# A Phase II Study of Nd-YAG Laser Therapy in Patients with Non-Operable Malignant Obstructive Endobronchial Lesions after Prior Chemotherapy and/or Radiation Therapy

Hanan Shawky[1], Ashraf Sayed Abd El- Haleem[2], Ibraheem Salah[3], Adel Alnozahy[4] and Anke Klingner[5]

[1]Clinical Oncology Department, Faculty of Medicine, Tanta University Hospital
[2]Armed forces
[3]Chest Department, Faculty of Medicine, Tanta University Hospital
[4]National Institute of Laser Enhanced Sciences, Cairo University
[5]Department of Physics, Basic Science, German University in Cairo
hannshawky@yahoo.com

**Abstract: Background:** Nd-YAG laser has long been used to treat cancers within the tracheobronchial tree. It offers the advantages of a relatively short duration of treatment, a low side effect profile, and a relatively low risk in patients with non-operable malignant obstructive endobronchial lesions. We report the first successful use of Nd-YAG laser as palliative management of non-operable malignant obstructive endobronchial lesions at Tanta University Hospital in cooperation with National Institute of Laser Enhanced Sciences, Cairo University and German University in Cairo. **Patients and methods:** A series of 16 patients with non-operable malignant obstructive endobronchial lesions after prior chemotherapy and/or radiation therapy at Clinical Oncology Department, Faculty of Medicine, Tanta University Hospital were treated with laser therapy at Chest Department, Tanta University Hospital, in cooperation with National Institute of Laser Enhanced Sciences, Cairo University and German University, in Cairo during the period between January 2011 and October 2013. Endpoints were response rate (RR) and safety. **Results:** The mean age was 50.2 ± 9.7 years old. Malignant primary lung cancer was reported in 62.5% of the cases; and in 37.5% of the patients the diagnosis was metastatic tumors. All patients had obstructive pneumonitis at time of start of Nd- YAG laser therapy, while dyspnea was, reported in 93.75% of the patients followed by cough (87.5%) and hemoptysis (81.25%)**.** Response rate was 81.4% with a significant improvement of clinical signs and symptoms, arterial blood gas indices and spirometric results, however, complete response (CR) occurred only in 2 (12.5%) patients. Progressive disease (PD) was recorded in 3 (18.75%) patients. Complications of the Nd- YAG laser therapy occurred in 8 of 16 cases (50%), included; bleeding in 31.25%, and respiratory failure in 6.25%. **Conclusion:** Nd-YAG laser is well-tolerated, and provides prompt and durable palliation in unresectable patients with malignant obstructive endobronchial lesions.

[Hanan Shawky, Ashraf Sayed Abd El- Haleem, Ibraheem Salah, Adel Alnozahy and Anke Klingner. **A Phase II Study of Nd-YAG Laser Therapy in Patients with Non-Operable Malignant Obstructive Endobronchial Lesions after Prior Chemotherapy and/or Radiation Therapy.** *J Am Sci* 2013;9(12):344-352]. (ISSN: 1545-1003). http://www.americanscience.org. 47

**Key words:** Nd-YAG laser, primary and secondary lung cancer, malignant obstructive endobronchial lesions.

## 1.Introduction

Patients with significant malignant obstructive endobronchial lesions are limited by dyspnea, respiratory distress, and obstructive pneumonia. For many of these patients, in the absence of intervention, their airway pathology may be the direct cause of death from suffocation[(1)].

A large number of patients with symptomatic and life threatening malignant airway pathology are not candidates for definitive surgical correction because of the extent of the disease or comorbidity[(1)]. Depending on the cause of the malignant obstruction, external beam radiation therapy, and/or chemotherapy, are frequent options for nonsurgical palliation and local and systemic control of tumor[(2,3)]. However, after chemotherapy and radiation patients may still have life-limiting airway obstruction. In this series, most of the patients had already exhausted standard therapy for their malignancy and were referred for endobronchial brachytherapy, photodynamic therapy, and Nd:YAG laser therapy because of the severity of their symptoms with no alternative treatment options[(4-7)].

