Review Article

Alternative minimally invasive approaches

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Abstract: The aim of this publication is to touch on selective examples of novel accesses to the chest, which are more minimal than the conventional triportal, or Robotic surgery. Thoracic surgery has moved quickly from open thoracotomy to video assisted thoracoscopic surgery (VATS) to robotic assisted thoracoscopic surgery (RATS) in less than 20 years. Making minimal invasive surgery more minimal is driven by many factors such as improved patient experience, cosmesis and industry opportunities. Some of these approaches will die a natural death; others will be a major milestone for future developments. Whereas it is easy to be skeptical and critical about new approaches, we are reminded how we felt about thoracotomy when we started a VATS programme. Therefore, new approaches should be seriously studied and peer reviewed, at the behest of them becoming fully adopted and recognized as standard by the generations to come.

Keywords: Video assisted thoracoscopic surgery (VATS); lung cancer; thymectomy; subxiphoid; mediastinoscopy

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Introduction

What is the motivation for making a successful minimal invasive surgery more minimal? Is it less pain? Less scars? Less operating time? Less expenses? Or perhaps it could be industry driven i.e., the more we make it complex for ourselves the more the new gadgets and gizmos are needed to help us with difficult angles and exposures? Perhaps it is the human quest to do something better than we did before. Perhaps it is a combination of all of the above. Minimally invasive surgery and minimal access surgery are not the two sides of the same coin. T Molnar suggested the term "minimally invasive" to be changed to "optimally invasive" surgery, which involves an adequate exposure commensurate to the patho-anatomical situation requirements (1). Perhaps thoracotomy in some situations is the "optimally invasive" choice, and that should be borne in mind. Whatever the access, patients' outcome should never be compromised comes hell or high water.

As keyhole surgeons in the chest we owe tuberculosis (TB) a great deal of respect. Incidentally it has fuelled the need for video assisted thoracoscopic surgery (VATS). My champion in the historical development of keyhole thoracic surgery has to be Hans Christian Jacobaeus, the Swedish internist 1879–1937. He was well ahead of his time. He practiced during the enthusiastic era of TB and published a seminal paper in 1923, well before general anaesthesia and ventilation via endotracheal tube were invented. He described introducing a scope in the chest using a trocar and cannula to release tuberculous adhesions, in an attempt to collapse the lung (2,3). Collapse therapy was the standard treatment for TB at the time. It must have been hard work! Since Jacobaeus' time Carlen in 1949 invented the double lumen tube, which was surprisingly for the same purpose of testing whether TB patients would tolerate collapse of their lung (4). Consequently lung isolation became a possibility. Positive pressure ventilation was possible only after the Danish polio epidemic in 1952, when medical students were called to live by the bedside of patients, hand-bagging those with respiratory muscles paralysis for weeks. The dramatic advances in the specialty of thoracic surgery have closely paralleled the introduction of new anesthetic practices, equipment and drugs (5).

The advent of VATS in 1992 (6,7) was a monumental step forward from open thoracotomy surgery. The world never looked back. Around 1999 robotic assisted thoracoscopic surgery (RATS) was started. Currently we are living a survival battle of robotics in thoracic surgery, and whether it will replace VATS at some point in the future is unknown. There was nothing wrong with the Concord plane that managed the trans-Atlantic trip between London and New York in only 4 hours. But where is the Concord today? In different museums of flights around the world, there was nothing wrong with the model but simply the Concorde was not cost-effective, and the price to pay was to spend the rest of time in a museum. Could the same be said about robotic surgery? Only time will tell. It is likely that we will see in the future hybrid technology between VATS and RATS. In the interim thoracic surgeons have been looking for ways to improve the existing VATS experience. The number of port access was reduced to one by Diego Gonzalez-Rivas from Spain, who championed the uniportal access. He published a nice graph about the historical progress of what uniportal can achieve. Literally there is nothing one can do by open thoracotomy or multiportal VATS that could not be done by Uniportal access. The list includes double sleeve and carinal resections in awake tubeless patients (8). Is this the ultimate in thoracic surgery? Time will tell.

