Excision of Pulmonary Nodules or Masses in Patients with Known Malignancies through Video-Assisted Thoracoscopic (VATS) Surgery

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Abstract - Introduction: The development of computed tomography (CT) have made more pulmonary nodules being found in patients with known malignancies during work-up or follow-up. Excision through video-assisted thoracoscopic surgery (VATS) can be applied as a reliable method for the diagnosis and treatment of these nodules. Patients and Methods: From July 1996 to June 2009, 78 patients with newly diagnosed or prior treated malignancies were found with indeterminate pulmonary nodules or masses which were excised through VATS. Forty-three males and thirty-five females were included with ages ranging from 14 to 88 (median: 61) years. Their known malignancies arose from the colo-rectal (26 patients), breast (17 patients), head and neck (10 patients), lung (8 patients), soft tissue sarcoma (6 patients) and others (12 patients). Since July 2001, CT-guided localization before VATS was used in 13 patients with small (<10mm) or deep (>5mm) pulmonary nodules. All the visible tumors were resected in patients undergoing this procedure for treatment. However, only one to two nodules were removed in patients for confirming diagnosis. Results: The resected tumor size ranged from 0.2cm to 6.5cm (Median: 1.5 cm) and the number of the resected tumors ranged from 1 to 5. All lesions were successfully resected through VATS. There were 52 of them undergoing this procedure for diagnosis and treatment (including malignant and benign lesions) and 26 of them for diagnosis only. The indication of the use of pre-operative CT guided localization included small lesion in 2, deep seated lesion in 3, both small an deep seated lesion in 6 and dense adhesion which can be predicted by prior intrathoracic radiation or operation history in 2 patients. Among these 78 patients, metastatic malignancies were diagnosed in 43 of them, 8 of them were secondary primary pulmonary neoplasms, and 27 of them were benign lesions (20 of them were granuloma with or without evidence of tuberculi infection). Subsequent conversion to open procedure (a utility incision from 4 to 11cm) was performed in 6 of the 8 patients with second primary lung carcinoma and 6 patients with the size of metastatic tumors larger than 3 cm in diameter. The median length of chest tube indwelling was 4 days. Over 90% (71/78) of patients can return to normal daily activity within 14 days. Conclusion: Resection of pulmonary nodules or masses through VATS for patients with prior or at
present malignancies can be helpful in their early and reliable diagnosis as well as minimally invasive and effective treatment. Pre-operative CT-guided localization can facilitate subsequent resection and avoid possible open procedures.

Keywords: video-assisted thoracoscopic surgery, computed tomography, pulmonary nodule, malignancy, localization.

I. INTRODUCTION

Pulmonary nodule(s) (PNs) or mass(es) is not uncommonly found, about 1 in 500 routine chest radiographs. The incidence would be higher in upcoming years due to the development of imaging techniques especially the computed tomography (CT) [1, 2]. The probability of malignancy for pulmonary nodules increases with the numbers and sizes of the lesion, ages of the patients, and history of prior or at present malignancies [3]. The use of CT scanning to work up or follow up patients with known malignancies makes increased and earlier detection of pulmonary nodule(s). However, traditional diagnostic procedures such as CT guided needle biopsy and positron emission tomography (PET) are unreliable for small lesions [4, 5], and routine surgical resection through open thoracotomy results in too much morbidity to be desired. Therefore, resection of these nodules through video-assisted thoracoscopic surgery (VATS) can be considered as a good choice for accurate diagnosis as well as effective and minimally invasive treatment [6-8]. Pre-operative CT-guided localization with hookwire or radiotracer injection can facilitate the subsequent resection and avoid conversion to open thoracotomy [7, 9]. Herein, we share our experiences in resection of pulmonary nodule(s) through VATS for the diagnosis or treatment in patients with known malignancies.

