ORIGINAL ARTICLE

Additional spirometry criteria predict postoperative complications after coronary artery bypass grafting (CABG) independently of concomitant chronic obstructive pulmonary disease

When is off-pump CABG more beneficial?

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KEY WORDS

CABG, chronic obstructive pulmonary disease, OPCAB, spirometry, prognosis

ABSTRACT

INTRODUCTION Concomitant chronic obstructive pulmonary disease (COPD) is associated with an increased rate of post-coronary artery bypass grafting (CABG) complications. The ratio of forced expiratory volume in 1 second to forced vital capacity (FEV_1/FVC) <70%, proposed by the Global Initiative for Chronic Obstructive Lung Disease as a criterion for the diagnosis of COPD, is criticized for not considering physiological, age-related changes in lung function.

OBJECTIVES The aim of the study was to evaluate which of the additional spirometric parameters, adjusted for age and the distribution of values in the population, represent the best predictors of post-CABG complications and to identify patients who are more likely to benefit from off-pump cardiac bypass (OPCAB) than from CABG.

PATIENTS AND METHODS In the retrospective cohort study, data from a total of 3617 CABG or OPCAB patients were recorded. Patients with COPD, diagnosed prior to admission, were classified according to the spirometry results: group 1 with FEV_1/FVC <70%, group 2 with FEV_1/FVC below the mean normal value adjusted to age, group 3 with FEV_1/FVC below the lower limit of normal (LLN), group 4 with FEV_1 <LLN. The control group comprised subjects with no history of COPD. The occurrence of post-CABG complications was analyzed using the χ^2 and Mann-Whitney U tests.

RESULTS FEV_1 below LLN predicted a higher incidence of reoperation, readmission to intensive care unit (ICU), sternal wound infection, pulmonary complications, and pulmonary edema after surgery ($p < 0.05$). CABG patients with FEV_1 below LLN stayed in the ICU significantly longer than OPCAB patients, and tended to require prolonged mechanical ventilation and more time from operation to discharge.

CONCLUSIONS FEV1 <LLN is the best prognostic marker for post-CABG complications independently of concomitant COPD. Patients with FEV1 <LLN have better outcomes after OPCAB compared with those post-CABG.

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INTRODUCTION Chronic obstructive pulmonary disease (COPD), a chronic disease resulting in airflow obstruction predominantly due to cigarette smoking, is associated with increased morbidity and mortality following cardiac surgery. In particular, mortality from coronary artery bypass grafting (CABG) increases with the severity of COPD. Off-pump cardiac bypass (OPCAB) surgery, which allows to avoid adverse inflammatory and hemodynamic complications associated with extracorporeal circulation, is generally preferred in COPD patients undergoing cardiac bypass surgery.[1-3]

The aim of this study was to assess which additional spirometry criteria best correlate with post-CABG complications and to examine if and when OPCAB reduces the risk of those complications in patients with COPD when compared with those undergoing classic CABG.

PATIENTS AND METHODS This is a retrospective cohort study of 3617 consecutive patients who underwent CABG or OPCAB at the Silesian Centre for Heart Disease from 2003–2006. Preoperative data including demographics and spirometry results, operative data, and postoperative complications were recorded by chart review.

One hundred and sixty-eight patients had been diagnosed with COPD prior to admission. Eighty patients had underwent spirometry before, 41 of whom met any of the inclusion criteria and were further analyzed. We excluded patients with the diagnosis of COPD who did not undergo spirometry (88 patients), and patients who underwent spirometry but did not fulfill any of the inclusion criteria (39 patients). Each patient fulfilling one or more inclusion criteria was analyzed in all matching groups.

Patients were classified into 4 groups based on the inclusion criteria regarding spirometry findings (TABLE 1):

GROUP 1 COPD diagnosed according to the criteria of the Global Initiative for Chronic Obstructive Lung Disease (forced expiratory volume in 1 second to forced vital capacity ratio – [FEV_1/FVC] <70%, 30 patients)

GROUP 2 FEV_1/FVC below the mean normal value adjusted to age (MNAA, 23 patients) (TABLE 2)

GROUP 3 FEV_1/FVC below the lower limit of normal (LLN = norm – 1.64 SD, which is the value of the 5th percentile for the general population, 17 patients)

GROUP 4 FEV_1 <LLN (32 patients including 20 patients with and 12 patients without COPD).