Lasers have affected health care in many ways. Clinical applications have been found in a number of medical and surgical specialities[(8)].

Exophytic lesions of the trachea and main-stem bronchi are the most amenable to therapy by laser, and improvement in symptoms correlates best with improved patency of large airways[(9)]. It could be used as a local treatment of primary and secondary malignant lung tumors, primarily in patients whose condition is not amenable to surgical resection[(10)], and it is considered one of the effective methods in relieving the obstruction and its related signs and symptoms[(11)].

Being repeatable in a short period compare to the other methods of treatment such as radiation therapy or surgery has made it as one of the most desirable palliative therapies for patients with lung tumors. Meanwhile, it is a quite non-expensive approach as compared to surgical intervention[11]. In addition, Nd-YAG laser therapy offers the advantage of speed over PDT, cryotherapy, external beam RT, and brachytherapy. Thus, Nd-YAG, when it can be done safely, remains the treatment of choice for intubated patients because of its speed. Furthermore, Nd- YAG Laser not only cuts but also seals blood vessels and bronchi and can prevent bleeding as well as air leaks[12].

On the basis of this evidence, we initiated this study to investigate the safety and, tolerability of Nd-YAG laser therapy in patients with histologically confirmed non-operable malignant obstructive endobronchial lesions.

## 2. Patients and Methods

### Patients

Between January 2011 and September 2013, 19 patients over the age of 18 years with histologically confirmed non-operable malignant obstructive endobronchial lesions, were the subjects of this study, of which 16 were assessable for response at Clinical Oncology Department, and Chest Department, Faculty of Medicine, Tanta University Hospital. Three patients were ineligible, not treated, or incorrectly treated: reasons included treatment refusal (n = 2) and medication-induced coagulopathy (n =1).

All of the patients had the obvious signs and symptoms of airway obstruction. Nd- YAG laser therapy intervention rather than supportive care was recommended when benefit from it appeared technically feasible and clinically meaningful (ie, life-expectancy greater than 1 month, adequate performance status independent of the airway limitations [Patients were required to have a Karnofsky performance status (KPS) of $\geq$60], and appropriate anatomy). Exclusion criteria included any medical condition that could interfere with coagulopathy eg. platelet count < 50,000/mm$^3$or partial thromboplastin time > 50 seconds.

All patients gave written informed consent.

### Study Design and Treatment

Our therapeutic technique using the Nd- YAG laser have previously been reported[11]. The Nd- YAG laser therapy was used for patients with severe tracheo-bronchial stenosis not improved with bronchoscopic mechanical dilatation or previous radiation therapy or chemotherapy and/or was felt to be too dyspneic to undergo surgical excision.

The ideal patient would have a short, central, endobronchial lesion that is not completely occlusive. This would allow passage of the Nd:YAG laser fiber alongside the lesion. Patients with a large amount of post-obstructive atelectasis with viable and reexpandable lung distal to the lesion will benefit from Nd:YAG laser, as opposed to those without viable lung distal to the obstruction. All of these factors should be considered prior to undertaking Nd:YAG laser in the patient suffering from signs and symptoms due to the airway obstruction

We assigned eligible patients to receive Nd-YAG laser therapy at power of 25-35 watt through either rigid or flexible fiberoptic bronchoscope. Flexible bronchoscopy usually supplemented rigid bronchoscopy, with the flexible bronchoscope used through the rigid scope to improve distal airway visualization, perform initial exploration distal to an obstructive lesion, and assist in aspirating blood and secretions. Adequate immobilization was required to ensure reproducibility via IV sedation and/or anesthesia. The length of the fiber chosen was based on knowledge of normal bronchial anatomy and an estimate of the length of tumor involvement.

