호흡기 환자의 수술 전 평가하기

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Definition of PPCs

- Definitions of postoperative pulmonary complications (PPCs) have varied widely.

- Conditions either to prolong the hospital stay or to contribute to morbidity and mortality

Arch Intern Med 1992;152:967-971
Acta Anaesthesiol Scand 1990;34:144-155
Chest 1979;76:123-129

Various definition of PPCs

Outcome measure	EPCO definitions (identical set used by Canet and colleagues[4] and subsequent studies)[5 6]	Other published definitions
Respiratory infection	Antibiotics for suspected infection with one or more of the following: new or changed sputum, new or changed lung opacities, fever, white blood cell count $>12 \times 10^9$ litre^{-1}	Two or more of the following for >48 h: new cough/sputum production, physical findings compatible with pneumonia, fever >38 °C, and new infiltrate on CXR[7]
Respiratory failure	Postoperative Pa_{O_2} <8 kPa (60 mm Hg) on room air, a Pa_{O_2}:FI_{O_2} ratio <40 kPa (300 mm Hg), or arterial oxyhaemoglobin saturation measured with pulse oximetry <90% and requiring oxygen therapy	Ventilator dependence for >1 postoperative day or re-intubation[8 9] Need for postoperative mechanical ventilation >48 h[10–13] Unplanned re-intubation because of respiratory distress, hypoxia, hypercarbia, or respiratory acidosis within 30 days of surgery[10 11 13–15] Re-intubation within 3 days requiring mechanical ventilation[16] Postoperative acute lung injury[17] ARDS[17–19] Requiring mechanical ventilation within 7 days of surgery[20 21] Requiring NIV[22]
Pleural effusion	CXR with blunting of costophrenic angle, loss of sharp silhouette of the ipsilateral hemidiaphragm in upright position, displacement of adjacent anatomical structures, or (in supine position) hazy opacity in one hemithorax with preserved vascular shadows	Pleural effusion requiring thoracocentesis[8 9 20]
Atelectasis	Lung opacification with mediastinal shift, hilum or hemidiaphragm shift towards the affected area, with compensatory hyperinflation in adjacent non-atelectatic lung	Requiring bronchoscopic intervention[20] Major atelectasis (one or more pulmonary segments)[23]
Pneumothorax	Air in the pleural space with no vascular bed surrounding the visceral pleura	Pneumothorax requiring thoracocentesis[20 22]
Bronchospasm	Newly detected expiratory wheeze treated with bronchodilators	Clinical diagnosis resulting in change in therapy[89] Refractory wheeze requiring parenteral drugs in addition to preoperative regimen[24]
Aspiration pneumonitis	Acute lung injury after inhalation of regurgitated gastric contents	
Pneumonia	CXR with at least one of the following: infiltrate, consolidation, cavitation;plus at least one of the following: fever >38 °C with no other cause, white cell count <4 or $>12 \times 10^9$ litre^{-1}, >70 yr of age with altered mental status with no other cause;-plus at least two of the following: new purulent/changed sputum, increased secretions/suctioning, new/worse cough/dyspnoea/tachypnoea, rales/bronchial breath sounds, worsening gas exchange	Radiographic change and antibiotics[89] Antibiotics with new/changed sputum or radiographic change or fever or increased white cell count >12 000 μl^{-1} [4] Two or more of the following for ≥2 consecutive days: new cough/sputum production, examination compatible with pneumonia, temperature >38 °C, and radiographic change[7 23] New or progressive infiltrate on CXR or crackles or dullness on percussion and any of the following: new purulent/changed sputum, positive blood cultures, isolation of pathogen from sputum[20 25] Positive sputum culture or infiltrate on CXR, and diagnosis of pneumonia or pneumonitis[18] New infiltrate on CXR plus fever, leucocytosis, and positive sputum Gram stain/culture[24]
ARDS		Ventilated, bilateral infiltrates on CXR, Pa_{O_2}:FI_{O_2} ≤300, minimal evidence of left atrial fluid overload within 7 days of surgery[19]
Tracheobronchitis		Purulent sputum with normal chest radiograph, no i.v. antibiotics[8 9]

Br J Anaesth. 2017 Mar 1;118(3):317-334.

Types of PPCs

- Important pulmonary complications
  - Pneumonia
  - Respiratory failure with prolonged mechanical ventilation
  - Bronchospasm
  - Atelectasis
  - Exacerbation of underlying chronic lung disease
  - Pulmonary edema
  - Death

N Engl J Med 1999; 340:937-944.

Severity of PPCs

Table 1 Grading of postoperative cardiopulmonary complications

	Diagnostic criteria	Grade I	Grade II	Grade III	Grade IV
					cardiac output
Pulmonary					
– Atelectasis	Chest-X rays, CT-scan, treatment	+ chest physiotherapy	+ CPAP	+ bronchial fibroscopy	
– Bronchopneumonia	Temperature, WBC count,bacteriology, treatment		+ antibiotics, on the ward	+ antibiotics and supportive respiratory treatment	+ respiratory failure
– Hypoxemia	SpO_2, PaO_2, A-aDO_2, PaO_2/FIO_2, chest X-rays treatment	+ oxygen therapy	+ oxygen therapy	PaO_2/FIO_2 < 220 + NIV ALI/ARDS	PaO_2/FIO_2 < 220 + intubation, mechanical ventilation,ALI/ARDS
– Respiratory failure	Need for ventilatory support			+ NIV	intubation, mechanical ventilation
– Bronchopleural fistula	bronchoscopy, treatment		+ endoscopic treatment	+ surgical closure, empyema	
– Pleural effusion	chest X-rays, drainage	mild	+ thoracic drainage		

Int J Chron Obstruct Pulmon Dis. 2007;2(4):493-515.

Incidence of PPCs

Study	Year	Design	PPCs	Sample size	PPC incidence (%)	Mortality rate with PPC (%)	Operative specialty
Canet and colleagues[29]	2015	Secondary analysis of 'PERISCOPE' Prospective multi-centre cohort; evaluating PPCs	RF	5384	4.2	10.3 (in hospital)	Multi-specialty elective and emergency, including abdominal, vascular, cardiac, and thoracic
Mazo and colleagues[6]	2014	'PERISCOPE' Prospective multicentre cohort; external validation of 'ARISCAT'	As per EPCO	5099	7.9	8.3 (in hospital)	Multi-specialty elective and emergency, including abdominal, vascular, cardiac, and thoracic
Canet and colleagues[4]	2010	'ARISCAT' Prospective multicentre cohort	As per EPCO	2464	5.0	19.5 (30 day) 24.4 (90 day)	Multi-specialty elective and emergency, including abdominal, vascular, cardiac, and thoracic
Scholes and colleagues[32]	2009	Prospective multi-centre cohort	More than four of the following: i. collapse/consolidation on CXR; ii. Sp_{O_2} <90%; iii. abnormal sputum production; iv. positive sputum culture; v. leucocytosis; vi. abnormal auscultation; or vii. physician's diagnosis	268	13.0	Not stated	Upper abdominal
McAlister and colleagues[20]	2005	Prospective single-centre cohort	RF, pneumonia, atelectasis, pneumothorax, pleural effusion	1055	2.7	Not stated	Multi-specialty (non-thoracic) elective, including abdominal
Yang and colleagues[12]	2015	Retrospective analysis of multi-centre prospective cohort (not specific to PPCs)	Pneumonia, UPI, or RF	165 196	5.8	Not stated	Elective major abdominal (non-vascular)
Jeong and colleagues[5]	2014	Retrospective single-centre analysis of prospectively collected cohort regarding PPC risk	As per EPCO	2059	6.8	Not stated	Multi-specialty elective and emergency, including abdominal (open and laparoscopic), vascular, cardiac, and thoracic
Blum and colleagues[19]	2013	Retrospective single-centre cohort	ARDS	50 367	0.2	27.0 (90 day)	Multi-specialty (non-cardiothoracic) elective and emergency, including abdominal
Brueckmann and colleagues[16]	2013	Retrospective single-centre cohort	UPI	33 769	0.43	16.0	Multi-specialty elective and emergency, including abdominal, vascular, cardiac, and thoracic
Gupta and colleagues[13]	2013	Retrospective analysis of multi-centre prospective cohort (not specific to PPCs)	Pneumonia	211 410	1.8	17.0 (30 day)	Multi-specialty elective and emergency, including abdominal, vascular, cardiac, and thoracic
Li and colleagues[18]	2013	Retrospective single-centre cohort	Pneumonia, pulmonary oedema, atelectasis, ARDS, pleural effusion	316	18.9	Not specific to PPC	Elective and emergency infrarenal AAA
Hua and colleagues[14]	2012	Retrospective analysis of multi-centre prospective cohort (not specific to PPCs)	UPI	231 548	1.9	28.0 (30 day)	Multi-specialty elective and emergency, including major abdominal, vascular (open and EVAR) cardiac, and thoracic
Kor and colleagues[17]	2011	Retrospective analysis of prospective single-centre cohort evaluating intraoperative ventilator settings and ALI	ALI/ARDS	4366	2.6	14.2	Multi-specialty elective, including abdominal (open and laparoscopic), vascular, cardiac, and thoracic
Gupta and colleagues[11]	2011	Retrospective analysis of multi-centre prospective cohort (not specific to PPCs)	RF, UPI	211 410	2.6	25.6 (30 day)	Multi-specialty elective and emergency, including abdominal, vascular, cardiac, and thoracic
Ramachandran and colleagues[15]	2011	Retrospective analysis of multi-centre prospective cohort (not specific to PPCs)	UPI	222 094	0.9	9.7 (low-risk group), 30.6 (high-risk group)	Elective multi-specialty (non-cardiac)
Smith and colleagues[23]	2010	Retrospective single-centre cohort	Pneumonia, acute bronchitis, atelectasis, exacerbation of pre-existing lung disease, RF, PE	329	7.0	16.0 (30 day)	Elective and emergency laparotomy, including AAA
Johnson and colleagues[33]	2007	Retrospective analysis of multi-centre prospective cohort (non-specific to PPCs)	RF, UPI	180 359	3.0	26.5 (30 day)	Elective and emergency major vascular and general
Arozullah and colleagues[25]	2001	Retrospective analysis of multi-centre prospective cohort (non-specific to PPCs)	Pneumonia	160 805	1.5	21 (30 day)	Multi-specialty (non-cardiac), including abdominal, vascular, and thoracic
Arozullah and colleagues[34]	2000	Retrospective analysis of multi-centre prospective cohort (non-specific to PPCs)	RF	81 719	3.4	27 (30 day)	Multi-specialty (non-cardiac), including abdominal, vascular, and thoracic

- The incidence of PPCs in major surgery ranges from <1 to 23%.
- One in five patients (14–30%) who have a PPC will die within 30 days of major surgery compared with 0.2–3% without a PPC

British Journal of Anaesthesia, 118 (3): 317–34 (2017)

Risk factors of PPCs

TABLE 1. POTENTIAL PATIENT-RELATED RISK FACTORS FOR POSTOPERATIVE PULMONARY COMPLICATIONS.