The control group comprised 3449 patients without COPD and spirometry.

Pulmonary complications were defined as pleural effusion requiring punction, pneumothorax requiring pleural drainage, pneumonia and/or pulmonary edema. Prolonged ventilation was defined as invasive ventilation for more than 10 h, prolonged intensive care unit (ICU) stay was defined as ICU stay of more than 24 h, and prolonged hospital stay from procedure to discharge was defined as hospital stay of more than 6 days. These cut-off points were established as medians in the whole group. Nonparametric data were analyzed by χ^2 test, and proportions were compared between groups using the Mann-Whitney U test. A $p < 0.05$ was considered statistically significant.

RESULTS Spirometry was available in 80 of the 168 patients with a preoperative diagnosis of COPD. However, the FEV_1/FVC ratio was <70% only in 30 of these 80 patients, therefore only 37.5% of these patients met the GOLD criteria for the diagnosis of COPD. The FEV_1/FVC ratio was below MNAA in 23 of these patients (28.8%), and FEV_1 was below LLN in 17 patients (21.3%). Thirty-two patients had FEV_1 <LLN independently

TABLE 1 Patient classification according to spirometry values. A patient fulfilling more than one criterion was analyzed in all matching groups.

		Spirometry criteria of the groups
control group	no COPD	no history or symptoms of COPD on admission
group 1	COPD diagnosed according to GOLD	FEV_1/FVC <70%
group 2	COPD diagnosed according to MNAA	FEV_1/FVC <MNAA (TABLE 2)
group 3	COPD diagnosed according to LLN	FEV_1/FVC <FEV_1/FVC LLN FEV_1/FVC LLN = actual FEV_1/FVC value – 1.64 RSD RSD = 7.17 for men RSD = 6.51 for women
group 4	FEV_1 <LLN with or without COPD	FEV_1 <FEV_1 LLN FEV_1 [l/s] LLN = actual FEV_1 value – 1.64 RSD RSD = 0.51 for men RSD = 0.38 for women

Abbreviations: COPD – chronic obstructive pulmonary disease, FEV1 – forced expiratory volume in 1 second, FEV1/FVC – forced expiratory volume in 1 second to forced vital capacity ratio, GOLD – Global initiative for chronic Obstructive Lung Disease, LLN – lower limit of normal, MNAA – mean normal value adjusted to age, RSD – residual standard deviation according to the European Respiratory Society Guidelines 1993

TABLE 2 FEV1/FVC mean normal value adjusted to age cut-off points for the diagnosis of chronic obstructive pulmonary disease with regard to lung function loss progressing with age[4]

age (years)	21–25	26–30	31–35	36 –40	41–50	51–60	61–70	71–80
FEV_1/FVC (%)	74	73	72	71	70	69	67	65

