Pretreatment Assessment of the Lung Resection Candidate

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CHEST® Congress 2019 | Thailand Bangkok | 10-12 April

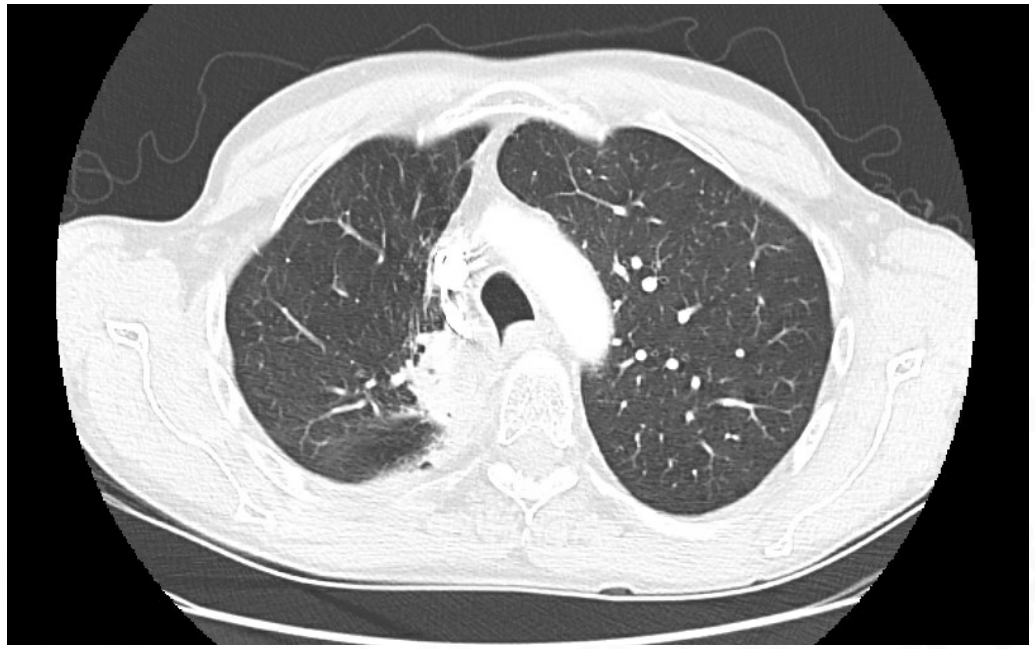
Disclosures

- None related to the content of this talk.

Case 1

- 50 year old man diagnosed with a stage IIIA squamous cell cancer of the right upper lobe (N2 involvement) was treated with definitive chemoradiation.
- Cancer has persisted at the tumor site. Restaging suggests no nodal involvement. He has received maximal doses of radiation.
- He feels he could walk at least 1/2 mile. He rides a bicycle with his 11 year old grandson, perhaps 10-12 city blocks. He has a chronic cough and recently an episode of frank hemoptysis.
- He is a former smoker with known COPD receiving an ICS/LABA and LAMA for maintenance therapy. He does not have known cardiac risks.

Case 1



- PFTs - FEV_1 1.38L, 39% predicted; DLCO 20.6, 70% predicted

Which statement is most correct about his preoperative evaluation?

A. He should have a cardiac stress test.

B. Segment methods for calculating predicted post-operative values will be more accurate than perfusion methods.

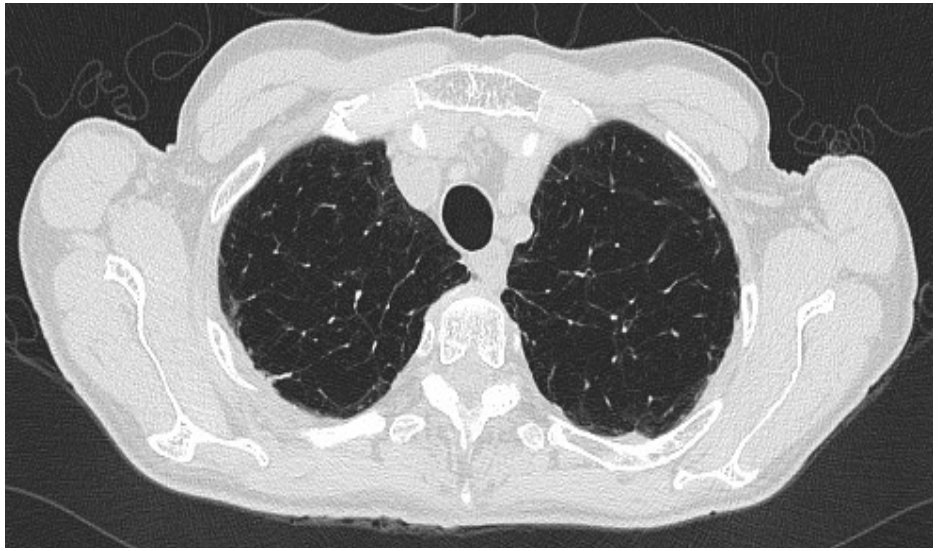
C. He should have some form of exercise test.

D. He should participate in pulmonary rehab prior to surgery.

Case 2

- A 70 year old smoker is seen with a localized adenocarcinoma of the lung. She currently feels well, exercising regularly without limitation from excessive dyspnea.
- She is an active smoker, down to 1 cigarette per week.
- She has been diagnosed with emphysema and started using maintenance tiotropium within the year.
- She developed a severe influenza infection 8 months ago. She required hospitalization and was discharged with home oxygen for 3 weeks.

Case 2



- Pulmonary function tests show severe obstruction (FEV_1 0.95L, 45% predicted) and a reduced diffusing capacity (42% predicted). Thoracic surgery does not feel that a wedge resection is feasible.

Which statement is most correct about her preoperative evaluation?

A. Her surgery should be delayed until she has been abstinent from smoking for 2 months.

B. Her FEV_1 suggests the risk of complications from lung resection is low.

C. Her DLCO suggests the risk of complications from lung resection is moderate.

D. The location of her cancer increases the risk of complications from lung resection.

Overview

- Striking the Best Balance
- Comparison of Benefits and Harms
  - Considerations
- Making the Decision

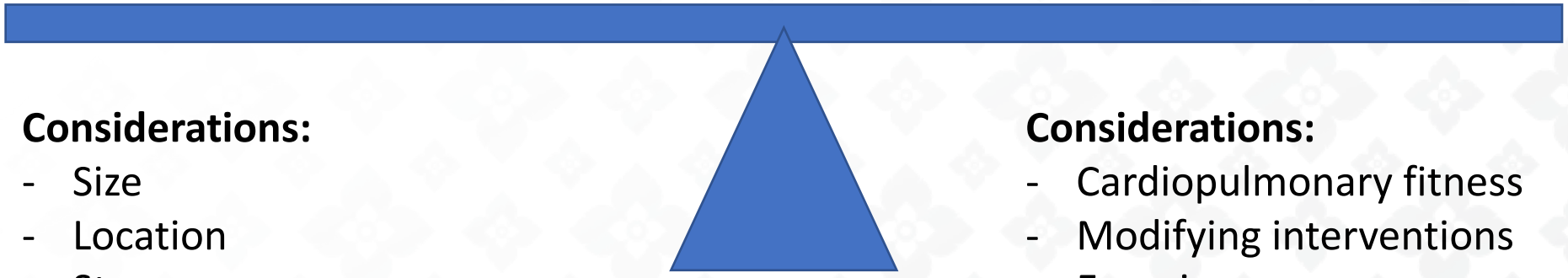
Striking the Best Balance

Benefits: surgery (traditional anatomic, sublobar) vs. SBRT

- Overall survival
- Disease free survival
- Recurrence

Harms: surgery (traditional anatomic, sublobar) vs. SBRT

- Mortality
- Morbidity
- Long-term QOL



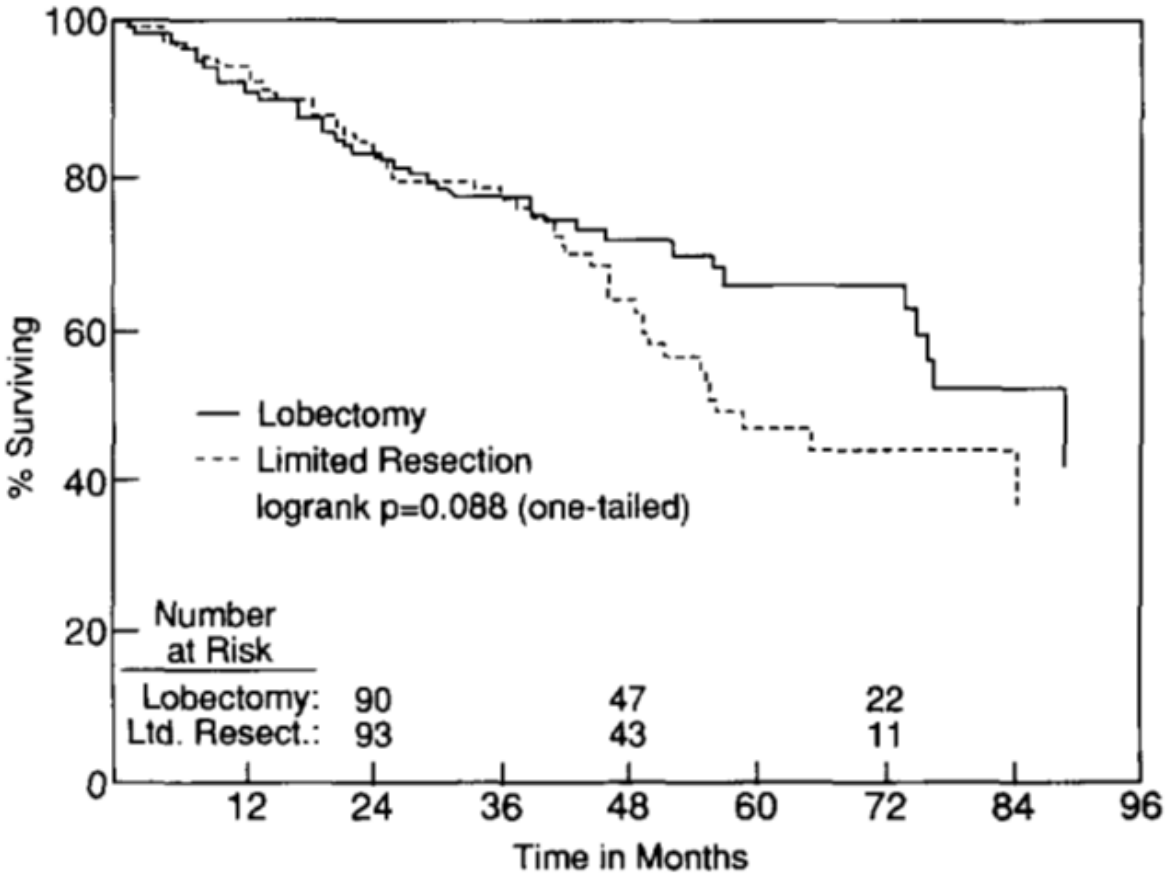
Considerations:

- Size
- Location
- Stage
- Availability

Considerations:

- Cardiopulmonary fitness
- Modifying interventions
- Experience
- Surgical approach

Lobe vs. Sub-lobar



Ginsberg, Ann Thorac Surg 1995.

Lobe vs. Sublobar

Author	Design	Lobe (N)	W/S (N)	Lobe (5 YS; %)	W/S (5 YS; %)	P-value
Ginsberg	RCT	127	120	73	56	.06
Okada	Prospective	260	305	89	89	NS
Koike	Prospective	159	74	90	89	NS
Kates	SEER	1402	688	HR 1.12		NS
Wisnivesky	SEER	969	196	HR 1.10		NS

Howington, Chest 2013.

