Minimal invasive anatomical lung resections

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Department of Radiology
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Minimal invasive anatomical lung resections

VATS 1.0

&

VATS 2.0
Thoracoscopic (VATS) lobectomy is now the new standard surgical modality for early-stage lung cancer.

NSCLC, all stages >50% VATS

Denmark

The Netherlands

Leuven

A National Study of Nodal Upstaging After Thoracoscopic Versus Open Lobectomy for Clinical Stage 1 Lung Cancer

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DLSA

DUTCH LUNG SURGERY AUDIT

NSCLC 2013:

all stages: 63%
Stage I: 90,5%
All indications: 400+ VATS anatomical resections
3.2.1. For patients with clinical stage I NSCLC, a minimally invasive approach such as video-assisted thoracic surgery (thoracoscopy) is preferred over a thoracotomy for anatomic pulmonary resection and is suggested in experienced centers (Grade 2C).

Q: When to choose a VATS approach for resection of NSCLC?

- **Survival equivalent** to open lobectomy, perhaps superior
- Better compliance with **adjuvant chemotherapy**
- Lower inflammatory response, less immunosuppressive
- Advantages in **quality of life**, less pain
- Fewer postoperative complications, shorter hospital stay


Q: When NOT to choose a VATS approach for resection of NSCLC?
A: When a thoracotomy results in a better operation.

- Oncologic concerns
- Feasibility - Safety
- Lung parenchyma sparing

Experience of the team
Survival is key outcome

- Complete resection
- Systematic nodal dissection

All vats anatomical resections, NSCLC

Stage I and pT2-3N0
Nodal upstaging

• pN+: Adjuvant chemotherapy can improve survival  
  Pignon J et al., J Clin Oncol 2008;26:3552-9

• Unforeseen pN+ in 15% after optimal clinical staging  
  Cerfolio et al., Ann Thorac Surg 2009;88:917-23

• After optimal clinical staging, nodal upstaging is surrogate for completeness of nodal evaluation (or quality of surgery)  
Lymph node evaluation: no difference between VATS and open


Lymph node evaluation

- Early experience
- Internal audit - analysis leads to more focused lymph node sampling

Attention to:
- Subcarinal space if upper lobectomy (esp left)
- Pos 5-6 after left lower lobectomy

Lymph Node Evaluation in Video-Assisted Thoracoscopic Lobectomy Versus Lobectomy by Thoracotomy

Chadrick E. Denlinger, MD, Felix Fernandez, MD, Bryan F. Meyers, MD, MPH, Wande Pratt, MD, Jennifer Bell Zoole, BSN, G. Alexander Patterson, MD, A. Sasha Krupnick, MD, Daniel Kreisel, MD, PhD, and Traves Crabtree, MD
Division of Cardiothoracic Surgery, Washington University School of Medicine, St. Louis, Missouri
7 from left

Upper border: the carina of the trachea
Lower border: the upper border of the lower lobe bronchus on the left; the lower border of the bronchus intermedius on the right
VATS vs Open cN0-unforeseen pN2 NSCLC

Issue with VATS & N1 nodes?
cN0 to pN1 upstaging
VATS vs Open

• STS general thoracic (voluntary) database
• 2001-2010 cT1-2N0M0 lobectomies
• N=4394 VATS, N=7137 Open
• Lower nodal upstaging in VATS group
cN0 to pN1 6.7% vs 9.3% p<0.001
• Lower confirmation of cN1 in VATS group
cN1 = pN1 42% vs 54% (p=0.002)

Possible bias

- **Selection bias**: surgeons avoiding patients with higher risk of upgrading, by factors not captured in propensity score. E.g. tumor location
- **Conversion for lymphadenectomy** not reported
- The VATS group had potentially a **better clinical staging**, and therefore less chance for peroperative upstaging?
  
  E.g. VATS patients might have had more PET scans, EBUS?

Farjah et al JTCVS 2008;56:162-6

cN0 to pN1 upstaging

Effect of proportion of VATS

‘High proportions of VATS’ - participants have equal upstaging compared to open predominant surgeons: 8%

Proportion = VATS/Total

P = .004

Fig 2. Prevalence of nodal upstaging (cN0 to pN1) by participant use of video-assisted thoracoscopic surgery (VATS).