II. MATERIALS and METHODS

From July 1996 to June 2009, we routinely studied the existence of pulmonary nodules (PNs) or masses by chest CT scan for all patients with known malignancies. There were 78 patients being identified with PNs or masses, which were excised through VATS for diagnosis and/or therapy. Sixty-two of them with prior treated malignancies were found during the follow-up period and the other sixteen of them were noted during the work-up of newly diagnosed malignancies. There were 43 males and 35 females with ages ranging from 14 to 88 (median: 61) years. Their known malignancies arose from the colo-rectal (26 patients), breast (17 patients), head and neck (10 patients), lung (8 patients), soft tissue sarcoma (6 patients) and others (12 patients) (Table 1). VATS would be performed after chest CT reviewing by the operator. Intra-operative localization of the pulmonary lesions was performed by finger palpation in most of our patients.
Since the introduction of pre-operative localization technique with CT guided hookwire insertion in 2001, there have been thirteen patients with small (<10mm), deep (>5mm from the pleural surface) lesions, or expecting with dense pleural adhesion, such as chronic inflammation, prior open thoracotomy or local irradiation) undergoing this procedure. CT scan needle localization by using same unit of CT scan (Tosiba, spiral CT with single scan ). Position of patient might be with supine, prone or lateral posture, depending on the location and depth of nodule from chest wall. We choose the nearest one. The nodule was localized on a thin section CT scan (collimation 3mm, total feed 5mm 120kV 230mAs). The marker we used is originally for the localization of breast lesion (Cook 20G x 15cm). It consisted of one introducer and one hooked guide wire. After finished assessment of nodule, we carried out local anesthesia by using 2% xylocaine with subcutaneous injection. The introducer was inserted from the point of measurement inch by inch that could be confirmed with intermittent CT fluoroscopy guidance. As the needle reaches the destination nodule, the introducer could be removed while the hooked guide wire remains at the nodule (Fig.1). The patient was then transported to Op room. VATS excision was performed under general anesthesia, with a double lumen endotracheal tube being placed through the guide of flexible bronchoscopy. The operative lung was insufflated. After prepping and draping, the scope port was inserted and its localization depends on the sites of the lesions. Two working ports or single utility incision (which would be required for larger (>25mm) or more centrally located lesions) were then applied for further works on tumor resections. Excising tumor located wedge of lung tissue was accomplished by the use of autosuture stapling device (EndoGIA, Autosuture, 30 to 60 mm in length and 3.5 to 4.8mm in thickness) (Fig. 2). The excised specimens were immediately sent to the pathologist for frozen section and histopathological examination. Conversion to open thoracotomy for subsequent lobectomy and mediastinal dissection was required for lesions being diagnosed as second primary non-small cell lung carcinomas (NSCLC). However, for some selective cases with very early (tumor<10mm and nodal negative clinically) NSCLC or with compromised pulmonary function, wedge resections with or without lymph nodes dissections would be adequate. After the operation, one to two 28 to 32Fr chest tubes were introduced into the chest cavity post-operatively, and their removal was determined by the draining fluid amount, character, any air-leakage or retained fluid or air in the chest cavity [8, 10].

III. RESULTS

The size of resected PNs or masses ranged from 0.2 to 6.5cm (median 1.5cm) and the
resected number of nodules per patients ranged from 1 to 5. The distributions of these above data as well as the location of the nodules were summarized on Table 1. For most patients with tumors larger than 3cm, the operations were delayed due to patients’ refusal of undergoing therapy at the initial stage and the remaining ones were due to misdiagnosis on chest film. Pre-operative CT guided localization was used in 13 patients, including small lesion in 2, deep seated lesion in 3, both small an deep seated lesion in 6 and dense adhesion in 2 of them (Table 1). Among these 78 patients, metastatic malignancies were diagnosed in 43 of them, 8 of them were secondary primary pulmonary neoplasms, and 27 of them were benign lesions (20 of them were granuloma with or without evidence of tuberculi infection). The distribution of their sizes and locations was summarized in Table 1. Except for one benign lesion (pseudotumor), all of these tumors larger than 3cm in diameter were malignant. However, predictions of the characters of the smaller (<2cm) PNs by CT imaging diagnosis were unreliable. Subsequent conversion to open procedure (a utility incision from 4 to 11cm) was performed in 6 of the 8 patients with second primary lung carcinoma and 6 patients with the size of metastatic tumors larger than 3 cm in diameter. Pulmonary lobectomy with mediastinal lymph node dissection was performed through the utility incisions of these six patients with resectable second primary lung carcinoma (Fig. 3). However, more limited resection with or without mediastinal lymph node dissection were performed in the other two cases, one with small (<10mm) lesion and nodal negative clinically assessed by CT and the other with compromised pulmonary function and old age (88 years old). No mortality was found postoperatively. There was 1 case with significant postoperative bleeding (over 1000cc on the first 24 hours) which were controlled subsequently after conservative treatment. Prolonged air leakage (>7days), pneumonia and wound infection were noted in 3, 1, and 2 cases which were recovered after conservative treatment. The median length of chest tube indwelling was 4 days. Over 90% (71/78) of these patients can return to normal daily activity within 14 days.

