

Cite this article as: Bagan P, De Dominicis F, Hernigou J, Dakhil B, Zaimi R, Pricopi C *et al.* Complete thoracoscopic lobectomy for cancer: comparative study of three-dimensional high-definition with two-dimensional high-definition video systems. *Interact CardioVasc Thorac Surg* 2015;20:820–4.

# Complete thoracoscopic lobectomy for cancer: comparative study of three-dimensional high-definition with two-dimensional high-definition video systems<sup>†</sup>

Patrick Bagan<sup>a,b,c,\*</sup>, Florence De Dominicis<sup>b</sup>, Jacques Hernigou<sup>a</sup>, Bassel Dakhil<sup>a</sup>, Rym Zaimi<sup>a</sup>,  
Ciprian Pricopi<sup>c</sup>, Françoise Le Pimpec Barthes<sup>c</sup> and Pascal Berna<sup>b</sup>

<sup>a</sup> Department of Thoracic and Vascular Surgery, Victor Dupouy Hospital, Argenteuil, France

<sup>b</sup> Department of Thoracic Surgery, Amiens Picardie University Hospital, Amiens, France

<sup>c</sup> Department of Thoracic Surgery and Lung Transplantation, Pitié-Salpêtrière Hospital, Paris V University, Paris, France

\* Corresponding author. Department of Thoracic and Vascular Surgery, Victor Dupouy Hospital, rue du lieutenant Prudhon, 95100 Argenteuil, France.  
Tel: +33-1-34232581; fax: +33-1-34232766; e-mail: patrick.bagan@ch-argenteuil.fr (P. Bagan).

Received 3 August 2014; received in revised form 1 February 2015; accepted 4 February 2015

## Abstract

**OBJECTIVES:** Common video systems for video-assisted thoracic surgery (VATS) provide the surgeon a two-dimensional (2D) image. This study aimed to evaluate performances of a new three-dimensional high definition (3D-HD) system in comparison with a two-dimensional high definition (2D-HD) system when conducting a complete thoracoscopic lobectomy (CTL).

**METHODS:** This multi-institutional comparative study trialled two video systems: 2D-HD and 3D-HD video systems used to conduct the same type of CTL. The inclusion criteria were T1N0M0 non-small-cell lung carcinoma (NSCLC) in the left lower lobe and suitable for thoracoscopic resection. The CTL was performed by the same surgeon using either a 3D-HD or 2D-HD system. Eighteen patients with NSCLC were included in the study between January and December 2013: 14 males, 4 females, with a median age of 65.6 years (range: 49–81). The patients were randomized before inclusion into two groups: to undergo surgery with the use of a 2D-HD or 3D-HD system. We compared operating time, the drainage duration, hospital stay and the N upstaging rate from the definitive histology.

**RESULTS:** The use of the 3D-HD system significantly reduced the surgical time (by 17%). However, chest-tube drainage, hospital stay, the number of lymph-node stations and upstaging were similar in both groups.

**CONCLUSIONS:** The main finding was that 3D-HD system significantly reduced the surgical time needed to complete the lobectomy. Thus, future integration of 3D-HD systems should improve thoracoscopic surgery, and enable more complex resections to be performed. It will also help advance the field of endoscopically assisted surgery.

**Keywords:** Video-assisted thoracic surgery lobectomy • Three-dimensional video system • Lung cancer

## INTRODUCTION

Video-assisted thoracic surgery (VATS) has been increasingly adopted by thoracic surgeons over the last two decades: nowadays, it is commonly used in the management of lung cancer. Traditionally, VATS has been based on two-dimensional (2D) imaging. The use of three-dimensional (3D) visualization technology in endoscopic surgery has been proposed, since the early 1990s, as a way to improve surgical performance. However, early 3D endoscopic video quality was poor such that its use had not been widely implemented [1, 2]. More recently, novel 3D-HD systems, which have imaging quality similar to that of stereoscopic

vision plus improved depth perception, can now provide significant benefits over 2D systems when performing endoscopic surgery [3–5]. However, a comparative assessment between 3D-HD and 2D-HD systems when performing a VATS lobectomy has not yet been conducted. This study aimed to evaluate the performances of a new 3D-HD system compared with a 2D-HD during complete thoracoscopic lobectomy (CTL).

