

VATS Lobectomy is Not Associated with Prohibitive Morbidity or Mortality in Patients with Predicted Post-operative FEV1 Less Than 40% of Normal

A Society of Thoracic Surgeons Database Analysis

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No Disclosures

Introduction

- ⌘ Patients considered for pulmonary resection frequently have impaired pulmonary function
- ⌘ FEV1 & DLCO are inversely correlated with postoperative mortality and complications following pulmonary resection

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- ⌘ Patients considered for pulmonary resection frequently have impaired pulmonary function
- ⌘ FEV1 & DLCO are inversely correlated with postoperative mortality and complications following pulmonary resection
- ⌘ Representation of FEV1 and DLCO:
 - ⌘ **Absolute values**
 - ⌘ **Percent predicted (FEV1% & DLCO%)**
 - Normalized to population data for age, sex, height
 - Better correlate of operative risk following pulmonary resection¹
 - ⌘ **Predicted postoperative (ppoFEV1% & ppoDLCO%)**
 - Preoperative estimates of remaining postoperative lung function
 - May better correlate with operative risk than their parent values²⁻⁴

¹ Win. Eur Respir J 2005; 25:549

³ Ferguson. Ann Thorac Surg 2008; 1158

² Kearney. Chest 1994; 105:753

⁴ Cerfolio. Ann Thorac Surg 2009; 8:405

Introduction

- ⌘ VATS lobectomy is associated with less morbidity than open lobectomy
- ⌘ VATS lobectomy patients with FEV1% <60% had decreased pulmonary complications than a non-matched open group ¹
- ⌘ Traditionally, ppoFEV1% and ppoDLCO% <40% represented increased operative risk for lobectomy (ACCP and BTS guidelines²⁻³)

Data supporting these recommendations are derived from the pre-VATS era, single institutions, small cohorts, and variable extent of resections.

¹ Ceppa. Ann Surg 2012; 256:487

² Colice. Chest 2007; 132:161

³ BTS. Thorax 2001; 56:89

Aims

1. To crystallize the utility of ppoFEV1% & ppoDLCO% for prediction of postoperative cardiopulmonary complications and mortality in patients undergoing open and VATS lobectomy for lung cancer
2. To investigate the potential benefit of VATS lobectomy in patients with compromised pulmonary function

Methods

- ⌘ STS - General Thoracic Database (version 2.081)
- ⌘ 2009-2011
- ⌘ Cohort: lung cancer patients undergoing open or VATS lobectomy or segmentectomy in which ppoFEV1% & ppoDLCO% could be calculated
- ⌘ VATS lobectomy and VATS segmentectomy were clustered into a single CPT code, requiring analysis of both groups together
 - *2.07 STS-GTD segmentectomy rate: 6.5% open, 8% VATS ¹

¹ Boffa. Ann Thorac Surg 2012; 94:347

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- ⌘ VATS lobectomy and VATS segmentectomy were clustered into a single CPT code, requiring analysis of both groups together
 - *2.07 STS-GTD segmentectomy rate: 6.5% open, 8% VATS ¹
- ⌘ ppoFEV1% and ppoDLCO% were calculated by anatomic method ²⁻⁴:

$$\text{ppoFEV1\%} = \text{measured FEV1\%} \times \frac{(19 - \# \text{ segments resected})}{19}$$