POTENTIAL RISK FACTOR*	TYPE OF SURGERY	STUDY	INCIDENCE OF PULMONARY COMPLICATIONS		UNADJUSTED RELATIVE RISK ASSOCIATED WITH FACTOR
			WHEN FACTOR WAS PRESENT	WHEN FACTOR WAS ABSENT	
			percent		
Smoking	Coronary bypass	Warner et al.[7]	39	11	3.4
	Abdominal	Wightman,[3] Morton,[8] Brooks-Brunn[9]	15–46	6–21	1.4–4.3
ASA class >II	Unselected	Wolters et al.[10]	26	16	1.7
	Thoracic or abdominal	Brooks-Brunn,[9] Kroenke et al.,[11] Hall et al.,[12] Garibaldi et al.[13]	26–44	13–18	1.5–3.2
Age >70 yr	Unselected	Wightman,[3] Pedersen[14]	9–17	4–9	1.9–2.4
	Thoracic or abdominal	Garibaldi et al.,[13] Thomas et al.,[15] Calligaro et al.[16]	17–22	12–21	0.9–1.9
Obesity	Unselected	Wightman[3]	11	9	1.3
	Thoracic or abdominal	Brooks-Brunn,[9] Hall et al.,[12] Garibaldi et al.,[13] Moulton et al.,[17] Dales et al.[18]	19–36	17–27	0.8–1.7
COPD	Unselected	Wightman,[3] Pedersen et al.,[5] Tarhan et al.[19]	6–26	2–8	2.7–3.6
	Thoracic or abdominal	Kroenke et al.[11]	18	4	4.7

N Engl J Med 1999; 340:937-944

Risk factors of PPCs

Factor	Strength of Recommendation†	Odds Ratio‡
Potential patient-related risk factor		
Advanced age	A	2.09–3.04
ASA class ≥ II	A	2.55–4.87
CHF	A	2.93
Functionally dependent	A	1.65–2.51
COPD	A	1.79
Weight loss	B	1.62
Impaired sensorium	B	1.39
Cigarette use	B	1.26
Alcohol use	B	1.21
Abnormal findings on chest examination	B	NA
Diabetes	C	
Obesity	D	
Asthma	D	
Obstructive sleep apnea	I	
Corticosteroid use	I	
HIV infection	I	
Arrhythmia	I	
Poor exercise capacity	I	

Ann Intern Med. 2006;144:581-595

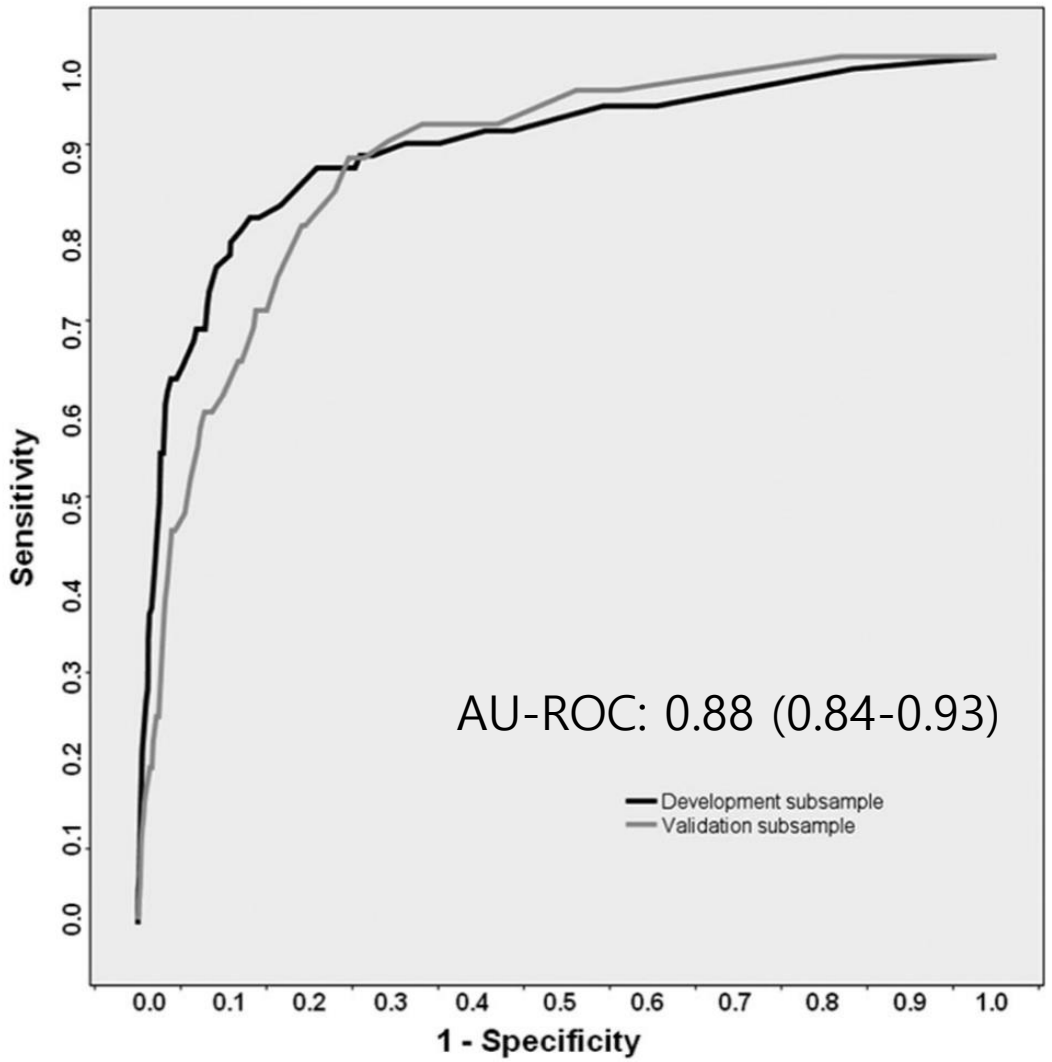
Risk factors of PPCs

Potential procedure-related risk factor		
Aortic aneurysm repair	A	6.90
Thoracic surgery	A	4.24
Abdominal surgery	A	3.01
Upper abdominal surgery	A	2.91
Neurosurgery	A	2.53
Prolonged surgery	A	2.26
Head and neck surgery	A	2.21
Emergency surgery	A	2.21
Vascular surgery	A	2.10
General anesthesia	A	1.83
Perioperative transfusion	B	1.47
Hip surgery	D	
Gynecologic or urologic surgery	D	
Esophageal surgery	I	
Laboratory tests		
Albumin level < 35 g/L	A	2.53
Chest radiography	B	4.81
BUN level > 7.5 mmol/L (>21 mg/dL)	B	NA
Spirometry	I	

Ann Intern Med. 2006;144:581-595

Predictive factors of PPCs

	Multivariate Analysis OR (95% CI) n = 1,624*	β Coefficient
Age, yr		
≤50	1	
51–80	1.4 (0.6–3.3)	0.331
>80	5.1 (1.9–13.3)	1.619
Preoperative Spo_2, %		
≥96	1	
91–95	2.2 (1.2–4.2)	0.802
≤90	10.7 (4.1–28.1)	2.375
Respiratory infection in the last month	5.5 (2.6–11.5)	1.698
Preoperative anemia (≤10 g/dl)	3.0 (1.4–6.5)	1.105
Surgical incision		
Peripheral	1	
Upper abdominal	4.4 (2.3–8.5)	1.480
Intrathoracic	11.4 (4.9–26.0)	2.431
Duration of surgery, h		
≤2	1	
>2 to 3	4.9 (2.4–10.1)	1.593
>3	9.7 (4.7–19.9)	2.268
Emergency procedure	2.2 (1.0–4.5)	0.768



Anesthesiology. 2010 Dec;113(6):1338-50.

Modifiable factors of PPCs

Patient factors	Procedure factors	Laboratory testing
Non-modifiable	**Non-modifiable**	Urea >7.5 mmol litre^{-1} [10 25]
Age [4–7 10 13 14 18 20 24 25 27 33 36]	Type of surgery: [4–7 10–13 15–18 23 25 27 29]	Increased creatinine [33]
Male sex [12 19 33]	• upper abdominal	Abnormal liver function tests [15]
ASA ≥II [5 11–14 16 19 27 33]	• AAA	Low preoperative oxygen saturation [4 6 29]
Functional dependence (frailty) [10–13 25 27 34 36]	• Thoracic	'Positive cough test' [20]
Acute respiratory infection (within 1 month) [4 6]	• Neurosurgery	Abnormal preoperative CXR [9 27]
Impaired cognition [7]	• head and neck	Preoperative anaemia (<100 g litre^{-1}) [4 6]
Impaired sensorium [25]	• vascular	Low albumin [5 10 27]
Cerebrovascular accident [25]	Emergency (*vs* elective) [4–6 10 11 16 18 19 23 25 29 33 36]	Predicted maximal oxygen uptake [32]
Malignancy [7 15]	Duration of procedure [6 12 14 20 22 27 29 32]	FEV_1:FVC <0.7 and FEV_1 <80% of predicted [5]
Weight loss >10% (within 6 months) [15 25]	Re-operation [18 23 36]	
Long-term steroid use [25]	Multiple GA during admission [19]	
Prolonged hospitalization [15]	**Modifiable**	
Modifiable	Mechanical ventilation strategy [3 19 63–71]	
Smoking [57 12 13 15 25 32 33 61]	GA (*vs* regional) [4 25 27 72]	
COPD [10 12 13 15–19 24 25 27 32 33 36]	Long-acting NMBDs and TOF ratio <0.7 in PACU [73]	
Asthma [20 32]	Residual neuromuscular block	
CHF [15 16 18 27 29 33]	Intermediate-acting NMBDs with surgical time <2 h (not antagonized) [21]	
OSA [62]	Neostigmine [21 74]	
BMI <18.5 or >40 kg m^{-2} [15]	Sugammadex with supraglottic airway [75 76]	
BMI >27 kg m^{-2} [7]	Failure to use peripheral nerve stimulator [21 74]	
Hypertension [15]	Open abdominal surgery (*vs* laparoscopic) [5 26 77–79]	
Chronic liver disease [29]	Perioperative nasogastric tube [18 20 22 23 25 80]	
Renal failure [19]	Intraoperative blood transfusion [19 25 36]	
Ascites [12]		
Diabetes mellitus [15 17]		
Alcohol [17 25]		
GORD [17]		
Preoperative sepsis [13–15 33]		
Preoperative shock [12]		

Br J Anaesth. 2017 Mar 1;118(3):317-334.

Q1. Who needs pulmonary evaluation?

1. Patient factors

- ✓ Older age (eg. ≥ 50 years old)
- ✓ Smoking history (eg. Current smoker)
- ✓ Underlying COPD / uncontrolled asthma / congestive heart failure
- ✓ Abnormal findings on chest examinations (eg. low SpO_2, wheezing, crackle)
- ✓ ASA ≥2 or functionally dependent ➔ May needs other evaluation

Q1. Who needs pulmonary evaluation?

2. Procedure factors

- ✓ General anesthesia
- ✓ Abdominal surgery (eg. Upper abdominal surgery)
- ✓ Vascular surgery (including peripheral vascular surgery)
- ✓ Emergency or Prolonged surgery (≥ 3 hours)
- ✓ Hypoalbuminemia, Anemia (or transfusion) ➔ May needs other evaluation

Q1. Who needs pulmonary evaluation?

ARISCAT score

Variable		Points
Age, years	≤50	0
	51-80	3
	>80	16
Preoperative SpO_2	≥96%	0
	91-95%	8
	≤90%	24
Respiratory infection in the last month*	No	0
	Yes	17
Preoperative anemia (Hgb ≤10 g/dL)	No	0
	Yes	11
Surgical incision	Peripheral	0
	Upper abdominal	15
	Intrathoracic	24
Duration of surgery	<2 hrs	0
	2-3 hrs	16
	>3 hrs	23
Emergency procedure	No	0
	Yes	8

ARISCAT Score	Risk group	Risk of PPCs
<26	Low	1.6%
26–44	**Intermediate**	**13.3%**
≥45	**High**	**42.1%**

Consider pulmonary evaluation if ARISCAT score≥26

Anesthesiology. 2014 Aug;121(2):219-31.

Is routine pre-operative CXR necessary?

- Pros
  - Prospective open multicenter study (8 centers, France)
  - 3959 patients
    - ✓group 1 (n = 2092) had no risk factors ➔ changes in policy (0.1%)
    - ✓group 2 (n = 946) had 1 risk factor ➔ changes in policy (0.3%)
    - ✓group 3 (n = 645) had 2 risk factors ➔ changes in policy (1%)
    - ✓group 4 (n = 276) had 3 risk factors or more ➔ changes in policy (1%)
  - Preoperative chest radiographs **should be routine** for patients about to undergo **general and gastrointestinal operations with ≥3 risk factors**

Eur J Surg. 1996 Aug;162(8):597-604.
Eur J Anaesthesiol. 1999 Nov;16(11):749-60.

Is routine pre-operative CXR necessary?

- Cons

Author and year	*Further investigations due to CXR abnormalities*	*Change in anesthetic management*	*Change in surgical management*	*Perioperative complications*
Boghosian 1987[6]				Overall : 9.6% Ages 60–70: 4% > 70: 17%
Bouillot 1996[7]		Change in anesthetic/ surgical management only because of abnormal CXR findings No risk factors: 0.1% Mild risk factors: 0.3% Moderate risk factors: 1% High risk factors: 1% Overall: 0.5%		CXRs helpful for diagnosis of complication No risk factors: 2% Mild risk factors: 7% Moderate risk factors: 10% High risk factors: 14% Overall: 5%
Gagner 1990[8]			1.3%	
Mendelson 1987[10]				Useful for comparison with 51% of patients having postoperative CXRs
Royal College of Radiologists 1979[11]		96.7% of patients with normal CXRs *vs* 96.1% with abnormal CXRs had inhalation anesthesia		Patients with preoperative CXRs had 12.8% incidence of complication *vs* 16% for those who had no preoperative CXRs
Silvestri 1999[14]	2.4%	3.7%		
Sommerville 1992[15]			1% (no risk factors) 4% (risk factors)	
Tape 1988[16]		5%		13% *vs* 9% (abnormal *vs* normal CXRs) 3% *vs* 2% (abnormal *vs* normal CXRs)
Umbach 1988[18]	47%	5.8%		
Wiencek 1987[19]	4%		2%	

Useful for comparison with 51% of patients having postoperative CXRs
Patients with preoperative CXRs had 12.8% incidence of complication *vs* 16% for those who had no preoperative CXRs

13% *vs* 9% (abnormal *vs* normal CXRs)
3% *vs* 2% (abnormal *vs* normal CXRs)

Can J Anaesth. Jun-Jul 2005;52(6):568-74.

