Microwave Ablation in Managing Lung Cancer: A Case Report

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Abstract

Lung tumors are effectively managed through surgery. But for inoperable lung cancers such as in advanced stages, poor respiratory function and other diseases like pulmonary inflammatory myofibroblastic tumor (PIMT), minimal invasive techniques like percutaneous microwave ablation (MWA) therapy is the preferred treatment option. MWA is a curative alternative approach used to destroy malignant tumor cells with minimal normal tissue damage. This instrument uses high frequency microwave energy waves that produce tissue-heating effects to destruct solid tumors. The purpose of this case report is to illustrate how MWA effectively managed four various cases of lung cancer.

Keywords: lung cancer, microwave ablation

Lung cancer recurrence and metastasis from other organs is now frequently observed.[1] For early stages, surgery remains the first choice of treatment but recent studies reported that 2-5% of non-small cell lung cancer (NSCLC) patients later develop metastasis or tumor recurrence.[2,3] Late stage patients are not the best candidates for curative surgery due to extent of the disease, comorbidities and poor cardio-respiratory function.

PIMT is a rare benign tumor that constitutes 0.7% of all lung lesions.[4-9] Diagnosis through biopsy and radiologic exam is difficult due to its varying cell characteristic and images. Management of this rare disease is dependent on the type of tumor, extent of disease and general health status of the patient.[10] For treatment purposes and to prevent recurrences, complete resection is necessary. However, not all are valid candidates undergo surgery.[11]

There are other available treatment options both for early and late stages of lung cancer and inflammatory myofibroblastic tumor (IMT) that are minimally invasive. These include chemotherapy, target therapy, radio therapy and thermal ablation which are proven safe and effective management options.[1,12-15]

MWA therapy is a technology that is image-guided and uses high frequency microwave energy waves that produce tissue-heating effects to destruct solid tumors. It is less invasive, proven effective, preserves normal lung parenchyma and can enhance the efficacy of chemotherapy and/or external beam radiation.[16]

The purpose of this study is to evaluate the safety and efficacy of MWA as an alternative treatment of lung tumors in different case scenarios.

Case Reports

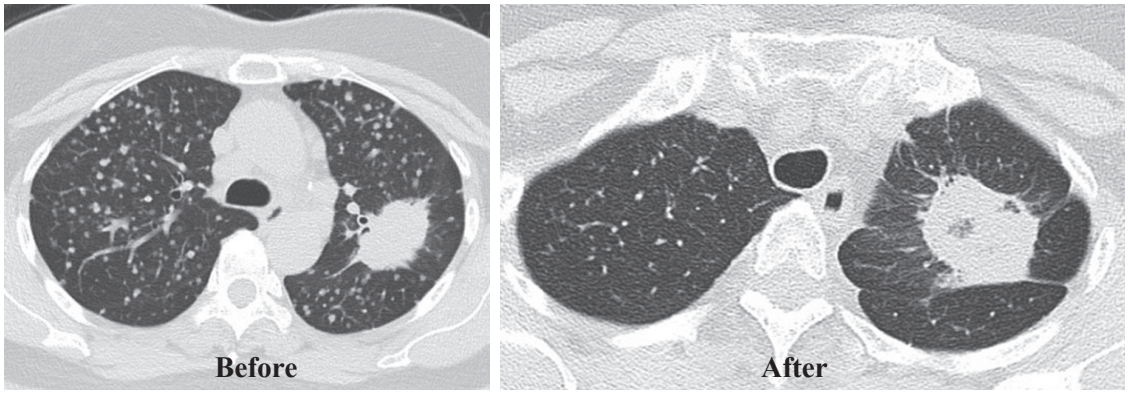
Case # 1

In October 2016, a 69-year-old female patient came for a routine check-up. She was asymptomatic, non-smoker and had no family history of tuberculosis or lung cancer. Her chest x-ray showed an ill-defined nodule at left upper lung, measuring about 4.0x4.2 cm, with diffuse nodular opacity in both lungs. Computed tomography (CT) of chest revealed multiple small nodules measuring 4 mm, 5 mm, and 6 mm at the right

lower lobe, right middle lobe and right upper lobe, respectively. A 45x35 mm mass with ill-defined border was seen at the left upper lobe (central to intermediate zone) together with multiple small nodules of up to 5 mm in diameters. There were also enlarged mediastinal nodes involved. Endobronchial Ultrasound Guide Sheath (GS), Transbronchial Needle Aspiration (TBNA) and Electromagnetic Navigation Bronchoscopy (ENB) were performed and results revealed adenocarcinoma. The epidermal growth factor receptor (EGFR), exon 19 deletion mutation was reported from her lung tissue specimen. Positron emission tomography (PET)/CT scan showed increased uptake foci at the following sites: lymph nodes at left cervical (maximum standard uptake value (SUVmax) 5.16), right lower cervical-supraclavicular (SUV max up to 7.02), and right axilla to subpectoral regions (SUVmax up to 4.93 at subpectoral node). Left upper lobe mass SUVmax was 18.33. A diagnosis of lung cancer (adenocarcinoma) stage IV was made and Gefitinib 250 mg, 1 tablet once daily, was prescribed.