Abbreviations: see TABLE 1

TABLE 3 Group characteristics

		Group 1 $FEV_1/FVC < 70\%$		Group 2 $FEV_1/FVC < MNAA$		Group 3 $FEV_1/FVC < LLN$		Group 4 $FEV_1 < LLN$		Group 5 control group no COPD		p			
		n = 30		n = 23		n = 17		n = 32		n = 3449		1 vs. 5	2 vs. 5	3 vs. 5	4 vs. 5
operation technique	CABG	12	40.0%	9	39.1%	9	52.9%	14	43.8%	2156	62.5%	<0.05	<0.05	NS	<0.05
	OPCAB	18	60.0%	14	60.9%	8	47.1%	18	56.3%	1293	37.5%				
number of grafts		30	2.6 ±1.3	23	2.6 ±1.3	17	2.8 ±1.3	32	2.8 ±1.2	3449	2.7 ±0.9	NS	NS	NS	NS
number of arterial grafts		30	1.1 ±0.5	23	1.1 ±0.5	17	1.1 ±0.2	32	1.1 ±0.4	3449	1.1 ±0.5	NS	NS	NS	NS
complete arterial revascularization		5	17%	5	22%	4	24%	5	16%	495	14%	NS	NS	NS	NS
sex	M	26	86.7%	19	82.6%	14	82.4%	23	71.9%	2627	76.2%	NS	NS	NS	NS
	F	4	13.3%	4	17.4%	3	17.6%	9	28.1%	822	23.8%				
age (years)		30	65 ±9	23	65 ±8	17	65 ±7	32	63 ±8	3449	61 ±9	<0.05	NS	NS	NS
CCS Class	1	1	3.3%	1	4.3%	0	0.0%	1	3.1%	145	4.2%	NS	NS	NS	NS
	2	12	40.0%	8	34.8%	6	35.3%	13	40.6%	1274	36.9%				
	3	13	43.3%	12	52.2%	9	52.9%	15	46.9%	1636	47.4%				
	4	4	13.3%	2	8.7%	2	11.8%	3	9.4%	394	11.4%				
NYHA Class	1	15	50.0%	12	52.2%	9	52.9%	17	53.1%	2568	74.5%	<0.05	<0.05	NS	NS
	2	15	50.0%	11	47.8%	8	47.1%	14	43.8%	769	22.3%				
	3	0	0.0%	0	0.0%	0	0.0%	1	3.1%	103	3.0%				
	4	0	0.0%	0	0.0%	0	0.0%	0	0.0%	9	0.3%				
LVEF [%]		30	48 ±11	23	48 ±13	17	50 ±12	32	47 ±10	3449	51 ±10	NS	NS	NS	NS
EuroSCORE		30	5 ±2	23	5 ±3	17	5 ±2	32	5 ±2	3449	3 ±2	<0.05	<0.05	<0.05	<0.05
diabetes mellitus		8	26.7%	6	26.1%	4	23.5%	12	37.5%	989	28.7%	NS	NS	NS	NS
diabetes treatment	diet	0	0.0%	0	0.0%	0	0.0%	1	8.3%	149	15.1%	NS	NS	NS	NS
	oral	6	75.0%	5	83.3%	4	100.0%	6	50.0%	415	42.0%				
	insulin	2	25.0%	1	16.7%	0	0.0%	5	41.7%	425	43.0%				
hipercholesterolemia		19	63.3%	16	69.6%	11	64.7%	23	71.9%	1476	42.8%	<0.05	<0.05	NS	<0.05
arterial hypertension		23	76.7%	17	73.9%	12	70.6%	25	78.1%	2517	73.0%	NS	NS	NS	NS
atrial fibrillation		1	3.3%	0	0.0%	0	0.0%	1	3.1%	173	5.0%	NS	NS	NS	NS
smoking history	never	1	3.3%	1	4.3%	1	5.9%	4	12.5%	1076	31.2%	<0.05	<0.05	<0.05	<0.05
	previous	17	56.7%	13	56.5%	8	47.1%	17	53.1%	2071	60.0%				
	current	12	40.0%	9	39.1%	8	47.1%	11	34.4%	302	8.8%				
kidney failure		2	6.7%	2	8.7%	2	11.8%	3	9.4%	173	5.0%	NS	NS	NS	NS
cerebral stroke history		0	0.0%	0	0.0%	0	0.0%	2	6.3%	197	5.7%	NS	NS	NS	NS

Abbreviations: CABG – coronary artery bypass grafting, CCS – Canadian Cardiac Society, LVEF – left ventricular ejection fraction, NS – nonsignificant, NYHA – New York Heart Association, OPCAB – off-pump coronary artery bypass, others – see TABLE 1

of COPD diagnosis. OPCAB was performed in 18 (60%) patients with FEV_1 <LLN.

TABLE 3 presents the preoperative characteristics of study patients. Their vascular status prior to CABG is presented in TABLE 4. The preoperative characteristics of patients undergoing CABG or OPCAB did not differ significantly in terms of gender, Canadian Cardiac Society class, New York Heart Association class, systemic hypertension, smoking history, prevalence of cerebrovascular events or diabetes mellitus in all groups. Characteristics of group 4 are listed in TABLE 5.

