

CHAPTER 1

PREOPERATIVE CARDIOPULMONARY FUNCTIONS AND OPERATION



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Advances in surgical techniques and anesthesiology increased operability of patients with comorbidities. Patients with comorbid conditions are prone to have higher preoperative and postoperative complications. The purpose of preoperative cardiopulmonary evaluation is to assess and reduce complication risks beforehand and to eliminate postoperative risk factors during postoperative period. Postoperative cardiopulmonary complications (POC) increase morbidity and mortality, prolong hospital stay and may require intensive care (1).

Correct preoperative assessment enables a patient to be operated with minimum risk. A thorough preoperative assessment of patients is shown to directly reduce delay or cancellation of operations (2-5). This assessment may also reveal previously unknown diseases or conditions, thus diminish risk of unexpected complications (6).

Pulmonary complications are detected more than cardiac complications in elective non-cardiac operations and these complications cause prolonged hospital stay (7). Postoperative pulmonary complication risk differs in thoracic and extrathoracic surgeries. Postoperative pulmonary complication risk for extrathoracic surgery is reported as 2-29%; whereas, it is 8-39% for thoracic surgery (8). The reason for this significant

difference is the various definitions of postoperative pulmonary complications. Postoperative pulmonary complications contribute to overall perioperative morbidity and mortality. National Surgery Quality Improvement Program (NSQIP) has shown that 6% of the 165,196 patient undergone abdominal surgery suffered from pulmonary complications (9). In a study with 1202 non-cardiac, nonthoracic surgeries, the presence of a pulmonary complication was shown to increase mortality, ICU admission and overall ICU stay (10).

Postoperative pulmonary complications are defined as fever, pulmonary signs and symptoms (cough, ronchus) or radiological changes in chest x-rays (atelecthesis, consolidation, pleural effusion) with clinical worsening and loss of function. Major postoperative pulmonary complications are (11);

- 1) Atelecthesis
- 2) Infection
- 3) Prolonged mechanical ventilation and respiratory failure
- 4) Acute exacerbation of chronic lung disease
- 5) Bronchospasm

Any patient undergoing major noncardiac surgery has a high risk for a cardiovascular incident. The risk is dependent on both the patient and the

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tient (99). Values more than 80% of the predicted is considered normal (100)

5) Ventilatory equivalents of carbon dioxide:

The ratio of VE to VCO₂ is known as ventilatory equivalent of carbon dioxide. Minute ventilation is regulated by the carbon dioxide produced, and hence, this ratio is quite constant throughout the performance of CPET. High values (≥ 34) at anerobic threshold is suggestive of gas exchange abnormality

6) **Oxygen desaturation** – Fall in oxygen saturation as measured by pulse oximetry is suggestive of diminished ability to increase oxygen transfer through alveolar capillary membrane during exercise. Desaturation of more than 4% is associated with increased rate of postoperative complications

7) **Cardiac indices** – Parameters such as peak heart rate achieved, arrhythmias noted, and electrocardiograph changes suggestive of ischemia should be noted. Underlying reason for inability to achieve target heart rate will help identifying cause of reduced exercise tolerance.

Systematic approach to preoperative evaluation of lung cancer is the key to favorable postoperative outcome. Surgical resection offers good long-term survival in case of lung cancer. Sublobar resections or nonsurgical treatment should be considered for a patient who is expected to become ventilator dependent postoperatively. Cardiopulmonary exercise testing provides a fair idea of the expected outcome in the postoperative period (101).