Is routine pre-operative CXR necessary?

- Meta-analysis

Author	Study design	Study group		All abnormalities		Unsuspected abnormalities			
						Total		Influencing management	
		Age (y)	N	N	%	N	%	N	%
Sane[23]	P	0–19	1500	111	7.4	41	2.7	0	0
Wood[24]	R	0–19	749	35	4.7	9	1.21	3	0.4
Farnsworth[25]	R	1–14	350	31	8.9	1	0.3	0	0
Maigaard[26]	P	>30	1256	57	4.5	2	0.2	0	0
Lamers[27]	P	>40	810	5	0.6	1	0.1	0	0
Wyatt[28]	R	>49	388	4	1.0	1	0.4	1	0.4
Gagner[29]	R	All	1000	74	7.4	6	0.6	0	0
Jeavons[30]	P	Adults	500	33	6.6	11	2.2	4	0.8
Rucker[31]	P	All	872	115	13.2	1	0.3	0	0
Thomsen[32]	R	>40	1823	241	13.0	42	2.3	4	0.2
Haubek[33]	P	1–94	400	24	6.0	6	1.9	0	0
Tape[17]	R	24–90	341	20	5.9	–	–	0	0
Catchlove[34]	R	40–>70	79	5	6.3	–	–	0	0
Petterson[35]	P	All	1530	134	8.8	–	–	2	0.1
Loder[36]	R	9–30	437	5	1.1	1	0.2	–	–
Turnbull[37]	R	Adults	691	38	5.5	10	1.4	–	–
Törnebrandt[3]	P	70–94	91	43	47.3	10	11	–	–
Seymore[11]	P	>65	233	93	40.0	–	–	–	–
Mendelson[38]	P	All	369	62	17.0	–	–	–	–
Wiencek[38]	P	Adults	237	101	42.6	–	–	–	–
Weibman[40]	R	0–90	734	213	29.0	–	–	–	–
All studies			14,390	1,444		140		14	
Weighted mean*					10.0		1.3		0.1
95% CI					8.6–11.3		0.0–2.8		0.0–0.6
Weighted mean (excluding[3])							1.0		
95% CI							0.0–2.5		

Can J Anaesth. 1993 Nov;40(11):1022-7.

Is routine pre-operative CXR necessary?

- Guidelines

American Society of Anesthesiologists, 2002	Consider chest radiography for: - Patients who **smoke** - History of **recent upper respiratory infection** with **COPD** - Patients with **cardiac disease** However, if these conditions are **chronic and stable**, preoperative chest radiography is **not necessarily indicated**
American College of Radiology, 2008	Chest radiography is usually appropriate for: - Patients with **acute cardiopulmonary findings** on history or physical examination - Patients **older than 70 years** who **have chronic cardiopulmonary disease** and have not had chest radiography in the **previous 6 months**
Institute for Clinical Systems Improvement, 2012	Chest radiography may be considered for patients with **signs or symptoms suggesting new or unstable cardiopulmonary disease**
NICE, 2016	**Do not routinely offer chest X-rays** before surgery

Is routine pre-operative CXR necessary?

- **Not recommended**

- Only considered in specific conditions:
  - ✓ Acute deterioration of respiratory symptoms (eg. newly developed dyspnea)
  - ✓ Abnormal cardiopulmonary signs (eg. wheezing)
  - ✓ Underlying chronic pulmonary disease (eg. COPD) in elderly without current CXR

Is routine pre-operative PFT necessary?

- In 460 patients undergoing abdominal surgery,

Variable	Odds ratio	95% confidence interval	*P* value	β-coefficient	Score
FEV_1 (<61% of predicted)	16·86	5·62–50·58	<0·001	2·825	10
Pa_{O_2} (<9·33 kPa)	6·42	2·48–16·61	<0·001	1·859	6·58
FEV_1 (61–79% of predicted)	3·80	1·40–10·36	0·009	1·337	4·73
Ischaemic heart disease	3·44	1·08–10·93	0·036	1·237	4·38
Operation for malignant tumours	3·24	1·75–6·00	<0·001	1·175	4·16
Age$^+$	1·04	1·00–1·08	0·047	0·036	0·13

Respir Med. 2000 Dec;94(12):1171-6.

- In 361 patients undergoing upper abdominal surgery,

Factors entered in the model (logitθ)	OR	95% CI	p-value
CMH	133	14.8–1199	<0.0001
FEV_1 (% pred)	0.93	0.88–0.98	<0.01
RV (L)	3.11	1.25–7.75	0.01
$T_{L,CO,sb}$ (% pred)	0.91	0.10–8.16	<0.0001

Eur Respir J. 1997 Jun;10(6):1301-8.

Is routine pre-operative PFT necessary?

- In a prospective cohort of 272 consecutive patients

Variable	Number of Patients with a Particular Finding	Odds Ratio (*95% Confidence Interval*)	p Value
Had spirometry performed	145	0.84 (0.53–1.35)	0.78
$FEV_1 < 1$ L/min*	10	7.9 (1.7–37.0)	0.02
FVC < 1.5 L/min*	8	11.1 (2.2–56.4)	0.005
Had arterial blood gases performed	66	0.7 (0.3–1.8)	0.61
$Pco_2 \geq 45$ mm Hg†	3	61.0 (3.8–986.4)	0.001
$Po_2 < 75$ mm Hg†	14	13.4 (1.3–14.1)	0.008
Had chest radiography performed	124	1.1 (0.7–1.7)	0.83
Chest radiograph abnormal‡	21	1.7 (0.6–4.9)	0.40

Am J Respir Crit Care Med. 2003 Mar 1;167(5):741-4.

- A matched case–control design with 116 patients (elective, abdominal), spirometric results were similar (FEV1; 2.4 L vs. 2.6 L, FVC; 3.6L vs. 3.6L)

Chest. 1996 Sep;110(3):744-50

Is routine pre-operative PFT necessary?

- Guideline

NICE, 2016	**Do not routinely offer PFTs** before minor surgery Consider PFTs before intermediate or major surgery if **ASA ≥3 due to respiratory conditions**

Intermediate	• primary repair of inguinal hernia • excising varicose veins in the leg • tonsillectomy or adenotonsillectomy • knee arthroscopy
Major or complex	• total abdominal hysterectomy • endoscopic resection of prostate • lumbar discectomy • thyroidectomy • total joint replacement • lung operations • colonic resection • radical neck dissection

ASA Classification	Definition	Examples (not limited)
I	Normal healthy patient	Healthy, non-smoker, minimal to no alcohol use
II	Mild systemic disease	Well controlled diabetes mellitus/hypertension, pregnancy, current smoker
III	Severe systemic disease	Poorly controlled diabetes mellitus/hypertension, COPD, reduced ejection fraction
IV	Patient with severe systemic disease	End stage renal disease (no dialysis), cerebrovascular accidents, myocardial infarction, sepsis, metastatic cancer with poor prognosis
V	Patient not expected to survive without procedure	Intracranial bleed with mass effect, ruptured aortic aneurysm, massive trauma
VI	Brain dead patient, organ donation	--

Contents

Interventions to reduce the risk for PPCs

Table 4. **Strength of the Evidence for Specific Interventions To Reduce the Risk for Postoperative Pulmonary Complications**

Risk Reduction Strategy	Strength of Evidence*	Type of Complication Studied
Postoperative lung expansion modalities	A	Atelectasis, pneumonia, bronchitis, severe hypoxemia
Selective postoperative nasogastric decompression	B	Atelectasis, pneumonia, aspiration
Short-acting neuromuscular blockade	B	Atelectasis, pneumonia
Laparoscopic (vs. open) operation	C	Spirometry, atelectasis, pneumonia, overall respiratory complications
Smoking cessation	I	Postoperative ventilator support
Intraoperative neuraxial blockade	I	Pneumonia, postoperative hypoxia, respiratory failure
Postoperative epidural analgesia	I	Atelectasis, pneumonia, respiratory failure
Immunonutrition	I	Overall infectious complications, pneumonia, respiratory failure
Routine total parenteral or enteral nutrition†	D	Atelectasis, pneumonia, empyema, respiratory failure
Right-heart catheterization	D	Pneumonia

Ann Intern Med. 2006 Apr 18;144(8):596-608.

Interventions to reduce the risk for PPCs

1. Medical optimization
: Chronic obstructive pulmonary disease and asthma should be optimally treated with bronchodilators and inhaled or oral steroids

2. Smoking cessation
: Cessation for >4 weeks reduces PPCs by 23%, and for >8 weeks by 47%

3. Anemia evaluation
: The cause of anemia should be established

4. Minimizing operative time
: A duration of surgery and anesthesia of >2h is independently associated with PPC development (OR, 4.9 (2.4–10.1) with >2h and 9.7 (4.7–19.9) with >3h)

Br J Anaesth. 2017 Mar 1;118(3):317-334.

Q2. Postoperative respiratory support

- Postoperative respiratory support
  - ✓ Continuous positive airway pressure (CPAP)
  - ✓ Nasal high-flow oxygen

Q2. Postoperative respiratory support

- Postoperative CPAP
  - might reduce **postoperative atelectasis, pneumonia and reintubation**
  - effects on mortality, hypoxia or invasive ventilation are uncertain

Analysis 2.1. Comparison 2 Adverse outcomes, Outcome 1 Significant atelectasis.

Study or subgroup	CPAP n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Carlsson 1981	10/13	10/11		20.37%	0.85[0.6,1.2]
Christensen 1991	20/34	9/17		22.57%	1.11[0.65,1.89]
Lindner 1987	0/17	4/17		8.46%	0.11[0.01,1.92]
Lotz 1984	3/16	6/16		11.28%	0.5[0.15,1.66]
Ricksten 1986	1/28	6/15		14.69%	0.09[0.01,0.67]
Stock 1985	5/23	17/42		22.62%	0.54[0.23,1.27]
Total (95% CI)	**131**	**118**		**100%**	**0.62[0.45,0.86]**
Total events: 39 (CPAP), 52 (Control)					
Heterogeneity: Tau^2=0; Chi^2=12.68, df=5(P=0.03); I^2=60.57%					
Test for overall effect: Z=2.89(P=0)					

Favours [CPAP] 0.01 0.1 1 10 100 Favours [Usual treatment]

Analysis 2.2. Comparison 2 Adverse outcomes, Outcome 2 Pneumonia.

Study or subgroup	CPAP n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Bohner 2002	2/99	5/105		19.92%	0.42[0.08,2.14]
Christensen 1991	7/34	5/17		27.37%	0.7[0.26,1.88]
Lindner 1987	1/17	1/17		4.11%	1[0.07,14.72]
Squadrone 2005	2/105	10/104		41.25%	0.2[0.04,0.88]
Stock 1985	0/23	2/42		7.35%	0.36[0.02,7.16]
Total (95% CI)	**278**	**285**		**100%**	**0.43[0.21,0.84]**
Total events: 12 (CPAP), 23 (Control)					
Heterogeneity: Tau^2=0; Chi^2=2.38, df=4(P=0.67); I^2=0%					
Test for overall effect: Z=2.44(P=0.01)					

Favours [CPAP] 0.01 0.1 1 10 100 Favours [Usual treatment]

Analysis 2.3. Comparison 2 Adverse outcomes, Outcome 3 Severe hypoxia.

Study or subgroup	CPAP n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Bohner 2002	5/99	17/105		86.09%	0.31[0.12,0.81]
Christensen 1991	6/34	2/17		13.91%	1.5[0.34,6.66]
Total (95% CI)	**133**	**122**		**100%**	**0.48[0.22,1.02]**
Total events: 11 (CPAP), 19 (Control)					
Heterogeneity: Tau^2=0; Chi^2=3.02, df=1(P=0.08); I^2=66.92%					
Test for overall effect: Z=1.9(P=0.06)					

Favours [CPAP] 0.01 0.1 1 10 100 Favours [Usual treatment]

Analysis 2.4. Comparison 2 Adverse outcomes, Outcome 4 Reintubation.