Wedge vs. SBRT

	% of Patients						
	LR	RR	LRR	DM	FFF	OS	CSS
SBRT	4	4	9	19	77	72	93
Wedge	20	18	27	21	65	87	94
P-value	.07	.34	.16	.96	.37	.01	.53

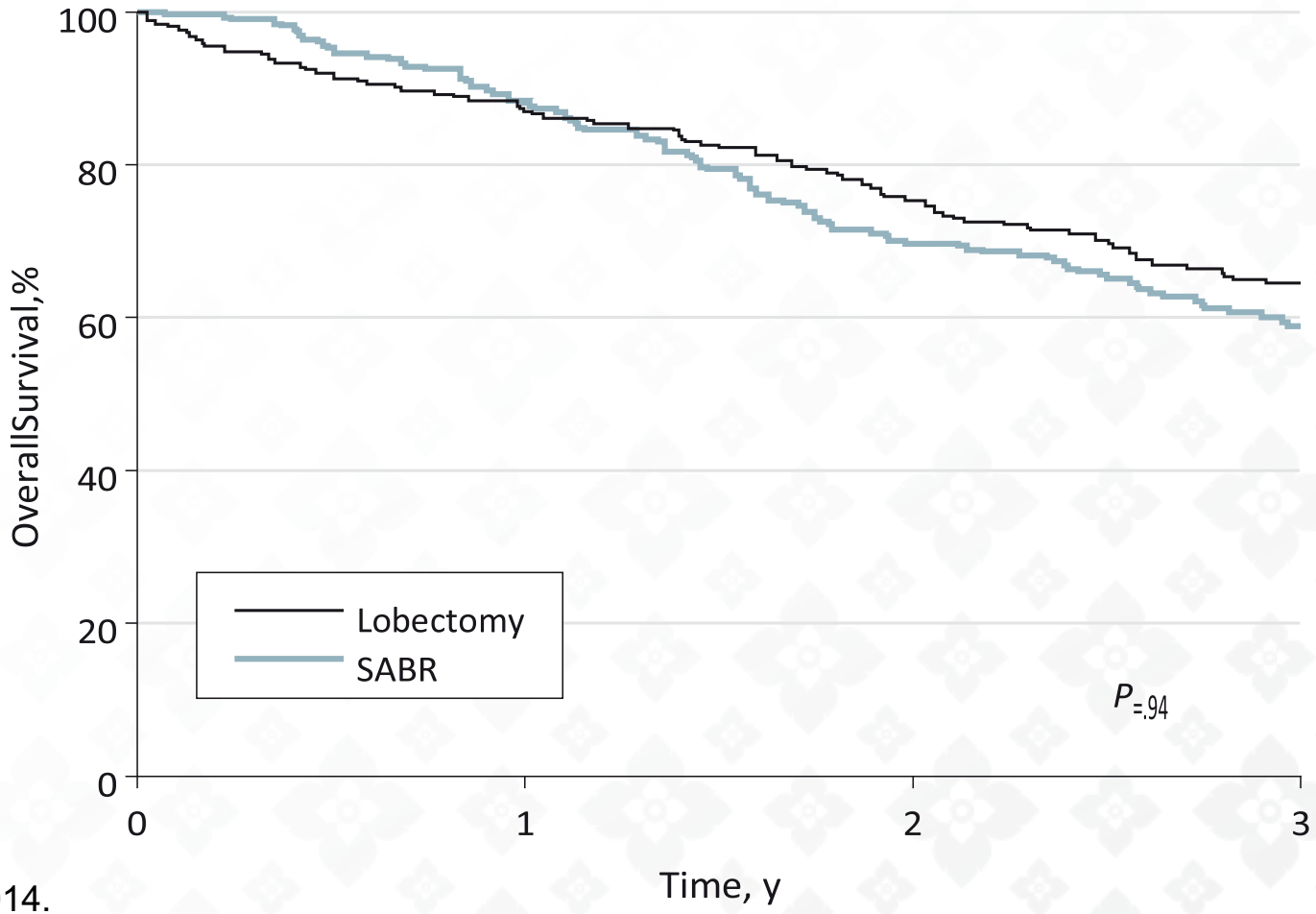
Grills, J Clin Oncol 2010.

Lobe vs. SBRT - Propensity Matched

- VATS lobectomy from 6 hospitals, SBRT from one
- Propensity score matching based on cTNM stage, age, gender, Charlson comorbidity score, lung function, and performance status.
- 64 SBRT and 64 VATS lobectomy patients matched from 527 SBRT and 86 VATS
- **Locoregional control better in SBRT group** at 1 and 3 years
- Distant recurrences and **overall survival not significantly different**

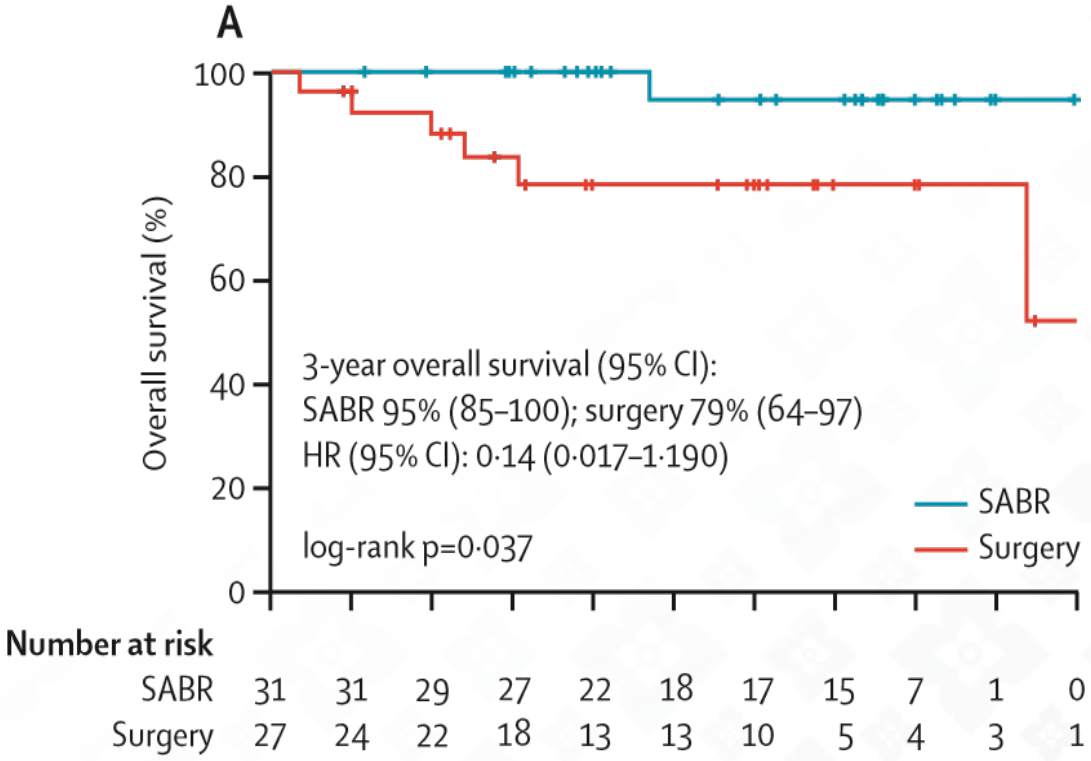
Verstegen, Ann Oncol 13.

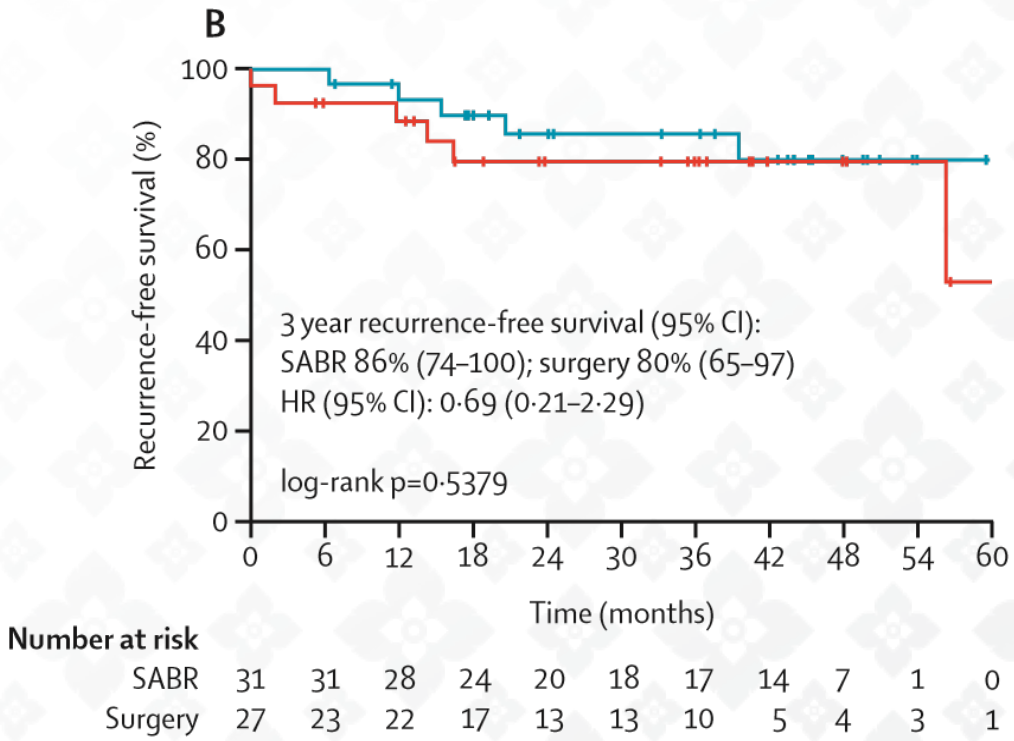
Lobe vs. SBRT - Propensity Matched



Shirvani, JAMA Surg 2014.

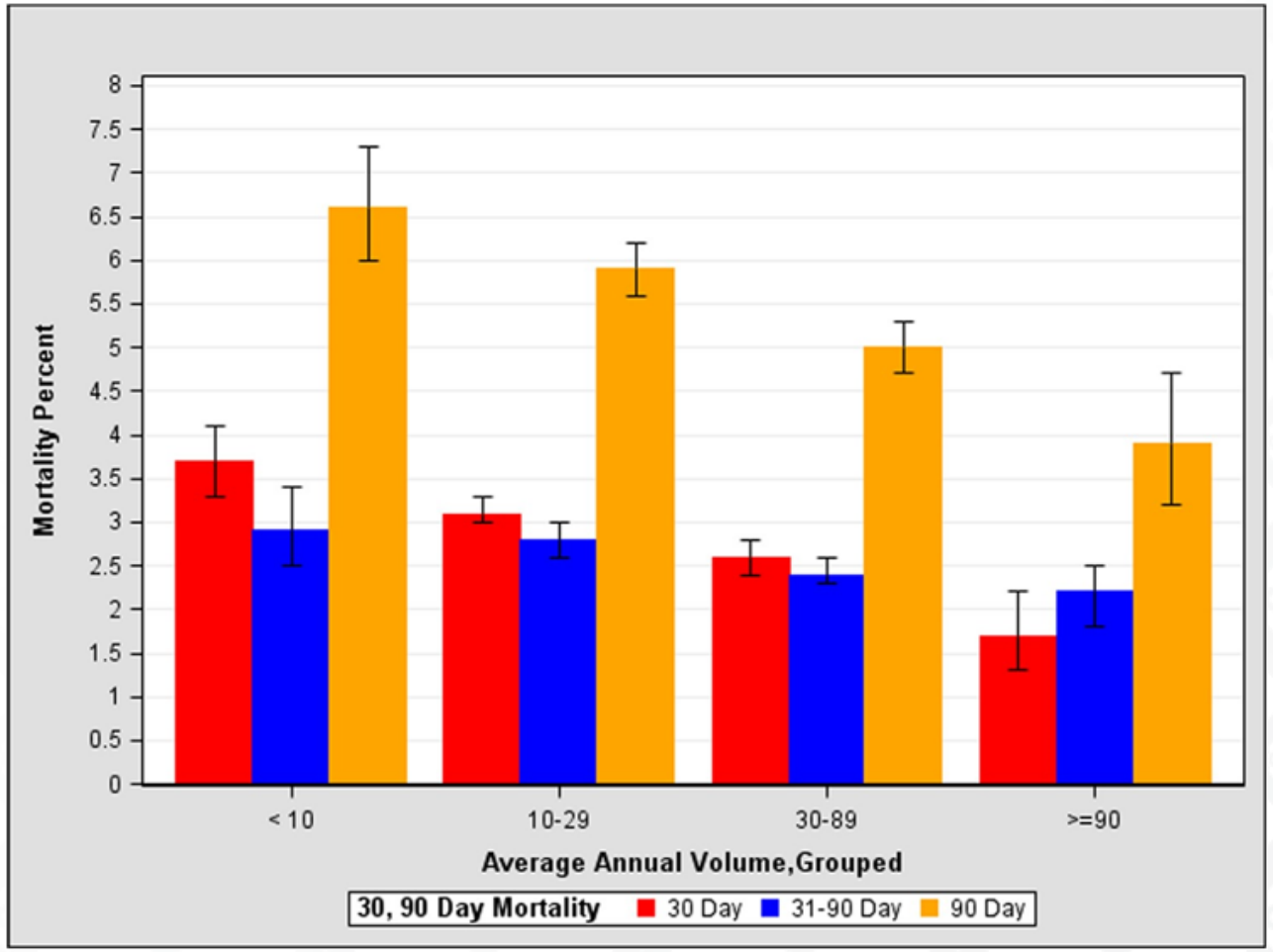
Comparative Efficacy





Chang, Lancet Oncol 2015.

Surgical Mortality



Pezzi, J Thorac Cardiovasc Surg 2014.

Surgical Morbidity

Complication	Actual Rate (%)	NSQIP Predicted (%)
Serious	16.6	8.8
Any	17.3	13.0
Pneumonia	6.0	3.2
Cardiac	1.4	0.7
Site infection	1.8	1.6
UTI	4.0	1.8
VTE	4.0	1.0
Renal failure	1.0	0.6
Return to OR	4.0	2.8
Death	1.0	1.8

Samson, J Thorac Cardiovasc Surg 2016.