¹ Boffa. Ann Thorac Surg 2012; 94:347

² BTS. Thorax 2001; 56:89

³ Cerfolio. Ann Thorac Surg 2009; 88:405

⁴ Brunelli. Ann Thorac Surg 2007; 83:1134

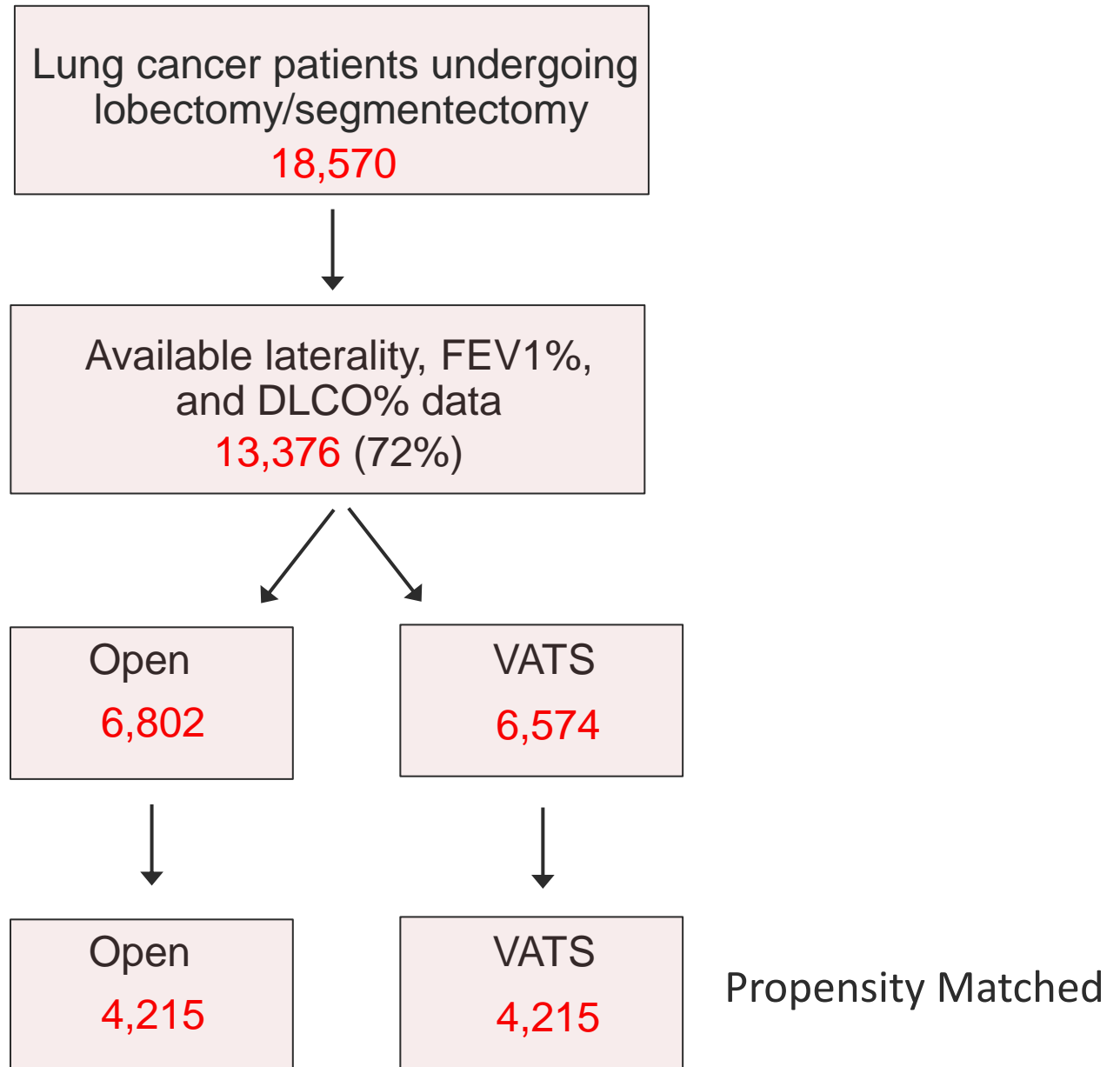
Methods

⌘ Mortality: death within 30 days or before discharge

⌘ Cardiopulmonary complications:

- ⌘ Atelectasis requiring bronchoscopy
- ⌘ Pneumonia
- ⌘ Adult respiratory distress syndrome (ARDS)
- ⌘ Bronchopleural fistula
- ⌘ Pulmonary embolus
- ⌘ Initial ventilator support greater than 48 hours
- ⌘ Reintubation
- ⌘ Tracheostomy
- ⌘ Ventricular arrhythmia requiring treatment
- ⌘ Myocardial infarction

Results: Patient Cohort



Results: Patient Cohort

| | Open n=6802 | VATS n=6574 | p-value* |
|---------------------|-----------------|-----------------|----------|
| Age (mean \pm SD) | 66.6 \pm 10.4 | 67.2 \pm 10.2 | 0.001 |
| Female | 3468 (51.0) | 3683 (56.0) | <0.001 |
| Race | | | 0.029 |
| Caucasian | 6031 (88.8) | 5855 (89.3) | |
| Black | 614 (9.0) | 524 (8.0) | |
| Asian | 134 (2.0) | 166 (2.5) | |
| Other | 16 (0.2) | 15 (0.2) | |
| BMI | 27.8 \pm 6.3 | 27.3 \pm 6.9 | <0.001 |
| FEV1% | 79.9 \pm 19.8 | 83.6 \pm 20.8 | <0.001 |
| DLCO% | 71.4 \pm 21.4 | 74.7 \pm 21.8 | <0.001 |
| ppoFEV1% | 63.1 \pm 16.3 | 66.2 \pm 17.0 | <0.001 |
| ppoDLCO% | 56.4 \pm 17.4 | 59.2 \pm 17.7 | <0.001 |
| Smoking | | | 0.002 |
| Current | 1804 (26.5) | 1590 (24.2) | |
| Never or Past | 4996 (73.5) | 4981 (75.8) | |
| Zubrod Score | | | <0.001 |
| 10 | 2499 (36.8) | 3085 (46.9) | |
| 11 | 3974 (58.4) | 3217 (49.0) | |
| 12 | 276 (4.1) | 235 (3.6) | |
| 13 | 48 (0.7) | 31 (0.5) | |
| 14 | 3 (0.0) | 2 (0.0) | |
| 15 | 0 (0.0) | 1 (0.0) | |
| ASA Risk Class | | | <0.001 |
| 1 | 24 (0.4) | 30 (0.5) | |
| 2 | 872 (12.8) | 1184 (18.0) | |
| 3 | 5066 (74.5) | 4930 (75.0) | |
| 4 | 839 (12.3) | 427 (6.5) | |

Results: Patient Cohort

| | Open n=6802 | VATS n=6574 | p-value* |
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| Asian | 134 (2.0) | 166 (2.5) | |
| Other | 16 (0.2) | 15 (0.2) | |
| BMI | 27.8 ± 6.3 | 27.3 ± 5.9 | <0.001 |
| FEV1% | 79.9 ± 19.8 | 83.6 ± 20.8 | <0.001 |
| DLCO% | 71.4 ± 21.4 | 74.7 ± 21.8 | <0.001 |
| ppoFEV1% | 63.1 ± 16.3 | 66.2 ± 17.0 | <0.001 |
| ppoDLCO% | 56.4 ± 17.4 | 59.2 ± 17.7 | <0.001 |
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Results: Patient Cohort

