheal perforation, endotracheal tube ignition, acquired subglottic web, subglottic stenosis, vocal cord fibrosis, arytenoid perichondritis e) complications of aluminum foil wrapped endotracheal tube i.e. airway obstruction from displaced aluminum foil, trauma to vocal cords during intubation, limited flexibility of tube f) other i.e. bleeding, infection, delayed healing, postoperative airway obstruction, otalgia, dysphagia and/or odynophagia, papilloma implantation on lips, nasopharynx, oropharynx, or oral cavity(31).

Advantages

Good results were found in the treatment of benign tumors and lesions of the larynx (vocal nodule, intubation granuloma, capillary hemangioma, vocal polyps, epithelial cysts), carcinoma of larynx (T_1, T_2) and oral cavity lesions(21); the difference in functional outcome was found in cases of early glottic carcinoma when compared with that of radiation therapy(32,33).

Papillomas involving the larynx and\or laryngotracheal lumen are normally not cured by laser surgery but, in many cases, the intervals between the treatment periods have become longer than those found after conventional endoscopic surgery; some cases responded to only one treatment.

In some cases, so many operations have had to be performed e.g. 81 times. This recurrence and extensive extension pattern may indicate the need for other modalities such as Interferon in the hope of achieving better results.

Vocal nodules and polyps can be removed by the conventional method but CO_2 laser provides an advantage in less bleeding and edema. Pre-operative and postoperative speech consultations with speech pathologists for correction of voice abuse are also indicated.

Lesions in the oral cavity and oropharynx could be excised as excisional biopsies like conventional excisional biopsies. In some cases, this could be done under local anesthesia. In suspicious lesions the excised specimens were removed with a wide margin and sent for frozen section. Complete healing of the resected area was found in the third or fourth postoperative weeks. During this period, antibiotics are necessary for the prevention of infection.

Various skin lesions have good response with CO_2 laser e.g. nevus, mole, papilloma, keloid and can be removed under local anesthesia.

CO_2 laser can vaporize lesions in the nasal cavity if the lesions are located in the anterior portion of the nasal cavity e.g. nasal papilloma, hemangioma, synechia and granuloma. However, if the lesions are located in the posterior portion, the operative field may be limited because the operative view is obscured by the presence of nasal turbi-

nates. Lasers e.g. KTP 532, Nd :YAG or Ho : YAG that can pass through a fiber optic tip when combined with operative endoscopy can provide a better approach. Limited experience regarding CO_2 laser surgery has been gained for ear surgery (e.g. laser stapedotomy, laser canaloplasty), esophageal lesions and tracheobronchial lesions.

SUMMARY

The CO_2 laser is a useful modality of treatment in otorhinolaryngologic surgery especially in the larynx. Our experience demonstrates the relative low incidence of complications (1%) and no mortality in otorhinolaryngology head and neck surgery.

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ประสบการณ์การผ่าตัดผู้ป่วยทางโสต ศอ นาสิกวิทยาด้วยคาร์บอนไดออกไซด์เลเซอร์ ช่วงเวลา 10 ปี ที่โรงพยาบาลรามาธิบดี รายงานตำแหน่งการผ่าตัดและผลแทรกซ้อน

วีระพล ประณีตวตกุล, พ.บ., บุญชู กุลประดิษฐารมณ์, พ.บ.*, สมยศ คุณจักร, พ.บ.*, ครรชิตเทพ ตั้นเผ่าพงษ์, พ.บ.*, ชัย อยู่สวัสดิ์, พ.บ.*, วิชิต ชีวเรืองโรจน์, พ.บ.*, เฉลิมชัย ชินตระการ, พ.บ.*, ธงชัย พงศ์มงพัฒน์, พ.บ.**

วัตถุประสงค์ : เพื่อเสนอประสบการณ์การผ่าตัดผู้ป่วยทางโสต ศอ นาสิกวิทยาด้วยคาร์บอนไดออกไซด์เลเซอร์ ช่วงเวลา 10 ปี โดยรายงานโรคที่รับการรักษา, ตำแหน่งการผ่าตัดและภาวะแทรกซ้อนที่เกิดขึ้น

วัสดุและวิธีการ : การศึกษาข้อมูลของผู้ป่วยทางโสต ศอ นาสิกวิทยาที่เข้ารับการผ่าตัดด้วยคาร์บอนไดออกไซด์เลเซอร์ ช่วงเวลา 10 ปี ตั้งแต่วันที่ 1 กรกฎาคม 2530 ถึง 30 มิถุนายน 2540 มีผู้ป่วยรวม 733 คนแยกเป็นชาย 370 คนและหญิง 363 คน เริ่มมีการผ่าตัดด้วยคาร์บอนไดออกไซด์เลเซอร์เป็นครั้งแรกที่โรงพยาบาลรามาธิบดีเมื่อวันที่ 10 กรกฎาคม 2530

ผลการศึกษา : ผู้ป่วยมีอายุในช่วง 2 เดือนถึง 93 ปี อายุเฉลี่ย 24.3 ปีค่ากลางอายุ 16 ปี มีการผ่าตัด 1,725 ครั้งโดยแบ่งเป็นการผ่าตัดด้วยอาการสลบ 1,570 ครั้ง (91%) และด้วยอาการชาเฉพาะที่ 155 ครั้ง (9%) ตำแหน่งที่ทำการผ่าตัดประกอบด้วย กล่องเสียง (77.22%) ช่องปากและคอหอย (12.64%) ผิวหนัง (5.04%) จมูกและโพรงไซนัส (3.31%) พบภาวะแทรกซ้อนในการผ่าตัดรวม 18 ครั้งจากการผ่าตัด 1,725 ครั้ง คิดเป็นอัตราการเกิดภาวะแทรกซ้อน 1% แบ่งเป็นภาวะแทรกซ้อนที่เกี่ยวกับการใช้คาร์บอนไดออกไซด์เลเซอร์ในการผ่าตัด 13 ครั้ง (0.75%) และภาวะแทรกซ้อนที่ไม่เกี่ยวกับการใช้คาร์บอนไดออกไซด์เลเซอร์ในการผ่าตัด 5 ครั้ง (0.25%) ไม่พบการเสียชีวิตในการศึกษานี้

สรุป : การใช้คาร์บอนไดออกไซด์เลเซอร์ในการผ่าตัดเป็นการรักษาทางโสต ศอ นาสิกวิทยาที่มีประโยชน์โดยเฉพาะอย่างยิ่งในกล่องเสียง ในการศึกษานี้พบว่ามีอุบัติการณ์เกิดภาวะแทรกซ้อนต่ำ (1%) และไม่พบการเสียชีวิต

คำสำคัญ : CO_2 Laser Surgery, Laser Complication

วีระพล ประณีตวตกุล, บุญชู กุลประดิษฐารมณ์, สมยศ คุณจักร, และคณะ
จดหมายเหตุทางแพทย์ ฯ 2544; 84: 339–348

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