Medical oncology has been recently advancing at lightening speed through the development of new chemotherapy, with lesser toxicity and major effectiveness. Oncological immunotherapy has reported astounding results in control of melanoma and other cancers. New radiotherapy advancements such as conformal intensity modulated radiotherapy and stereotactic body radiotherapy (SBRT) are re-charting the role of surgery. That being said; the thoracic surgeon remains to be concerned with offering patients the best oncologic outcome with the least surgical invasiveness. How to gauge this invasiveness remains to be seen. From time to time it is not illogical to take a step backwards and rethink where we are going. Such an approach has lead to the advent of tubeless, awake surgery, which is gaining popularity (9).

The aim of this publication however, is to touch on selective examples of contemporary novel access approaches to the chest. Some are mind blowing, others could be regarded as transitional in the grand scheme of human development. Nevertheless, what this paper will not attempt is to discuss established techniques such as conventional multi or uniportal intercostal approach or robotic surgery.

Single port subxiphoid thymectomy

The logic of "median structures require median approach" is very valid. If the thymus gland were to be approached by minimal access then a central approach either above or below the sternum would be logical. Originally described by Kido *et al.* in 1999 the subxiphoid approach reported a single access via a subxiphoid port (10). Previous publications have described the subxiphoid port combined with additional intercostal ports, or adding a transcervical incision (11). Thymectomy can be performed within the mediastinum without instruments transgressing a chest cavity, or with opening one or both pleural cavities. Interestingly Jiang *et al.* [2016] managed uniportal subxiphoid approach in non-intubated patients using glasses-free 3D vision (12). Suda and colleagues from Japan have demonstrated a single port subxiphoidal approach to resect the thymus by VATS and by RATS (13). The subxiphoid port is definitely less painful compared to an intercostal port in our experience, but most importantly it is extendable. It is therefore more logical to open the subxiphoid skin incision longitudinally rather than transversely, and should the need arise extend it along the linea alba to retrieve large tumours. At Southampton (UK) we use a similar tripolar approach, and were able to retrieve 7.4 cm thymoma via the subxiphoid port. Previously the recommended limit for intercostal retrieval was 5 cm (14). Zieliński from Poland added a brilliant modification very recently [2016] (15). He approached the chest completely from outside the chest, operating via two subcostal and one subxiphoid port. The most single annoying factor for experienced VATS surgeons is the limitation of movement imparted by a narrow intercostal space. Yet for the utility subcostal ports one is required to use very long instruments, and in our hands some of the angles were not achievable.

Benefits

(I) Patient lie supine, ready for median sternotomy in case of catastrophic bleeding or the need for conversion in Masaoka stage III/IV;
(II) no need for lung isolation when using Carbon dioxide. A single lumen intubation is all that is needed;
(III) bilateral access to both pleural spaces, and clear view of both phrenic nerves;
(IV) access to the neck at suprasternal notch, and ease of

retrieval of thymic horns;
(V) subxiphoid retrieval port is extendable to the size of the specimen;
(VI) same results to VATS via right or left chest, same length of hospital stay 1–2 days

Risks and limitations

(I) CO2 mandatory;
(II) seal around the subxiphoid port might be difficult, but have a look at this smart solution from Liu (Liu CC. 201605 Unedit Subxiphoid single port. Available online: https://www.youtube.com/watch?v=x_tlRCgKSDQ);
(III) possibility of opening the peritoneal space, gas under the diaphragm and ileus;
(IV) risk of epigastric hernia, and hence the need for meticulous closure;
(V) theoretical risk of iatrogenic Morgagni hernia, as the diaphragm is not stitched back to sternum;
(VI) not recommended for Masaoka stages III and IV.