## PATIENTS AND METHODS

### Study design

This was a prospective, comparative, multicentre study that involved three French thoracic surgery departments: Victor Dupouy

<sup>†</sup>Presented at the 22nd European Conference on General Thoracic Surgery, Copenhagen, Denmark, 15–18 June 2014.

hospital in Argenteuil, Amiens university hospital and Georges Pompidou university hospital.

## Preoperative work-up

The preoperative work-up included a clinical staging protocol: this consisted of a chest radiography, a fibre-optic bronchoscopy, a thoracic, upper abdominal, cerebral CT scan and systematic PET scan. Histology was obtained by CT scan-guided transthoracic biopsies of tumours.

Preoperative functional evaluation consisted of spirometric and plethysmographic tests, assessment of diffusing capacity of the lungs for carbon monoxide (DLCO) and arterial blood-gas measurement. Criteria of operability were based on predictive post-operative values of FEV1 and DLCO. A thoracoscopic lobectomy was planned if the multidisciplinary oncological committee decided surgical resection.

## Eligibility criteria for participants

All consecutive patients admitted for a histologically proven T1 non-small-cell lung cancer (NSCLC) inferior or equal to 3 cm in diameter and located in the left lower lobe were initially eligible.

## Exclusion criteria

**Preoperative.** Clinical nodal or distant metastases. Contraindication to VATS approach (history of pleuritis and prior thoracic surgery). Respiratory contraindication to lobectomy.

**Perioperative.** Patients with pleural symphysis and/or without an interlobar fissure were excluded.

Informed consent was obtained from all patients. This study was approved by the Ethics Committee of the Victor Dupouy Hospital.

## Surgical technique

Artificial ventilation was performed in lateral decubitus position with a double-lumen endobronchial tube. A complete port-accessed thoracoscopic approach with 100% monitor vision was used for lower lobectomies in all patients. The 3D video needed specific glasses dedicated to the 3D monitor. Three thoracoports (for endoscopic instruments and bipolar energy device, 7 mm in diameter; for 30° optic Karl Storz® Tuttlingen, 10 mm in diameter and for stapler, 15 mm in diameter) were placed respectively in the fourth intercostal space on the anterior axillary line, on the fifth intercostal space on the midaxillary line and posterior axillary line in the seventh intercostal space (Figs 1 and 2). The 15 mm port was used for vessels, lung parenchyma and bronchus endo-stapling. This most posterior port also allowed lobe extraction only for lower lobectomies. The anterior port allowed lobe extraction for middle and upper lobectomies. Mediastinal lymph node dissection was then performed after lobectomy. The pain control was obtained with paravertebral catheter. This catheter was removed at the same time of chest tube removal.



**Figure 1:** Incisions for thoracoport placement for left lower complete thoracoscopic lobectomy. (A): 10 mm in diameter for optic. (B) 7 mm in diameter for endoscopic instrument and bipolar energy device. (C) 15 mm in diameter for stapling and lobe extraction (lower lobectomies).



**Figure 2:** Operating theatre set-up. (A) 3D screen with endothoracic vision (back of the patient). (B) 2D screen without need of dedicated glasses. (C) Three-port placement with 30° 3D optic Karl Storz® Tuttlingen.

## Randomization

The complete thoracoscopic lobectomies (CTLs) were performed by the same surgeon using a 3D-HD or 2D-HD system. Patients were randomized in the operating theatre after pleural examination into two groups with the Internet randomizer for clinical trial EOL© (Medsharing, Fontenay-Sous-Bois, France). The software balanced automatically by blocks of 6 patients to either undergo CTL with 2D-HD video system (Karl Storz® Tuttlingen, Germany) or undergo CTL with 3D-HD video system (Karl Storz® Tuttlingen, Germany, in 8 patients, EndoFLEX 3D, Olympus, Japan, in 1 patient). Sample size was determined by the randomizer software.

## Data collection

The clinical parameters were collected during the preoperative consultation by the pulmonologist, during surgery by the nurses and postoperatively by the surgeon at 30 and 180 days.

