La réduction de volume pulmonaire

Belgian Nursing Day 2025

Dr Vander Kuylen Maarten & Taton Olivier - Département de pathologie thoracique – HUB Erasme

Liège – 12/12/2025

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CONFLITS D'INTÉRÊTS

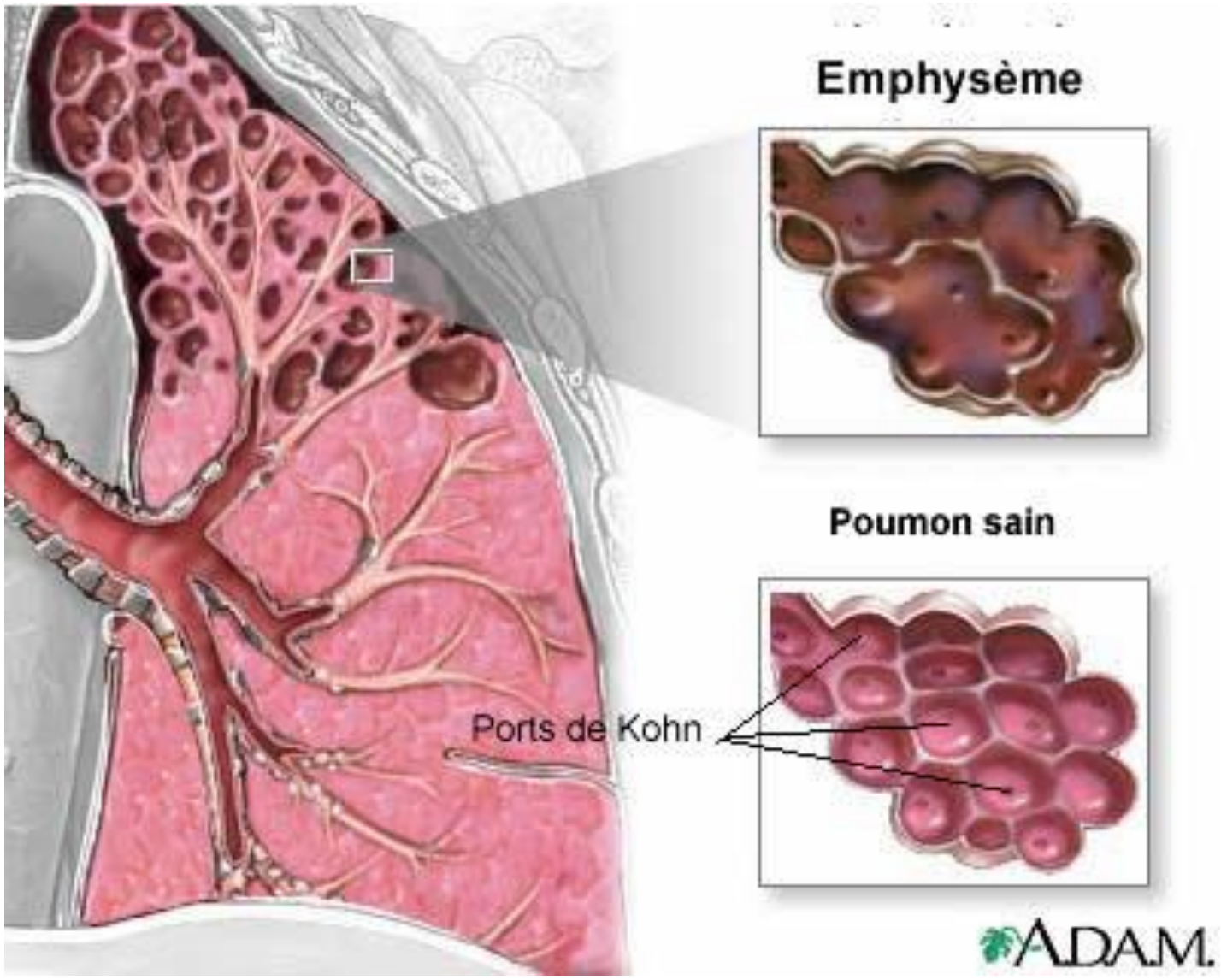
- Maarten Vander Kuylen :
  - Advisory Board : PulmonX

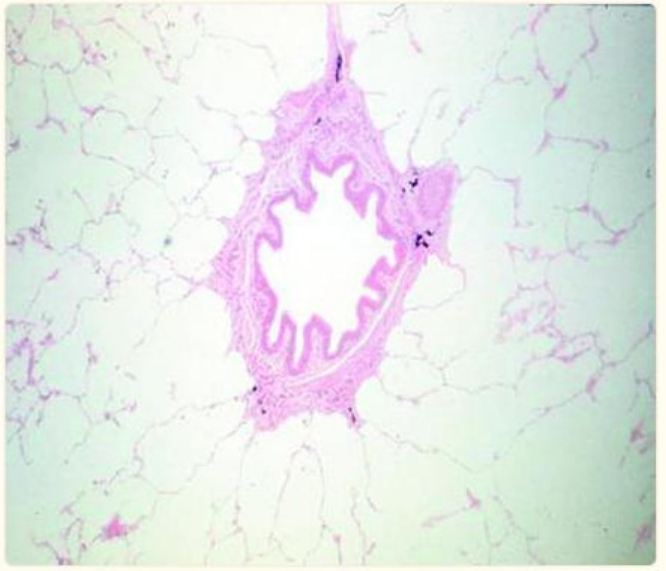
- Olivier Taton :
  - Advisory Board : PulmonX
  - Speaker fee : PulmonX

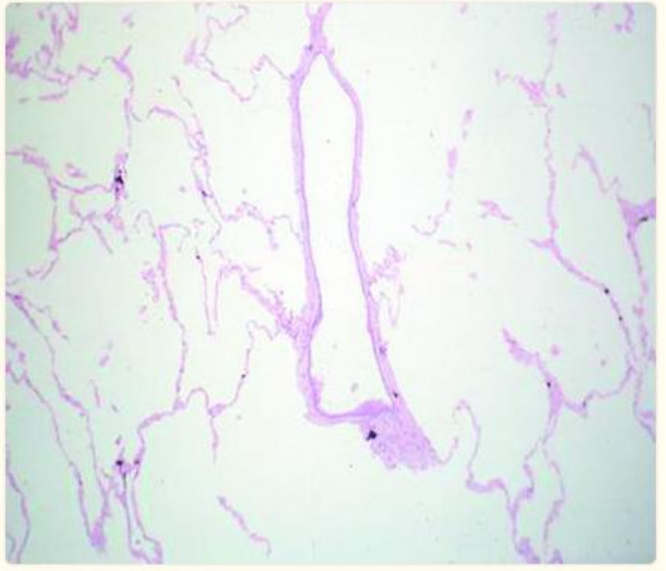
PLAN

1. Pourquoi réduction de volume ?
2. Chez quel patient ?
3. Réunion multidisciplinaire
4. Technique chirurgicale
5. Technique endoscopique
6. Transplantation pulmonaire
7. Perspectives
8. Conclusions

