You Can't Put It Back: Anesthetic Management for Lung Resection

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This review will focus on patients for pulmonary resection surgery but the general principles apply to patients with pulmonary disease having any intra-thoracic surgical procedure. An evidence-based strategy will be developed to allow the Anesthesiologist to stratify patients according to their risk of perioperative complications and also to direct anesthetic management to modify the risk. To assess the patients preoperatively it is necessary to have an understanding of the risks specific to this type of surgery.[1] The major cause of perioperative morbidity and mortality in the thoracic surgical population is respiratory complications. For other types of surgery, cardiac and vascular complications are the leading cause of early perioperative morbidity and mortality.

The best assessment of respiratory function comes from a history of the patient's quality of life.[2] It is useful to have objective measures of pulmonary function that can be used to guide anesthetic management and to have this information in a format that can be easily transmitted between members of the health care team. There are many factors that determine overall respiratory performance.[3] It is useful to think of the respiratory function in three related but somewhat independent areas: respiratory mechanics, gas exchange, and cardio-respiratory interaction.

1) Respiratory Mechanics: Many tests of respiratory mechanics and volumes show correlation with post-thoracotomy outcome. It is useful to express these as a percent of predicted volumes corrected for age, sex and height (e.g.: FEV1 %). Of these, the most valid single test for post-thoracotomy respiratory complications is the predicted postoperative forced expiratory volume in one second (ppoFEV1 %) calculated as:[4]

ppoFEV1 % = preoperative FEV 1% x (1- % functional lung tissue removed/100).

A study from the 1980's found that patients with a ppoFEV1 >40% had no or minor post-resection respiratory complications. Major respiratory complications were only seen in the subgroup with ppoFEV1 <40% and patients with ppoFEV1 <30% required postoperative mechanical ventilatory support.[5] The use of epidural analgesia has decreased the incidence of complications in the high-risk group.[6]

2) **Lung Parenchymal Function:** Arterial blood gas data such as PaO_2 < 60 mmHg or $PaCO_2$ > 45 mmHg have been used as cut-off values for pulmonary resection. Cancer resections have now been successfully done or even combined with volume reduction in patients who do not meet these criteria.[7] The most useful test of the gas exchange capacity of the lung is the diffusing capacity for carbon monoxide (DLCO).[8] The DLCO correlates with the total functioning surface area of alveolar-capillary interface. The DLCO can be used to calculate a post-resection (ppo) value using the same calculation as for the FEV1. A ppoDLCO <40% predicted correlates with both increased respiratory and cardiac complications and is relatively independent of the FEV1.[9]

3) **Cardio-pulmonary Interaction:** The most important assessment of respiratory function is an assessment of the cardio-pulmonary interaction. The traditional test is stair climbing.[10] The ability to climb 3 flights or more is closely associated with decreased mortality and morbidity. Less than 2 flights is very high risk. Formal laboratory exercise testing with maximal oxygen consumption (VO_2max) is the "gold standard" for assessment of cardio-pulmonary function. Climbing 5 flights of stairs approximates a VO_2 max of >20ml/kg/min and less than one flight a VO_2 max <10ml/kg/min.[11] In a high-risk group of patients (mean pre-operative FEV1= 41% predicted) there was no perioperative mortality if the preoperative VO_2max was >15ml/kg/min.[12] Alternatives to VO_2max include the six-minute walk test (6MWT)[13] and exercise oximetry.[14] For patients with moderate to severe COPD the 6MWT has a high correlation with VO_2max, which can be estimated from the distance in meters/30 (i.e. for a 6MWT distance of 450m, VO_2max = 450/30= 15 ml/kg/min).[15]

4) **Ventilation Perfusion (V/Q) scintigraphy:** Prediction of post-resection pulmonary function can be further refined by assessment of the pre-operative contribution of the lung or lobe to be resected using V/Q lung scanning.[16] If the lung region to be resected is non- or minimally functioning the prediction of post-operative function can be modified accordingly. This is particularly useful in pneumonectomy patients and should be considered for any patient who has a ppoFEV1 <40%. Other tests of pulmonary function such as split-lung function studies and flow-volume loops have not shown sufficient predictive validity for widespread universal adoption in potential lung resection patients.

5) **Combination of Tests:** No single test of respiratory function has shown adequate validity as a sole pre-operative assessment. Prior to surgery an estimate of respiratory function in all 3 areas: lung mechanics, parenchymal function and cardio-pulmonary interaction should be made for each patient. If a patient has a ppoFEV1 >40% it should be possible for that patient to be extubated in the operating room at the conclusion of surgery assuming the patient is

alert, warm and comfortable ("AWaC"). If the ppoFEV1 is >30% and exercise tolerance and lung parenchymal function exceed the increased risk thresholds then extubation in the operating room may be possible depending on the status of associated diseases (see below). Those patients in this subgroup who do not meet the minimal criteria for cardio-pulmonary and parenchymal function should be considered for staged weaning from mechanical ventilation post-operatively so that the effect of the increased oxygen consumption of spontaneous ventilation can be assessed. Patients with a ppoFEV1 20-30% and favorable predicted cardio-respiratory and parenchymal function can be considered for early extubation if thoracic epidural analgesia if used. The validity of this approach has been confirmed by the National Emphysema Treatment Trial which found an unacceptably high mortality for lung volume reduction surgery in patients with preoperative FEV1 and DL_{CO} values <20% predicted.[17]

INTER-CURRENT MEDICAL CONDITIONS:

1) **Reactive Airways Disease:** Broncho-constriction is assessed by history, physical examination and evaluation of pulmonary function response to bronchodilators. All COPD patients should receive maximal bronchodilator therapy as guided by their symptoms. In a patient who is poorly controlled on sympathomimetic and anticholinergic bronchodilators, a trial of corticosteroids may be beneficial.[18] It is not clear if corticosteroids are as beneficial in COPD as they are in asthma.

Is referral to a Chest Physician indicated? The Anesthesiologist will have to decide if the patient with reactive airways disease is adequately managed preoperatively, i.e. functionally at his/her usual level of exercise tolerance and with flow-rates >80% of stable baseline. If preoperative management of bronchospasm is inadequate or if there is any evidence of current respiratory infection, the patient should be referred to a Chest or Family Physician for therapy preoperatively.

With advances in Anesthetic management the incidence of life-threatening intra-operative bronchospasm has become very low.[19] However, the Anesthesiologist must always respect the management principles for patients with reactive airways: preoperative optimization of bronchodilation, minimal (or no) instrumentation of the airways, instrument the airways only after appropriate depth of anesthesia with a bronchodilating anesthetic (Propofol, Ketamine, Sevoflurane), and maintenance of anesthesia with a bronchodilating anesthetic and appropriate warming and humidification of inspired gases.[20] In patients with bronchial hyper-reactivity (FEV1 <70% and >10% increase with bronchodilator) on regular bronchodilator therapy, post-intubation wheezing can be significantly reduced by addition of a 5-day preoperative course of corticosteroids (methylprednisolone 40mg/day p.o.).[21]

2) **Age:** If a patient is 80 years of age and has a stage I lung cancer, their chances of survival to age 85 are better with the tumor resected than without.[22] However, the rate of respiratory complications (40%) is double that expected in a younger population and the rate of cardiac complications (40%), particularly arrhythmias, triple that which should be seen in younger patients. Although the mortality from lobectomy in the elderly is acceptable, the mortality from pneumonectomy (22% in patients >70 years),[23] particularly right pneumonectomy, is excessive. Pulmonary resection in the elderly should be regarded as a high-risk procedure for cardiac complications and cardiopulmonary reserve is the most important predictor of outcome in this population.[24]

3) **Cardiac Disease:** Cardiac complications are the second most common cause of peri-operative morbidity and mortality in the thoracic surgical population.

a) Ischemia. the majority of pulmonary resection patients have a smoking history and already have one risk factor for coronary artery disease.[25] Pulmonary resection surgery is an "intermediate risk" procedure in terms of peri-operative cardiac ischemia.[26] Non-invasive testing is indicated in patients with major (unstable ischemia, recent infarction, severe valvular disease, significant arrhythmia) or intermediate (stable angina, remote infarction, previous congestive failure, or diabetes) clinical predictors of myocardial risk and also in the elderly.

b) Arrhythmia: Dysrhythmias, particularly atrial fibrillation, are a frequent complication of pulmonary resection surgery.[27] Factors known to correlate with an increased incidence of arrhythmia are the amount of lung tissue resected, age, intraoperative blood loss, and intra-pericardial dissection.[28] Prophylactic therapy with Digoxin has not been shown to prevent these arrhythmia's. Diltiazem has been shown to be effective.[29]

4) **Renal Dysfunction.** Renal dysfunction following pulmonary resection surgery is associated with a very high incidence of mortality (19%).[30] The factors which are associated with an elevated risk of renal impairment are: history of previous renal dysfunction, diuretic therapy, pneumonectomy, postoperative infection and transfusion.