Independent variables

The patients’ independent variables collected for the univariate analysis were age, gender, FEV1, DLCO, operating theatre duration time (recorded on the operating- theatre software ‘Opera’, CHC, Quebec), duration of chest tube drainage, number of lymph node stations dissected and number of upstaging from N0 to N1 or N2 on pathological examination.

Binary outcomes measures

Operating theatre duration time (recorded on the operating-theatre software ‘Opera’, CHC, Quebec) and events that occurred during the first 30 postoperative days were taken into account to assess for morbidity and mortality rates. Thirty-day morbidity was considered relevant to this study in cases of acute postoperative bacterial pneumonia, adult respiratory distress syndrome (ARDS), acute respiratory failure, empyema, bronchopleural fistula, pulmonary oedema, non-infectious ARDS, pulmonary embolism, myocardial infarction, acute renal failure, atrial or ventricular arrhythmia that required treatment and reoperation for bleeding.

Statistical analyses

Univariate analysis was conducted using Student’s unpaired *t*-test for parametric comparisons between the two groups and The Mann–Whitney *U*-test was used for non-parametric analysis. A test was considered statistically significant if *P* < 0.05. Data were analysed using the SPSS software, version 10.0 (SPSS, Inc., Chicago, IL, USA).

RESULTS

Demographic, pathological and clinical features of the overall population

Between January and December 2013, 18 (14 males, 4 females) consecutive patients with Stage I non-small-cell lung cancer and referred for a left lower lobectomy were included in the study into two groups of 9 patients. The mean age was 65.6 years (range: 49–81 years). Demographic, pathological and clinical characteristics of the two groups are presented in Table 1.

Binary outcomes

The mean operating time was decreased in the Group 3D patients (*P* < 0.001). The drainage and hospitalization duration, the number of lymph node stations and upstaging were similar in both groups. Morbidity rate was 11.1% in each group (Group 2D: acute post-operative bacterial pneumonia, *n* = 1; Group 3D: recurrent pleural effusion, *n* = 1). There was no vascular wound or conversion to thoracotomy. No postoperative deaths occurred.

DISCUSSION

Most of the studies, which showed superiority of 3D system, have been conducted using an endotrainer. Our study is the first series that intended to analyse the effect of 3D technology on operative

Table 1: Comparison of the results between the two groups based on the video system

| Characteristics                          | Group 2D<br>( <i>n</i> = 9) | Group 3D<br>( <i>n</i> = 9) | <i>P</i> -values |
|--|-----------------------------|-----------------------------|------------------|
| Age (mean)                               | 64.1                        | 70                          | 0.3              |
| Sex (M/F)                                | 7/2                         | 7/2                         | –                |
| FEV1 (mean %)                            | 76                          | 104                         | 0.16             |
| DLCO (mean %)                            | 59                          | 67                          | 0.007            |
| Operating theatre duration<br>time (min) | 176.5                       | 145.8                       | <0.001           |
| Operative blood loss (ml)                | 238                         | 216                         | 0.74             |
| Morbidity ( <i>n</i> )                   | 1                           | 1                           | –                |
| Mortality ( <i>n</i> )                   | 0                           | 0                           | –                |
| Drainage duration (days)                 | 4.5                         | 3.9                         | 0.2              |
| Lymph node station (mean)                | 4.5                         | 5.3                         | 0.1              |
| Number of upstaging ( <i>n</i> )         | N1 (1)<br>N2 (1)            | N1 (2)<br>N2 (0)            | 0.8<br>0.5       |

Continuous data are presented as means.

performance during thoracoscopic lobectomy and to assess its advantages and disadvantages over 2D imaging in the field of thoracic surgery.

Learning curve for video-assisted thoracic surgery

The latest generation of 3D imaging in endoscopic surgery seems to facilitate surgical performance of surgeons without laparoscopic background [6]. Votanopoulos *et al.* [7] reported that 3D imaging offered significant advantages when teaching laparoscopic skills to inexperienced individuals. In a more recent study, Cicione *et al.* [5] observed that, similarly, the benefit of the 3D-HD imaging was greater for laparoscopic-naïve urologists than for experts in carrying standardized tasks. In a recent consensus statement, VATS experts concluded that 50 cases were required to overcome the VATS lobectomy learning curve [8]. The introduction of this 3D-HD imaging system could help to reduce this period particularly for young surgeons during their training phase, and could increase the rate of VATS procedures for anatomical lung resection.