Stage I NSCLC ≤ 5cm and cN0
Shifting from OPEN to VATS over time in cStage I NSCLC patients

- 2007-09 n=130 (Mainly OPEN)
  - OPEN: 93.8%
  - VATS: 6.2%

- 2010-11 n=109 (transition/Learning VATS)
  - OPEN: 34.9%
  - VATS: 65.1%

- 2012-14 n=132 (Mainly VATS)
  - OPEN: 12.9%
  - VATS: 87.1%
Stage I NSCLC ≤ 5cm and cN0
Potentially resectable NSCLC (or suspected) staged with CT and PET/CT (2171 pts) 2002-2008

If central T and/or SUV max > 8

Med, EUS and/or EBUS 146 pts

Clinically staged I NSCLC (721 pts)

140 pts were N0

715 pts proceeded to resection

Clinically staged stage II, III or IV (1450 pts)

p Stage I on resection (99 pts)

Benign (101 pts)

p Stage I (405 pts)

581 pts

p Stage II N=70 (47 pts N1 = 5.7%) 8.1%

p Stage III N=106 (69 pts N2 = 9.6%) 11.9%

p Stage IV N=17

Metastasis N=16

Cerfolio et al., Ann Thorac Surg 2009;88:917-23
Stage I NSCLC ≤ 5cm and cN0
### Open vs VATS

#### Risk Factors / Procedures

<table>
<thead>
<tr>
<th></th>
<th>OPEN</th>
<th>VATS</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>177</td>
<td>194</td>
<td></td>
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<tr>
<td>Age</td>
<td>66.89</td>
<td>66.29</td>
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<td>Sex (% Male)</td>
<td>77.4%</td>
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<td>ASA score</td>
<td>2.27</td>
<td>2.38</td>
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<td>25.6</td>
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<td>FEV1%</td>
<td>81.40</td>
<td>88.60</td>
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<td>FVC%</td>
<td>97.69</td>
<td>102.37</td>
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<td>FEV1(L)/FVC(L)</td>
<td>66.25</td>
<td>68.64</td>
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<td>DLCO%</td>
<td>70.84</td>
<td>75.37</td>
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<td>ppoFEV1%</td>
<td>64.31</td>
<td>70.68</td>
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<td>ppoDLCO%</td>
<td>55.91</td>
<td>60.00</td>
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<td>Cardiac Comorbidities</td>
<td>54.8%</td>
<td>55.7%</td>
<td>0.867</td>
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<td>Other Comorbidities</td>
<td>9.6%</td>
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<td>ESTS Predicted mortality</td>
<td>2.60%</td>
<td>2.26%</td>
<td>0.031</td>
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<td>ESTS Predicted morbidity</td>
<td>17.71%</td>
<td>16.06%</td>
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<td>EBUS performed</td>
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<td>Mediastinoscopy performed</td>
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<td>19.1%</td>
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<td>EBUS or VMA performed</td>
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<td>Procedure</td>
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<td>Pneumonectomy</td>
<td>2.8%</td>
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<td>Bilobectomy</td>
<td>8.5%</td>
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<td>Sleeve lobectomy</td>
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<td>Lobectomy</td>
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<td>93.3%</td>
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<tr>
<td>Segmentectomy</td>
<td>5.6%</td>
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#### Oncologic Factors / PostOP

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<th>VATS</th>
<th>Sig. (2-tailed)</th>
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<tbody>
<tr>
<td>n</td>
<td>177</td>
<td>194</td>
<td></td>
</tr>
<tr>
<td>Histology</td>
<td></td>
<td></td>
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<tr>
<td>Adenocarcinoma</td>
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<tr>
<td>BAC</td>
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<tr>
<td>Large cell</td>
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<td>3.1%</td>
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<tr>
<td>Other</td>
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<td>Diameter of lesion (cm)</td>
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<td>Clinical T</td>
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<tr>
<td>cT1a</td>
<td>26.7%</td>
<td>50.3%</td>
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<td>cT1b</td>
<td>17.6%</td>
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<td>cT2a</td>
<td>55.7%</td>
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<td>Lesion visible on broncho</td>
<td>27.0%</td>
<td>5.0%</td>
<td>&lt;0.0001</td>
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<tr>
<td>Dindo</td>
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<tr>
<td>Grade 0</td>
<td>42.4%</td>
<td>51.5%</td>
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<td>Grade 1</td>
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<td>Grade 5</td>
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<td>Hospital Stay (d)</td>
<td>14.86</td>
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<td>Lymph node stations examined</td>
<td>5.34</td>
<td>4.97</td>
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<td>NODAL UPSTAGING</td>
<td>18.0%</td>
<td>11.0%</td>
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Clinical Stage I NSCLC