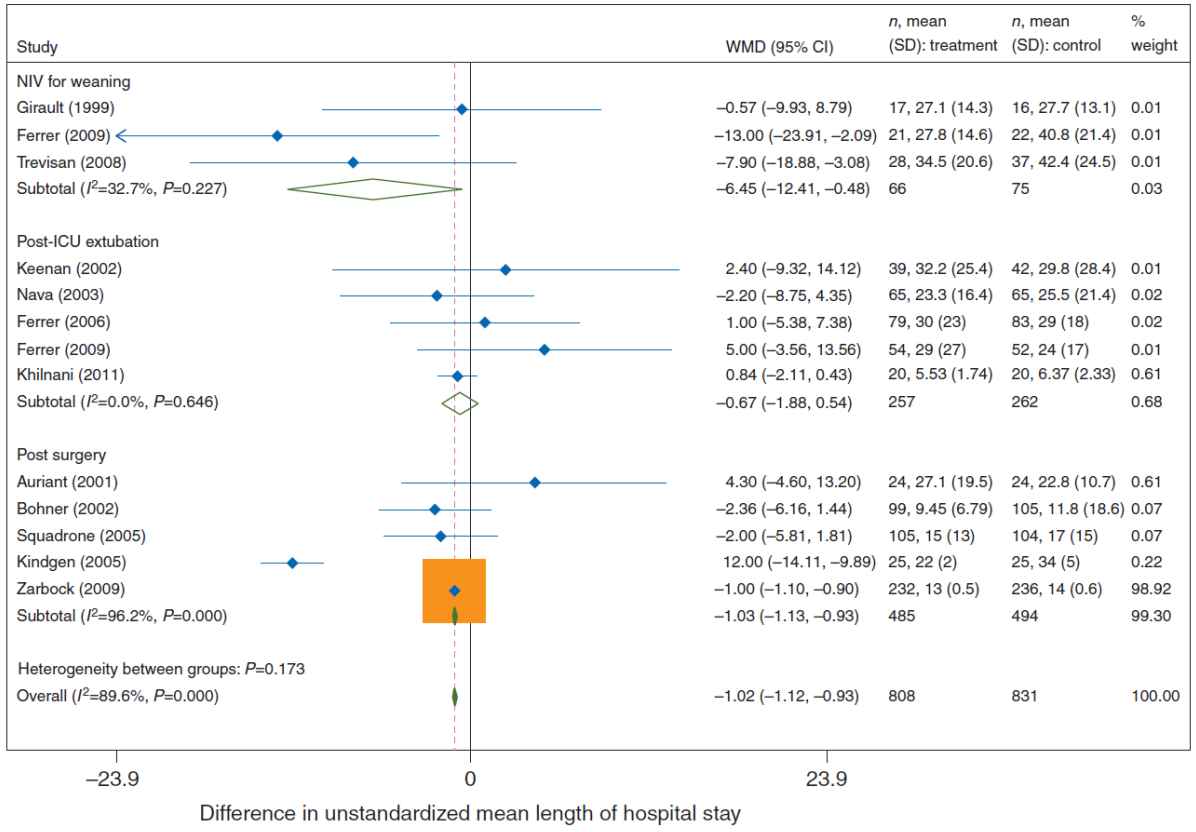
Study or subgroup	CPAP n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Bohner 2002	1/99	5/105		32.57%	0.21[0.03,1.78]
Squadrone 2005	1/105	10/104		67.43%	0.1[0.01,0.76]
Total (95% CI)	**204**	**209**		**100%**	**0.14[0.03,0.58]**
Total events: 2 (CPAP), 15 (Control)					
Heterogeneity: Tau^2=0; Chi^2=0.26, df=1(P=0.61); I^2=0%					
Test for overall effect: Z=2.68(P=0.01)					

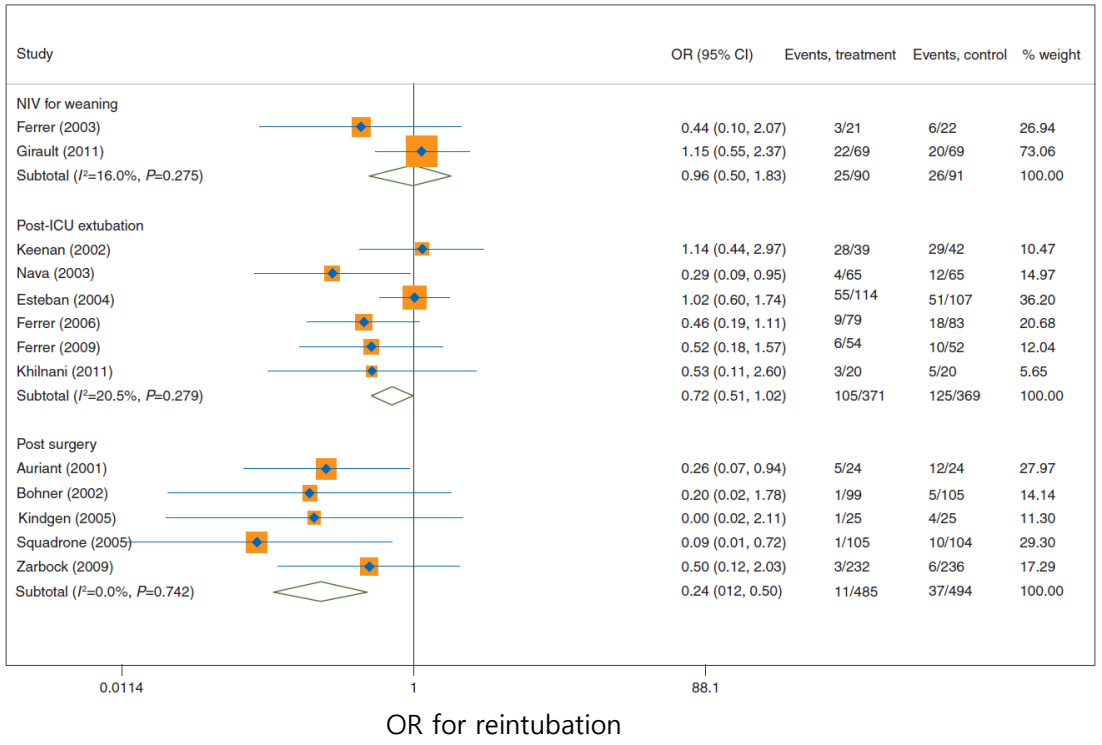
Favours [CPAP] 0.01 0.1 1 10 100 Favours [Usual treatment]

Cochrane Database Syst Rev. 2014 Aug; 2014(8): CD008930.

Q2. Postoperative respiratory support

- Postoperative NIV (mostly CPAP)
  - might reduce **length of stay, reintubation, pneumonia, and hospital death**





British Journal of Anaesthesia 109 (3): 305–14 (2012)

Q2. Postoperative respiratory support

- Postoperative CPAP (PRISM trial)
  - Although CPAP has an important role in the treatment of respiratory failure after surgery, **routine use of prophylactic post-operative CPAP is not recommended**.

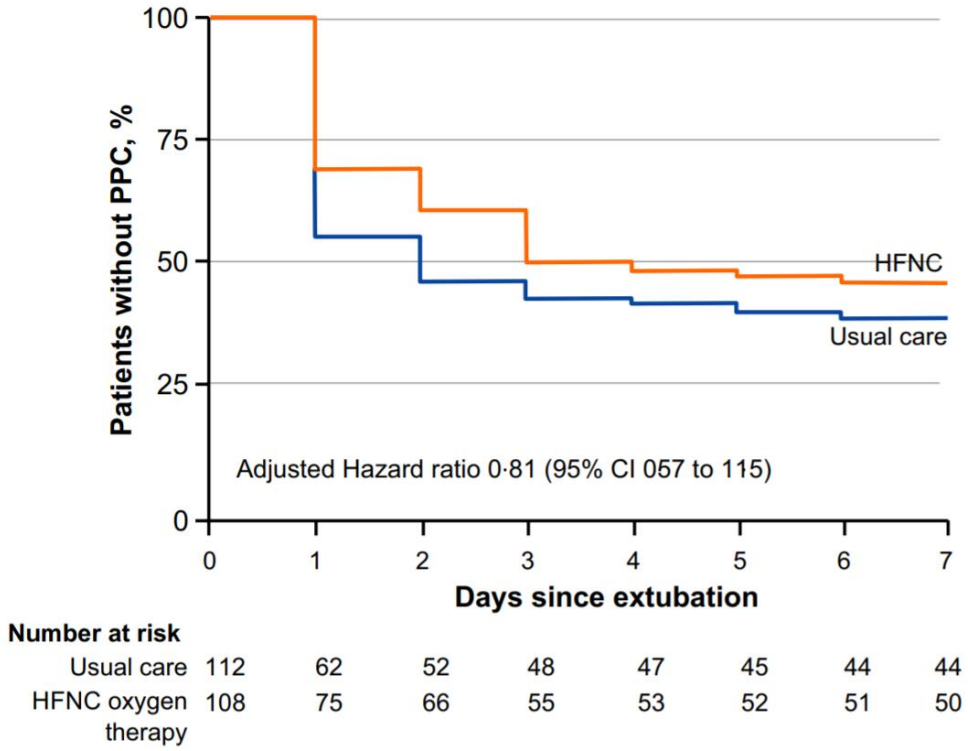
	Usual care	CPAP	Adjusted OR (95% CI)	p value
Primary outcome*				
Pneumonia, endotracheal re-intubation, or death within 30 days of randomisation	197/2397 (8·2%)	195/2396 (8·1%)	1·01 (0·81–1·24)	0·95
Secondary outcomes†				
Pneumonia within 30 days of randomisation	117/2397 (4·9%)	123/2396 (5·1%)	1·06 (0·82–1·38)	0·66
Endotracheal re-intubation within 30 days of randomisation	90/2398 (3·8%)	80/2397 (3·3%)	0·89 (0·65–1·21)	0·45
All-cause mortality within 30 days of randomisation	33/2398 (1·4%)	30/2397 (1·3%)	0·91 (0·55–1·50)	0·71
Postoperative infection within 30 days of randomisation	741/2393 (31·0%)	738/2395 (30·8%)	0·99 (0·87–1·12)	0·89
Postoperative mechanical ventilation within 30 days of randomisation‡	210/2393 (8·8%)§	230/2395 (9·6%)¶	1·17 (0·94–1·45)	0·16
All-cause mortality within 1 year of randomisation	230/2363 (9·7%)	213/2374 (9·0%)	0·91 (0·75–1·11)	0·37

Lancet Respir Med. 2021 Jun 18;S2213-2600(21)00089-8.

Q2. Postoperative respiratory support

- Postoperative nasal high-flow oxygen
  - Multicenter RCT (OPERA trial) in France
  - **No reduction in PPCs**

Outcomes	No./total no. (%)		ARR or between-group difference (95 % CI)	*p* value
	Usual care	HFNC oxygen therapy		
Primary outcomes				
Postoperative hypoxaemia[a,b]				
1 h after extubation	27/112 (24)	23/108 (21)	−3 (−14 to 8)	0.62
After discontinuation of the study treatment	34/112 (30)	29/108 (27)	−4 (−15 to 8)	0.57
Secondary outcomes				
Need for supplemental oxygen therapy after treatment discontinuation	92/112 (82)	79/108 (73)	−9 (−20 to 2)	0.11
Pulmonary complications[c] within 7 days				
Grade 1 or 2	49/112 (44)	37/108 (34)	−10 (−25 to 4)	0.17
Grade ≥3	19/112 (17)	21/108 (20)	2 (−8 to 13)	0.63
Bronchial congestion	14/112 (13)	16/108 (15)	2 (−7 to 11)	0.62
Hypoxaemia[d]	30/112 (27)	30/108 (28)	0 (−11 to 13)	0.87
Pneumonia	10/112 (9)	10/108 (9)	0 (−7 to 8)	0.93
Need for intubation or NIV for respiratory failure[e]	14/112 (13)	20/108 (19)	6 (−4 to 16)	0.22
Surgical reoperation within 7 days[f]	5/112 (4)	2/108 (2)	−3 (−7 to 2)	0.45
Unexpected ICU admission	16/112 (14)	16/108 (15)	0 (−9 to 10)	0.91
ICU length of stay (days)	5 (3–13)	6 (4–16)	3 (−5 to 12)	0.53
Hospital length of stay (days)	11 (7–18)	12 (7–20)	0.5 (−3.5 to 4.5)	0.58
In-hospital mortality	3/112 (3)	2/108 (2)	−1 (−5 to 3)	0.68



Intensive Care Med. 2016 Dec;42(12):1888-1898.

Q3. Who benefits bronchoscopy?

- Bronchoscopy does not add to respiratory therapy in the treatment of acute lobar atelectasis

- However, subgroup patients may have benefits
  - ✓ Atelectasis without air bronchograms
  - ✓ Unable to maintain airway hygiene independently
  - ✓ Remain symptomatic after 24 hours of aggressive chest physiotherapy (every 4 hours)

Am Rev Respir Dis. 1979 Jun;119(6):971-8.

Q3. Who benefits bronchoscopy?