Limitations of the three-dimensional-imaging system

During the initial phase, no relevant difficulties occurred with nausea, vertigo, double vision, burning eyes or visual fatigue. Several nurses and students who were close to the screen complained of headaches during the beginning of the operation. This discomfort generally disappeared after a 15-min period. For persons suffering from persistent discomfort, a second screen with 2D vision was available (Fig. 2).

Operating time

It is well established that VATS resection carries intrinsic limitations, including reduced depth perception of the operative field caused by the use of 2D monitors. This results in prolonged

surgical time compared with open thoracotomy lobectomies [9]. Our mean operating time for a 2D VATS lobectomy was similar to those reported in large series of purely endoscopic lobectomies [8–10]. After a 10-year experience of 2D VATS lobectomy, our mean operating time has decreased from 202 min in 2003 [11] to 176 min in 2013. In the last 5 years of our experience with the 2D video system, we used high definition video system that contributed to the operating time reduction.

Then after, 3D-HD vision increased the lobectomy completion speed of 17% in only in a 1-year period, and resulted in a mean operating time of 145 min. In this series, despite the small sample size of our two groups, due to the restricted inclusion and exclusion criteria, the reduction of operating time was highly significant in favour of the 3D-HD system.

The 3D-imaging system improved depth perception, spatial location and precision especially during advanced technical manoeuvres [6, 7]. The 3D-imaging system also reduced the number of correctional moves needed, and provided a higher degree of accuracy during grasping [12]. We noticed that the 3D system improved the accuracy of vessels and fissure dissection with a reduction of time needed especially for artery and vein ligation. Similarly to Sahu and colleagues [13], we noticed that depth perception and hand-eye coordination were excellent with the 3D imaging system, leading to accurate and swift dissection. These authors also affirm that the 3D-HD system offers many advantages of robotic surgery at low cost and with the use of conventional laparoscopic equipment. They stated that advantages of 3D laparoscopy were well appreciated in training models as well as during operative procedures.

## Completeness of the peribronchial and hilar lymph node evaluation

Because imaging did not identify the nodal metastases, nodal upstaging is completely dependent on the efficacy of lymph node resection. The prevalence of nodal upstaging is also used as a surrogate for the completeness of nodal evaluation in the VATS approach [14]. Even with a faster lobectomy performance, our rate of N1 upstaging in Group 3D suggests that the 3D thoracoscopic approach achieved similar complete nodal evaluations to that of the 2D thoracoscopy for patient with clinically stage I primary lung cancer.

## CONCLUSION

The future integration of 3D systems should improve the outcomes and training within the field of thoracoscopic surgery, and enable more complex resections. It will also help to advance the field of endoscopically assisted oncological surgery. An efficient 3D system increases thoracoscopic surgical performance within a shorter time. The superiority of the 3D system that we noticed need to be confirmed using larger, prospective, multi-institutional databases.

