Review

Thoracoscopic Surgery for Lung Cancer

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Thoracoscopic surgery has raised awareness in minimizing invasiveness in respiratory surgery. In the case of lung cancer, technical difficulties associated with standard curative surgery may not allow the use of a total thoracoscopic procedure. Although thoracoscopic lung cancer surgery is minimally invasive and safe, it demands a high level of skill and care. Surgery is often performed using a small incision and direct vision, with the thoracoscope serving as a light source. However, thoracoscopic surgery is expected to progress further in the near future. In addtion, a new surgical system that comprehends both open and video-assisted thoracic surgery (VATS) may gain popularity. (Ann Thorac Cardiovasc Surg 2006; 12: 383–7)

Key words: thoracoscopic surgery, video-assisted thoracic surgery, lung cancer

Introduction

Lung cancer is the most deadly of all cancers. According to the Vital Statistics of Japan (Ministry of Health, Labour and Welfare of Japan), nearly 56,000 patients died of lung cancer in 2002. Many patients with lung cancer are elderly or have impaired respiratory function due to smoking. When operating on these patients, maintaining both respiratory function and quality of life is as valuable as ensuring survival. Recently, increased attention has been paid to using minimally invasive, thoracoscopic surgery on these patients.

What is Thoracoscopic Surgery?

Thoracoscopic surgery involves making a small incision and the insertion of a thoracoscope which contains a small camera. The operative field is viewed on a monitor via the camera. Therefore, thoracoscopic surgery is also called "video-assisted thoracic surgery (VATS)". This type of surgery can minimize the size of the chest opening and subsequent tissue damage. This results in less postoperative sequelae than open surgery. Since 1992, thoracoscopic surgery — as well as other endoscopic techniques — has been used by many hospitals in Japan for benign diseases, and various improvements in these techniques have been made.

The biggest change brought on by the use of thoracoscopic surgery was the increased desirability for minimally invasive techniques. Previously, the focus was on the surgical procedure, and little attention was paid to the size of the wound or postoperative pain and sequelae. After the advent of thoracoscopic surgery, however, surgeons and patients began to pay attention to operative wound size and the importance of decreasing the invasiveness of surgery.

When thoracoscopic surgery was first introduced the early 1990s, the major target for this surgery was the comparatively simple operation on a young person's spontaneous pneumothorax. This technique was not considered for malignant diseases because the required surgical procedure for malignant cases differed largely from that for a benign disease, i.e., damage to internal organs was deemed a necessary part of the procedure to ensure a complete cure. However, radical surgery for a malignant disease is complex and technically demanding. As such,

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small surgical wounds, short surgical times, a low incidence of intraoperative hemorrhage, and a simple operative procedure were not primary goals of surgery for a malignant disease.

Several years later, surgeons became acquainted with the use of thoracoscopic surgery for the treatment of benign diseases, and both the instruments and surgical devices have improved. As a result, several surgeons have begun to use thoracoscopic surgery for the radical treatment of lung cancer. This has lead to a growth in the use of total thoracoscopic lung cancer surgery. Leading surgeons have reported that short- to mid-term results of thoracoscopic lung cancer resection are excellent with patients experiencing an ideal postoperative quality of life.[1–6)]

Total thoracoscopic surgery involves the maneuvering of surgical instruments which are guided by viewing on a monitor, using remote handling (i.e., without the sense of touch). To perform this surgery, surgeons must be able to manipulate instruments without looking at their hands, thus demonstrating high levels of hand-eye coordination. In addition, surgeons must be able to visualize three-dimensional figures from a flat view. Although these skills are common to the "videogame generation", they are not easily learnt in older people. Thus, many older surgeons are unable to use thoracoscopic surgery.

In many institutes, technically demanding radical lung cancer surgery cannot be performed using thoracoscopic techniques as maneuverability within the surgical space is limited. Moreover, many surgeons who majored in cancer surgery have had little chance to perform thoracoscopic surgery for benign diseases as a necessary fundamental training. They are therefore unable to replace their skilled open thoracic surgery techniques with new thoracoscopic techniques. Instead, their interest in minimally invasive surgery has focused on creating a smaller chest wound while performing conventional open surgery. For example, the former postero-lateral incision, the so-called standard thoracotomy, has been reduced from 50 cm to 30 cm or less. This technique is called "small incisional thoracotomy". Later, the incision was again reduced by using the thoracoscope as a light source. In this modification, the main chest opening for a thoracotomy is reduced to nearly 10 cm, but the surgeon still visually inspects the inside of the thorax directly. On the other hand, the assistant's view of the operative field is through the thoracoscope, which is usually placed through another small incision. Such surgery is also called "VATS" in Japan. In this technique, the conventional instruments are used along with specially modified instruments. The incision is smaller and the skill level needed is more sophisticated. This procedure allows the use of direct vision, although only a limited narrow one-directional view is permitted. Surgical manipulation is also restricted. In short, this Japanese style of VATS focuses on the patience and proficiency of the surgeon, and is generally thought to be an inconvenient style of open thoracic surgery.