A month after the first dose of treatment, plasma EGFR became negative of mutation. Four months thereafter, a follow-up PET/CT scan revealed marked regression and moderate size reduction of the primary malignant tumor. The tyrosine kinase inhibitor (TKI) was continuously provided for a year until her follow-up chest CT scan in November 2017 showed that those multiple small metastatic nodules were stable-to-slightly increased in size. The primary lesion at left upper lobe itself had also increased in size from 2.7x1.8 cm to 3.2x2.0 cm and a new daughter nodule was found at the posterior border of the primary lesion. Repeat plasma EGFR remained negative, CEA was 4.66 ng/mL, and EGFR from repeat tissue biopsy was negative of mutation and resistance. Cytology from repeat EBUS was positive for adenocarcinoma. She refused to undergo chemo- and radiation therapy and preferred only surgical management. However, the cardiovascular surgeon advised that surgery was not an option owing to her poor general health and the metastases of the disease. Later, she developed moderate hemoptysis. MWA as palliative therapy was offered as an option.

Ablation planning using her chest CT scan result, to confirm the size and location, was done. Lesion sizes were marked from coronal plane diameter (2.60 cm) and sagittal plane diameter (3.18 cm). Under intravenous sedation, grid and needle guide were applied to the marked lesion. Emprint percutaneous antenna was inserted into the target tumor thoroughly. A CT scan was then preformed again to confirm the right location. Once the correct position was established, Emprint MWA at 100 watts was applied for 4 minutes to cover all areas of the tumor. No complication (such as pneumothorax, pleural effusion or bleeding) was observed. Immediately post-MWA, no more hemoptysis was noted. She was advised to take TKI treatment. Eight months post MWA, PET/CT scan reported progression of intra-pulmonary metastasis.



Before MWA shows the left lung mass.

A month after MWA shows the continuous burning effect from MWA to the lung mass.

Figure 1: Chest CT scan of Case# 1

Case # 2

This is a case of a 29-year-old male from the Middle East, diagnosed with IMT. In December 2016, he was admitted to a local hospital in his country due to fever and cough. Initial diagnosis was multilobar pneumonia and this was managed by antibiotics but he was unresponsive. Chest CT scan reported multifocal pneumonia complicated by left lower lung abscess, few mass-like opacities seen in the right lung with enlarged lymph nodes. Differential diagnosis was lymphoma versus bronchoalveolar carcinoma. Bronchoscopy was performed and revealed narrowed posterior segment of right upper lobe. Mucosa of upper lobe is found to be erythematous and swollen. Pathology was negative of aspergillus antigen, malignancy or pneumocystis pneumonia. Additional tests were also negative of HIV, pneumococcal, mycoplasma, chlamydia serology and mycobacterium infections. CT guided biopsy was done and revealed segmental interstitial fibrosis with chronic inflammation composed of lymphoid cells and few eosinophil with no evidence for malignancy, TB or lymphoma. At this time, he was prescribed with low dose corticosteroids and Azathioprine.

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In June 2017, he was re-admitted due to hemoptysis. Chest CT scan showed interval reduction in the size of the right upper mass and mild reduction in the size of the left upper and lower lobe masses, interval increase in the number of small bilateral nodular opacities. He was then screened for autoimmune disease but had negative results. Bronchoscopy was repeated and showed a clot in right upper lung bronchus. CT guided biopsy was performed and impression was organizing pneumonia versus IgG4 disease. He was managed by prednisolone 60 mg for 2 weeks, tapered gradually. The tissue specimen slides were then sent to the United Kingdom (UK) for further studies. The opinion from the UK was IMT versus pneumonia versus IgG4 disease. ALK and ROSE studies were negative. He was unresponsive to steroids and radiological appearance was not compatible with organizing pneumonia. Bronchial artery embolization and possible upper lobectomy were suggested but deferred due to patient's condition. Hemoptysis was controlled conservatively and excisional biopsy was advised to obtain definite diagnosis. He then decided to seek further management in Thailand.