- Toilet bronchoscopy is particularly beneficial
  - ✓ Retained secretions are visible / audible
  - ✓ An inability to remove secretions
  - ✓ Air-bronchograms are not present at the chest radiograph
  - ✓ Lobar atelectasis

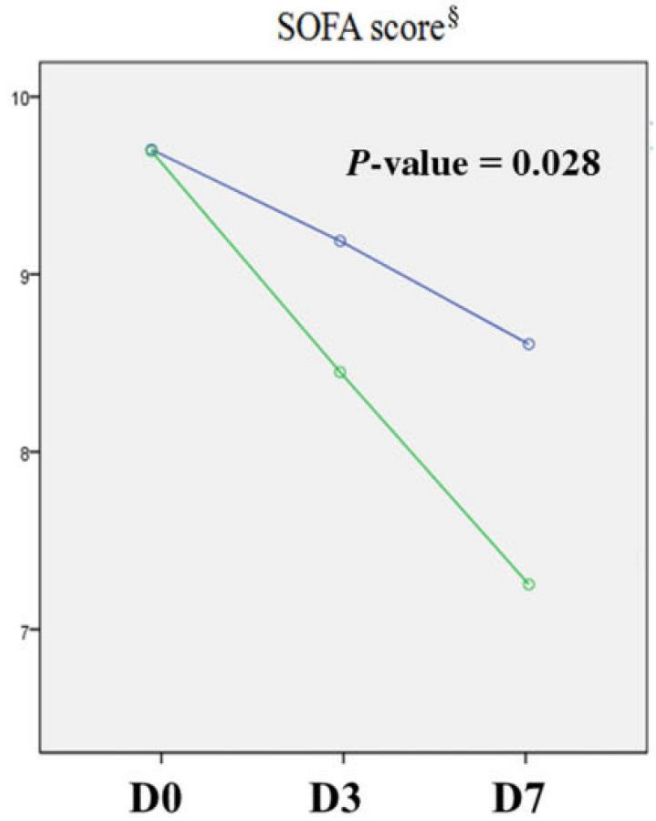
American Reviews in Respiratory Diseases, 119, 971–8.
American Surgery, 50, 441–5.
Critical Care Medicine, 22, 1880–3.

Q3. Who benefits bronchoscopy?

- If aspiration pneumonia is suspected, bronchoscopy can be beneficial

Table 4 Multivariate analysis to assess risk factors for 90-day mortality

Risk factors	OR (95% CI)	*P*-value
Age ≥65	1.070 (0.358–3.198)	0.904
Male	2.634 (0.754–9.195)	0.129
Initial APACHE II score	1.087 (1.023–1.155)	0.007
Initial LIS	1.485 (0.734–3.004)	0.272
Initial SOFA score	1.208 (1.019–1.431)	0.029
Early bronchoscopy	0.412 (0.192–0.883)	0.023
Admission on weekend or holiday	1.672 (0.668–4.187)	0.273
Initial appropriate empirical antibiotics†	0.306 (0.126–0.741)	0.009



Respirology. 2015 Oct;20(7):1115-22

Contents

Preoperative assessment in asthmatics

- Asthma control status
  - Dyspnea, wheezing, & exacerbation history
  - Medication (Systemic steroid for 2W within current 6M)
  - FEV_1<80%
  - Smoking (cessation ≥8W)

- Aspirin / NSAID hypersensitivity
  - 10~28% of asthma patients / Avoid drugs in severe or uncontrolled asthma

- Types of surgery / anesthesia
  - Abdominal/Thoracic surgery, General anesthesia/Intubation, prolonged surgery time

J Allergy Clin Immunol. 2007 Nov;120(5 Suppl):S94-138.

Preoperative management in asthma

1. 임상양상

일반적인 천식 환자에서 수술 전후로 위험성이 증가한다는 근거는 없다. 그러나 만성폐쇄폐질환을 동반한 환자나 폐기능이 감소되어 있는 천식 환자에서는 위험성이 증가할 수 있다. 천식 환자에서 수술 중 또는 수술 이후 심한 기관지경련이 일어나는 빈도는 적지만 발생할 경우에는 생명을 위협할 수도 있다.

2. 치료

정규 수술인 경우 수술 전에 천식 조절 상태 등에 대한 세심한 주의가 필요하다. 특히 중증 천식, 조절되지 않는 증상을 가진 경우, 천식 악화 병력, 지속적인 폐기능 감소 등이 동반된 경우에는 더욱 주의가 필요하다. 응급 수술인 경우 천식 조절이 잘 되지 않은 상태에서 즉각적인 수술이 필요한지를 고려하여야 한다. 오랜 기간 고용량의 흡입 스테로이드를 사용한 경우 또는 지난 6개월 동안 경구 스테로이드를 2주 이상 사용한 경우 수술 중 급성부신기능부전의 위험이 있으므로 수술 전후로 하이드로코티손을 투여하여야 한다. 모든 천식 환자에게 수술 전후로 지속적인 천식 유지치료를 하는 것이 중요하다.

Korean Guideline for Asthma 2021

Preoperative management in asthma

Guidelines for preoperative pharmacotherapy.

Clinical characteristics of asthma	Corresponding preoperative pharmacologic therapy
• No asthma symptoms • Not on any asthma medications • No flares in asthma symptoms over past year • Spirometry does not show significant obstruction	• No additional asthma therapy preoperatively
• On bronchodilators only • No history of oral corticosteroid use • Spirometry is not below baseline	• Initiate therapy with inhaled corticosteroid, beclomethasone 400 μg per day or equivalent dose, one week before surgery • If spirometry is below baseline or patient is having flare of symptoms consider adding prednisone 0.5 mg/kg for 5 days before surgery
• Already on inhaled corticosteroid • Spirometry at or below baseline	• Continue treatment with inhaled corticosteroid • Treat with prednisone 0.5 mg/kg for 5 days before surgery • Treat with hydrocortisone 100 mg IV every 8 hours the morning before surgery and postoperatively until stable
• Patient is already on oral steroids	• Increase dose of oral steroids for 5 days before surgery • Treat with hydrocortisone 100 mg IV every 8 hours the morning before surgery and postoperatively until stable

J Asthma. 2006 May;43(4):251-4.

Preoperative risk stratification in asthmatics

- Asthma symptoms within 1 month
  - Day symptom ≥3/week
  - SABA ≥3/week
  - Night symptom
  - Limitation with normal activity

  ≥3 ➔ uncontrolled
  1-2 ➔ partially controlled

- No symptom but FEV_1<80% or Previous AE ≥1/year ➔ **Considered as partially controlled asthma**

- Systemic steroid or high-dose ICS for 2W within current 6M ➔ **Considered as uncontrolled asthma**

J Allergy Clin Immunol. 2007 Nov;120(5 Suppl):S94-138.

Practical strategy for preoperative management

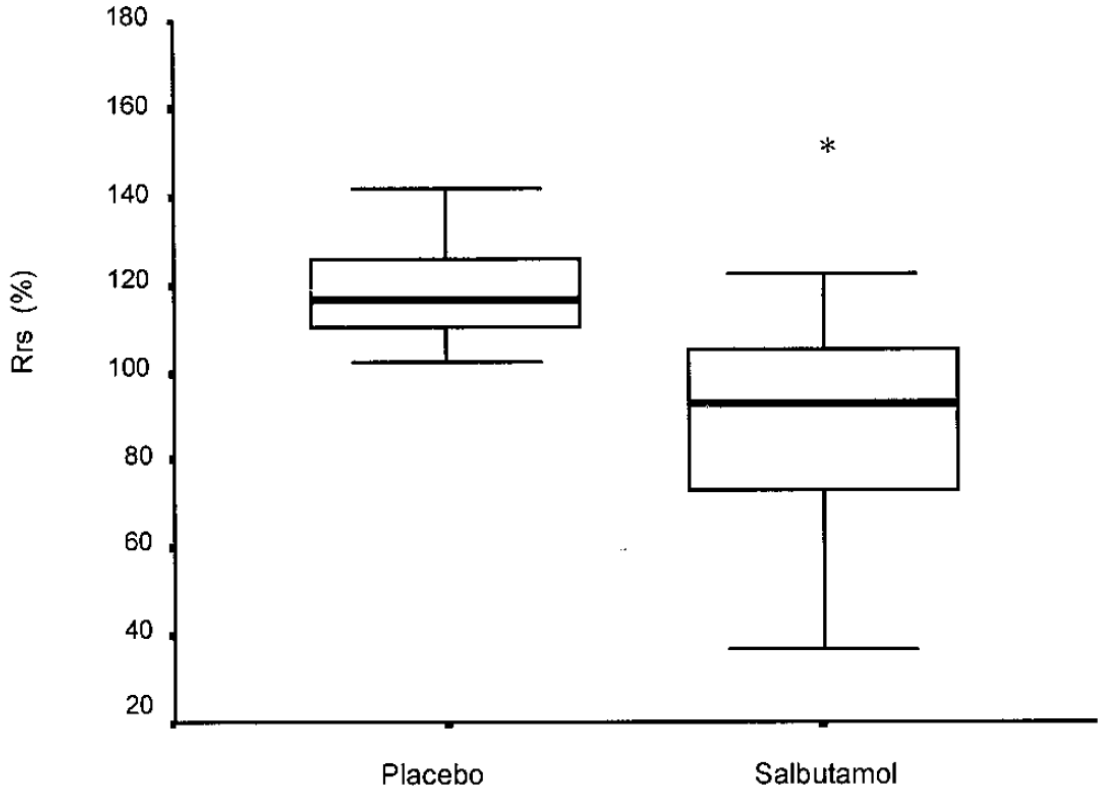
- **Uncontrolled asthma patients**
  - **Hydrocortisone 100mg ivs q8hr** (MN and/or on call, until stable)
  - **Salbutamol 2.5mg nebulization**: on call from OR, 이후 q6~8hr 유지
    (ICS 사용이 어려울 경우 Budesonide 1mg nebulization q 12hr)
  - Prn) Aminophylline ➔ No longer recommended (Only for rapid recovery from LOC)
    - Loading : 5mg/kg (over 30 min, mix with 5DW 100cc)
    - Maintenance: 0.25-0.5mg/kg/hr (mix with 5DW or N/S 500cc)
    - TDM/dose modification after 48 hours

Ann Med Surg (Lond). 2021 Oct; 70: 102874.
J Allergy Clin Immunol. 2007 Nov;120(5 Suppl):S94-138.

Salbutamol use before surgery

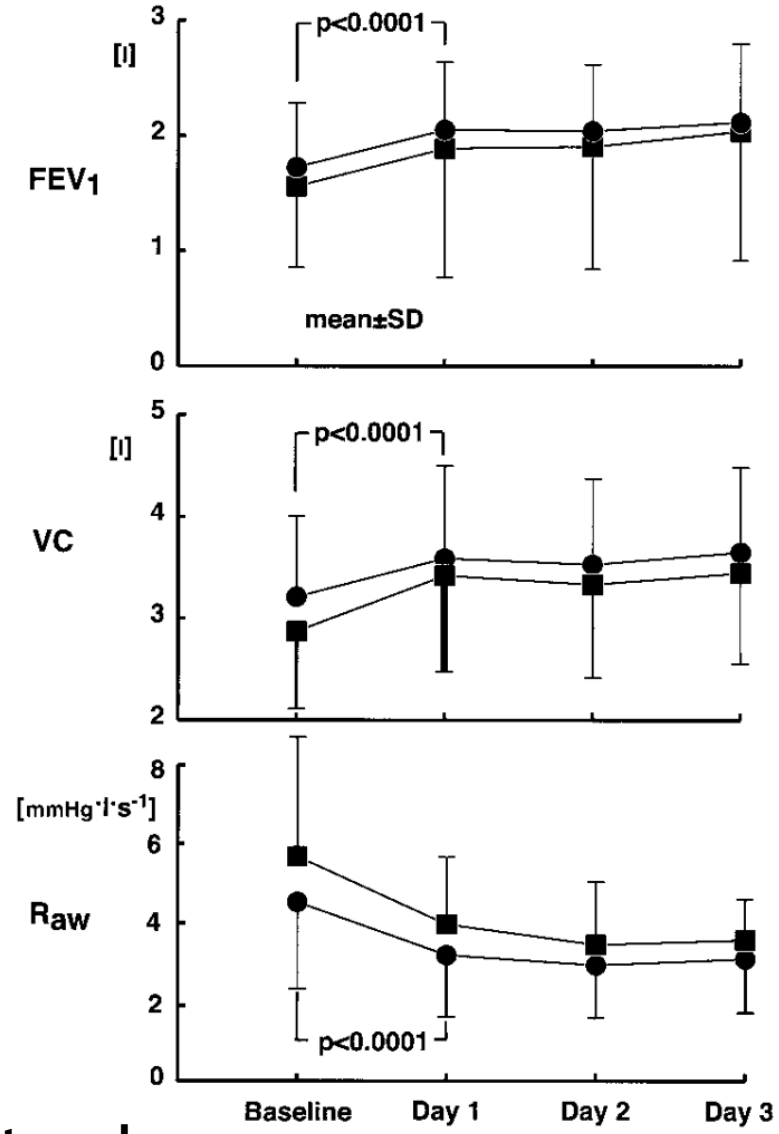
Variable	Mask	ETT
Tidal volume (mL/kg)		
Placebo	5.0 ± 0.8	4.3 ± 0.4
Salbutamol	5.1 ± 0.5	3.8 ± 0.4
Respiratory rate (breaths/min)		
Placebo	35.8 ± 2.6	41.2 ± 3.2
Salbutamol	29.4 ± 1.7	32.3 ± 1.6
Expiratory time (s)		
Placebo	1.1 ± 0.1	1.0 ± 0.1
Salbutamol	1.4 ± 0.1	1.3 ± 0.1
Crs (mL/Pa)		
Placebo	1.64 ± 0.31	1.59 ± 0.35
Salbutamol	2.16 ± 0.42	1.45 ± 0.34
Rrs ($Pa \cdot mL^{-1} \cdot s^{-1}$)		
Placebo	0.33 ± 0.02	0.37 ± 0.02
Salbutamol	0.52 ± 0.07	0.44 ± 0.05

