

VATS -VIDEO-ASSISTED THORACIC SURGERY

THE PAST, PRESENT STATUS AND FUTURE

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ABSTRACT

Video assisted thoracic surgery (VATS) has developed very rapidly in the last over two decade and is very good alternative to conventional open thoracotomy as a standard procedure for simple thoracic operations and as an option or complementary procedure for some more complex operations. In this paper we will review its developmental history, the present status and future prospective

Keywords - VATS, Pneumothorax, Emphyema, Lung Cancer, Esophagus, Mediastinum

VATS, THE PAST

Historical Perspective

Use of rigid thoracoscope started over hundred years ago when Dr Jacobaeus in 1909 reported his experiences in the diagnosis and treatment of pleural effusions by

thoracoscope. Most of these patients were suffering from pulmonary tuberculosis(the era of enthusiasm, Cutler 1933), it was rarely performed after start of ATT –anti tubercular drugs after 1950(the era of neglect, Viskum and Enk 1981).The development of fiber-optic light transmission cables, the illumination and image processing techniques and refinement of related instruments made VATS easy and easily applied procedure after 1990s (the era of revolutions and rapid development, Mack et al 1992, Muller et al 1992, Muldr 1993) And now VATS has become a basic and important technique for a thoracic surgeon

Traditional Rigid thoracoscope

Structure of traditional thoracoscope is similar to other rigid endoscope (e.g. cystoscope) It is a hollow metallic tube with a small light bulb over the tip of scope. It belonged to the type of direct line of sight vision with distally lighted tubes. It has some limitations like- the magnitude of the image is limited, second, only the operator can see the operative field clearly, and lastly the functions of assisted instruments are not so good (Jacobaeus1923)

VATS Equipment

The introduction of video-assisted imaging system amplifies the function of thoracoscopy. It cannot only magnify the image with the aid of better instruments, but also share the images with all people performing this procedure (Kaiser and Daniel

1993).The minimal requirements of VATS include a zero-and/or 30 degree rigid telescope(s), a light source and cable, a camera and an image processor. The optional devices include a slave monitor, a semi-flexible telescope and a video –recorder (Mack and Krasner 1994).The choice of the telescope diameter can range from 3mm to 10mm, depending on the type of procedure. The 30 degree angled viewing scope can help us check the pleural cavity with broader visual field (Landreneau et al 192b).The choice of light source and cable should accord with the output power, the source of light and light transmission medium. The recommended light source and the output power for VATS are inert gas (e.g. Xenon) mediated “cold light” at 300W, higher than used in other endoscopes (Rivas et al 2002).The reason why VATS needs higher light output power is that the blood in the operation field will absorb up to 50% of the light (Beber and Siperstein 2001).Regarding the light transmission, thinner light fibres lead to better light transmission. The light transmission media can be classified as glass or quartz. The best light transmission media is quartz which is expansive and fragile (Schwaitzberg 2001).The most commonly used camera in VATS is the CCD (charged coupled device) type, which can convert the light signals to digital ones(Berber and Siperstein2001).The number of prisms used in the camera can be one(one chip), or three (three chips) and the latter is usually selected for VATS because it can correct the chromographic phase differences

(especially for red light)(Berber and Siperstein 2001)

VATS, THE PRESENT STATUS-

1. Spontaneous Pneumothorax (SP)

Today VATS plays crucial role in the treatment of spontaneous pneumothorax. Spontaneous pneumothorax (SP) can be treated by various methods, ranging from observation or chest tube drainage to bullectomy or pleurectomy (Jacco et al 2000).VATS has been applied to treat SP since the 1990s, and had gradually become the standard treatment for SP (Cardillo et al 2000). The indication of VATS in SP is changing, and not limited to patients with recurrent or primary SP (Hats et al 2000).The advantage of VATS is that it permits a minimally invasive, safe and effective procedure not only to treat the SP episodes but also to prevent recurrence (Horizon et al 2002) Spontaneous pneumothorax can be classified into primary and secondary type. Primary spontaneous pneumothorax (PSP) is defined as pneumothorax without underlying lung disease, and mostly affects young and thin males. It is usually caused by ruptured pleural blebs (Adala et al 2001).Secondary spontaneous pneumothorax(SSP) usually occurs in aged people where it is associated with other lung diseases such as chronic obstructive pulmonary disease(COPD) or tuberculosis(Luh et al 1996)

Although simple aspiration or chest tube drainage are still commonly applied for treatment of first episode