Treatment volumes were determined on the basis of contrast-enhanced computed tomography (CT) of the chest and diagnostic bronchoscopy to evaluate the airway. After inserting fiberoptic bronchoscope, the tip of the quartz was placed about 1- to 2-cm from the contrast-enhancing lesion depending on the location. The dose of the Nd- YAG laser therapy was delivered over 10 – 40 minutes. The fiber was moved so as to cover the entire target volume.

All of our patients had a minimum of 3 bronchoscopies: the original bronchoscopy to evaluate the airway plus the one Nd- YAG laser treatment, and the one subsequent bronchoscopic toilet and debridement. Subsequent bronchoscopic toilet and debridement was done on a case-by-case basis.

Patients were discharged 24 hours after the procedure if otherwise stable. No special airway management or restrictions beyond routine judicious hydration were used, but patients with recurrent problems of endobronchial obstruction by secretions were treated with frequent nebulizer treatments with acetylcysteine, bronchoscopic toilet and debridement, and occasionally with chest physiotherapy.

### Surveillance and Follow-up

The baseline examination included a complete medical history, physical examination, determination of performance status, spirometry, and contrast-enhanced CT of the chest. After Nd- YAG laser therapy, patients underwent clinical evaluation mainly according to their clinical signs and symptoms before and after treatment, and a comprehensive evaluation of the improvement by bronchoscopic examination and contrast-enhanced CT on the first post-procedural

24-48 hours to assess treatment response of each patient.

Palliative improvement was considered to have occurred if the stenotic opening of a previously obstructed trachea or bronchi was enlarged with relief of dyspnea, cough and/or wheezing and physiologically demonstrated reduction in air flow obstruction. Maximal expiratory and inspiratory flow volume loops performed in each patient before and at least three weeks after laser therapy; results were compared with previously published standards[13-16]. Furthermore, Tumor successful ablation was defined according to the Criteria explained by Rosenberg et al[10].

Early adverse outcomes were assessed by patient symptoms and signs, and late outcomes were assessed by patient follow-up visits, follow-up bronchoscopy, discussions, or combinations thereof with the patient, or patient's family.

After completion of treatment, patients were evaluated by physical examination, chest radiography, and CT 6 weeks after the procedure then every 3 months and every 6 months thereafter to radiographically document first sites of tumor progression or recurrence. The development of an increase in size of the residue compared with the initial control findings, or a new, low-density mass in the region of the treatment target volumes bed was considered evidence for local tumor progression even in the absence of symptoms; cytologic or histologic confirmation of recurrent disease.

When there was tumor progression, after an initial response to Nd- YAG laser therapy, patients were treated at the investigator's discretion, and the type of second-line therapy was usually, in the form of repeated ablation.

**Statistical Analysis**

The primary end point was treatment response; secondary end point was safety. Response rate and safety are reported for all treated patients.

SPSS [Statistical package (version 12.0)] was used for data analysis. Mean and standard deviation were estimates of quantitative data, with statistical significance assessed by the log-rank test.

## 3. Results

**Patient Characteristics**

Patients ≥18 years of age with histologically proven non-operable malignant obstructive endobronchial lesions, were eligible for the study. Patient demographics and baseline disease characteristics for the eligible 16 patients are listed in table 1.

The mean age was 50.2 ± 9.7 years old, (range; 21-71 years old). The majority of patients had a Karnofsky performance status (KPS) of <80 (56.25%). Trachea was the most common site of obstruction, reported in 43.75 % of the patients followed by right main bronchus (25%) and left main bronchus (18.75%). Histopthological slide revisions were confirmed the diagnosis of malignant primary lung cancer in 62.5% of the reviewed cases; and in 37.5% of the patients the diagnosis was metastatic tumors. Breast (2cases), larynx, kidney, colon, and thyroid (each one case) were the original sites of metastasis. All patients with non-operable malignant obstructive endobronchial lesions had undergone previous chemotherapy and/or radiation therapy.