Impact on Pulmonary Function

- **FEV_1**: 84-91% of pre-operative values when measured up to 6 months after lobectomy, and 64-66% after pneumonectomy.[1-3]
- **DLCO**: 89-96% of pre-operative values when measured up to 6 months after lobectomy, and 72-80% after pneumonectomy.[1,3]
- **VO_2 peak**: 87-100% of pre-operative values after lobectomy, and 71-89% after pneumonectomy.[1-3] 70% of baseline 3 years after pneumonectomy.[4]

1. Bolliger, *Eur Respir J* 1996. 2. Nezu, *Chest* 1998. 3. Brunelli, *Chest* 2007. 4. Smulders, *Chest* 2004.

Impact on Pulmonary Function

Sub-lobar Resection

- 12-month post-operative **FEV_1 of 93.3%** of the pre-operative value in patients with normal lung function who underwent **segmentectomy**.[1] **87.3%** of the pre-operative value in those who had a **lobectomy.**
- FVC, FEV_1, maximum voluntary ventilation (MVV), and DLCO all decreased after lobectomy for stage I lung cancer.[2] **Only the DLCO was decreased in those who had a segmentectomy.**
- 40 patients who had a thoracotomy, 13 wedge resections, 14 lobectomies, and 13 a thoracotomy alone (inoperable tumor).[3] **No decline in measures of pulmonary function or exercise capacity in the wedge resection group**. Similar declines were seen in the lobectomy and thoracotomy alone groups.

1. Takizawa, *J Thorac Cardiovasc Surg* 1999. 2. Keenan, *Ann Thorac Surg* 2004. 3. Nugent, *Thorax* 1995.

Impact on Pulmonary Function

	1-2 Segments	3-5 Segments	P-value
FEV_1 (L)	0.1	0.3	0.003
FEV_1 (% predicted)	4.3	8.2	0.055
DLCO (ml/min/mmHg)	1.3	2.4	0.015
DLCO (% predicted)	3.6	5.9	0.280

Macke, J Cardiothorac Surg 2015.

Quality of Life

- Lower than the general population.
- Physical measures decline at the 1 month post-op time but return to baseline by 3 months post-op.
- Mental measures may not decline throughout.
- Poor correlation with measures of pulmonary function or other high-risk patient features.

Brunelli, *Ann Thorac Surg* 2007.

SBRT Toxicities

Toxicity	Risk
Central airway toxicity	Tumors close to the bronchial tree
Esophageal toxicity	Volume of esophagus exposed to higher doses of radiation
Vascular injury including hemoptysis	Central location, squamous cell, cavitation, endobronchial involvement
Radiation pneumonitis	0-29%, grade 3-5 uncommon, mean dose, V5, V20, lower zone, ILD
Other pulmonary toxicities	Rare
Chest wall and skin toxicities	Peripheral lesions, younger age, smoking, obesity
Brachial plexopathy	Apical tumors, dose threshold
Vagus nerve injury	Central tumor

Kang, Cancers 2015.

SBRT Toxicities

	Number of Patients by Grade (N=55)		
	3	**4**	**5**
Blood or bone marrow	2	0	0
Coagulation	1	0	0
Constitutional symptoms	1	0	0
Dermatologic	2	0	0
Gastrointestinal	1	0	0
Infection	2	0	0
Metabolic	1	1	0
Muskuloskeletal	3	0	0
Neurology	1	0	0
Pulmonary	8	1	0
Most severe	13 (24%)	2 (4%)	0

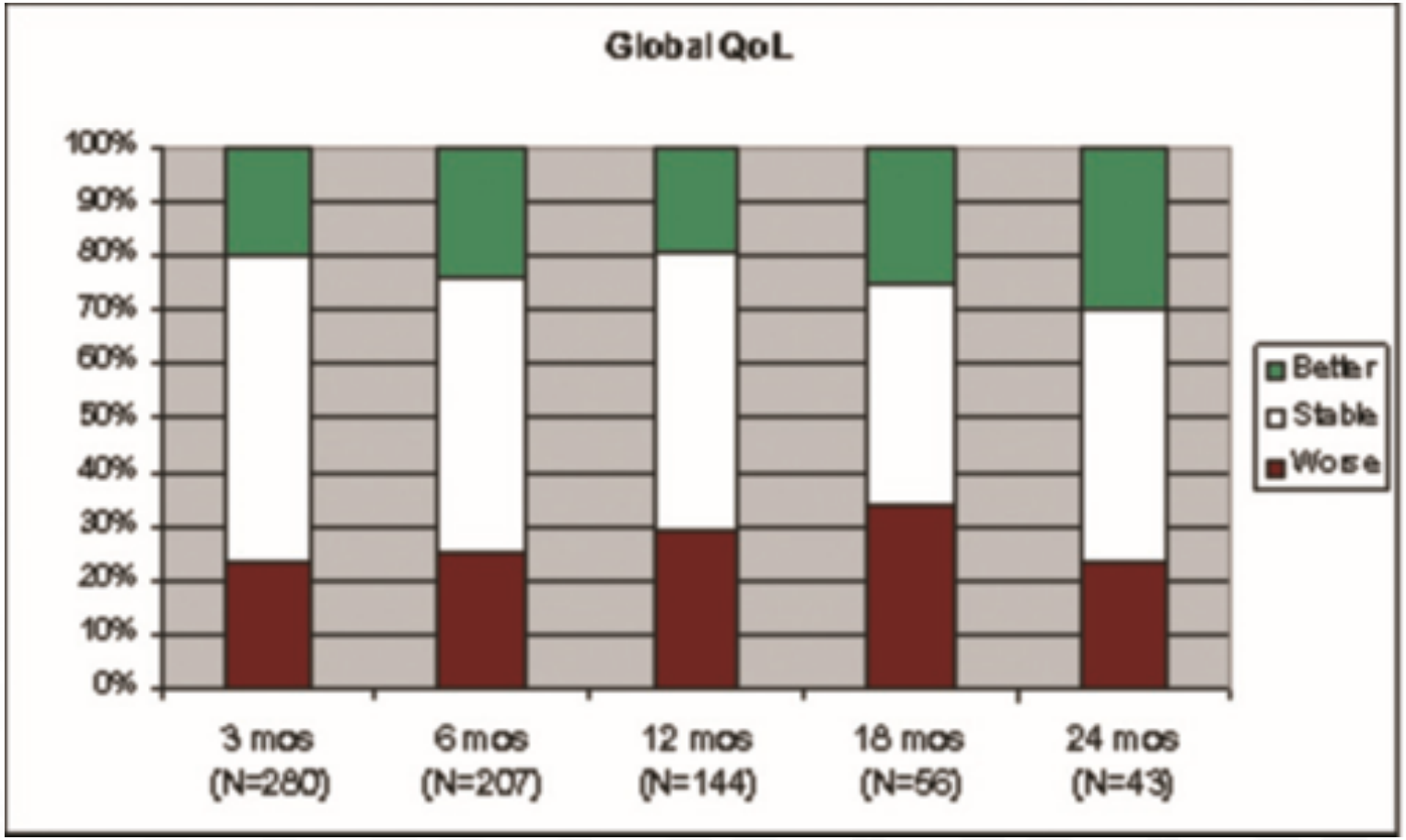
Timmerman, JAMA 2010.

Impact on Pulmonary Function

	Normal	GOLD I-II	GOLD III-IV
FEV_1, L	0.14	0.13	0.06
FEV_1, %	2.6	3.6	0.0
FVC, L	0.19	0.07	0.08
FVC, %	4.8	2.4	0.3

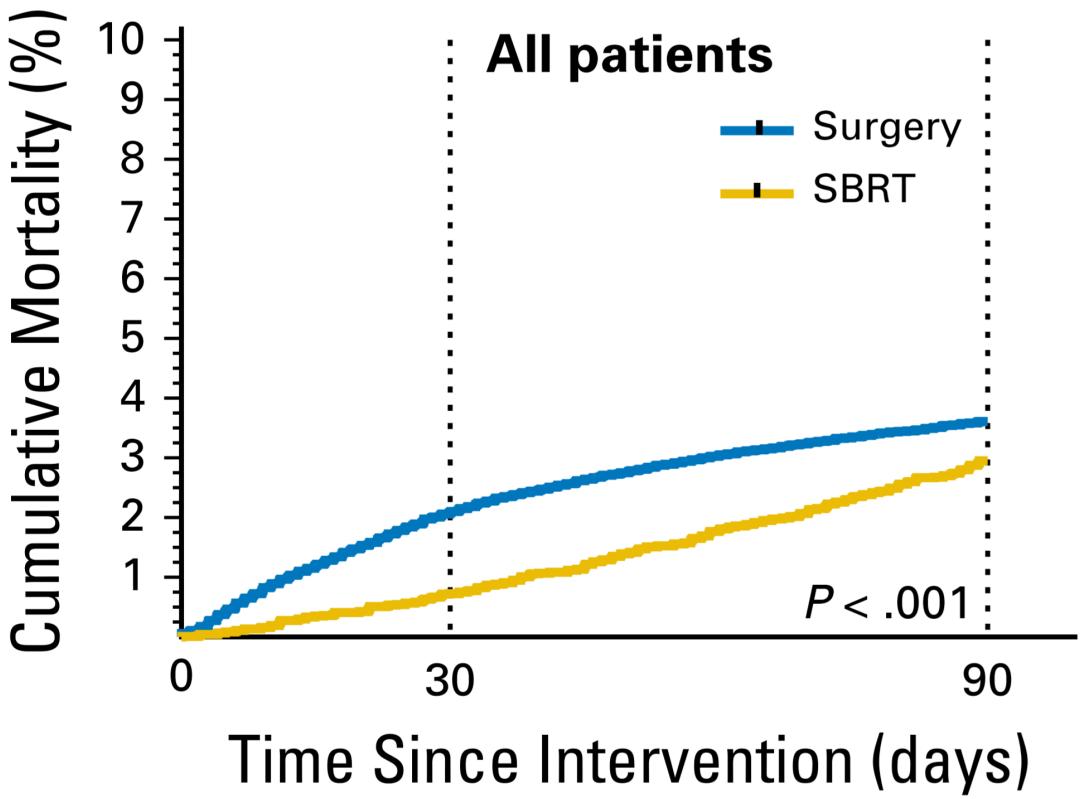
Takeda, Chest 2013.

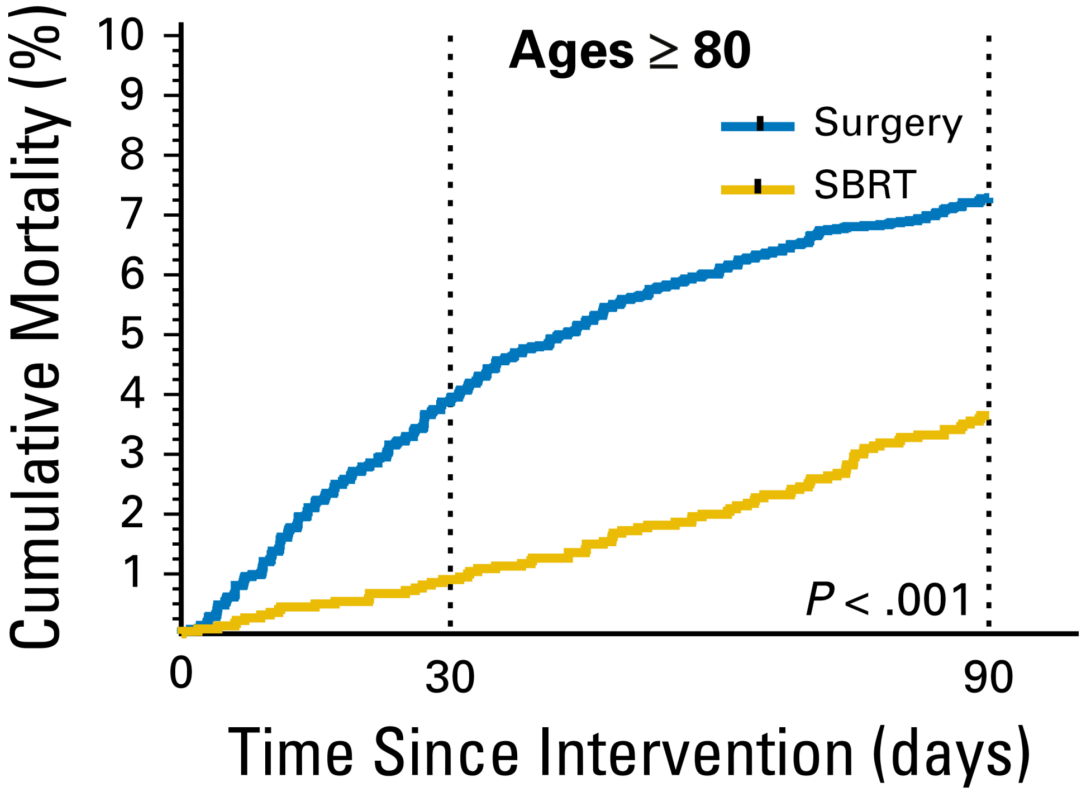
Impact on QOL



Lagerwaard, J Thorac Oncol 2012.

Comparative Early Mortality





Stokes, J Clin Oncol 2018.