Single port subxiphoid lobectomy and nodal dissection

The advantage of less pain with the subxiphoid access over intercostal ports has tempted thoracic surgeons to extend it to lung resection. The first report of single port subxiphoid thoracoscopic upper lobectomy was made by Liu *et al.* 2014 (16). The same author reported in the same year using the subxiphoid single port access to treat bilateral spontaneous pneumothorax (17). He also reported a subxiphoid single port middle lobectomy (Liu CC. 201505 Subxiphoid single port RML lobectomy. Available online: https://www.youtube.com/watch?v=SIakfJTQ5tg). Suda *et al.* [2014] used a single port subxiphoid thoracoscopic approach for bilateral metastasectomy (18). Hernandez-Arenas *et al.* [2016] published an initial experience with 153 cases of uniportal subxiphoid VATS major resections (19). Their technique included resection of the xiphoid cartilage for access. Their rate of conversion was 8.5% to either conventional VATS or open thoracotomy. Sixty percent of their patients had no pain by the first postoperative week. The paper stated clearly that complete lymphadenectomy might be compromised.

Benefits

(I) Less pain, paraesthesia and numbness compared to intercostal ports;
(II) retrieval port extendable, without the risk of rib fracture;
(III) cosmetically more aesthetic.

Risks & limitations

(I) Questionable safety record; 8.5% conversions. Control of major bleeding by extending the subxiphoid access is unlikely to be useful and thoracotomy is required;
(II) difficult to create the subxiphoid port in the lateral position;
(III) good access on right, not so good on left, instrumentation over a beating heart is problematic;
(IV) cutting the xiphoid cartilage mitigates against pain—free benefit;
(V) access to nodal dissection is limited and complete lymphadenectomy is not achievable;
(VI) unscrupulous closure can lead to epigastric hernia;
(VII) not suitable for low-volume thoracic surgeons.

Suprasternal videomediastinoscopic right upper lobectomy

The technique of mediastinoscopy (by direct vision) to sample mediastinal nodes was described by Deslauriers in 1976 (20). Later it was improved by the introduction of the video mediastinoscope. Azorin *et al.* 1996 used the suprasternal access to close a post-pneumonectomy fistula (21). Zieliński from Poland championed this approach. In 2007 he demonstrated how to perform suprasternal videomediastinoscopic right upper lobectomy (22). Since then he has used the suprasternal approach to perform thymectomy, trans-cervical extended lymph adenectomy (TEMLA), resection of mediastinal tumours and metastases, right and left upper lobectomies, and closure of bronchopleural fistula following left pneumonectomy. The critical step to obtain wide access to the chest is to elevate the manubrium with a special retractor. Zieliński and Rami-Porta edited an elaborate book [2014] about the transcervical approach in thoracic surgery (23). Various possible uses, contraindications and caveats about the suprasternal access were described.

Çagatay Tezel [2016] [Tezel C. Videomediastinoscopic upper lobectomy (2016). Available online: https://www.youtube.com/watch?v=5Hdo1rdaZ9g] from Turkey described videomediastinoscopic right upper lobectomy in a patient immediately after performing total thyroidectomy

via a cervical incision. They required an additional intercostal port for dealing with the incomplete fissure and for retrieval of the lobe. All being well this is a great approach, especially for dual indication, but slightly worrying if catastrophic bleeding is to be salvaged.

Benefits

(I) Cosmetically nice, and less painful;
(II) does what it says on the tin; currently right or left upper lobectomy is feasible;
(III) suitable for dual indications such as thyroidectomy and lobectomy;
(IV) can perform TEMLA at the same time of lung resection.

Risks and limitation

(I) Approach to lower lobes is yet to be attempted;
(II) not suitable for patients with previous sternotomy such as heart operations;
(III) the great vessels on the way in might limit the access and on the way out might cause serious bleeding if overstretched, especially in the presence of severe atherosclerosis;
(IV) nodal dissection especially of the lower groups 8 & 9 might be difficult.

The future

There are seminal historic events that shape the future. Who would have thought that two empty cans and a piece of string would be the basis of invention of the telephone, and subsequently the mobile phones, social media, Facebook, Google and YouTube? It is common nowadays that surgical novel operations, modifications and improvements are published in YouTube, before being peer reviewed and published in paper format. The effect is immediate and the rest of the world has access without paying prescription fees. In thoracic surgery we are not isolated, and the future of minimal access is being shaped by these influential developments around us. Some will be game changers, others will die a natural death.

