



Perioperative Pulmonary Rehabilitation for Lung Cancer Surgery

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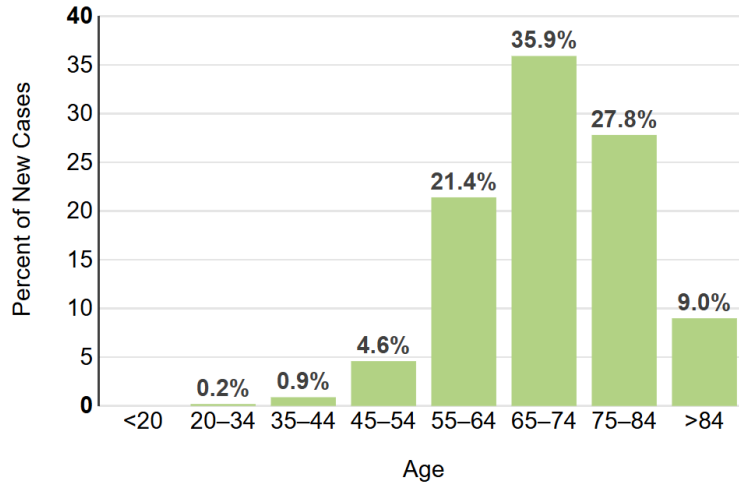
Perioperative Pulmonary Rehabilitation

Factors to consider for surgery

Comprehensive Rehabilitation

Lung Cancer

Percent of New Cases by Age Group: Lung and Bronchus Cancer



Lung and bronchus cancer is most frequently diagnosed among people aged 65-74.

Median Age
At Diagnosis

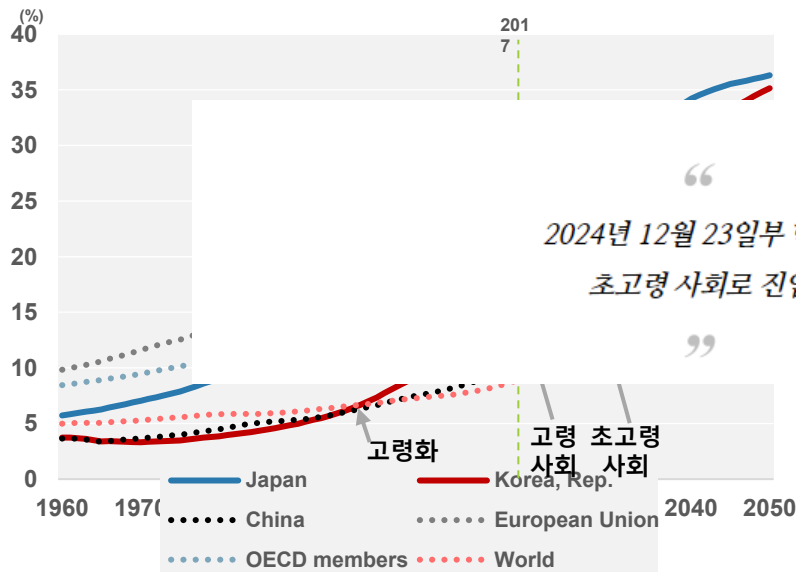
71



고령화 사회

한국은 세계에서 가장 빠른 속도로 고령 사회 ('17) → 초고령 사회 ('26) 진입이 예상됨.

전체 인구 중 65세 이상 고령자 비중



“
2024년 12월 23일부 한국,
초고령 사회로 진입
”

고령 (14%~) → 초고령 (20%~) 사회 진입 기간

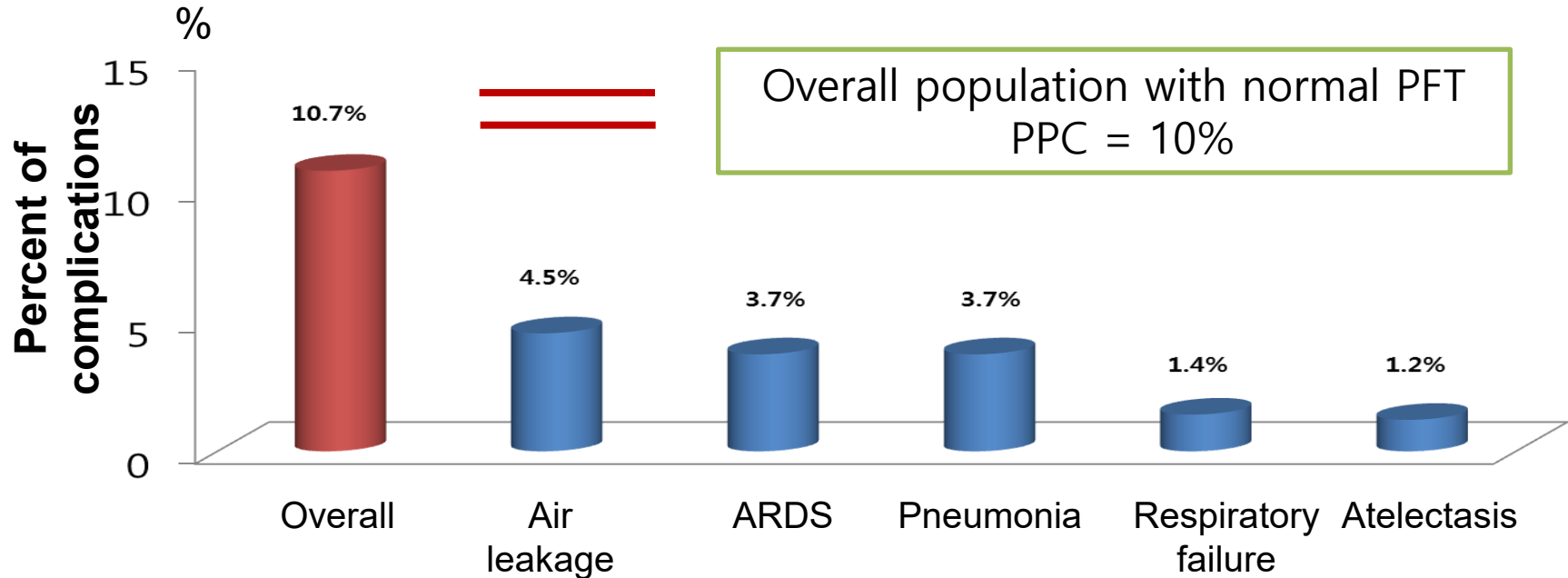


* 고령화 사회 : 65세 이상 인구가 전체 인구의 7% 이상
 고령 사회 : 65세 이상 인구가 전체 인구의 14% 이상
 초고령 사회 : 65세 이상 인구가 전체 인구의 20% 이상 (UN 기준)



Postoperative Pulmonary complications (PPCs)

Healthy elderly patients (≥ 70 years) without COPD and ILD

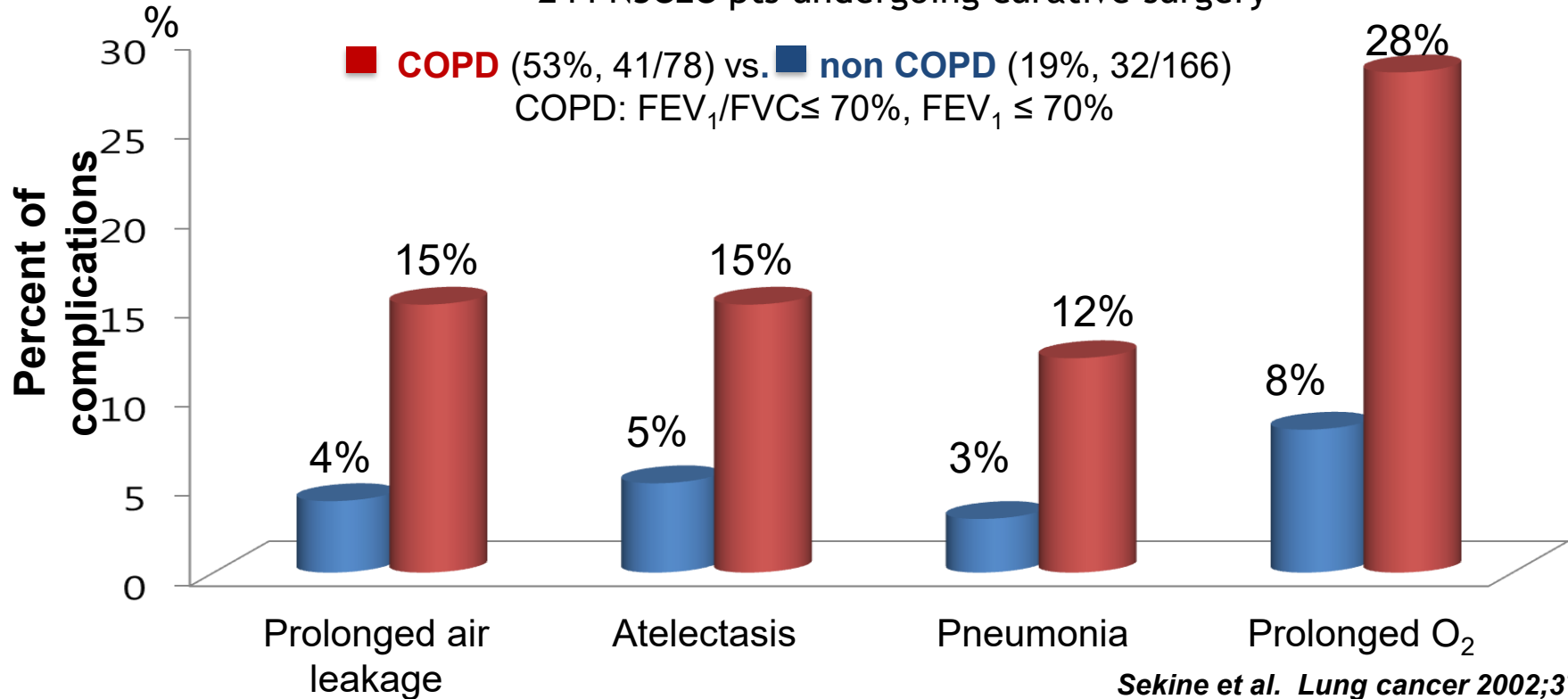




PPCs in COPD vs. non COPD

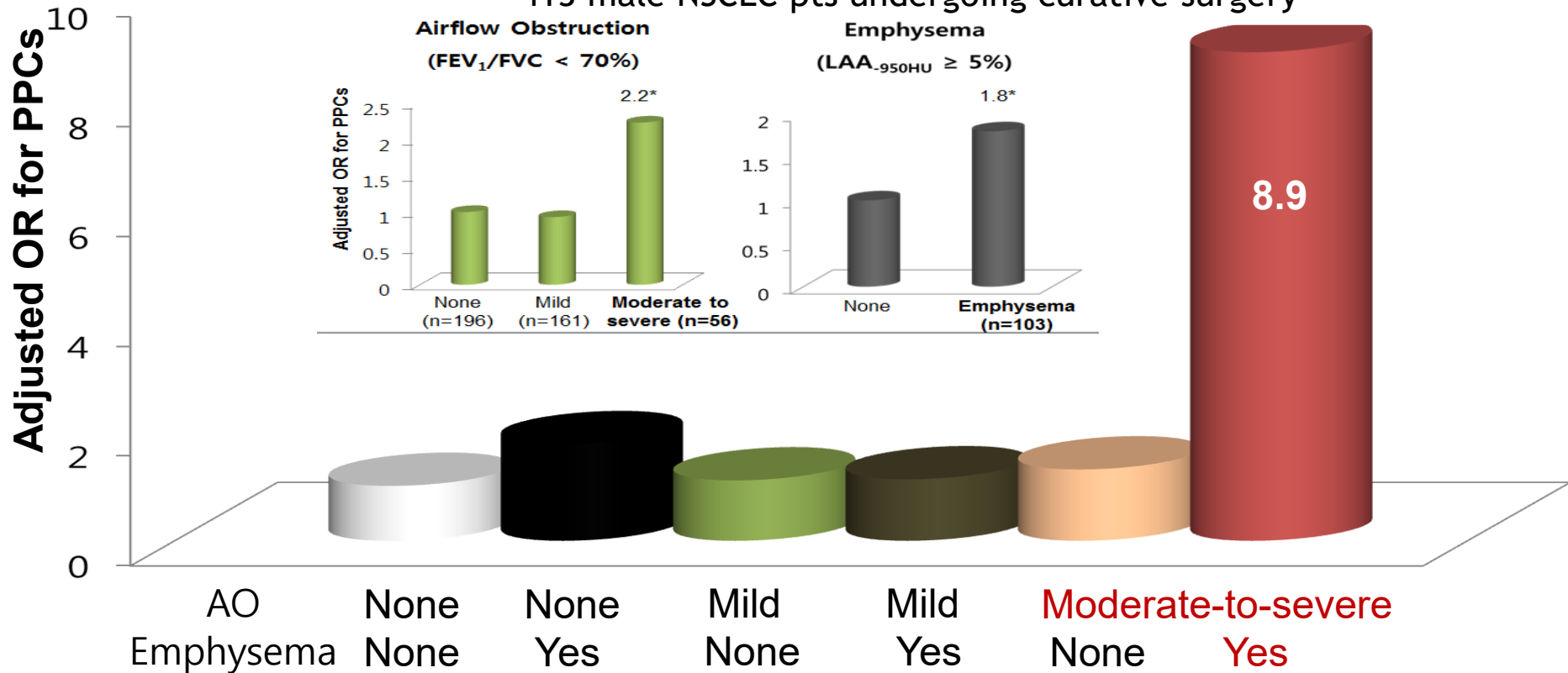
244 NSCLC pts undergoing curative surgery