The mean time from diagnosis of endobronchial obstruction to the start of therapy with Nd- YAG laser was 2.7 days, standard deviation ± 0.9842, (range, 1- 5 days). All patients had obstructive pneumonitis at time of start of Nd- YAG laser therapy, while dyspnea was, reported in 93.75% of the patients followed by cough (87.5%) and hemoptysis (81.25%). Isolated inspiratory stridor was not observed.

**Treatment**

A total of 19 administrations of Nd- YAG laser therapy were given. All sessions were initiated at the initial planned doses.

Among the 16 patients who were assigned to receive Nd- YAG laser therapy, 9 (56.25%) received Nd- YAG laser therapy as one session with significant improvement in the obstruction during the first 24 hours following Nd-YAG laser therapy. However, 4 (25%) were treated repeatedly, each patient received the subsequent Nd- YAG laser therapy treatments at 48-h intervals (Two sessions for initial management of a single tumor were necessary in 2 cases; in 2 other cases, three sessions were needed). For these patients, relative improvement of obstruction sites was observed during the first 72 hours after the first attempt of laser therapy. All these Nd- YAG laser therapy treatments were completed within 1 week of the first Nd- YAG laser therapy session.

Three patients (18.75%) prematurely discontinued Nd- YAG laser therapy because of disease progression (in 3 patients).

Unplanned interruptions in Nd- YAG laser therapy sessions were usually brief (median, 2 days). Interruptions due to the complications of therapy occurred in only 1 (6.25%) patient. In 2 other patients (12.5%), reasons of interruptions were mainly administrative (e.g., Nd- YAG laser therapy equipment maintenance, or technical problems).

**Safety and Tolerability**

We analyzed adverse events due to Nd- YAG laser therapy from study entry until disease progression or last follow-up. Complications of the Nd- YAG laser therapy occurred in 8 of 16 cases (50%).

**Table1. Demographic characteristics of the 16 patients with non-operable malignant obstructive endobronchial lesions**

| Characteristic | No. of patients (%) |
|---|---|
| **Age (years)** | |
| Mean | 50.2 |
| Range | 21 – 71 |
| < 50 years | 7 (43.75) |
| ≥50 years | 9 (56.25) |
| **Sex** | |
| Male | 5 (31.25) |
| Female | 11 (68.75) |
| Male to female ratio | 2.2 : 1 |
| **Karnofsky performance status before Nd- YAG laser therapy** | |
| ≥80 | 7 (43.75) |
| < 80 | 9 (56.25) |
| **Karnofsky performance status after Nd- YAG laser therapy** | |
| ≥80 | 13 (81.25) |
| < 80 | 3 (18.75) |
| **Time from diagnosis of endobronchial obstruction to Nd- YAG laser therapy (days)** | |
| Mean | 2.7407 |
| Standard deviation | ±0.9842 |
| Median | 3 |
| Range | 1 – 5 |
| < 2 | 2 (12.5) |
| 2 – 4 | 11(68.75) |
| > 4 | 3 (18.75) |
| **Corticosteroid and bronchodilator therapy** | |
| ***Before Nd- YAG laser therapy*** | |
| Yes | 15 (93.75) |
| No | 1 (6.25) |
| ***After Nd- YAG laser therapy*** | |
| Yes | 3 (18.75) |
| No | 13 (81.25) |
| **Finding on pathological review** | |
| Malignant primary lung cancer | 10 (62.5) |
| Metastatic tumors | 6 (37.5) |
| **Sites of obstruction** | |
| Right main bronchus | 4 (25) |
| Left main bronchus | 3 (18.75) |
| Right intermedius bronchus | 2 (12.5) |
| Trachea | 7 (43.75) |
| **Presenting symptoms** | |
| Dyspnea | 15 (93.75) |
| Obstructive pneumonitis | 16 (100) |
| Cough | 14 (87.5) |
| Hemoptysis | 13 (81.25) |
| Fever | 11 (68.75) |

During the Nd- YAG laser therapy, mild parenchymal bleeding, occurred in 3 cases (18.75%) which, was always self-limited and led to temporary hemoptysis in 1 of these cases (6.25%).