IV. DISCUSSION

Approaches for PNs or masses depend on the nature of the lesions, the nature of the patients, and the physician or surgeon who assumes responsibility for its further evaluation and treatment [11-13]. Imaging evaluations of PNs or masses by CT or PET, which can not only detect increased in numbers and decreased in sizes of nodules, but also be used to differentiate between benign and malignant pulmonary lesions [14, 15]. However, their reliabilities in accurate diagnosis of small PNs are questionable [4, 5]. The choices of approaches, according to their possibilities of malignancies from clinical information, include observation, biopsy or surgical
excision [1]. If prior radiographs revealed the PNs or masses stable in size for at least two years and the presence of calcium in characteristic patterns, and ages of patients less than 35 years without any associated risk factors, then serial radiographs follow-up for every 3 to 6 months are appropriate [1, 16]. However, if this PNs or masses were newly diagnosed, continuously growing in serial follow-up, in patients of old age, with history of smoking or known malignancies, metastatic or second primary carcinomas should be considered until proven otherwise [11, 13, 16].

Besides confirming the benignancy of PNs or masses, their differentiations from metastatic to secondary primary malignancies were also crucial. Prior tumor type and number of nodules will influence the diagnosis of PNs in these patients. Solitary pulmonary nodule (SPN) is more likely to be a second primary lung carcinoma than multiple nodules. SPN in patients with carcinomas of the head and neck, bladder, breast, cervix, bile ducts, esophagus, ovary, prostate, or stomach, were more likely to be a primary bronchogenic carcinoma than a metastatic lesion. SPN in patients with carcinomas of the colon, salivary glands, adrenal gland, thyroid, thymus, kidney or uterus had fairly even odds in the above two possibilities. However, SPN will be more likely a metastatic lesion than a primary tumor in patients with melanoma, sarcoma, or testicular carcinoma [17-19].

The clinical approaches of PNs appearance in patients with known malignancies are controversial. More aggressive strategies should be considered for the following reasons. Firstly, timely and accurate diagnosis of PNs is important for the adequate management of these patients. The possibilities of metastatic lesions will be higher in these patients, and as well the implications on the selection of their treatment and prediction of their prognosis are enormous [7]. Secondly, the differentiation between the metastatic and second primary pulmonary malignancies will influence the choice of treatment. Moreover, from our experiences accurate and timely diagnosis are still valuable even though the PNs were diagnosed as a benign lesion, because around three fourths of them were definitive or suspicious tuberculomas which require anti-TB chemotherapy [8]. Similar results were also observed in studies from other TB-prevalent countries [20, 21]. Since the diagnoses for small PNs by conventional procedures such as bronchoscopy and needle aspiration/biopsy are unreliable, and the possibility of malignancies are much higher which require surgical resection after the above procedures, surgical excision becomes a reasonable choice for accurate diagnosis and effective treatment [7, 11, 22]. The development of VATS has gradually replaced conventional open thoracotomy because the former can provide an equal effective but much less invasive approach to excise most of the PNs [10].
Preoperative localization is most useful for patients undergoing subsequent VATS resection for small (<10mm in diameter) and deeply seated (>5mm from pleural surface) pulmonary nodules. Even for superficial small nodules, localization can also make VATS resection faster [23]. Localization techniques include preoperative image-guided injection of methylene blue, placement of hooks, coils, radiotracer markers, intraoperative visual exploration, finger or instrument palpation, and ultrasonographic localization [24, 25]. Usually, a combination of CT scan, digital palpation, methylene blue labelling and endosonographic inspections is used. There have been developing new localization techniques in recent years, such as applying skin fiducials for registration followed by localization by positioning sensor of navigation system [26]. Miyoshi et al (2006) [27] reported the use of fluoroscopy-assisted thoracoscopic surgery after computed tomography-guided bronchoscopic metallic coil marking with simulation by means of virtual bronchoscopy.