In September 2017, mini thoracotomy and wedge resection of the right upper lobe lung nodules were performed in a different medical facility in Thailand. Pathology reported IMT. The recommendation was targeted therapy treatment. He came to our medical center for consultation and treatment options. Repeat Chest CT scan revealed consolidative mass like lesion at the right upper lung, measuring about 4.9x8.6 cm in size, with internal calcifications and mass extended in to the right main bronchus, multiple spiculate nodules at the both lungs are detected. A few of lymph nodes at the carinal region are also noted. (Figure 2)

Physical examination revealed 15 kg body weight loss, mild dyspnea and occasional hemoptysis. Tumor debulking using rigid bronchoscopy was performed to destroy a part of the right upper lung mass obstructing the right main bronchus. Bleeding was controlled by argon plasma coagulation. Stent was placed on the right main bronchus to dilate the airway. No complications were noted post procedure. MWA was advised to treat unresectable lung tumors. The next day, MWA was performed on the remaining right lung mass. Lesion sizes were right upper mass coronal plane diameter at 6.77cm and sagittal plane diameter at 8.28 cm. CT imaging was done to confirm location. Under intravenous sedation, grid and needle guide were applied to the marked lesion. Normal saline bag of 1000cc was applied to avoid unnecessary burn. Emprint percutaneous antenna is inserted into the right lung mass thoroughly which was confirmed by chest CT scan. Emprint MWA 100 watts is applied for 10 minutes. Then, second location was navigated by CT scan. Antenna was pulled under the pleura and positioned to a different angle to reach the second zone and lesion. Ablation 100 watts is applied for another 10 minutes to cover all areas of the tumor. CT scan was repeated to assess overall result and possible complications. No untoward signs and symptoms were noted.

Figure 2.1: Chest CT scan image

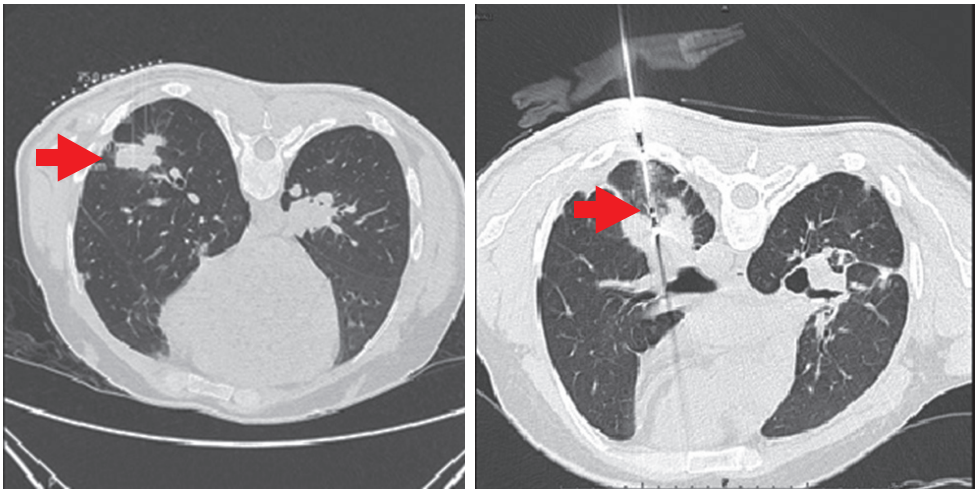

Figure 2.2: The first photo show the measurement and location of lesion prior to needle insertion of MWA. Meanwhile, the second photo illustrates the needle inserted into the lesion.

A month following the first session of MWA, repeat chest CT scan reported continuous burning effect of MWA partially destructing the right upper lobe mass. A second session of MWA was performed targeting the right lower lobe mass which measures 2.60 cm coronal, 45 watts for 5.15 minutes was applied. Two weeks after the second session of MWA, the right upper lobe mass underwent repeat MWA which now measures 4.21 cm coronal and 3.06 cm sagittal. The lesion is located at the right upper lobe which leaves a margin of 2.52 cm between the aorta and mass. CT image was done to confirm size and location followed by application of grid and needle guide. Normal saline of 1000 ml was prepared to avoid unnecessary burns. Emprint percutaneous antenna 20 cm was inserted and antenna penetrated the center of the tumor. Overall shaft depth was 8.46 cm. Chest CT scan was again done to confirm proper position. Emprint MWA of 45watts in 4 minutes was applied. No untoward reactions were observed at the third session of MWA.

Six months after MWA, PET/CT scan reported metabolic progression of existing mass at RUL, nodules at RLL and LUL. Unchanged hypermetabolic enhanced infiltrative intramuscular tumor mass along the anteromedial aspect of the left proximal arm with cortical erosion of adjacent humerus.

This is the first case of IMT reported to be destroyed by MWA. Also, this is the first known case of MWA used with stent placement.