In contrast, total thoracoscopic surgery, although associated with the previously described disadvantages, is characterized by a clear and precise picture on the monitor, and clear views for everyone in the operating room. Moreover, repeat observations are possible, as the surgery is recorded. Advantages of this technique include the fact that wound damage is minimal as the incision is smaller, postoperative chest pain is minimal because intercostal extension by extractor is unnecessary, and postoperative recovery is quicker.

Is Japanese Style Video-Assisted Thoracic Surgery Appropriate for Thoracoscopic Surgery?

Whether Japanese style VATS is appropriate for thoracoscopic surgery remains controversial. Thoracoscopic surgery is essentially a surgical procedure performed with the use of a monitor provided by the thoracoscope. Surgery performed using direct vision is vastly different from endoscopic surgery. The nature of the debate concerning the appropriateness of this newer technique focuses on social economic issues. In the current social medical fee system in Japan, endoscopic surgery is more expensively than open surgery.

Surgeons who cannot perform total thoracoscopic lung cancer surgery, have learned the Japanese style VATS in order to reduce invasiveness. Consequently they expect more financial compensation than if open surgery is performed.

If Japanese style VATS is regarded as an endoscopic surgery, the surgeon will get greater financial benefit.

The choice of familiar small incisional open surgery than unconfident total thoracoscopic procedure may be justified because of ensuring patients' safety.

Academically, the discussion differs. Japanese style VATS is essentially a conventional open thoracic procedure that approximates the minimal invasiveness of total thoracoscopic surgery. Due to this major difference, Japanese style VATS cannot replace total thoracoscopic surgery.

Lung Cancer and Thoracoscopic Surgery

Surgical procedures of lung cancer include palliative surgery, standard curative surgery, and extended surgery. Of these procedures, palliative surgery is used for patients with impaired organ function and/or at high risk. This procedure aims to relieve symptoms of the disease or provide a short-term life extension. In these situations, quality of life is emphasized, and minimally invasive thoracoscopic surgery is indicated. Technically, limited procedures such as a partial wedge resection are employed.

Standard curative surgery aims to cure the disease. This technique permits a higher level of invasiveness, and includes lung lobectomy and lymph node dissection. Although somewhat complex, thoracoscopic curative resection can be used in many patients by skilled surgeons. However, because thoracoscopic procedures are performed inside the thorax and allow less maneuverability, selection of appropriate patients is important. If the patient's lung was a small lesion remaining inside the lung parenchyma, he/she is a good candidate for thoracoscopic curative surgery. Most of these patients have stage IA disease.

Thoracoscopic surgery has some advantages such as the ability to view the normally difficult to see apical and/or basal region because of the fine view provided by the scope. The scope also allows a view of adhesiolysis of the chest wall and lung. On the contrary, disadvantages of thoracoscopic surgery include less maneuverability when treating large tumors and inflammatory adhesions of the peri-vascular region, especially of the pulmonary arteries, which have a tight inflammatory attachment to the lymph nodes. In the case of tumor invasion outside the lung parenchyma, thoracoscopic surgery is not generally indicated. Mediastinal invasion is also not appropriate for thoracoscopic surgery.

In the conventional open surgery for lung cancer, lymph node dissection is regularly performed. With the thoracoscopic procedure, maneuverability is inferior to the open thoracic procedure, although mostly the same dissection is possible if no peri-vascular adhesion nor lymph node swelling exists. However, once these exist, the thoracoscopic procedure is insufficient and one should convert to open surgery. In addition, if a large tumor exists, for example, stage IB disease, a thoracoscopy is not recommended in most institutes. Surgical maneuvering in the narrow apical area is extremely difficult compared with the wide basal area. In the more advanced stages of cancer (stage II and higher), thoracoscopy is only experimental. Extended surgery is also not indicated.