SP, these procedures have major disadvantages such as low success rate and higher recurrence rate (Andrivet et al 1995). Schoenenberger et al (1991) showed that 18% of patients with PSP and 40% with SSP treated by chest tube drainage had persistent air leakage, and that 25% to 50% of them suffered from recurrence of pneumothorax during follow up period

Introduction of VATS has become a preferred procedure for most PSP and some SSP because of much better treatment effects and lower recurrence rate when compared with tube drainage or aspiration, as well as its minimal invasiveness compared to open thoracotomy (Hatz et al 2000, Loubani and Lynch 2000). Therefore VATS for SP reduces morbidity and cost of the procedure to the patient. (Liu et al 1999, Hatz et al 2000, Luh et al 1996, Casadio et al 2002)

There are many procedures which can be done with VATS for treating SP (Luh et al 2004, Sugamura et al 2002, Horio et al 2002) These procedures can be resection or ligation of blebs or bullae and obliteration of pleural space. Use of self made endoscopic loop for ligation of bullae or blebs in patients of SP is safe and effective. Bullectomy is combined with some procedure to obliterate the pleural space like parietal pleurectomy, talc powder spray, chemical or mechanical pleurodesis. Mechanical abrasion with gauze piece is effective in preventing pneumothorax recurrence. Some authors (Lynch et al 2000, Luh et al 1996) recommended the

use of additional tetracycline pleurodesis. Horio et al (2002) found that additional pleurodesis by electrocautery of parietal pleura in a patch fashion can worsen post operative chest pain or pulmonary function. Most of authors recommend mechanical abrasion only or combined with intrapleural injection of tetracycline as procedure of choice for pleural obliteration in SP

2. Special type of spontaneous pneumothorax

Catamenial pneumothorax is a rare type of recurring SP in women during menstruations and is associated with thoracic endometriosis. In these women VATS is useful method to diagnose and treat thoracic endometriosis and SP by pleural abrasion (Hsieh et al 2000, Korom et al 2004)

3 Traumatic pneumothorax

The indications for VATS in-chest trauma are –

1. Retained hemothorax. 2. Persistent pneumothorax.
3. Evaluation and management of diaphragm in penetrating thoracoabdominal injuries.
- 4 Management of infected pleural collections
5. Diagnosis and management of on-going intra pleural bleeding in hemodynamically stable patients (Korom et al 2004). VATS has better results, improved outcomes and decreased length of stay and better

diagnostic benefits in above mentioned conditions.

VATS in Pleural effusion/empyema

1. Parapneumonic effusions or empyema

Parapneumonic effusion is an accumulation of pleural fluid associated with an ipsilateral pulmonary infection. 10-20% patients of parapneumonic effusions develop a complicated parapneumonic effusion (CPE) or pleural empyema (PE) (Sahn 1993). The CPE or PE have significant morbidity despite effective antibiotic treatment which has decreased their incidence significantly. (Lemmer et al 1987, Neild et al 1985)

The appropriate management of CPE or PE remains controversial. Most of them are treated initially by antibiotics with or without repeat chest aspiration, closed thoracostomy or fibrinolytics (Mandall et al 1987, Colice et al 2000). Surgical methods like open thoracostomy, decortications and thoracoplasty are used in patients refractory to aforementioned conservative treatments (Colice et al 2000, Bayes et al 1987, Gregoire et al (1987, Hoover et al 1986, Luh et al 2005)

VATS plays a bridging role between the medical and aggressive surgical managements, (Landrieu et al 1995, Boutros et al 2002, Klena et al 1998, Stammberger et al 2000, Liu et al 2002). Development of angled video – optical endoscopic equipment and effective endosurgical instruments has

expanded the role of VATS techniques to a wide variety of intra thoracic diseases previously requiring thoracotomy (Mack et al 1992, Ridley and Braimbridge 1991)

44 retrospective studies involving 1369 paediatric patients (MEDLINE database) between 1987-2002 were analysed. Four methods were compared – 1. Chest tube drainage alone (16 studies 611pts), 2. Chest tube drainage with fibrinolytic instillation (10 studies, 83pts), 3. Thoracotomy (13 studies 226 pts) and 4. VATS (22 studies 449 pts). Results: VATS was associated with shorter hospital stay. The duration of chest tube placement and antibiotic use is uncorrelated with treatment methods. This study had no evidence based standards (Gates et al 2004)