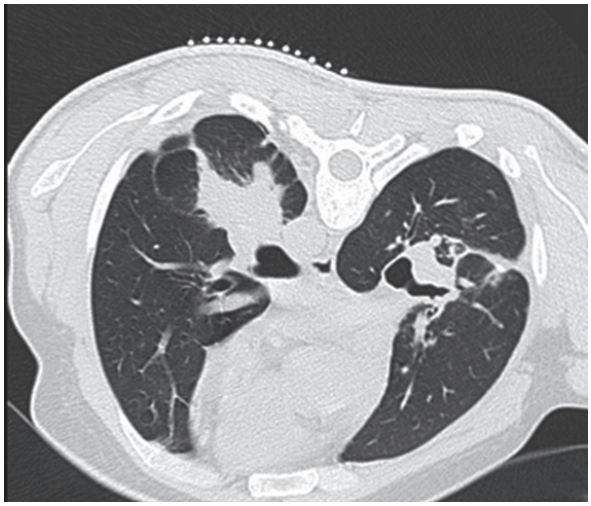

Figure 2.3: The burning effect of MWA a month after the first treatment session.

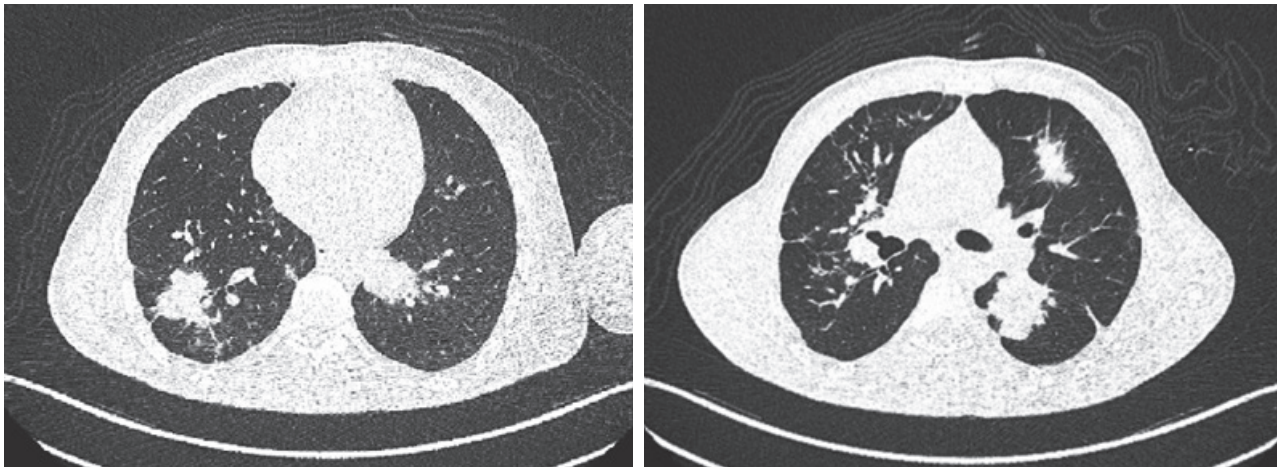

Figure 2.4: The CT scan images show the progression of lung mass.

Case # 3

This is a case of a 41-year-old female, foreign patient who came for consultation due to difficulty with breathing and persistent weight loss for a year. She was previously diagnosed with pneumonia and was treated with antibiotics but was unresponsive. She is a former smoker for 1.5 years. Chest CT scan reported right lung has infiltrative tumor involving entire right lung with size on axial plane = 12x8cm at right lower lobe, 10.6 x 107cm at right upper lobe; tumor involving posterior chest wall and right posterior ribs No. 7,8,9. There is inferior invasion of right diaphragm, serosal surface and parenchyma of right hepatic lobe. Visualized mediastinal lymph nodes were 18mm in short dimension at right paratracheal region, 28mm at right tracheobronchial region, 39mm at subcarinal region. There is an 8mm nodule at superior segment of left lower lobe and 12 mm cyst at left upper lobe. Tumor debulking using rigid bronchoscopy was recommended to extract part of the tumor blocking her airway. Stent placement was advised to help dilate air passage. Bleeding was controlled by argon plasma coagulation. Cytology report was squamous cell carcinoma, PD-L1 (22C3) positive. PET scan reported intensely increased uptake in infiltrative tumor in the right lung, more pronounced in right lower lobe region with SUVmax up to 24.97. Invasion to diaphragm, adjacent ribs dome of liver is presented. Increased uptake foci in mediastinal nodes are observed such as matted node or mass and involved the subcarina and right hilum (SUVmax 15.79), right upper paratracheal (SUVmax 16.16) right lower paratracheal (SUVmax 13.83) and left lower paraesophageal node SUV max 16.82. There is also increased uptake in anterior diaphragmatic node (SUVmax 9.01).

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Figure 3.1: Chest CT scan shows the lung mass almost completely invading the right lung.