*Rrs=Respiratory resistance



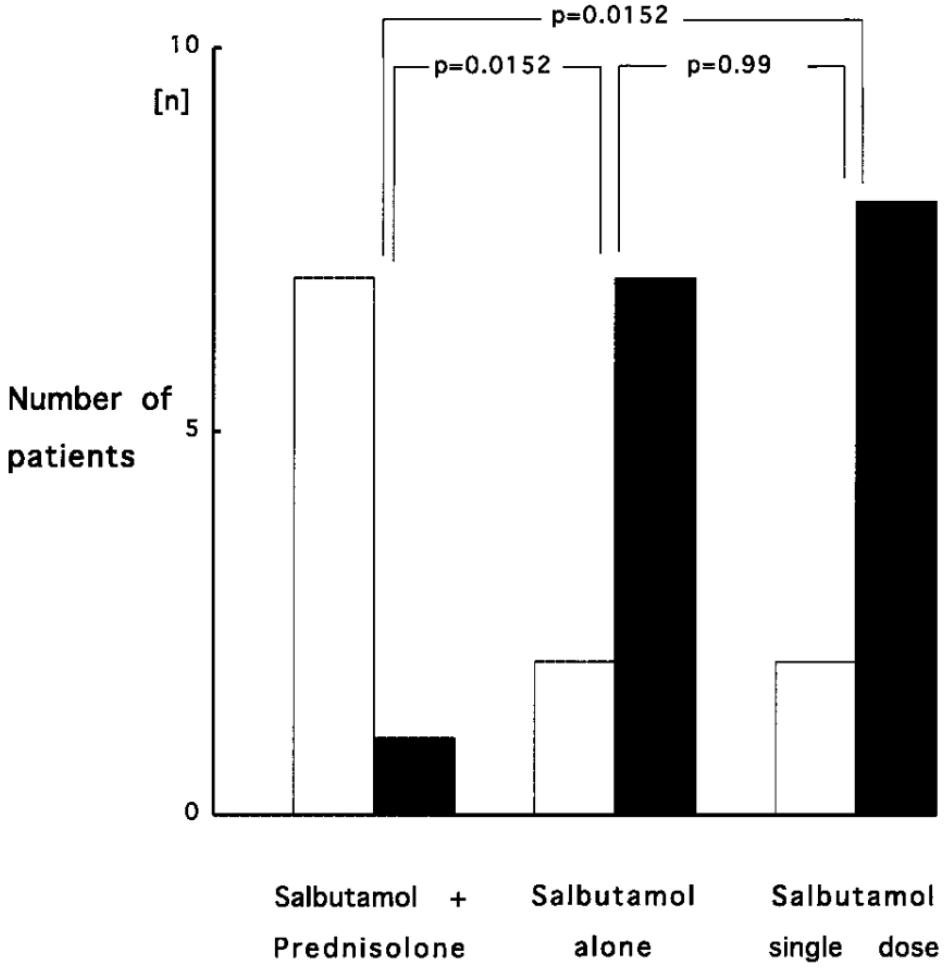
Anesth Analg. 2001 Oct;93(4):898-902.

Methylprednisolone + Salbutamol



■ Salbutamol
● Mpd+Salbutamol

Wheezing before/after surgery



Anesthesiology 2004; 100:1052–1057

Practical strategy for preoperative management

- **Partially controlled asthma patients**
  - **Hydrocortisone 100mg ivs q8hr** (MN and/or on call, until stable)
  - or **Methylprednisolone 0.5mg/kg ivs** (before 5days to 4-6 hrs of surgery)

  - **Salbutamol 2.5mg nebulization**: on call from OR, 이후 q6~8hr 유지
    (ICS 사용이 어려울 경우 Budesonide 1mg nebulization q 12hr)

- **Well controlled asthma patients**
  - **ICS (±bronchodilator)**
  - **Salbutamol 2.5mg nebulization**: on call from OR, 이후 q6~8hr 유지

Ann Med Surg (Lond). 2021 Oct; 70: 102874.
J Allergy Clin Immunol. 2007 Nov;120(5 Suppl):S94-138.

Contents

COPD is an important risk factor of PPC

- COPD 환자는 **수술 후 호흡기 합병증의 위험이 증가**한다.
- COPD 환자의 수술 전 평가에서 **폐기능이 유일한 기준이 되어서는 안되며**, ASA (American Society of Anesthesiologist) 점수체계 등의 복합 평가도구를 이용하는 것이 수술 위험도 예측에 도움이 된다.
- 수술 시행은 **동반질환 유무, 환자의 상태, 수술 필요성**을 고려하여 외과 전문의, 마취과 전문의, 호흡기내과 전문의의 토의 후 최종결정한다.
- **급성 악화가 있는 경우에는 수술을 연기**한다.

COPD 진료 지침 2018 (대한결핵 및 호흡기학회)

Postponing elective surgery

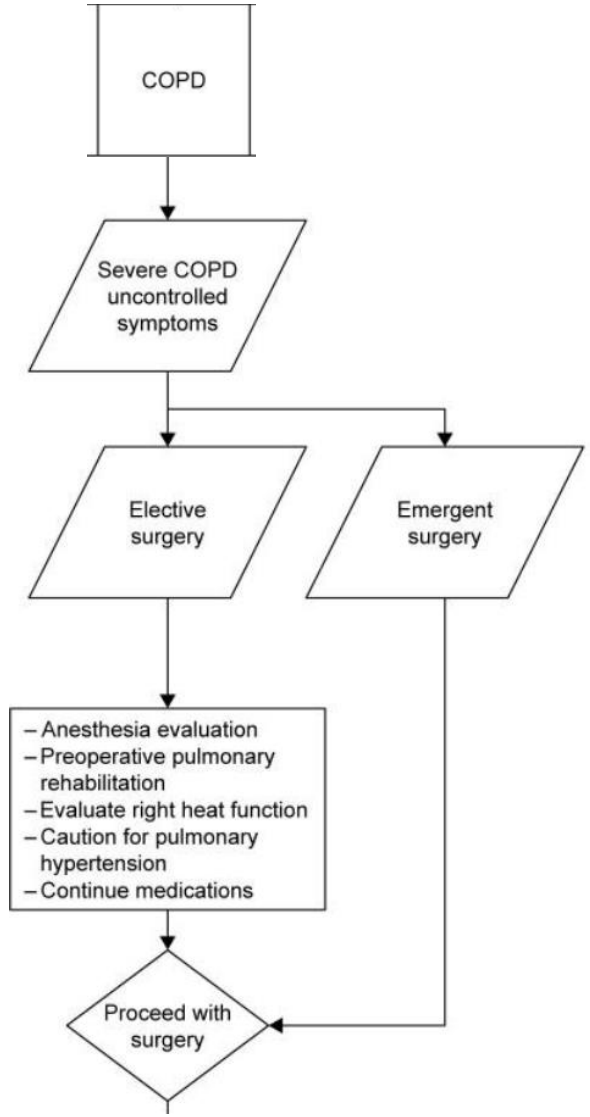
- **만성폐쇄성폐질환 증상이 갑자기 악화되거나 상기도 감염이 의심되는 경우 수술 시 합병증이 크게 증가하므로 가능한 수술을 미루는 것이 좋다.**
- 미루는 기간은 환자의 증상이 원래 기저 수준으로 돌아갈 때까지로 환자마다 다르다.
- 그 기간 동안 주로 흡입기관지확장제와 머스카린대항제 그리고 짧은 기간의 전신 스테로이드, 항생제 치료가 시행된다.

J Korean Med Assoc 2020 September; 63(9):532-539

Suggested peri-operative optimization

- **Pulmonary rehabilitation**
- **Nutrition**
- **Smoking cessation**
- **Symptom optimization**
- **Pharmacological optimization**

Anaesthesia. 2021 May;76(5):681-694.



Health Serv Insights. 2016; 9(Suppl 1): 9–23.

Preoperative corticosteroid in COPD

- RCT (n=40), COPD patients (FEV_1<70%) with Coronary Artery Bypass Surgery
- Intervention: oral prednisolone (20 mg/daily) beginning 10 days before the operation and continued to the date of discharge

	Group I	Group II	p Value
Cross-clamp time (minute)	46 ± 4.65	47.2 ± 4.28	0.402
CPB time (minute)	66.8 ± 5.81	68.9 ± 5.67	0.956
CABG + Carotid endarterectomy	–	1	0.5
CABG + Bullectomy	1	1	0.756
Average graft no.	2.6 ± 0.99	2.7 ± 0.95	0.744
LIMA	20	20	1
Radial artery	6	5	0.5
Bronchospasm	1	3	0.302
Tracheostomy	–	1	0.5
Re intubation		4	0.001
Entubation periods*	6.8 ± 1.7	14.9 ± 3.7	0.001***
Sternal dehiscence	–	1	0.5
Wound infection	–	2	0.244
Rhythm disturbance	1	7	0.044
ICU stay (day)	1.4 ± 0.68	5.2 ± 3.25	0.0001
Hospital stay (day)	8.3 ± 1.17	12.95± 2.95	0.0001
Hospital mortality	–	2	0.244
Pleural effusion**	1	4*	0.171

J Card Surg. 2005 May-Jun;20(3):252-6.

Preoperative corticosteroid in COPD

- In the patients with FEV_1/FVC <0.7, corticosteroid before abdominal surgery

TABLE 3 Postoperative pulmonary complications and in-hospital mortality according to use of systemic corticosteroid

	Steroid ($n = 30$)	Non-steroid ($n = 56$)	*P* value
Postoperative pulmonary complications	4 (13.3%)	16 (28.6%)	0.111
Atelectasis	2 (6.7%)	7 (12.5%)	0.400
Bronchospasm	1 (3.3%)	3 (5.4%)	1.000
Bronchitis/Pneumonia	1 (3.3%)	6 (10.7%)	0.233
Postoperative non-pulmonary complications[a]	7 (23.3%)	4 (7.1%)	0.032
Adrenal insufficiency	2 (6.7%)	0	
Sepsis	2 (6.7%)	0	
Abdominal complications	2 (6.7%)	4 (7.1%)	
Wound dehiscence	3 (10.0%)	1 (1.8%)	
In-hospital mortality	2 (6.7%)	1 (1.8%)	0.242

Clin Respir J. 2018 Jan;12(1):227-233.

Contents

Reduction of pulmonary function after resection

- **Across various studies, postoperative pulmonary function values were assessed at various time intervals after lobectomy or pneumonectomy**

FEV_1:

– 84-91% of preoperative values after lobectomy

– 64-66% after pneumonectomy

DL_{CO} :

– 89-96% of preoperative values after lobectomy

– 72-80% after pneumonectomy

VO_2 max:

– 87-100% of preoperative values after lobectomy

– 71-89% after pneumonectomy

Cleve Clin J Med. 2012 May;79 Electronic Suppl 1:eS17-22.

Preoperative FEV_1

- >2,000 patients in 3 large data in the 1970s: **Mortality rate of <5% if**
  - **Preoperative FEV_1> 2 L for a pneumonectomy**
  - **Preoperative FEV_1> 1.5 L for a lobectomy**

- If no dyspnea on exertion or interstitial lung disease,
  - **FEV_1 >80% predicted or >2 L** ➔ suitable for **pneumonectomy** without further physiologic evaluation
  - **FEV_1 >1.5 L** ➔ suitable for a **lobectomy** without further physiologic evaluation

ACCP clinical practice guidelines (2007)
BTS clinical practice guidelines (2001)

Percentage > Absolute value of FEV_1

- All values expressed as a **percentage** of the normal predicted value are correlated significantly with complicated **post-operative course and poor surgical outcome**.