2. Malignant pleural effusions (MPEs)-

Malignancy is second most common cause of pleural effusion in patients over 50 yrs old. Around 40% of all pleural effusions are malignant. One half of all patients with metastatic cancer develop malignant pleural effusion (Burrows et al 2000). Lung cancer is most common primary malignancy followed by breast, lymphoma, ovarian and GIT carcinoma – about 80% all carcinomas in pts with MPE (Burrows et al 2000, Sahn 1998)

The prognosis of patients with MPE is poor with reported 1 and 6 months mortality rates of 54% and 85% respectively (Sahn 1998, Wang and Goldstraw 1993). Mean survival is less

than 6 months once MPE appears (Davies et al 1999, Belani et al 1998) 2.5 months for lung cancer and 7 months for breast carcinoma (Wiseberg and ben-Zeev 1993). The main symptoms are dyspnoea (96%) chest pain (57%) and cough (44%) when volume of effusion is more than 500ml. These symptoms limit exercise ability and impair quality of life

Treatment of MPE is palliative and focuses on safe and cost effective symptom relief. Treatment options are fluid drainage and pleurodesis via thoracostomy or with VATS (Toms et al 2000, Patz 1998, Erasmus et al 2000, Light 2000). Use of VATS has the advantage as it allows optimal preparation of the pleural space and homogeneous pleurodesis under visual control

In Pulmonary benign or malignant disease

1. Cancer diagnosis/staging

VATS has been established an essential diagnostic tool for lung cancer staging which is minimally invasive. It helps in getting histological and molecular staging (Sihoe and Yim 2004). Traditionally CT is most sensitive method to detect the lung nodule and spiral CT can detect subcentimeter pulmonary nodules (SCPNs) requiring further diagnostic work up. Bronchoscopic or needle biopsy of majority of SCPNs is not practical. VATS is possible for SCPNs but should be done in controlled manner to reduce the resection of benign lesions (Miller 2002). In North America

mediastinoscopy is preferred over VATS in lung cancer staging

Although VATS has been shown to be very useful in diagnosis of lung lesions but it is an operative procedure requiring GA and in hospital stay and cost is involved for equipment and training. (Moffat et al).

Increasing use of neoadjuvant treatment in the surgical management of lung cancer has made initial staging more important. Conventional modes of staging including CT, bronchoscopy and even mediastinoscopy lack diagnostic accuracy in the evaluation of mediastinal nodal metastases. So diagnosis of lung cancer by combined VAM-video assisted mediastinoscopy and VATS should be considered.

2. Minor lung resections –

Role of VATS in SCPN has been described above. Limited lung resections (wedge resection or segmentectomy) may yield good long term results in selected cases, as does lobectomy. VATS is less invasive and has compatible effectiveness in the treatment of stage I NSCLC – non small cell lung cancer (Endo et al 1003)

3. Major lung resection

There is still much debate on the role of VATS in major lung resections especially for treatment of lung cancer. Kaseda and Aoki (2002) reported their 10 yrs experience in VATS lobectomy for Stage I lung cancer with 97.2% 8 yrs survival rate for Stage IA lung

cancer better than outcomes by thoracotomy. VATS lobectomy for lung cancer is less painful, hospital stay is short, less inflammatory response and better upper arm mobility (Swenson and Batirel 2002).It needs further Phase III trial

Minimal invasive surgery VATS has drawbacks and limitations like long training, cost containment and oncological aspects. Limited resections are avoided due to higher recurrence rates and worse long term survival (Korst and Ginsberg 2001).VATS is usually considered in pts with Stage I NSCLC. It is less painful and recovery is fast. Absolute indications of VATS for lung cancer are yet to be defined (Russo 2002) Tumour recurrence over the port site has never been reported.

VATS lobectomy can be performed through utility minithoracotomy (Solaini et al 2001, Nomori et al 2001).Pulmonary hilar dissection can be performed sequentially (Solaini 2001, Nomori et al 2001) or stapled simultaneously(Lewis et al 1999). In less than 10% pts conversion to standard thoracotomy was required. The operation time halved after 10yrs training and the complication rate was 11% less than thoracotomy. The 5yrs survival rate for Stage I A lung cancer was over 90% .