EMPHYSEME

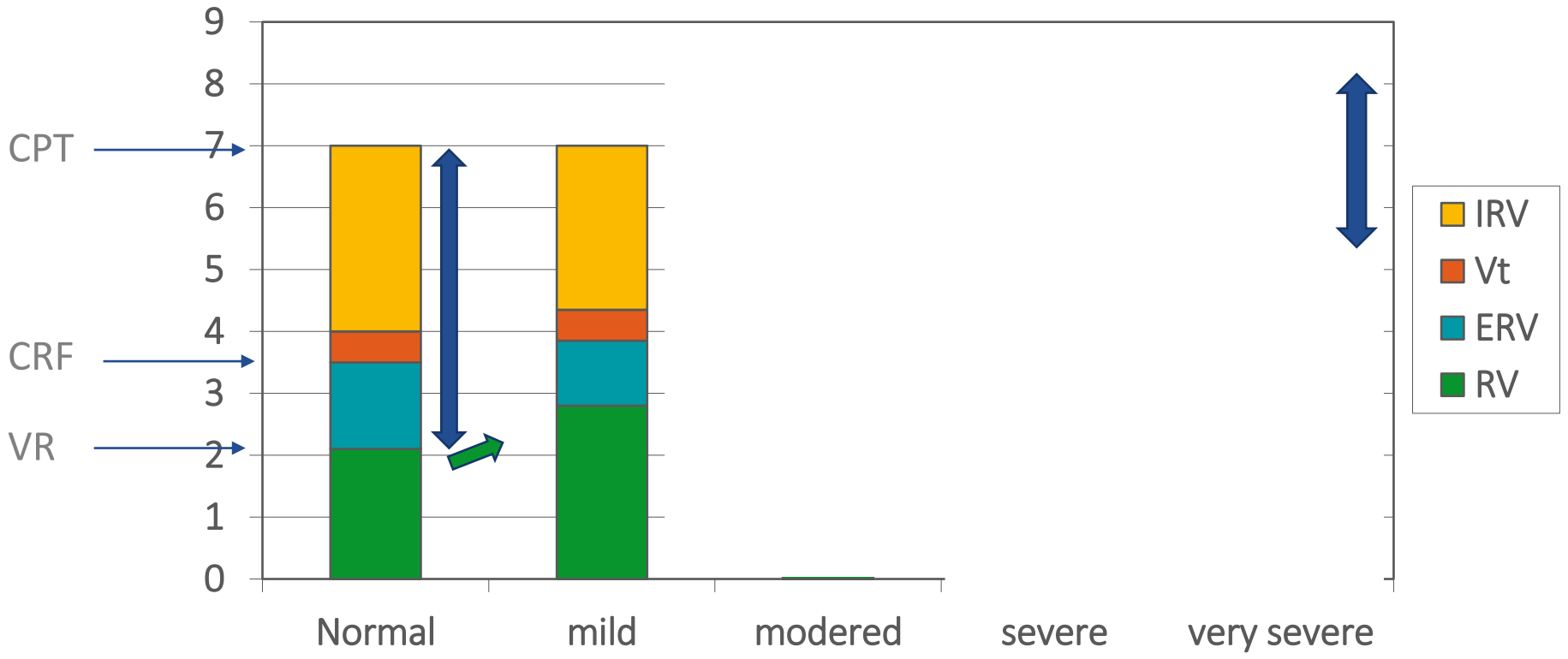




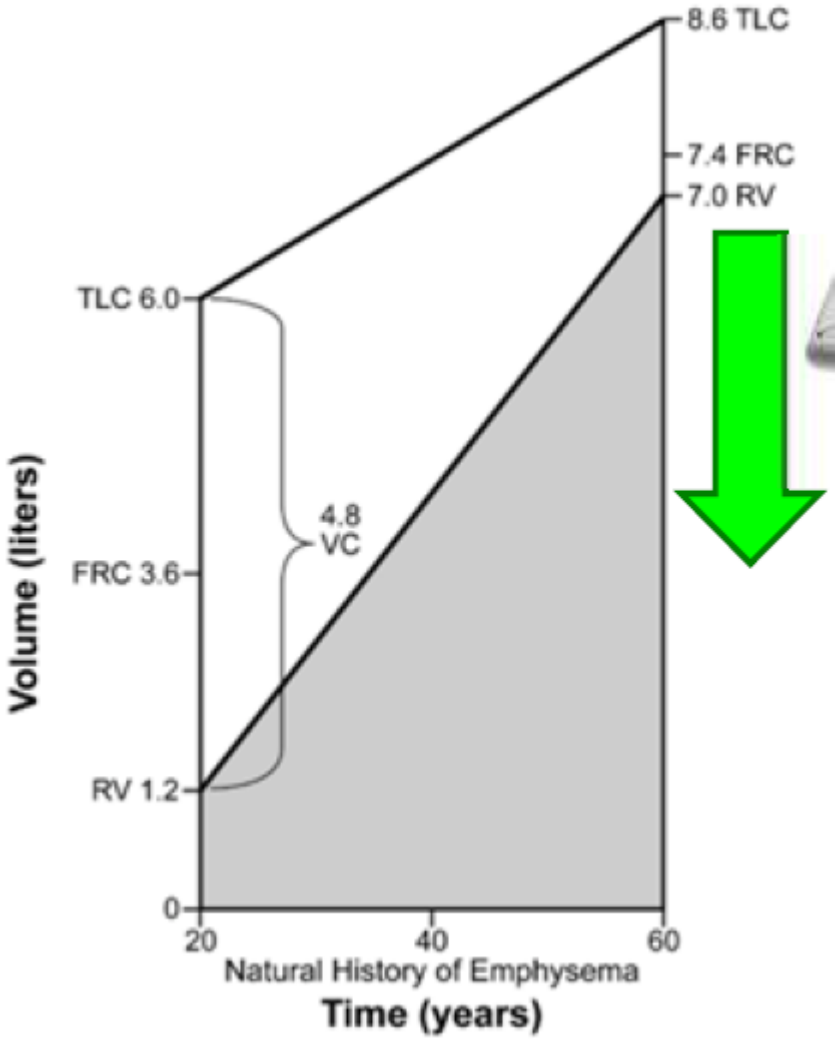


Trappage d'air et Hyperinflation statique

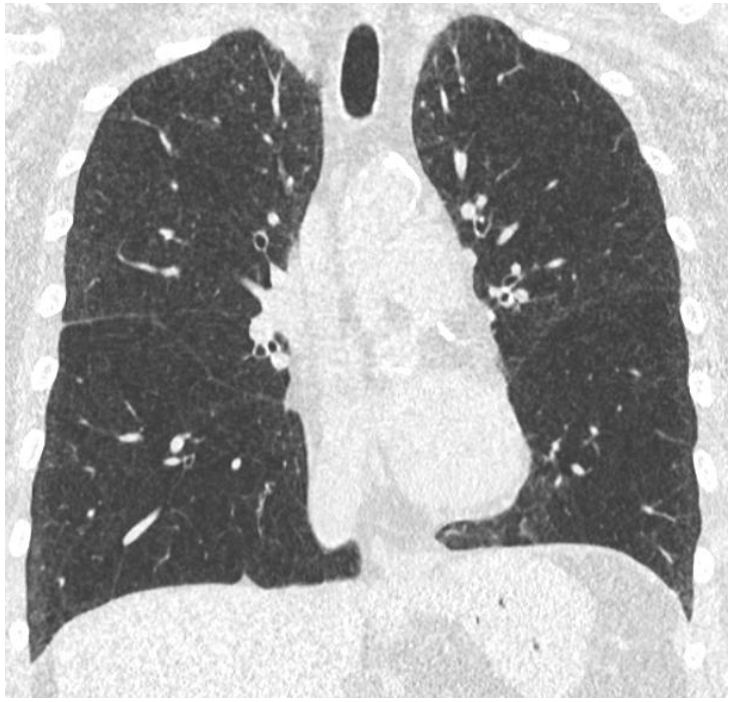
Signe précoce d'obstruction / hyperinflation = ↗VR/CPT



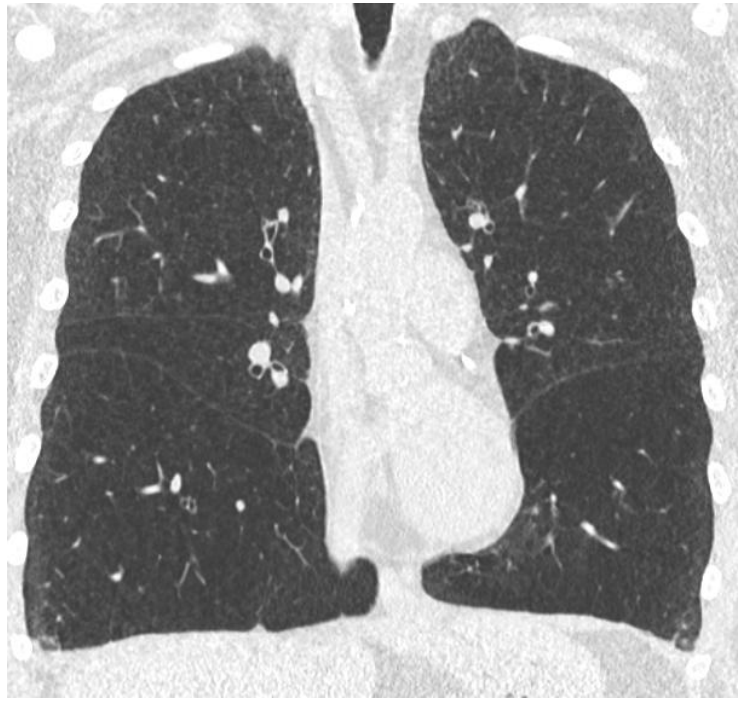
Hyperinflation statique :