Pulmonary function data for patients with and without a complicated post-operative course

	Uncomplicated	Complicated	Difference (95% CI)	p-value
Subjects n	82	28		
FEV1 L	2.0±0.6	1.9±0.8	0.1 (-0.2–0.4)	0.44
FEV1 % pred	82.9±19.5	69.6±19.4	13.4 (4.9–21.8)	0.002
FVC L	3.2±0.8	3.4±1.0	-0.2 (-0.6–0.2)	0.24
FVC % pred	102.4±17.7	96.7±15.6	5.7 (-1.8–13.2)	0.13
***D*L,CO % pred**	76.4±17.9	65.0±15.9	11.4 (3.9–19.1)	0.004
ppo FEV1 L	1.4±0.5	1.3±0.5	0.1 (-0.1–0.3)	0.34
ppo FEV1 % pred	58.0±14.5	49.2±16.4	8.8 (3.3–15.3)	0.009
ppo *D*L,CO % pred	53.8±14.8	44.8±13.1	9.0 (2.5–15.4)	0.007
PPP	3228±1428	2346±1309	882 (257–1507)	0.006

Pulmonary function data for patients with and without a poor outcome

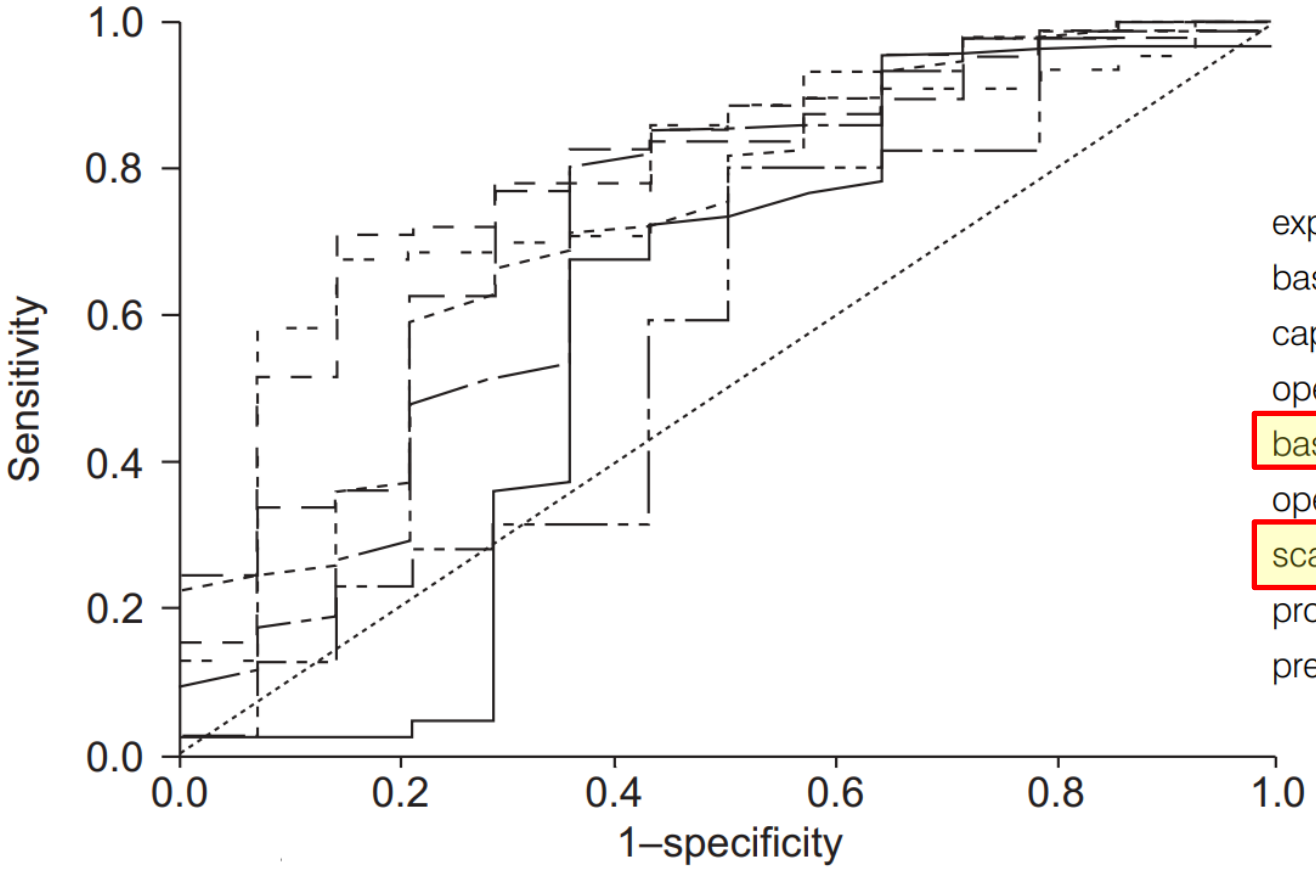
	Satisfactory outcome	Poor outcome	Difference (95% CI)	p-value
Subjects n	96	14		
FEV1 L	2.0±0.6	1.9±0.9	0.2 (-0.2–0.5)	0.42
FEV1 % pred	81.8±19.5	63.0±18.4	18.8 (7.8–29.8)	0.001
FVC L	3.2±0.8	3.6±1.1	-0.3 (-0.8–0.2)	0.18
FVC % pred	102.0±17.9	93.6±10.3	8.4 (-1.3–18.1)	0.01
***D*L,CO % pred**	75.7±17.1	59.7±17.7	15.9 (6.2–25.7)	0.002
ppo FEV1 L	1.4±0.5	1.±0.5	0.2 (-0.1–0.5)	0.12
ppo FEV1 % pred	57.7±14.7	42.0±13.0	15.7 (7.5–24.0)	<0.001
ppo *D*L,CO % pred	53.5±14.6	37.9±8.3	15.6 (7.6–23.5)	<0.001
PPP	3209±1417	1644±705	1564 (796–2333)	<0.001

***ppo = predicted postoperative**

Eur Respir J. 2005 Apr;25(4):594-9.

PPO FEV_1 & PPO DLCO

ROC curve for satisfactory outcome



***ppo = percent predicted postoperative**

Receiver-operating characteristic curves (——: baseline forced expiratory volume in one second (FEV1; L; area under the curve (AUC) 0.587); ------: baseline FEV1 (% pred; AUC 0.731); — - —: baseline carbon monoxide diffusing capacity of the lung ($D_{L,CO}$; % pred; AUC 0.701); — - - —: baseline predicted post-operative (ppo) FEV1 (L; by ventilation/perfusion (V'/Q') scan; AUC 0.587); -- --: baseline ppo $D_{L,CO}$ (% pred; by V'/Q' scan; AUC 0.772); – – –: predicted post-operative product (PPP; AUC 0.792); — — baseline ppo FEV1 (% pred; by V'/Q' scan; AUC 0.752); ·····: reference line (AUC 0.5). Diagonal segments are produced by ties. The PPP is the product of ppo FEV1 and ppo $D_{L,CO}$ (both % pred).

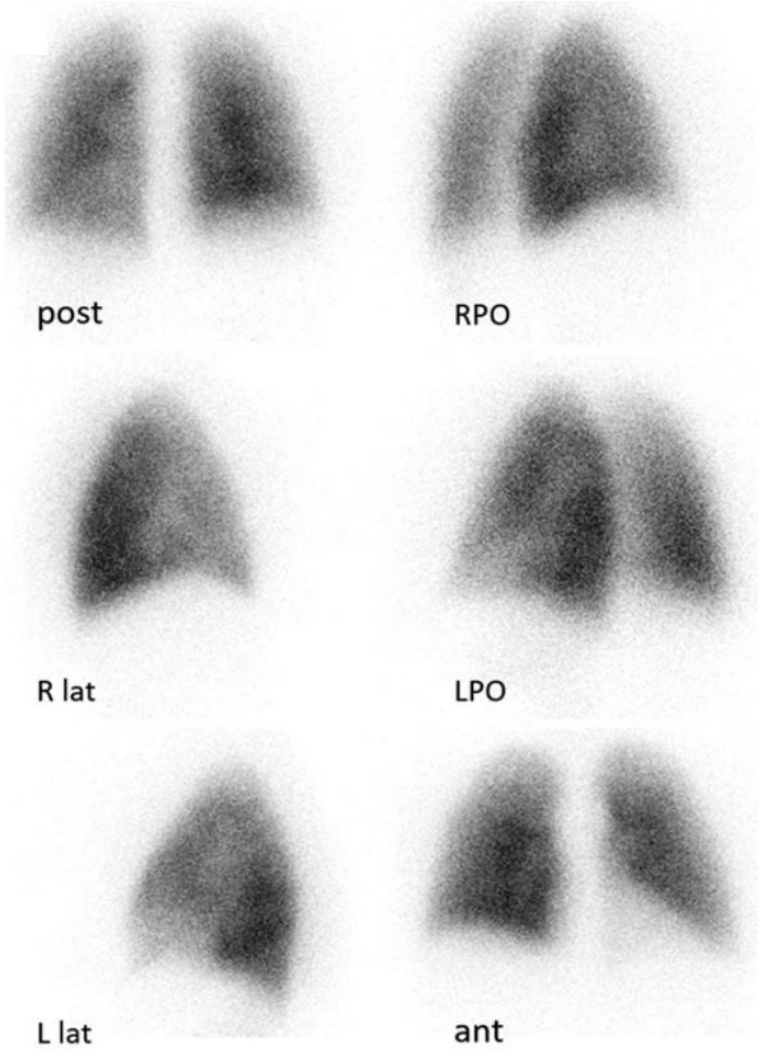
Eur Respir J. 2005 Apr;25(4):594-9.

Definition of PPO FEV_1 & PPO DLCO

PPO FEV_1=
preop FEV_1 x (1 –number of functional lung segments to be resected / total number of functional segments)

PPO DL_{CO}=
preop DL_{CO} x (1 - number of functional lung segments to be resected / total number of functional segments)

Lung perfusion scan



	Rt. lung	Lt. lung
Upper zone	9.1%	13.5%
Middle zone	25.3%	29.2%
Lower zone	12.6%	10.3%
Total	47%	53%

Calculation of PPO FEV_1

Preop FEV_1=1.27L, 67.6% (Predicted FEV_1=1.88L)

PPO FEV_1=

preop FEV_1 x (1 –number of functional lung segments to be resected / total number of functional segments)