VATS in Esophageal diseases

1. In Esophagectomy

VAT esophagectomy for carcinoma esophagus have some benefits like less pain and better preservation of

pulmonary functions postoperatively (McAnena et al 1994, Akaishi et al 1997) .Complete surgical resection is regarded the best treatment providing best chance of cure. Traditional transthoracic esophagectomy is considered the best choice as it provides good exposure for extended lymphadenectomy which provides better long term survival. But transthoracic esophagectomy cause significant post-operative pain, and pulmonary complications which increases morbidity and make hospital stay prolonged (Dexter et al 1996,Nagawa et al 1994, Lee and Miller 1997).Thus transhiatal esophagectomy which can remove esophagus without thoracotomy has gained popularity. However it is not accepted as a curative treatment because lymph node clearance is not adequate. Being a blind procedure chances of surgical complications like bleeding or trachea bronchial tree injuries are more. (DePaula et al 1995, Luketich et al 1998a)

In this respect, VATS approach offers an interesting alternative, with the advantages of transhiatal or transthoracic approaches (Akaishi et al 1996, Cuschieri et al 1992).The technique of esophagectomy and reconstruction include laparoscopic transhiatal esophagectomy, thoracoscopic and laparoscopic esophagectomy, thoracoscopic and laparoscopic esophagectomy and laparoscopic gastric mobilization with right mini-thoracotomy (Luketich et al 1998b, Law et al 1997, Nguyen et al 1999). According to some series (Dexter et al 1996, Law et al 1997) the

survival rate for Carcinoma esophagus undergoing VATS esophagectomy has similar results to those patients undergoing transthoracic esophagectomy. Some other series reported that pulmonary complications cannot be effectively decreased by using VATS approach (Nagawa et al 1994, Robertson et al 1996, Gassot et al 1995). VATS is actively tried in Japan and Asia (Akaishi et al 1996)

2. Anti reflux surgery

Gastroesophageal reflux disease (GERD) can result in many complications, such as esophageal inflammation, ulceration, stricture or Barrett's esophagus (pre malignant change). The role of surgery in the management of GERD has become important after the application of laparoscopic techniques to antireflux operations (Wu et al 1996, Pitcher et al 1994; Sataloff et al 1997) VATS was rarely applied in the treatment of GERD.

3. Myotomy for achalasia

Achalasia of the esophagus, characterized by a long history of dysphagia, regurgitation of undigested food and weight loss, is caused by inadequate lower esophageal sphincter (LES) relaxation. Several treatments can be chosen, such as medical (calcium entry blocker or botulinum toxin) treatment, balloon dilatation, and surgery (myotomy). Myotomy can be performed by thoracoscopic or laparoscopic approach (Pelligrini et al., 1993; Shimi et al., 1991; Hunter et al., 1997). The latter has some advantages, such as easier in anesthesia and surgical approach. Moreover, the myotomy can

be clearly extended into the stomach and antireflux procedure can be easily performed by laparoscopic approach (Shimi et al., 1991; Hunter et al., 1997). VATS myotomy is reserved for patients who have diffuse esophageal motor disorders or recurrent symptoms after laparoscopic procedures (Pelligrini et al., 1993).

In mediastinal lesions

1. VATS approaches to thymus

(1) For Myasthenia Gravis (MG): There exist some controversies over the optimal treatment of MG. The choices of surgical approach for thymectomy include median sternotomy with or without a transverse cervical extension, partial sternotomy, transcervical or VATS approach. Some series advocated maximal thymectomy (Jaretzki et al., 1988), which remove not only the thymus but also anterior mediastinal fat in front of the phrenic nerve. However, the clinical improvement was not significantly better than the conventional trans-sternal or transcervical approach (Cooper et al., 1987). The VATS approach for thymectomy result in significantly less pain and lower analgesic requirement, as well as shorter hospital stay and cosmetically better wound (Yim et al., 1995). The VATS thymectomy for MG showed no significant difference in clinical improvement from the series performing trans-sternal thymectomy (Cooper et al., 1987; Mack et al., 1996 et al., 1994). There are also controversies over the techniques of VATS approach. Some series advocated left-sided approaches (Mineo et al., 1996) but some other series approached through the right side (Mineo et al., 1997; Yim, 1997). The goal of VATS approach for MG is to remove the thymus and the anterior mediastinal

tissue completely, and which side to approach depends on the surgeon's preference.

(2) For thymoma: VATS approach for thymoma is still limited to patients with Masaoka Stage I (well encapsulate) tumors (Landreneau et al., 1992a). The ultimate concern for the treatment of thymoma is the complete resection of the mass and the thymus, instead of the methods of approach.