| | Open n=6802 | VATS n=6574 | p-value* |
|---|----------------|----------------|----------|
| cT | | | <0.001 |
| T1 | 3554(53.9) | 4397(69.0) | |
| T2 | 2295(34.8) | 1631(25.6) | |
| T3 | 601(9.1) | 267(4.2) | |
| T4 | 145(2.2) | 78(1.2) | |
| cN | | | <0.001 |
| N0 | 5409(82.0) | 5756(90.3) | |
| N1 | 692(10.5) | 383(6.0) | |
| N2 | 480(7.3) | 212(3.3) | |
| N3 | 19(0.3) | 20(0.3) | |
| Preop Chemo | 884(13.3) | 374(5.8) | <0.001 |
| Preop RT | 714(10.7) | 329(5.0) | <0.001 |
| CAD | 1517(22.7) | 1362(20.9) | 0.012 |
| CHF | 194(2.9) | 189(2.9) | 1.0 |
| PVD | 713(10.7) | 624(9.6) | 0.038 |
| CVD | 584(8.8) | 485(7.5) | 0.006 |
| HTN | 4144(61.8) | 4029(61.7) | 0.91 |
| COPD | 2476(37.2) | 2188(33.7) | <0.001 |
| Diabetes | 1355(20.3) | 1090(16.7) | <0.001 |
| Last Creatinine (mean±SD) | 1.0±0.6 | 1.0±0.6 | 0.16 |
| Last Hemoglobin (mean±SD) | 13.0±1.7 | 13.3±1.6 | <0.001 |
| Steroid Use | 262(3.9) | 187(2.9) | 0.001 |
| General Thoracic Reoperation | 433(6.5) | 277(4.2) | <0.001 |

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Results: Multivariate Analyses - Complications

| Variable | Open ¹ n=6802 | |
|----------|-----------------------------|---------|
| | OR(95%CI) | p-value |
| ppoFEV1% | 1.015(1.009,1.021) | <0.001 |
| ppoDLCO% | 1.011(1.005,1.016) | <0.001 |

?

¹Adjusted for significant univariate predictors of cardiopulmonary complications including age, gender, smoking status, Zubrod score, ASA risk class, clinical T descriptor, preoperative radiotherapy, coronary artery disease, hypertension, COPD, and thoracic reoperation.

Results: Multivariate Analyses - Complications

| Variable | Open ¹ n=6802 | | VATS ² n=6574 | |
|-----------------|-----------------------------|---------|-----------------------------|---------|
| | OR(95%CI) | p-value | OR(95%CI) | p-value |
| ppoFEV1% | 1.015(1.009,1.021) | <0.001 | 1.011(1.004,1.017) | 0.002 |
| ppoDLCO% | 1.011(1.005,1.016) | <0.001 | 1.007(1.000,1.013) | 0.038 |

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²Adjusted for significant univariate predictors of cardiopulmonary complications including age, smoking status, Zubrod score, ASA risk class, coronary artery disease, peripheral vascular disease, COPD, and last creatinine level.

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| Variable | Open ¹ n=6802 | | VATS ² n=6574 | |
|-----------------|-----------------------------|---------|-----------------------------|---------|
| | OR(95%CI) | p-value | OR(95%CI) | p-value |
| ppoFEV1% | 1.015(1.009,1.021) | <0.001 | 1.011(1.004,1.017) | 0.002 |
| ppoDLCO% | 1.011(1.005,1.016) | <0.001 | 1.007(1.000,1.013) | 0.038 |
| FEV1% | 1.014(1.010,1.019) | <0.001 | 1.008(1.003,1.014) | 0.002 |
| DLCO% | 1.010(1.006,1.014) | <0.001 | 1.006(1.000,1.011) | 0.033 |

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Results: Multivariate Analyses - Mortality

| Variable | Open ¹ n=6802 | |
|----------|-----------------------------|---------|
| | OR (95% CI) | p-value |
| ppoFEV1% | 1.017 (1.005, 1.030) | 0.007 |
| ppoDLCO% | 1.023 (1.010, 1.035) | <0.001 |

⌵

¹Adjusted for significant univariate predictors of postoperative mortality including age, gender, smoking status, Zubrod score, ASA risk class, congestive heart failure, steroid use, and thoracic reoperation.

Results: Multivariate Analyses - Mortality

| Variable | Open ¹ n=6802 | | VATS ² n=6574 | |
|----------|-----------------------------|---------|-----------------------------|---------|
| | OR (95% CI) | p-value | OR (95% CI) | p-value |
| ppoFEV1% | 1.017 (1.005, 1.030) | 0.007 | 1.001 (0.982, 1.020) | 0.95 |
| ppoDLCO% | 1.023 (1.010, 1.035) | <0.001 | 1.026 (1.007, 1.047) | 0.007 |

⌵

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| | OR(95%CI) | p-value | OR(95%CI) | p-value |
| ppoFEV1% | 1.017(1.005, 1.030) | 0.007 | 1.001(0.982, 1.020) | 0.95 |
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| ppoFEV1% | 1.017(1.005,1.030) | 0.007 | 1.001(0.982,1.020) | 0.95 |
| ppoDLCO% | 1.023(1.010,1.035) | <0.001 | 1.026(1.007,1.047) | 0.007 |
| FEV1% | 1.014(1.004,1.024) | 0.006 | 0.998(0.984,1.014) | 0.84 |
| DLCO% | 1.017(1.008,1.027) | <0.001 | 1.019(1.004,1.035) | 0.013 |