Patients with COPD, as diagnosed by the GOLD criteria, as well as patients with FEV_1/FVC < MNAA or FEV_1/FVC <LLN, had an increased postoperative incidence of pulmonary complications (TABLE 6). However, these patients did not require prolonged ventilation, prolonged ICU or hospital stay after surgery.

Patients with FEV_1 <LLN had an increased risk of reoperation, readmission to ICU, sternal wound infection, pulmonary complications, and pulmonary edema after surgery (TABLE 6).

ICU stay of patients with FEV_1 below LLN, who underwent OPCAB, was significantly shorter compared with patients undergoing CABG (0.96 vs. 2.79 days, p <0.01). This patient group also tended to demonstrate an increased risk of prolonged ventilation following CABG (12.7 h) compared with OPCAB (9.0 h) and prolonged hospital stay after CABG (7.5 days) compared with OPCAB (6.0 days) (p = nonsignificant [NS]) (TABLE 7).

In the control group patients undergoing OPCAB required a shorter ICU stay compared with CABG patients (1.39 vs. 1.62 days, but with p = NS), significantly shorter mechanical ventilation (13.2 vs. 15.8 h, p <0.01), and shorter hospitalization from procedure to discharge (6.4 vs. 6.8 days, p <0.001).

The data lacked statistical power to analyze postoperative mortality (no deaths in groups 1–3, one death in group 4, 59 deaths in the control

TABLE 4 Preoperative coronary artery characteristics

	Stenosis	Group 1		Group 2		Group 3		Group 4	
LM	significant	7	(23.3%)	4	(17.4%)	3	(17.6%)	5	(15.6%)
	critical	8	(26.7%)	7	(30.4%)	5	(29.4%)	6	(18.8%)
LAD	significant	11	(36.7%)	9	(39.1%)	7	(41.2%)	15	(46.9%)
	critical	16	(53.3%)	11	(47.8%)	8	(47.1%)	16	(50.0%)
CX	significant	11	(36.7%)	8	(34.8%)	4	(23.5%)	11	(34.4%)
	critical	9	(30.0%)	7	(30.4%)	6	(35.3%)	9	(28.1%)
RCA	significant	5	(16.7%)	4	(17.4%)	3	(17.6%)	7	(21.9%)
	critical	18	(60.0%)	13	(56.5%)	10	(58.8%)	19	(59.4%)
D1	significant	8	(26.7%)	6	(26.1%)	5	(29.4%)	10	(31.3%)
	critical	3	(10.0%)	3	(13.0%)	3	(17.6%)	4	(12.5%)
IM	significant	1	(3.3%)	0	(0.0%)	0	(0.0%)	0	(0.0%)
	critical	2	(6.7%)	2	(8.7%)	1	(5.9%)	2	(6.3%)
OM1	significant	4	(13.3%)	3	(13.0%)	2	(11.8%)	4	(12.5%)
	critical	1	(3.3%)	1	(4.3%)	1	(5.9%)	1	(3.1%)
OM2	significant	0	(0.0%)	0	(0.0%)	0	(0.0%)	2	(6.3%)
	critical	0	(0.0%)	0	(0.0%)	0	(0.0%)	1	(3.1%)
PDA	significant	1	(3.3%)	1	(4.3%)	1	(5.9%)	2	(6.3%)
	critical	1	(3.3%)	0	(0.0%)	0	(0.0%)	0	(0.0%)

Significant stenosis – 30% for LM and 50% for other arteries, critical stenosis – 50% for LM and 90% for other arteries

Abbreviations: CX – circumflex coronary artery, D1 – diagonal coronary artery, IM – intermediate coronary artery, LAD – left anterior descending coronary artery, LM – left main coronary artery, OM1 – first obtuse marginal coronary artery, OM2 – second obtuse marginal coronary artery, PDA – posterior descending coronary artery, RCA – right coronary artery

group), stroke, minor neurological complications, psychosis, or postoperative kidney failure. None of the patients with spirometry abnormalities required hemofiltration. The occurrence of postoperative atrial fibrillation (AF) or atrial flutter (AFL) was comparable between all COPD groups and the control group.