**Conflict of interest:** none declared.

## REFERENCES

- [1] McDougall EM, Soble JJ, Wolf JS Jr, Nakada SY, Elashry OM, Clayman RV. Comparison of three dimensional and two-dimensional laparoscopic videosystems. *J Endourol* 1996;10:371–4.
- [2] Kum CK, Goh P, Alexander DJ, Mochala S. Three-dimensional versus two-dimensional imaging for laparoscopic suturing. *Br J Surg* 1997;84:35.
- [3] Wagner OJ, Hagen M, Kurmann A, Horgan S, Candinas D, Vorburger SA. Three-dimensional vision enhances task performance independently of the surgical method. *Surg Endosc* 2012;26:2961–8.
- [4] Storz P, Buess GF, Kunert W, Kirschniak A. 3D HD versus 2D HD: surgical task efficiency in standardised phantom tasks. *Surg Endosc* 2012;26:1454–60.
- [5] Cicione A, Autorino R, Breda A, De Sio M, Damiano R, Fusco F *et al.* Three-dimensional vs standard laparoscopy: comparative assessment using a validated program for laparoscopic urologic skills. *Urology* 2013; 82:1444–50.
- [6] Lusch A, Bucur PL, Menhadji AD, Okhunov Z, Liss MA, Perez-Lanzac A *et al.* Evaluation of the impact of three-dimensional vision on laparoscopic performance. *J Endourol* 2014;28:261–6.
- [7] Votanopoulos K, Bruniciardi FC, Thornby J, Bellows CF. Impact of three-dimensional vision in laparoscopic training. *World J Surg* 2008;32:110–8.
- [8] Yan TD, Cao C, D'Amico TA, Demmy TL, He J, Hansen H *et al.* International VATS Lobectomy Consensus Group. Video-assisted thoracoscopic surgery lobectomy at 20 years: a consensus statement. *Eur J Cardiothorac Surg* 2014;45:633–9.
- [9] Deen SA, Wilson JL, Wilshire CL, Vallières E, Farivar AS, Aye RW *et al.* Defining the cost of care for lobectomy and segmentectomy: a comparison of open, video-assisted thoracoscopic, and robotic approaches. *Ann Thorac Surg* 2014;97:1000–7.
- [10] Fournel L, Zaimi R, Grigoriou M, Stern JB, Gossot D. Totally thoracoscopic major pulmonary resections: an analysis of perioperative complications. *Ann Thorac Surg* 2014;97:419–24.
- [11] Bagan P, Feito B, Martinod E, Destable MD, Tremblay B, Morere J *et al.* Influence of thoracic approach on postoperative outcome and survival in patients with stage I bronchogenic carcinoma. *Lung Cancer* 2003;41(S8):S82.
- [12] Kunert W, Storz P, Kirschniak A. For 3D laparoscopy: a step toward advanced surgical navigation: how to get maximum benefit from 3D vision. *Surg Endosc* 2013;27:696–9.
- [13] Sahu D, Mathew MJ, Reddy PK. 3D Laparoscopy—help or hype; initial experience of a tertiary health centre. *J Clin Diagn Res* 2014;8:NC01–3.
- [14] Boffa DJ, Kosinski AS, Paul S, Mitchell JD, Onaitis M. Lymph node evaluation by open or video-assisted approaches in 11,500 anatomic lung cancer resections. *Ann Thorac Surg* 2012;94:347–53.

**eComment. Integrating three-dimensional vision in thoracoscopic surgery: Is there a learning curve?**

**Authors:** Eleftherios Spartalis, Panagiotis Lainas, Dimitrios Dimitroulis and Nikolaos Nikiteas

2nd Department of Propedeutic Surgery, University of Athens, Medical School, Athens, Greece

doi: 10.1093/icvts/ivv095

© The Author 2015. Published by Oxford University Press on behalf of the European Association for Cardio-Thoracic Surgery. All rights reserved.

We read with great interest the article titled "Complete thoracoscopic lobectomy for cancer: comparative study of three-dimensional high-definition with two-dimensional high-definition video systems", by Bagan *et al.* [1]. This study demonstrated that an efficient three-dimensional (3D) display system increases thoracoscopic surgical performance within a shorter operating time.

Stereoscopic imaging has been developed in an attempt to address one of the main limitations of thoracoscopic or laparoscopic surgery, which is two-dimensional (2D) vision. Still, data on the learning curve during adaptation of such technology in clinical practice are scarce. It is well documented that 3D systems used in robotic surgery improved the surgical accuracy and patient safety. The use of 3D glasses, however, has sometimes induced unwanted visual disturbance, nausea or other ocular symptoms.

Last month, Xu *et al.* [2] reported that such a 3D surgical system as compared with 2D systems resulted in increment of the visual fatigue, showing statistically significant differences in blurred vision, dry eyes, eyestrain or headache. On the other hand, Kyriazis *et al.* [3] stated that the 3D system offered visual comfort during the procedure, and therefore, the transition from 2D to 3D for the expert surgeon was rapid.

According to Bagan *et al.*, no relevant difficulties occurred during the initial phase. The complete thoracoscopic lobectomies, however, were performed by the same person, who is undoubtedly an experienced thoracoscopic surgeon. On the contrary,