Results of Thoracoscopic Surgery for Lung Cancer

According to reports comparing thoracoscopic surgery results with open surgery in patients with lung cancer, thoracoscopy is associated with a slightly longer operating time, and equal or less operative bleeding. In terms of postoperative pain, thoracoscopy leads to less pain, as judged by the requirement of analgesics. Postoperative complications and complaints occur less frequently and hospital stays are shorter with thoracoscopic surgery.[7–9]

Reports of lung cancer treated with thoracoscopic surgery in many institutes show that survival is no worse than, or even superior to, that seen with open surgery in patients with stage IA disease.[10–13] In most of these reports, retrospective evaluations were made by comparing procedures performed in the previous or same period without randomization. Thus, the backgrounds of the patients were not always comparable. Generally, patients who undergo thoracoscopic surgery are technically less complicated than patients who undergo open procedures, and these two categories cannot be compared easily. Although the excellent postoperative condition associated with thoracoscopic surgery may suggest a better prognosis, the rationale and reproducibility of these results needs to be determined. As thoracoscopy is a technically demanding and non-standardized procedure, multi-institutional, prospective, randomized, controlled studies are difficult to perform. The fact that open thoracic surgery had previously become the "gold standard" without being compared to any other technique shows that the evaluation of surgical approaches may not allow comparative studies.

The Risk of Thoracoscopic Surgery for Lung Cancer

Radical surgery for lung cancer using an open procedure is an established technique with a surgical mortality rate of about 2–3%.[14,15] To perform the same surgery using a thoracoscope might introduce additional risks. However, to date, the author and colleagues have experienced nearly 500 lung cancer patients treated by thoracoscopy but no mortality, so the procedure is assumed to be primarily safe.

However, this assumption may be because thoraco-

scopic surgery is not applicable for advanced disease where extended surgical procedures may be required. Despite this, thoracoscopy was frequently used in high-risk patients with complicated diseases, and no serious postoperative complications have been observed. This suggests that thoracoscopy is safe compared with open procedures.

However safe the surgical technique is, latent risks do exist with thoracoscopic techniques. First, confusion due to insufficient understanding of the visibility of the anatomy through the thoracoscope may occur. Second, the risk of injury to organs exists due to poor use of the remote-controlled operative device. Such injuries could occur with difficulties in keeping the instrument in the thorax, unfamiliarity with the instruments, and the use of sharp-tipped devices. Third, injury due to manipulation outside the field of vision may occur. For example, unexpected contact of the electro-caurtery device may injure the vessel behind the surgical structure. It is thus important to work only within the field of vision and place the scope appropriately to view all necessary areas. Fourth, the possibility of instrument malfunction exists. For example, the endo-stapler is the key device for thoracoscopic surgery, and enables essential cutting and sealing. However, useful the device may be, it could malfunction. Various incomplete staple formations are seen, although there have been few reports of this. At worst, although extremely rare, the stapler has been fired but the staples were absent. Most of these malfunctions are considered technical issues that could have been avoided if the instruments were used properly, as with simple human errors, mechanical problems are difficult to eradicate. In terms of the newly developed endoscopic surgery, any troubles are likely to be sensationalized to the public and become "social problems". Surgeons must be conscious that these troubles may occur, have the necessary skills to operate the machines, and then inform patients about all risks involved in their surgery. Once problems occur, the issue should be resolved with respect to social issues, and steps should be taken to prevent similar incidents in the future. The fate of thoracoscopic surgery seems to depend on how society reacts to this new surgical technique.

The Future of Thoracoscopic Surgery

Thoracoscopic surgery provides an excellent view of the operative field that is superior to the naked eye. In addition, the thoracoscope can enter and observe anywhere in the thoracic cavity. It also provides an intrathoracic view to everybody simultaneously and records the images. In the future, technical improvements will enable thoracoscopy to provide even better views. If the precise tumor location or noteworthy deep vessels can be observed by thoracoscopy, the safety of this procedure will increase. In addition, computer system will undoubtedly be created that will lead to a robotic era of surgery.

Education and Training of Thoracoscopic Surgery

Thoracoscopic surgery for lung cancer combines two aspects: oncologic lung cancer treatment and minimally invasive thoracoscopic surgery. Both issues are extremely important and achieving a balance between them is difficult. From the standpoint of the thoracoscopist, their skills, acquired through experience with benign disease procedures, should be applied to highly standardized, oncologic treatment methods for curative lung cancer surgery. From the standpoint of lung cancer surgeon, he or she is being asked to change the standardized open lung surgery to thoracoscopic surgery, a technique in which they may lack confidence and find difficult. Thus, these two groups may find it difficult to reach common ground.