REFERENCES

- Lakshminarasimhachar A, Smetana GW. Preoperative evaluation: estimation of pulmonary risk. *Anesthesiol Clin* 2016;34:71–88.
- Fischer SP. Development and effectiveness of an anesthesia preoperative evaluation clinic in a teaching hospital. *Anesthesiology* 1996;85:196–206.
- Ferschl MB, Tung A, Sweitzer B, et al. Preoperative clinic visits reduce operating room cancellations and delays. *Anesthesiology* 2005;103:855–9.
- Van Klei WA, Moons KG, Rutten CL, et al. The effect of outpatient preoperative evaluation of hospital inpatients on cancellation of surgery and length of hospital stay. *Anesth Analg* 2002;94:644–9.
- Blitz JD, Kendale SM, Jain SK, et al. Preoperative evaluation clinic visit is associated with decreased risk of in-hospital postoperative mortality. *Anesthesiology* 2016;125:280–94.
- Selzer A, Sarkiss M. Preoperative Pulmonary Evaluation, *Med Clin North Am*. 2019 May;103(3):585–599. doi: 10.1016/j.mcna.2018.12.016.
- Smetana GW, Lawrence VA, Cornell JE. Preoperative pulmonary risk stratification for noncardiothoracic surgery: systematic review for American College of Physicians. *Ann Intern Med* 2006; 144:581–95.
- Bapojc S, Whitaker J, Schulz T, et al. Preoperative evaluation of the patient with pulmonary disease. *Chest* 2007;132:1637–45.
- Yang CK, Teng A, Lee DY, Rose K. Pulmonary complications after major abdominal surgery: National Surgical Quality Improvement Program analysis. *J Surg Res* 2015; 198:441.
- Fernandez-Bustamante A, Frenzl G, Sprung J, et al. Postoperative Pulmonary Complications, Early Mortality, and Hospital Stay Following Noncardiothoracic Surgery: A Multicenter Study by the Perioperative Research Network Investigators. *JAMA Surg* 2017; 152:157.
- Canet J, Mazo V. Postoperative pulmonary complications. *Miverna Anesteziol* 2010; 76:138
- Daniel John Doyle; Emily H. Garmon. American Society of Anesthesiologists Classification (ASA Class). Last Update: January 19, 2019. StatPearls
- O'Donohue W. Postoperative pulmonary complications. *Postgrad Med* 1992;91:167–75
- Hall JC, Tarala RA, Tappert J, Hall JL. Prevention of respiratory complications after abdominal surgery: a randomised clinical trial. *BMJ* 1996;312:148–52.
- Türk Toraks Derneği Preoperatif Uzlaşısı Raporu 2014
- Djokovic J L, Hedley- Whyte J. Prediction of outcome of surgery and anesthesia in patients over 80 . *JAMA* 1979; 242: 2301.
- McAlister FA, Khan NA, Straus SE, et al. Accuracy of the pre-operative assessment in predicting pulmonary risk after non-thoracic surgery. *Am J Respir Crit Care Med* 2003;167:741–4.
- Canet J, Gallart L, Gomar C, et al. Prediction of postoperative pulmonary complications in a population-based surgical cohort. *Anesthesiology* 2010; 113:1338
- Pasulka PS, Bistian BR, Benotti PN et al. The risk of surgery in obese patients. *Ann Intern Med* 1986; 104: 540–46
- Clavellina- Gaytan D, Velazquez- Fernandez D, Del-Villar E, et al. Evaluation of spirometric testing as a routine preoperative assessment in patients undergoing bariatric surgery. *Obes Surg* 2015; 25:530.
- Hall JC, Tarala MD, Hall JL, et al. A multivariate analysis of the risk of pulmonary complications after laparotomy. *Chest* 1991; 99: 923–27.
- Blouw EL, Rudolph AD, Narr BJ, et al. The frequency of respiratory failure in patients with morbid obesity undergoing gastric bypass. *AANA J* 2003; 71: 45–50.
- Barrera R, Shi W, Amar D, et al. Smoking and timing of cessation. Impact on pulmonary complications after thoracotomy. *Chest* 2005; 127:1977–83.