Slebos, AJRCCM, 2015

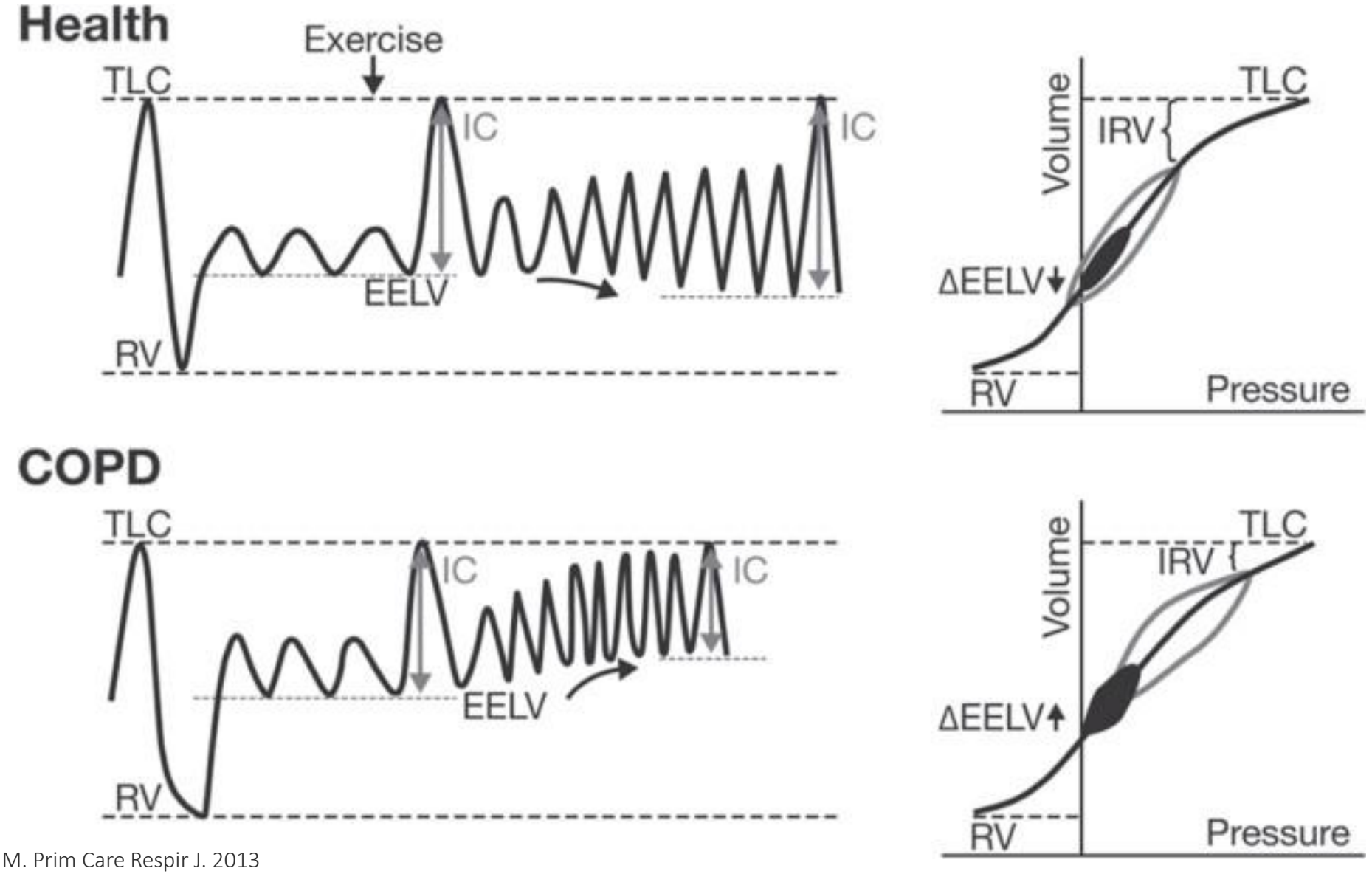


FRC



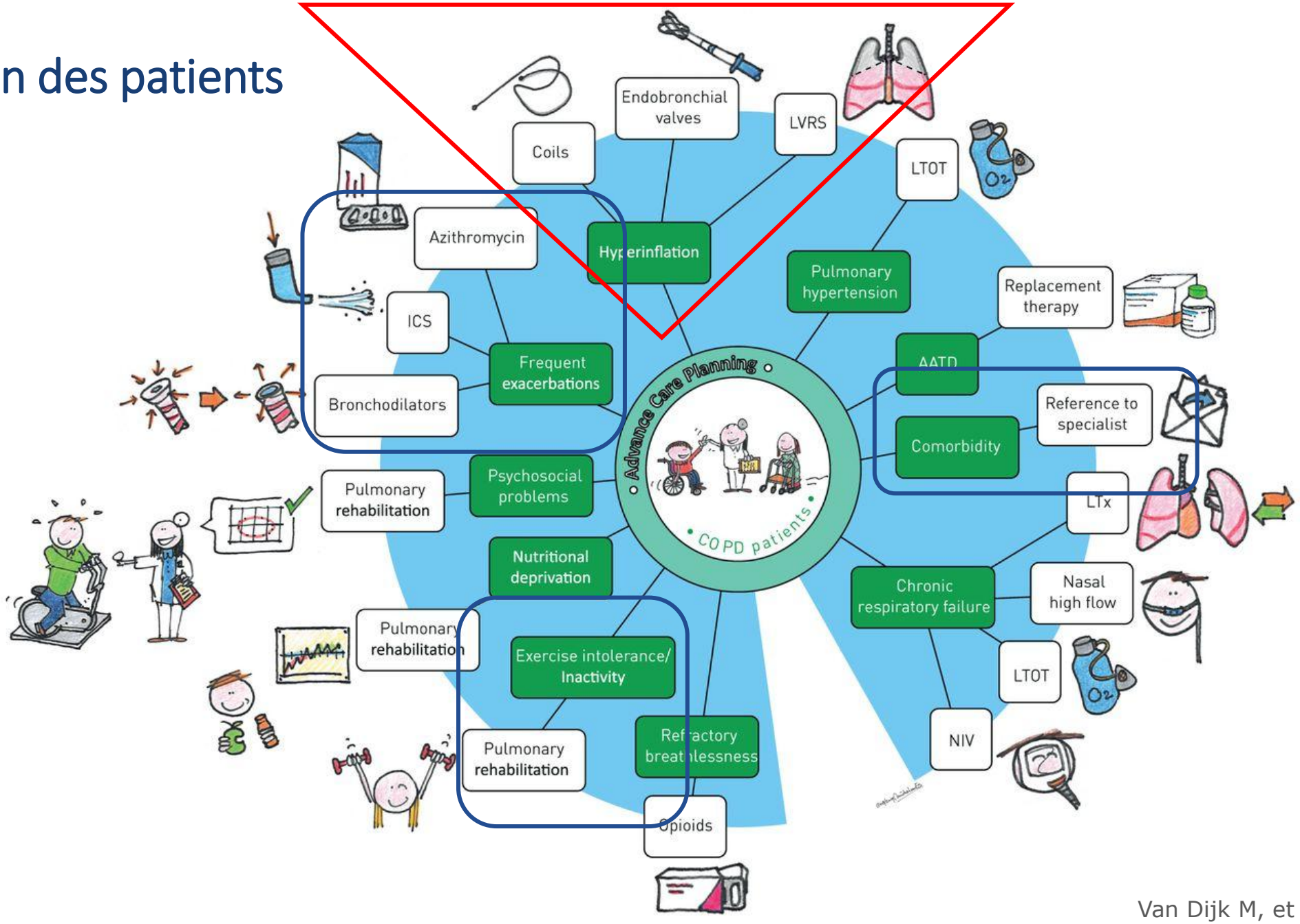
TLC

HYPERINFLATION DYNAMIQUE



Thomas M. Prim Care Respir J. 2013

Sélection des patients



Van Dijk M, et al. ERJ Res. 2020

SÉLECTION DES PATIENTS

Multidisciplinary discussion

Endoscopic lung volume reduction

Lung transplantation

Lung volume reduction surgery

Treatment of patients with severe emphysema :

Medical:

- Arrêt du tabac
- Revalidation pulmonaire
- Nutrition
- Vaccination (against influenza, pneumococcal infection and SARS-CoV-2)
- Bronchodilatateurs/Oxygène
- Traitement biologique

Obligatoire !!!

Femme – 71 ans

→ REPRISE REVALI
→ va le faire

AR avec CT + EFR
(me semble déjà 1 peu trop loin!