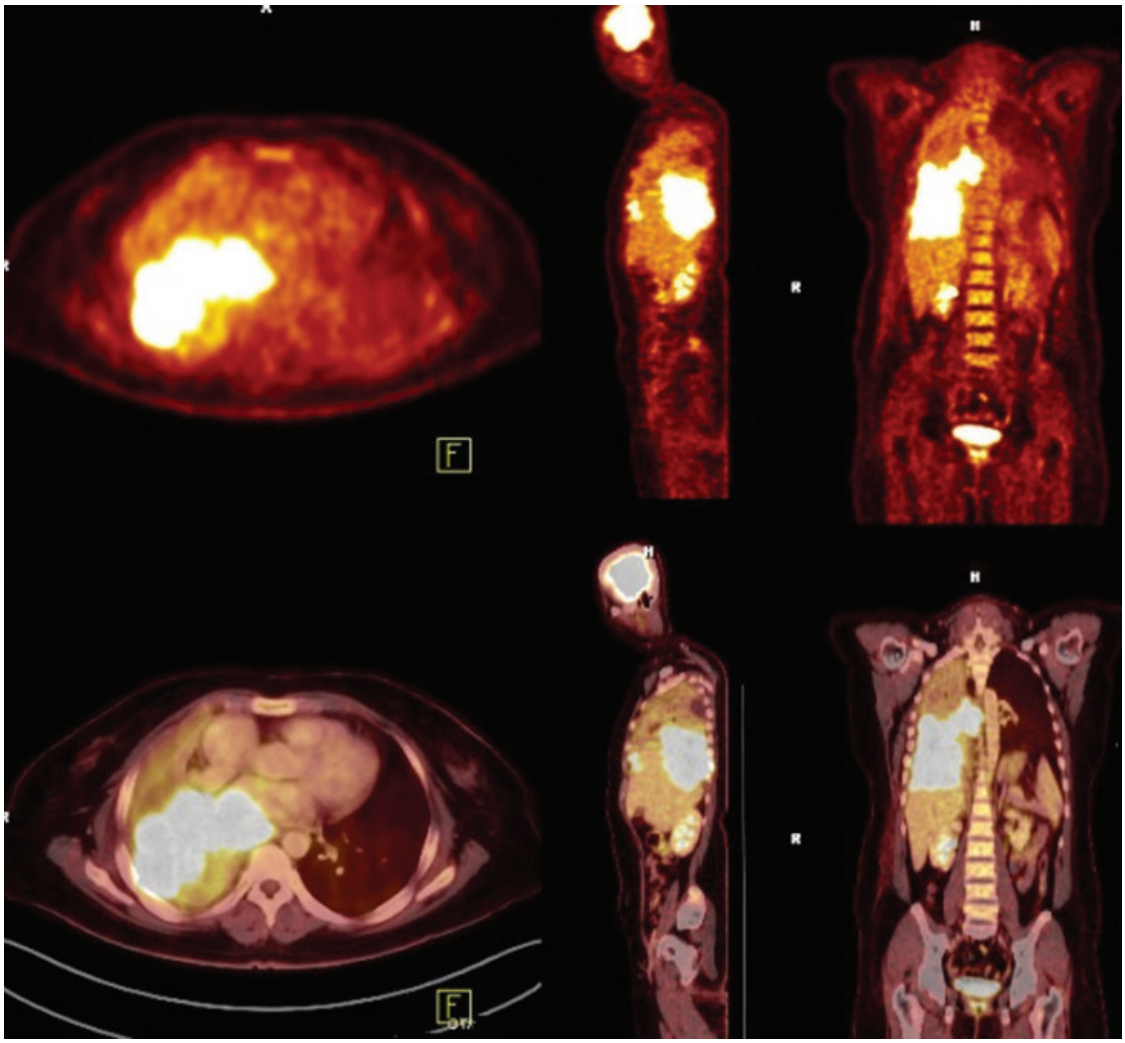

Figure 3.2: PET/CT scan exhibits increase uptake of right lung mass.

She was treated with 5 cycles of chemotherapy (Cisplatin and Gemzar) for 4 months. Post chemotherapy, follow up chest CT scan reported that there has been no obvious change in size of the rest of right lower lung mass, now showing as an irregular opacity with cavitary change at right lower lung, abutted adjacent pleura, encased proximal segmental and lobar bronchi, with rather decreased right pleural effusion and mildly increased aeration of right lower lobe. Her symptoms also persisted. The Oncologist's recommendation is for her to undergo another cycle of chemotherapy using a higher grade of chemo drugs or immunotherapy but response to treatment is unpredictable. She refused prolonged treatment and prefers to go to her home country. MWA therapy was advised to compliment previous chemotherapy. She consented to undergo MWA. The target lesions were coronal plane diameter 4.12cm and sagittal plane diameter 3.68 cm at right lower lobe lung. Since the lesion is located near the diaphragm, the antenna was placed 2 cm above the diaphragm. CT scan was done to confirm size and location. Under IV sedation, grid needle was applied then emprint percutaneous antenna was thoroughly inserted to the tumor. CT scan was again done to re-confirm position. Emprint MWA 45 watts for 2 minutes were applied with predicted ablation zone of 1.8 cm diameter to ablate the tumor carefully. Chest CT scan was again done to assess the result and possible complications. No immediate untoward signs and symptoms were noted.