Comparative Morbidity

- **SBRT – 3 treatment related grade 3 adverse events** (2 – dyspnea/cough, 3 – chest pain, 1 – fatigue)
- **Surgical resection – 1 died** of surgical complications, **12 with grade 3-4 adverse events** (1 – grade 4 dyspnea, 4 – grade 3 dyspnea, 2 – lung infections, 4 – chest pain, 1 each – bleeding, fistula, hernia, anemia, fatigue, nausea, weight loss, arrhythmia)

Chang, Lancet Oncol 2015.

Cardiac Risk

Variables	Coefficients	SEM	p Value	Bootstrap %[b]
IHD	1.4	0.3	<0.0001	98%
Creatinine > 2 mg/dL	0.97	0.5	0.06	54%
Cerebrovascular disease	1.32	0.4	0.003	82%
Pneumonectomy	1.46	0.3	<0.0001	99%

ThRCRI Score	Risk Class	Number of Cases	Major Cardiac Complications
0	A	1,173	18 (1.5%)
1–1.5	B	468	27 (5.8%)
2–2.5	C	16	3 (19%)
>2.5	D	39	9 (23%)

Brunelli, Ann Thorac Surg, 2010.

Standard Lung Function Testing

Absolute and percent predicted FEV_1:

- Pre-operative values of **2L for pneumonectomy and 1.5L for lobectomy** have been suggested. FEV_1 above these thresholds = low risk of mortality.[1-3]
- Pre-operative **FEV_1 < 60% predicted** - OR of 2.7 for respiratory complications and 1.9 for 30-day mortality.[4]
- The mean FEV_1 was 75% predicted in uncomplicated resections and 66% in complicated resections.[5]
- A value of 80% predicted or higher has been suggested in a reported algorithm as a cutoff.[6]

1. Boushy, *Chest* 1971. 2. Wernly, *J Thorac Cardiovasc Surg* 1980. 3. Miller, *J Thorac Cardiovasc Surg* 1993. 4. Licker, *Ann Thorac Surg* 2006. 5. Loewen, *J Thorac Oncol* 2007. 6. Wyser, *Am J Respir Crit Care Med* 1999.

Standard Lung Function Testing

Diffusing capacity

- The DLCO is a **predictor of post-operative complications including death**, length of hospital stay and hospital costs.[1-3]
- Individuals with a **pre-operative DLCO less than 60% predicted** had a higher risk of respiratory complications, hospitalizations for respiratory compromise, and lower median dyspnea scores.[4]
- The mean DLCO was 77% predicted in those without complications and 67% in those with.[5]

1. Markos, *Am Rev Respir Dis* 1989. 2. Ferguson, *J Thorac Cardiovasc Surg* 1988. 3. Wang, *Ann Thorac Surg* 1997. 4. Bousamra, *Ann Thorac Surg* 1996. 5. Loewen, *J Thorac Oncol* 2007.

Standard Lung Function Testing

- The FEV_1 and DLCO have **only a modest correlation**. 43% of patients with an FEV_1 > 80% predicted had a DLCO < 80% predicted.

Groups	Number of patients	FEV1–DLCO correlation coefficients
Entire dataset	872	0.38
Elderly (>70 years old)	330	0.38
Young (<70 years old)	542	0.39
FEV1 > 80%	508	0.20
FEV1 < 80%	364	0.23
ppoFEV1 < 40%	50	0.19
ppoFEV1 > 40%	822	0.35

Brunelli, *Eur J Cardiothorac Surg* 2006.

Predicted Post-Operative Values

Comparison

- A study of 44 subjects comparing radionuclide perfusion scan, quantitative CT, and 3 segment methods.
  - **Perfusion imaging outperformed other methods** for all measures.
  - All **other methods performed well in those who had a lobectomy**. Segment methods did not perform well in those who had a pneumonectomy.[1]
- Perfusion imaging prediction outperformed the segment method in 32 patients who underwent pneumonectomy.[2]

1. Bolliger, *Respiration* 2002. 2. Smulders, *Chest* 2004.

Predicted Post-Operative Values

- The $ppoFEV_1$ is an **independent predictor of complications, including mortality**.[1-3]
- All with $ppoFEV_1$ **less than 30%** developed respiratory failure or died.[4]
- 70% with a $ppoFEV_1$ less than 35% experience complications.[5]
- Individuals with a $ppoFEV_1$ greater than 34% or greater than 58% of the pre-operative value have a decreased post-operative mortality.[6,7]
- No deaths if $ppoFEV_1$ greater than 40% and a 50% mortality rate in those less than 40%.[8]

1. Kearney, *Chest* 1994. 2. Mitsudomi, *J Surg Oncol* 1996. 3. Ribas, *Eur Respir J* 1998. 4. Nakahara, *Ann Thorac Surg* 1988. 5. Brunelli, *Chest* 1997. 6. Putnam, *Ann Thorac Surg* 1990. 7. Wahi, *Ann Thorac Surg* 1989. 8. Markos, *Am Rev Respir Dis* 1989.

Predicted Post-Operative Values

- The ppoDLCO was a **predictor of mortality**.[1]
- Others determined it to be an **independent predictor of pulmonary complications, morbidity, and death**.[2-4]
- A **ppoDLCO < 40%** was a predictor of post-operative complications in patients with a normal FEV_1.[5]
- The predicted postoperative product (PPP) was found to be the best predictor of surgical mortality.
  - A PPP less than 1650 was found in 75% of those who died and 11% of those who survived surgery.[6]

1. Ribas, *Eur Respir J* 1998. 2. Ferguson, *J Thorac Cardiovasc Surg* 1995. 3. Ferguson, *Ann Thorac Surg* 2008. 4. Santini, *Thorac Cardiov Surg* 2007. 5. Brunelli, *Eur J Cardiothorac Surg* 2006. 6. Pierce, *Am J Respir Crit Care Med* 1994.

CHEST Guidelines

- In patients with lung cancer being considered for surgery, it is recommended that **both FEV_1 and DLCO be measured in all patients and that both $ppoFEV_1$ and ppoDLCO are calculated**.
  - For pneumonectomy candidates, we suggest to use Q scan to calculate predicted postoperative values of FEV_1 or DLCO.
  - For lobectomy patients, segmental counting is indicated to calculate predicted postoperative values of FEV_1 or DLCO.

Brunelli, Chest 2013.

CHEST Guidelines

- In patients with lung cancer being considered for surgery, **if both ppoFEV_1 and ppoDLCO > 60% predicted, no further tests are recommended**.
  - Values of both ppoFEV_1 and ppoDLCO > 60% indicate low risk for perioperative death and cardiopulmonary complications following resection including pneumonectomy.

Brunelli, Chest 2013

Exercise Testing

- The **altitude reached on a stair climbing test** was **associated with cardiopulmonary complications**, mortality, and costs. A cutoff of 12 m altitude had a PPV of 40% for morbidity and 13% for mortality with a NPV of 78% for morbidity and 97% for mortality.[1]
- Those unable to perform a stair climbing test due to underlying co-morbidities have an increased risk of mortality after major lung resection.[2]
- A cutoff of 18 m was found to be an independent predictor of 5-year survival, both cancer and non-cancer related in a cohort with resected stage I NSCCa.[3]

1. Brunelli, *Ann Thorac Surg* 2008. 2. Brunelli, *Eur J Cardiothorac Surg* 2005. 3. Brunelli, Ann Thorac Surg 2012.

Exercise Testing

Stair-Climbing Cutoff, m	Morbidity		Mortality	
	PPV	NPV	PPV	NPV
12	40%	78%	13%	97%
14	31%	78%	6%	97%
18	28%	80%	5%	98%
22	28%	83%	5%	99%

Brunelli, Ann Thorac Surg 2008.

Exercise Testing

Relationship between shuttle walk distance and surgical outcome in all patients undergoing surgical resection ($n=103$)

Shuttle distance (m)	Poor outcome	Good outcome	Total
<250	8 (66%)	4	12
<300	10 (44%)	13	23
<400	19 (37%)	33	52
>400	15 (29%)	36	51
140–780	34 (33%)	69	103

Win, *Eur J Cardiothorac Surg* 2004.

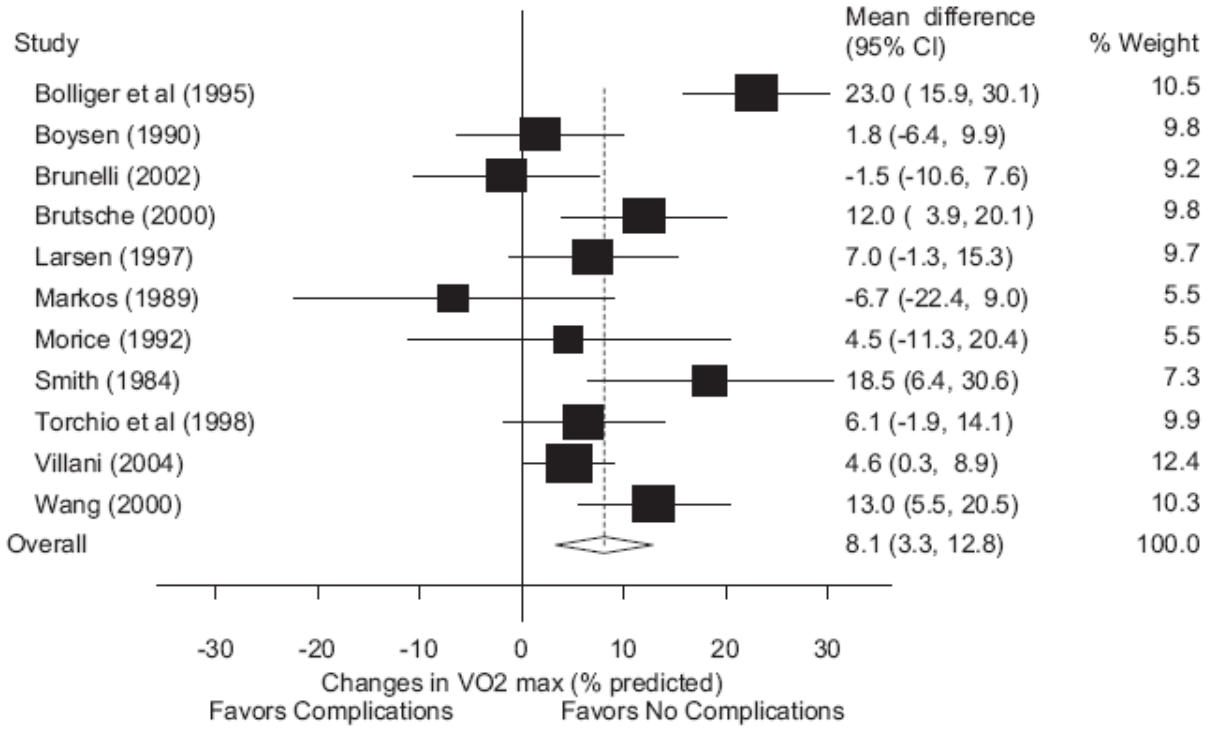
Exercise Testing

- A **6-minute walk test distance of 1000 feet or greater** has been found to predict positive outcome.[1]
- The 6-minute walk test distance was the best predictor of post-operative respiratory failure.[2]
- **HRR <12** 1 minute after 6-minute walk test was an independent predictor of cardiopulmonary complications with an OR of 4.3.[3]
- A distance of 500 m and 100% predicted used to predict risk of postoperative complications (OR 2.6) and prolonged hospitalization.[4]

1. Holden, Chest 1992. 2. Pierce, Am J Respir Crit Care Med 1994. 3. Ha, J Cardiothorac Surg 2015. 4. Marjanski, Eur J Cardiothorac Surg 2015.

Exercise Testing

- VO_2 peak has been reported to be a **predictor of post-operative complications including post-operative and long-term mortality**.[1,2]



1. Benzo, *Respir Med* 2007. 2. Jones, *Cancer* 2010.

Exercise Testing

Author	**Findings** (VO_2 peak in ml/kg/min)
Olsen	Mean VO_2 peak 11.3 in those without complications and 7.8 in those with
Bolliger	**ppoVO_2 peak < 10 – 100% mortality**
Bolliger	Mean VO_2 peak 84% predicted in those without complications and 61% in those with
Larsen	VO_2 peak < 50% predicted – high mortality
Smith	**All with VO_2 peak < 15 had complications**
Bechard	VO_2 peak < 10 – 29% mortality; > 20 – 0%
Win	Mean VO_2 peak 92% predicted in those with a satisfactory outcome and 66% in others
Brutsche	VO_2 peak and extent of resection independent predictors of complications
Loewen	VO_2 peak < 65% or 16 more likely to have complications; <15 – resp failure or death
Win	VO_2 peak 91.7% predicted - satisfactory outcome, 65.9% in those with a poor outcome
Brunelli	**No deaths if VO_2 peak > 20**, 13% mortality if VO_2 peak was < 12

Exercise Testing

Table 5—*Positive and Negative Predictive Probabilities of Poor Outcome ($\dot{V}O_2$peak % Predicted)**

Threshold, %	Good Outcome if $\dot{V}O_2$ Is Greater Than Threshold	Poor Outcome if $\dot{V}O_2$ Is Less Than or Equal to Threshold
50	85/96 (89)	2/3 (67)
60	77/85 (91)	5/14 (36)
65	71/76 (93)	8/23 (35)
70	65/70 (93)	8/29 (28)
75	57/61 (93)	9/38 (24)

*Data are presented as No. of patients/total patients (%).