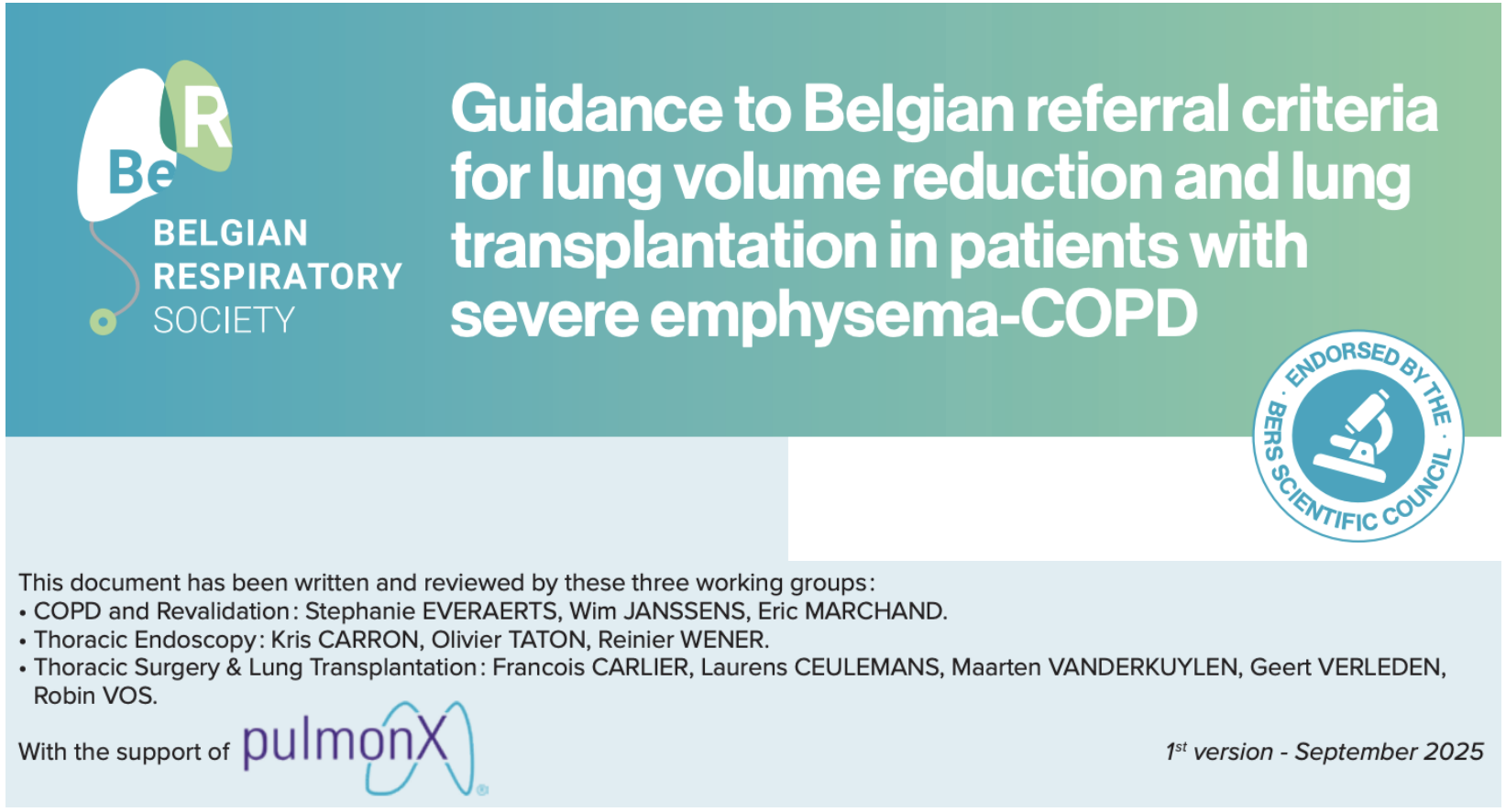
	Before	1 year
FEV_1, l (%)	1.0 (31)	1.7 (45)
RV, l (%)	6.4 (292)	3.3 (151)
CAT, p	25	18
6MWT, m	280	325

Reva
3 mois

1 mois

Temps !!! (6 mois)
Jamais une urgence

SÉLECTION DES PATIENTS



SÉLECTION DES PATIENTS

- **Disabling dyspnea (mMRC ≥ 2) despite optimal medical therapy including**
  - o Smoking cessation;
  - o LABA-LAMA
  - o ICS and/or azithromycin, when appropriate;
  - o Pulmonary rehabilitation. For patients not yet included in a rehabilitation program, motivation, willingness and ability to engage in a pulmonary rehabilitation program is a prerequisite;
  - o Long-term oxygen therapy, when appropriate.

- **PFTs criteria:**
  - Post-bronchodilator FEV1 ≤ 50% pred (GLI ref. equation)*;
  - Severe hyperinflation defined as
    - o RV ≥ 175% pred (GLI ref. equation), measured by body plethysmography*;
    - o RV/TLC > 0.55.

** Reimbursement criteria for endobronchial valves.*

- **Imaging criteria**

Presence of moderate to severe emphysema on lung CT scan.

CONTRAINDICATION FOR LUNG VOLUME REDUCTION

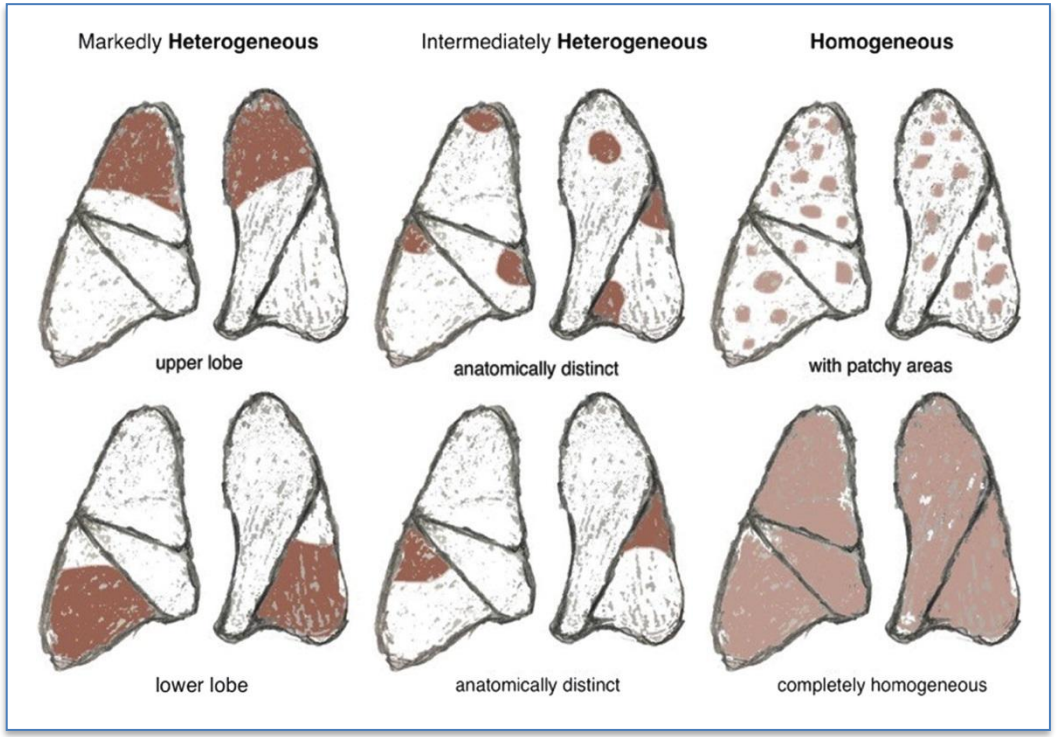
COPD patients with the following characteristics are not good candidates for LVR and should not be referred if at least one of the following criteria is met in stable state and under optimal therapy

- Severe chronic hypoxemia i.e., PaO2 breathing room air < 45 mmHg*;
- Severe chronic hypercapnia i.e., PaCO2 > 60 mmHg*;
- Significant pulmonary hypertension confirmed by right heart catheterization (PAPm > 30 mmHg)*,§;
- Bronchorrhea (need for daily or regular chest drainage)*;
- Uncontrolled asthma*;
- ILD*;
- Active lung parenchymal disease, whether inflammatory* or infectious;
- Active lung cancer;
- Diaphragm paralysis;
- Patients with pulmonary nodule without proof of prolonged stability, unless discussed for LVRS allowing for resection of the nodule (to be assessed at the expert center);
- Chronic heart failure with left ventricular ejection fraction < 40%.

** These patients might be candidates for LTx.*

§ Right heart catheterization can be performed after referral, at the treating center.