A small reactive effusion as a side effect in 3 of 16 cases (18.75%) never necessitated drainage was reported.

Two of our patients had concomitant parenchymal bleeding and dyspnea that required

hospitalization. Analysis indicated that 1 of the 2 patients developed airway perforation. This patient was managed non-operatively without consequence. The other patient required intubation and medical treatment 3 days after start of Nd- YAG laser therapy due to severe dyspnea and respiratory failure.

**Treatment outcomes**

In the first 6 patients enrolled in the study, 5 responses were observed, allowing the total accrual of 16 patients.

After Nd:YAG laser interventions, the primary effectiveness rate according to the criteria used was 81.25% (13⁄16). These patients showed improvement in the signs and symptoms due to the airway obstruction after laser therapy, however, complete improvement occurred only in 2 (12.5%) patients. Early patient outcomes were graded on a subjective clinical scale of no symptoms (12.5%), improved with mild symptoms (43.75%), improved with moderate symptoms (25%), or worsening of symptoms (progressive disease) which was recorded in 3 (18.75%) patients, (Table 2), with Nd:YAG laser being more effective for tumors in the trachea or main bronchi (85.7% {12\14}) than for tumors in intermedius bronchus (50% *{1\2}*).

**Table 2. Treatment outcomes graded on a subjective clinical scale (*N* = 16 patients)**

| Treatment outcomes | N | % |
|---|---|---|
| Complete improvement (no symptoms) | 2 | 12.5 |
| Improved with mild symptoms | 7 | 43.75 |
| Improved with moderate symptoms | 4 | 25 |
| Progressive disease | 3 | 18.75 |

Results of pulmonary function studies before laser therapy, demonstrated severe airflow limitation on expiration in all cases, as well as on inspiration in 10 cases.

In 9 of the 13 patients with improvement in the signs and symptoms due to the airway obstruction after a single Nd:YAG laser treatment, laser treatment was followed by improvement in most functional indices, as well as symptomatic amelioration. Symptomatic relief following a single laser treatment persisted for more than one year in 8 patients, while one patient succumbed to his underlying emphysema one month after Nd:YAG laser therapy.

In the 4 patients treated repeatedly with Nd-YAG laser therapy, clinical and physiologic improvement developed following a second laser treatment in 2 patients. While, clinical and physiologic improvement developed following a third laser treatment in the other 2 patients. Relief persisted for up to one year in one patient; in the other 3 patients, re-stenosis occurred during the first 6 months following Nd- YAG laser therapy and a salvage therapy was required.

Patients failed during the Nd- YAG laser therapy, (3 patients) received best supportive care and further treatment was at the physician's discretion. The response to salvage therapy was not recorded as part of our study.

**Surveillance and Follow-up**

The short duration of follow-up precludes definitive assessment of late Nd- YAG laser therapy effects; only 6 patients were alive with a follow-up longer than 18 months. Signs of local tumor progression at follow-up despite an initial record of complete ablation, were apparent on contrast-enhanced CT in 2 patients. One patient developed hemoptysis, subsequent work-up indicated a local recurrence of the disease with positive sputum cytology. It was controlled by Nd- YAG laser photocoagulation and supportive care 13 months after initial beginning of Nd- YAG laser therapy. A second patient developed dyspnea with progressive short-term, cough 17 months after beginning of Nd- YAG laser therapy. The repeated treatment with Nd- YAG laser was successful, resulting in a secondary effectiveness rate of 100% (At 26 months, these 2 patients were still alive without evidence of tumor progression).