DISCUSSION COPD is associated with increased post-CABG complications, including postoperative pneumothorax or pulmonary edema[5], longer ICU and hospital stay[6,7], and in-hospital mortality[8]. Samuels et al. reported increased post-CABG in-hospital mortality for patients with severe COPD, who require steroid treatment as opposed to patients with COPD not requiring steroids, especially in those aged ≥75 years.[9] However, investigators have reported conflicting findings concerning the impact of COPD on post-CABG complications. Manganas et al.[10] found no evidence of increased post-CABG mortality in patients with COPD, although these patients demonstrated an increased incidence of postoperative chest infection and AF, and required longer hospital stay. Prapas et al. reported no association between COPD and prolonged mechanical ventilation after OPCAB.[11]

Postoperative respiratory complications increased hospital length of stay as well as mid-term mortality of CABG patients with severe left ventricular dysfunction, defined as left ventricular ejection fraction ≤30%.[12] These, together with prolonged mechanical ventilation (extubation) time, were also identified as independent risk factors of postoperative acute renal failure requiring renal replacement therapy after cardiac surgery in patients with preoperatively normal renal function, a complication that increases both hospital length of stay and in-hospital mortality.[13]

Our study did not confirm an observation that COPD was a risk factor for postoperative AF or AFL.[14]

The phenomenon of overdiagnosing of COPD, which we observed in our research, is a troublesome finding. In 88 of 168 patients referred to hospital with a preexisting diagnosis of COPD, spirometry had never been performed although it was the method of choice for diagnosing COPD.[15] Furthermore, 50 of 80 patients (62.5%) with COPD, and spirometry performed prior to admission, did not meet the diagnostic spirometry criterion for COPD.[15] To conclude, 52% of diagnoses were made without spirometry and in another 30% the diagnosis of COPD was made despite the lack of diagnostic criteria in spirometry. A correct, spirometry-based diagnosis of COPD was noted only in 18% of patients referred for CABG with coexisting COPD. Damarla et al. reported on a 35% ratio of spirometry performed in patients with the diagnosis of COPD, which is well below our findings (48%); however, in those patients with spirometry performed the interpretation was correct in 70% and not in 37.5% as in our paper.[16]

The GOLD criteria for the diagnosis of COPD[15] have been criticized as being too

TABLE 5 Characteristics of group 4: CABG vs. OPCAB

		Group 4 (FEV_1 <LLN)				
		CABG n = 14		OPCAB n = 18		p
number of grafts		3.79	±0.70	2.06	±0.80	<0.05
number of arterial grafts		1.07	±0.62	1.06	±0.24	NS
complete arterial revascularization		0	0.0%	5	27.8%	NS
sex	M	8	57.1%	15	83.3%	NS
	F	6	42.9%	3	16.7%	
age		63.8	±5.8	63.4	±9.9	NS
CCS Class	1	0	0.0%	1	5.6%	NS
	2	5	35.7%	8	44.4%	
	3	7	50.0%	8	44.4%	
	4	2	14.3%	1	5.6%	
NYHA Class	1	8	57.1%	9	50.0%	NS
	2	6	42.9%	8	44.4%	
	3	0	0.0%	1	5.6%	
	4	0	0.0%	0	0.0%	
LVEF (%)		48	±8	47	±11	NS
EuroSCORE		5	±2	5	±3	NS
diabetes mellitus		7	50.0%	5	27.8%	NS
diabetes treatment	diet	1	14.3%	0	0.0%	NS
	oral	2	28.6%	4	80.0%	
	insulin	4	57.1%	1	20.0%	
hipercholesterolemia		9	64.3%	14	77.8%	NS
arterial hypertension		11	78.6%	14	77.8%	NS
atrial fibrillation		1	7.1%	0	0.0%	NS
smoking history	never	3	21.4%	1	5.6%	NS
	previous	7	50.0%	10	55.6%	
	current	4	28.6%	7	38.9%	
kidney failure		1	7.1%	2	11.1%	NS
cerebral stroke history		2	14.3%	0	0.0%	NS

Abbreviations: see TABLES 1 and 3

rigid and not considering physiological age-related changes in lung function. As a consequence, FEV_1/FVC <70% can lead to a misdiagnosis of COPD in healthy elderly patients, and FEV_1/FVC >70% can fail to detect significant airflow obstruction in young COPD patients. That is why we included alternative spirometry criteria for airflow obstruction, adjusting for age (FEV_1/FVC compared with MNAA)[4] and relating to population values (FEV_1/FVC and FEV_1 compared with LLN).[17]