Chest CT morphology analysis



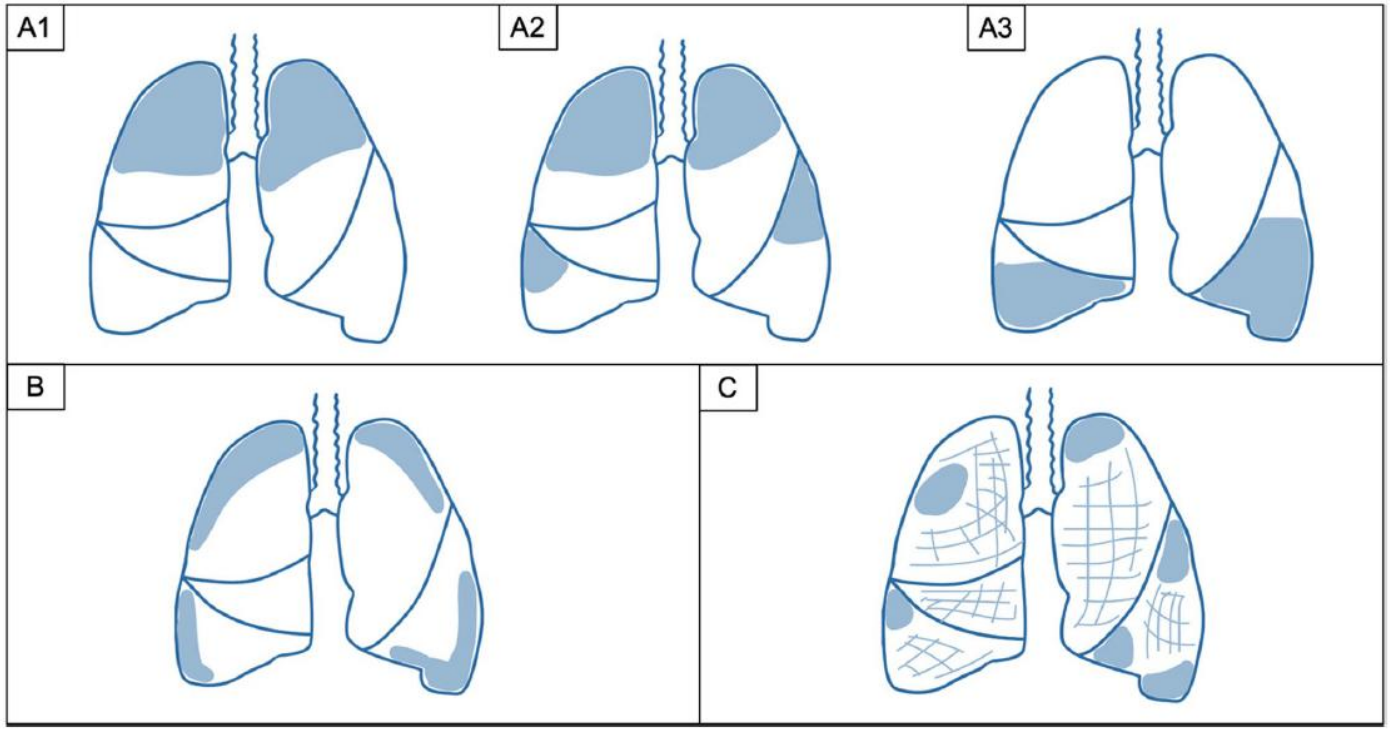
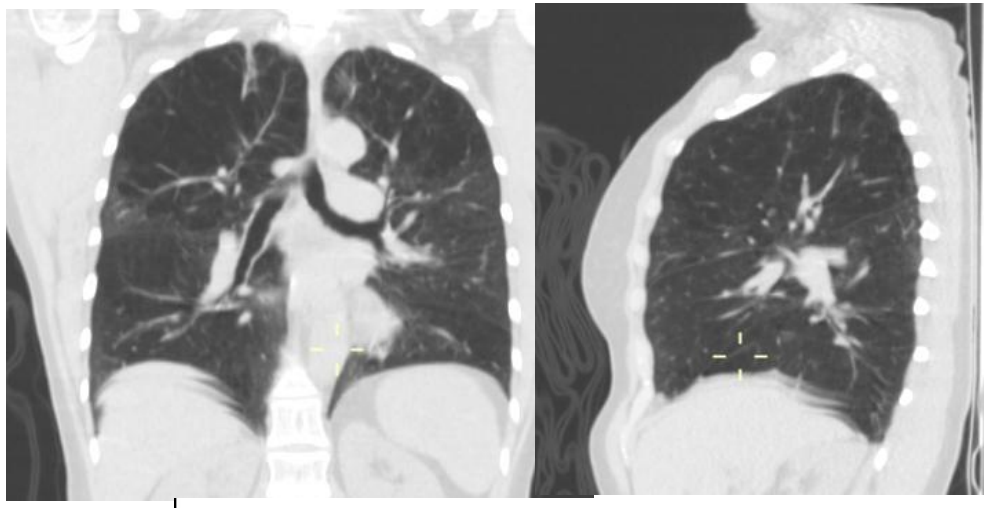
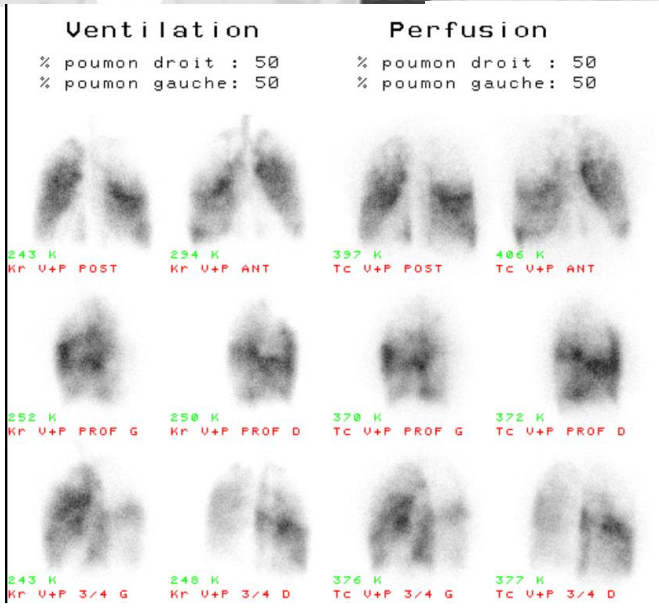
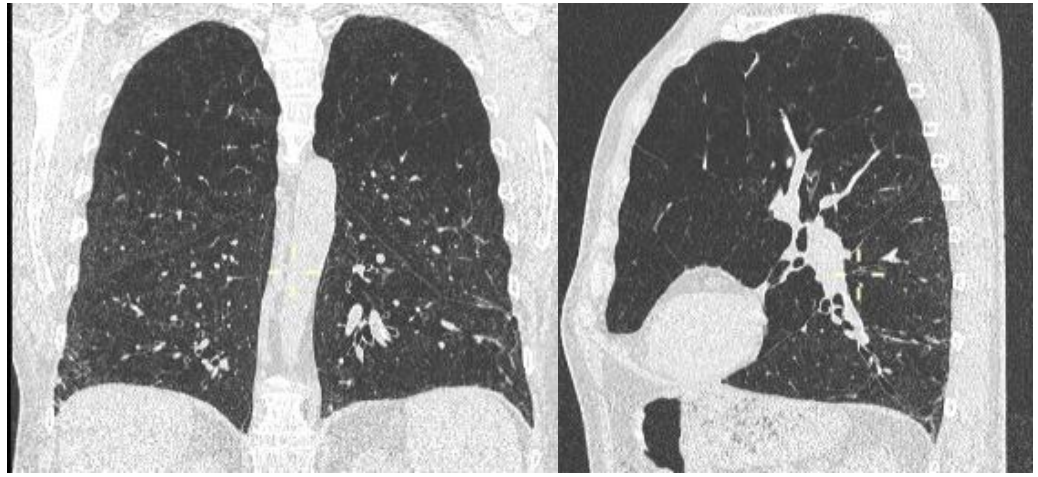


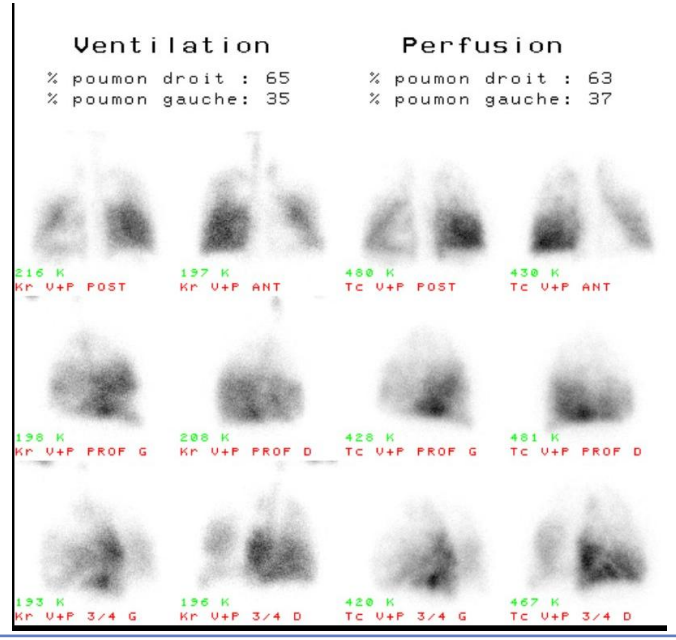
Fig. 1 Emphysema morphology classification. Emphysema morphology as described by W. Weder (1997). **A** Markedly heterogeneous emphysema with upper lobe predominance (**A1**), upper lobe and apical part lower lobe predominance (**A2**), lower lobe predominance (**A3**). **B** Intermediate heterogeneous emphysema (distinct regional difference in severity of emphysema maximally in one or more than one but not in adjacent lung segments of either lung, paraseptal emphysema). **C** Homogeneous emphysema (emphysematous regions equally distributed or with patchy areas)

LVRS OU ELVR




Ventilation
% poumon droit : 50
% poumon gauche: 50
Perfusion
% poumon droit : 50
% poumon gauche: 50
243 K
Kr V+P POST
294 K
Kr V+P ANT
397 K
Tc V+P POST
406 K
Tc V+P ANT
252 K
Kr V+P PROF G
250 K
Kr V+P PROF D
370 K
Tc V+P PROF G
372 K
Tc V+P PROF D
243 K
Kr V+P 3/4 G
248 K
Kr V+P 3/4 D
376 K
Tc V+P 3/4 G
377 K
Tc V+P 3/4 D