24. Wetterslev J, Hansen EG, Kamp-Jensen M, et al. PaO₂ during anaesthesia and years of smoking predict late postoperative hypoxaemia and complications after upper abdominal surgery in patients without preoperative cardiopulmonary dysfunction. *Acta Anaesthesiol Scand* 2000; 44:916.
25. Turan A, Mascha EJ, Roberman D, et al. Smoking and perioperative outcomes. *Anesthesiology* 2011;114:837–46.
26. Gronkjaer M, Eliassen M, Skov-Ettrup LS, et al. Preoperative smoking status and postoperative complication: a systematic review and meta-analysis. *Ann Surg* 2014; 259:52–71.
27. Schmid M, Sood A, Cambell L, et al. Impact of smoking on perioperative outcomes after major surgery. *Am J Surg* 2015; 210–221.
28. Angela Selzer, Mona Sarkiss. Preoperative Pulmonary Evaluation. *Med Clin N Am* 103 (2019) 585–599
29. Smetana GW. Preoperative pulmonary evaluation: Identifying and reducing risks for pulmonary complications. *Cleveland Clinic Journal of Medicine* 2006; 73:36–41.
30. Kroenke K, Lawrence VA, Theroux JF, et al. Postoperative complications after thoracic and major abdominal surgery in patients with and without obstructive lung disease. *Chest* 1993; 104:1445–51.
31. Çetinkaya E. Preoperatif Risk Faktörleri. İç: Zamnani A ed. *Perioperatif Pulmoner Değerlendirme*. İstanbul: Toraks Kitapları sayı 5; 2006; 1–6.
32. Gupta H, Ramanan B, Gupta PK, et al. Impact of COPD on postoperative outcomes: results from a national database. *Chest* 2013; 143: 1599.
33. Lawrence VA, Dhanda R, Hilsenbeck SG, Page CP. Risk of pulmonary complications after elective abdominal surgery. *Chest* 1996; 110: 744–50.
34. Fuster RG, JAM Argudo, Albarova OG, et al. Prognostic value of chronic obstructive pulmonary disease in coronary artery bypass grafting. *Eur J Cardiothorac Surg* 2006;29:202–9.
35. Global Initiative for Chronic Obstructive Lung Disease—Global strategy for the diagnosis, management and prevention of chronic obstructive pulmonary disease, 2019
36. Erdich T, Sadovnikoff N. Anesthesia for patients with severe chronic obstructive pulmonary disease. *Curr Opin Anaesthesiol* 2010;23:18–24.
37. Mujovic N, Mujovic N, Subotic D, et al. Preoperative pulmonary rehabilitation in patients with non-small cell cancer and chronic obstructive pulmonary disease. *Arch Med Sci* 2014;10(1):68–75.
38. Costescu F, Slinger P. Asthma. In: Sweitzer BJ, editor. *Preoperative assessment and management*. 3rd edition. Philadelphia: Wolters Kluwer; 2019. p. p171–4.
39. Alfillle PH, Shapiro L. The patient with a lung transplant for subsequent surgery. In: Sweitzer BJ, editor. *Preoperative assessment and management*. 3rd edition. Philadelphia: Wolters Kluwer; 2019. p. p190–3.
40. Warner DO, Warner MA, Barnes RD, et al. Perioperative respiratory complications in patients with asthma. *Anesthesiology* 1996; 85: 460–67
41. Woods BD, Sladen RN. Perioperative considerations for the patient with asthma and bronchospasm. *Br J Anaesth* 2009;103 (Suppl. 1):i57–i65.
42. Pein LC, Grammer LC, Patterson R. Minimal complications in a surgical population with severe asthma receiving prophylactic corticosteroids. *J Allergy Clin Immunol* 1998; 82: 696–700
43. Singh M, Liao P, Kobah S, et al. Proportion of surgical patients with undiagnosed obstructive sleep apnea. *Br J Anaesth* 2013;110(4):629–36.
44. Memtsoudis SG. The impact of sleep apnea on postoperative utilization of resources and adverse outcomes. *Anesth Analg* 2014;118(2):407–18.
45. Chung F, Memtsoudis SG, Ramachandran SK, et al. Society of Anesthesia and Sleep Medicine guidelines on preoperative screening and assessment of adult patients with obstructive sleep apnea. *Anesth Analg* 2016;123(2):452–73.
46. Price LC, Montani D, Jais X, et al. Noncardiothoracic, nonobstetric surgery in mild to-moderate pulmonary hypertension. *Eur Respir J* 2010; 35: 1294.
47. Meyer S, McLaughlin VV, Seyfarth HJ, et al. Outcomes of noncardiac, nonobstetric surgery in patients with PAH: an international prospective survey. *Eur Respir J* 2013; 41:1302.
48. Gouvea F, Gouvea G. Pulmonary hypertension. In: Sweitzer BJ, editor. *Preoperative assessment and management*. 3rd edition. Philadelphia: Wolters Kluwer; 2019. p. p139–42.
49. Lai HC, Wang KY, et al. Severe pulmonary hypertension complicates postoperative outcome of non-cardiac surgery. *Br J Anaesth* 2007; 99: 184.
50. Raina A, Humbert M. Risk assessment in pulmonary arterial hypertension. *Eur Respir Rev* 2016;25(142):390–8.
51. Pilkington SA, Taboada D, Martinez G. Pulmonary hypertension and its management in patients undergoing non-cardiac surgery. *Anaesthesia* 2015;70:56–70.
52. DeHoyos A, DeCamp M. Preoperative smoking cessation for lung resection patients. In: Ferguson MK, editor. *Difficult decision in thoracic surgery: an evidence-based approach*. 3rd edition. London: Springer-Verlag; 2014. p. 85–98.
53. Qaseem A, Snow V, Fitterman N, et al. Risk Assessment for and Strategies To Reduce Perioperative Pulmonary Complications for Patients Undergoing Noncardiothoracic Surgery: A Guideline from the American College of Physicians. *Ann Intern Med* 2006;144:575–80.
54. Kroenke K, Lawrence VA, Theroux JF, et al. Postoperative complications after thoracic and major abdominal surgery in patients with and without obstructive lung disease. *Chest* 1993;104:1445–51.
55. Trayner EM, Girish M, Gottlieb S, et al. Symptom limited stair climbing and the cardiopulmonary risk index as predictors of post operative pulmonary complications after high risk surgery A multicenter trial. *Am J Respir Crit Care Med* 1995;151:A292.
56. Arslan V, Barrera R, Ginsberg R, et al. Cardiopulmonary risk index (CPRI) does not predict complications after thoracic surgery. *Am J Respir Crit Care Med* 1996;153:A676.