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Results: Propensity Analysis

| Variable | Open n=4215 | VATS n=4215 | p-value* |
|-----------------|----------------|----------------|----------|
| Age (mean ± SD) | 67.2 ± 10.2 | 67.2 ± 10.3 | 1.0 |
| Female | 2246 (53.3) | 2246 (53.3) | 1.0 |
| Race | | | 0.98 |
| Caucasian | 3763 (89.3) | 3766 (89.3) | |
| Black | 352 (8.4) | 345 (8.2) | |
| Asian | 92 (2.2) | 96 (2.3) | |
| Other | 8 (0.2) | 8 (0.2) | |
| BMI (mean ± SD) | 27.6 ± 6.0 | 27.6 ± 6.3 | 0.89 |
| Smoking | | | 0.94 |
| Current | 1072 (25.4) | 1074 (25.5) | |
| Never or Past | 3143 (74.6) | 3140 (74.5) | |
| Zubrod Score | | | 0.99 |
| 0 | 1776 (42.1) | 1783 (42.3) | |
| 1 | 2261 (53.6) | 2255 (53.5) | |
| 2 | 154 (3.7) | 155 (3.7) | |
| 3-4 | 24 (0.6) | 22 (0.5) | |
| ASA Risk Class | | | 0.84 |
| I-II | 631 (15.0) | 639 (15.2) | |
| III | 3218 (76.3) | 3223 (76.5) | |
| IV | 366 (8.7) | 353 (8.4) | |
| cT | | | 0.94 |
| T1 | 2642 (62.7) | 2627 (62.3) | |
| T2 | 1283 (30.4) | 1307 (31.0) | |
| T3 | 229 (5.4) | 222 (5.3) | |
| T4 | 61 (1.4) | 59 (1.4) | |

Open
n=4215

VATS
n=4215

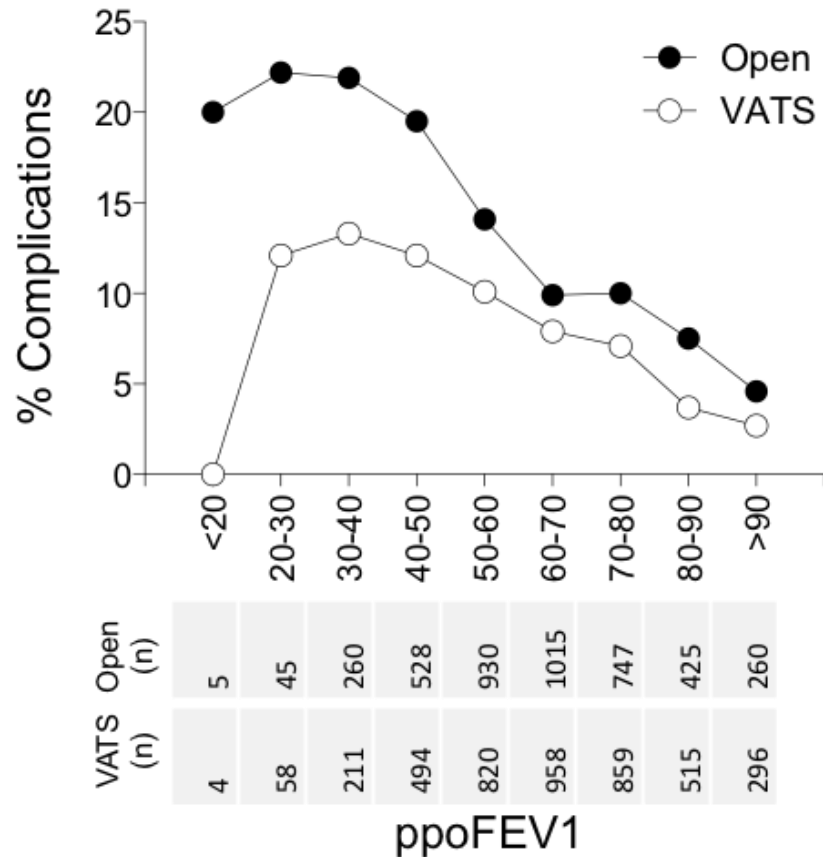
Results: Propensity Analysis

| Variable | Open n=4215 | VATS n=4215 | p-value* |
|---------------------------------|----------------|----------------|----------|
| cN | | | 0.77 |
| N0 | 3721(88.3) | 3726(88.4) | |
| N1 | 327(7.8) | 311(7.4) | |
| N2 | 156(3.7) | 169(4.0) | |
| N3 | 11(0.3) | 9(0.2) | |
| Preop Chemo | 264(6.3) | 280(6.6) | 0.44 |
| Preop RT | 244(5.8) | 245(5.8) | 0.96 |
| CAD | 939(22.3) | 939(22.3) | 1.0 |
| CHF | 116(2.8) | 122(2.9) | 0.69 |
| PVD | 448(10.6) | 448(10.6) | 1.0 |
| CVD | 366(8.7) | 353(8.4) | 0.61 |
| HTN | 2658(63.1) | 2610(61.9) | 0.29 |
| COPD | 1542(36.6) | 1527(36.2) | 0.73 |
| Pulmonary HTN | 63(1.5) | 58(1.4) | 0.90 |
| Diabetes | 781(18.5) | 777(18.4) | 0.91 |
| Last Creatinine (mean ± SD) | 1.0 ± 0.6 | 1.0 ± 0.6 | 0.78 |
| Last Hemoglobin (mean ± SD) | 13.2 ± 1.7 | 13.2 ± 1.6 | 0.53 |
| Steroid Use | 140(3.3) | 141(3.3) | 0.95 |
| General Thoracic Reoperation | 198(4.7) | 193(4.6) | 0.79 |