Ventilation
% poumon droit : 65
% poumon gauche: 35
Perfusion
% poumon droit : 63
% poumon gauche: 37
216 K
Kr V+P POST
197 K
Kr V+P ANT
480 K
Tc V+P POST
430 K
Tc V+P ANT
198 K
Kr V+P PROF G
208 K
Kr V+P PROF D
428 K
Tc V+P PROF G
481 K
Tc V+P PROF D
193 K
Kr V+P 3/4 G
196 K
Kr V+P 3/4 D
420 K
Tc V+P 3/4 G
467 K
Tc V+P 3/4 D

HISTORY OF EMPHYSEMA SURGERY

1952 Head & Avery

- Intracavitary suction of bullae and blebs

1958 Brantigan

- Pulmonary resection
- Lung denervation
- Resection of bronchial arteries

Mortality 15 to 20%

1995 Cooper

- Bilateral LVRS by sternotomy
- Alternative or « bridge » to LTx

1996 Cooper & Patterson

- LVRS par VATS

Resection of Non-functional pulmonary parenchyma (20-35%)

↓

↓ hyperinflation

↓ obstruction of the airways

↓

↑ ventilatory mechanics

respiratory muscles and elastic recoil of the lung

↑ Gas exchange

by modifying regional perfusion and ventilation

NAEF. ANN THORAC SURG 1997; 64:1506-8
Cooper et al. JTCVS 1995;123:513-25

Evidence for LVRS

National Emphysema Treatment Trial (NETT)

- Multicentric prospective RCT
- OMT vs. OMT + LVRS
- End points:
  - Primary: short- and long-term survival, excercise performance
  - Secondary: lung function, patient symptoms, quality of life.

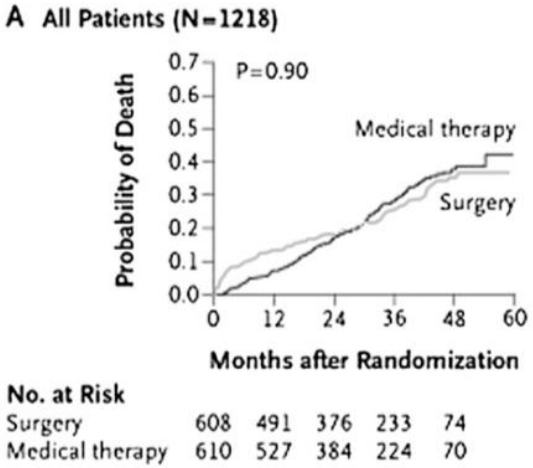
- 3777 patients (1998 - 2002) → 1218 randomised

Nett. 2001. NEJM; 345: 1075-83
Nett. 2003. NEJM; 348: 2059-73

NETT: Results

OMT vs. OMT + LVRS:

- 29.2 months of FU
- 90-day mortality rate:
  - 1.3% vs. 7.9% (p<0.001)
- Overall mortality
  - 160 vs 157 patients
  - Simular in both groups



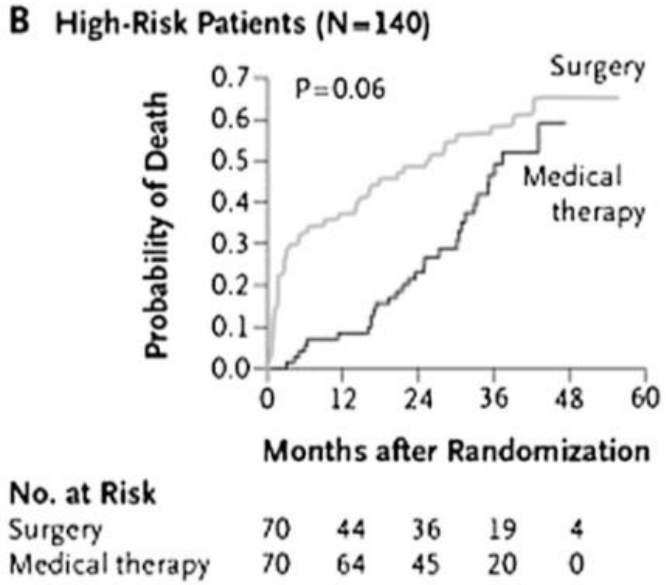
NETT: Results

BUT… a subgroup… HIGH RISK OF DEATH

- N = 140 (70 vs. 70)
- 30-day mo
  - 16% (p<0.0

NO LVRS

- If survival :
  - Limited improvement on other end points



FEV1 ≤ 20% pred. with:

DLCO ≤ 20% pred.
or
Homogeneous emphysema

Nett. 2001. NEJM; 345: 1075-83

Lung Volume reduction surgery (LVRS)

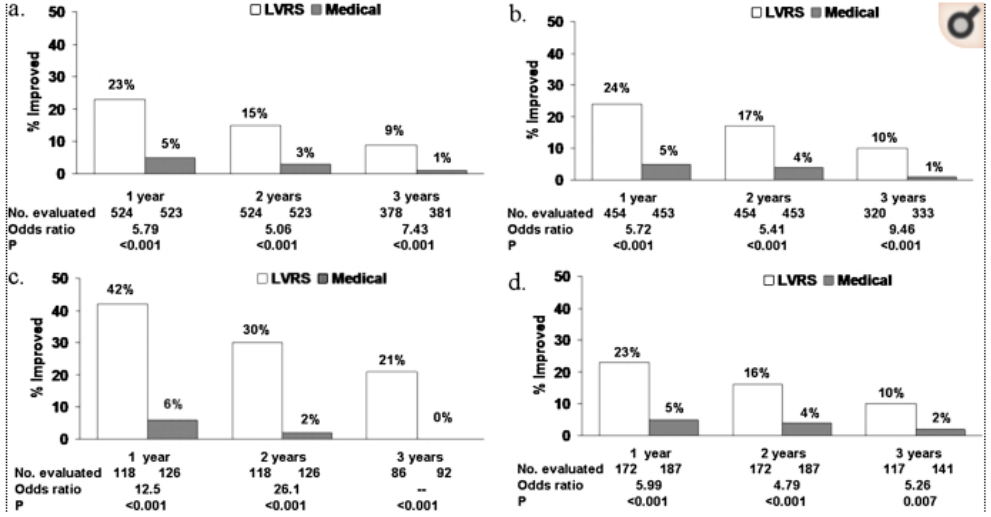
NETT: Results

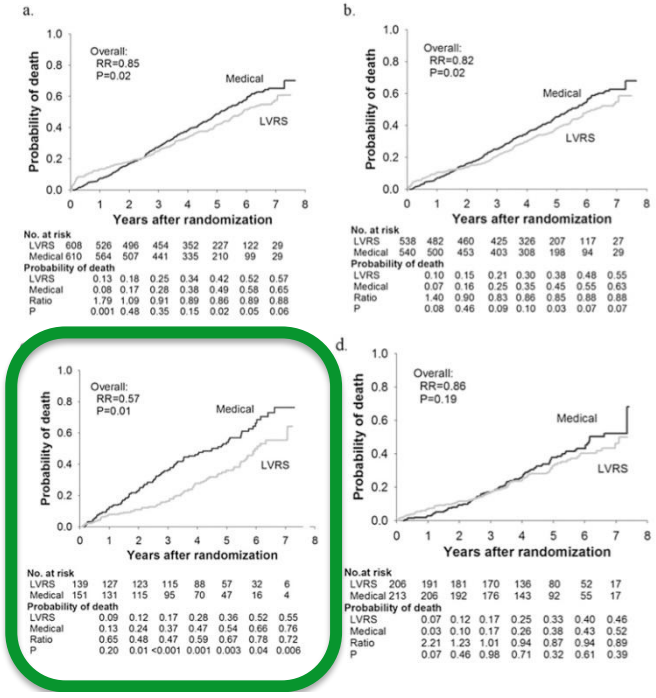
Long-term Survival:

- Improved after LVRS despite the expected higher mortality immediate postoperative
- Advantage in Upper-lobe predominant with low base-line exercise capacity

Long-term Functional outcome:

- Improved after LVRS





(a) All patients (n=1218)
(b) Non-high-risk patients (n=1078)
(c) Upper lobe-predominant with low exercise capacity (n=290)
(d) Upper lobe-predominant with high exercise capacity (n=419)

Lung Volume reduction surgery (LVRS)

Morbidity in LVRS

TABLE 5. COMPLICATIONS FOLLOWING LUNG VOLUME REDUCTION SURGERY IN NETT (n = 511)

Intraoperative	
None	91%
Hypotension	0.4%
Arrhythmia	1.2%
Hypoxemia	2.2%
Cardiac arrest	0.4%
Uncontrolled air leak	1.0%
Postoperative (within 30 d of surgery)	
None	41.3%
Major pulmonary morbidity*	29.8%
Failure to wean	8.0%
Tracheostomy	8.2%
Pneumonia	18.2%
Reintubation	21.8%
Ventilation > 2 d	13.6%
Major cardiovascular morbidity*	20.0%
Arrhythmia requiring Rx	18.6%
Myocardial infarction	1.0%
Pulmonary embolus	0.8%
Reoperation for air leak	3.3%
Readmit to ICU	11.7%
Mediastinitis	0.6%
Sternal debridement	0.6%
Sepsis	2.5%
Epidural catheter complications	0.8%
Readmit to hospital	2.5%
Urinary retention	3.5%

Information from Reference 40. Patients may have more than one complication.