Physiotherapy: Patients with COPD have fewer post-operative pulmonary complications when a program of chest physiotherapy is initiated preoperatively.[31] Among COPD patients, those with excessive sputum benefit the most from chest physiotherapy.[32] A comprehensive program of pulmonary rehabilitation involving physiotherapy, exercise, nutrition and education has been shown to consistently improve functional capacity for patients with severe COPD.[33] Atelectasis in the post-operative period leads to increased capillary permeability and an inflammatory response with subsequent lung injury if it persists[34] it should be treated with aggressive physiotherapy.[35]

Lung Cancer: At the time of initial assessment cancer patients should be assessed for the "4-M's" associated with malignancy: mass effects,[36] metabolic abnormalities, metastases[37] and medications. The prior use of medications which can exacerbate oxygen induced pulmonary toxicity such as bleomycin should be considered.[38] Recently we have seen several lung cancer patients who received preoperative chemotherapy with cis-platinum and then developed an elevation of serum creatinine when they received non-steroidal anti-inflammatory analgesics (NSAIDS) post-operatively. For this reason we now do not routinely administer NSAIDS to patients who have been treated recently with cis-platinum.

Smoking Cessation: In non-pulmonary surgery a pre-operative smoking cessation program can significantly decrease the incidence of respiratory complications (8 weeks abstinence), wound complications (4 weeks abstinence) and intra-operative myocardial ischemia (48 hr. abstinence).[39] However in thoracic surgical patients, pulmonary complications are decreased in those who are not smoking versus those who continue to smoke up until the time of surgery.[40] The perioperative period is a specific stimulus for patients to stop smoking, 55% patients were found to remain abstinent from smoking one-year after aorto-coronary bypass, versus only 25% 1 year after angioplasty and 14% after angiography and physician counseling is a major part of the stimulus[41]. Smoking cessation can be achieved in >50% of perioperative patients with a structured program and can result in an overall decrease of complications of >50%.[42]

Perioperative Surgical Environment Factors: There are multiple factors in the surgical environment that can contribute to lung injury in this patient. One of the most obvious is the surgical approach. If these procedures can be done with a minimally invasive technique vs. an open laparotomy the decrease in respiratory complications is well documented.[43]

Atelectasis: Atelectasis is a frequent post-operative complication of open surgical procedures. Atelectasis occurs intra-operatively as part of essentially any general anesthetic.[44] Anesthesiologists are aware of this and techniques to avoid it with use of air oxygen mixtures, PEEP and recruitment maneuvers are used frequently.[45] However, Anesthesiologists are often not aware that atelectasis is a pathological state, and in the post-operative period leads to increased capillary permeability and an inflammatory response with subsequent lung injury if it persists.[46] Both retrospective[47] and prospective[48] studies have consistently shown that appropriate thoracic epidural analgesia reduces the incidence of respiratory complications (atelectasis, pneumonia and respiratory failure)after major abdominal and thoracic surgery. It has also been recently demonstrated that aggressive physiotherapy with CPAP in the post-operative period in patients who develop early desaturation after major abdominal surgery leads to lower rates of major respiratory complications.[49]

Postoperative Analgesia: The strategy for postoperative analgesia should be developed and discussed with the patient during the initial preoperative assessment. Only epidural techniques have been shown to consistently decrease post-thoracotomy respiratory complications.[50,51] Thoracic epidural analgesia is superior to lumbar epidural analgesia due to the synergy which local anesthetics have with opioids in producing neuraxial analgesia. Studies suggest that epidural local anesthetics increase segmental bio-availability of opioids in the cerebrospinal fluid[52] and increase the binding of opioids by spinal cord receptors.[53] Only the segmental effects of thoracic epidural local anesthetic and opioid combinations can reliably produce increased analgesia with movement and increased respiratory function following a chest incision.[54] In patients with coronary artery disease, thoracic epidural local anesthetics reduce myocardial oxygen demand and supply in proportion,[55] unlike lumbar epidural local anesthetics.[56] Thoracic epidural analgesia has been shown to be associated with a decreased risk of requiring post-operative ventilatory support.[57]

At the time of initial pre-anesthetic assessment the risks and benefits of the various forms of post-thoracotomy analgesia should be explained to the patient. Potential contraindications to specific methods of analgesia should be determined such as coagulation problems, sepsis or neurologic disorders. When it is not possible to place a thoracic epidural due to concerns with patient consent or other contraindications, our current second choice for analgesia is a paravertebral infusion of local anesthetic via a catheter placed intraoperatively in the open hemithorax by the surgeon.[58] This is combined with intravenous patient-controlled opioid analgesia and NSAIDS.

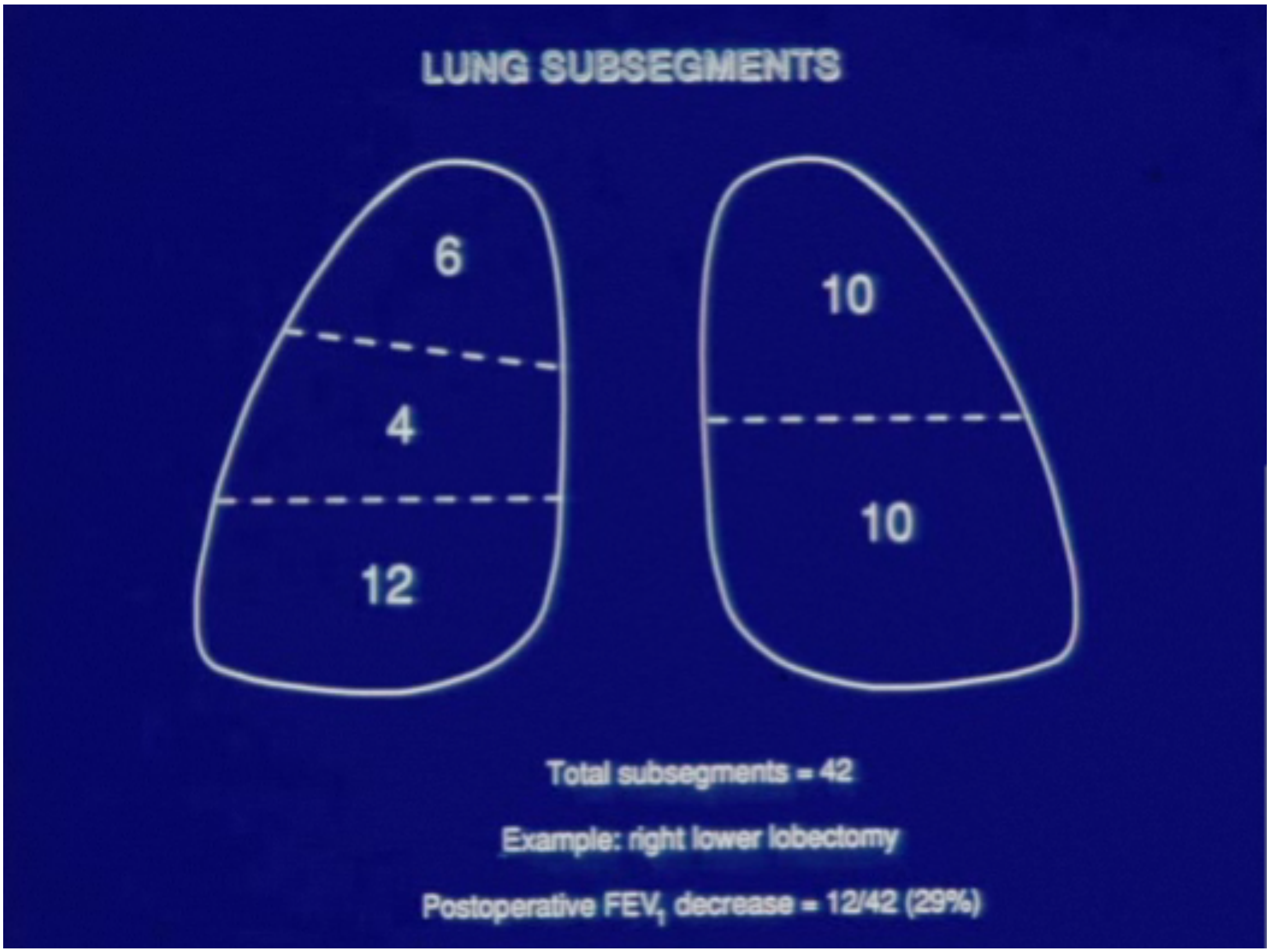
If the patient is to receive prophylactic anticoagulants and it is elected to use epidural analgesia, appropriate timing of anticoagulant administration and neuraxial catheter placement need to be arranged. ASRA guidelines suggest an interval of 2-4 hours before or one hour after catheter placement for prophylactic heparin administration.[59] Low molecular weight heparin (LMWH) precautions are less clear, an interval of 12-24 hours before and 24 hours after catheter placement are recommended.

SUMMARY

Recent advances in anesthetic care have improved outcomes for patients with respiratory disease having major surgery. Understanding and stratifying the perioperative risks allows the anesthesiologist to develop a systematic focused approach to these patients, which can then be used to both assess and manage these patients.