Previous studies have reported that the absolute FEV_1 value has a better correlation with the post-CABG course than the diagnosis of COPD as determined by FEV_1/FVC. Lower preoperative FEV_1 is also a predictor of in-hospital mortality[8] as well as of 5-year survival after CABG, independently of age[7]. Our findings are consistent with this observation, as FEV_1 <LLN correlated with pulmonary complications and a worse prognosis, independently of FEV_1/FVC that met the GOLD or adjusted criteria for the diagnosis of COPD. Since the LLN is easy to calculate, we would suggest calculating this value preoperatively. This could be used to identify patients who may benefit from nebulisation of β-agonists and an intraoperative dose of systemic steroid.[18]

Data from cardiothoracic centers have provided varied results as to the outcomes for COPD patients undergoing CABG compared with OPCAB. The Münster group has recently reported similar outcomes in COPD patients undergoing OPCAB compared with CABG.[19] However, duration of operation was significantly longer using the off-pump technique in this series, and longer duration of surgery (but neither obesity nor COPD) has previously been identified as an independent risk factor for sternal complications after internal thoracic artery grafting.[20] Previous smaller studies on COPD patients demonstrated that OPCAB is associated with a lower incidence of respiratory complications[1], earlier extubation time[2,3], shorter ICU stay[2] and a general positive trend in lower morbidity and mortality[3]. However, COPD is associated with an increased risk of emergency intraoperative conversion from OPCAB to CABG (mostly secondary to respiratory failure), which is associated with increased operative mortality and morbidity.[21]

In the present study, FEV_1 <LLN correlated with prolonged ICU stay, ventilation and hospitalization time after CABG when compared with OPCAB. These findings are in line with the previous studies demonstrating worse outcomes in patients with severe COPD undergoing CABG.[9,10]

We identified several limitations of this retrospective study, including a small sample size, the lack of spirometry data for the control group, and the lack of a long-term follow-up. Perioperative nebulization of bronchodilators was not routinely used in our center at that time.

COPD is a common condition in patients undergoing CABG or repeat CABG[22], and is an independent predictor of late post-CABG mortality[23-25] and quality of life even 10 years after CABG[26]. The overall benefits of the operation for this group of patients have been confirmed.[23] Improved peri- and postoperative management techniques need to be developed in order to maximize the potential benefit of CABG for COPD. We suggest that future prospective studies of COPD patients undergoing coronary bypass surgery incorporate alternative spirometry parameters, including the comparison of FEV_1/FVC with MNAA and comparison of FEV_1 with LLN, in addition to the GOLD criteria. This may help to identify a group of patients who may have better outcomes after OPCAB. In our study, patients with FEV_1 <LLN benefited from OPCAB compared with CABG in terms of a significantly shorter ICU stay, a tendency to shorter mechanical ventilation and hospitalization time after surgery.

Compared with healthy subjects, this group also demonstrated an increased incidence

TABLE 6 Comparative analysis of clinical postoperative data in 4 patient groups and controls