However, local tumor progression at follow-up despite an initial record of partial ablation, were apparent on contrast-enhanced CT in 3 patients (18.75%). The repeated treatment with Nd- YAG laser was successful, resulting in a secondary effectiveness rate of 66.7% (2 of 3 patients). In the remaining patient, the CT scan detected the proximal tumor margin but did not accurately assess the distal margin of the tumor and underestimated the amount of parenchymal tumor involvement. The difficulty in accurate preoperative assessment is demonstrated in this case. This patient died of intractable tracheobronchial bleeding happened during the repeated treatment with laser therapy that led to death in the absence of a coagulation disorder or thrombocytopenia.

The remaining patient with follow-up longer than 18 months is doing well without any clinical signs of respiratory impairment.

## 4. Discussion

Nd:YAG laser therapy is one of the most effective modalities for tumor ablation within the tracheobronchial tree[2,17]. The advantage of Nd-YAG is speed with an immediate effect[3]. Although there are a variety of possible airway interventions, Nd-YAG Laser is one of the principal endoscopic treatment to manage non-operable malignant obstructive endobronchial lesions.

What will be the role of Nd:YAG laser therapy, and where does it fit in with respect to other therapeutic modalities for airway obstruction by non-operable malignant obstructive endobronchial lesions? A variety of interventional modalities, including stenting, photodynamic therapy (PDT), endoluminal brachytherapy, and Nd:YAG laser, are utilized to relieve airway obstruction and bleeding[18].

Expandable metal stents have been shown to facilitate weaning from mechanical ventilation[19]. Indications for airway stents include malignant tracheobronchial obstruction with extrinsic compression of the large airways, tracheal stenosis, or bronchial stenosis[20]. Expandable metal stents are not indicated for endobronchial malignant lesions. Nd:YAG laser therapy is effective for endobronchial lesions[2]. Stents may be complimentary to Nd:YAG laser therapy in such cases after Nd:YAG laser therapy reopens the airway.

Photodynamic therapy (PDT) is effective for endobronchial lesions[3]. Moghissi et al[21] concluded that endoscopic PDT in patients with lung cancer and major airway obstruction is more effective than Nd-YAG laser treatment with respect to percent of luminal patency and pulmonary functions at 1 month. The Nd-YAG laser has some disadvantages compared to PDT. The Nd-YAG laser has a risk of causing endobronchial ignition[3]. There is also the risk of the endotracheal tube or the laser fiber catching fire. This risk is increased in patients requiring a fraction of inspired oxygen (Fio2) > 40%[22,23]. Perforation of a major vessel is always a concern. This is more likely when the anatomy is distorted as can occur due to a tumor. Nd-YAG laser is relatively contraindicated in those patients in whom the bronchial lumen cannot be adequately visualized due to tumor[24-26]. In contrast, PDT does not have any limits on the Fio2 content and can be used safely in patients receiving mechanical ventilation with a high Fio2 requirement. The inability to visualize the bronchial lumen is not a contraindication for PDT because it is only necessary to be able to pass the fiber alongside the lesion. This allows treatment of some lesions that may have more risk with the Nd-YAG laser. The Nd-YAG laser has been used to treat malignant endobronchial obstructions[27,28]. However, the advantage of Nd-YAG is speed. PDT typically takes two to three sessions, whereas the Nd-YAG has an immediate effect in most cases. PDT also results in significant mucus plugging after the PDT is completed, secondary to tumor necrosis. Since this usually occurs after bronchoscopy is completed, PDT frequently results in atelectasis. This mucus plugging becomes a problem when dealing with tracheal lesions, however. For this reason, the ND-YAG is probably superior for large endotracheal lesions. It does offer immediate palliation of respiratory symptoms with an improved quality of life and frequently length of life as well.