Probability vs. Overall Survival (months)

P = 0.0689

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<th>VATS</th>
<th>OPEN</th>
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<td>0</td>
<td>76.9</td>
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<td>36</td>
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<tr>
<td>48</td>
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At risk: 0, 12, 24, 36, 48

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<tr>
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<tr>
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<td>24</td>
<td>133</td>
<td>73</td>
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<td>36</td>
<td>114</td>
<td>38</td>
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<td>48</td>
<td>90</td>
<td>12</td>
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<td>87.38</td>
<td>64.38</td>
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<tr>
<td>VATS</td>
<td>194</td>
<td>----</td>
<td>60.66</td>
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Risk factor for upstaging: Central Tumor (visible on bronchoscopy)

Binary Logistic regression Model
Dependant variable: Nodal Upstaging
Forward: Conditional (entry 0,05, removal 0,10)

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<tr>
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<th>B</th>
<th>S.E.</th>
<th>df</th>
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<th>Exp(B)</th>
<th>95% C.I. for EXP(B)</th>
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<td>1,091</td>
<td>0,345</td>
<td>1</td>
<td>0,002</td>
<td>2,978</td>
<td>1,514 - 5,855</td>
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<td>Constant</td>
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<td>0,178</td>
<td>1</td>
<td>0</td>
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<td>0,743</td>
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<td>0,584</td>
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<td>ppoFEV1</td>
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<td>0,549</td>
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<td>ppoDLCO</td>
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<td>0,546</td>
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<tr>
<td>ESTS Predicted morbidity</td>
<td>0,135</td>
<td>1</td>
<td>0,713</td>
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<td>Histology</td>
<td>1,504</td>
<td>5</td>
<td>0,913</td>
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<td>EBUS/Mediastinoscopy performed</td>
<td>0,921</td>
<td>1</td>
<td>0,337</td>
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<td>Clinical T-statusT</td>
<td>5,468</td>
<td>2</td>
<td>0,065</td>
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<td>VATS vs. Open</td>
<td>1,256</td>
<td>1</td>
<td>0,262</td>
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</table>
Technical aspects

VATS anatomical resections
Patient Installation

Lateral decubitus
Flex table break:
hip down for camera

Vacuum mattress
Fixation band over pelvis/hip
Operation Theater Setup

- Surgeon and assistant anterior
- Scrub nurse posterior

Port placement

Camera port: in line with fissure
Anterior port: anterior to m. latissimus dorsi
Posterior port: triangulation
VATS lobectomy in 10 steps


**Operation Theater Setup**
Surgeon and assistant anterior
Scrub nurse posterior
Flexible monitors

**Patient Installation**
Double lumen tube
Lateral decubitus
Flex table (xiphoid), hip down
Fixation to the table

1: Place ports

- **Anterior**: in line with fissure; 7° ic
- **Utility**: anterior M. Lat. Dorsi: wound retractor; 4° ic
- **Posterior**: triangulation
10mm trocar in camera port

2: Release inferior pulmonary ligament (camera in anterior port)

3: Turn table towards you (camera in posterior port):

4: Open posterior pleura

- **Right**: pos 7, dissect C², pos 11
- **Left**: pos 7, free posterior PA

5: Turn table away from you (camera in anterior port):

6: Open anterior pleura

- **Right**: pos 4
- **Left**: pos 5 & 6

7: Isolate target lobar vein

8: Make tunnel between parenchyma and artery \(\rightarrow\) Staple the fissure

9: Divide anatomical structures from anterior to posterior as-you-go

10: Extract specimen in a bag, place a tunneled drain

**Legend**

- Ao: Aorta
- AzV: Azygos Vein
- C²: Secondary Carina
- E: Esophagus
- ic: Intercostal Space
- (i)PV: (Superior) Pulmonary Vein
- (L)Br: (Left) Main Bronchus
- PA: Pulmonary Artery
- PhrN: Phrenic Nerve
- RBr: Right Main Bronchus
- RecN: Recurrent Laryngeal Nerve
- RUL: Right Upper Lobe
- RLL: Right Lower Lobe
- SCV: Superior Caval Vein
- VN: Vagal Nerve