		Group 1 FEV_1/FVC <70% n = 30		Group 2 FEV_1/FVC <MNAA n = 23		Group 3 FEV_1/FVC <LLN n = 17		Group 4 FEV_1 <LLN n = 32		Control group no COPD n = 3449		p 1 vs. 5	p 2 vs. 5	p 3 vs. 5	p 4 vs. 5
reoperation		3	10.0%	3	13.0%	3	17.6%	5	15.6%	178	5.2%	NS	NS	NS	<0.05
reintubation		0	0.0%	0	0.0%	0	0.0%	0	0.0%	68	2.0%	NS	NS	NS	NS
pulmonary complications		6	20.0%	6	26.1%	5	29.4%	9	28.1%	276	8.0%	<0.05	<0.05	<0.05	<0.05
pleural effusion/punction		2	6.7%	2	8.7%	1	5.9%	2	6.3%	77	2.2%	NS	NS	NS	NS
pneumothorax/drainage		1	3.3%	1	4.3%	1	5.9%	1	3.1%	78	2.3%	NS	NS	NS	NS
pneumonia		0	0.0%	0	0.0%	0	0.0%	0	0.0%	16	0.5%	NS	NS	NS	NS
pulmonary edema		1	3.3%	1	4.3%	0	0.0%	2	6.3%	23	0.7%	NS	NS	NS	<0.05
neurological complications		1	3.3%	1	4.3%	0	0.0%	3	9.4%	224	6.5%	NS	NS	NS	NS
psychosis		0	0.0%	0	0.0%	0	0.0%	0	0.0%	113	3.3%	NS	NS	NS	NS
encefalopathy		0	0.0%	0	0.0%	0	0.0%	0	0.0%	10	0.3%	NS	NS	NS	NS
cerebral stroke		1	3.3%	1	4.3%	0	0.0%	1	3.1%	52	1.5%	NS	NS	NS	NS
new-onset atrial fibrillation		4	13.3%	3	13.0%	2	11.8%	5	15.6%	352	10.2%	NS	NS	NS	NS
kidney failure		0	0.0%	0	0.0%	0	0.0%	1	3.1%	129	3.7%	NS	NS	NS	NS
hemodiafiltration		0	0.0%	0	0.0%	0	0.0%	0	0.0%	40	1.2%	NS	NS	NS	NS
infectious complications		0	0.0%	0	0.0%	0	0.0%	2	6.3%	49	1.4%	NS	NS	NS	NS
sternal wound infection		0	0.0%	0	0.0%	0	0.0%	2	6.3%	17	0.5%	NS	NS	NS	<0.05
readmission to ICU		0	0.0%	0	0.0%	0	0.0%	2	6.3%	34	1.0%	NS	NS	NS	<0.05
death		0	0.0%	0	0.0%	0	0.0%	1	3.1%	59	1.7%	NS	NS	NS	NS
mechanical ventilation (h)		9		9		9		10.5		10		NS	NS	NS	NS
ICU length of stay (day)		0.94		0.96		1.01		1.02		1.00		NS	NS	NS	NS
hospitalization time after surgery (day)		6		6		6		6		6		NS	NS	NS	NS
condition at discharge	good	29	96.7%	22	95.7%	17	100.0%	30	96.8%	3333	98.3%	NS	NS	NS	NS
	poor	1	3.3%	1	4.3%	0	0.0%	1	3.2%	42	1.2%				
	severe	0	0.0%	0	0.0%	0	0.0%	0	0.0%	15	0.4%				

Abbreviations: ICU – intensive care unit, others – see TABLES 1 and 3

TABLE 7 Comparison of postoperative data for patients in group 4 following CABG vs. OPCAB

		Group 4 (FEV_1 <LLN)				
		CABG n = 14		OPCAB n = 18		p
reoperation		2	14.3%	3	16.7%	NS
reintubation		0		0		–
pulmonary complications		6	42.9%	3	16.7%	NS
pleural effusion/punction		1	7.1%	1	5.6%	NS
pneumothorax/drainage		1	7.1%	0	0.0%	NS
pneumonia		1	7.1%	1	5.6%	NS
pulmonary edema		0		0		–
neurological complications		2	14.3%	1	5.6%	NS
psychosis		0		0		–
encefalopathy		0		0		–
cerebral stroke		0	0.0%	1	5.6%	NS
new-onset atrial fibrillation		1	7.1%	4	22.2%	NS
kidney failure		1	7.1%	0	0.0%	NS
hemodiafiltration		0		0		–
infectious complications		1	7.1%	1	5.6%	NS
sternal wound infection		1	7.1%	1	5.6%	NS
readmission to ICU		2	14.3%	0	0.0%	NS
death		1	7.1%	0	0.0%	NS
mechanical ventilation (h)		12.70		9.00		NS
ICU length of stay (day)		2.79		0.96		p <0.01
hospitalization time after surgery (day)		7.50		6.00		NS
condition at discharge	good	13	100.0%	17	94.4%	NS
	poor	0	0.0%	1	5.6%	
	severe	0	0.0%	0	0.0%	

Abbreviations: see TABLES 1, 3 and 6

of pulmonary complications, sternal wound infections, reoperation, and readmission to ICU after bypass surgery (CABG or OPCAB), and therefore the criterion of FEV_1 <LLN might help identify those patients who could benefit from some of the known preventive strategies to reduce postoperative complications.