■ **COPD** (53%, 41/78) vs. ■ **non COPD** (19%, 32/166)
COPD: FEV₁/FVC ≤ 70%, FEV₁ ≤ 70%



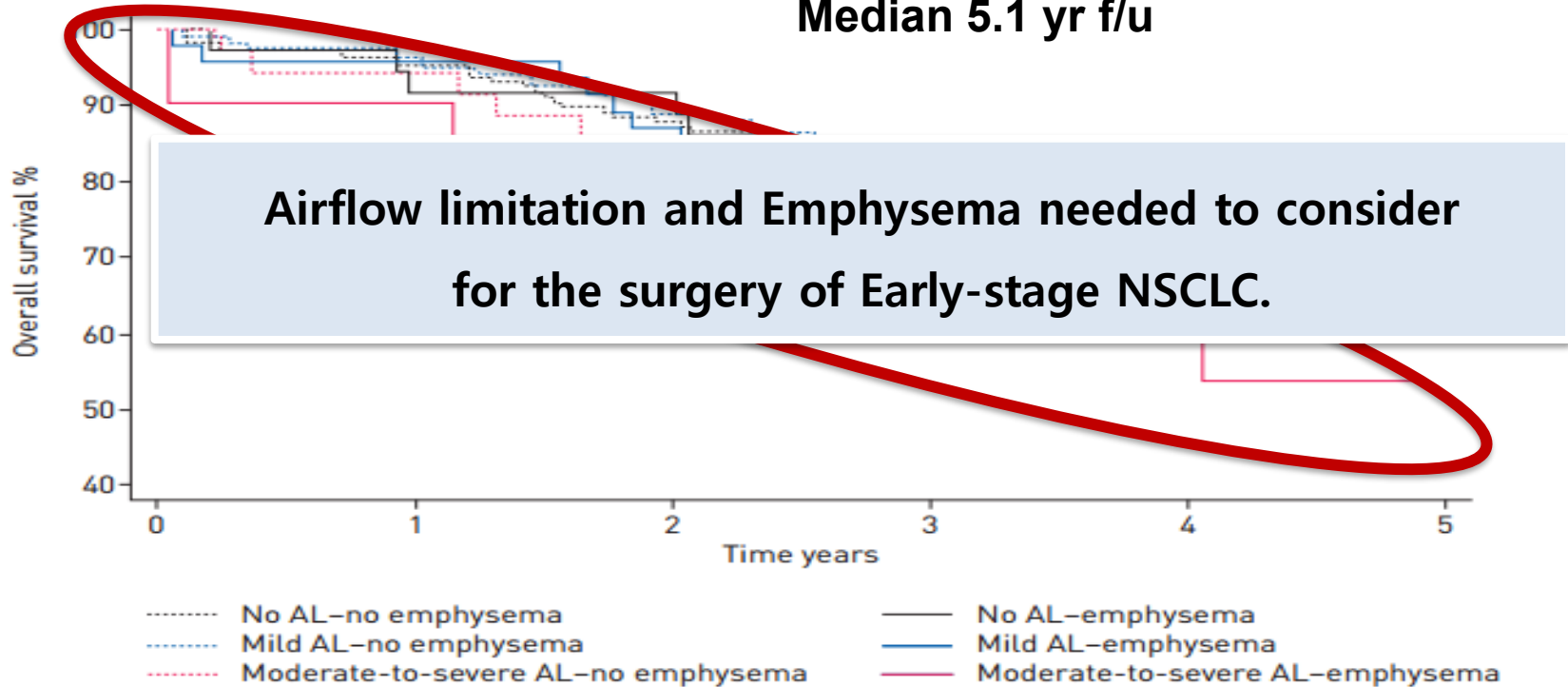
PPCs in COPD

413 male NSCLC pts undergoing curative surgery



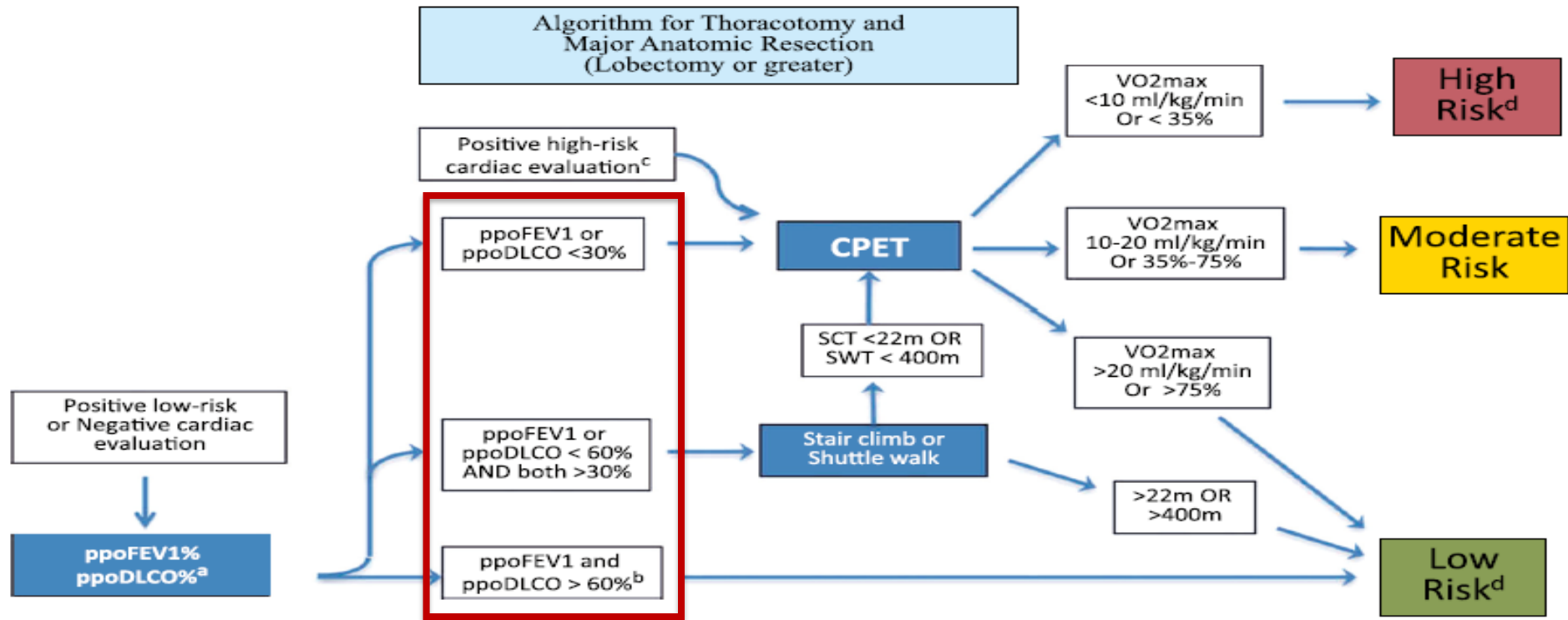
Mortality

Median 5.1 yr f/u





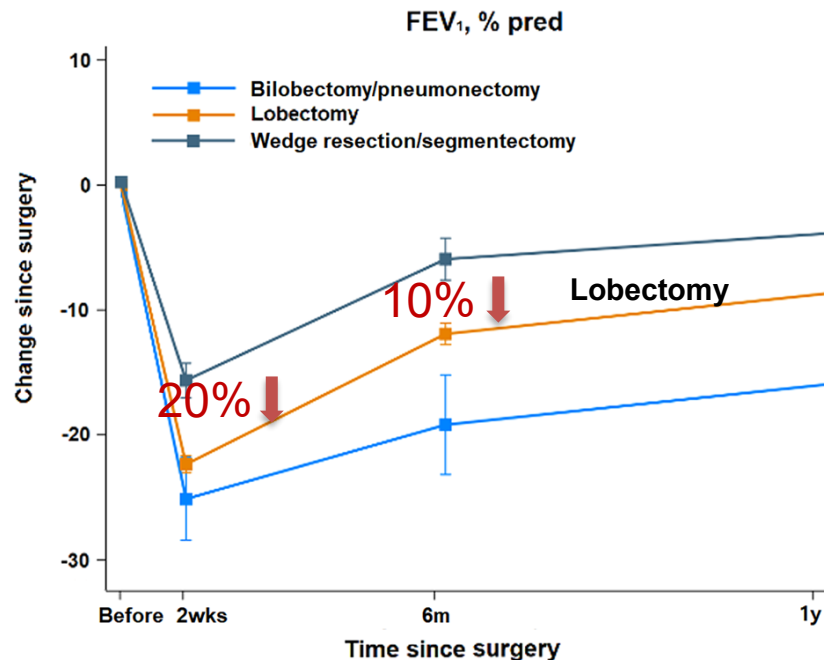
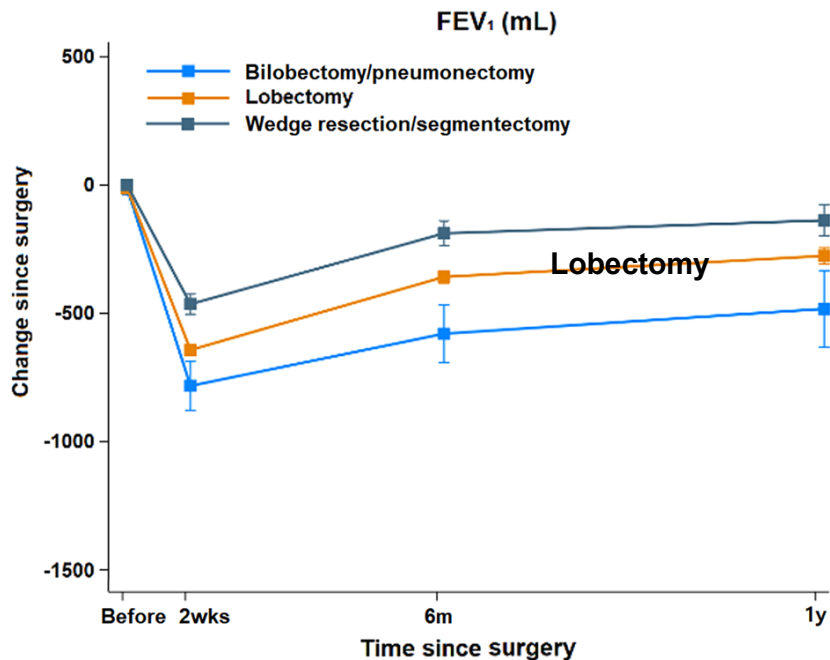
Physiologic evaluation of the patients with lung cancer





수술 종류에 따른 폐기능 변화

626 Patients with curative lung cancer surgery (March 2016 – October 2018)



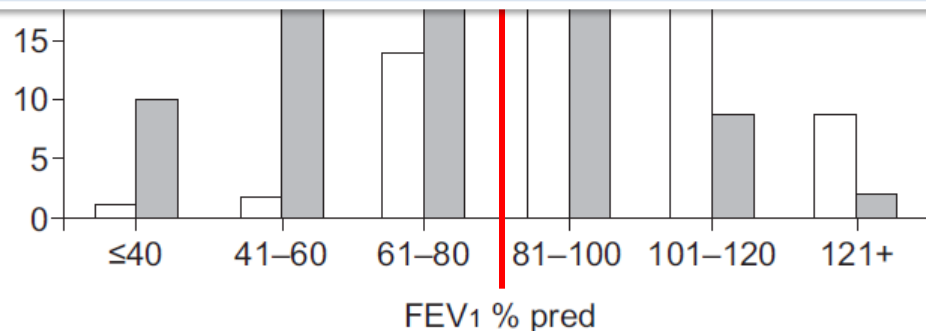


Distribution of FEV1 % pred LCA vs. matched smoking controls

N=446, matched with age, sex and smoking Hx (randomly recruited community control)



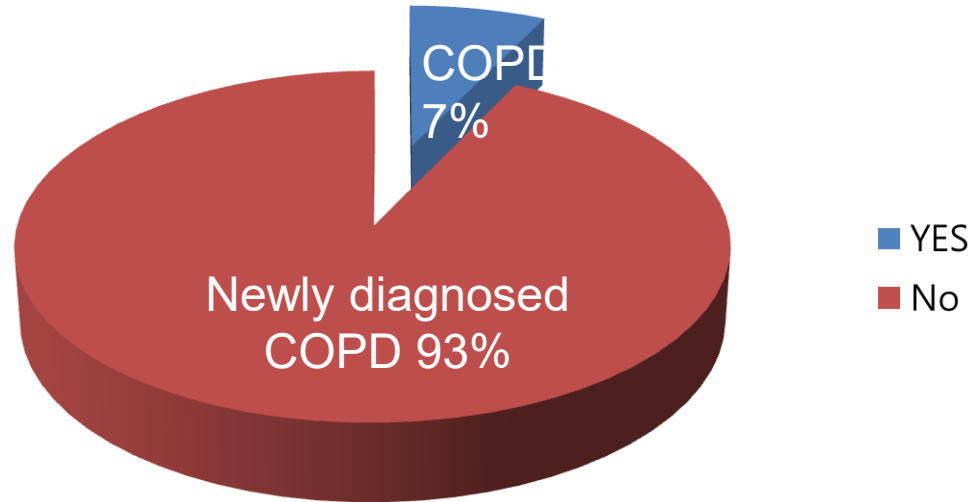
6-fold increased prevalence in COPD than matched smokers in newly diagnosed lung cancer cases.





Untreated COPD

N=221 LCA with ever smokers, **111 COPD** vs. 110 non-COPD

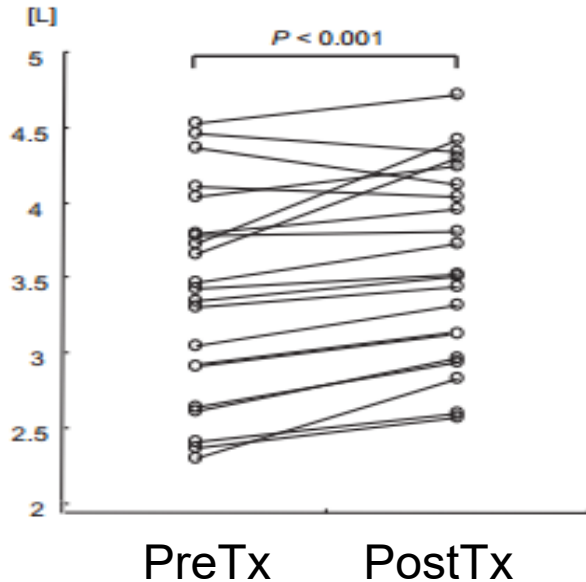




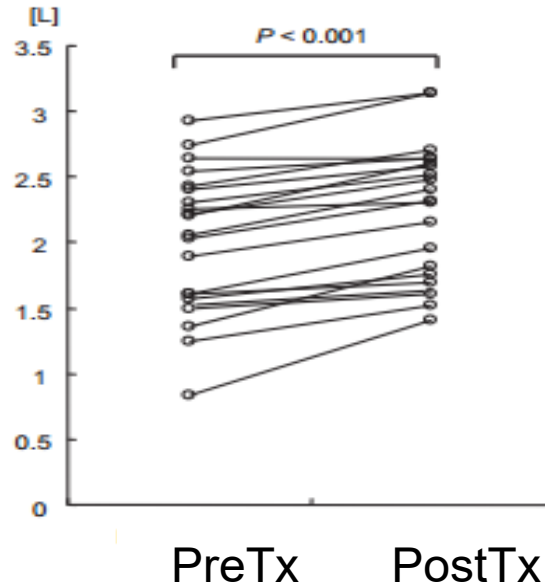
Effect of Tiotropium in LCA patients with untreated COPD

Two-week preoperative treatment with TIOT
(n=21, untreated COPD)

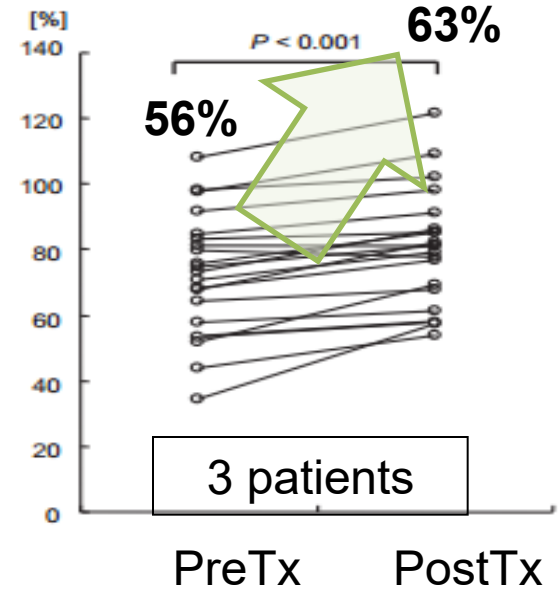
FVC (L)



FEV₁ (L)



FEV₁ (% pred)





Inhalers



LAMA + LABA

 Glycopyrronium Indacaterol	 Acridinium Formoterol
 Umeclidinium Vilanterol	 Tiotropium Olodaterol

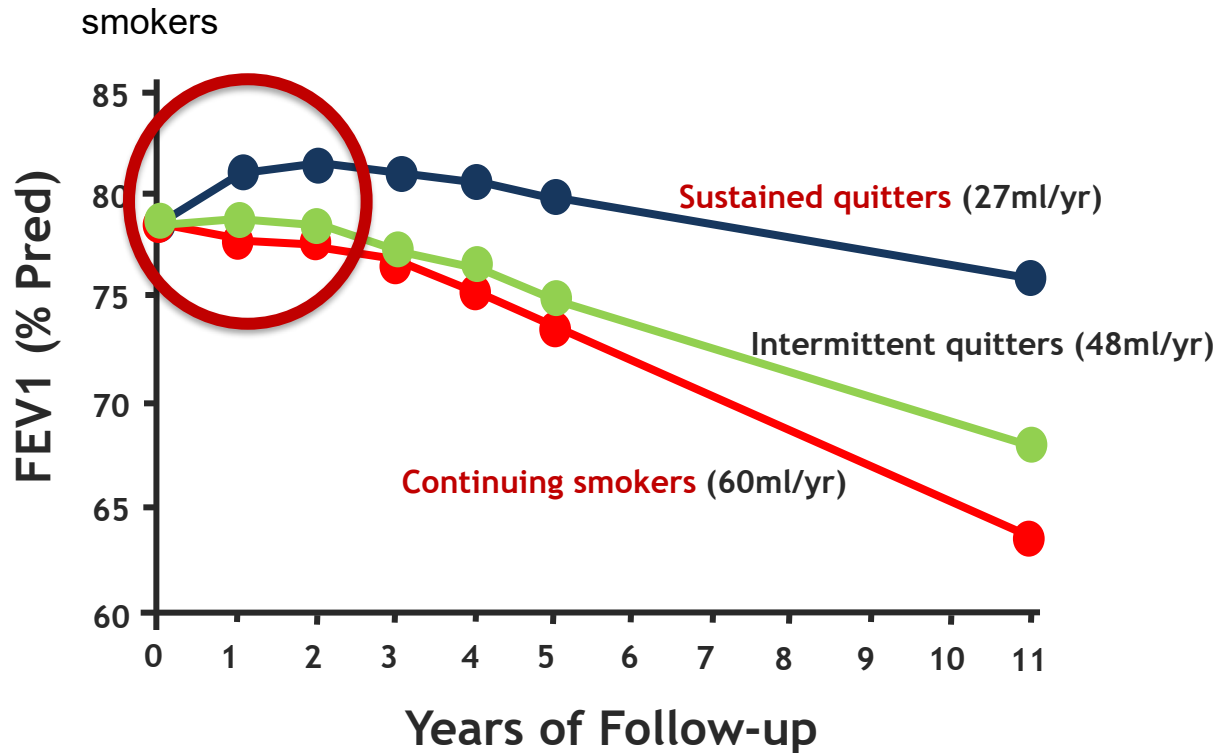


Acridinium
(에클리라®)



Fluticasone furoate / Vilanterol
(렐바®)

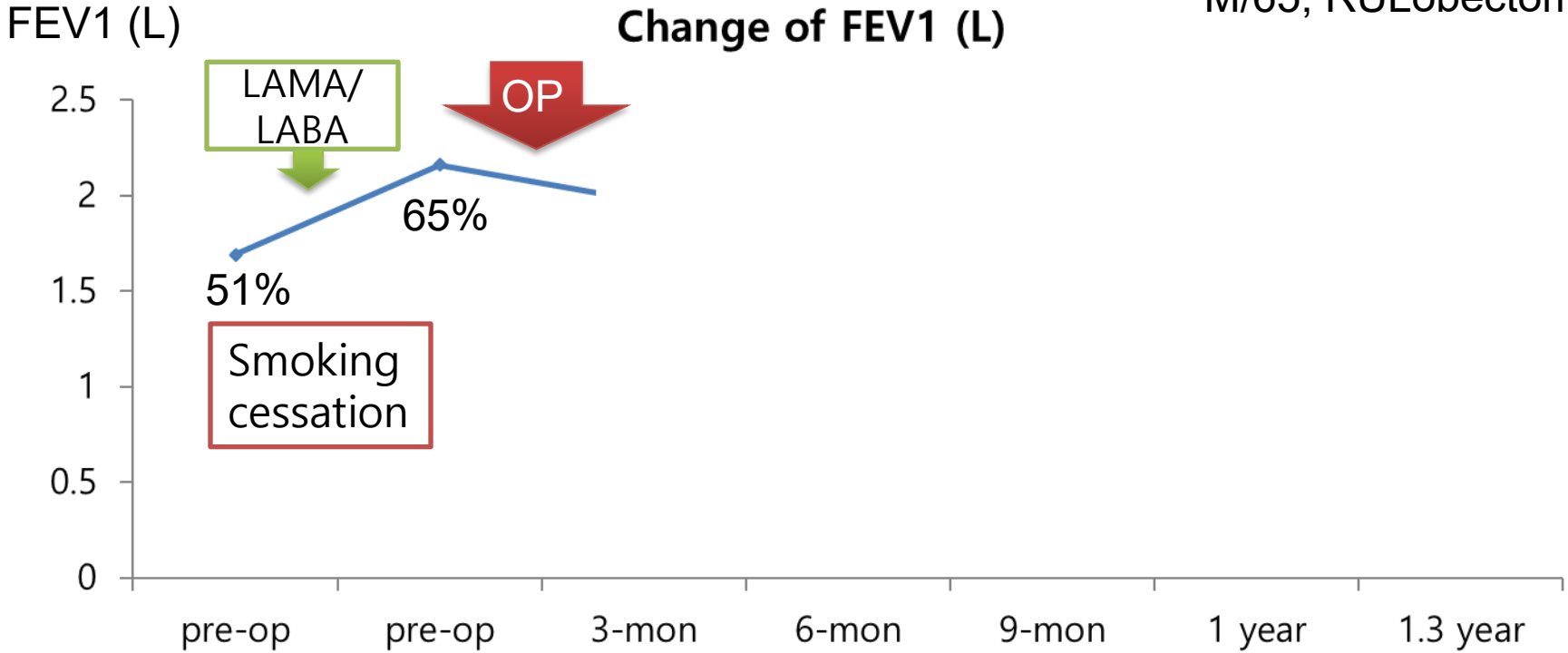
Smoking status





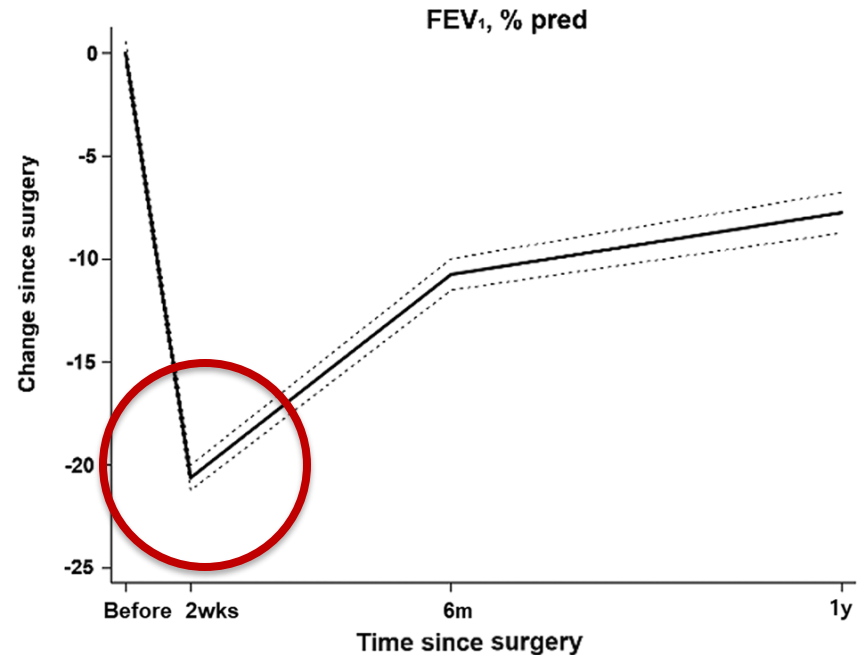
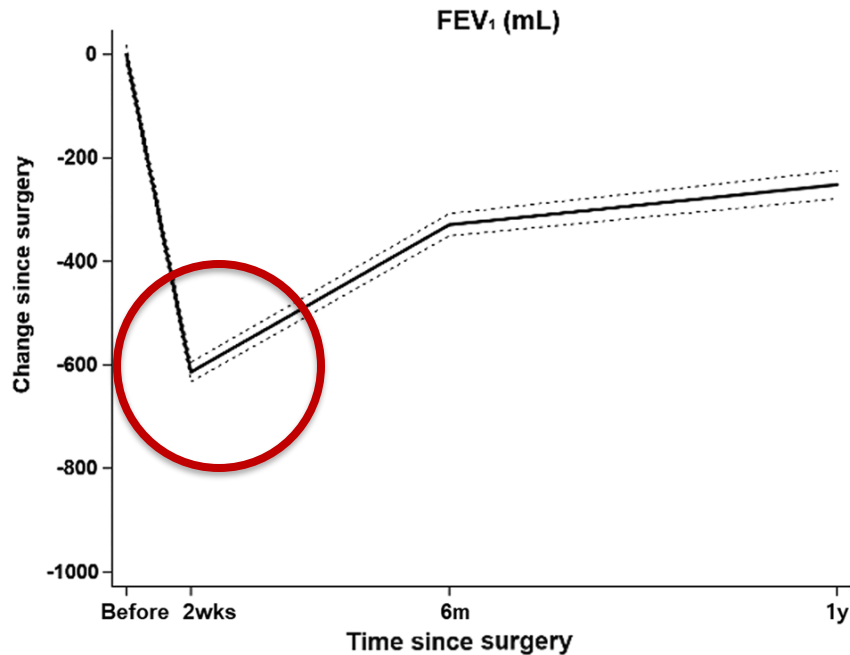
COPD management in LCA