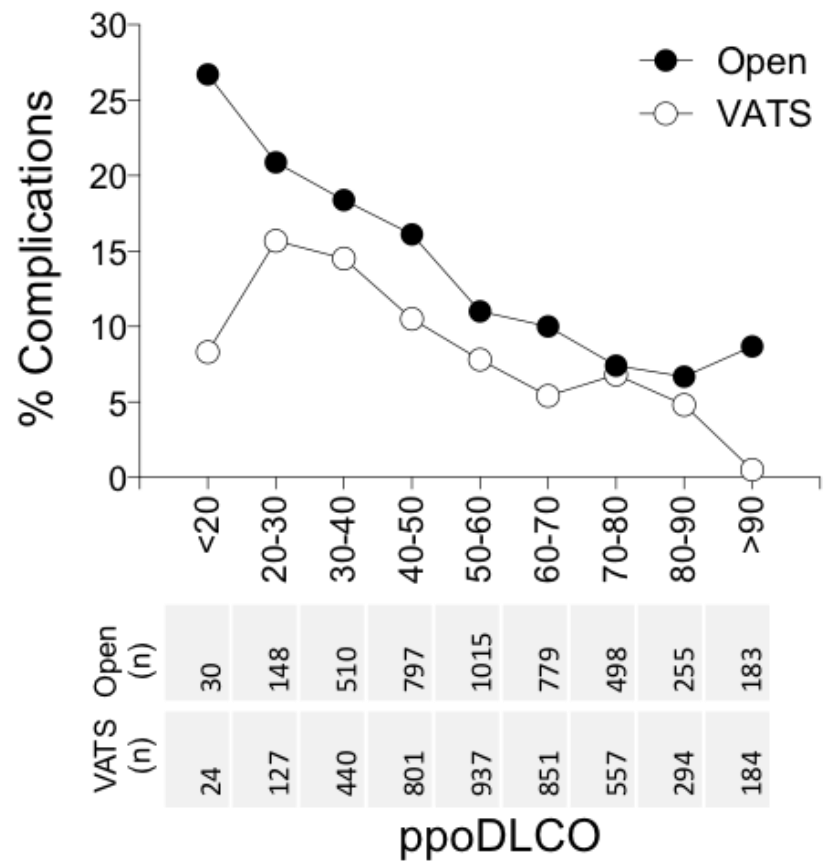
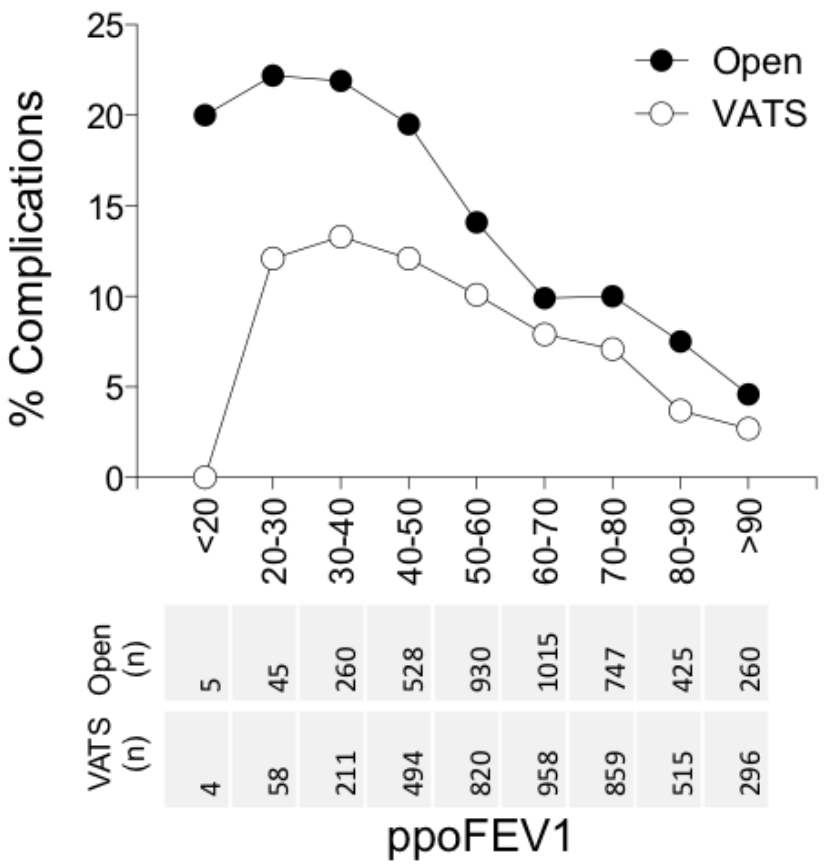
Open
n=4215