Nevertheless, from the standpoint of citizens who undergo surgery, the demand for minimally invasive procedures is steadily increasing. The current supply of thoracoscopic surgeons has been sporadic over the past 10 years and will be far less than required in the near future. Thus, the demand for education and training is urgent.

It is first necessary to establish a standard of thoracoscopic surgery for lung cancer. Second, newer surgeons should learn surgical techniques that include comprehension of open thoracic and thoracoscopic surgery, based on fundamentals of surgery and oncology.

References

1. Kawahara K, Iwasaki A, Shiraishi T, Okabayashi K, Shirakusa T. Video-assisted thoracoscopic lobectomy for treating lung cancer. *Surg Laparosc Endosc* 1997; **7**: 219–22.
2. Yim AP, Izzat MB, Liu HP, Ma CC. Thoracoscopic major lung resections: an Asian perspective. *Semin Thorac Cardiovasc Surg* 1998; **10**: 326–31.
3. Walker WS. Video-assisted thoracic surgery (VATS) lobectomy: the Edinburgh experience. *Semin Thorac Cardiovasc Surg* 1998; **10**: 291–9.
4. Morikawa T, Katoh H, Takeuchi E, Ohbuchi T. Technical feasibility of video-assisted lobectomy with radi-

cal lymphadenectomy for primary lung cancer. *Surg Laparosc Endosc* 1998; **8**: 466–73.
5. McKenna RJ Jr, Wolf RK, Brenner M, Fischel RJ, Wurnig P. Is lobectomy by video-assisted thoracic surgery an adequate cancer operation? *Ann Thorac Surg* 1998; **66**: 1903–8.
6. Stammberger U, Steinacher C, Hillinger S, Schmid RA, Kinsbergen T, Weder W. Early and long-term complaints following video-assisted thoracoscopic surgery: evaluation in 173 patients. *Eur J Cardiothorac Surg* 2000; **18**: 7–11.
7. Sugiura H, Morikawa T, Kaji M, Sasamura Y, Kondo S, Katoh H. Long-term benefits for the quality of life after video-assisted thoracoscopic lobectomy in patients with lung cancer. *Surg Laparosc Endosc Percutan Tech* 1999; **9**: 403–8.
8. Nagahiro I, Andou A, Aoe M, Sano Y, Date H, Shimizu N. Pulmonary function, postoperative pain, and serum cytokine level after lobectomy: a comparison of VATS and conventional procedure. *Ann Thorac Surg* 2001; **72**: 362–5.
9. Solaini L, Prusciano F, Bagioni P, Di Francesco F, Basilio Poddie D. Video-assisted thoracic surgery major pulmonary resections. Present experience. *Eur J Cardiothorac Surg* 2001; **20**: 437–42.
10. Thomas P, Doddoli C, Yena S, et al. VATS is an adequate oncological operation for stage I non-small cell lung cancer. *Eur J Cardiothorac Surg* 2002; **21**: 1094–9.
11. Walker WS, Codispoti M, Soon SY, Stamenkovic S, Carnochan F, Pugh G. Long-term outcomes following VATS lobectomy for non-small cell bronchogenic carcinoma. *Eur J Cardiothorac Surg* 2003; **23**: 397–402.
12. Gharagozloo F, Tempesta B, Margolis M, Alexander EP. Video-assisted thoracic surgery lobectomy for stage I lung cancer. *Ann Thorac Surg* 2003; **76**: 1009–15.
13. Kopp R, Weidenhagen R, Reinmiedl J, et al. Outcome following lung resections for pT1 non-small cell lung cancer. *Eur J Surg Oncol* 2006; **32**: 329–34.
14. Allen MS, Darling GE, Pechet TT, et al. Morbidity and mortality of major pulmonary resections in patients with early-stage lung cancer: initial results of the randomized, prospective ACOSOG Z0030 trial. *Ann Thorac Surg* 2006; **81**: 1013–20.
15. Doddoli C, Aragon A, Barlesi F, et al. Does the extent of lymph node dissection influence outcome in patients with stage I non-small-cell lung cancer? *Eur J Cardiothorac Surg* 2005; **27**: 680–5.