Some of our reported patients underwent VATS excision while the pulmonary masses were large (> 3cm) in diameter. These mainly attributed to delay in management instead of detection in imaging. Most of them were informed with a “nodular shadow” on their chest radiograph, but they refused to perform surgical procedures to confirm the diagnosis because either them or their attending physicians did not have the concept of minimally invasive VATS. Moreover, the lack of knowledge of surgical role in treating single metastasis to the lung made these patients missed the golden time of early detection and effective management. Furthermore, the possibility of second primary lung carcinomas were usually neglected by general physicians, and this should be differentiated from metastatic lesions because it would influence the choice of treatment strategies. One more point to emphasize is that VATS excision is still valuable for our diagnosis and treatment even if the PNs were benign, because of the high probabilities of TB in which aggressive therapies were still required. Therefore more communications and interactions for each others to format consensus and establish guideline of therapies for these patients will be mandatory in the future.

There still exist some debates on the role of VATS and method of resection in patients with primary lung carcinoma. For patients with Stage I lung cancer, VATS lobectomy had revealed equivalent long-term survival as by open thoracotomy in prior literature [28]. Limited resection with or without mediastinal lymph nodes dissection through VATS has also been reported in some Japanese studies, and this provides patients with undetermined pulmonary nodules early diagnosis as well as effective treatment, even for those being diagnosed by frozen section as primary lung carcinomas [29-31].
In conclusion, resection of pulmonary nodules or masses through VATS for patients with prior or at present malignancies can be helpful in their early and reliable diagnosis as well as minimally invasive and effective treatment. Pre-operative CT-guided localization can facilitate subsequent resection and avoid possible open procedures.

REFERENCES


[12] Libby DM, Smith JP, Altorki NK,


Legends
Fig. 3. Lobectomy and mediastinal lymph nodes dissection through VATS for patients with second primary bronchogenic carcinoma. (A) right upper lobectomy (B) mediastinal (Gr 3) lymph node dissection (C) the ports design for VATS. (D) pulmonary tumor and the resected specimen.

Table 1. Patients characteristics and treatment results

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>78</td>
</tr>
<tr>
<td>Sex (Male: Female)</td>
<td>43:35</td>
</tr>
<tr>
<td>Age in years (Median)</td>
<td>14 to 88 (61)</td>
</tr>
<tr>
<td>Indications- suspected metastasis after</td>
<td></td>
</tr>
<tr>
<td>Colo-rectal carcinoma</td>
<td>26</td>
</tr>
<tr>
<td>Breast carcinoma</td>
<td>17</td>
</tr>
<tr>
<td>Head and Neck malignancies</td>
<td>10</td>
</tr>
<tr>
<td>Lung carcinoma</td>
<td>8</td>
</tr>
<tr>
<td>Soft tissue sarcoma</td>
<td>6</td>
</tr>
<tr>
<td>Others</td>
<td>12</td>
</tr>
<tr>
<td>Numbers of resection</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>71</td>
</tr>
<tr>
<td>2-5 (only in metastatic lesions)</td>
<td>7</td>
</tr>
<tr>
<td>Location of nodule(s)</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>42</td>
</tr>
<tr>
<td>Left</td>
<td>32</td>
</tr>
<tr>
<td>Both</td>
<td>4</td>
</tr>
<tr>
<td>Size of nodule(s)** in cm (Median)</td>
<td></td>
</tr>
<tr>
<td>More than 3cm</td>
<td>15</td>
</tr>
<tr>
<td>2 to 3 cm</td>
<td>18</td>
</tr>
<tr>
<td>Less than 2cm</td>
<td>45</td>
</tr>
</tbody>
</table>
PreOp CT hookwire localization Indications:

- Small lesion (<10mm) 2
- Deep seated lesion (>5mm) 3
- Small and Deep seated lesion 6
- Dense adhesion can be predicted 2

Mean duration of operations* (minutes / Median) 20 to 220 / 55

Results of histology:

- Metastatic malignancy(ies) 43
- Second primary pulmonary neoplasm 8
- Benign lesions 27 (20 granulomas)

Post-operative stay (days / Median) 4 to 25 / 5

Post-operative chest tube (range / Median ) 2 to 21 / 4

* not including the time after conversion thoracotomy and waiting for frozen section results.

** the largest nodule will be used for patients with multiple nodules resection.