VATS
n=4215

Results: Propensity Analysis - Complications

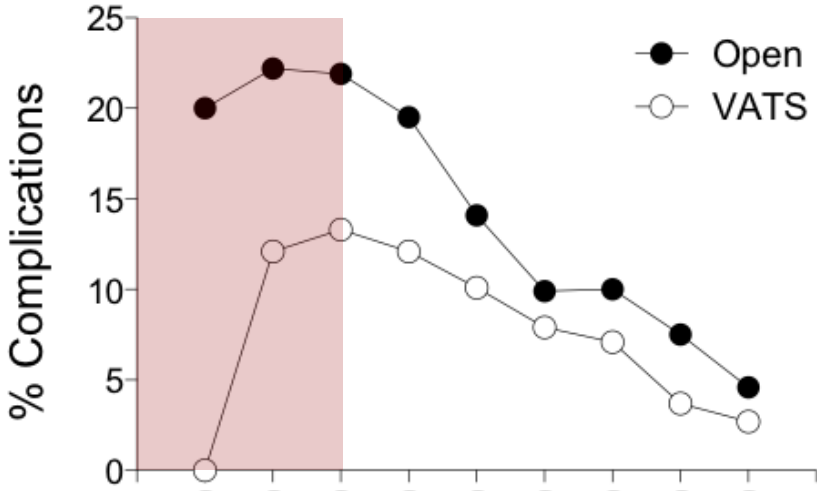


Results: Propensity Analysis - Complications



Results: Propensity Analysis - Complications

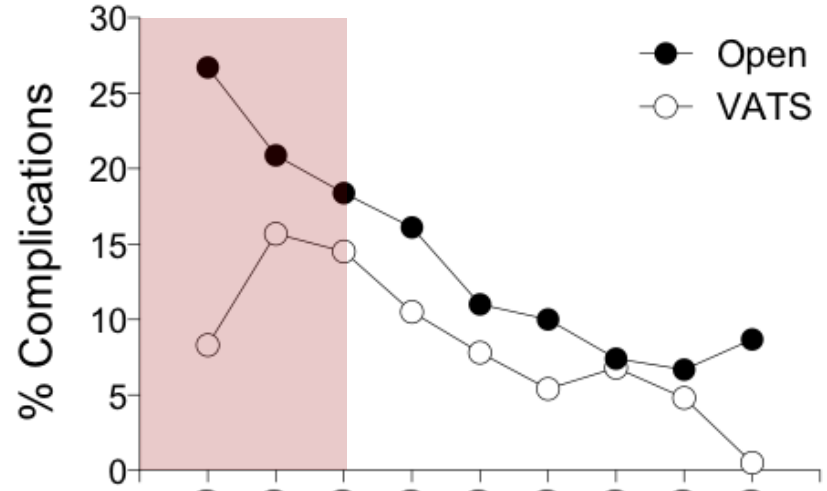
ppoFEV1 <40% Open 21.9%
 VATS 12.8%
 p=0.005



| | | | | | | | | | |
|----------|---|----|-----|-----|-----|------|-----|-----|-----|
| Open (n) | 5 | 45 | 260 | 528 | 930 | 1015 | 747 | 425 | 260 |
| VATS (n) | 4 | 58 | 211 | 494 | 820 | 958 | 859 | 515 | 296 |

ppoFEV1

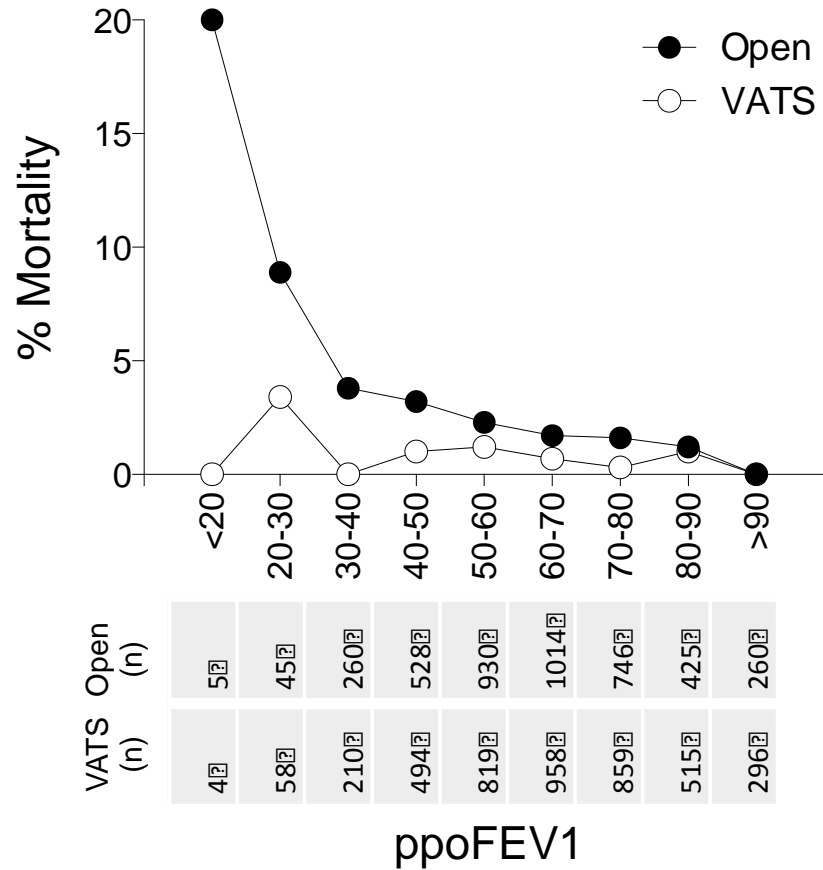
ppoDLCO <40% Open 14.9%
 VATS 10.4%
 p=0.016