57. Arozullah AM, Daley J, Henderson WG, Khuri SF. Multifactorial risk index for predicting postoperative respiratory failure in men after major noncardiac surgery. The National Veterans Administration Surgical Quality Improvement Program. *Ann Surg* 2000;232:242-53.
58. Brooks-Brunn JA. Predictors of postoperative pulmonary complications following abdominal surgery. *Chest* 1997; 111:564.
59. Moller AM, Maaloe R, Pederson T. Postoperative intensive care admittance: the role of tobacco smoking. *Acta Anaesthesiol Scand* 2001; 45:345.
60. Rezaigui S, Jayr C. Prevention of respiratory complications after abdominal surgery. *Ann Fr Anesth Reanim* 1996;15:623-46.
61. Coccoline F, Catena F, Pisano M, et al. Open versus laparoscopic cholecystectomy in acute cholecystitis. Systematic review and metaanalysis. *Int J Surg* 2015; 18:196
62. Brown SR, Goodfellow PB. Transverse versus midline incisions for abdominal surgery. *Cochrane Database Syst Rev* 2005;(4):CD005199.
63. McAlister FA, Khan NA, Straus SE, et al. Accuracy of the preoperative assessment in predicting pulmonary risk after nonthoracic surgery. *Am J Respir Crit Care Med* 2003; 167:741
64. Hedenstierna G, Edmark L. The effects of anesthesia and muscle paralysis on the respiratory system. *Intensive Care Med* 2005;31:1327-35
65. Hausman MS Jr, Jewell ES, Engoren M. Regional versus general anesthesia in surgical patients with chronic obstructive pulmonary disease: does avoiding general anesthesia reduce the risk of postoperative complications? *Anesth Analg* 2015; 120:1405
66. Saied NN, Helwani MA, Weavind LM, et al. Effect of anaesthesia type on postoperative mortality and morbidities; a matched analysis of the NSQIP database *Br J Anaesth* 2017; 118:105
67. Berg H, Roed J, Viby-Mogensen J, et al. Residual neuromuscular block is a risk factor for postoperative pulmonary complications. A prospective pulmonary complications after atracurium, vecuronium and pancuronium. *Acta Anaesthesiol Scand.* 1997; 41:1095.
68. Murphy GS, Szokol JW, Marymont JH, et al. Residual neuromuscular blockade and critical respiratory events in the postanesthesia care unit. *Anesth Analg* 2008; 107:130
69. Zamani A. Preoperative Pulmonary Assessment, TTS Publishing. 2006: 7-16
70. Sweitze BJ, Smetana GW. Identification and evaluation of the patient with lung disease. *Anesthesiology Clin* 2009;27:673-86.
71. Gass GD, Olsen GN. Preoperative pulmonary function testing to predict postoperative morbidity and mortality. *Chest* 1986;89:127-35.
72. Smentana GW. Preoperative pulmonary evaluation. *N Engl J Med* 1999;340:937-44.
73. Wong DH, Weber EC, Schell MJ. Factors associated with postoperative pulmonary complications in patients with severe chronic obstructive pulmonary disease. *Anesth Analg* 1995;80:276-84.
74. Khan MA, Hussain SF. Preoperative pulmonary evaluation. *J Ayub Med Coll Abbottabad* 2005;17:82-6.
75. Hodkgin J. Prognosis in chronic obstructive pulmonary disease. *Clin Chest Med* 1990;3:555-69.
76. Powell NB, Riley RW, Guilleminault C, Murcia GN. Obstructive sleep apnea, continuous positive airway pressure, and surgery. *Otolaryngol Head Neck Surg* 1988;99:362-9.
77. Doyle RL. Assessing and modifying the risk of postoperative pulmonary complications. *Chest* 1999;115:77-81.
78. Kearny DJ, Lee TH, Reilly JJ, et al. Assessment of operative risk in patients undergoing lung resection: importance of predicted pulmonary function. *Chest* 1994;105:753-9.
79. Expert Panel on Thoracic Imaging, McComb BL, Chung JH, et al. ACR appropriateness criteria routine chest radiography. *J Thorac Imaging* 2016;31(2):w13-5.
80. Pourier P, Alpert MA, Fleisher LA, et al. Cardiovascular evaluation and management of severely obese patients undergoing surgery: a science advisory from the American Heart Association. *Circulation* 2009;120:86-95.
81. Vintch JRE, Hansen JE. Preoperative evaluation and relation to postoperative complications. In: Crapo JD, Glassroth J, Karlinsky J, King TE (eds). *Baum's Textbook of Pulmonary Disease*. 7th ed. Lippincott Williams&Wilkins 2004:113-32.
82. Lee TH, Marcantonio ER, Mangione CM, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. *Circulation* 1999;100:1043-9.
83. Cohn SL. Preoperative evaluation for noncardiac surgery. *Ann Intern Med* 2016; 165(11): ITC81-96.
84. Gupta PK, Gupta H, Sundaram A, et al. Development and validation of a risk calculator for prediction of cardiac risk after surgery. *Circulation* 2011; 124:381-7.
85. Bilimoria KY, Liu Y, Paruch JL, et al. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons. *J Am Coll Surg* 2013;217(5):833-42.
86. Liu Y, Cohen ME, Hall BL, et al. Evaluation and enhancement of calibration in the American College of Surgeons NSQIP surgical risk calculator. *J Am Coll Surg* 2016;223(2):231-9.
87. Gupta H, Gupta PK, Fang X, et al. Development and validation of a risk calculator predicting respiratory failure. *Chest* 2011;140:1207-15.
88. Gupta H, Gupta PK, Schuller D, et al. Development and validation of a risk calculator for predicting postoperative pneumonia. *Mayo Clin Proc* 2013;88:1241-9.
89. Datta T, Lahiri B. Preoperative evaluation of patients undergoing lung resection surgery. *Chest* 2003; 123:2096-103
90. Baser S, Shannon VR, Eapen GA, et al. Pulmonary dysfunction as a major cause of inoperability among patients with non-small-cell lung cancer. *Clin Lung Cancer* 2006;7:344-9.
91. Meguid RA, Brooke BS, Chang DC, et al. Are surgical outcomes for lung cancer resections improved at teaching hospitals? *Ann Thorac Surg* 2008;85:1015-25.