M/65, RULobectomy



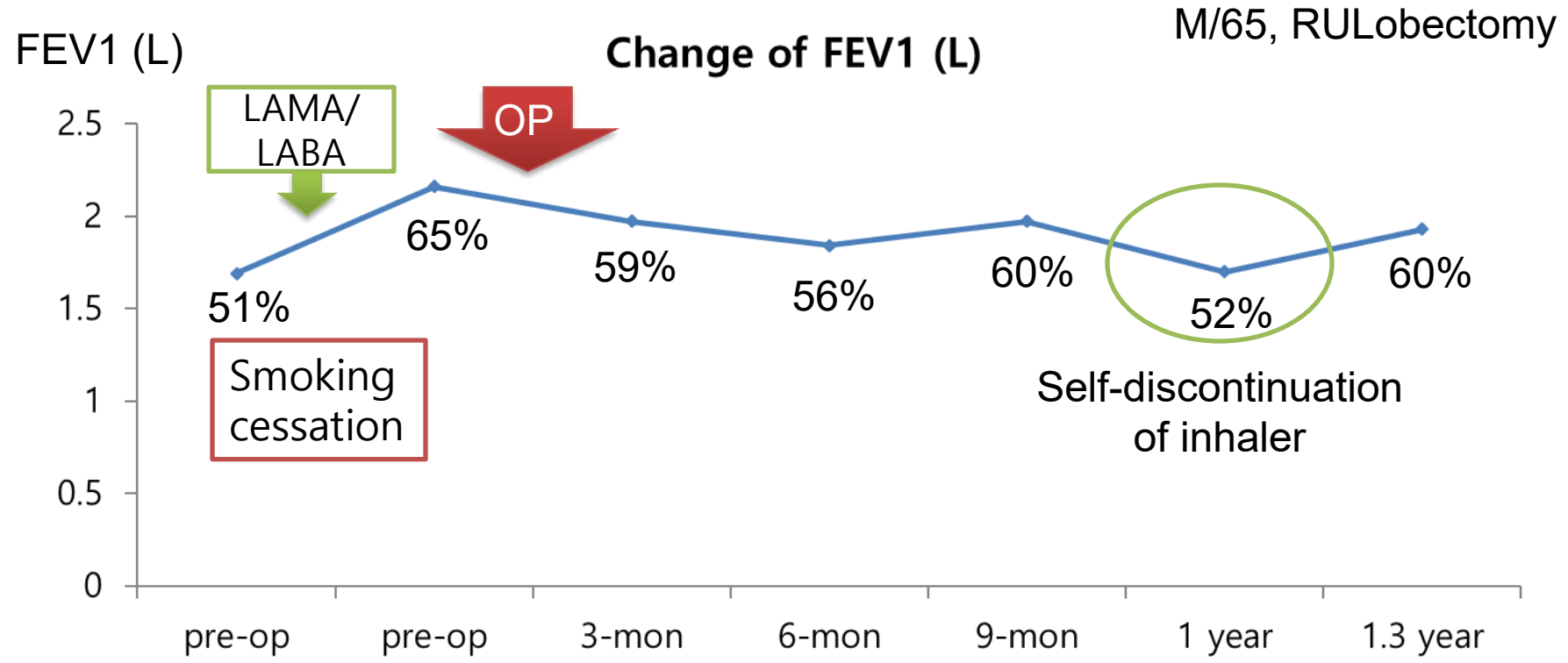
폐수술 후 폐기능 변화

626 Patients with curative lung cancer surgery (March 2016 – October 2018)





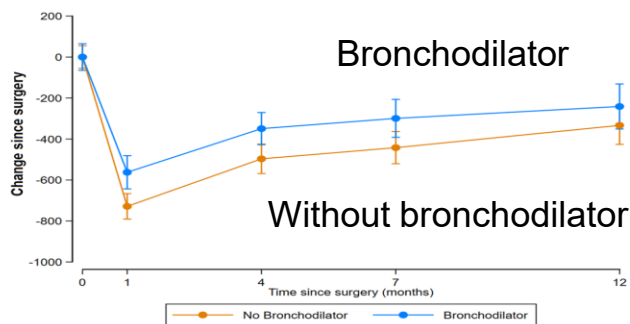
COPD management in LCA



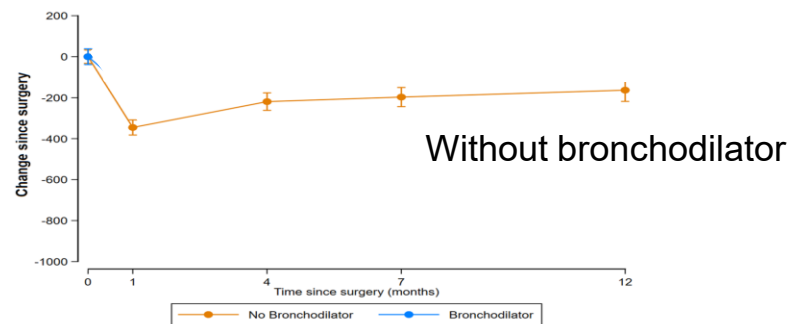
The effect of bronchodilator

Patients with airflow obstruction ($FEV_1/FVC < 70\%$ and $FEV_1 < 80\%$ pred and curative lung cancer surgery (Jan 2016 – December 2018) :156 without bronchodilator vs. 112 (42%) with bronchodilator

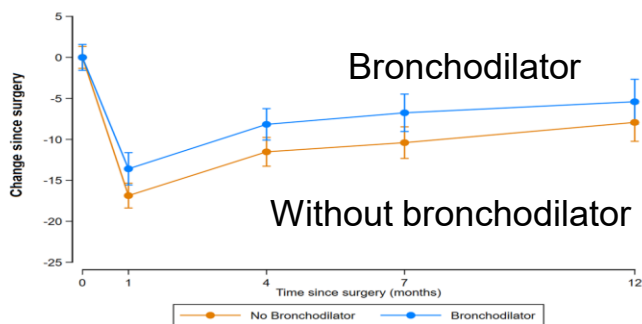
(A) FVC (mL)



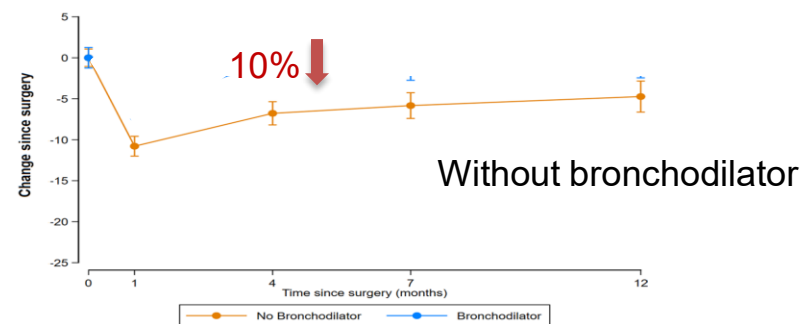
(C) FEV₁ (mL)



(B) FVC, % predicted



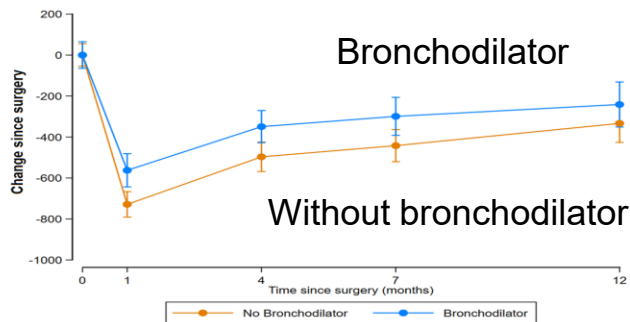
(D) FEV₁, % predicted



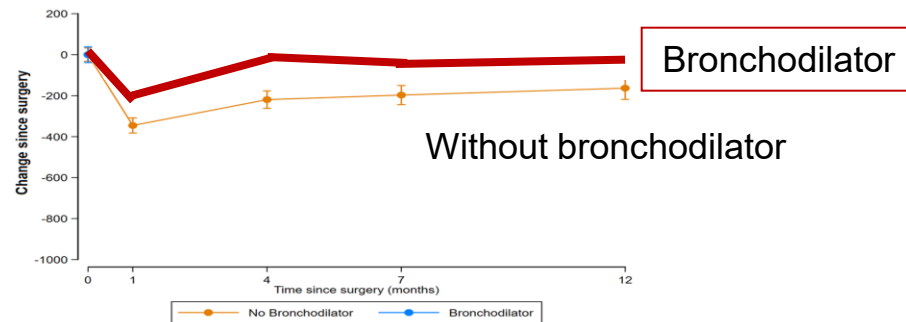
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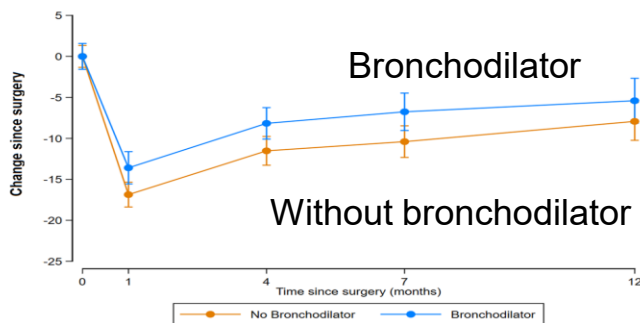
(A) FVC (mL)



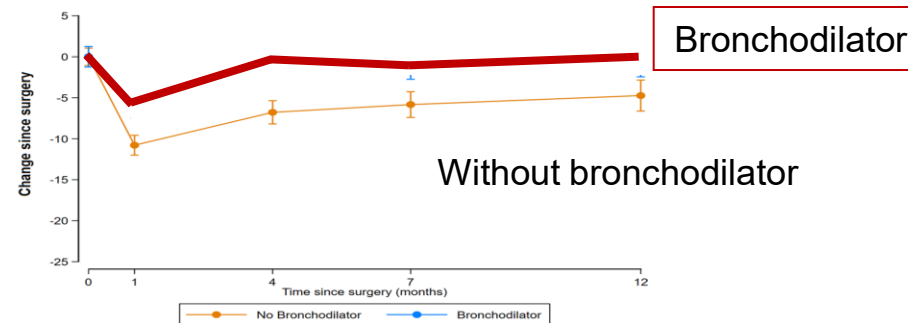
(C) FEV₁ (mL)



(B) FVC, % predicted



(D) FEV₁, % predicted



To investigate the effect of perioperative fixed-dose dual bronchodilator therapy on post-operative pulmonary function among mild-to-moderate COPD patients undergoing lung cancer surgery

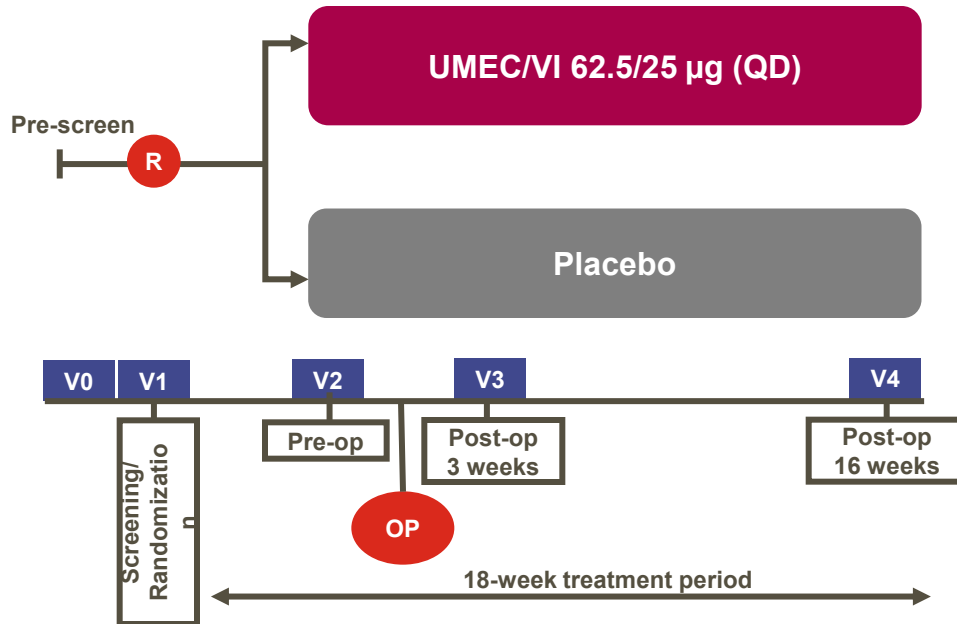


SILK

(**S**tudy of the **I**nhaler effect on reducing **L**ung function deterioration after **L**ung cancer surgery in **K**orea)

Study Design

18-Week randomized, double blind, placebo-controlled, parallel-group study

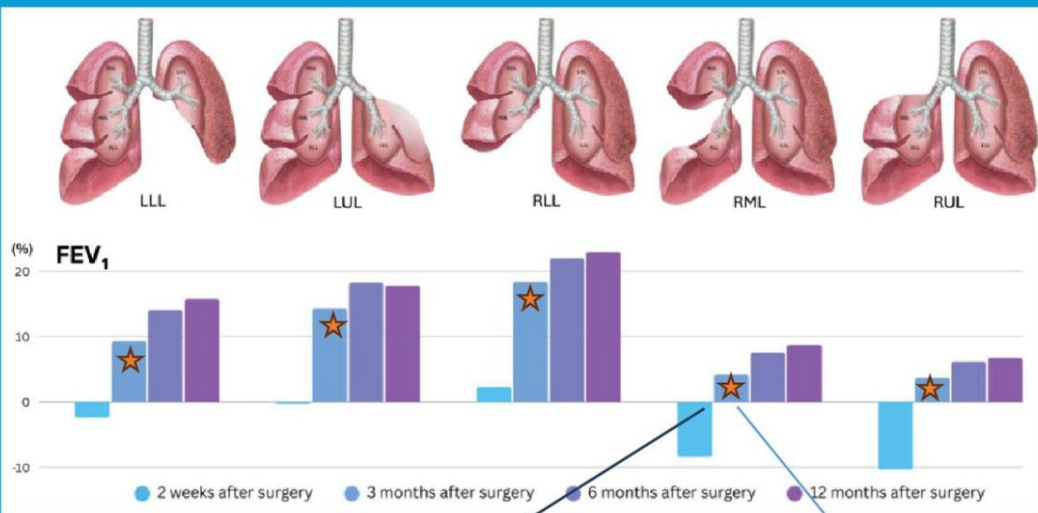


204 Newly diagnosed COPD patients randomised

- Aged 40+ years
- No dyspnea or mMRC Gr 0 or 1
- Post-bronchodilator FEV₁ %pred: ≥70% pred
- No history of inhaler use

- **Primary endpoint:** trough FEV₁ at Week 16
- Secondary endpoints includes: lung function QoL, 6MWT
- Safety

Lobe-specific Variability in Postoperative Pulmonary Function in Lung Cancer Patients: A Longitudinal Analysis and Comparison with Traditional Predictive Models



RML and RUL:
not reach their PPO-FEV1
 by **2 weeks** after surgery

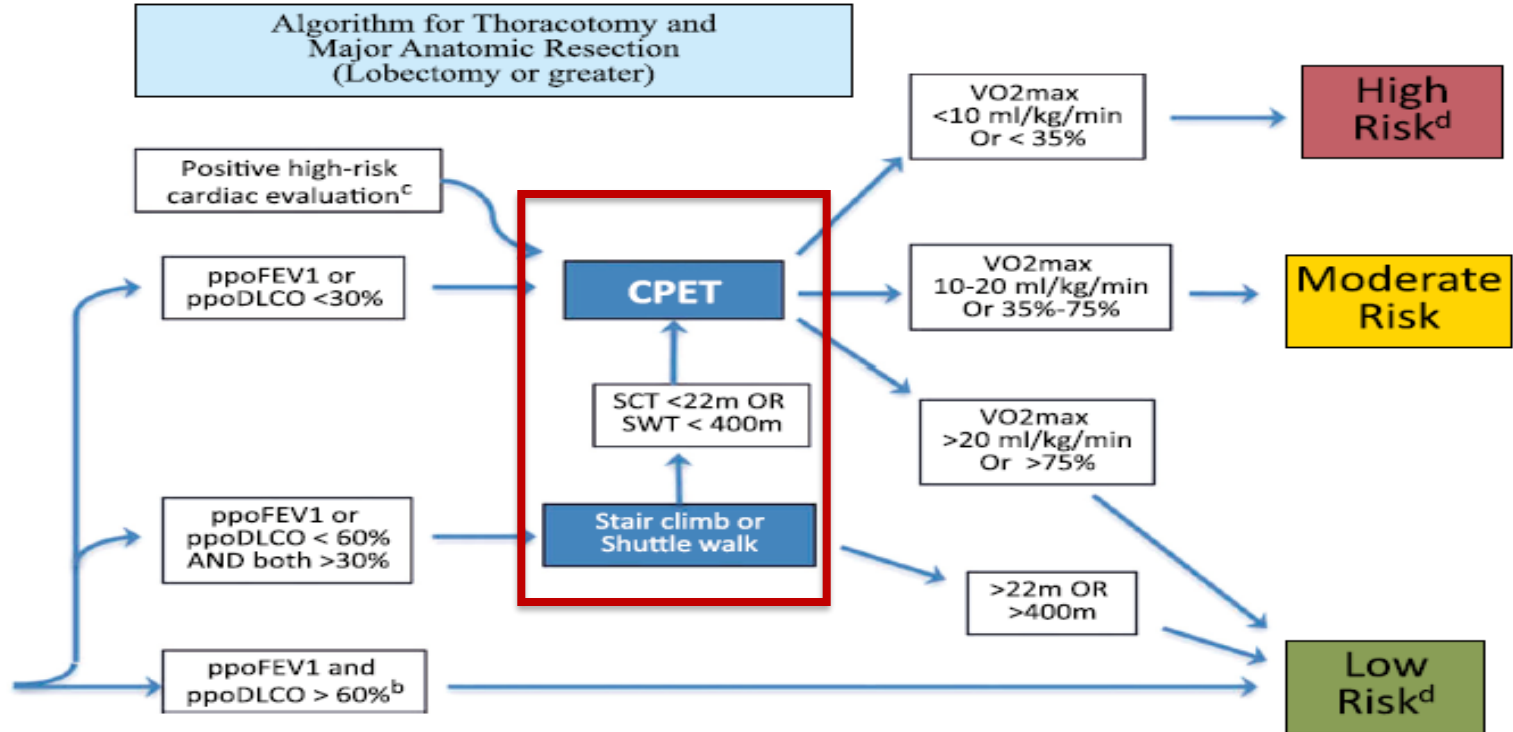
By **3 months** postoperatively,
all lobes exceeded their PPO

- Right upper lobectomy (vs. right lower lobectomy)
- Thoracotomy (vs. VATS)
- Non-recovery by 6 months
- Low physical activity

Postoperative pulmonary function recovery varied significantly by resected lobe, with most lobes showing better recovery than predicted postoperative (PPO) values.