2. VATS approaches to posterior mediastinum

Many reports documented that VATS can be used safely in the diagnosis and treatment of posterior mediastinal lesions, such as neurogenic tumors, mediastinal cysts, esophageal leiomyomata, and paravertebral abscesses (Bardini et al., 1992; Bousamra et al., 1996; DeCamp et al., 1995). There are several important considerations before performing VATS for posterior mediastinal masses. At first, the chest CT scan has to be reviewed to exclude intraspinal involvement (the "dumbbell tumor"). All dumbbell lesions had to be evaluated by the neurologists. Then, the possibility of lymphoma should be excluded, in which fine needle biopsy should be first considered. Last of all, the possibilities of pheochromocytoma or ganglioneuroblastoma should be excluded. These lesions rarely appeared in adults, and the release of catecholamine intraoperatively might result in severe problems. After exclusion of the above conditions, VATS can be safely performed for the resection of posterior mediastinal masses (Heltzer et al., 1995; Hazelrigg et al., 1993a; Liu et al., 2000a).

VATS in chest trauma

VATS plays a definitive role in the diagnosis and treatment of thoracic trauma. VATS can be indicated in patients with hemodynamically stable acute or retained hemothorax, empyema, diaphragmatic injuries, chylothorax, foreign body removal and treatment of persistent air leakage from lung parenchyma (Aram et al., 1997; Bartek et al., Graeber and Jones, 1993; Graham et al., 1994; Heniford et al., 1997; Liu et al., 1997b). However, it is contraindicated in patients with unstable hemodynamic, major airway injury, massive hemorrhage or inability to tolerate one lung ventilation (Jones et al., 1981; Lang-Lazdunski et al., 1997; Smith et al., 1993).

VATS in sympathectomy or splanchnicectomy

VATS upper thoracic sympathectomy is applied most commonly in patients with palmar (T2 and T3) or axillary (T4) hyperhidrosis, followed by Raynaud's syndrome or Buerger's disease of the upper limb (Byrne et al., 1993; Drott and Claes, 1996; Lau and Cheng, 1997). VATS lower thoracic sympathectomy or splanchnicectomy, which should be first and mainly performed on the left side, is indicated in patients with intractable upper abdominal pain from malignancy or pancreatitis (Noppen et al., 1998). VATS upper sympathectomy should be reserved for patients with severe hyperhidrosis and refractory to other treatments, because the incidence of compensatory sweating, a troublesome complication, is extraordinarily high (Andrews and Rennie, 1997; Herbst et al., 1994).

VATS. FUTURE PERSPECTIVES

VATS, although widely applied, still has some difficulties for surgeons because of the loss of 3D vision, sense of touch and dexterity. A number of systems, such as telepresence operation systems have been developed to solve these problems by increasing the dexterity, adding motion tracking and filtering tremor motions (Satava, 1995; Hill et al., 1991; Garcia-Rutz et al., 1997). It can also be applied in the field of surgical education that students can perform VATS surgery by using virtual reality surgical simulators, instead of the real patients (Playter and Raibert, 1997; Delp et al., 1997). The challenge of applying these techniques in the human body is far more difficult than their uses in other industries. Nonetheless, we believe that these obstacles will be surmounted in the near future.

VATS. COST ANALYSIS

Regarding the cost analysis of VATS versus thoracotomy, many factors should be considered, such as selection criteria for VATS, general hospital charges, operative cost of equipment and disposables, operative time and room charges, postoperative morbidity or mortality, duration of chest tube drainage and length of stay, outpatient management, long-term benefits or complications (van Schil, 2003). The cost of equipment and disposables is higher for VATS. However, VATS may result in more rapid recovery and shorter hospital stay (Liu et al., 2003). So far there is still lack of prospective randomized study to compare the cost differences between VATS and thoracotomy in certain procedure. Some retrospective or non-randomized studies revealed different results in various thoracic

surgical procedures, such as lung biopsy, wedge resection of lung, pneumothorax, lung volume reduction surgery or lung cancer (Molin et al., 1994; Hazelrigg et al., 1993b; Sugi et al., 1998; Crisci and Coloni, 1996; Kim et al., 1996; Ko and Waters, 1998). In conclusion, procedure related costs of VATS are higher.

CONCLUSION

The development of thoracoscopy has almost one-hundred years of history. It was not widely applied in surgery until the video-assisted devices were incorporated in the last two decades. At present, most basic and many advanced thoracic surgical procedures can be performed by VATS, with smaller wounds, less pain, shorter hospital stay, and with as good outcomes compared with conventional surgery. It is believed that there will be more and more surgical procedures being performed by VATS. However, surgeons should keep in mind that VATS is only a method, instead of the goal, of the treatment. And thus conversion to open procedures should be done without hesitation if patients' life safeties were threatened or oncological principles were compromised.

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