It is my prediction that "liquid biopsy" will be one of those game changers. In our present time it is possible to detect four malignant cells in a lymph node by genomic studies, including flowcytometry. The node is mushed into a liquid and analysed in hours by automated machines. Compare that to our current reliance on a pathologist to analyse 30 nodes per patient, each sliced in 10 dimensions and producing a final report in 7–10 days. If the Genomic analysis is as reliable as the pathologist report and commensurate with survival studies then simply we could do without the pathologist. This will be a game changer in the sense that we do not need to extract surgical specimens intact, as currently mandated by the pathologist. They could be blended within the chest, aspirated and then analysed by flowcytometry. The wider application of molecular techniques in detecting micrometastases would revolutionize oncological surgical practice. Histological examination under the microscope by a pathologist could be something of the past across the board of surgical practice

Scarless or natural orifice transluminal surgery (NOTS)

Transgastric appendicectomy, transgastric ligation of fallopian tube and trans-umbilical or transvaginal cholecystectomy have already been described (24). This is not fiction, but today's reality. How far will this go? Time will tell. Such today's realities make one wonders when will it be possible to see transbronchial lobectomy for lung cancer? One day in the not too distant future it will be possible to use the bronchoscope to make a hole in the bronchus and gain access inside the pleural space. It will be possible to introduce mini octopus surgical instruments such as the Eagle Claw VII device (I call it the Swiss knife!) through the scope to disconnect the main structures (arteries, veins, bronchus and fissures) (25). Whilst in the chest the lobe is then blended into a soup by a blender extended from the Swiss-knife, and then aspirated out. At the end of the operation the bronchoscope is withdrawn to allow the bronchus to be sealed using superglue, or stitches. The soup (or liquid biopsy) is then subjected to genomic analysis which will tell us exactly the load of malignant cells and their profile, i.e., squamous, adenocarcinoma etc. there will be no external scars, and the patient could be discharged home the same day. Is it a dream? Time will tell.

And finally: the end of surgery is nigh

Clinicians at the Imperial College Healthcare NHS Trust (London, UK) recently used a high-intensity "MRI-guided focused ultrasound waves" to treat patients with tremors, without any surgical incisions. Several high-energy ultrasonic beams were directed from different angles to the target area

in the brain, aided precisely by a computer programme. Only at the point of intersection of all beams, the calculated final dose is reached. The technique is akin to SBRT. The procedure is done under local anaesthetic and the patient is discharged home the same day. The development is one of the most serious in the history of surgery, as it jeopardises the existence of the discipline. Imagine a patient with lung cancer being ventilated in a hybrid theatre to control breathing, and targeted MRI-guided focused ultrasound energy was directed to his/her lung cancer. The beams cause conformational necrosis and cut the blood supply to the tumour, which then heals into a scar within the lung. Who needs surgery? Only time will tell.