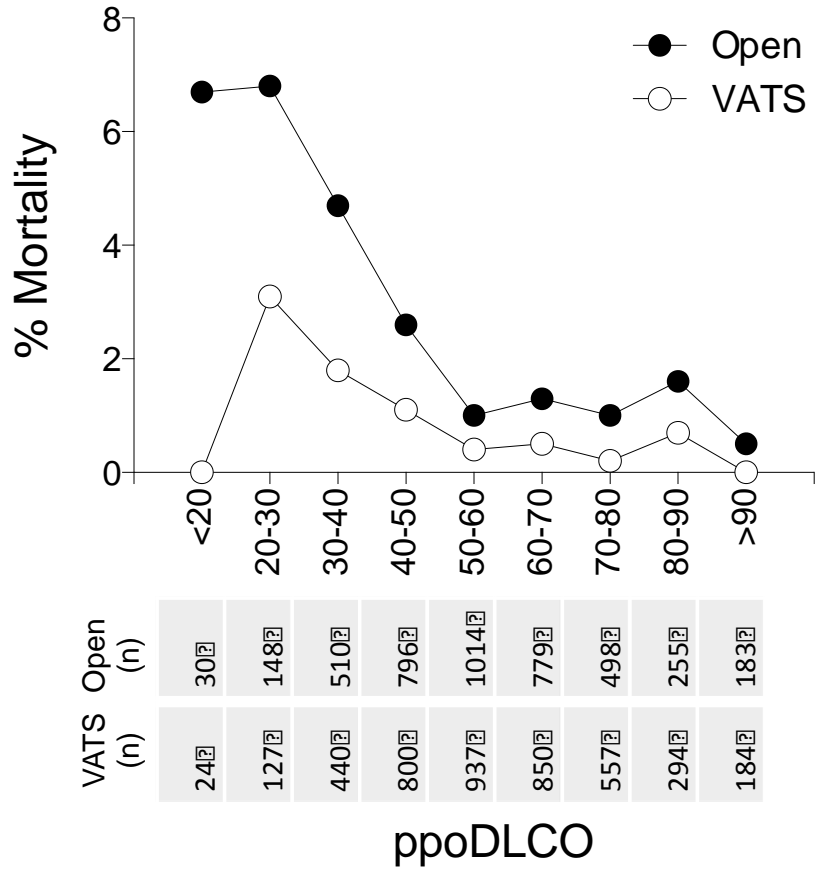
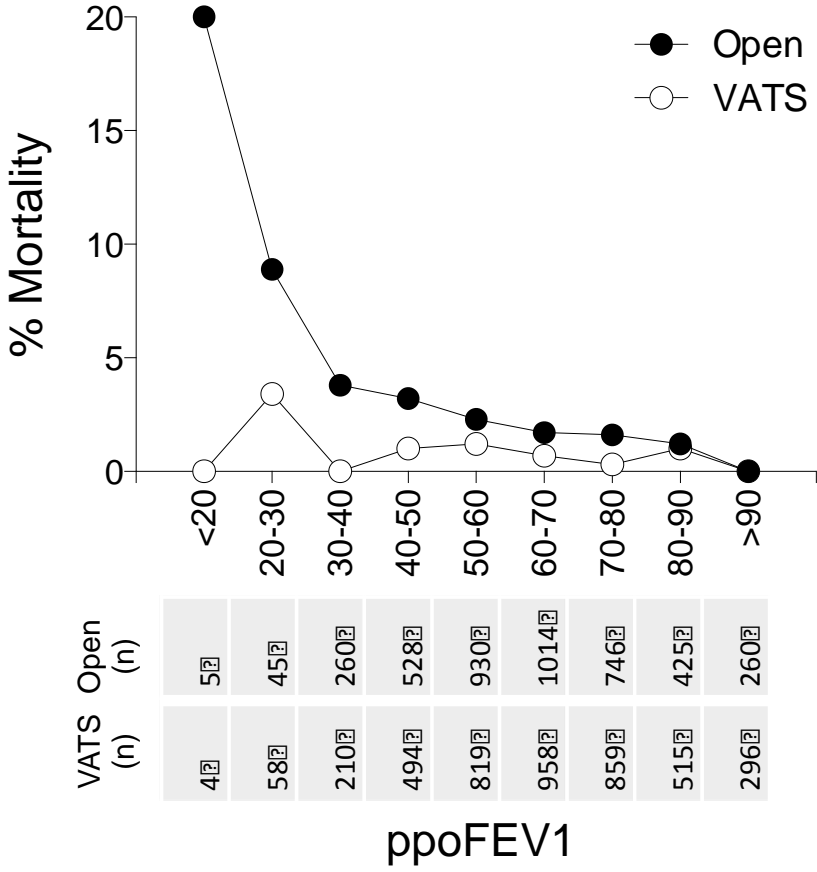
| | | | | | | | | | |
|----------|----|-----|-----|-----|------|-----|-----|-----|-----|
| Open (n) | 30 | 148 | 510 | 797 | 1015 | 779 | 498 | 255 | 183 |
| VATS (n) | 24 | 127 | 440 | 801 | 937 | 851 | 557 | 294 | 184 |