One month PET/CT scan follow-up reported almost total regression of the pre-existing large hypermetabolic mass in right lung with some residual pleural metastasis at right lung base. Total regression of the lymph node metastases in right side of the mediastinum and paraesophageal node. No hypermetabolic lesion to suggest new metastasis. Healing of the locally invaded right posterior lower ribs.

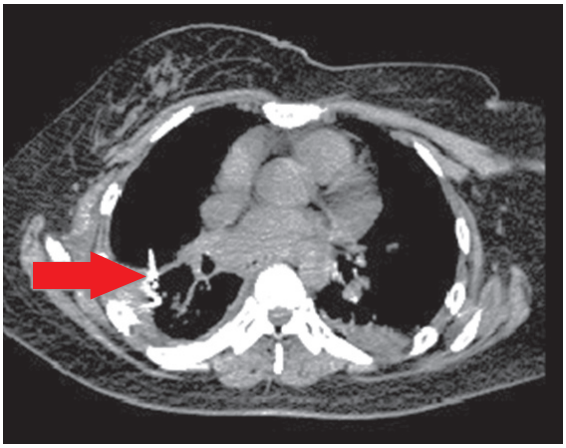

Figure 3.3: This illustrates the needle insertion into the lung mass prior to MWA being is delivered.

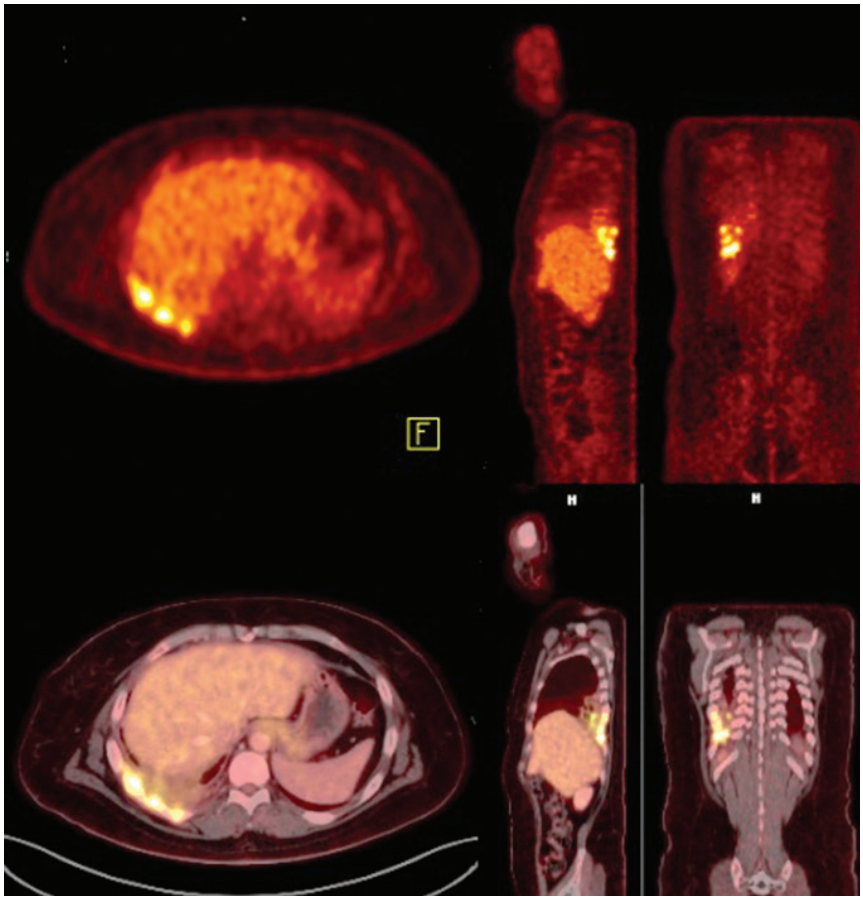

Figure 3.4: One month follow-up PET/CT scan after chemotherapy and MWA therapy shows almost total regression of right lung mass.

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Case # 4

This is a case of a 68-year-old female patient, diagnosed with thyroid cancer, metastasis to the lung. In 2011, she underwent total thyroidectomy with radical dissection followed by modified right neck dissection and radioiodine I-131 therapy in 2016. In 2017 she was diagnosed with malignant thyroid neoplasm: recurrent at right neck and had episodes of moderate hemoptysis and mild chest pain. Chest CT scan reported multiple various-sized nodules in both lungs, more on the right lung, size up to 2.6 cm; the one at right hilum focally obliterating right middle lobe bronchus and possibly invading anterior wall of adjacent right lower lobe bronchus. There is a 3.4x2.7x4.5 cm lobulated heterogeneously enhancing mass at right lower neck region, obliterating right jugular vein and effacing right common carotid artery anteromedially. Endobronchial Ultrasound Transbronchial Needle Aspiration, Rigid bronchoscopy to debulk the tumor and stent placement to dilate the airway were performed. Pathology report was papillary neoplasm. The patient was later lost on follow-up but came back after a year due to recurrent hemoptysis.