REFERENCES

1. Slinger PD, Johnston MR. Preoperative Assessment: An Anesthesiologist's Perspective. Thorac Surg Clin 2005, 15: 11-25
2. British Thoracic Society. Guidelines on the selection of patients with lung cancer for surgery. Thorax 2001; 56: 89-108
3. Epstein SK, Failing LJ, Daly BDT, Celli BR. Predicting complications after pulmonary resection. Chest 1993;104:694-700.
4. Win T, Jackson A, Sharples L, et al. Relationship between pulmonary function and lung cancer surgical outcome. Eur Respir J 2005, 25: 594-9
5. Nakahara K, Ohno K, Hashimoto J, et al. Prediction of postoperative respiratory failure in patients undergoing lung resection for cancer. Ann Thorac Surg 1988;46: 549-52.
6. Cerfolio RJ, Allen MS, Trastak VF, Deschamps C, Scanbon PD, Pairolero PC. Lung resection in patients with compromised pulmonary function. Ann Thorac Surg 1996;62:348-51.
7. McKenna RJ, Fischel RJ, Brenner M, Gelb AF. Combined operations for lung volume reduction surgery and lung cancer. Chest 1996;110: 885-8.
8. Amar D, Munoz D, Weiji S, et al. A clinical prediction rule for pulmonary complications after thoracic surgery for primary lung cancer. Anesth Analg 2010; 110: 1343-8
9. Wang J, Olak J, Ferguson MK. Diffusing capacity predicts mortality but not long-term survival after resection for lung cancer. J Thorac Cardiovasc Surg 1999; 17: 581-85.
10. Olsen GN, Bolton JWR, Weiman DS, Horning CA. Stair climbing as an exercise test to predict postoperative complications of lung resection. Chest 99: 587-90, 1991
11. Beckles MA, Spiro SG, Colice GL, et al. The physiologic evaluation of patients with lung cancer being considered for resectinal surgery. Chest 2003; 123: 105s-114s
12. Walsh GL, Morice RC, Putnam JB, et al. Resection of lung cancer is justified in high risk patients selected by oxygen consumption. Ann Thorac Surg 1994;58:704.
13. Cahalin L, Pappagianapoulos P, Prevost S, Wain J, Ginns L. The relationship of the 6-min walk test to maximal oxygen consumption in transplant candidates with end-stage lung disease. Chest 1995;108:452-57.
14. Ninan M, Sommers KE, Landranau RJ, et al. Standardized exercise oximetry predicts post pneumonectomy outcome. Ann Thorac Surg 1997;64:328-33.
15. Carter R, Holiday DB, Stocks J, et al. Predicting oxygen uptake for men and women with moderate to severe chronic obstructive pulmonary disease. Arch Phys Med Rehabil 2003; 84: 1158-64
16. Vesselle H. Functional imaging before pulmonary resection. Semin Thoracic Cardiovasc Surg 2001; 13: 126-135.
17. National Emphysema Treatment Trial Research Group. A Randomized Trial Comparing Lung-Volume-Reduction Surgery with Medical Therapy for Severe Emphysema. New Eng J Med 348: 2059-73, 2003
18. Nisar M, Eoris JE, Pearson MG, Calverly PMA. Acute broncho-dilator trials in chronic obstructive pulmonary disease. Am Rev Resp Dis 1992; 146:555
19. Bishop M, Cheny F. Anesthesia for patients with asthma: low risk but not no risk. Anesthesiology 1996, 85: 455-6
20. Hurford W. The bronchospastic patient. Int Anesthesiol Clinics 2000, 38: 77-90
21. Silvanus MT , Groeben H, Peters J. Corticosteroids and Inhaled Salbutamol in Patients with Reversible Airway Obstruction Markedly Decrease the Incidence of Bronchospasm after Tracheal Intubation. Anesthesiology 2004; 100: 1052-57
22. Osaki T, Shirakusa T, Kodate M, et al. Surgical treatment of lung cancer in the octogenarian. Ann Thorac Surg 1994;57:188-93.
23. Mizushima Y, Noto H, Sugiyama S, et al. Survival and prognosis after pneumonectomy in the elderly. Ann Thorac Surg 1997;64:193-8.
24. Brunelli A, Monteverde M, Al Rafai M , et al. Stair climbing test as a predictor of cardiopulmonary complications after pulmonary lobectomy in the elderly. Ann Thorac Surg 2004; 77: 266-70
25. Barry J, Mead K, Nadel EC, et al. Effect of smoking on the activity of ischemic heart disease. JAMA 1989; 261:398-402.
26. ACC/AHA Guideline Update for Perioperative Cardiovascular Evaluation for Noncardiac Surgery-Executive Summary. Anesth Analg 2002;94:1052-64
27. Ritchie AJ, Danton M, Gibbons JRP. Prophylactic digitalisation in pulmonary surgery. Thorax 1992;47:41-3.
28. Didolkar MS, Moore RH, Taiku J. Evaluation of the risk in pulmonary resection for bronchogenic carcinoma. Am J Surg 1974;127:700-705.
29. Amar D, Roistacher N, Burt ME, et al. Effects of diltiazem versus digoxin on dysrhythmias and cardiac function after pneumonectomy. Ann Thorac Surg 1997;63:1374-81.
30. Golledge J, Goldstraw P. Renal impairment after thoracotomy: incidence, risk factors and significance. Ann Thorac Surg 1994;58:524-8.
31. Warner DO. Preventing postoperative pulmonary complications. Anesthesiology 2000;92:1467-71.
32. Selsby D, Jones JG. Some physiological and clinical aspects of chest physiotherapy. Br J Anaesth 1990;64:621-31.
33. Kesten S. Pulmonary Rehabilitation and Surgery for end-stage lung disease. Clinic Chest Med. 1997;18:174-81.
34. Duggan M, Kavanagh B. Pulmonary Atelectasis a pathological perioperative entity. Anesthesiology 2005; 102: 838-54
35. quadrone V, Coha M, Cerutti E, et al. Continuous positive airway pressure for treatment of Postoperative hypoxemia. JAMA 2005; 293: 589-95
36. Gilron I, Scott WAC, Slinger P, Wilson JAS. Contralateral lung soiling following laser resection of a bronchial tumor. J Cardiothorac Vasc Anesth 1994;8:567-9.
37. Mueurs MF. Preoperative screening for metastases in lung cancer patients. Thorax 1994;49:1-3.
38. Ingrassia TS III, Ryu JH, Trasek VF, Rosenow EC III. Oxygen-exacerbated bleomycin pulmonary toxicity. Mayo Clin Proc 1991;66:173-8.
39. Warner DO. Helping surgical patients quit smoking: why, when and how. Anesth Analg 2005; 101: 481-7
40. Bonde P, McManus K, McAnespie M, McGuigan J. Lung surgery: identifying the subgroup at risk for sputum retention. Eur J Cardiothorac Surg 2002;22:18-22.
41. Crouse JR, Hagaman AP. Smoking cessation in relation to cardiac procedures. Am J Epidemiol 1991; 134: 699-703
42. Thomsen T, Tonnesen H, Moller AM. Effect of preoperative smoking cessation interventions on postoperative complications and smoking cessation. Br J Surg 2009; 96: 451-61
43. Ramivohan SM, Kaman L, Jindal R, et al. Postoperative pulmonary function in laparoscopic versus open cholecystectomy: prospective, comparative study. Indian J Gastroenerol 2005; 24: 6-8
44. Lindberg P, Gunnarsson L, Tokics L, et al. Atelectasis and lung function in the postoperative period. Acta Anaesthesiol Scand 1992, 36 : 546-53
45. Tusman G. Bohm SH. Suarez-Sipmann F Alveolar recruitment improves ventilatory efficiency of the lungs during anesthesia. Can J Anesth 2004: 51: 723-7
46. Duggan M, Kavanagh B. Pulmonary Atelectasis a pathological perioperative entity. Anesthesiology 2005; 102: 838-54
47. Ballantyne,J.C.; Carr,D.B.; deFerranti,S. The comparative effects of postoperative analgesic therapies on pulmonary outcome: cumulative meta-analysis of randomized, controlled trials. Anesth Analg 1998; 86: 598-612
48. Rigg J, Jamrozik K, Myles P, et al. Epidural anaesthesia and analgesia and outcome of major surgery: a randomized trial. Lancet 2002, 359: 1276-82
49. Squadrone V, Coha M, Cerutti E, et al. Continuous positive airway pressure for treatment of Postoperative hypoxemia. JAMA 2005; 293: 589-95
50. Rigg J, Jamrozik K, Myles P, et al. Epidural anaesthesia and analgesia and outcome of major surgery: a randomized trial. Lancet 2002, 359: 1276-82
51. Licker M, de Perrot M, Hohn L, et al. Perioperative mortality and major cardio-pulmonary complications after lung surgery for non-small call carcinoma. Eur J Cardiothorac Surg 1999;15: 314-9.
52. Hansdottir V, Woestenborghs R, Nordberg G. The pharmacokinetics of continuous epidural sufentanil and bupivacaine infusion after thoracotomy. Anesth Analg 1996;83:401-6.
53. Tejwani GA, Rattan AK, Mcdonald JS. Role of spinal opioid receptors in the antinociceptive interactions between intrathecal morphine and bupivacaine. Anesth Analg 1992;74:726-34.
54. Hansdottir V, Bake B, Nordberg G. The analgesic efficiency and adverse effects of continuous epidural sufentanil and bupivacaine infusion after thoracotomy. Anesth Analg 1996;83:394-400.
55. Saada M, Catoire P, Bonnet F,et al. Effect of thoracic epidural anesthesia combined with general anesthesia on segmental wall motion assessed by transesophageal echocardiography. Anesth.Analg 1992;75:329-335.
56. Saada M, Duval A-M, Bonnet F, et al. Abnormalities in myocardial wall motion during lumbar epidural anesthesia. Anesth Analg 1989;71: 26-33.
57. Cywinski JB, Xu M, Sessler D, et al. Predictors of prolonged post-operative endotracheal intubation in patients undergoing thoracotomy for lung resection. J Cardiothorac Vasc Anesth 2009; 23: 766-9
58. Karmakar MK. Thoracic paravertebral block. Anesthesiology 2001;95:771-80.
59. Horlocker TT, et al. Regional anesthesia in the patient receiving antithrombotic or thrombolytic therapy. ASRA Guidelines. Reg Anesth Pain Med 2010; 35: 64-101.