ppoDLCO

Results: Propensity Analysis - Mortality

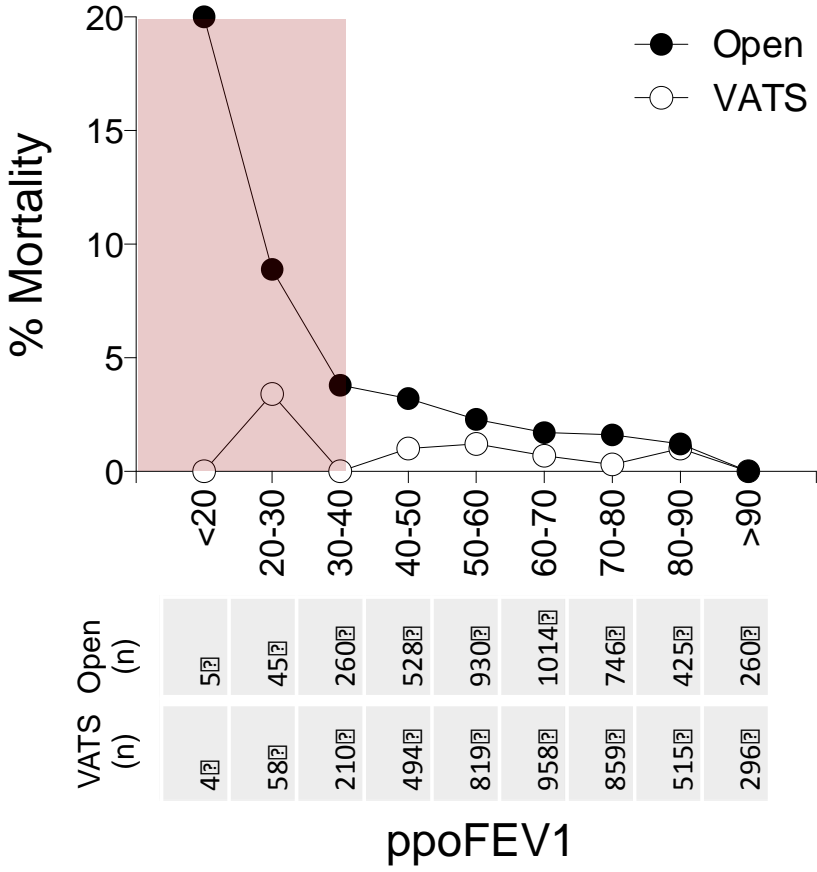


Results: Propensity Analysis - Mortality

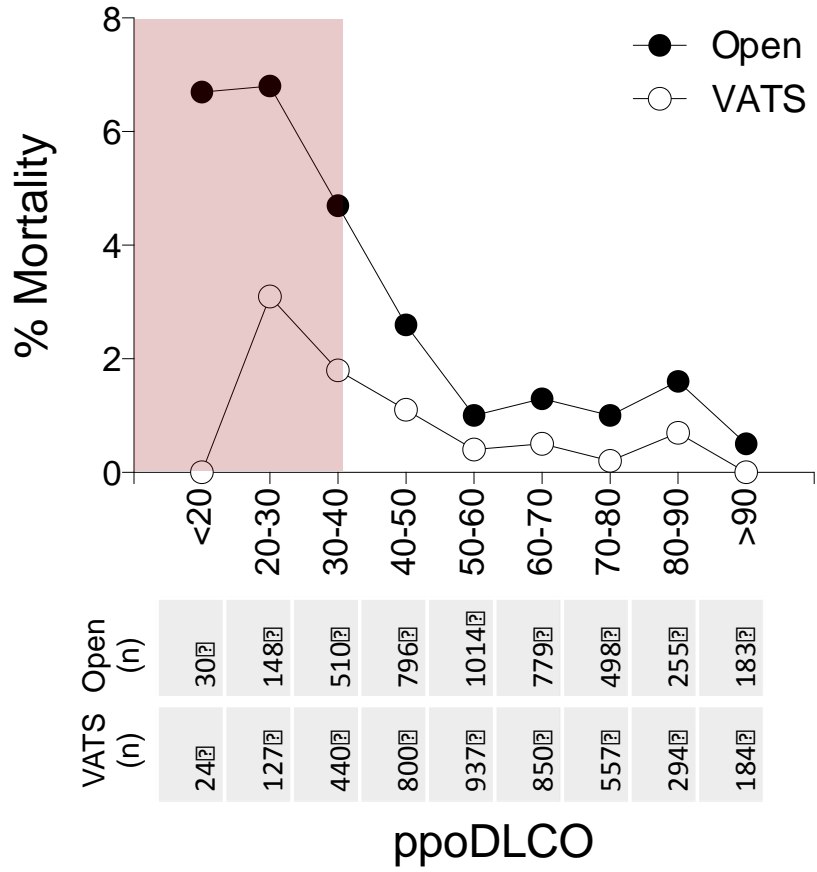


Results: Propensity Analysis - Mortality

ppoFEV1 <40% Open 4.8%
 VATS 0.7%
p=0.003



ppoDLCO <40% Open 5.2%
 VATS 2.0%
P=0.003



Limitations

- ⌘ Retrospective Design
- ⌘ Categorization of lobectomy with segmentectomy
- ⌘ Non-accounting for non-functional lung parenchyma

Conclusions

- ⌘ ppoFEV1% is a useful predictor of operative morbidity in patients undergoing VATS lobectomy for lung cancer
- ⌘ ppoDLCO% is a useful predictor of operative morbidity and mortality in patients undergoing VATS lobectomy for lung cancer
- ⌘ The VATS approach dramatically reduces morbidity and mortality of lobectomy in patients with compromised pulmonary function



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Thank you



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Appendix: Postoperative Events of Entire Cohort

| | Open n=6802 | VATS n=6574 | P-value* |
|--|----------------|----------------|----------|
| Atelectasis requiring bronchoscopy | 397 (5.8) | 184 (2.8) | <0.001 |
| Pneumonia | 376 (5.5) | 204 (3.1) | <0.001 |
| ARDS | 82 (1.2) | 35 (0.5) | <0.001 |
| Bronchopleural fistula | 32 (0.5) | 18 (0.3) | 0.066 |
| Pulmonary embolus | 35 (0.5) | 16 (0.2) | 0.011 |
| Ventilator support >48 hours | 69 (1.0) | 32 (0.5) | <0.001 |
| Reintubation | 362 (5.3) | 149 (2.3) | <0.001 |
| Tracheostomy | 108 (1.6) | 56 (0.9) | <0.001 |
| Ventricular arrhythmia requiring treatment | 57 (0.8) | 37 (0.6) | 0.062 |
| Myocardial infarction | 38 (0.6) | 25 (0.4) | 0.16 |
| At least one complication | 888 (13.1) | 496 (7.5) | <0.001 |
| Death | 141 (2.1) | 52 (0.8) | <0.001 |

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Appendix: Propensity Analysis: non-ppo, parent values