Chest CT scan revealed multiple enhancing pulmonary and subpleural nodules scattering throughout both lungs, sized up to 2.6cm in diameter. The one at right hilum focally obliterates right middle lobe bronchus and possibly invades anterior wall of adjacent right lower lobe bronchus. There is a 5.0cmx4.1cmx3.6cm lobulated heterogeneously enhancing mass in right lower neck region, obliterating right jugular vein and effacing right common carotid artery anteromedially. There are two sclerotic lesions at T10 body and left 5th rib, size up to 0.9 cm. There is a suspected 1.8-cm hemangioma-like lesion at T6 body. Repeat tumor debulking and argon plasma coagulation was performed to help clear her airway and stop hemoptysis. The patient decided to be on palliative care and was offered MWA therapy. The first lesion was located at right lower lobe 1.76 cm near the diaphragm which measures 1.42 cm, saggital. CT scan was performed to confirm the location. The percutanoues antenna was inserted 20 cm anteriorly through the tumor and overall shaft is 13.32 cm. MWA 45 watts for a minute was applied. Predicted ablation zone is 1.4 cm diameter. Repeat chest CT scan was done to check for complications.

Two weeks after the first session, MWA was performed at left lower lobe lesion which measures 2.63 cm, coronal plane. CT scan was done to confirm location and size. Emprint percutaneous antenna was inserted 15 cm from the lateral body. The antenna was pushed to the other side of the tumor touching the heart. The antenna is placed at the edge of tumor which leaves margin of over 2 cm from the heart. Overall shaft depth was 8.24 cm. MWA 45 watts for 2.30 minutes was applied and predicted zone was 1.9 cm diameter. Air leak was found on post-procedure chest CT scan. This was managed by intercostal chest drain insertion. A day after, repeat chest x ray reported no more pneumothorax. No hemoptysis was observed. The patient did not come back for a follow up check-up.

Discussion

MWA can be used to treat primary and secondary malignancies. In this study, we reported how MWA is used to manage four different cases of lung cancer and PIMT. The first case is diagnosed with adenocarcinoma then underwent TKI therapy but had tumor recurrence after a year of treatment. MWA is advised as palliative therapy. The second case is diagnosed with IMT and received several treatments- even surgery with no success. MWA is performed to shrink recurring tumors that obstructed his airway. The third case, diagnosed of squamous cell carcinoma received MWA to compliment chemotherapy. For the fourth case, thyroid cancer-metastasis to the lung, MWA is performed as palliative management and to help stop lung hemorrhage.

Surgical resection is the standard treatment with best chance of disease remission and survival.[16,17] However, in this report, all cases were poor surgical candidates. Minimal invasive procedure such as MWA is the best option as palliative care. The main objective of MWA for all of these cases is to help maintain a patent airway by eradicating as much malignant cells while preventing further tissue damage.

There are several reports published that demonstrates MWA as an effective way to manage and control malignancies. In three studies, each with more than fifty subjects, yielded 1-year survival rates reported 47.6% to 83%, 2-year survival rates ranging from 23.8% to 73%, and 3-year survival rates ranging from 14.3% to 61%.[16, 18-20] Our study, although reported only four cases, has further proven that MWA is effective in different types of lung malignancies. All four patients tolerated the procedure well with one case of pneumothorax.

MWA for four patients was administered under local anesthesia and moderate sedation. The MWA instrument that we used was Emprint Ablation System with Thermosphere Technology. This system can produce 0 to 100 watts at 2,450 $\pm$ 50 MHz. A microwave antenna with gauge 14, 15 to 20 cm length using circulation cooling system was placed into the tumor with the guidance of chest CT scan. Once position was confirmed, ablation was performed with a power of 45 to 100 watts for 1 to 8 minutes per site. The power and time depends on the size of the target lesion as seen in Table 1 below. Repeat chest CT scan was performed after MWA to check for air leak or other possible complications. Also, to prevent infection, antibiotic was administered prophylactically before ablation.