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Footnote

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References

1. Molnar TF. Quest for the best procedure in minimal access thoracic surgery: Optimization of what? J Minim Access Surg 2006;2:227-30.
2. Jacobaeus HC. The cauterization of adhesions in pneumothorax treatment of tuberculosis. Surg Gynecol Obstet 1921;32:493-500.
3. Jacobaeus HC. The Cauterization of Adhesions in Artificial Pneumothorax Treatment of Pulmonary Tuberculosis under Thoracoscopic Control. Proc R Soc Med 1923;16:45-62.
4. Carlens E. A new flexible double-lumen catheter for bronchospirometry. J Thorac Surg 1949;18:742-6.
5. Brodsky JB, Lemmens HJ. The history of anesthesia for thoracic surgery. Minerva Anestesiol 2007;73:513-24.
6. Roviaro G, Rebuffat C, Varoli F, et al. Videoendoscopic pulmonary lobectomy for cancer. Surg Laparosc Endosc 1992;2:244-7.
7. Kirby TJ, Mack MJ, Landreneau RJ, et al. Initial experience with video-assisted thoracoscopic lobectomy. Ann Thorac Surg 1993;56:1248-52; discussion 1252-3.
8. Gonzalez-Rivas D. Uniportal thoracoscopic surgery: from medical thoracoscopy to non-intubated uniportal video-assisted major pulmonary resections. Ann Cardiothorac Surg 2016;5:85-91.
9. Rocco G. Non-intubated uniportal lung surgery†. Eur J Cardiothorac Surg 2016;49 Suppl 1:i3-5.
10. Kido T, Hazama K, Inoue Y, et al. Resection of anterior mediastinal masses through an infrasternal approach. Ann Thorac Surg 1999;67:263-5.
11. Zieliński M. Technique of transcervical--subxiphoid-vats "maximal" thymectomy in treatment of myasthenia gravis. Przegl Lek 2000;57 Suppl 5:64-5.
12. Jiang L, Liu J, Shao W, et al. Non-intubated subxiphoid uniportal video-assisted thoracoscopic thymectomy using glasses-free 3D vision. J Thorac Dis 2016;8:E1602-4.
13. Suda T, Kaneda S, Hachimaru A, et al. Thymectomy via a subxiphoid approach: single-port and robot-assisted. J Thorac Dis 2016;8:S265-71.
14. Detterbeck FC, Parsons AM. Thymic tumors: a review of current diagnosis, classification and treatment. In: Patterson A, Cooper JD. (editors). Pearson's Thoracic and Esophageal Surgery 3rd edition. Philadelphia: Churchill Livingstone, 2008:1589-614.
15. Zieliński M, Rybak M, Solarczyk-Bombik K, et al. Subxiphoid VATS approach for the mediastinum. Video-

assist Thorac Surg 2017;2:1.
16. Liu CC, Wang BY, Shih CS, et al. Subxiphoid single-incision thoracoscopic left upper lobectomy. J Thorac Cardiovasc Surg 2014;148:3250-1.
17. Liu CC, Wang BY, Shih CS, et al. Subxyphoid single-incision thoracoscopic pulmonary metastasectomy. Thorac Cancer 2015;6:230-2.
18. Suda T, Ashikari S, Tochii S, et al. Single-incision subxiphoid approach for bilateral metastasectomy. Ann Thorac Surg 2014;97:718-9.
19. Hernandez-Arenas LA, Lin L, Yang Y, et al. Initial experience in uniportal subxiphoid video-assisted thoracoscopic surgery for major lung resections. Eur J Cardiothorac Surg 2016;50:1060-6.
20. Deslauriers J, Beaulieu M, Dufour C, et al. Mediastinopleuroscopy: a new approach to the diagnosis of intrathoracic diseases. Ann Thorac Surg 1976;22:265-9.
21. Azorin JF, Francisci MP, Tremblay B, et al. (Closure of bronchopleural fistula by video-assisted mediastinal surgery after pneumonectomy). Presse Med 1996;25:805-6.
22. Zieliński M, Pankowski J, Hauer Ł, et al. The right upper lobe pulmonary resection performed through the transcervical approach. Eur J Cardiothorac Surg 2007;32:766-9.
23. Goudie E, Liberman M. Cervical Video-Assisted Thoracoscopic Surgery (C-VATS). In: Zieliński, Marcin, Rami-Porta, Ramón (editors). The Transcervical Approach in Thoracic Surgery. ebook: Springer, 2014:61-6.
24. Kall AN, Marescaux J, Zorron R. editors. Natural Orifice Translumenal Endoscopic Surgery: Textbook and Video Atlas. John Wiley & Sons, 2012:1-10.
25. Chiu PW, Lau JY, Ng EK, et al. Closure of a gastrotomy after transgastric tubal ligation by using the Eagle Claw VII: a survival experiment in a porcine model (with video). Gastrointest Endosc 2008;68:554-9.

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