External beam radiation therapy (RT) is another alternative for locally advanced lung cancer. External beam RT is the most frequently used radiation technique for lung cancer[29]. High-dose external beam RT requires many weeks of daily treatment. Side effects include damage to surrounding organs, which can lead to significant morbidity from esophagitis and pneumonitis[30]. Because radiation generally is not always successful in opening an obstructed airway, Nd-YAG laser is useful in allowing prompt relief of obstructive pneumonia or immediate palliation of respiratory distress with a distinct advantage over external beam RT because Nd-YAG laser is quicker. Decreased time away from the ICU also decreases the risk and difficulty associated with transport of these critically ill patients, as Nd-YAG laser intervention may provide immediate and durable palliation that can rescue the patient from imminent death and assure an improved quality of life

Brachytherapy is another modality to treat malignant locally invasive tumors in the airways. Brachytherapy involves the placement of radioactive sources into the desired target. The goal is to safely deliver high radiation doses to tumors with relative sparing of the surrounding tissues. Originally, brachytherapy for endobronchial tumors involved low-dose-rate treatment. This was a lengthy procedure, and there was a risk to personnel of radiation exposure. Later on, there has been a resurgence in brachytherapy for endobronchial disease. In the early 1990s, Speiser and Spratling[31] showed that high-dose-rate remote afterloading brachytherapy had similar success for treatment of endoluminal disease as lower dose rates. The time required for this procedure is markedly lower and also reduces the risk to personnel. In the study be Collins et al[30] of 406 patients, only 83 patients had a repeat bronchoscopy. Of these patients, complete tumor resolution occurred in 65% at the 3-month point. The risks of brachytherapy are made evident by this study, in which 38 of the 83 patients (46%) developed varying degrees of radiation reaction ranging from bronchitis to fibrosis, and 32 of the 406 patients (8%) had fatal hemoptysis[32]. For the intubated patient with large obstructing lesions, brachytherapy appears to be a less feasible option than Nd-YAG laser. Besides the above-stated risk of fatal hemoptysis, there are technical problems. With high-dose-rate remote afterloading, the patient would have to be isolated for the duration of the treatment for a minimum of 10 to 15 min. In these critically ill patients, the isolation time and high risk of fatal hemoptysis make brachytherapy a less favorable option than Nd-YAG laser.

Cryotherapy has been used for the treatment of tracheobronchial obstruction. Originally, it required rigid bronchoscopy to allow passage of the probe. Later on, the development of flexible cryoprobe has permitted cryotherapy to be performed via flexible fiberoptic bronchoscope. In a study by Mathur et al,[33] 18 of 20 patients had all visible endobronchial tumor cleared by cryotherapy. The risks of cryotherapy include excessively rapid thawing, premature detachment of the probe that may result in bleeding or tissue fracture, and damage to normal tissue by inappropriate placement of the cryoprobe[34]. The major disadvantage of cryotherapy vs Nd-YAG laser is the time required for a response in the tumor size. In a study by Marasso et al[35], there was a mean improvement of 22% 2 weeks after a single cryotherapy treatment and only an additional 20% improvement 4 weeks after a second treatment. Cryotherapy requires 2 to 4 weeks to be maximally effective. The main drawback of cryotherapy in the patient receiving mechanical ventilation is the amount of time required for a clinically significant response. This amount of time is longer than PDT and much longer than Nd-YAG laser.

This is the first report of Nd:YAG laser therapy in patients suffering from the signs and symptoms due to the airway obstruction by non-operable malignant obstructive endobronchial lesions at Tanta University Hospital in cooperation with National Institute of Laser Enhanced Sciences, Cairo University and German University in Cairo. Nd:YAG laser therapy works on both primary and metastatic disease to the lung, as shown in our study (malignant primary lung cancer in 62.5% of our cases; and in 37.5% of the patients the diagnosis was metastatic tumors). The preoperative assessment of the tumor is essential. It was successful in the majority of our patients. These cases illustrate that in the appropriate patient, Nd:YAG laser therapy offers an appropriate option to assist in relief of signs and symptoms due to the airway obstruction.