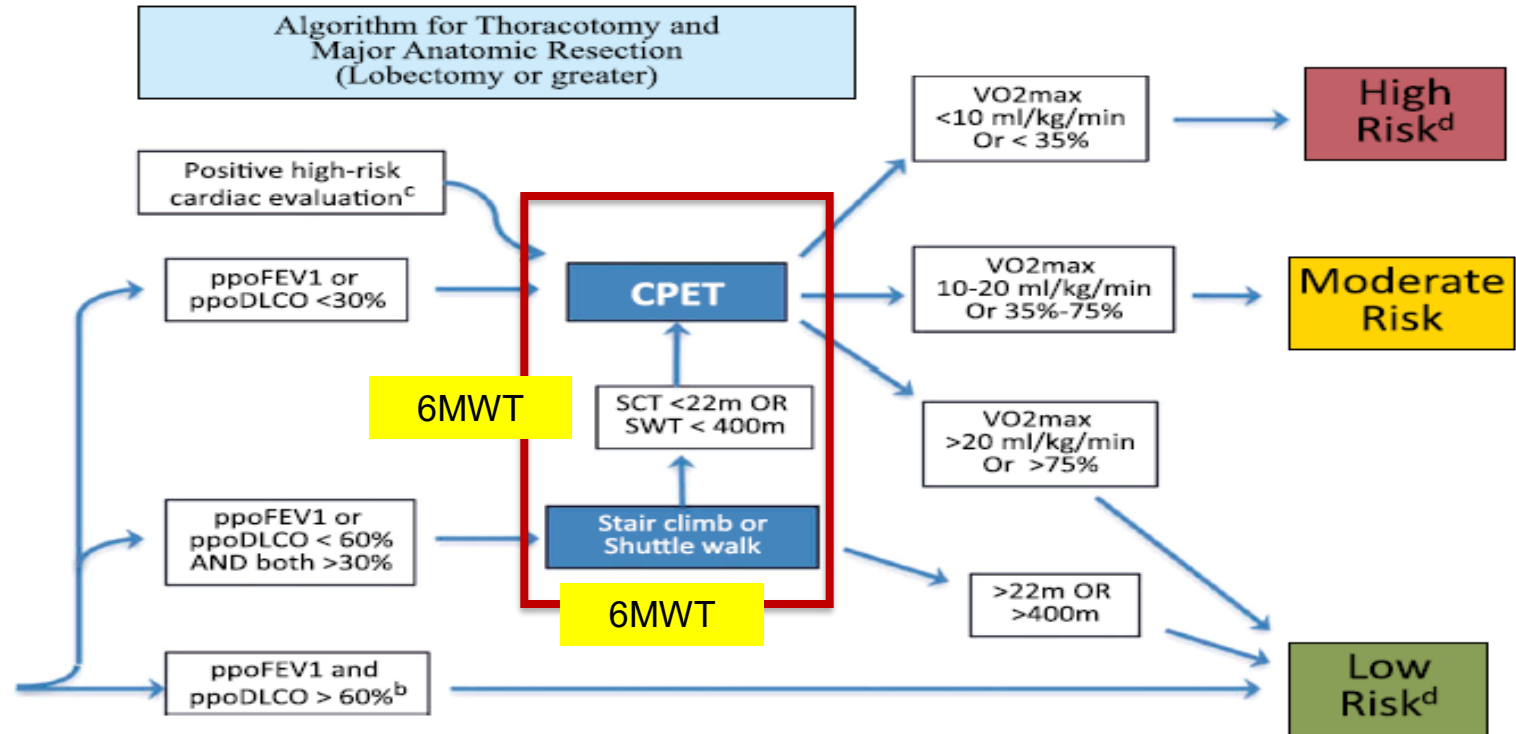


Physiologic evaluation of the patients with lung cancer





Physiologic evaluation of the patients with lung cancer



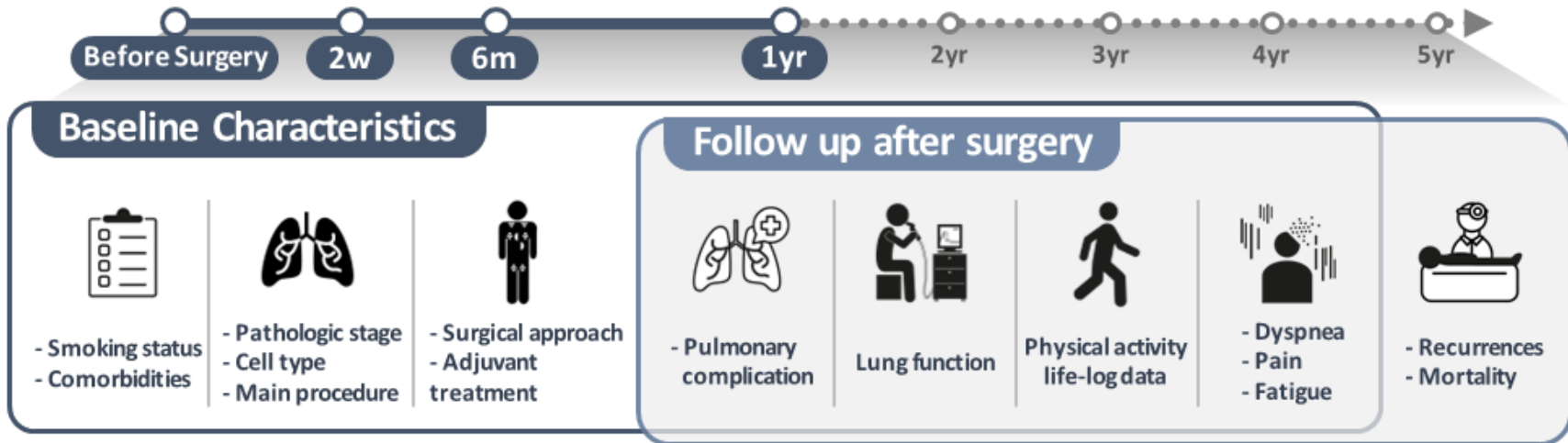
Cohort Study design

Coordinated Approach To Cancer patients' Health for Lung Cancer (CATCH – LUNG) cohort

- 폐암 수술전 환자 대상 Cohort study 추적 관찰 연구 수행 (2016. 3~2021.12, n=1026)

Coordinated Approach to Cancer Patients' Health for Lung Cancer

— CATCH LUNG-Cohort



CATCH-Lung Cohort

Low risk groups which was defined as ppoDLco and ppoFEV₁ ≥ 60% (N = 298)

6MWT ≥ 400 m (N = 277)

6MWT < 400 m (N = 21)

3.3%

4.8%

Moderate risk group which was defined as ppoFEV₁ or ppoDLco < 60% and ppoFEV₁ and ppoDLco ≥ 30% (N = 118)

6MWT ≥ 400 m (N = 104)

6MWT < 400 m (N = 14)

8.7%

28.6%

Postoperative pulmonary complications

8.3%

9.5%

14.4%

42.9%

Postoperative cardiopulmonary complications



Integrated Assessment

Age

Comorbidity

Lung function

Exercise Capacity

LAMA + LABA



Glycopyrronium
Indacaterol



Acclidinium
Formoterol



Umeclidinium
Vilanterol



Tiotropium
Olodaterol

6MWD > 400m

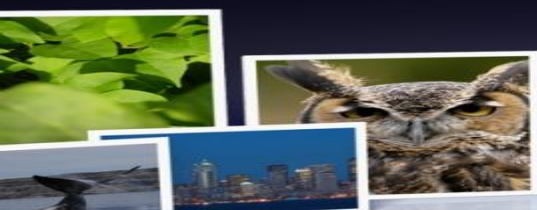
**Surgical
Option**



Perioperative Pulmonary Rehabilitation

Factors to consider for surgery

Comprehensive Rehabilitation



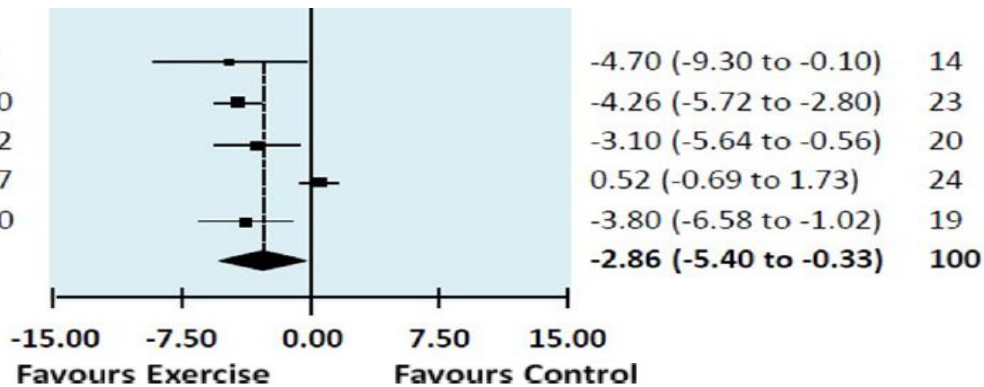
Preoperative Rehabilitation

Length of hospital stay

Lung Cancer

Author, year	Pre-op Exercise	Total	Control	Total
Benzo, 2011	6.30 (3.00)	9	11.00 (6.30)	8
Pehlivan, 2011	5.40 (2.67)	30	9.66 (3.09)	30
Fang, 2013	11.80 (3.23)	22	14.9 (5.16)	22
Licker, 2016	10.14 (2.96)	74	9.62 (4.44)	77
Lai, 2017	6.90 (4.40)	30	10.70 (6.40)	30

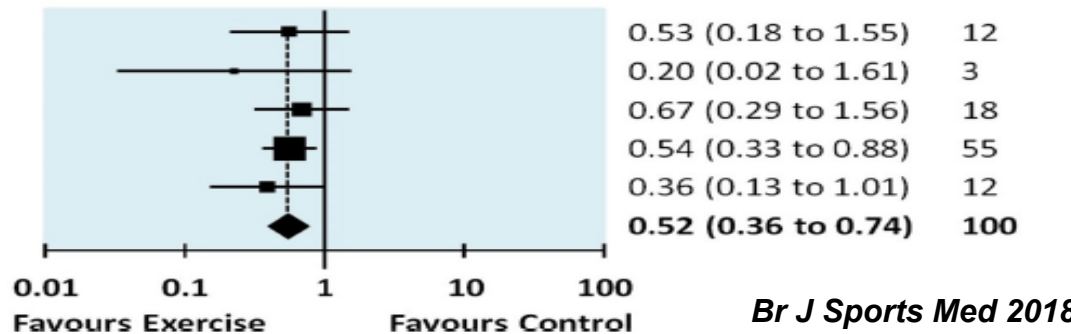
Pooled Effect: $I^2 = 0\%$



Postop. complication

Author, year	Number of events / Total	
	Pre-op Exercise	Control
Lung Cancer		
Benzo, 2011	3 / 9	5 / 8
Pehlivan, 2011	1 / 30	5 / 30
Fang, 2013	6 / 22	9 / 22
Licker, 2016	17 / 74	33 / 77
Lai, 2017	4 / 30	11 / 30

Pooled Effect: $I^2 = 0\%$





암환자 운동 지침

FITT

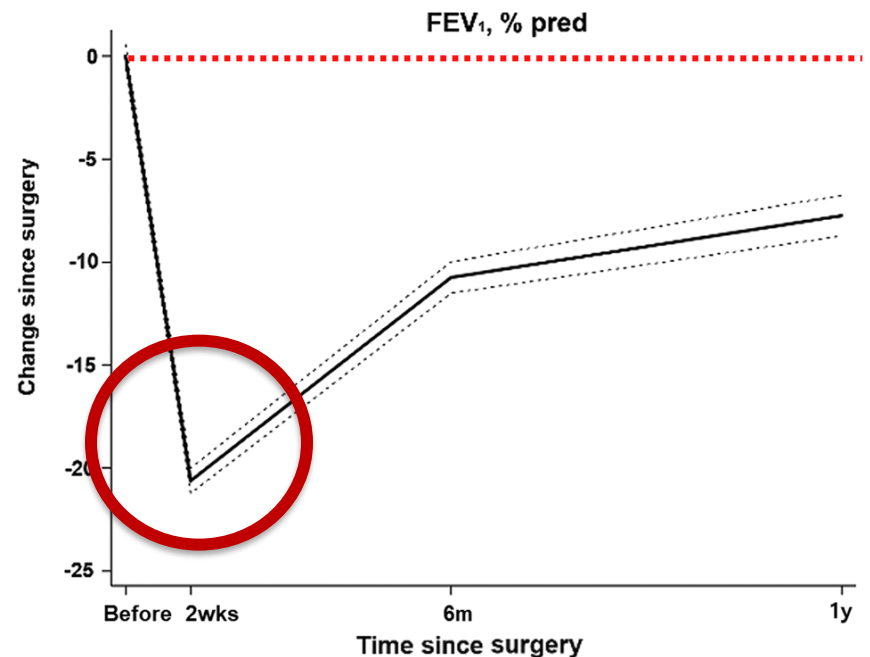
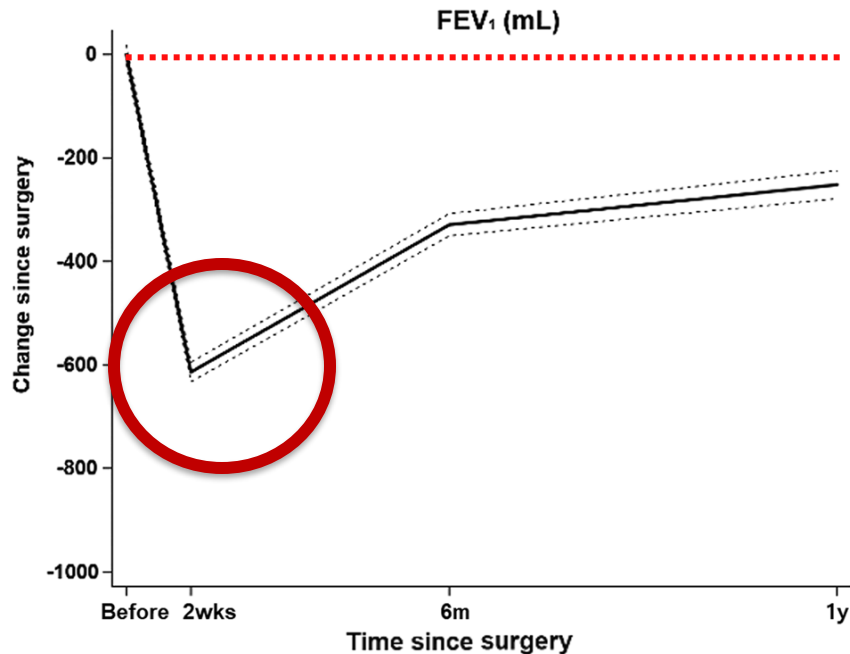
■ 암 환자를 위한 FITT 권고(194,196,258,259)

	유산소 운동	저항운동	유연성 운동
빈도	주 3~5일	주 2~3일	주 2~3일 이상 가능하면 매일
강도	중강도($40\sim59\% \dot{V}O_2R$; $64\sim75\%$ HR_{max} ; 운동자각도 $12\sim13$)에서 고강도($60\sim89\% \dot{V}O_2R$; $76\sim95\% HR_{max}$; RPE $14\sim17$)	저강도(1RM의 30% 미만)에서 시작하여 가능한 만큼 적게 점증적으로 증가	가능한 만큼 관절가동범위(ROM)로 움직임.
시간	주당 75분 이상의 고강도 혹은 주당 150분 이상의 중강도 활동 혹은 이들의 동등한 조합	최소한 1세트 8~12회 반복	정적 스트레칭을 10~30초 유지
형태	걷기, 자전거, 수영과 같은 대근육군을 사용하는 지속적이고 규칙적인 활동	모든 대근육군을 목표로 프리웨이트, 저항성 운동기구, 혹은 체중부하를 이용한 기능적인 일(예: 앉았다 일어서기)	모든 대근육군에서 스트레칭 혹은 운동가동범위에서 운동. 스테로이드, 방사선 또는 수술을 치료받은 결과로 특정 부위의 관절이나 근육이 제한됨

1RM, 1회 최대반복; HRmax, 최대심박수; HRR, 여유심박수; ROM, 관절가동범위; RPE, 운동자각도; $\dot{V}O_2R$, 여유산소섭취량.

폐수술 후 폐기능 변화

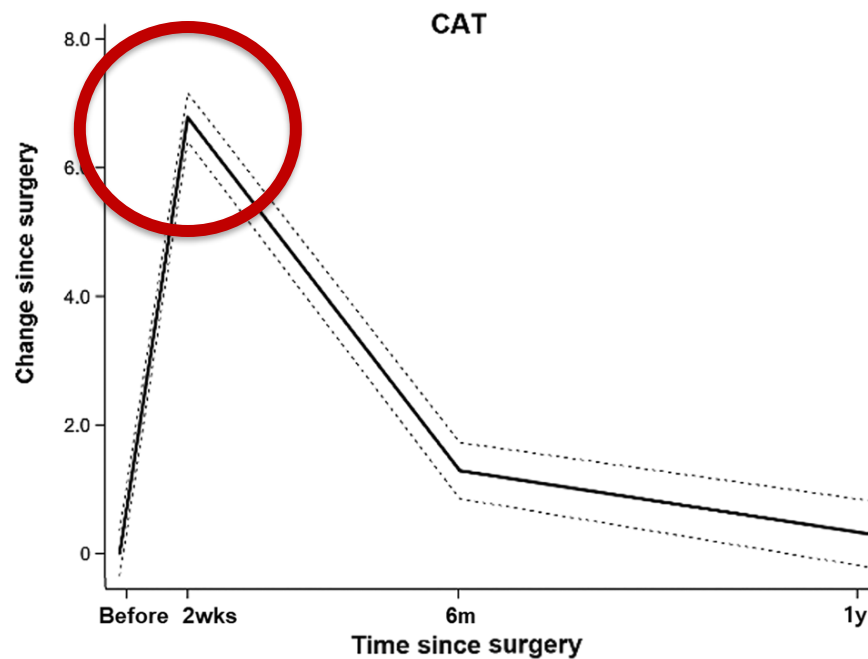
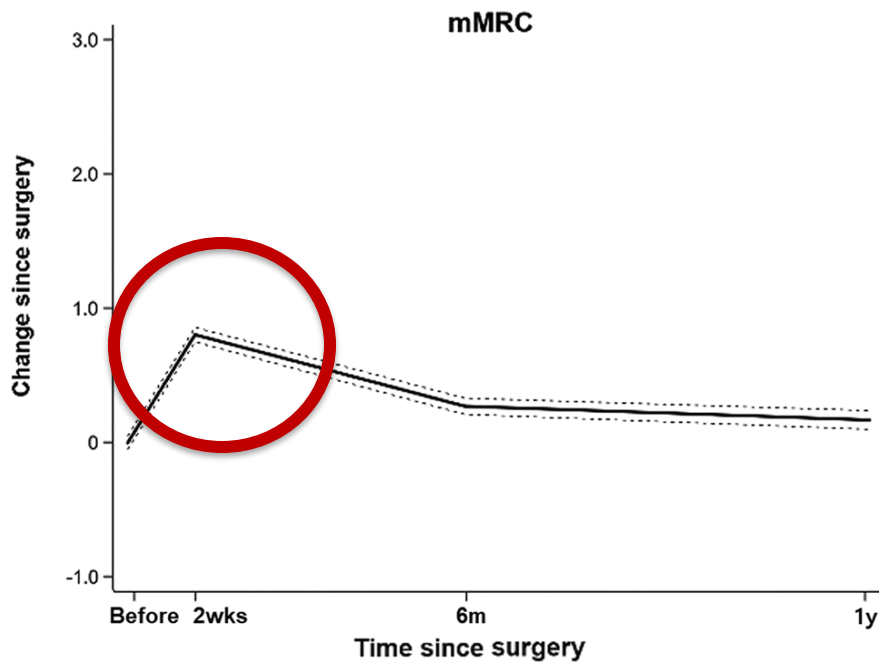
626 Patients with curative lung cancer surgery (March 2016 – October 2018)





호흡곤란 및 삶의 질 변화

626 Patients with curative lung cancer surgery (March 2016 – October 2018)





CAT (COPD Assessment Test)

상태 (Good)	점 수						상태 (Poor)
	0	1	2	3	4	5	
나는 전혀 기침을 하지 않는다.			2				나는 항상 기침을 한다.
나는 가슴에 전혀 가래가 없다.			2				나는 가슴에 가래가 가득 차 있다.
나는 전혀 가슴이 답답함을 느끼지 않는다.						5	나는 가슴이 아주 답답함을 느낀다.
나는 언덕이나 계단을 오를 때 전혀 숨이 차지 않는다.						5	나는 언덕이나 계단을 오를 때 아주 숨이 차다.
나는 집에서 활동하는데 전혀 제약을 받지 않는다.					4		나는 집에서 활동하는데 많은 제약을 받는다.
폐질환에도 불구하고 나는 외출에 자신이 있다.				3			폐질환으로 인하여 나는 외출하는데 전혀 자신이 없다.
나는 잠을 깊이 잔다.				3			폐질환으로 인하여 나는 잠을 깊이 자지 못한다.
나는 기운이 왕성하다.						5	나는 전혀 기운이 없다.
CAT Score : 29							

Cough
 Mucus
 Chest
 Breathlessn
 Activities
 Confidence
 Sleep
 Energy

	Before surgery	2 weeks after surgery	6 months after surgery	1 year after surgery
Cough frequency				
Adjusted mean (SE)	0.82 (0.05)	2 (0.05)	0.96 (0.06)	0.68 (0.06)
Change from baseline (95% CI) ^a	Reference	1.18 (1.05, 1.31)	0.15 (0.01, 0.28)	-0.14 (-0.27, 0.00)
Amount of phlegm				
Adjusted mean (SE)	0.83 (0.05)	0.89 (0.05)	0.77 (0.05)	0.67 (0.05)
Change from baseline (95% CI) ^a	Reference	0.05 (-0.06, 0.16)	-0.06 (-0.18, 0.05)	-0.16 (-0.27, -0.04)
Chest tightness				
Adjusted mean (SE)	0.5 (0.05)	1.3 (0.05)	0.5 (0.05)	0.47 (0.05)
Change from baseline (95% CI) ^a	Reference	0.8 (0.68, 0.91)	-0.01 (-0.12, 0.11)	-0.04 (-0.15, 0.08)
Breathlessness walking upstairs				
Adjusted mean (SE)	1.28 (0.06)	2.85 (0.06)	1.97 (0.06)	1.79 (0.07)
Change from baseline (95% CI) ^a	Reference	1.57 (1.43, 1.71)	0.7 (0.55, 0.84)	0.52 (0.37, 0.66)
Home activities limited				
Adjusted mean (SE)	0.05 (0.03)	0.64 (0.03)	0.16 (0.04)	0.1 (0.04)
Change from baseline (95% CI) ^a	Reference	0.59 (0.51, 0.68)	0.12 (0.03, 0.21)	0.06 (-0.04, 0.15)
Not confident leaving home				
Adjusted mean (SE)	0.08 (0.04)	1.26 (0.04)	0.23 (0.05)	0.15 (0.05)
Change from baseline (95% CI) ^a	Reference	1.19 (1.07, 1.3)	0.16 (0.04, 0.28)	0.08 (-0.04, 0.2)
Sleep disturbance				
Adjusted mean (SE)	0.96 (0.06)	1.56 (0.07)	0.86 (0.07)	0.86 (0.07)
Change from baseline (95% CI) ^a	Reference	0.6 (0.44, 0.75)	-0.1 (-0.26, 0.06)	-0.42 (-0.58, -0.25)
Lack of energy				
Adjusted mean (SE)	1.49 (0.06)	2.5 (0.06)	1.84 (0.06)	1.8 (0.06)
Change from baseline (95% CI) ^a	Reference	1 (0.87, 1.14)	0.35 (0.21, 0.49)	0.31 (0.17, 0.46)



Conclusions

In conclusion, our study demonstrated longitudinal changes in pulmonary function and integrated PROs in a large prospective cohort after lung cancer surgery. Lung function and PROs improved over time, but patients suffered from dyspnea and symptoms along with sharply decreased lung function in the early postoperative period, independent of the extent of surgery. Thus, physicians are required to stay attentive regarding lung function decline and associated symptoms after surgery and could provide proper information with emotional support as their lung function and QOL are expected to improve with time. Further studies are needed to establish intervention programs for these patients.