LUNG SUBSEGMENTS
6
4
12
10
10
Total subsegments = 42
Example: right lower lobectomy
Postoperative FEV1 decrease = 12/42 (29%)

Pulmonary Resection Morbidity and Mortality

	All Cases (LCSG '89)
Mortality	4%
Respiratory Complications	21%
Cardiac Complications	15%

Prediction of Postoperative Respiratory Failure in Patients Undergoing Lung Resection for Cancer

- 156 patients, lobect.88, pneumonect.26
  respiratory complications 26%

- ppoFEV1 >50%: no/minor complic's.
- ppoFEV1 <40%: +/- major resp. complic's.
- ppoFEV1 <30%: 10/10 postop. ventilation
  6/10 died

Nakahara K, et al. Ann Thorac Surg 46: 549, 1988

Relationship Between Pulmonary Function and Lung Cancer Surgical Outcome

N= 110, Lobx 60%, Px 33%, Segm./Wdg. 17% Age 69 +/- 8 yr., M/F 60/40 %

<u>Survive/No Maj. Resp. Complic.: 96 (87%)</u>	<u>Death/Resp. Failure: 14 (13%)</u>
ppoFEV1=58% (+/- 15%)	ppoFEV1= 42% (+/- 13%) p< .001
ppoFEV1 = 1.4 L	ppoFEV1 = 1.0 L (n.s.)

Suggested Threshold: ppoFEV1 = 40%

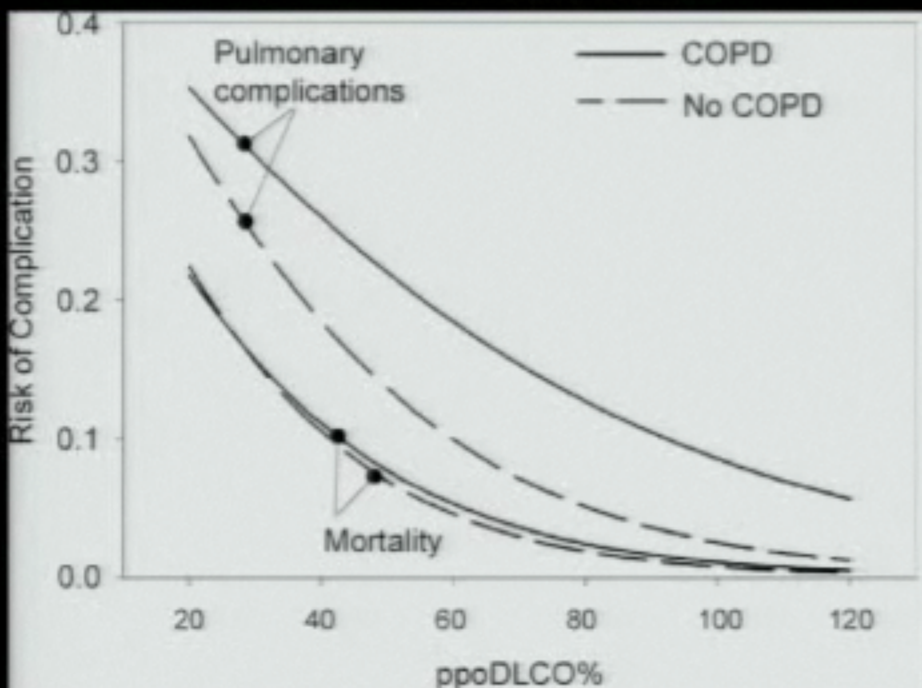
Win T, et al. Eur Respir J 2005, 28 : 594-9

Optimizing Selection of Patients for Major Lung Resection

- 376 patients, lobect. 284, pneumonect. 92
- mortal. 8%, complic's: resp. 20%, cardiac 23%
- predicted postoperative diffusing capacity for carbon monoxide (ppoDLCO%) best predictor
- little interrelationship between ppoDLCO% and ppoFEV1%

Ferguson MK. et al. J Thorac Cardiovasc Surg 109: 275. 1995

Diffusing Capacity Predicts Morbidity after Lung Resection



Ferguson MK, Vigneswaran WT. Ann Thorac Surg 2008, 85: 1158-64

Clinical Prediction Rule for Pulmonary Complications After Thoracic Surgery for Primary Lung Cancer

- ppoDLCO% most valid test (p<.0001)
- Risk Threshold ppoDLCO = 50%
- Preop. Chemotherapy (p=.02)
- Chemotherapy can decrease DLCO
- ppoFEV1% (p=.07)
- (no consistent exercise testing)

(n = 956)

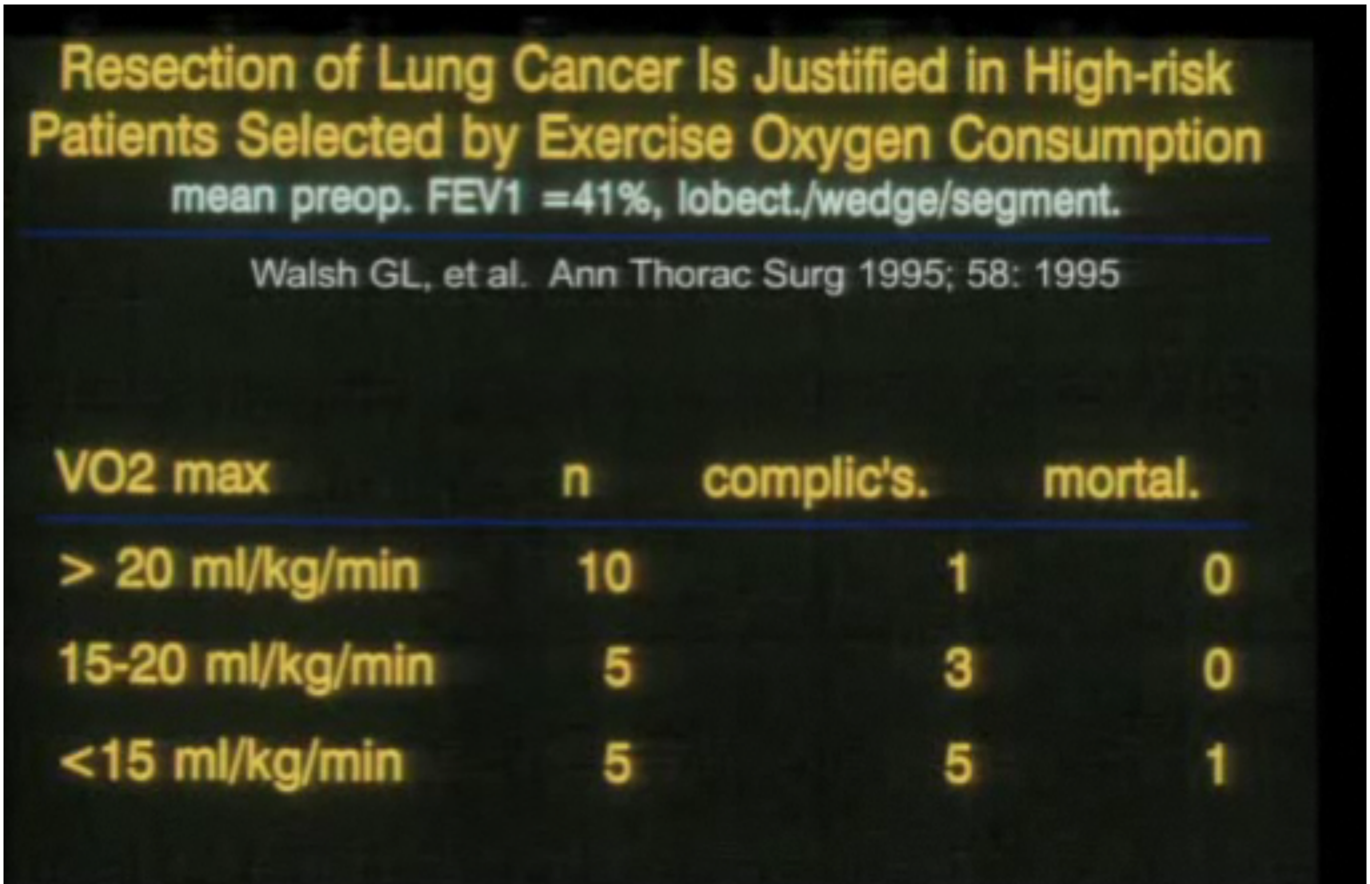
Amar D, et al. Anesth Analg 2010,110: 1343-8

National Emphysema Treatment Trial

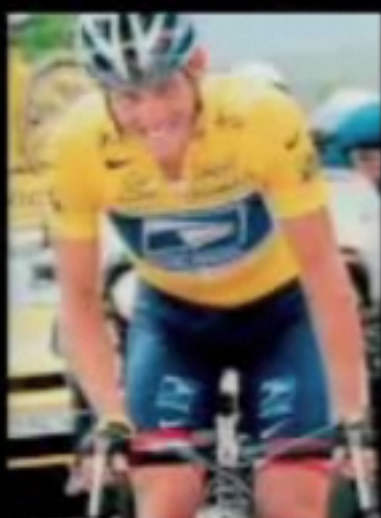
NEJM 348: 2059-78, 2003

Increased Risk of Death:

- Homogeneous Emphysema
- FEV1 < 20%
- DLCO < 20%



Impact of aerobic exercise capacity and procedure related factors in lung cancer surgery. Licker M, et al. Eur Resp J 2011; 37: 1189-98

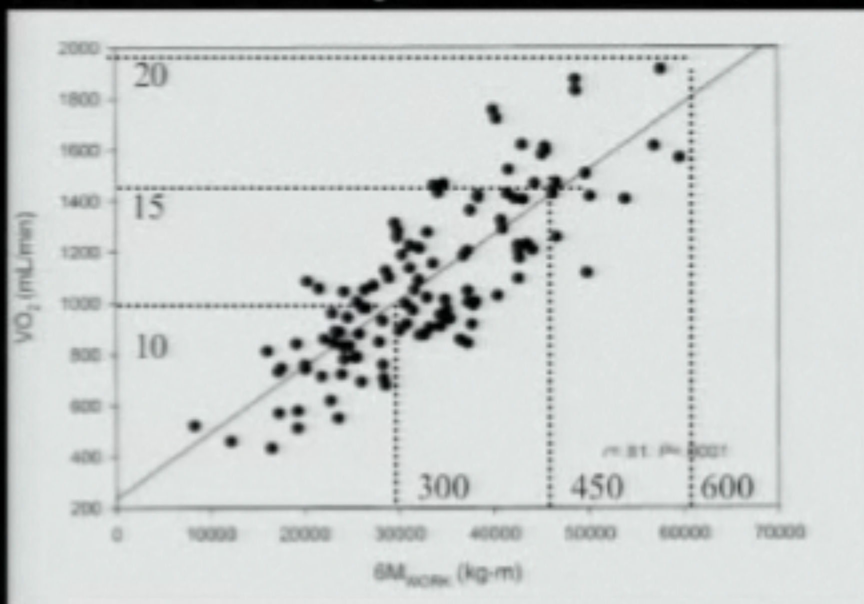


Lance Armstrong

- VO2 max = 85ml/kg/min
- J Appl Physiol 98: 2191, 2005

Predicting Oxygen Uptake for Men and Women With Moderate to Severe COPD

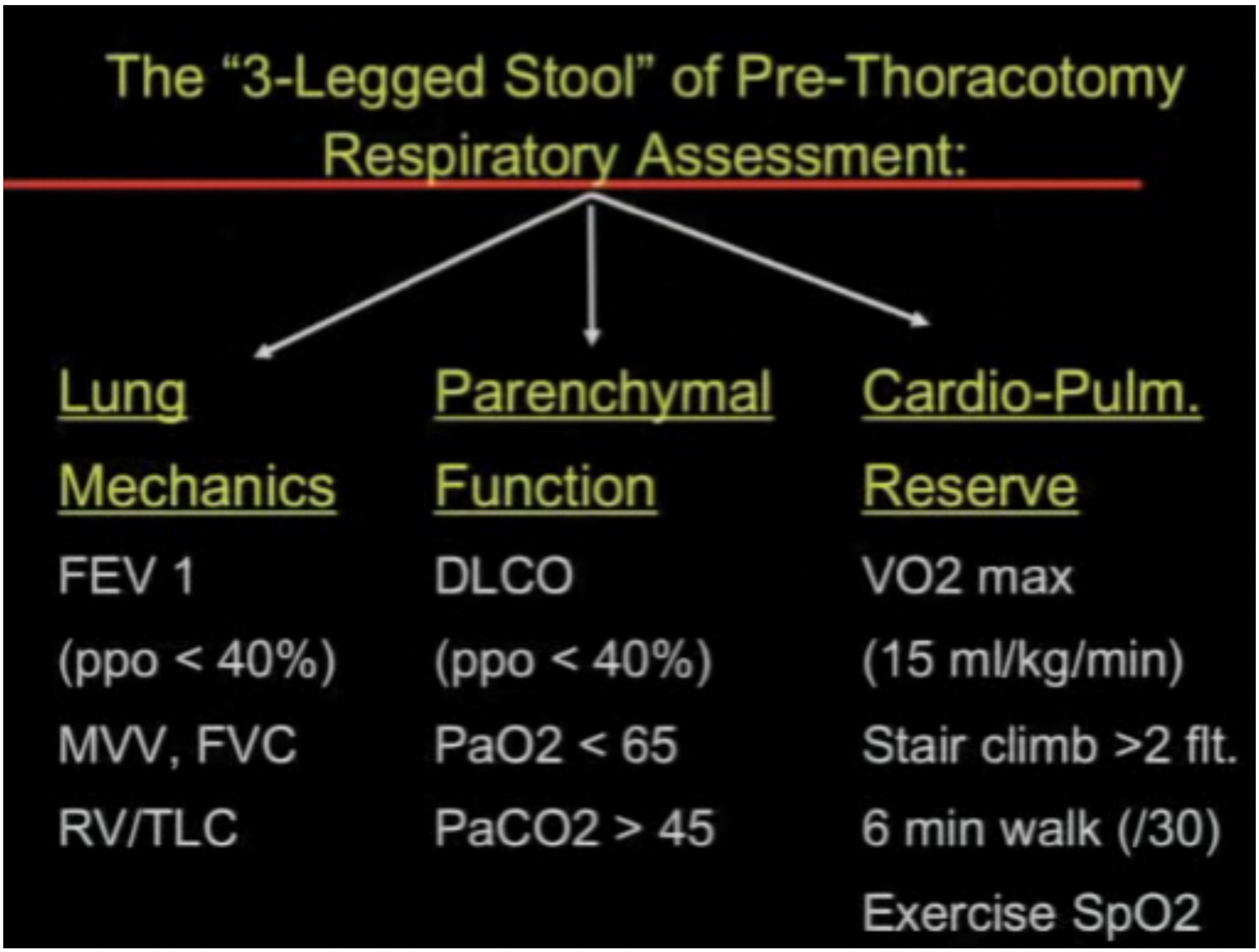
Carter R, et al. Arch Phys Med Rehab 2003, 84: 1158-64