**Instruments** (+ backup open thoracotomy set)

References:

2. Based on: Van Huijstee PJ, Siebenga J, Bollen ECM. Standaardtechniek c-VATS lobectomie in 10 stappen. (Poster spread in the Netherlands showing the Heerlen VATS technique)
Opening of the fissure with staplers:
Left oblique fissure
Fissure first (with staplers), Hilum last

• ‘Tunnel’ technique in ‘fissureless’ patients
• Advantages:
  – Identification of segmental anatomy
  – Superior view on anatomical variations
  – Auto-exposure
  – Comfortable for less experienced surgeons
  – N1 lymphadenectomy
  – Alternative to ‘Hilum first technique’ in the ‘fissureless’ patient
Minimal invasive anatomical lung resections

VATS 2.0

VATS segmentectomies

&

VATS for higher stage
Lobectomy = the gold standard

Lung Cancer Study Group
Ginsberg RG. Randomized trial of lobectomy versus limited resection for T1N0 NSCLC. Ann Thorac Surg 1995;60:615-23

- Same postoperative mortality and morbidity
- 3 X ↑ rate of local recurrence
- Long-term follow-up: decreased survival
- 30% ↑ overall death rate
- 50% ↑ death rate of cancer
**Indication**

**sublobar anatomical resection:**

**Intentional** *

- 50% GGO < 2cm
- Solid < 1cm ?
- Resection margin ≥ Diameter lesion

**Compromised** *

- Borderline lung function
- Comorbidities
- Synchronous bilateral lesions

Indication sublobar anatomical resection:

**Intentional** *

- 50% GGO < 2cm
- Solid < 1cm ?
- Resection margin ≥ Diameter lesion

**Compromised** *

- Borderline lung function
- Comorbidities
- Synchronous bilateral lesions

VATS Segments: Feasibility

Easy:
S 6
S 1-3 left (culmen / trisegmentectomy/ lingulasparing lobectomy)
S 4-5 left (lingula)
S6 sparing lobectomy

Moderate:
Apicodorsal 1+2
Individual S1/2/3
(Individual segments S4/5)
Anteromedial basal segments lower lobe

Hard:
Individual (lateral) basal segments S7-10
• 10-2009 to 1-2014
• N= 315 patients planned for vats anatomical resections
• Outcome:
  – 4,4 % (n= 14) conversions
  – 85,8 % (n=267) (sleeve) (bi) lobectomies
  – 0,6 % (n=2) pneumonectomies
  – 10,2 % (n=32) sublobar anatomical resections
Intention to treat by vats segmentectomy:
40 patients*

Indication:
– 23 bronchuscarcinoma (NSCLC)
– 2 carcinoid
– 2 benign (aspergilloma, CPAM)
– 13 metastatic

Median age: 60 (14-76) yrs

*Exclusion: 1 combined upper lobectomy with S6
Outcome (n = 40)

• 38 successful vats anatomical sublobar resections of which 6 additional completion vats lobectomies (same surgery)
  – 5x small margin
  – 1x positive node at tertiary carina
• 2 conversions:
  – Bleeding pulmonary artery at culmenectomy
  – Hilar fibrosis post lung transplant
• Median hospital stay (n=40): 6 (3-28)
• 90-day mortality: n=1 (metastatic)
Hybrid chest wall resection post induction
Large tumor with fused right oblique fissure
Hybrid chest wall resection
Conclusion

Minimal invasive anatomical lung resections

- Stage I NSCLC: preference for VATS lobectomy
- Nodal dissection is similar to open surgery
- VATS and Thoracotomy groups are different in tumor size, central tumor, type of resection...
- Central tumor is risk factor for nodal upstaging
- VATS 2.0: ready to go
Covidien cadaver workshops
VATS anatomical resections

Day 1: 2 cases Live surgery & presentations:
  How we do it: VATS lobectomies
  The fissure first technique
  Most common intra-operative complications

Day 2: Cadaver workshop
  3X2 participants, 3 tutors (Leuven, Gent, Brussels)
  Unfrozen cadavers
Thank you!

& Philip Lerut, Jan Lesaffer, James Villeneuve, Lieven Depypere
Alessia Stanzi, Youri Sokolow (Brussels), Fred De Ryck (Ghent),
Johnny Moons