In a study of 177 advanced lung cancer lesions causing endobronchial stenosis or obstruction, treated with Nd:YAG laser therapy. The overall treatment effectiveness was 81% for Nd:YAG laser, with Nd:YAG laser being more effective for tumors in the trachea or main bronchi (93%) but not for tumors in lobar or segmental bronchi (73%)[36].

This study agrees with the results of our study, the primary effectiveness rate according to the criteria used was 81.25% (13⁄16). These patients showed improvement in the signs and symptoms due to the airway obstruction after laser therapy, with Nd:YAG laser being more effective for tumors in the trachea or main bronchi (85.7% {12\14}) but not for tumors in intermedius bronchus (50% *{1\2}*).

Furthermore, our results in this study confirm the findings from other earlier investigation of the use of the Nd-YAG laser in endotracheal and endobronchial malignancy[27,37-39]. All healthcare providers treating patients with obstructions in the endobronchial system should make palliative care a priority by assessing for pain, dyspnea, coping and psychosocial distress, and other symptoms at each patient that may encounter to reduce patient morbidity, improve quality of life, and potentially prolong survival. Several previous studies evaluated the effectiveness of Nd-YAG laser in relieving the signs and symptoms of airway obstruction achieved a significant improvement in dyspnea as well as other disabling symptoms among the patients with airway obstruction after Nd-YAG laser therapy[40-43], that is consistent with the results of our study in this regard.

The most important side effects of Nd-YAG laser therapy are perforation and bleeding as well as burning during the process of laser therapy[44-46].

Furukawa et al.[36] analyzed adverse events due to Nd- YAG laser therapy. Nd:YAG therapy, did result in massive bleeding in 6%, perforations in 3%, and a procedural mortality rate of 1.7%[36].

In our study, during the Nd- YAG laser therapy, mild parenchymal bleeding, occurred in 3 cases (18.75%) which, was always self-limited and led to temporary hemoptysis in 1 of the cases (6.25%). A small reactive effusion as a side effect occurred in 3 of the 16 cases (18.75%) which never necessitated drainage. However, two of our patients had concomitant parenchymal bleeding and dyspnea that required hospitalization. Analysis indicated that 1 of the 2 patients developed airway perforation. This patient was managed non-operatively without consequence. The other patient required intubation and medical treatment 3 days after start of Nd- YAG laser therapy due to severe dyspnea and respiratory failure.

In conclusion, we report the first successful use of the Nd- YAG laser therapy to improve patients from signs and symptoms due to the airway obstruction by primary bronchogenic carcinoma as well as secondary metastatic malignant endobronchial lesions at Tanta University Hospital in cooperation with National Institute of Laser Enhanced Sciences, Cairo University and German University in Cairo**.** The experience gained in the treatment of the sixteen patients here in our study, described fosters two conclusions. First, better imaging modalities to assess the length of endobronchial tumor and the extent of its involvement by noninvasive radiographic studies such as routine x-ray and/or CT scans of the endotracheal and endobronchial malignancy, in addition to bronchoscopic confirmation is required to improve patient selection. The second major conclusion from this study is that in selected patients, the use of the

Nd-YAG laser may be an acceptable therapeutic alternative to traditional methods. Nd- YAG laser therapy offers the advantage of speed over PDT, cryotherapy, external beam RT, and brachytherapy. Thus, Nd-YAG, when it can be done safely, remains the treatment of choice for intubated patients because of its speed. Thus, Nd- YAG laser therapy should be considered an important tool in those patients with tumors in the trachea or main bronchi. However, larger studies need to be performed to further evaluate the cost-effectiveness of Nd- YAG laser therapy and its effect on quality-of-life measures.

**Corresponding author**
**Hanan Shawky**
Clinical Oncology Department, Faculty of Medicine, Tanta University Hospital
hannshawky@yahoo.com

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11/12/2013