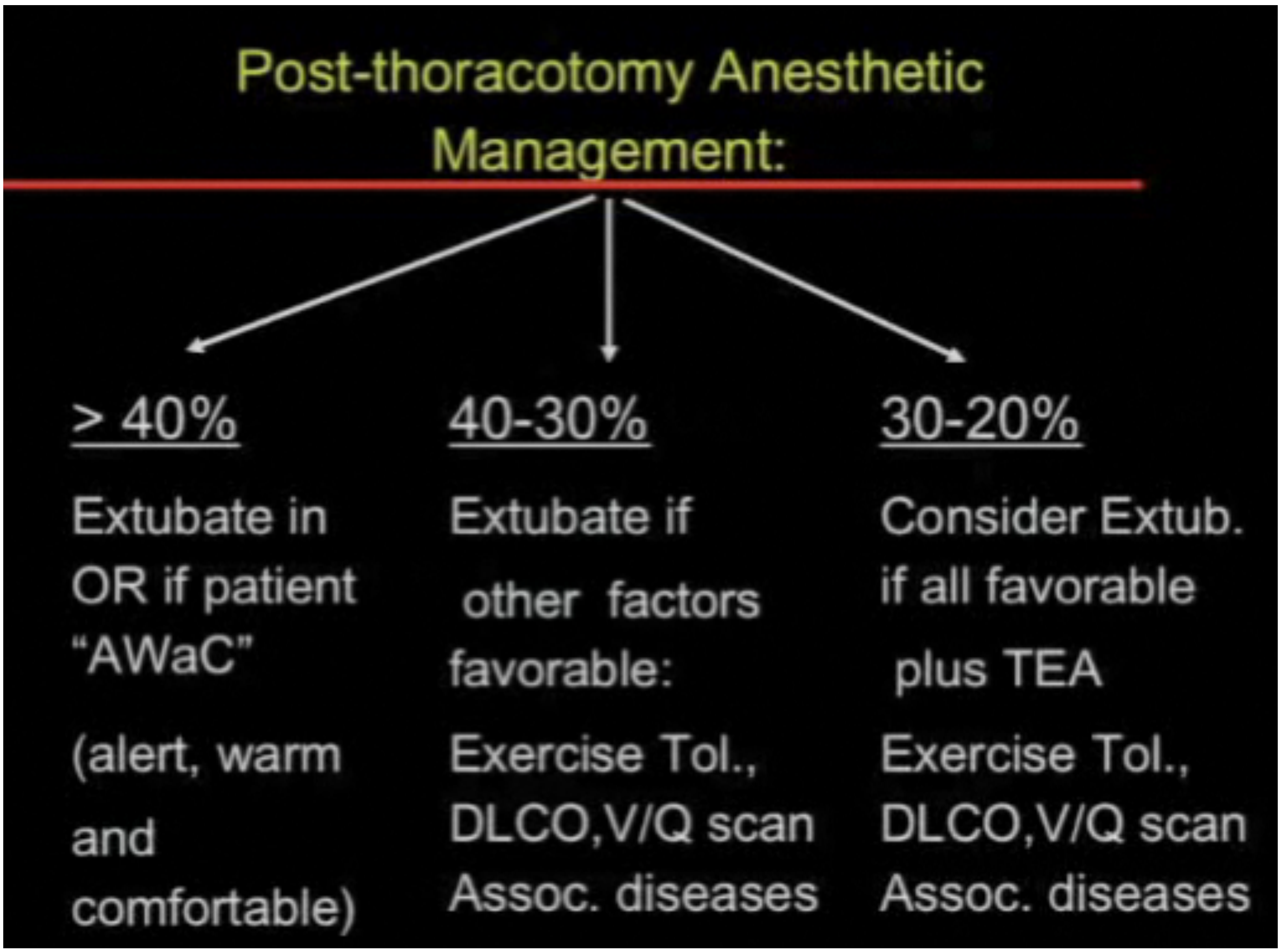


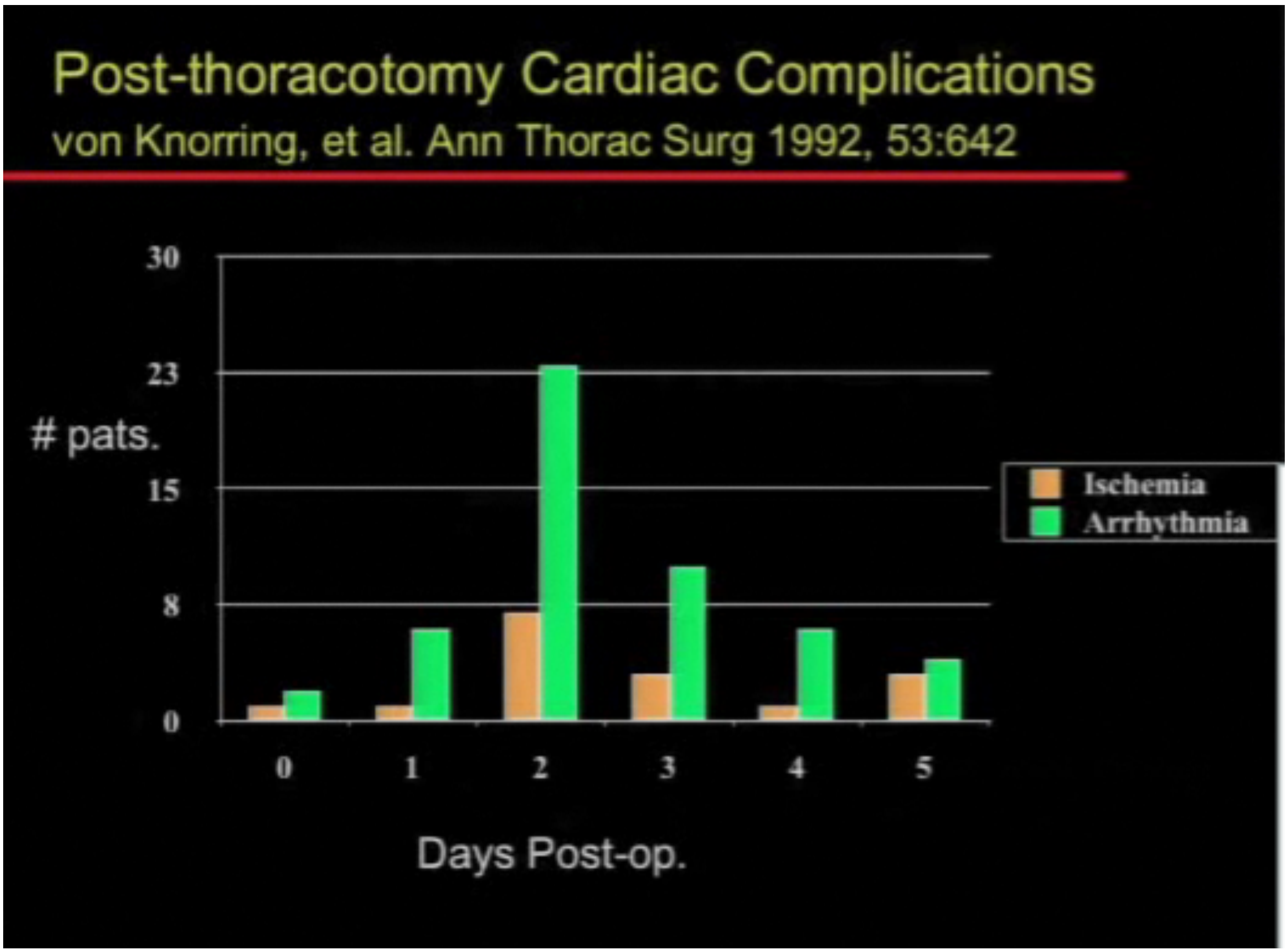
(100 kg.
Patient)

VO2max = 6MWTdist.(M)/30

(450M = 15 ml/kg/min)


The "3-Legged Stool" of Pre-Thoracotomy Respiratory Assessment:
Lung Mechanics
FEV 1
(ppo < 40%)
MVV, FVC
RV/TLC
Parenchymal Function
DLCO
(ppo < 40%)
PaO2 < 65
PaCO2 > 45
Cardio-Pulm. Reserve
VO2 max
(15 ml/kg/min)
Stair climb >2 flt.
6 min walk (/30)
Exercise SpO2


Post-thoracotomy Anesthetic Management:
> 40%
Extubate in OR if patient "AWaC" (alert, warm and comfortable)
40-30%
Extubate if other factors favorable:
Exercise Tol., DLCO,V/Q scan Assoc. diseases
30-20%
Consider Extub. if all favorable plus TEA
Exercise Tol., DLCO,V/Q scan Assoc. diseases

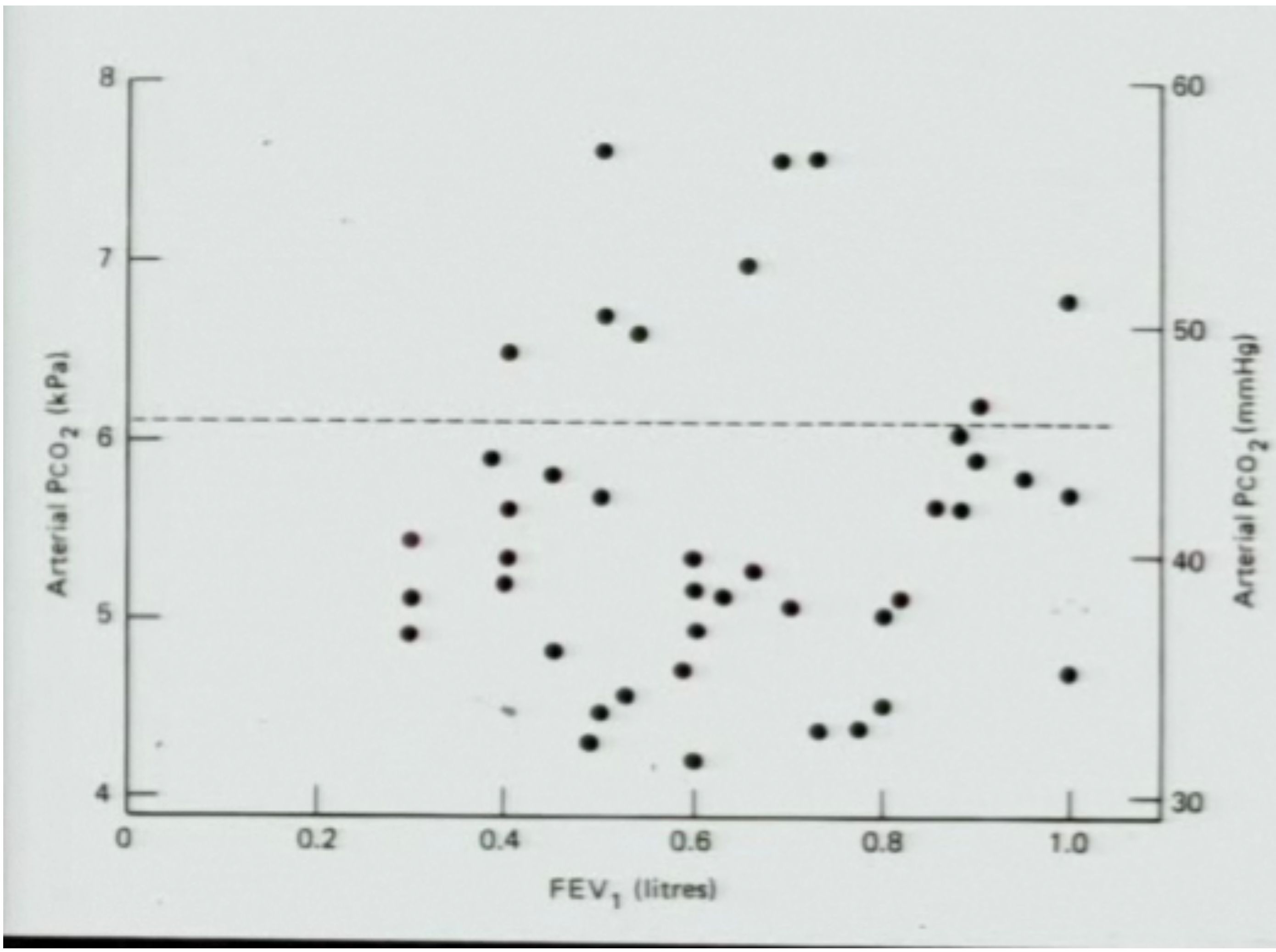

Post-thoracotomy Cardiac Complications
von Knorring, et al. Ann Thorac Surg 1992, 53:642
30
23
pats.
15
8
0
0
1
2
3
4
5
Days Post-op.
Ischemia
Arrhythmia