Win, *Chest* 2005.

Exercise Testing

- 204 patients had a CPET regardless of their standard lung function parameters:
  - CPET did not add to risk stratification if the FEV_1 and DLCO were > 80%.
  - Either FEV_1 or DLCO < 80%, but both $ppoFEV_1$ and ppoDLCO > 40%, there were 5 deaths, 3 of which occurred in patients with a peak VO_2 < 12 ml/kg/min.
  - **$ppoFEV_1$, ppoDLCO, or both < 40% tolerated resection if their peak VO_2 was > 10 ml/kg/min.**
  - $ppoFEV_1$ < 30% or PPP < 1650 tolerated resection reasonably well if the peak VO_2 was > 10 ml/kg/min.

Brunelli, *Chest* 2009.

CHEST Guidelines

- In patients with lung cancer being considered for surgery, if **either the ppoFEV_1 or ppoDLCO are < 60% predicted and both are above 30% predicted**, it is recommended that a **low technology exercise test** (stair climb or shuttle walk test) is performed.

Brunelli, Chest 2013.

CHEST Guidelines

- In patients with lung cancer being considered for surgery, with **either a ppoFEV$_1$ < 30% predicted or a ppoDLCO < 30% predicted** performance of a **formal cardiopulmonary exercise test (CPET)** with measurement of maximal oxygen consumption (VO$_2$ max) is recommended.
  - Either ppoFEV$_1$ < 30% predicted or a ppoDLCO < 30% predicted indicate an increased risk for perioperative death and cardiopulmonary complications with anatomic lung resection.

Brunelli, Chest 2013

CHEST Guidelines

- In patients with lung cancer being considered for surgery who **walk < 40 shuttles (or < 400 m) on the shuttle walk test or climb < 22 m** at symptom limited stair climbing test performance of a formal **cardiopulmonary exercise test (CPET)** with measurement of maximal oxygen consumption (VO_2 max) is recommended.
  - Walking < 40 shuttles (or < 400 m) on the SWT or climbing < 22 m at symptom limited stair climbing test suggests an increased risk for perioperative death and cardiopulmonary complications with anatomic lung resection.

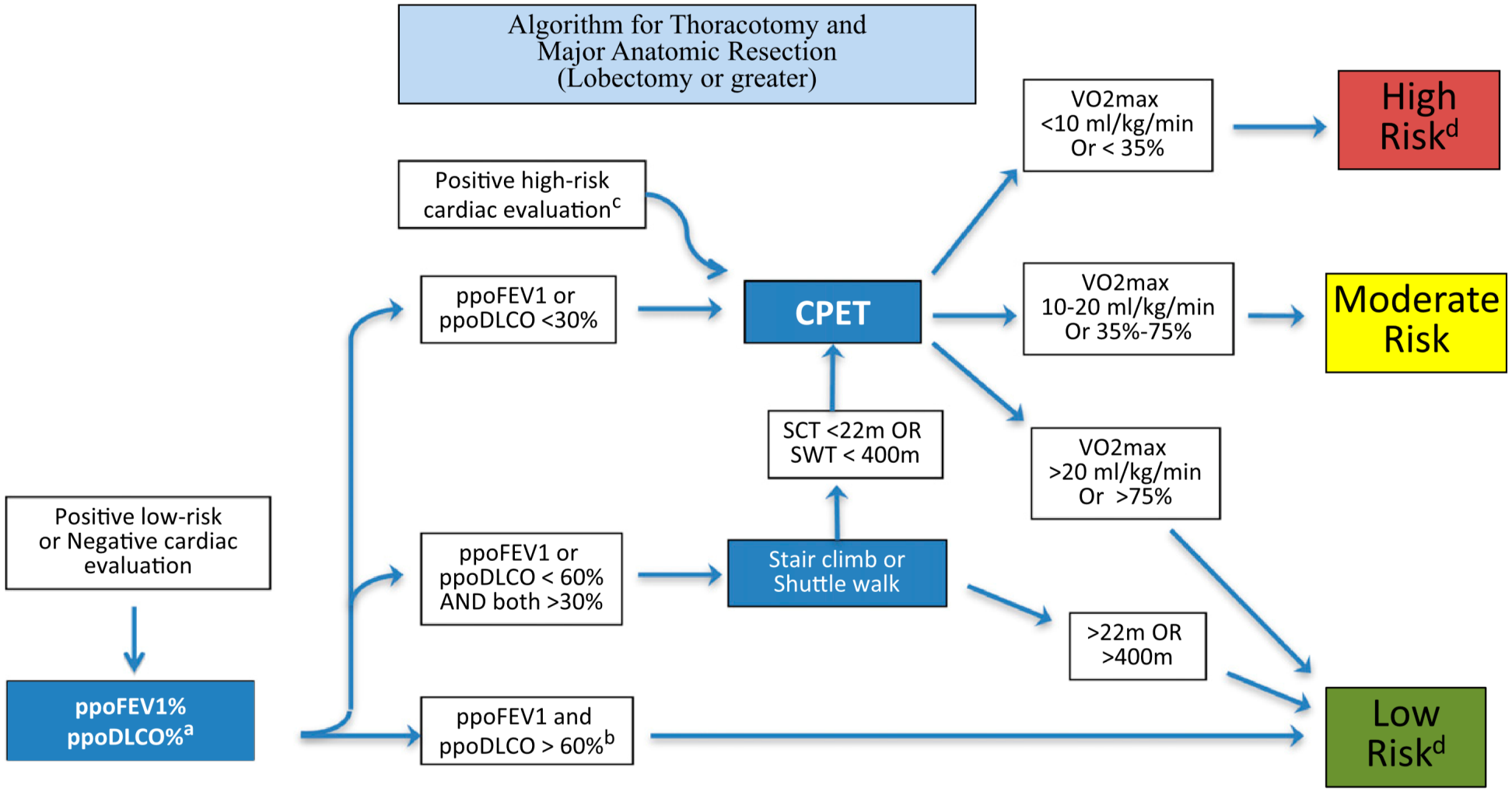
Brunelli, Chest 2013.

CHEST Guidelines

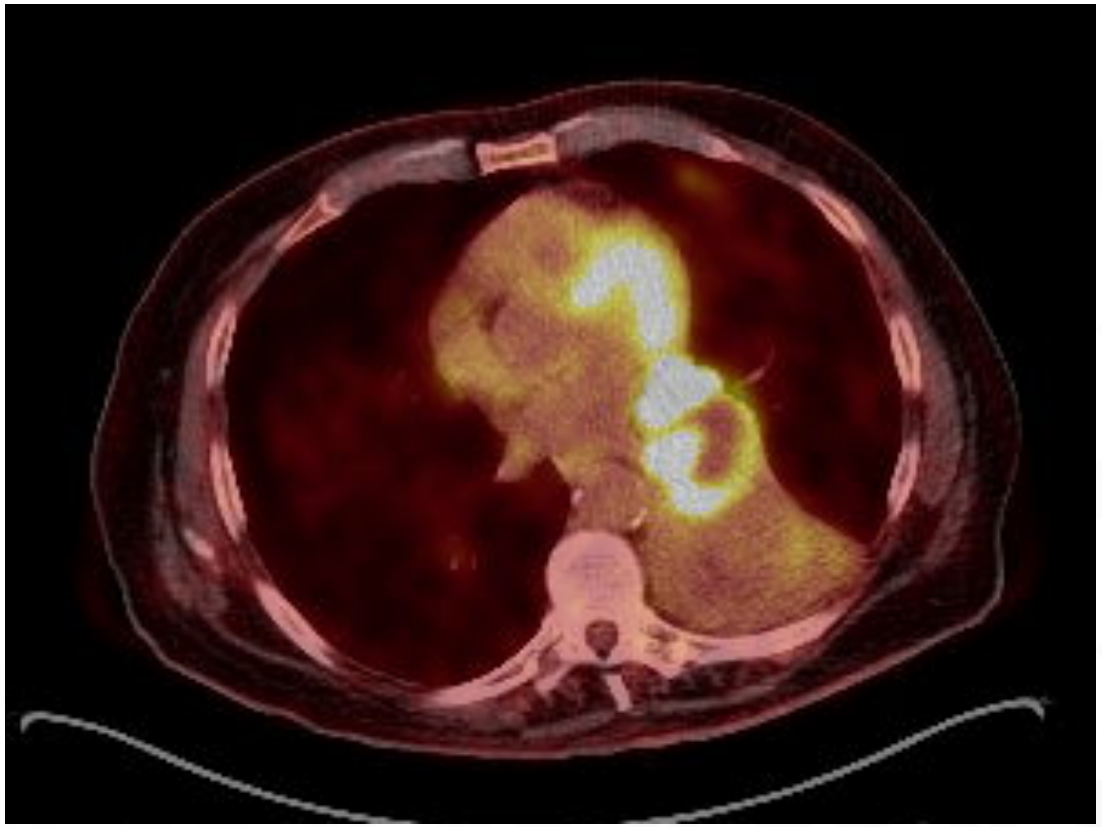
- In patients with lung cancer being considered for surgery, with a **VO_2 max < 10 ml/kg/min or < 35% predicted**, it is recommended that they are counseled about **minimally invasive surgery, sublobar resections or nonoperative treatment**.
  - For values of VO_2 max in the range of 10 to 15 mL/kg/min an increased risk of mortality is expected. However, data are less definitive for making decisions based solely on those values without taking into account other factors like ppoFEV_1 and DLCO as well as patient comorbidities.

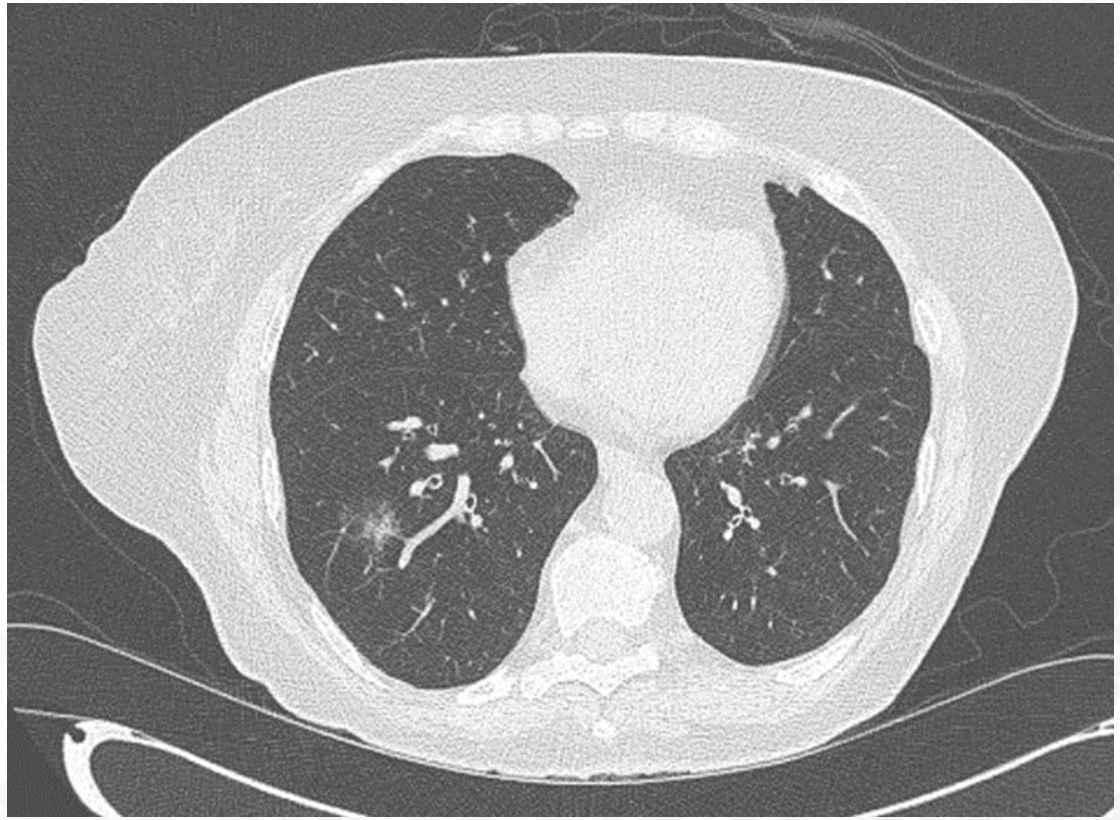
Brunelli, Chest 2013.