Definition of abbreviations: ICU = intensive care unit; NETT = National Emphysema Treatment Trial; Rx = therapy.

CHALLENGING THE High –risk patients

Outcome After Lung Volume Reduction Surgery in Patients With Severely Impaired Diffusion Capacity

Claudio Caviezel, MD, Nadja Schaffter, Didier Schneiter, MD, Daniel Franzen, MD, Ilhan Inci, MD, Isabelle Opitz, MD, and Walter Weder, MD

Departments of Thoracic Surgery and Pneumology, University Hospital Zurich, Zurich, Switzerland

Long-term survival and symptomatic relief in lower lobe lung volume reduction surgery†

Periklis Perikleous, Annabel Sharkey, Inger Oey, Rocco Bilancia, Sara Tenconi, Sridhar Rathinam and David A. Waller*

Department of Thoracic Surgery, Glenfield Hospital, University Hospitals of Leicester, Leicester, UK

Chronic hypercapnia should not exclude patients from lung volume reduction surgery[1]

Wilfried Wisser[a,*], Walter Klepetko[a], Ömer Senbaklavaci[a], Theo Wanke[b], Eva Gruber[c], Edda Tschernko[c], Ernst Wolner[a]

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[c]Department of Anesthesiology, University of Vienna, Vienna, Austria

Received 28 September 1997; revised version received 23 March 1998; accepted 12 May 1998

Functional improvements in ventilatory mechanics after lung volume reduction surgery for homogeneous emphysema[1]

Wilfried Wisser[a,*], Edda Tschernko[b], Theo Wanke[d], Ömer Senbaclavaci[a], Manfred Kontrus[c], Ernst Wolner[a], Walter Klepetko[a]

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[c]Department of Cardiothoracic Surgery, University of Vienna, Vienna, Austria
[d]Department of Radiology, University of Vienna, Vienna, Austria
Lainz Hospital, Vienna, Austria

Persistent Benefit From Lung Volume Reduction Surgery in Patients With Homogeneous Emphysema

Walter Weder, MD, Michaela Tutic, MD, Didier Lardinois, MD, Wolfgang Jungraithmayr, MD, Sven Hillinger, MD, Erich W. Russi, MD, and Konrad E. Bloch, MD

Division of Thoracic Surgery and Pulmonary Division, University Hospital, Zurich, Switzerland

Repeated lung volume reduction surgery is successful in selected patients†

Arthur Kostron', Michaela Horn-Tutic', Daniel Franzen, Peter Kestenholz, Didier Schneiter, Isabelle Opitz, Malcolm Kohler and Walter Weder*

Department of Thoracic Surgery and Division of Pulmonology, University Hospital, Zurich, Switzerland

Lung volume reduction surgery in selected patients with emphysema and pulmonary hypertension†

Claudio Caviezel[a,†], Carlson Aruldas[a,†], Daniel Franzen[b], Silvia Ulrich[b], Ilhan Inci[a], Didier Schneiter[a], Walter Weder[a] and Isabelle Opitz[a,*]

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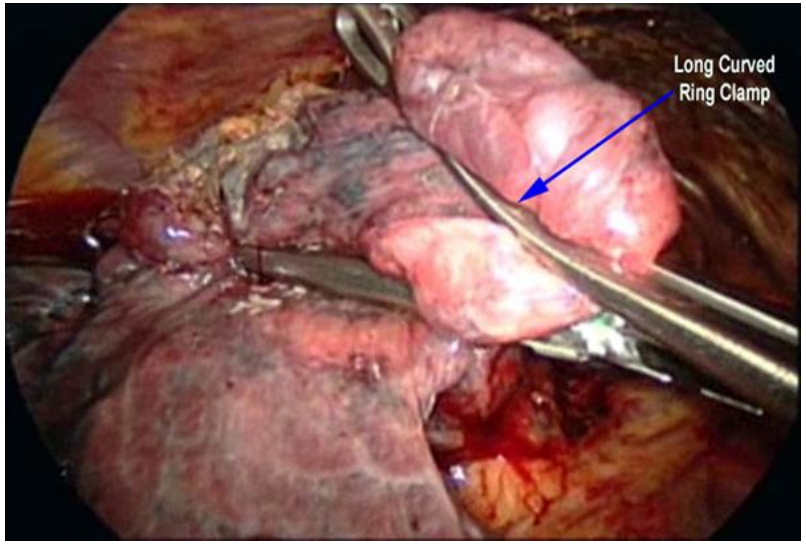
[b] Department of Respiratory Diseases, University Hospital Zurich, Zurich, Switzerland

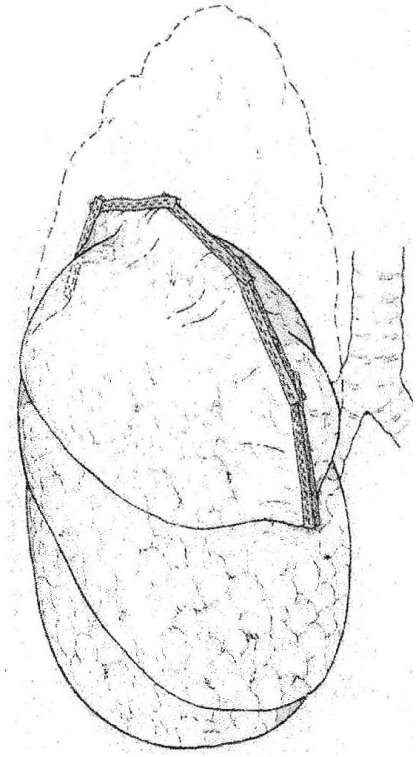
... IN SELECTED PATIENTS

Lung Volume reduction surgery (LVRS)

Fig. 1. Staple line through portion of left upper lobe with use of pericardial strips for buttressing. This technique has eliminated air leakage at staple line.