뇌과학으로 풀어본 의사-환자 관계의 신비

환자의 마음

파브리치오 베네데티 지음 | 이은 옮김

THE PATIENT'S BRAIN

Like humans, animals care of themselves and others for a better survival, and in so doing adopt different strategies. The movement of the cilia in unicellular protists to the ventral commissure of the brain should not be thought of as a phylogenetic scale. From unicellular organisms to human social insects, the amoeba is at the bottom and primates at the top. There is, today, considerable evidence for an extensive divergence of evolutionary lines, which involves both parallel evolutionary lines and extinction of intermediate lines (Simpson, 1945). Therefore, some of the strategies adopted by simple organisms, e.g. unicellular, do not necessarily mean that these have then evolved into those strategies that are used by higher mammals. However, it is crucial to understand that both simple and complex organisms can take care of themselves at different levels, and this occurs on the basis of different physiological mechanisms and behavioural repertoires. Some of these mechanisms and strategies are already present in unicellular organisms, such as the paramecium, also known as Lady Slipper, a freshwater protist especially found in scums. The paramecium takes care of itself in different ways. For example, it contains intracellular organelles, the contractile vacuoles, which are used to pump excess water out of the cell (Wichterman 1986). These intracellular structures are surrounded by a cell membrane that can be retracted (Fig. 1.1A). Without such a mechanism, the paramecium would explode when it absorbs too much water. In other words, like many other unicellular organisms, it can also solve simple problems of osmosis when, for example, it is in a hypotonic solution. It has a series of cilia on the membrane of the oral groove. When the cell encounters an obstacle, it can simultaneously, the paramecium moves forward and the cilia change their direction and beat forward. After a while, the cilia beat backward again, and the paramecium too moves forward. If it hits the obstacle again, this process will go on until the obstacle is overcome. Other unicellular protists show similar mechanisms. The amoeba has vacuoles that can regulate intracellular osmotic pressure by expelling excess water through vesicles (Loren 1973). In this case, the overloader vacuole moves towards the surface of the cell in order to fuse with the cell membrane and release its contents into the extracellular environment. The amoeba can also face harsh conditions, such as an acidic environment. In such a situation, it enters a dormant state, whereby the metabolic activities, feeding and locomotion are slowed down, the so-called cyst (Fig. 1.1B). In a microbial cyst, a wall surrounding the cell membrane is formed. This wall increases the resistance of the organism to the raw harsh environment. For example, the wall of the cyst of the bacterium *Bacillus anthracis* contains sulfuric acid which confers a negative charge to the cyst. The negativity, in turn, prevents the attachment of the cyst.

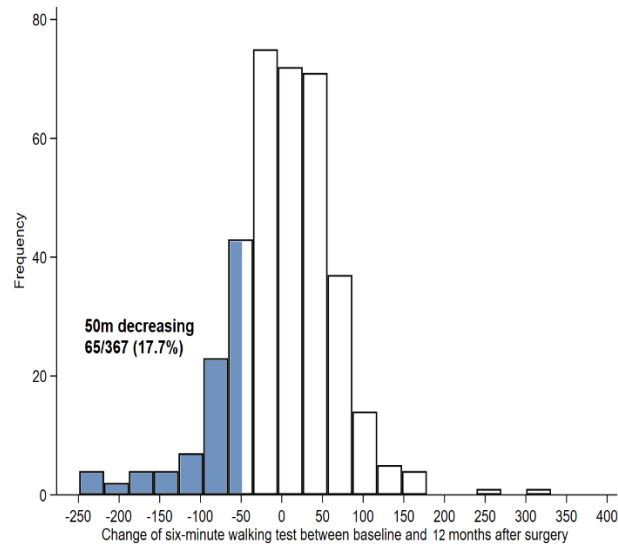
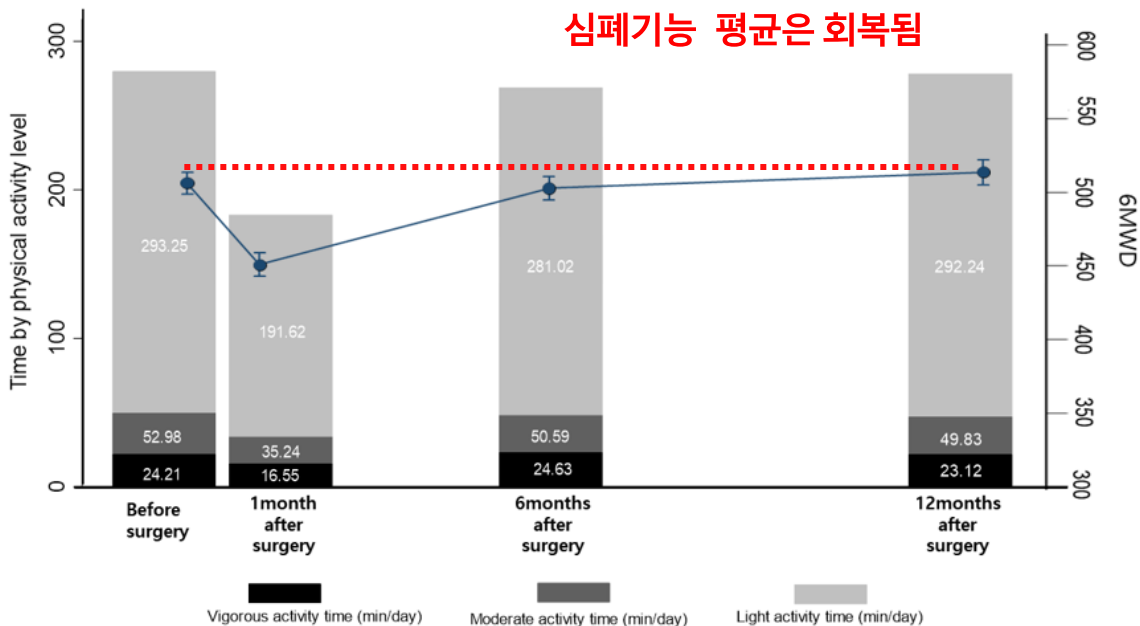
정년의사



운동능력

Changes of steps per day and 6MWD

심폐기능 평균은 회복됨



1 year after surgery

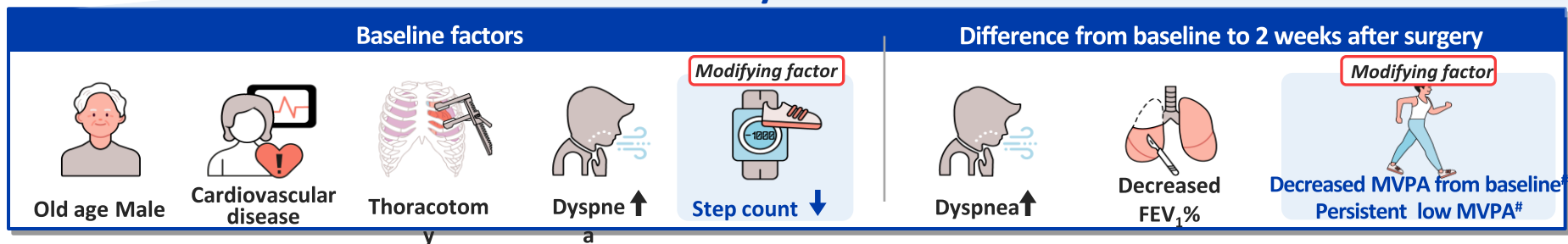
Factors associated with failure of cardiopulmonary function recovery after lung cancer surgery

Modifying factor는 신체활동으로, 수술전 신체활동과 수술직후 신체활동이 중요함을 보고함.

The CPF remarkably decreased at 2 weeks after surgery, but it almost fully recovered to baseline level at 6 months after surgery.

However, among 419 patients, 24.1% and 17.7% showed **failure of CPF* recovery** at 6 months and 1 year after surgery, respectively.

Factors associated with failure of CPF recovery at 6 months

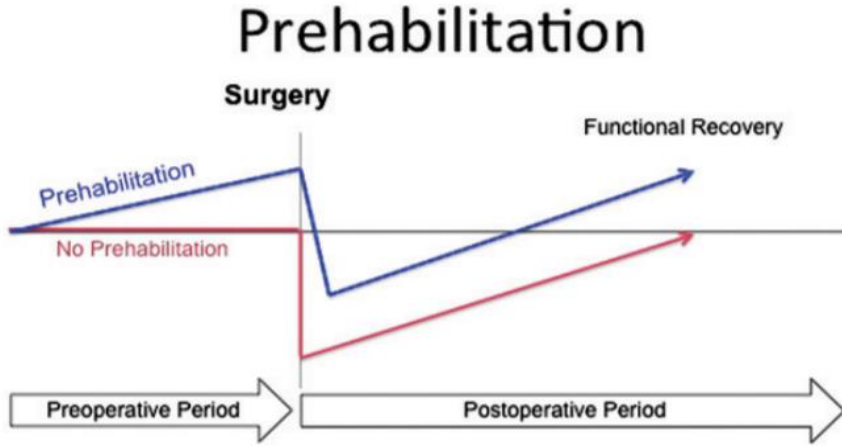


* CPF recovery failure: decreased in 6MWD by more than 50 m from baseline to 6 months after surgery, *CPF, Cardiopulmonary function; #MVPA, moderate to vigorous physical activity





폐암 수술 전후 관리의 필요성



Carli F. et al. Curr Opin Clin Nutr Metab Care. 2005; 8: 23-32.

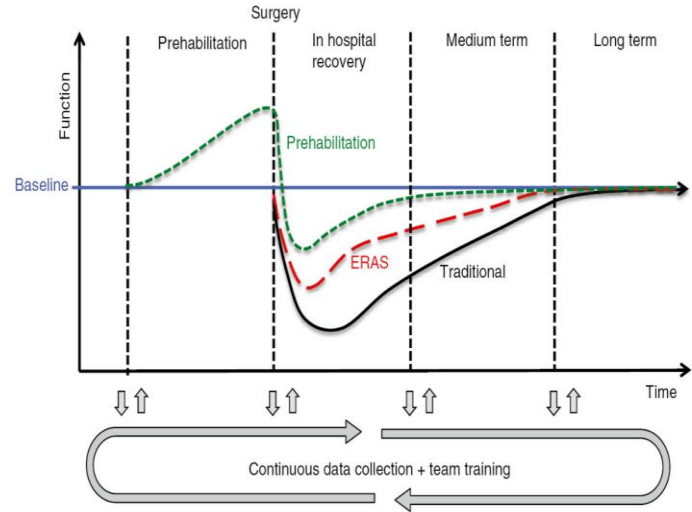


Figure 2:

Model of the effect of prehabilitation and ERAS on functional recovery.

ERAS: Enhanced Recovery After Surgery Protocol



수술 전후 운동 프로그램

수술 전·후 권장 운동

Phase I 1. 수술 전 대기기간

일상생활을 유지하며, 꾸준한 운동을 지속합니다. 평소 운동 경험이 없었다면, 무리가 되지 않도록 천천히 걷기 운동부터 시작합니다.

유산소 운동	• 걷기를 포함한 유산소 운동	22-25쪽
근력 운동	• 하체, 복부, 상체 근력 운동	28-34쪽
스트레칭 운동	• 전신 스트레칭	37-41쪽

2. 수술 후 입원 중

담당 의료진의 지시에 따르며, 호흡 운동을 실시합니다.

유산소 운동	• 제자리 걷기 연습 (낙상 주의) • 천천히 병동 내 걷기 운동부터 시작	22-24쪽
스트레칭 운동	• 침상 스트레칭	37, 41쪽

Phase II 1. ~ 수술 후 3주

실내운동부터 시작하며, 30-40분 이내 운동을 여러 번 나누어 실시합니다. 운동 중 호흡을 자연스럽게 하며, 운동 시간 외에도 호흡 운동을 꾸준히 지속합니다.

유산소 운동	• 실내 외 걷기 운동 (1회당 30-40분 이내) • 실내 자전거 운동 (부하없이 분당 60회 속도)	22-24쪽
스트레칭 운동	• 어깨를 포함한 전신 스트레칭	37-41쪽

4. ~ 수술 후 2개월

가벼운 일상생활을 할 수 있으며, 체력에 따라 활동량을 서서히 증가시킵니다.

유산소 운동	• 실내 외 걷기 운동 (1회당 60분 이내)	22-25쪽
근력 운동	• 기구없이 저항도 근력 운동 (하체부터 시작)	28-30쪽
스트레칭 운동	• 어깨를 포함한 전신 스트레칭	37-41쪽

5. ~ 수술 후 6개월

일상생활을 유지하며, 꾸준히 운동을 지속합니다. 자신의 체력에 맞게 운동 강도와 활동량을 조절하며, 근력 운동을 병행합니다.

유산소 운동	• 걷기를 포함한 유산소 운동	22-25쪽
근력 운동	• 하체, 복부, 상체 근력 운동	28-34쪽
스트레칭 운동	• 전신 스트레칭	37-41쪽

Phase III



Research Trends

	Previous study	In this study
Respiratory muscle training	<ul style="list-style-type: none"> Incentive spirometry Breathing exercise (Diaphragmatic breathing, Abdominal breathing, coughing technique,,) 	<ul style="list-style-type: none"> Incentive spirometry Breathing exercise (Diaphragmatic breathing, Abdominal breathing, coughing technique,,)
Endurance training	<ul style="list-style-type: none"> Upper- and lower-limb exercise (treadmill, ergometer,,) 	<ul style="list-style-type: none"> Physical activity by using fitbit and face-to-face instruction
Strength training	<ul style="list-style-type: none"> Weight machine 	

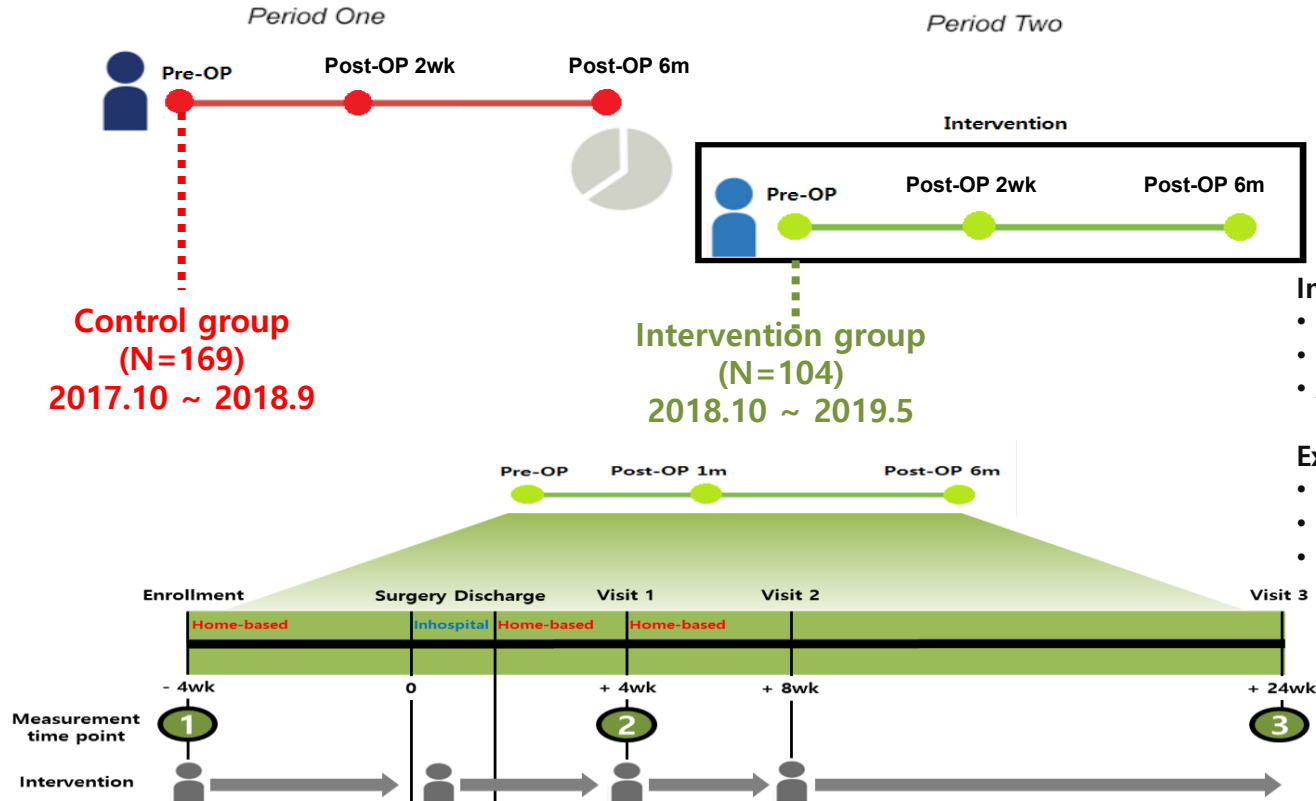


*In-hospital
Supervised
Intensive*

VS.