Algorithm


Algorithm for Thoracotomy and Major Anatomic Resection (Lobectomy or greater)
Positive high-risk cardiac evaluation[c]
ppoFEV1 or ppoDLCO <30%
CPET
VO2max <10 ml/kg/min Or < 35%
High Risk[d]
VO2max 10-20 ml/kg/min Or 35%-75%
Moderate Risk
SCT <22m OR SWT < 400m
VO2max >20 ml/kg/min Or >75%
Positive low-risk or Negative cardiac evaluation
ppoFEV1 or ppoDLCO < 60% AND both >30%
Stair climb or Shuttle walk
>22m OR >400m
ppoFEV1% ppoDLCO%[a]
ppoFEV1 and ppoDLCO > 60%[b]
Low Risk[d]

Considerations





Considerations

- **COPD**: smaller decline in FEV_1 after lobectomy (0-8%) compared to those without COPD (16-20%).[1-3] The fall in DLCO and VO_2 max was more variable (3-20% for DLCO, 0-21% for VO_2 max).[2-3]
- **Location**: can influence the degree of loss of lung function.[3]
- **Recovery**: pulmonary function and exercise capacity increased from the time of surgery through 6 months after lobectomy. Not beyond 3 months post pneumonectomy.[3-5]

1. Edwards, *Thorax* 2001. 2. Bobbio, *Eur J Cardiothorac Surg* 2005. 3. Brunelli, *Chest* 2007. 4. Bolliger, *Eur Respir J* 1996. 5. Nezu, *Chest* 1998.

Considerations

LVRSx

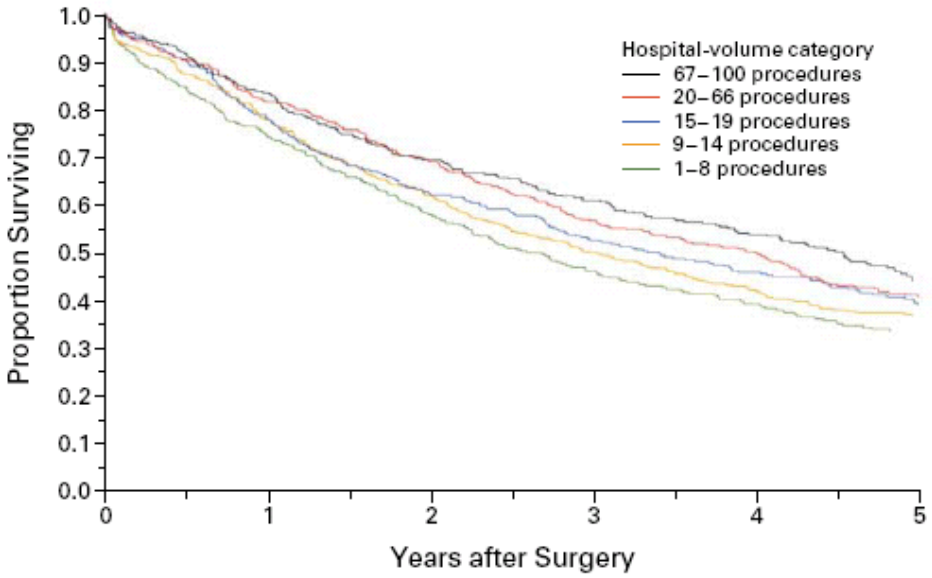
- In select patients with severe emphysema, **removal of the most emphysematous portion of their lung can lead to improvements in lung function**.[1-3]
- Localized lung cancer has been found in approximately 5% of those undergoing lung volume reduction surgery.[4]

Author	Paitents	Cancer	Preop FEV_1 (%)	Postop FEV_1 (%)	Mortality (%)
Choong	21	21	29	40	0
Edwards	14	14	40.7	41.5	14
DeRose	14	9	27	35	7
DeMeester	5	5	29.6	42.3	0
Ojo	11	3	26.2	38.5	0
McKenna	51	11	21.7	49	0
Pompeo	16	16	0.92*	1.20*	0

1. Geddes, *N Engl J Med* 2000. 2. NETT Research Group, *N Engl J Med* 2001. 3. NETT Research Group, *N Engl J Med* 2003. 4. Rozenshtein, *Radiology* 1998.

Considerations

- Patients who undergo resection for lung cancer at **hospitals performing large numbers of such procedures have fewer peri-operative deaths and survive longer** than those whose surgery is performed at hospitals with a low volume.[1,2]



1. Little, *Ann Thorac Surg* 2005. 2. Bach, *N Engl J Med* 2001.

Considerations

- Patients who see **physicians with a higher volume** are more likely to have their cancers histologically confirmed, and to receive active treatment for their cancer.[1]
- Patients who are **diagnosed by or referred to a specialist** within 6 months of diagnosis have been shown to have a lower risk of death.[2]
- In-hospital mortality post lung resection is lower at **teaching hospitals** than non-teaching hospitals independent of patient volume.[3]

1. Muers, *Thorax* 1996. 2. Gregor, *Thorax* 2001. 3. Meguid, *Ann Thorac Surg* 2008.

Open Thoractomy vs. VATS

	Open (%)	VATS (%)
Respiratory complications	32	27
Extended length of stay	16	8
Mortality	4	2

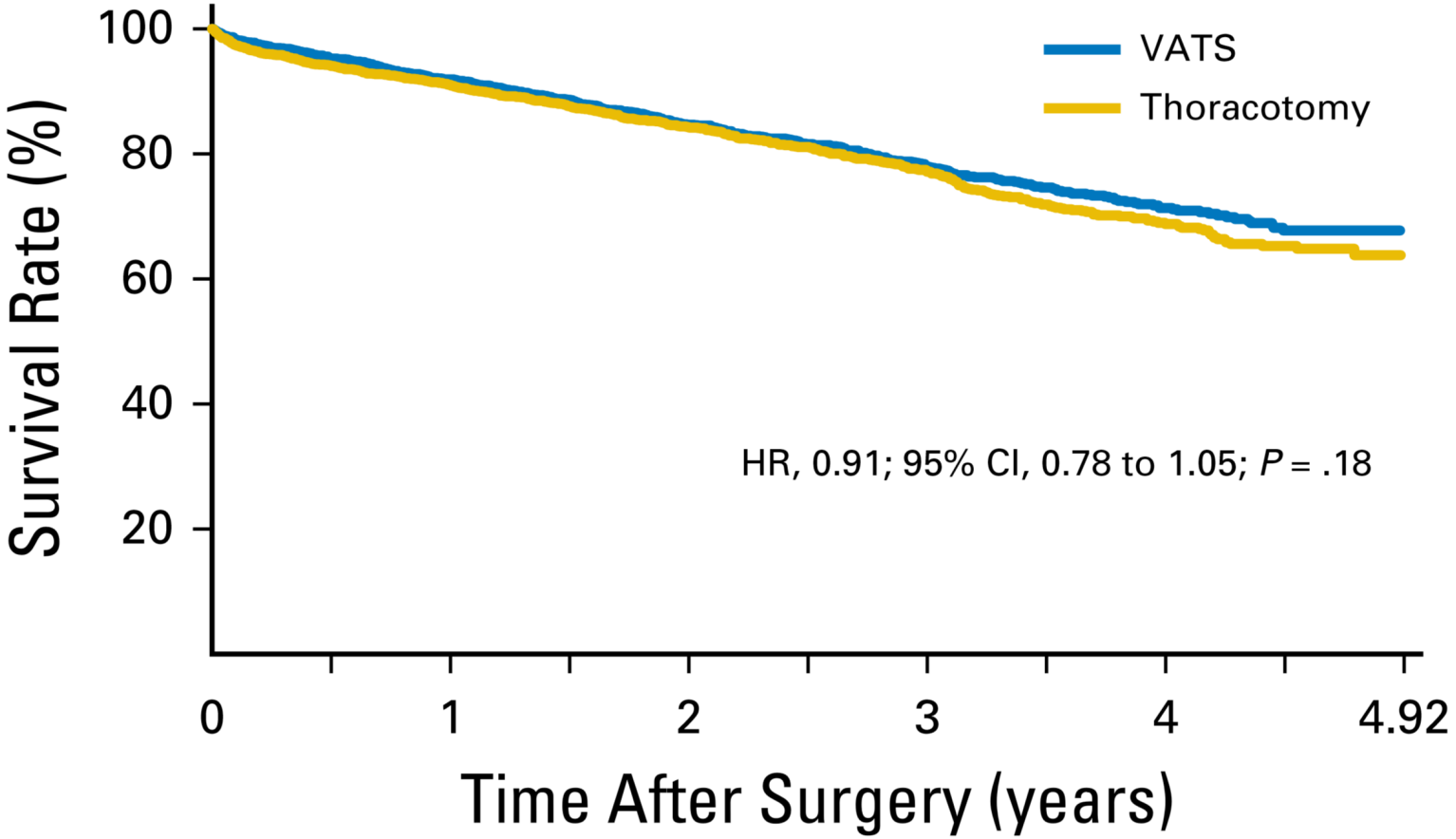
Ezer, Ann Am Thorac Soc 2018.

Surgical Approach – VATS in the Elderly

	VATS	Thoracotomy
Length of stay (days)	5	6
ICU admission (%)	2.5	14.8
Discharge to rehab (%)	5.0	22.5
30 day readmission (%)	0	8.6

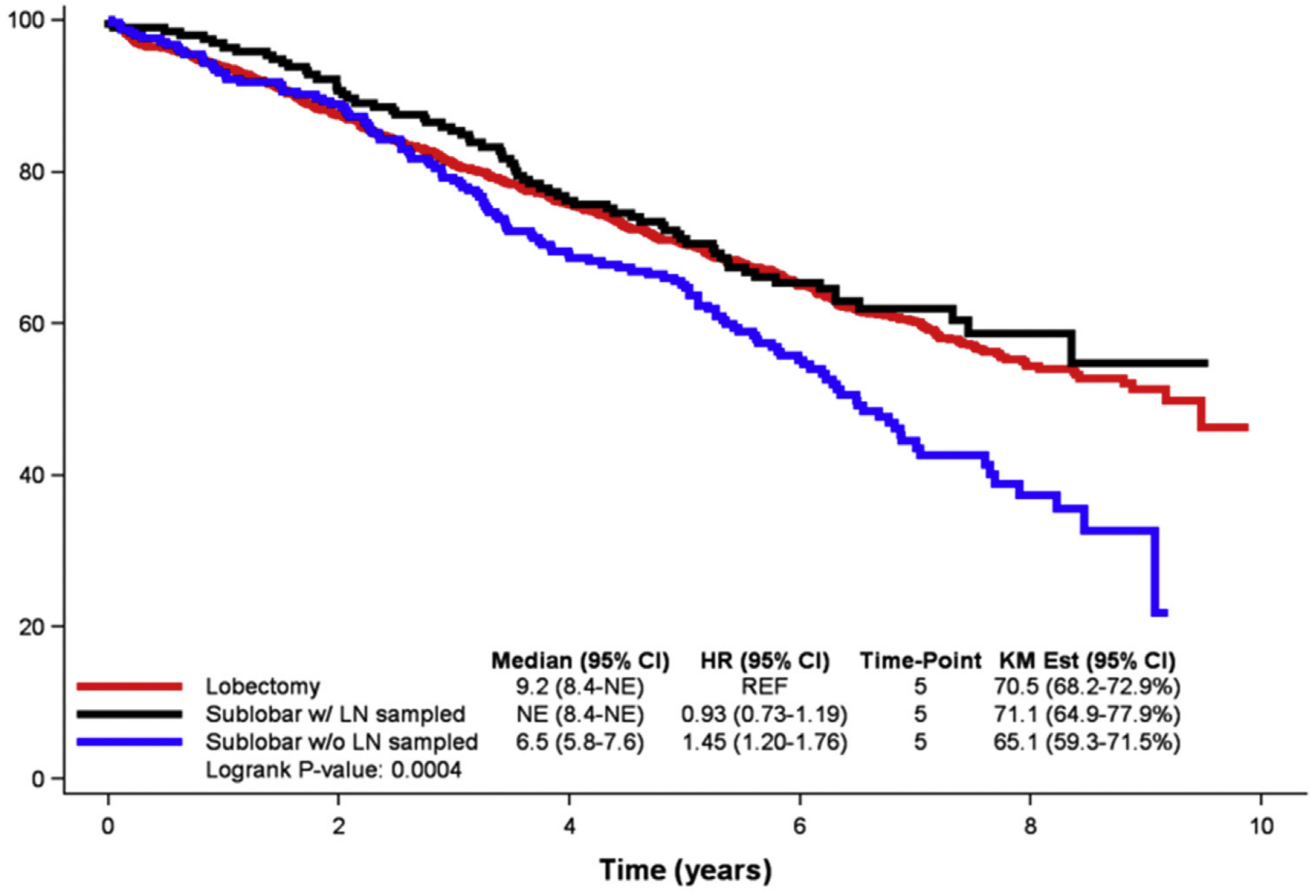
Port, Ann Thorac Surg 2011.

VATS vs. Thoracotomy Survival



Boffa, J Clin Oncol 2018.