Stair Climbing Predicts Post-lobectomy Complications in the Elderly

n= 109, Age >70, mortal. 3%, morbid. 27%

- ppo FEV1 % p= 0.05
- Cardiac co-morbidity p= 0.02
- Stair climbing p= .002

Brunelli A, et al. Ann Thorac Surg 77: 226-70, 2004



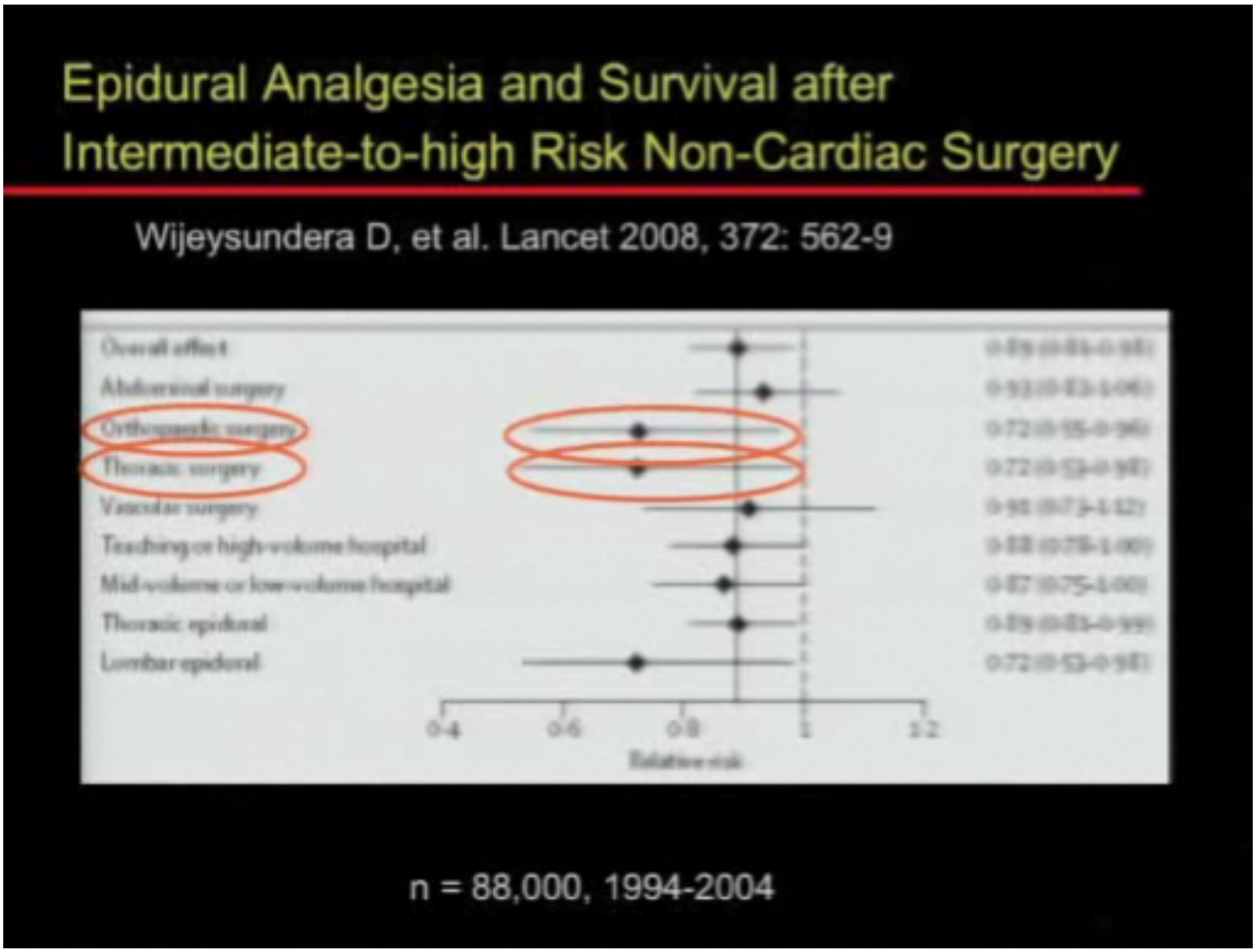
8
7
6
5
4
Arterial PCO_2 (kPa)
60
50
40
30
Arterial PCO_2 (mmHg)
0
0.2
0.4
0.6
0.8
1.0
FEV_1 (litres)

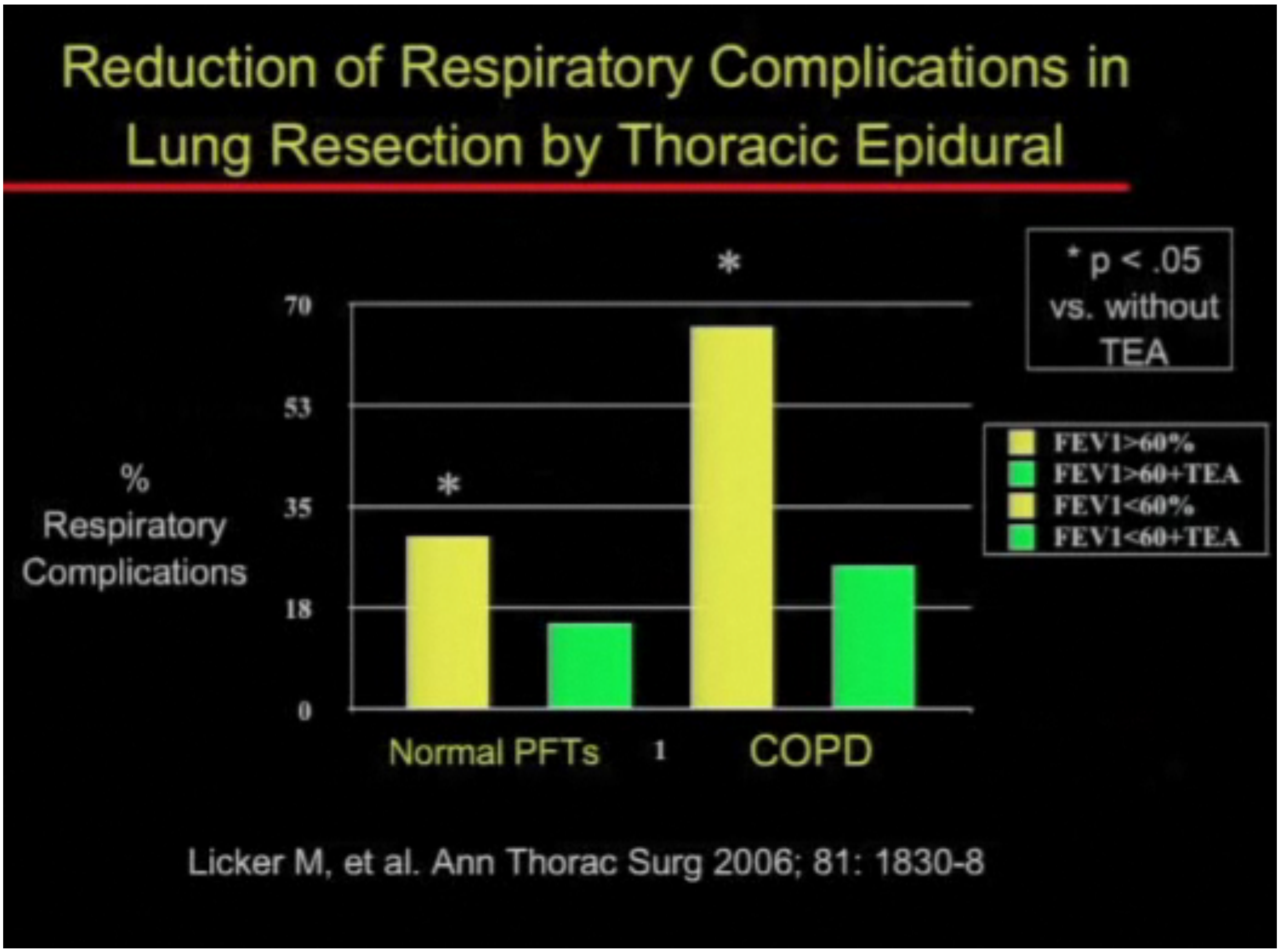
Pre-anesthetic Considerations for Lung Cancer (the "4 Ms")