*Home-based
unsupervised
Lifestyle*

Study Design



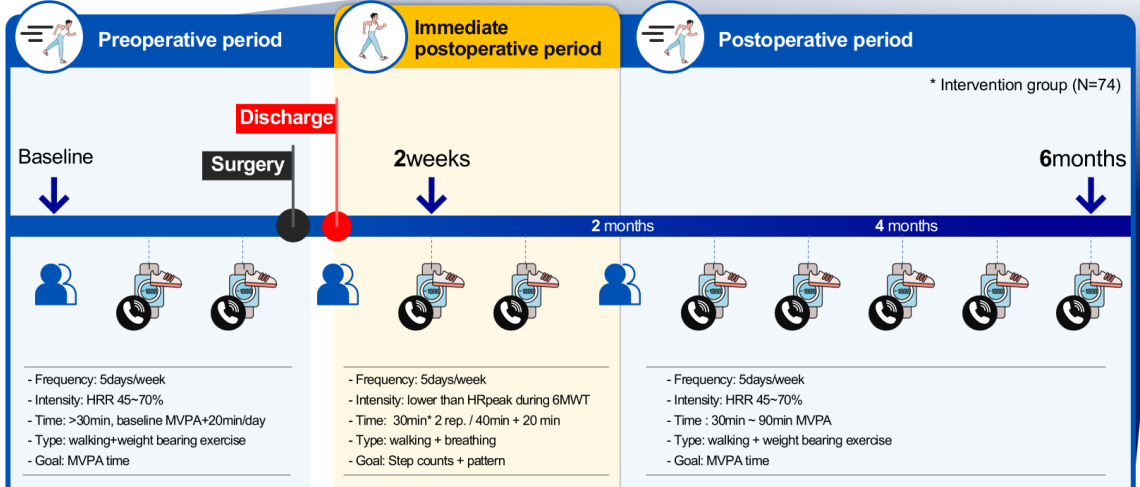
Control group
(N=169)
2017.10 ~ 2018.9

Intervention group
(N=104)
2018.10 ~ 2019.5

- Inclusion Criteria:**
- NSCLC
 - ECOG PS < 1
 - Age: 18~75 yrs

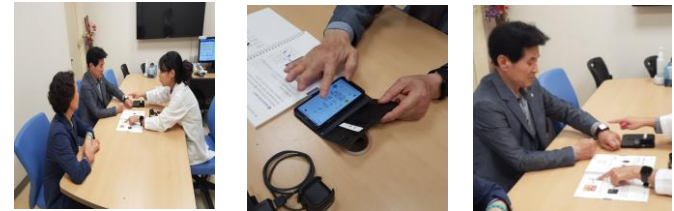
- Exclusion Criteria:**
- Multiple cancer
 - Neoadjuvant therapy
 - Recurrent lung cancer

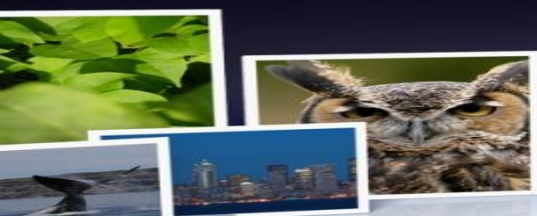
Study Design



- ↓ Outcomes measurement point
- 📱 Intervention using wearable and tele (weekly or biweekly)
- 👤 Face to face intervention

웨어러블 기기와 app 사용 교육





Intervention Program Components

Table. Description of the content in the intervention for the experimental group

Term	Before surgery (1~6weeks)	Discharge ~ 3 weeks after surgery	~ 2 months after surgery	6 months After surgery
Aim	<ul style="list-style-type: none"> - Improvement of Cardiorespiratory function - Prevention of complications - postoperative management 	<ul style="list-style-type: none"> - Symptom Control -Improvement of Respiratory Function - Return to the Life 	<ul style="list-style-type: none"> - Symptom Control -Improvement of Respiratory Function - Return to the Life 	<ul style="list-style-type: none"> - Symptom management -Improvement of Cardiorespiratory function -Muscle Strength Training
Frequency	5 times a week	5 times a week	5 times a week	5 times a week
Intervention components	<ul style="list-style-type: none"> - Cardiorespiratory Endurance Exercise - Respiratory & Strength Training 			
Counseling	<ul style="list-style-type: none"> - Face to face & Tele counseling 	<ul style="list-style-type: none"> - In hospital education - Tele counseling - Face to face counseling 	<ul style="list-style-type: none"> - Face to face & Tele counseling 	<ul style="list-style-type: none"> Tele counseling

Initial test

- PFT
- Physical activity
- Cardiorespiratory function
- Symptom & pain

Middle test

- PFT
- Physical activity
- Cardiorespiratory function
- Symptom & pain

Post test

- PFT
- Physical activity
- Cardiorespiratory function
- Symptom & pain

Preoperative exercise



Non-activity pattern

오늘 주 월 화 수 9월 2일 (금)

걸음 수 Floors 칼로리 소모량



합계 6,067 걸음 수 9 오름 층 수 4.26 km 1,773 칼로리

activity pattern

오늘 주 월 화 수 9월 1일 (목)

걸음 수 Floors 칼로리 소모량



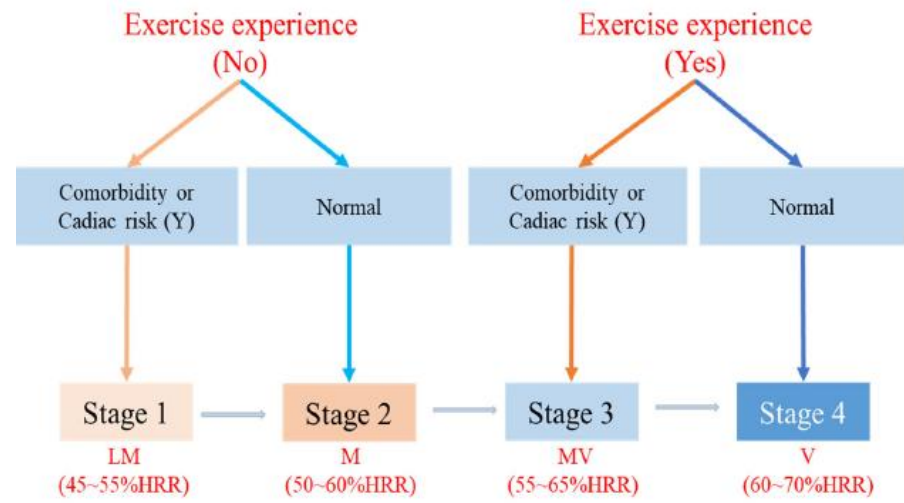
합계 13,925 걸음 수 36 오름 층 수 9.78 km 2,176 칼로리



Intervention Program Components

안정성 확보를 위한 사전 평가

Algorithm for setting exercise intensity levels adjusted for comorbidity and cardiac risk

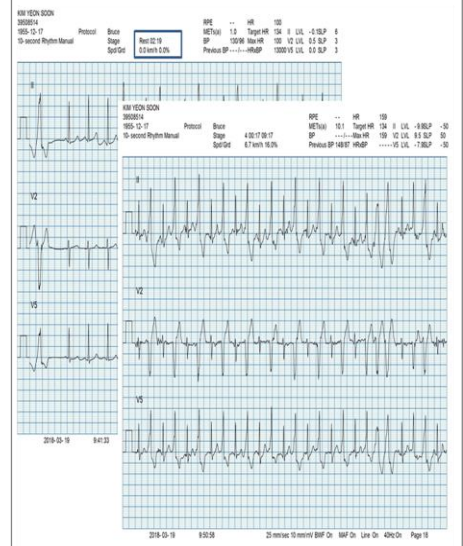


C-Stress Final Report

Tabular Summary

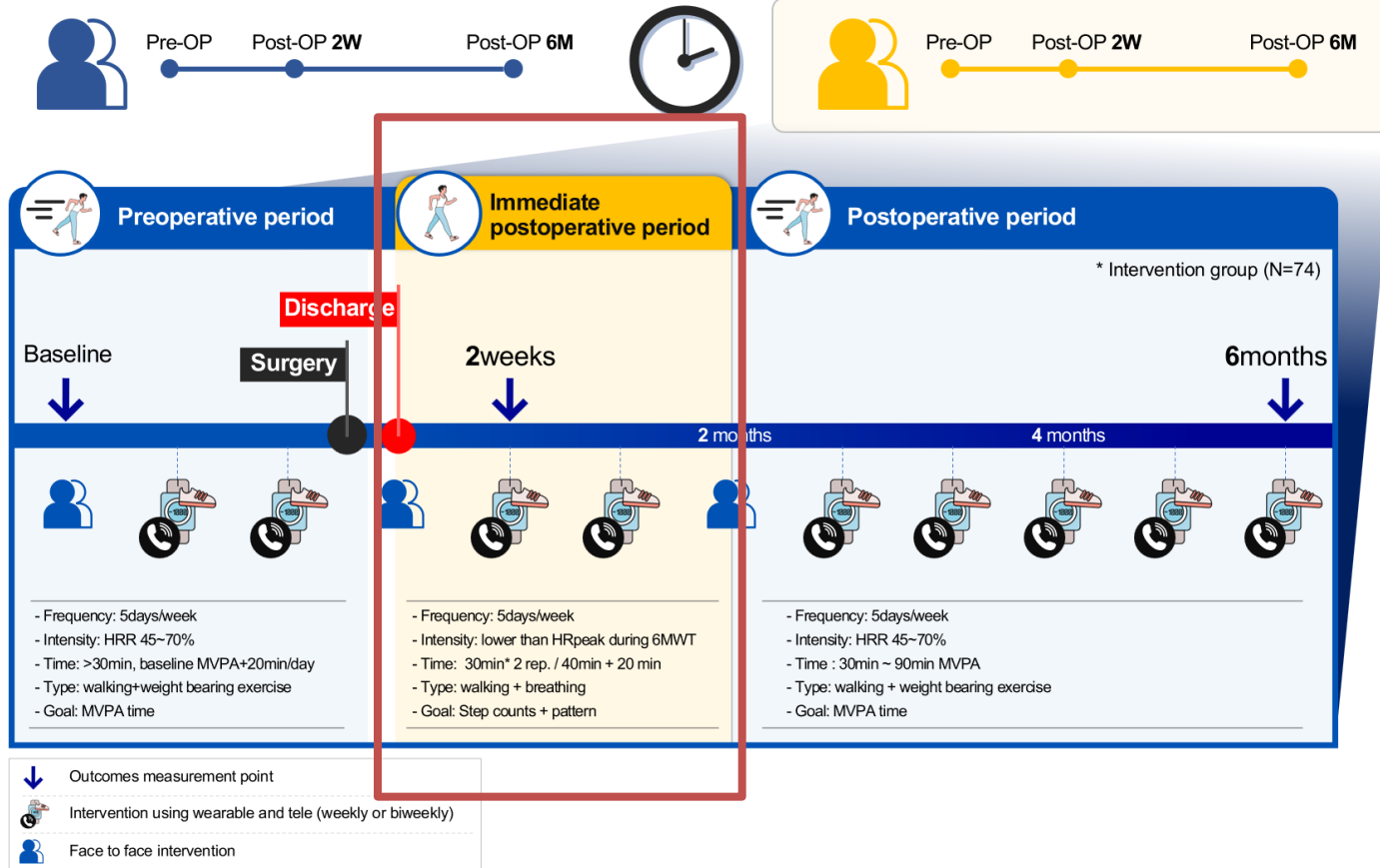
Stage	Total Stage Time	HR	ER	SpO2	BP	HRaP
REST	02:27	94	29	...	130/88	10220
Stage 1	01:00	105	38	...	...	...
Stage 2	01:00	122	55	...	...	...
Stage 3	01:00	148	50	...	...	...
Stage 4	00:41	160	54	...	...	...
RECOVERY	01:00	126	44	...	170/84	12178
	02:00	111	28	...	170/83	10836
	03:00	96	13	...	170/83	10896
	04:00	89	25	...	169/84	14774
	04:14	85	25	...	169/84	14110

$(160-82) \times 0.7 + 82 = 136$
 $(160-82) \times 0.8 + 82 = 144$



- * Exercise experience (Y, N): IPAQ-7 MVPA ≥ 150 min/week & Fitbit: MVPA ≥ 30 min/day
 - **Comorbidity (Y, N): Diabetes, hypertension, lung disease (COPD), arthritis
 - ***Cardiac risk (Y, N): Arrhythmia, beta blocker, ST-level depress > 1 mm during cardiopulmonary exercise test (CPET), Hypertension (DBP > 100) during CPET at baseline
- $HR_{max} = 220 - \text{age}$ or HR_{max} of GXT test
 $\%HRR(\text{Target heart rate}) = (HR_{max} - HR_{rest}) \times \text{Exercise Intensity \%} + HR_{rest}$

Study Design





Intervention Program Components

Table. Description of the content in the intervention for the experimental group

Term	Before surgery (1~6weeks)	Discharge ~ 3 weeks after surgery	~ 2 months after surgery	6 months After surgery
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Frequency	5 times a week	5 times a week	5 times a week	5 times a week
Intervention components	<ul style="list-style-type: none"> - Cardiorespiratory Endurance Exercise - Respiratory & Strength Training 	<ul style="list-style-type: none"> - Symptom Control - Walking & Respiratory (in spirometer) muscle training - (option) Nutrition Counseling 	<ul style="list-style-type: none"> - Symptom Control - Walking & Respiratory (in spirometer) muscle training - (option) Nutrition Counseling 	
Counseling	<ul style="list-style-type: none"> - Face to face & Tele counseling 	<ul style="list-style-type: none"> - In hospital education - Tele counseling - Face to face counseling 	<ul style="list-style-type: none"> - Face to face & Tele counseling 	<ul style="list-style-type: none"> Tele counseling

Initial test

- PFT
- Physical activity
- Cardiorespiratory function
- Symptom & pain

Middle test

- PFT
- Physical activity
- Cardiorespiratory function
- Symptom & pain

Post test

- PFT
- Physical activity
- Cardiorespiratory function
- Symptom & pain

Immediate post-operative exercise



Breathing exercise

FITT – VP: 1month after surgery

6MWT before discharge





6MWT to adjust exercise intensity

Check

- Preoperative exercise capacity (preop PFT, GXT, exercise habit & Sx), comorbidities
- Postoperative status (V/S, complications, pain & exercise)
- C/T removal & CXR

6MWT

- 6MWT with exercise physiotherapists and nurses and check HR & SPO₂ during after 6MWT

Education

- Education based on the results: exercise intensity, type of exercise & deep breathing
- Pain control medication, comorbidities

구분		Monitoring	Indication
Level A	6MWT	HR, SPO ₂	Tube removal & planned to discharge
Level B	6MWT + ECG monitoring	HR, SPO ₂ , ECG	Pulmonary/CV complications



Immediately post-operative exercise

Postoperative

점증적으로 활동량과 강도 증가시키기

수술 후 빠른 기능 회복을 위한 프로그램
(from discharge until 2 months after surgery)

• Phase II:

Same intensity

Longer duration

FITT – VP

- Frequency: 5days/wk
- Intensity: lower than HR_{peak} during 6MWT or 140 of HR
- Time: 1time <60min walking (30min* 2 rep. / 40min + 20 min)
- Type: walking + breathing
- Volume: Steps & activity time

- ◆ Function <3 METs: 1rep. X 15min X 3~4 rep.
- ◆ Function 3-5 METs: 1rep. X 30min X 2~3 rep.

- *Activity time & Daily steps*
- *5 days per week*
- *Goal setting & Edit goal (achievement rate_70%, 30%)*



Dyspnea
barrier

Perioperative pulmonary rehabilitation Considerations

1. Safety & Effectiveness

- Control exercise intensity

2. Goal Setting & Edit Goal

- Achievement Rate > 70% → Goal change
- Achievement Rate < 30% → Barriers check



1 주마다 전화

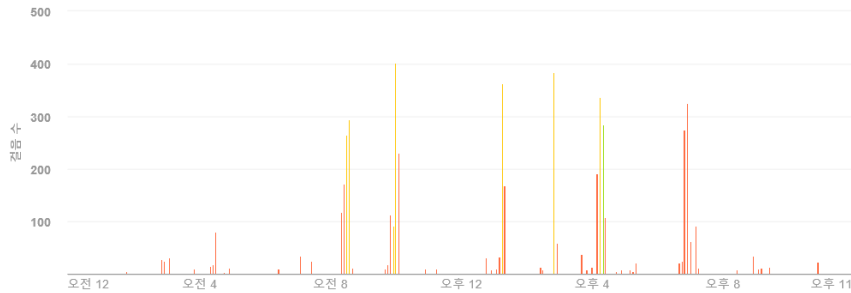




Immediately post-operative exercise

6 Days After Surgery

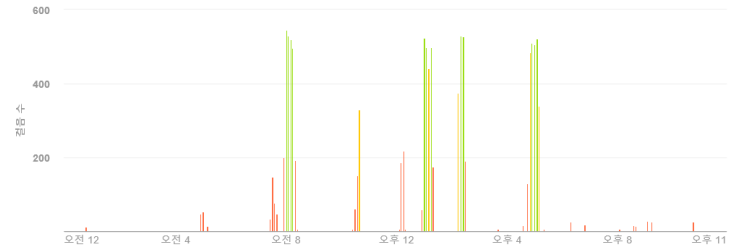
걸음 수 Floors 칼로리 소모량



합계 5,066 걸음 수 2.44 km 1,903 칼로리

17 Days After Surgery

걸음 수 Floors 칼로리 소모량



합계 10,389 걸음 수 3 오르 증수 6.79 km 2,003 칼로리

Exercise
in more frequent manner
with less intensity



Post-operative (~ 2 months) Exercise

호흡
코로 깊이 들이쉬고
입으로 뱉는다

몸체
5도 앞으로
기울인다

사선
10-15m 앞
땅바닥 주시

팔
[자 또는 V자
(기급적 90도 유지)]

발달기 순서
뒷꿈치 → 발바닥 → 발가락

보폭은 체력이 증가
될수록 넓게 한다

<자료 : 한국워킹협회>

실내 걷기 운동

야외 걷기 운동

Indoor/
outdoor
walking

Light
weight
exercise

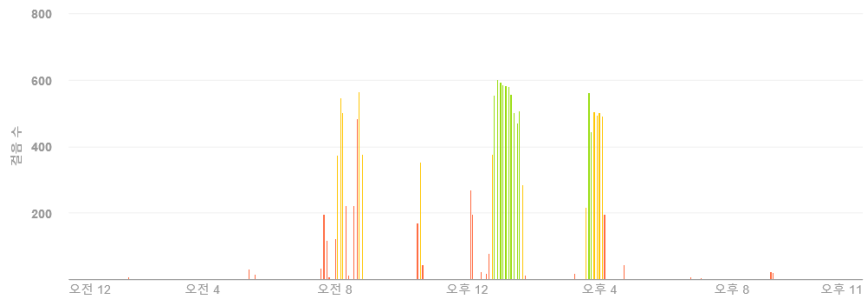


Post-operative (~ 2 months) Exercise

37 Days After Surgery

오늘 주 월 년 1월 20일 (일)

걸음 수 Floors 칼로리 소모량



합계 14,754 걸음 수 5 오른 층수 8.4 km 2,155 칼로리

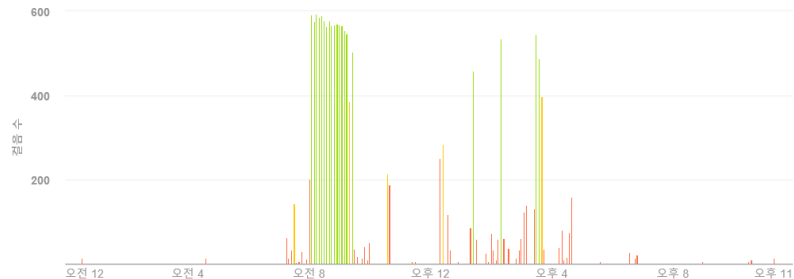
Decreased exercise frequency in a day

Increased exercise intensity and duration

50 Days After Surgery

오늘 주 월 년 2월 3일 (일)

걸음 수 Floors 칼로리 소모량



합계 15,218 걸음 수 5 오른 층수 10.68 km 2,255 칼로리



Intervention Program Components

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Middle test

- PFT
- Physical activity
- Cardiorespiratory function
- Symptom & pain

Post test

- PFT
- Physical activity
- Cardiorespiratory function
- Symptom & pain



Intervention Program Components

Postoperative

수술 후 빠른 기능 회복을 위한 프로그램

Postoperative-intervention (from 2months until 6 months after surgery)

• Phase III:

FITT – VP (from 2months until 6 months)

- Frequency: 5days/week
- Intensity: baseline level
- Time: 30min ~ 60min or 90min MVPA
- Type: walking + weight-bearing exercise
- Volume: Steps & activity time

점증적으로 활동량과 강도 증가시키기



	VO2max (ml/kg/min)	6MWT (m)	PA (IPAR-Q)
Pre	300 (8.6 METs)	554	Moderate 2*120min Walking 7*90min
op1m	-	510	Walking 5*70min
op6m	318 (9.1 METs)	560	Moderate 5*55min Walking 7*105min



Post-operative (~ 6 months) Exercise

FITT – VP: ~ 6 months after surgery

- **Frequency:** 5 days per week
- **Intensity:** HRR 45~70% (intensity before surgery)
- **Time:** MVPA 30 min ~ 60 min or 90min at once
- **Type:** walking + **weight-bearing exercise**
- **Volume :** **daily steps & MVPA time**
- **Progression :** additional 20~50% step & activity time