Surgical Approach – Sublobar Resection in LPA



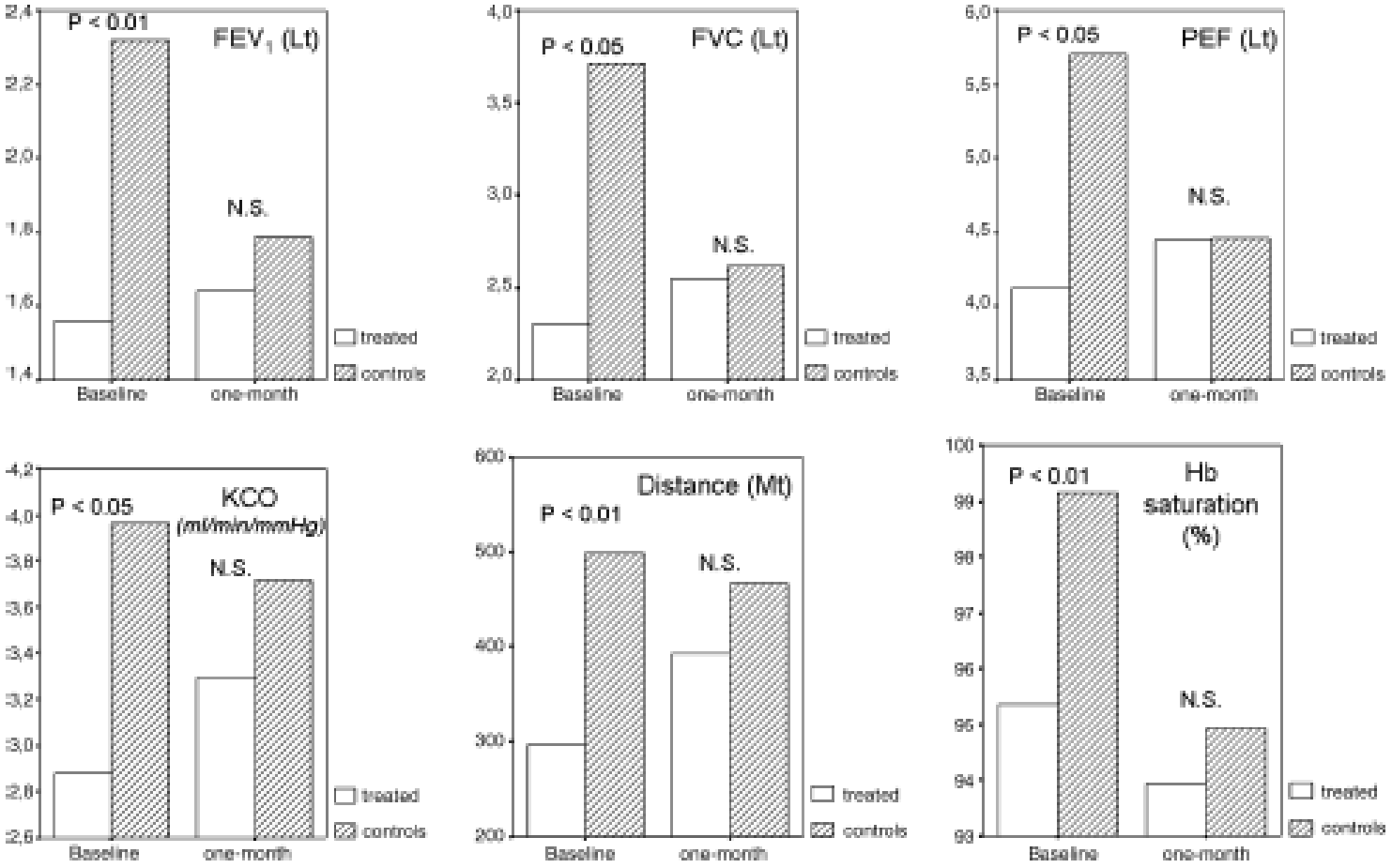
Cox, J Thorac Oncol 2017.

Considerations

- Those who continue to smoke within one month of a pneumonectomy are at increased risk for developing major pulmonary events.[1]
- Unable to find a paradoxical increase in pulmonary complications among those who **quit smoking** within two months.[2]
- Review found **smoking abstinence led to fewer PPCs**, though the optimal timing of cessation not identified.[3]
- The sooner one is able to quit, the more likely it is that he or she will remain abstinent after surgery.[4]

1. Vaporciyan, *Ann Thorac Surg* 2002. 2. Barrera, *Chest* 2005. 3. Zaman, Interact Cardiovasc Thorac Surg 2012. 4. Dresler, *Chest* 1996.

Peri-Operative Considerations - Rehab



Cesario, *Lung Cancer* 2007.

CHEST Guidelines

- In patients with lung cancer it is recommended that they be assessed for curative surgical resection by a **multidisciplinary team**, which includes a thoracic surgeon specializing in lung cancer, medical oncologist, radiation oncologist and pulmonologist.

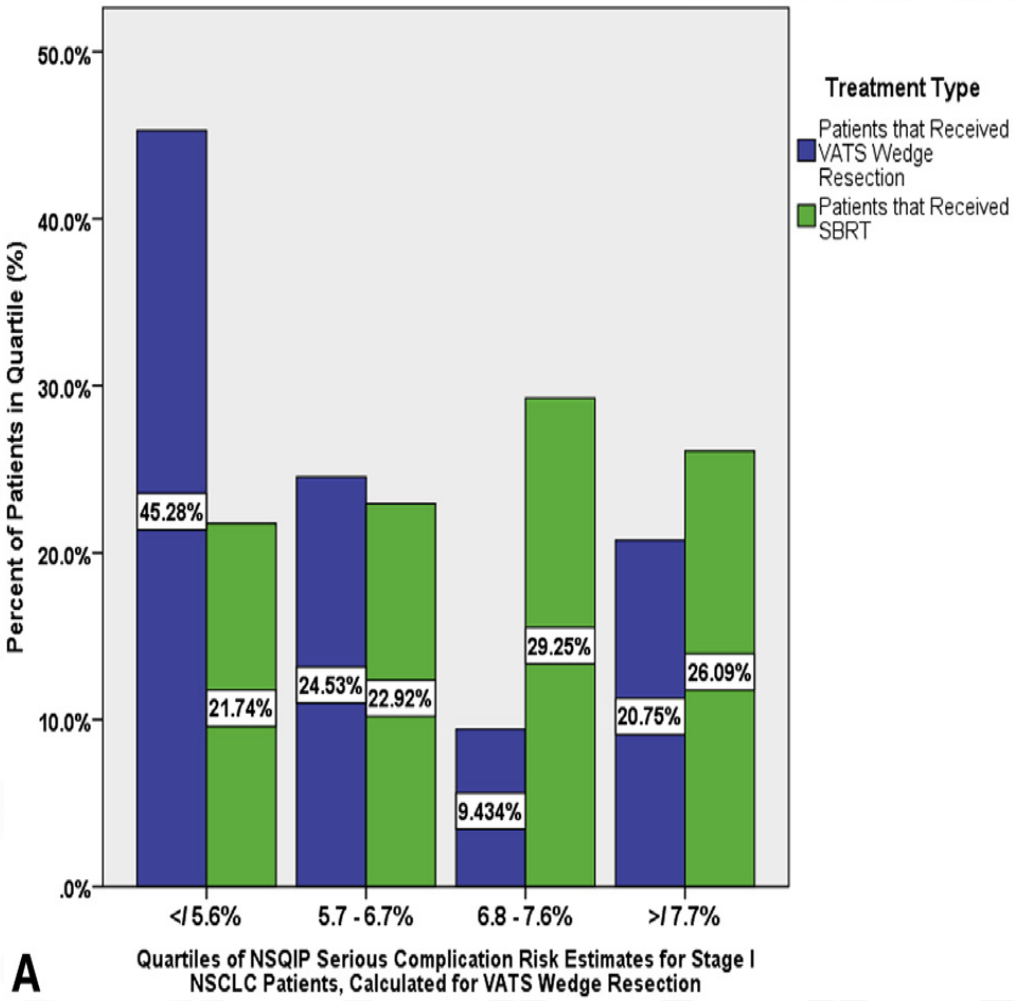
Brunelli, Chest 2013.

CHEST Guidelines

- In all patients with lung cancer being considered for surgery who are actively smoking**, tobacco dependence treatment** is recommended.
- In patients with lung cancer being considered for surgery and deemed at **high risk** (as defined by the proposed functional algorithm, ie, ppoFEV_1 or ppoDLCO < 60% and VO_2 max < 10 mL/kg/min or < 35%), **preoperative or postoperative pulmonary rehabilitation** is recommended.

Brunelli, Chest 2013.

Ability to Select



Samson, J Thorac Cardiovasc Surg 2016.

Ability to Select

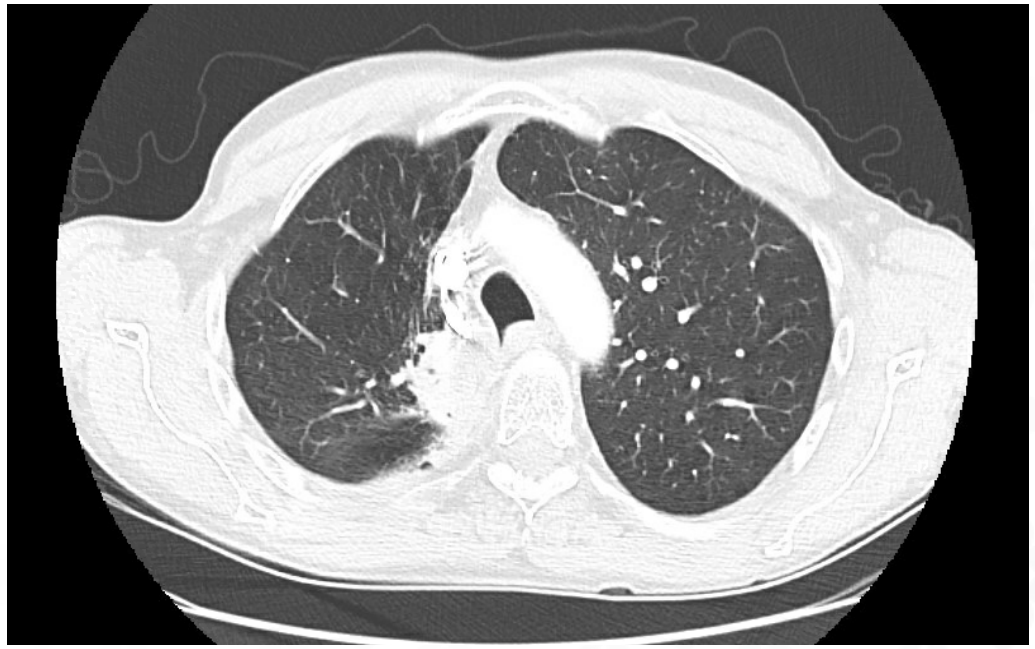
Characteristic	Pulmonologist	Thoracic Surgeon	Radiation Oncologist
CCI	32	66	43
WHO-PS	33	2	21
Age	17	24	24
Patient preference	16	5	12
COPD GOLD	2	3	0

Hopman, Radiother Oncol 2015.

Case 1

- 50 year old man diagnosed with a stage IIIA squamous cell cancer of the right upper lobe (N2 involvement) was treated with definitive chemoradiation.
- Cancer has persisted at the tumor site. Restaging suggests no nodal involvement. He has received maximal doses of radiation.
- He feels he could walk at least 1/2 mile. He rides a bicycle with his 11 year old grandson, perhaps 10-12 city blocks. He has a chronic cough and recently an episode of frank hemoptysis.
- He is a former smoker with known COPD receiving an ICS/LABA and LAMA for maintenance therapy. He does not have known cardiac risks.

Case 1



- PFTs - FEV_1 1.38L, 39% predicted; DLCO 20.6, 70% predicted

Which statement is most correct about his preoperative evaluation?