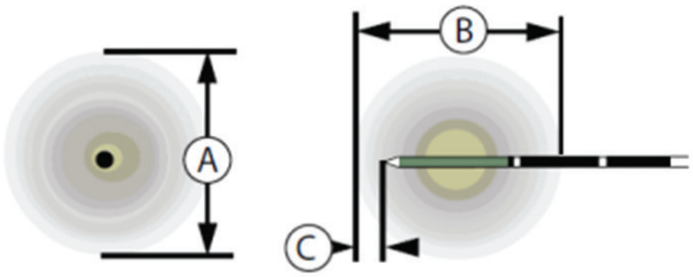
Table 1: This table shows the amount of power and duration delivered to the lesion according to its size

Table A			100 Watts
A	B	C	MM:SS
1.7 cm	2.9 cm	0.2 cm	1:00
2.8 cm	3.5 cm	0.3 cm	3:30
3.5 cm	3.8 cm	0.4 cm	8:30
3.7 cm	4.1cm	0.4 cm	10:00

Table B			75 Watts
A	B	C	MM:SS
1.8 cm	2.8 cm	0.2 cm	1:30
3.0 cm	3.2 cm	0.3 cm	5:30
3.4 cm	3.8 cm	0.6 cm	10:00

Table C			45 Watts
A	B	C	MM:SS
1.5 cm	2.4 cm	0.1cm	2:20
2.7 cm	3.3 cm	0.3 cm	7:50
3.0 cm	3.2 cm	0.5 cm	10:00

Table C		45 Watts
A	B	MM:SS
3.5 cm	4.2 cm	5:00
3.8 cm	4.3 cm	10:00



Radius of the heatwave
A = width of heat
B = length of heat
C = distance between needle and heat effect

1.MM:SS (minute:second)
2.W (Watt)
3.CM³ (Cubic Centimeter)

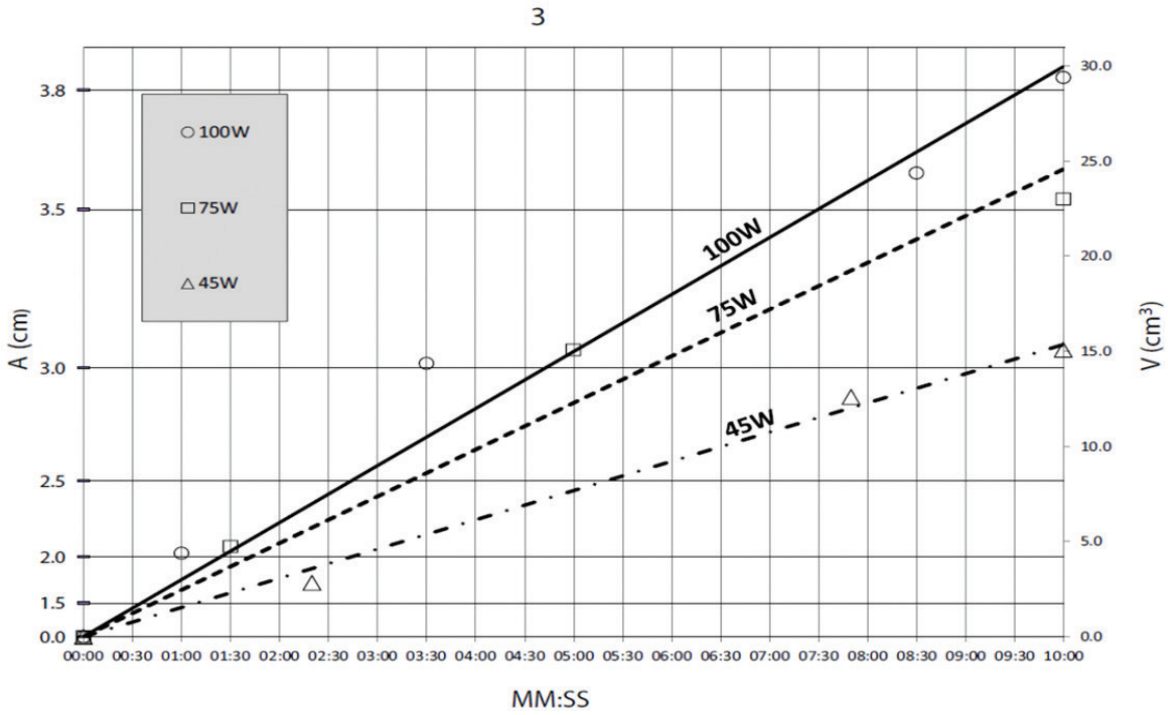


Figure 4: This graph shows the MWA power and duration in relation to the size of the lung lesion

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MWA is proven to be a safe procedure but this has the following possible risks and complications: pneumothorax, pleuritis, pulmonary abscess, pulmonary hemorrhage, lung inflammation, thoracic wall injury and mortality.[21] In research undertaken by Steinke et al., the rate of traumatic pneumothorax is reported to be as high as 50% noting that 50% required chest drain.[22] From our case studies, one out of four had an incidence of pneumothorax which was managed by intercostal chest drain.

With a high mortality rate of pulmonary malignancy and increasing number of cases of tumor recurrence, minimal invasive procedures are emerging especially for non-surgical patients as an effective treatment option.

Conclusion

MWA is a minimally invasive, effective treatment for various cases of lung cancer. This emerging technique should be increasingly considered especially for patients who are not good candidates for surgery.

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