Exercise intensity to prior to surgery

- *Activity time & Daily steps*
- *5 days per week*
- *Goal setting & edit goal (achievement rate_70%, 30%)*



Post-operative (~ 6 months) Exercise

Exercise with similar intensity to prior to surgery

호흡
코로 깊이 들이쉬고
입으로 뱉는다

몸체
5도 앞으로
기울인다

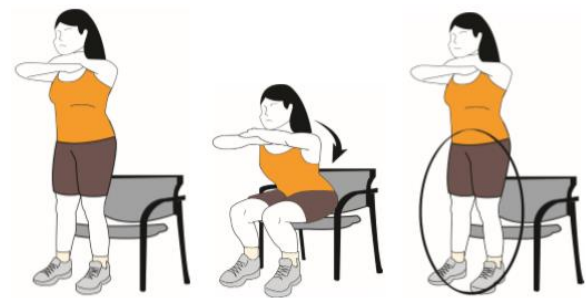
시선
10-15m 앞
명바닥 주시

팔
[자 또는 V자
(가급적 90도 유지)]

발딛기 순서
뒷꿈치 → 발바닥 → 발가락

보폭은 체력이 증가
될수록 넓게 한다

<자료: 한국워킹협회>

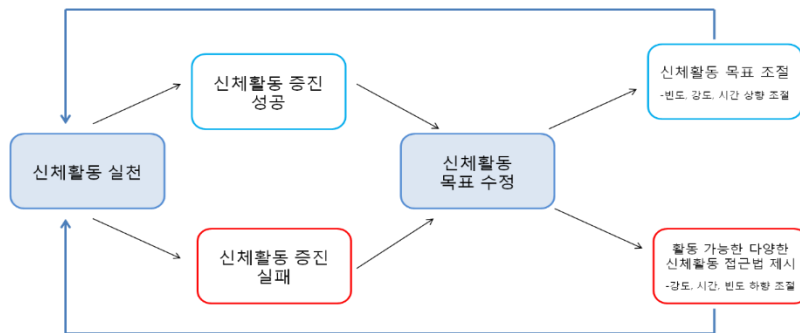




Intervention Program Components

		Phase I	Phase II		Phase III
Goal achievement		MVPA	Steps/day	Steps/day	MVPA
Yes (>70%)	Increase	+ 10–30 min (1 day ≥ 30 min)	+ 1000–3,000 steps/day	+ 1000–3,000 steps/day	+10–30min (≤90 min/day)
	Maintain (30~70%)	Maintain			
No (≤30%)	Decrease	- 10–30 min (1 day ≥ 30 min)	- 1,000–3,000 steps/day	- 1,000–3,000 steps/day	- 10–30min (1 day ≥ 30 min)

Goal achievement; time achieve days/5 days * 100%

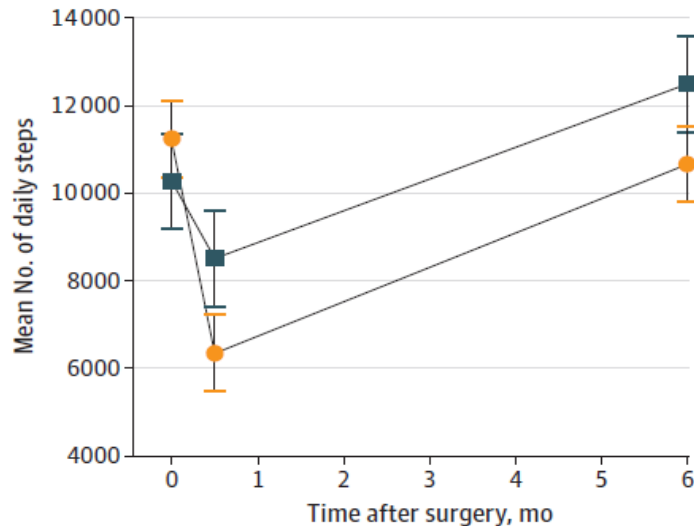




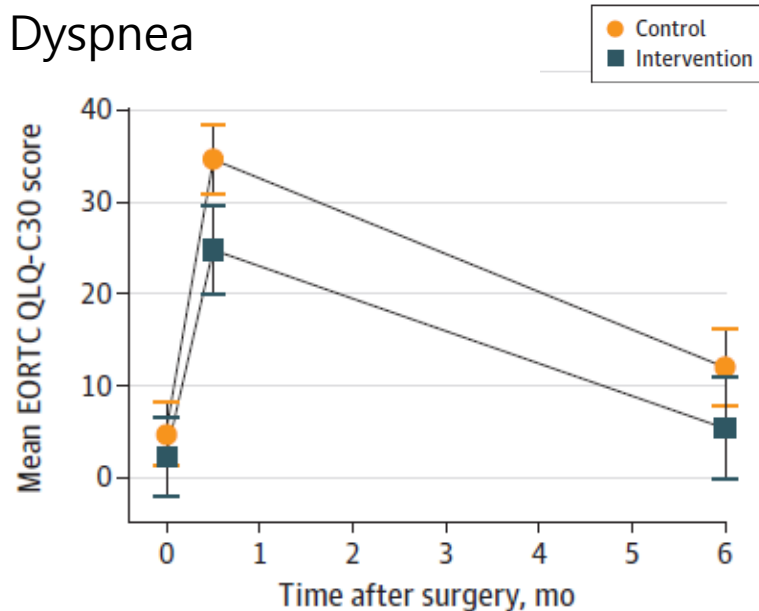
Wearable Device-Based Intervention

Integration of perioperative exercise interventions using wearable devices improved daily steps and dyspnea at 6 months after lung cancer surgery compared with usual care.

Daily steps



Dyspnea

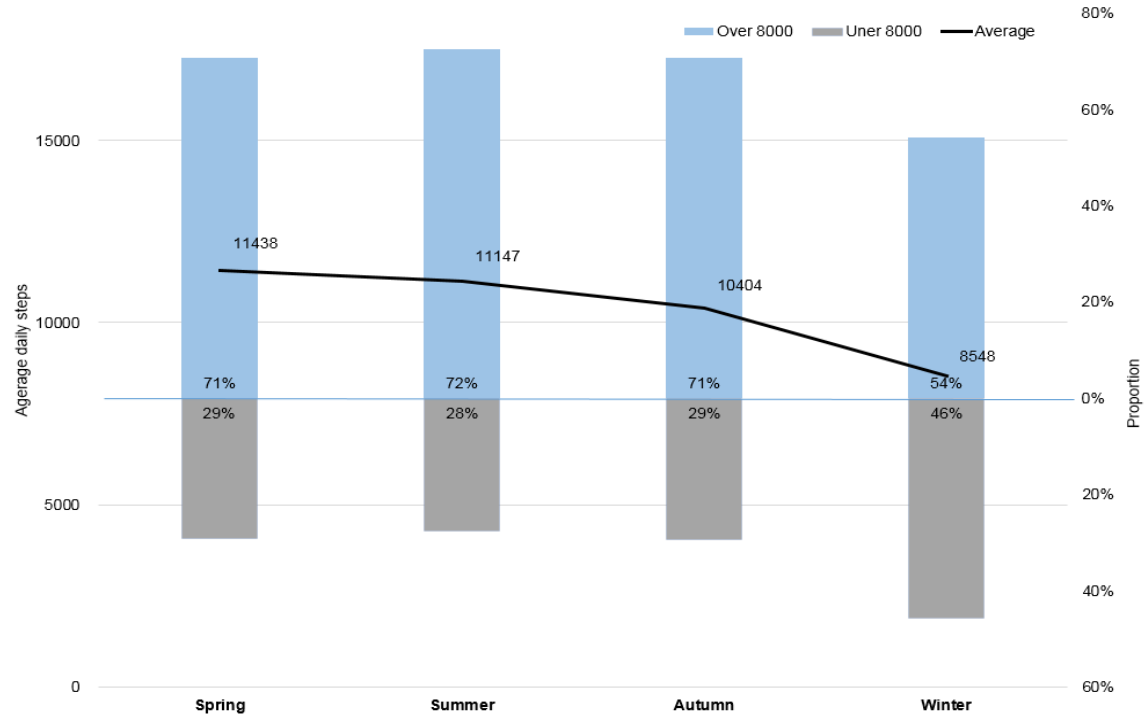




Seasonality of Physical Activity

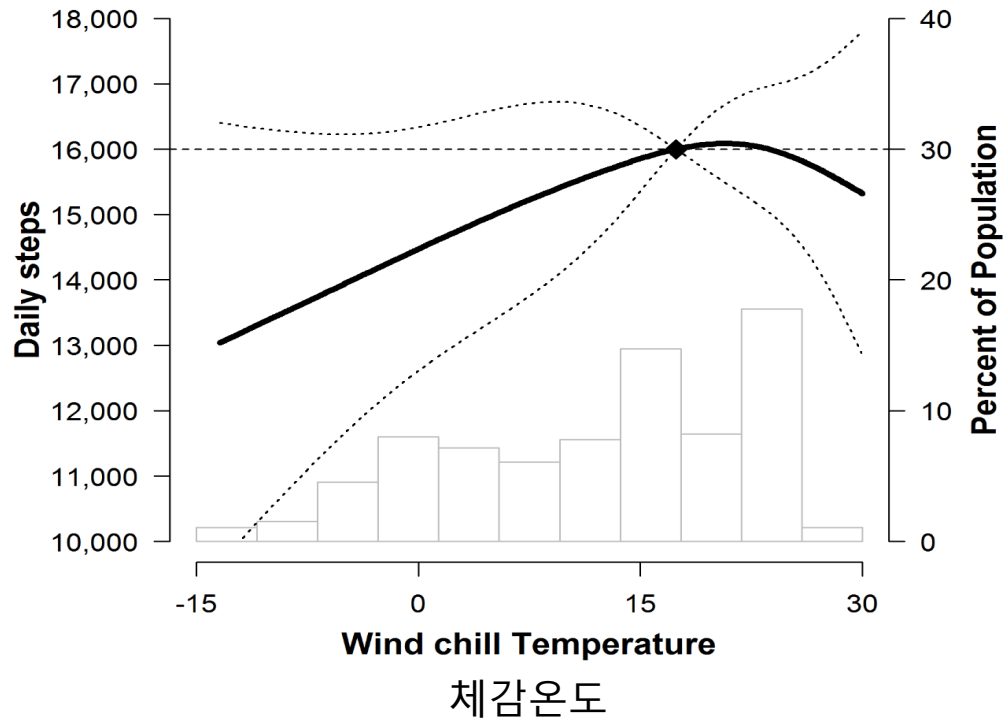


LCA patients before lung cancer surgery





Change of Daily Steps By Wind Chill Temperature (체감 온도)





Summary

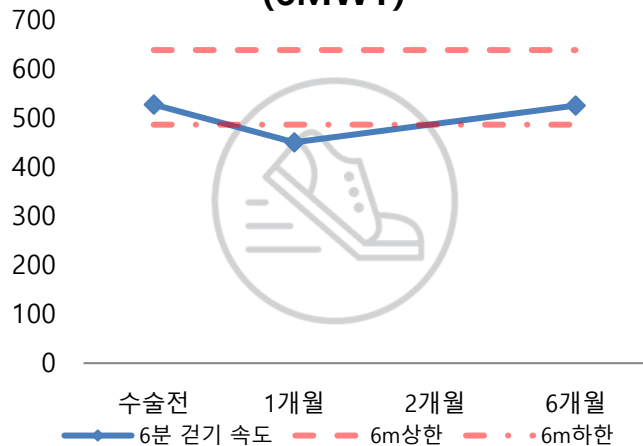
Factors to consider
for surgery

Integrated assessment:
age, comorbidity, PFT, PA

Comprehensive
Rehabilitation

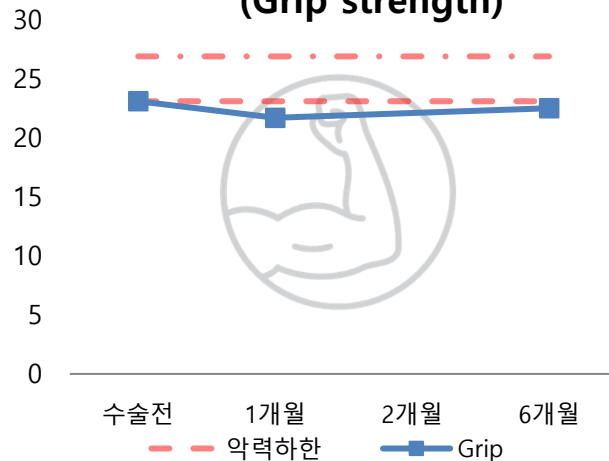
Adjusted exercise program
with symptoms management
at each time points

Cardiopulmonary Function (6MWT)



- 6분 걷기 검사는 6분 동안 걸은 거리를 이용하여 심폐기능을 평가합니다.
- 심폐기능이 높으면 심장과 폐의 기능이 좋아 근육에 산소를 공급 능력이 좋아져 일상생활에서 숨이 덜 차게 됩니다.
- 심폐기능을 높이기 위해서는 약간 힘들다는 느낌으로 **하루 20분~1시간 이내의 운동 (걷기, 등산, 수영, 자전거 등) 이 권장됩니다.**
- 주 3회 이상 꾸준히 실천하는 것이 좋습니다.

Muscle strength (Grip strength)



- 악력검사는 전완(팔뚝)의 힘을 측정하여, 근력을 평가합니다.
- 근력이 강하면 무거운 물체도 쉽게 들 수 있으며, 일상에서 피로도 덜 느끼게 됩니다.
- **근력 강화**를 위해서는 **아령이나 체중을 이용한 근력 운동이 권장됩니다.**
- 주 2회 이상, 각 부위별 2 set 이상, 1 set 당 10~15회씩 반복 합니다.



Rehabilitation programing Considerations

신체활동 증진을 위해 알아야 할 수칙

1. 나에게 맞는 신체활동 찾기

- 자신의 체력이나 건강 목표에 맞추어 신체활동 방법을 선택합니다.
- 적절한 수준의 활동 강도와 양을 지킵니다.
- 무리한 운동은 부상과 같은 부작용의 위험이 있으니 주의합니다.

2. 준비 운동과 정리 운동 하기

- 준비 운동과 정리 운동은 본 운동 전과 후에 합니다.
- 운동 전 · 후 5-10분간 스트레칭을 하여 관절이 다치지 않도록 하고, 급격한 심혈관계 반응을 예방합니다.

3. 조금씩 증가시키기

- 운동을 처음 시작하거나 운동 경험이 많지 않은 사람은 낮은 운동 강도로 시작하고, 운동 시간은 짧게 여러 번 나누어 실시합니다.
- 운동량을 늘릴 때에는 매일 조금씩 증가시키며, 관절이나 신체에 무리가 되지 않도록 합니다.

4. 올바른 방법으로 근력 운동 하기

- 신체의 각 주요 부위별로 골고루 실시합니다.
- 근력 운동은 주 2-3일로 격일로 실시합니다. 만약 체력이 낮은 경우, 낮은 강도로 매일 실시합니다.
- 정확한 동작과 적절한 호흡을 유지하고, 운동전문가의 지도를 받는 것이 좋습니다.

5. 안전하게 운동하기

- 안전한 환경에서 알맞은 운동 장비와 보호 장구를 사용합니다.
- 보호자와 함께 운동 하는 것이 좋습니다.

6. 체력이 낮은 경우 주의하기



- 1시간 이상의 지속적인 운동보다는 30-40분씩 나누어 여러 번 하는 것이 좋습니다.
- 낙상 예방을 위해 균형성 운동을 실시합니다.

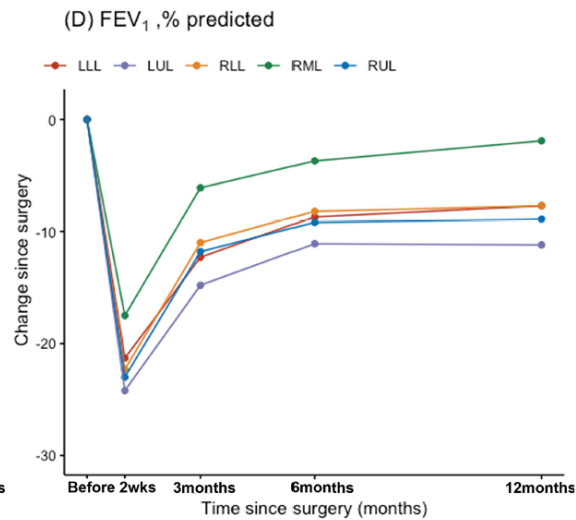
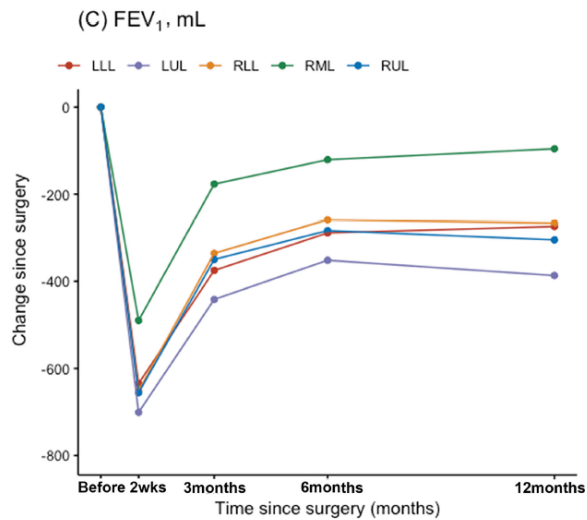
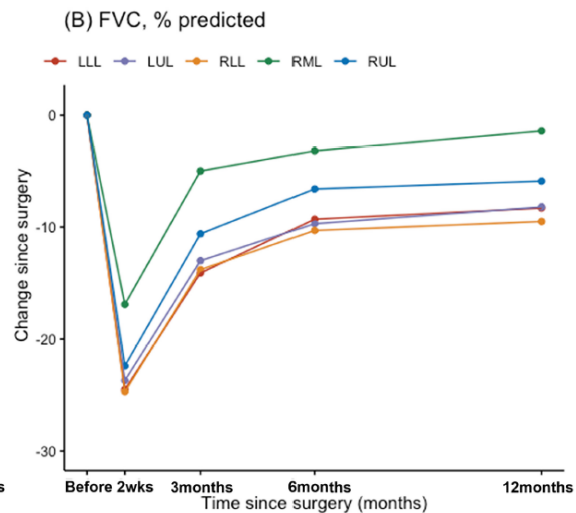
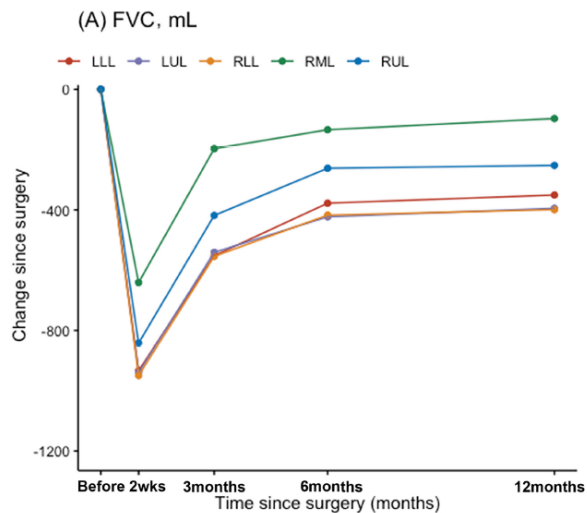