92. Memtsoudis SG, Besculides MC, Zellos L, Patil N, Rogers SO. Trends in lung surgery: United States 1988 to 2002. *Chest* 2006;130:1462-70
93. Gaensler EA, Cugell DW, Lindgren I, et al. The role of pulmonary insufficiency in mortality and invalidism following surgery for pulmonary tuberculosis. *J Thorac Surg* 1955;29:163-87.
94. Miller JI, Grossman GD, Hatcher CR. Pulmonary function test criteria for operability and pulmonary resection. *Surg Gynecol Obstet* 1981;153:893-5.
95. Liptay MJ, Basu S, Hoaglin MC, et al. Diffusion lung capacity for carbon monoxide (DLCO) is an independent prognostic factor for long-term survival after curative lung resection for cancer. *J Surg Oncol* 2009;100:703-7.
96. Yuan N, Fraire JA, Margetis MM, Skaggs DL, Tolo VT, Keens TG. The effect of scoliosis surgery on lung function in the immediate postoperative period. *Spine*. 2005;30:2182-5
97. Berger KI, Addrizzo-Harris DJ. Physiologic Evaluation of the Patient With Lung Cancer Being Considered for Resectional Surgery Diagnosis and Management of Lung Cancer, 3rd ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest*. 2013;143(Suppl):e166S-90S. [PubMed: 23649437]
98. Loewen GM, Watson D, Kohman L, Herndon JE, 2nd, Shennib H, Kernstine K, et al. Cancer and Leukemia Group B. Preoperative exercise Vo2 measurement for lung resection candidates: Results of Cancer and Leukemia Group B Protocol 9238. *J Thorac Oncol*. 2007;2:619-25.
99. Balady GJ, Arena R, Sietsema K, Myers J, Coke L, Fletcher GF, et al. Clinician's guide to cardiopulmonary exercise testing in adults: A scientific statement from the American Heart Association. *Circulation*. 2010;122:191-225.
100. Joint Statement of the American Thoracic Society (ATS) and the American College of Chest Physicians (ACCP). ATS/ACCP statement on cardiopulmonary exercise testing. *Am J Respir Crit Care Med*. 2003;167:211-77.
101. Preeti Mittal Roy Preoperative pulmonary evaluation for lung resection. *J Anaesthesiol Clin Pharmacol*. 2018 Jul-Sep;34(3): 296-300