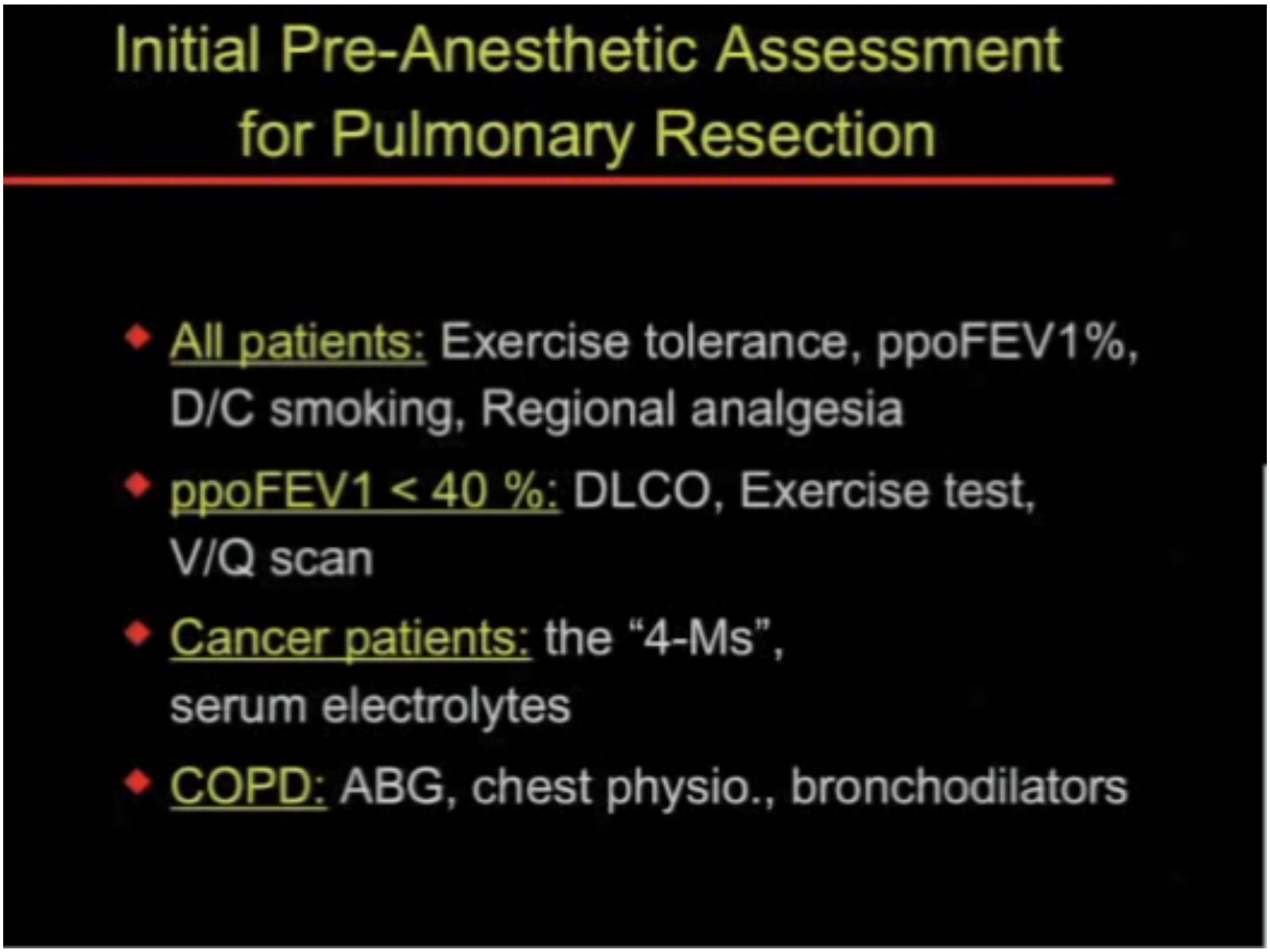
- Mass Effects
- Metabolic Effects: Na+, Ca++
  Eaton-Lambert
- Metastases
- Medications: Bleomycin, Cis-Platinum

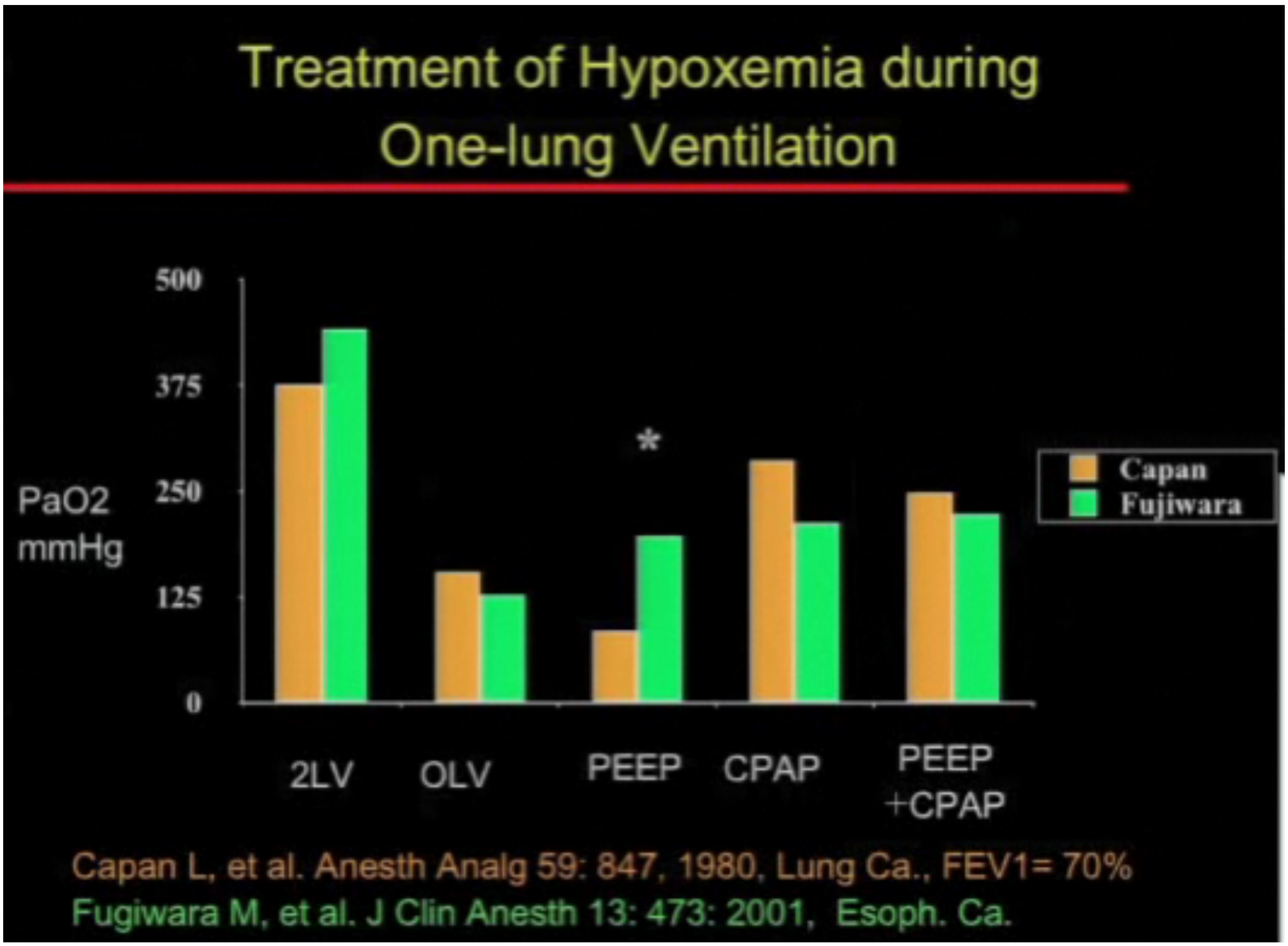
Evidence-Based Therapies that Improve Outcomes in Pulmonary Resection

- Chest Physiotherapy
  Warner DO, Anesthesiology 2000, 92: 1467
- Smoking Cessation
  Warner DO, Anesth Analg 2005; 101: 481-7
- Thoracic Epidural Analgesia


Epidural Analgesia and Survival after Intermediate-to-high Risk Non-Cardiac Surgery
Wijeysundera D, et al. Lancet 2008, 372: 562-9
Overall effect
Abdominal surgery
Orthopaedic surgery
Thoracic surgery
Vascular surgery
Teaching or high-volume hospital
Mid-volume or low-volume hospital
Thoracic epidural
Lumbar epidural
0·89 (0·81–0·98)
0·93 (0·83–1·06)
0·72 (0·55–0·96)
0·72 (0·53–0·98)
0·91 (0·73–1·12)
0·88 (0·78–1·00)
0·87 (0·75–1·00)
0·89 (0·81–0·99)
0·72 (0·53–0·98)
0·4
0·6
0·8
1
1·2
Relative risk
n = 88,000, 1994-2004


Reduction of Respiratory Complications in Lung Resection by Thoracic Epidural
* p < .05 vs. without TEA
70
53
35
18
0
% Respiratory Complications
*
*
FEV1>60%
FEV1>60+TEA
FEV1<60%
FEV1<60+TEA
Normal PFTs
1
COPD
Licker M, et al. Ann Thorac Surg 2006; 81: 1830-8


Initial Pre-Anesthetic Assessment for Pulmonary Resection
All patients: Exercise tolerance, ppoFEV1%, D/C smoking, Regional analgesia
ppoFEV1 < 40 %: DLCO, Exercise test, V/Q scan
Cancer patients: the “4-Ms”, serum electrolytes
COPD: ABG, chest physio., bronchodilators


Treatment of Hypoxemia during
One-lung Ventilation
500
375
250
125
0
PaO2
mmHg
*
Capan
Fujiwara
2LV
OLV
PEEP
CPAP
PEEP
+CPAP
Capan L, et al. Anesth Analg 59: 847, 1980, Lung Ca., FEV1= 70%
Fugiwara M, et al. J Clin Anesth 13: 473: 2001, Esoph. Ca.