We demonstrated that patients with a preoperative exertional dyspnea require spirometry testing before establishing the diagnosis of COPD. The GOLD spirometry criteria (FEV_1/FVC <70%) are currently applied in the diagnosis of COPD, but alternative spirometry parameters (including FEV_1 <LLN and FEV_1/FVC <MNAA) may be useful in pre-CABG assessment of these patients. Prospective studies regarding these and other spirometry measures should be performed to elucidate their relevance in predicting postoperative complications and to determine those who would benefit more from OPCAB than from CABG.

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Dodatkowe kryteria spirometryczne pozwalają przewidzieć powikłania po pomostowaniu aortalno-wieńcowym (CABG) niezależnie od współtowarzyszącego rozpoznania przewlekłej obturacyjnej choroby płuc

Kiedy korzystniejsze jest CABG bez użycia krążenia pozaustrojowego?

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krążenie pozaustrojowe, pomostowanie aortalno-wieńcowe, przewlekła obturacyjna choroba płuc, rokowanie, spirometria

STRESZCZENIE

WPROWADZENIE Współistnienie przewlekłej obturacyjnej choroby płuc (*chronic obstructive pulmonary disease* – COPD) u pacjentów poddawanych pomostowaniu aortalno-wieńcowemu (*coronary artery bypass grafting* – CABG) wiąże się z większym ryzykiem wystąpienia powikłań w okresie pooperacyjnym. Kryterium rozpoznania COPD zaproponowane przez *Global Initiative for Chronic Obstructive Lung Disease* – stosunek natężonej objętości wydechowej pierwszosekundowej do natężonej pojemności życiowej (*the ratio of forced expiratory volume in 1 second to forced vital capacity* – FEV_1/FVC) <70% – jest krytykowane za brak uwzględniania fizjologicznych zmian w płucach, zachodzących z wiekiem.

CELE Celem badania była ocena, która z dodatkowych danych spirometrycznych uwzględniających wiek i rozkład parametrów oddechowych w populacji jest najlepsza w oszacowaniu ryzyka powikłań po CABG oraz identyfikacja pacjentów odnoszących większą korzyść z pomostowania aortalno-wieńcowego bez użycia krążenia pozaustrojowego (*off-pump cardiac bypass* – OPCAB) niż z CABG.

PACJENCI I METODY Jest to retrospektywne badanie kohortowe 3617 pacjentów poddanych CABG lub OPCAB. Pacjenci z rozpoznaną przed przyjęciem do zabiegu COPD podzieleni zostali na grupy według wyniku spirometrii: grupa 1: FEV_1/FVC <70%, grupa 2: FEV_1/FVC < średnia norma dla wieku, grupa 3: FEV_1/FVC < dolna granica normy (*lower limit of normal* – LLN), grupa 4: FEV_1 <LLN. Grupę kontrolną stanowili pacjenci bez wywiadu i objawów COPD. Występowanie powikłań po CABG porównywano między grupami z zastosowaniem testu χ^2 i testu U Manna i Whitney'a.

WYNIKI FEV_1 <LLN wiązała się ze zwiększonym ryzykiem reoperacji, ponownego przyjęcia na oddział intensywnej terapii (*intensive care unit* – ICU), infekcji rany mostka, powikłań płucnych i obrzęku płuc po operacji ($p < 0,05$). Pacjenci z FEV_1 poniżej LLN poddani CABG w porównaniu do OPCAB wymagali istotnie dłuższego pobytu na ICU i wykazywali tendencję do przedłużonej wentylacji mechanicznej i przedłużonego czasu od operacji do wypisania ze szpitala.

WNIOSKI Niezależnie od rozpoznania COPD, wartość FEV_1 <LLN najlepiej przewiduje wystąpienie komplikacji po CABG. Wyniki pacjentów z FEV_1 <LLN były lepsze po przeprowadzonej OPCAB w porównaniu z CABG.

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