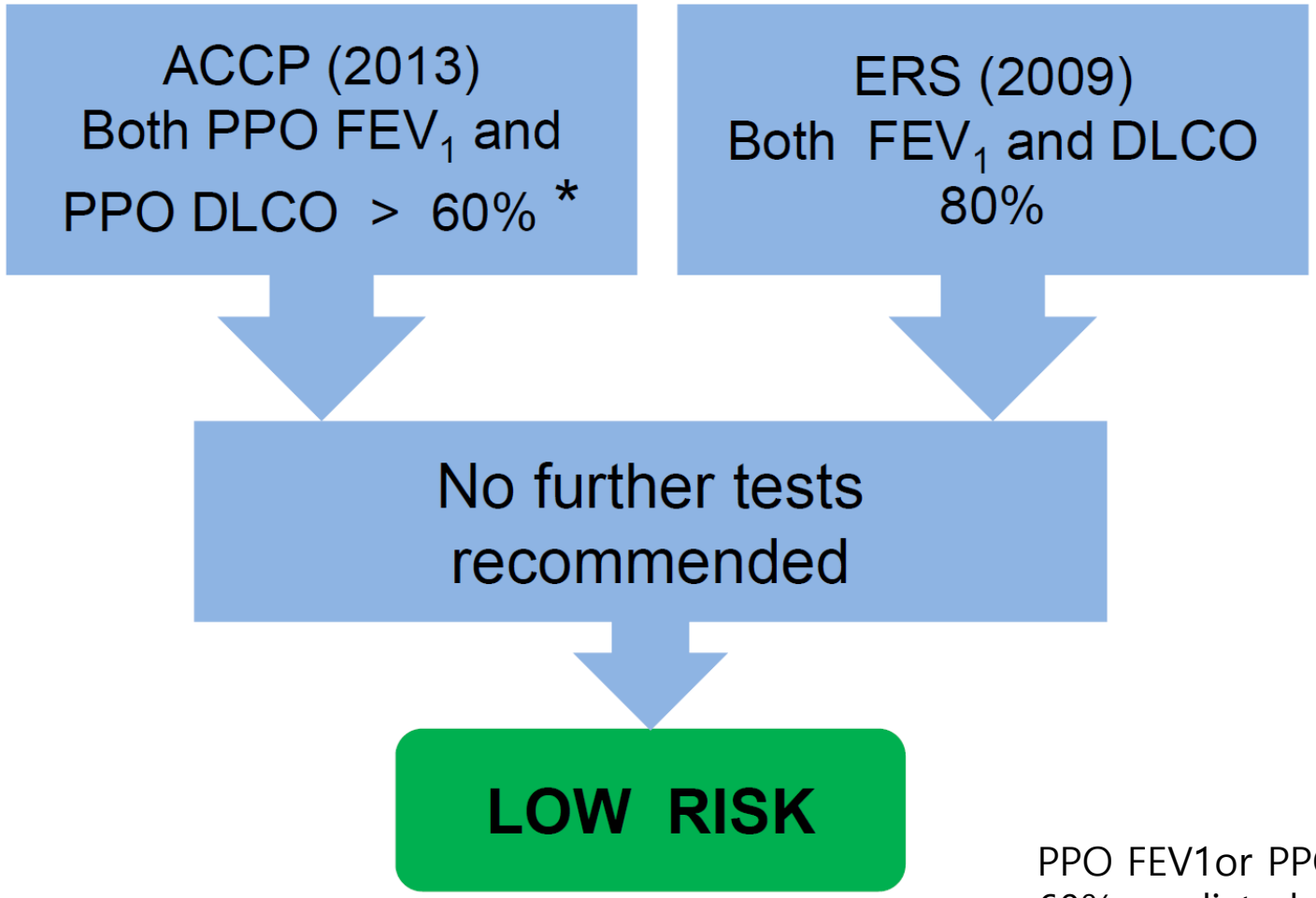
In case of RULobectomy,

PPO FEV_1(L) = 1.27 x (1-0.091) = 1.15L

PPO FEV_1(%) = 1.15/1.88*100 = 61.2%

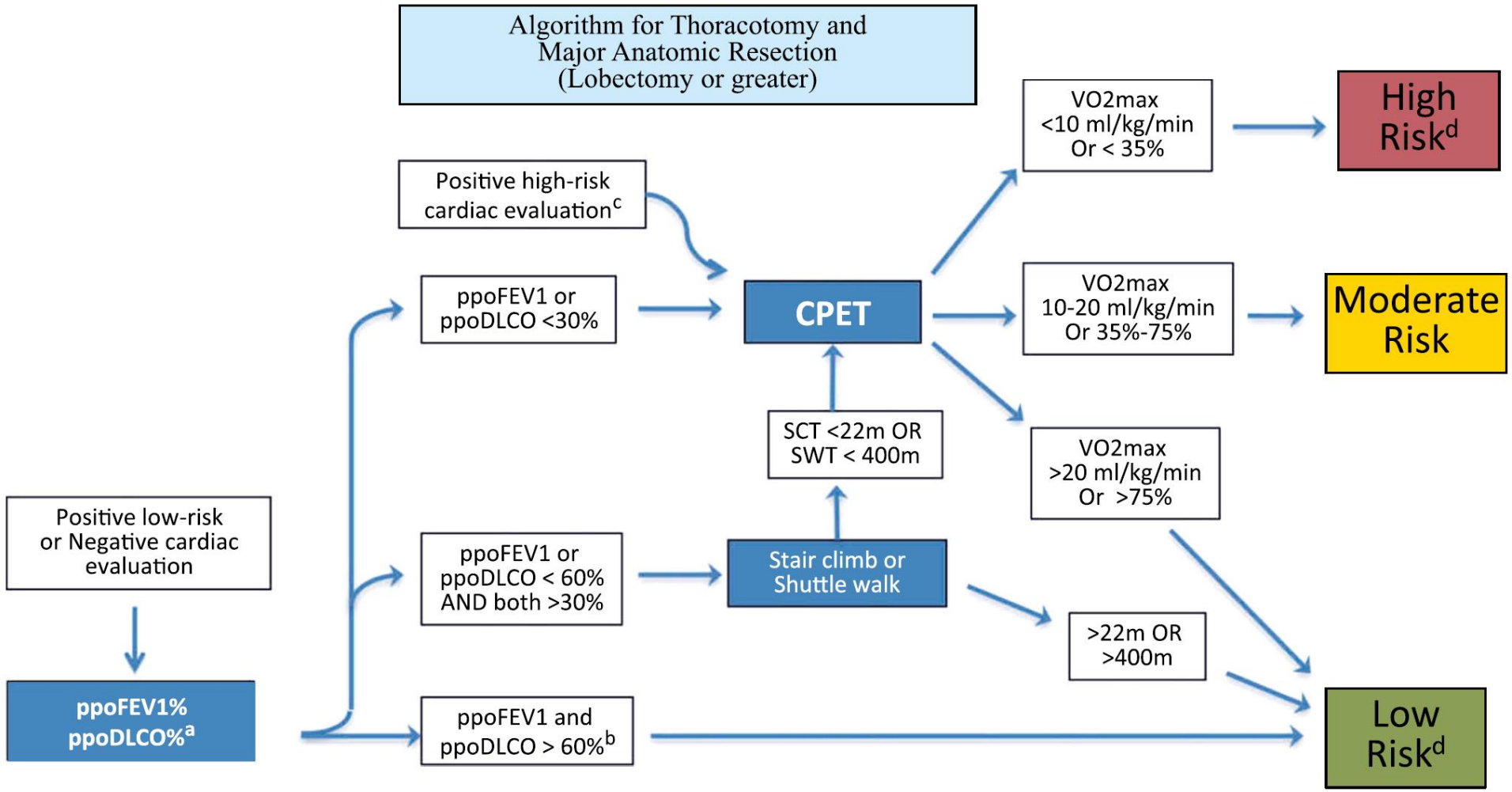
	Rt. lung	Lt. lung
Upper zone	9.1%	13.5%
Middle zone	25.3%	29.2%
Lower zone	12.6%	10.3%
Total	47%	53%

Recommendation: FEV_1 and DLCO



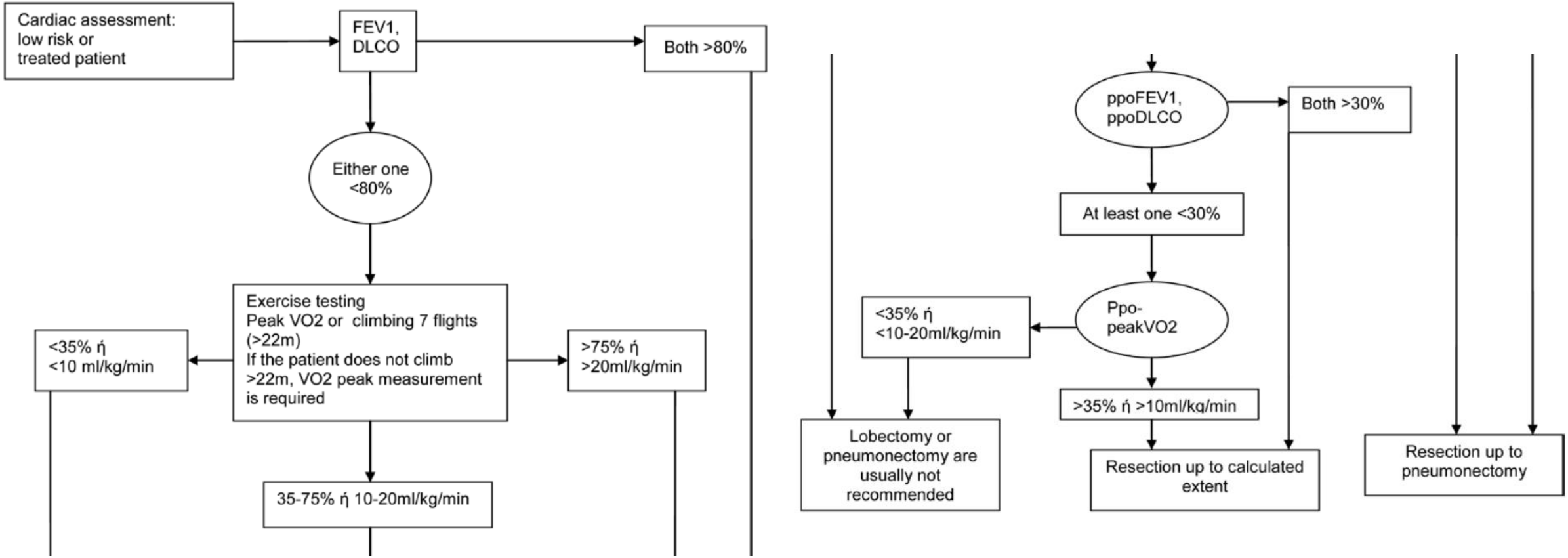
PPO FEV1or PPO DLCO cut off values of 60% predicted values has been chosen based on indirect evidences and expert consensus opinion.

Recommendation: ACCP



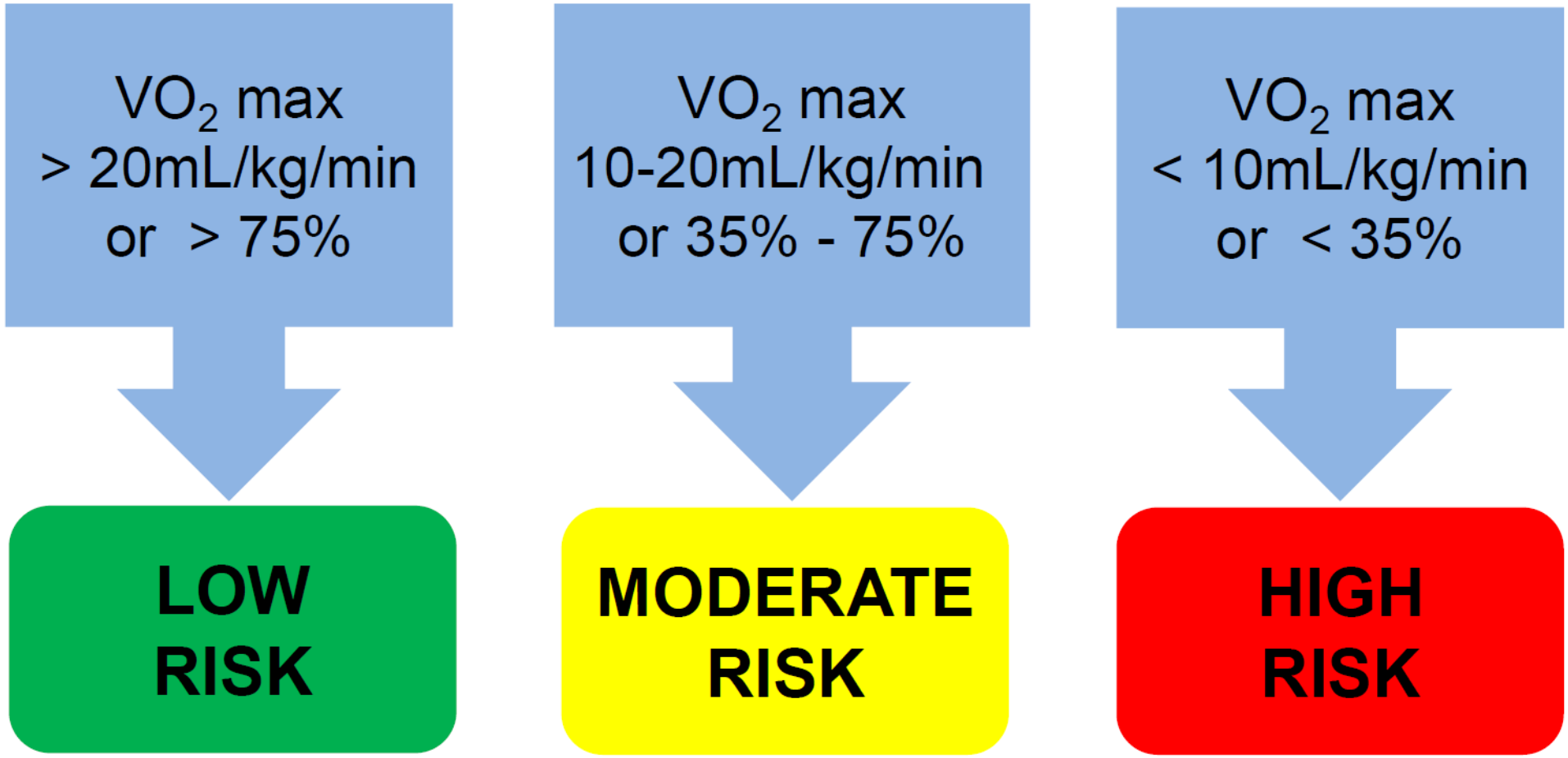
ACCP clinical practice guideline (2013)
Chest. 2013 May;143(5 Suppl):e166S-e190S.

Recommendation: ERS/ESTS



ERS/ESTS clinical practice guideline (2009)
Eur Respir J. 2009 Jul;34(1):17-41.

Recommendation: CPET



ACCP clinical practice guideline (2013)
ERS/ESTS clinical practice guideline (2009)

Contents

Summary

- **Who needs pulmonary evaluation?**

Pulmonary evaluation is needed if ARISCAT score≥26

- **Which postoperative respiratory support needs to be considered?**

Consider CPAP (5-10cmH_20, 1-5 days) in high risk for atelectasis or pneumonia

- **Who benefits bronchoscopy?**

Consider bronchoscopy in poor expectoration, lobar atelectasis, or aspiration pneumonia

Summary

- **Emergency surgery in uncontrolled / partially controlled asthmatics**

Hydrocortisone 100mg tid / Methylprednisolone 0.5mg/kg qd + SABA on call

- **COPD**

Avoid surgery during AE or infection, No routine use of preoperative corticosteroid

- **Lung resection surgery**

1) FEV_1 % / DL_{CO} % (>80%), PPO FEV_1 % / PPO DL_{CO} % (>60%)

2) SWT (>400m)/SCT(>22m)

3) CPET (VO_2 max >20ml/kg/min (75%) or <10ml/kg/min (35%))

Thank you for your attention