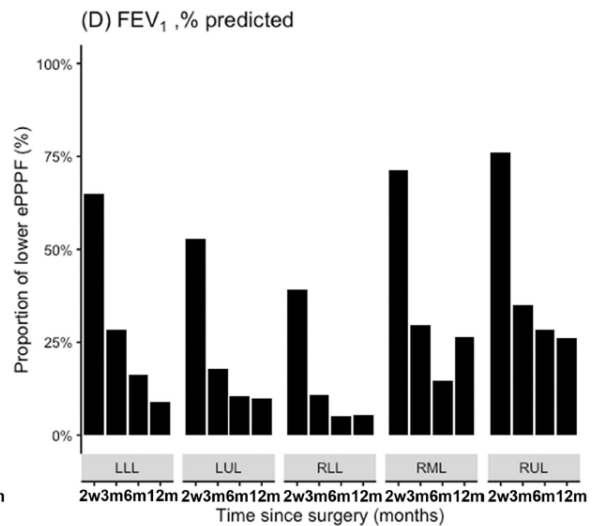
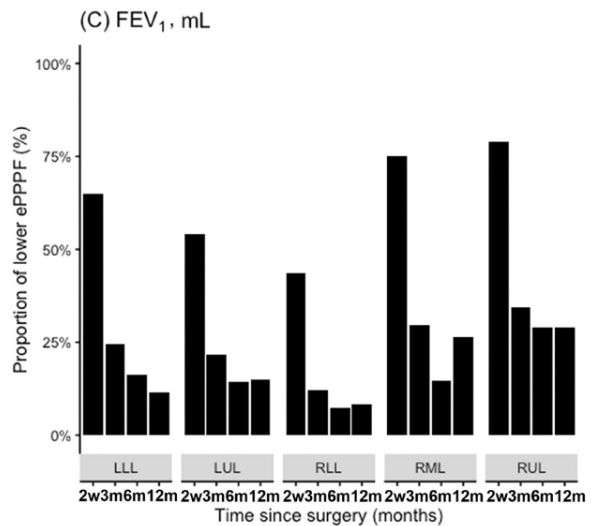
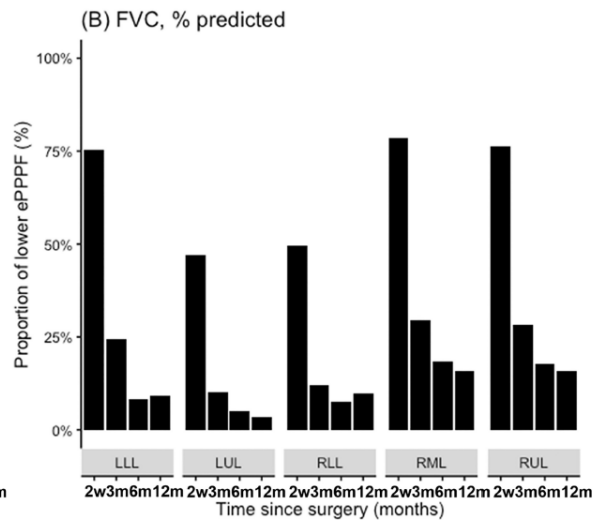
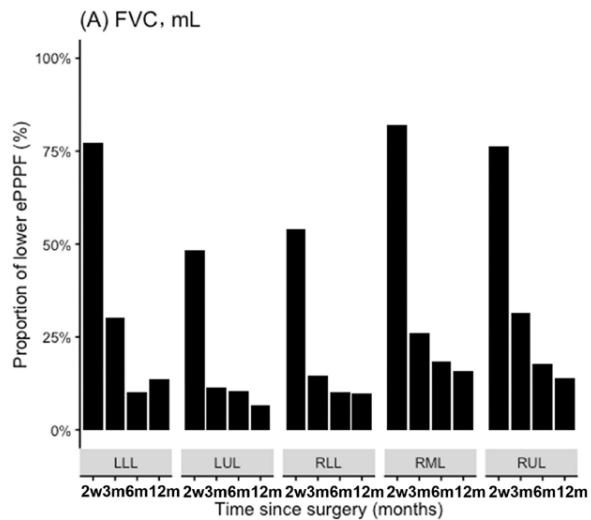
경청해 주셔서 감사합니다.

ORIGINAL ARTICLE **OPEN ACCESS**

Lobe-Specific Variability in Postoperative Pulmonary Function in Lung Cancer Patients: A Longitudinal Analysis and Comparison With Traditional Predictive Models

Yeong Jeong Jeon¹  | Sumin Shin² | Sunga Kong^{3,4} | Seongwoo Yang⁵ | Jong Ho Cho¹ | Hong Kwan Kim¹ |
Young Mog Shim^{1,3} | Danbee Kang^{4,5} | Hye Yun Park⁶ 





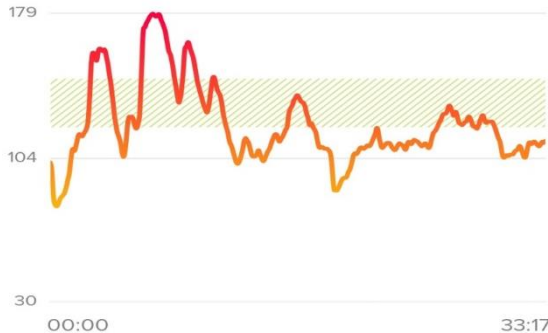
Activity Monitoring Using Wearable Device



심박수 구간



심박수



걷기 4:19 오후, 수요일 11월 14, 2018

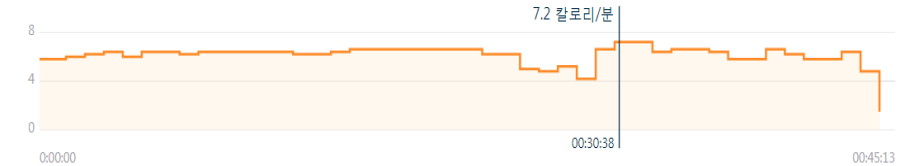
45:13 분 105 bpm 273 칼로리

운동 세부 정보

심박수
105 평균 분당 심박수
36 분 최대 심박
9 분 심장강화운동
0 분 지방 연소



칼로리 소모량
6 칼로리/분



영향
+3,841 / 13,108 걸음

+273 / 2,645 칼로리 소모

+43 / 110 분(활동 시간)

HR monitoring & recoded during exercise



Reference Guide to Target Exercise volume & goal

- Exercise volume
 - 10 min walk = 1000 steps
- 6MWT (6MWD)
 - exercise intensity (%) X ([6MWD/6] X time)

Ex) 6MWD = 300 meter walk

- 300 m / 6 = 50 m/min
- 50 m/min X 30min = 1500 m
- 60% speed = 900 m walk during 30 min

But, individual walking patterns and speed should be considered.

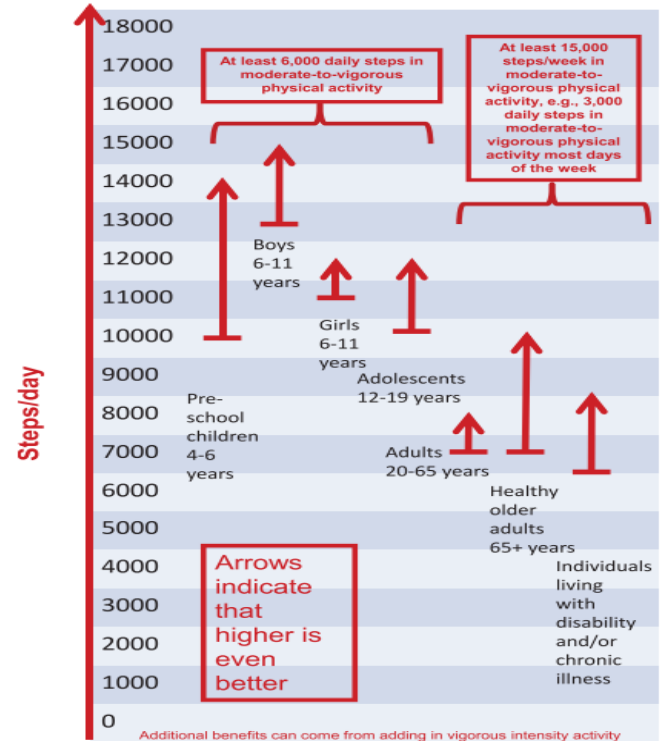


Figure 1 Steps/day scale schematic linked to time spent in MVPA.

Exercise Recommendation with Asthma Patients



■ FITT RECOMMENDATIONS FOR INDIVIDUALS WITH ASTHMA

FITT

	Aerobic	Resistance	Flexibility
Frequency	3–5 d · wk ⁻¹	2–3 d · wk ⁻¹	≥2–3 d · wk ⁻¹ with daily being most effective
Intensity	Begin with moderate intensity (40%–59% HRR or $\dot{V}O_2R$). If well tolerated, progress to 60%–70% HRR or $\dot{V}O_2R$ after 1 mo.	Strength: 60%–70% of 1-RM for beginners; ≥80% for experienced weight trainers Endurance: <50% of 1-RM	Stretch to the point of feeling tightness or slight discomfort.
Time	Progressively increase to at least 30–40 min · d ⁻¹ .	Strength: 2–4 sets, 8–12 repetitions Endurance: ≤2 sets, 15–20 repetitions	10–30 s hold for static stretching; 2–4 repetitions of each exercise
Type	Aerobic activities using large muscle groups such as walking, running, cycling, swimming, or pool exercises	Weight machines, free weight, or body weight exercises	Static, dynamic, and/or PNF stretching

1-RM, one repetition maximum; HRR, heart rate reserve; PNF, proprioceptive neuromuscular facilitation; $\dot{V}O_2R$, oxygen uptake reserve.

Exercise Recommendation with COPD Patients



FITT

FITT RECOMMENDATIONS FOR INDIVIDUALS WITH CHRONIC OBSTRUCTIVE PULMONARY DISEASE (76,77,86,106,117)

	Aerobic	Resistance	Flexibility
Frequency	At least 3–5 d · wk ⁻¹	2–3 d · wk ⁻¹	≥2–3 d · wk ⁻¹ with daily being most effective
Intensity	Moderate-to-vigorous intensity (50%–80% peak work rate or 4–6 on the Borg CR10 Scale)	Strength: 60%–70% of 1-RM for beginners; ≥80% for experienced weight trainers Endurance: <50% of 1-RM	Stretch to the point of feeling tightness or slight discomfort.
Time	20–60 min · d ⁻¹ at moderate-to-high intensities as tolerated. If the 20- to 60-min durations are not achievable, accumulate ≥20 min of exercise interspersed with intermittent exercise rest periods of lower intensity work or rest.	Strength: 2–4 sets, 8–12 repetitions Endurance: ≤2 sets, 15–20 repetitions	10–30 s hold for static stretching; 2–4 repetitions of each exercise
Type	Common aerobic modes including walking (free or treadmill), stationary cycling, and upper body ergometry	Weight machines, free weight, or body weight exercises	Static, dynamic, and/or PNF stretching

1-RM, one repetition maximum; PNF, proprioceptive neuromuscular facilitation.

Maintenance Exercise Program

Exercise



Symptom control



nutrition



PREDISPOSING FACTORS

- EXTERNAL TRIGGERS (e.g. sight of exercise facility)
- COGNITIVE FACTORS (knowledge, attitudes, awareness)
- INTERNAL TRIGGERS (e.g. experience of symptoms relieved by PA)

ENABLING FACTORS

- SKILLS
- SUFFICIENT HEALTH AND PHYSICAL ABILITY
- OPPORTUNITIES (time, facility, equipment)
- LACK OF HURRY, STRESS

REINFORCING FACTORS

- SOCIAL SUPPORT
- FEEDBACK ON PROGRESS
- EXTERNAL REWARDS
- INTERNAL REWARDS (satisfaction enjoyment, good health)

PHYSICAL ACTIVITY

Precede-proceed Model



Criteria for tolerance of anatomic surgical resection

- Surgical Interventions
 - Lung Surgery
 - The risk of postoperative complications from lung resection appears to be increased in patients with decreased predicted **postoperative pulmonary function (FEV_1 or $DLco < 30\sim 40\%$ predicted).**



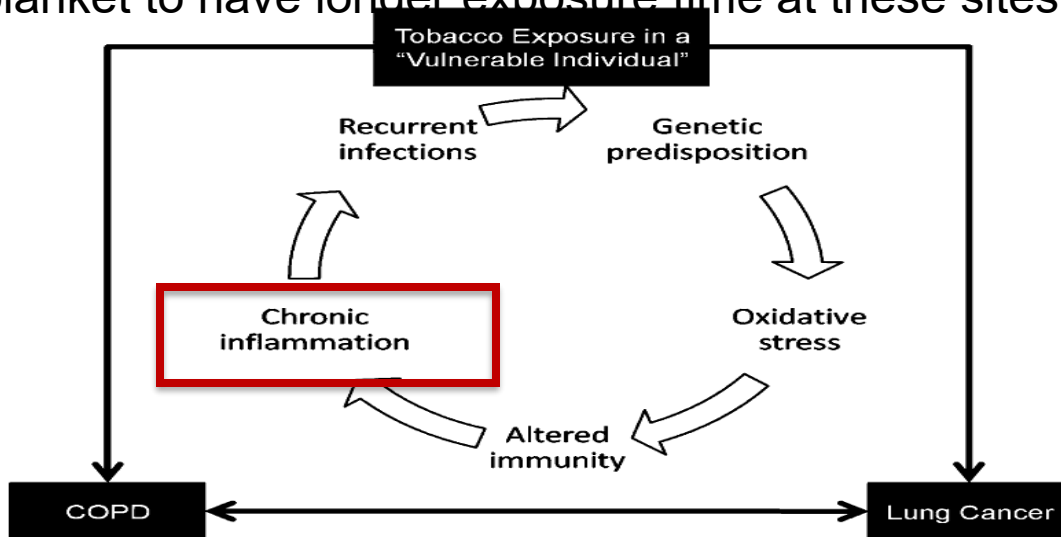
Possible Mechanisms

Smoking → Chronic inflammation

→ Repeated injury and repair, stimulating cell turnover and potential genetic errors

→ Lung cancer

Impaired mucociliary clearance in COPD → carcinogens from the smoke in the mucous blanket to have longer exposure time at these sites





Possible Mechanisms

Smoking → Chronic inflammation

→ Repeated injury and repair, stimulating cell turnover and potential genetic errors

→ Lung cancer

Impaired mucocillary clearance in COPD → carcinogens from the smoke in the mucous blanket to have longer exposure time at these sites

1. Patients with emphysema may have increased susceptibility to smoking-related biological damage, including damage to the DNA, which ultimately determines the aggressiveness of the tumor cells

2. tumor progression is enhanced in emphysematous lungs where matrixmetalloproteinases are rich

COPD and lung cancer

Share underlying host susceptibility factors

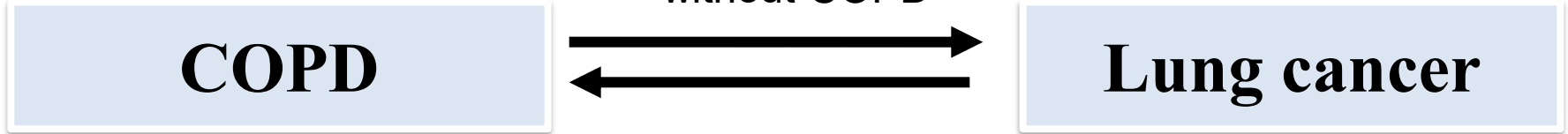


Diagnosis of lung cancer in COPD

Assessment of concomitant chronic diseases

The presence of COPD may actually increase the risk for other diseases; this is **particularly striking for COPD and lung cancer.**

Up to 5-fold higher risk of lung cancer than smokers
without COPD



6-fold increased prevalence in COPD than matched smokers
in newly diagnosed lung cancer cases



Rehabilitation programing Considerations

나에게 질문하기

1. 신체활동 생각하기

- 1) 신체활동을 해야 하는 이유는 무엇인가요?
- 2) 신체활동을 해야 하는 구체적인 목표/목적은 무엇인가요?

2. 신체활동 준비하기

- 1) 일상생활에서 하고 있는 신체활동으로는 무엇이 있나요?
- 2) 규칙적인 신체활동을 위해 할 수 있는 활동은 무엇이며, 장소는 어디인가요?
- 3) 하루 중 언제 가능한가요?
- 4) 하루 몇 분 가능한가요?
- 5) 일주일에 몇 회 가능한가요?
- 6) 스스로 활동적인 사람이 될 수 있을 것이라고 믿나요?
- 7) 나의 신체활동을 방해하는 것이 있나요?
- 8) 신체활동을 방해하는 것들을 극복하기 위한 구체적인 해결방법은 어떤 것들이 있을까요?

3. 신체활동 시작하기

- 1) 구체적인 나의 신체활동 목표는 무엇인가요?
- 2) 운동 실천 일지 작성을 지속적으로 하고 있나요?
- 3) 나는 어떤 상황에서도 신체활동을 할 수 있는 사람이라는 확신이 있나요?

4. 신체활동 지속하기

- 1) 지속적인 신체활동이 필요한 이유는 무엇인가요?
- 2) 구체적인 목표를 다시 정한다면 무엇인가요?
- 3) 현재 자신의 신체활동을 평가한다면, 수정이 필요한가요?
- 4) 신체활동을 지속함에 있어 문제가 있나요? 극복할 방법으로는 무엇이 있을까요?
- 5) 만약 규칙적인 신체활동을 못했다면, 1~2주 안에 다시 신체활동을 시작할 수 있나요?



Dyspnea
barrier

Perioperative pulmonary rehabilitation Considerations

1. Safety & Effectiveness

- Control exercise intensity

2. Adverse events

- Severe breathing difficulties
- Severe pain
- HR elevation
- Fever $>38^{\circ}\text{C}$

3. Goal Setting & Edit Goal

- Achievement Rate $> 70\%$ \rightarrow Goal change
- Achievement Rate $< 30\%$ \rightarrow Barriers check





Rehabilitation programing Considerations

나의 운동 목표

- 나는 "나의 (목적) _____" 을 위해 운동을 하겠습니다.
- 나는 (장소) _____ 에서, (종목) _____ 운동을 하겠습니다.
- 나의 운동 강도는 약간 힘들다 라는 느낌으로 하며, 너무 힘들거나 통증이 있는 경우, 운동 강도를 낮추거나 운동을 멈추겠습니다.
- 나는 운동 강도가 너무 약하거나 쉽다고 느껴지는 경우, 운동 강도와 시간을 서서히 증가시키겠습니다.
- 나는 운동 강도 조절과 운동 실천을 확인하기 위해 운동 실천 일지에 운동 중 자각도 (힘든 정도)를 매번 기록하겠습니다.

참가자 _____ 서명

이럴 때 운동은 안돼요!

운동 전

- 운동 전 열이 38도 이상인 경우
→ 운동을 합니다.

운동 중

- 운동 시작 후 통증이 심해지는 경우
- 가슴이 조여오거나 통증이 생길 경우
- 어지럽거나 정신이 몽롱해 질 경우
- 현기증이 있거나, 식은땀이 나는 경우
- 근육마비 증상이 생기는 경우
- 시야가 부엌게 변하는 경우
→ 운동을 멈추고 증상이 회복된 후 귀가합니다.

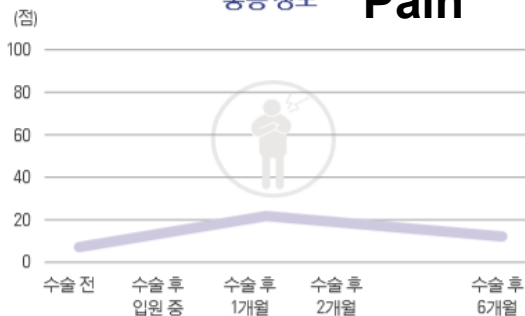
만약, 운동 중 특이사항이 생기면 운동을 중단하고, 운동 실천 일지에 기록하거나 프로그램 담당자에게 연락하세요.

☎ 02) 2148-9498

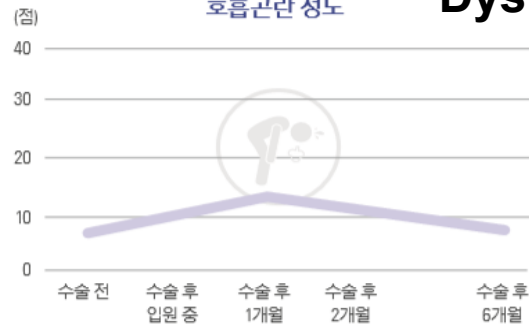


Rehabilitation programing Considerations

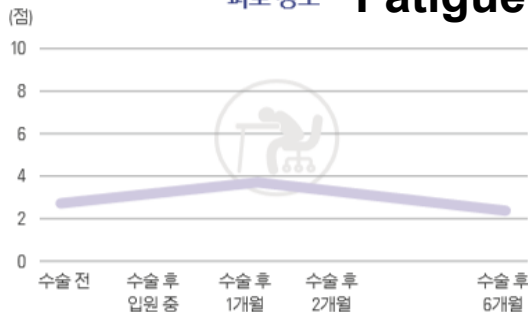
통증 정도 **Pain**



호흡곤란 정도 **Dyspnea**



피로 정도 **Fatigue**



수면장애 정도 **Sleep discomfort**