A. He should have a cardiac stress test.

B. Segment methods for calculating predicted post-operative values will be more accurate than perfusion methods.

C. He should have some form of exercise test.

D. He should participate in pulmonary rehab prior to surgery.

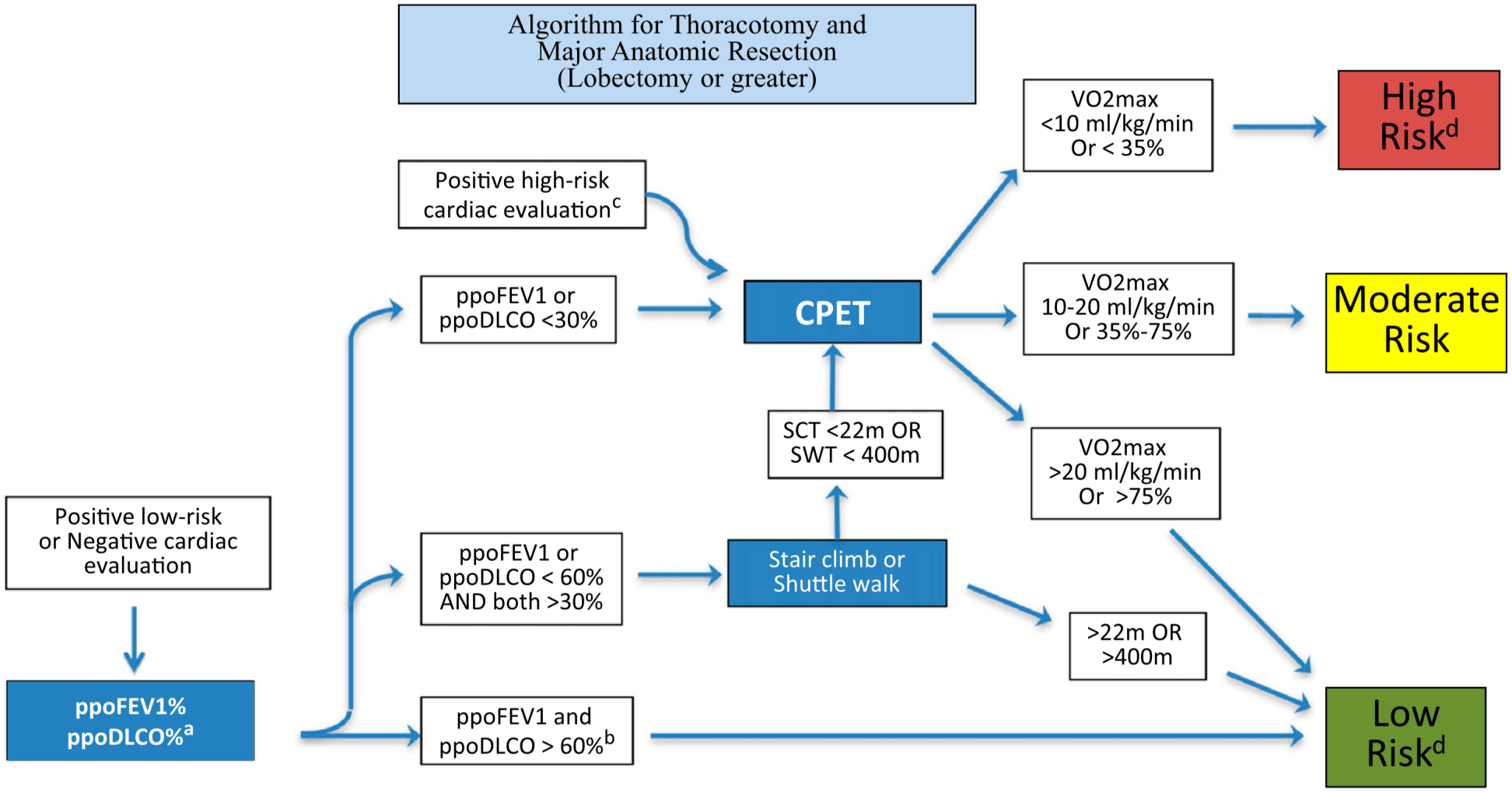
Case 1

- Quantitative perfusion scan - 16% to right upper and 16% to right lower.
- ppoFEV_1 - 33% predicted; ppoDLCO 59% predicted
- Walk 6 – 330m, 63% predicted, SpO2 95% on RA at rest and 91% during the walk, HRR 16
- CPET - peak VO_2 21.4 ml/kg/min, 67% predicted, MVV 34% predicted, breathing reserve depleted at 1.5%, pO_2 at baseline 68 mmHg.

This patient would be considered:

A. Low risk
B. Moderate risk
C. High risk
D. Prohibitive risk

Algorithm


Algorithm for Thoracotomy and Major Anatomic Resection (Lobectomy or greater)
Positive high-risk cardiac evaluation[c]
ppoFEV1 or ppoDLCO <30%
CPET
VO2max <10 ml/kg/min Or < 35%
High Risk[d]
VO2max 10-20 ml/kg/min Or 35%-75%
Moderate Risk
SCT <22m OR SWT < 400m
VO2max >20 ml/kg/min Or >75%
Positive low-risk or Negative cardiac evaluation
ppoFEV1 or ppoDLCO < 60% AND both >30%
Stair climb or Shuttle walk
>22m OR >400m
ppoFEV1% ppoDLCO%[a]
ppoFEV1 and ppoDLCO > 60%[b]
Low Risk[d]

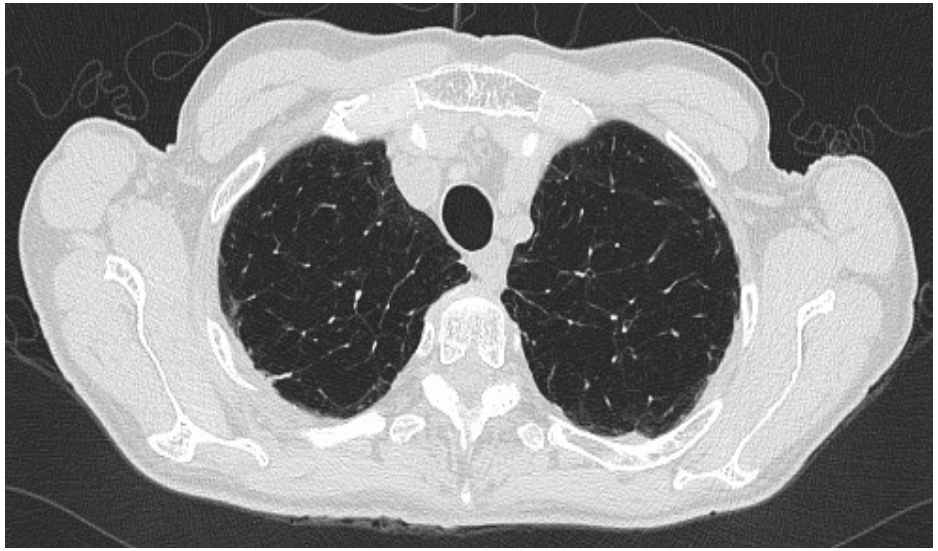
Case 1: Nuances

- No other treatment option
- Young age
- Upper lobe location
- Ventilatory limitation
- Prior treatment

Case 2

- A 70 year old smoker is seen with a localized adenocarcinoma of the lung. She currently feels well, exercising regularly without limitation from excessive dyspnea.
- She is an active smoker, down to 1 cigarette per week. She has been diagnosed with emphysema and started using maintenance tiotropium within the year. She developed a severe influenza infection 8 months ago. She required hospitalization and was discharged with home oxygen for 3 weeks.

Case 2



- Pulmonary function tests show severe obstruction (FEV_1 0.95L, 45% predicted) and a reduced diffusing capacity (42% predicted). Thoracic surgery does not feel that a wedge resection is feasible.

Which statement is most correct about her preoperative evaluation?

A. Her surgery should be delayed until she has been abstinent from smoking for 2 months.

B. Her FEV_1 suggests the risk of complications from lung resection is low.

C. Her DLCO suggests the risk of complications from lung resection is moderate.

D. The location of her cancer increases the risk of complications from lung resection.

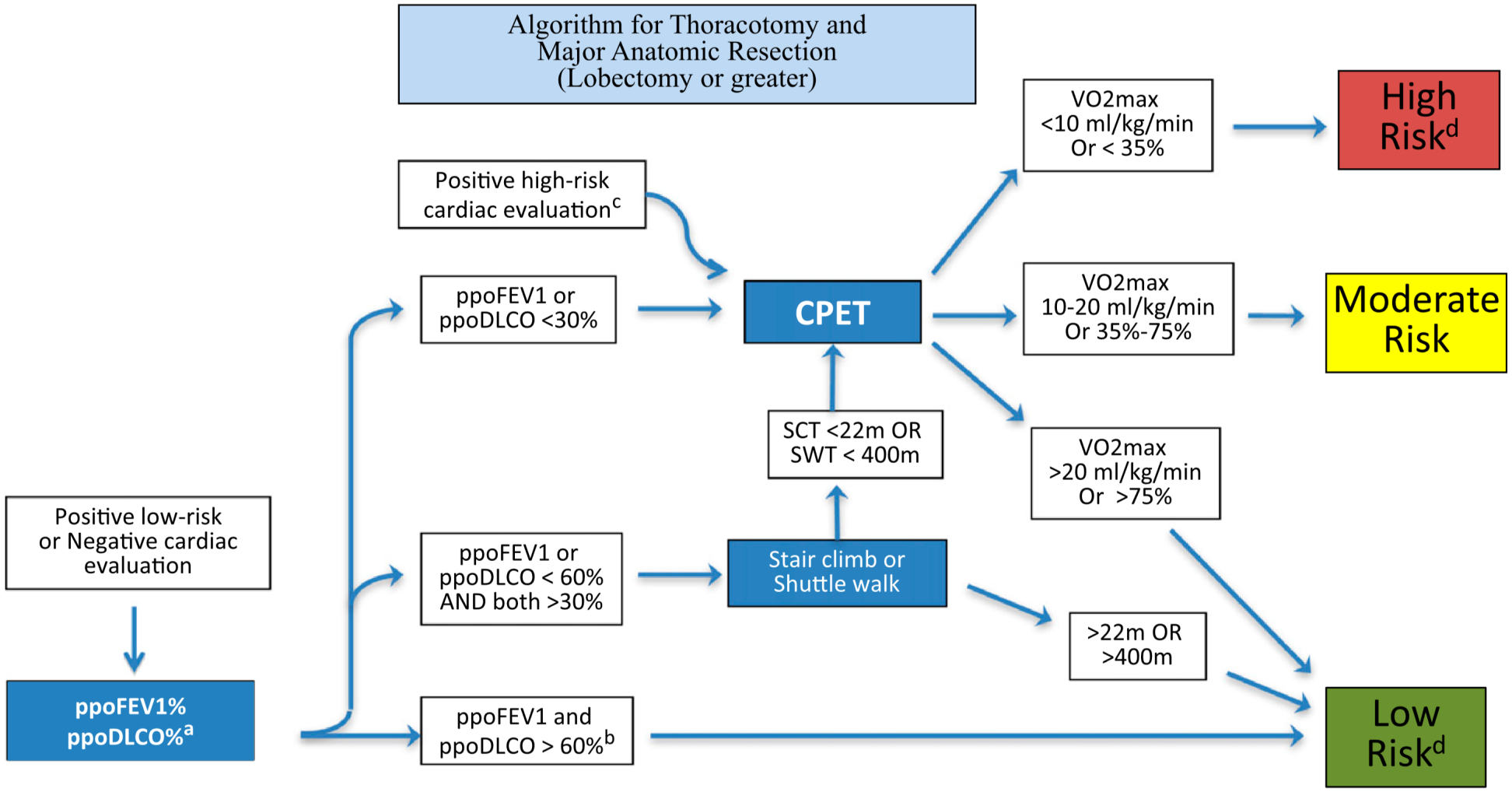
Case 2

- Pulmonary function tests show severe obstruction (FEV_1 0.95L, 45% predicted) and a reduced diffusing capacity (42% predicted).
  - ppoFEV1 – 33%, ppoDLCO – 31%
- A cardiopulmonary exercise test showed a peak VO_2 of 17 ml/kg/min (80% predicted).
  - There was ventilatory limitation (no breathing reserve at peak exercise) and her SpO_2 fell from 96% on RA at rest to 92% during the test.

This patient would be considered:

A. Low risk
B. Moderate risk
C. High risk
D. Prohibitive risk

Algorithm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ppoFEV1 or ppoDLCO <30%
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High Risk[d]
VO2max 10-20 ml/kg/min Or 35%-75%
Moderate Risk
SCT <22m OR SWT < 400m
VO2max >20 ml/kg/min Or >75%
Positive low-risk or Negative cardiac evaluation
ppoFEV1 or ppoDLCO < 60% AND both >30%
Stair climb or Shuttle walk
>22m OR >400m
ppoFEV1% ppoDLCO%[a]
ppoFEV1 and ppoDLCO > 60%[b]
Low Risk[d]

Case 2: Nuances

- Other reasonable treatment option
- Upper lobe predominant emphysema, lower lobe resection
- Ventilatory limitation
- Patient values

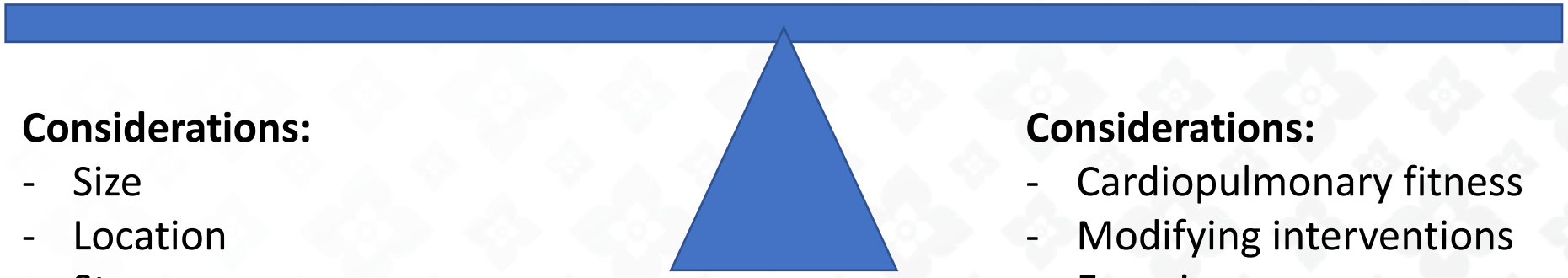
Striking the Best Balance

Benefits: surgery (traditional anatomic, sublobar) vs. SBRT

- Overall survival
- Disease free survival
- Recurrence

Harms: surgery (traditional anatomic, sublobar) vs. SBRT

- Mortality
- Morbidity
- Long-term QOL



Considerations:

- Size
- Location
- Stage
- Availability

Considerations:

- Cardiopulmonary fitness
- Modifying interventions
- Experience
- Surgical approach

Summary

- Striking the best balance
- Comparison of Benefits and Harms
  - Considerations
- Making the Decision