Cooper et al. JTCVS 1995;123:513-25





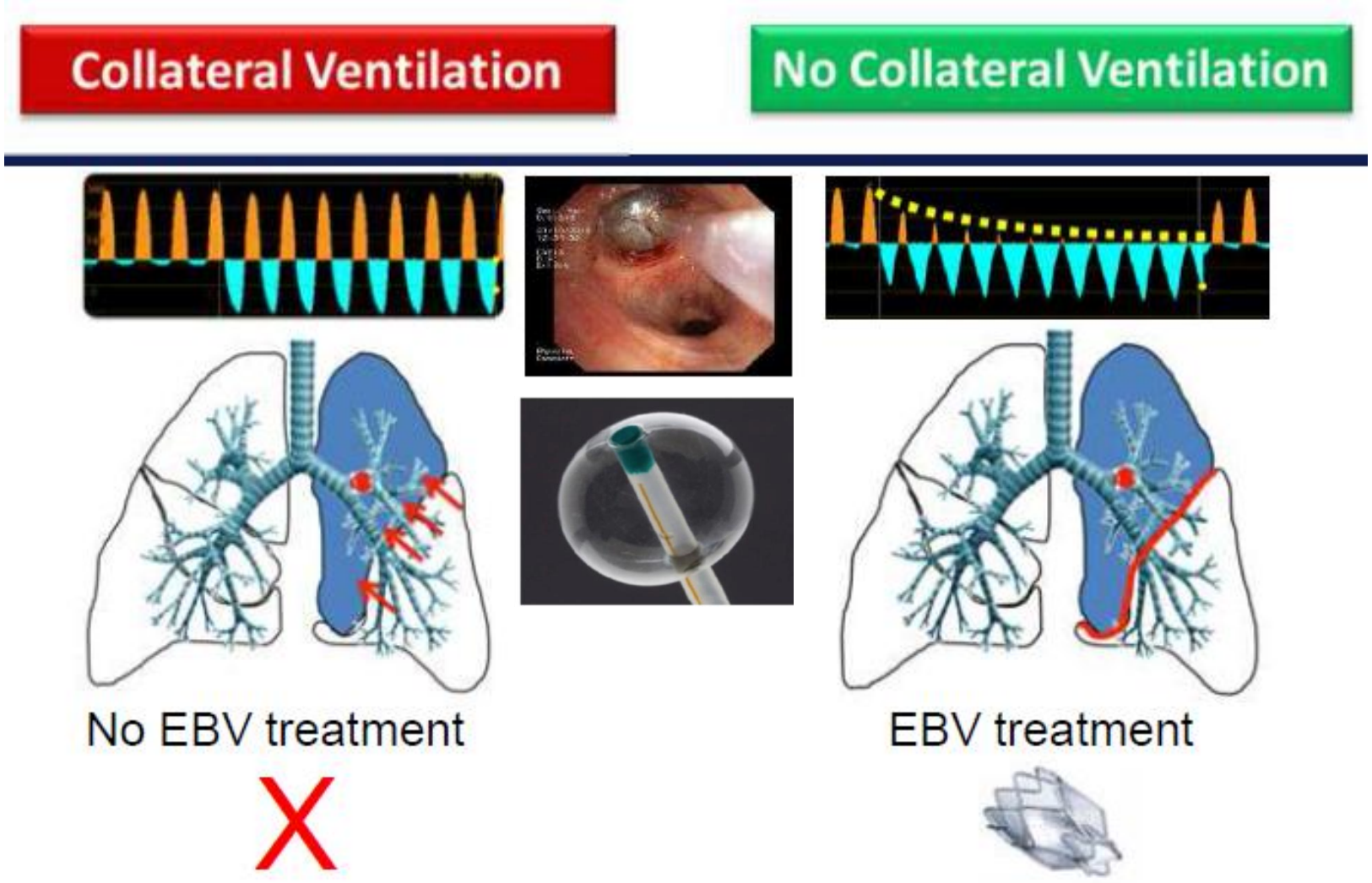
VATS

- Procedure is fully video-assisted
- Non-rib spreading

Valves endobronchiques

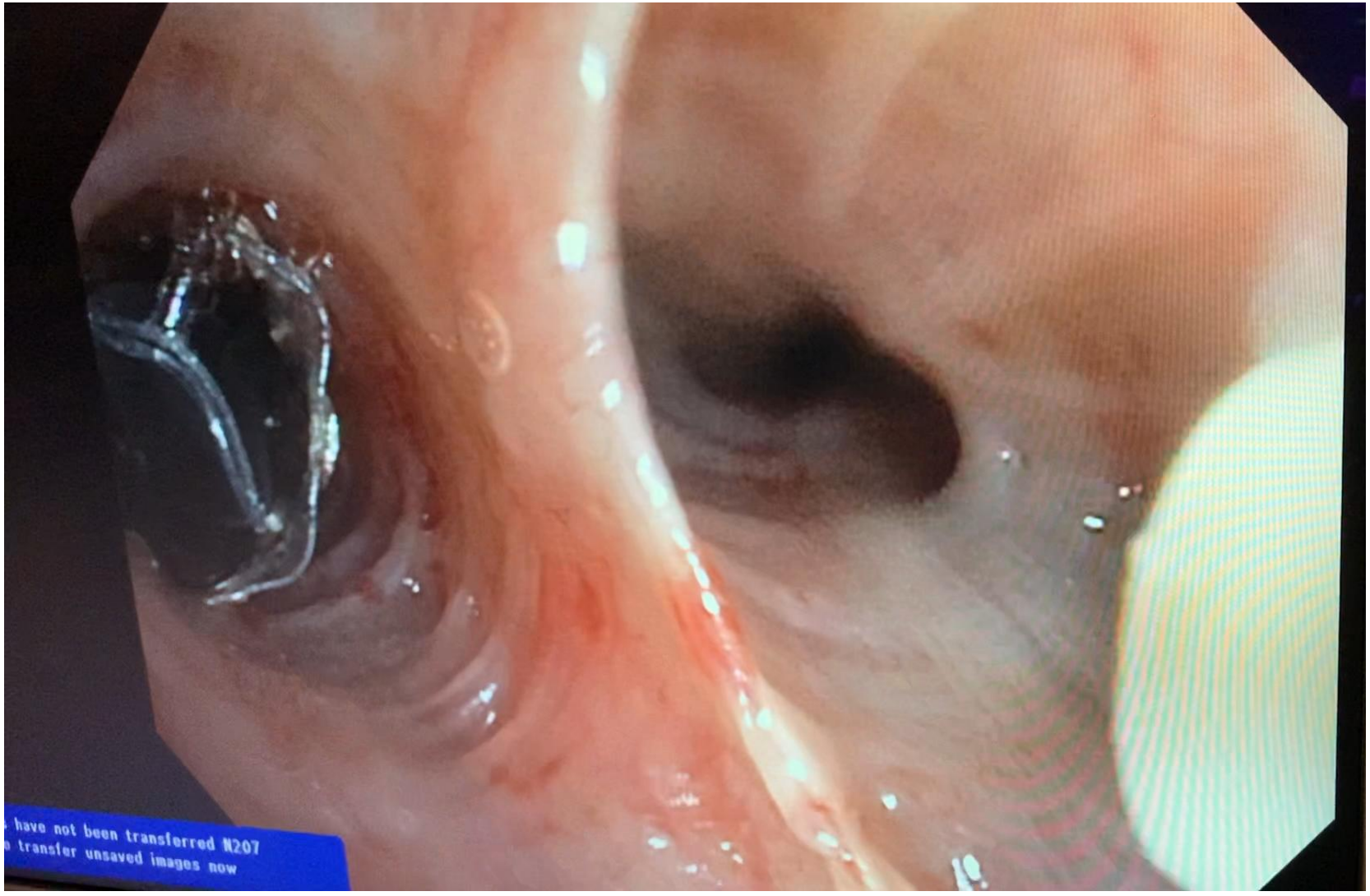
Valves endobronchiques

Ventilation collatérale – Procédure Chartis :



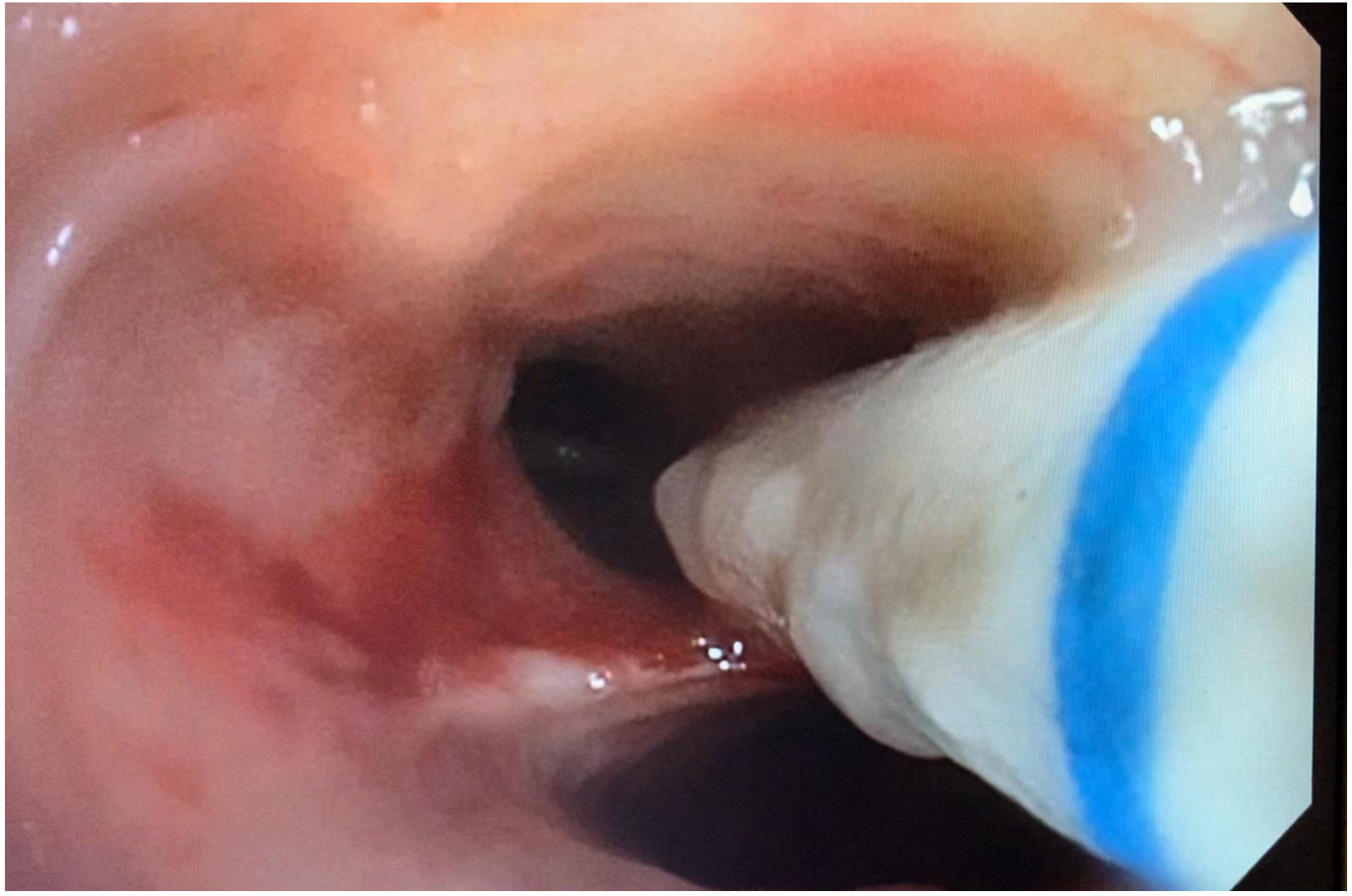
Valves endobronchiques

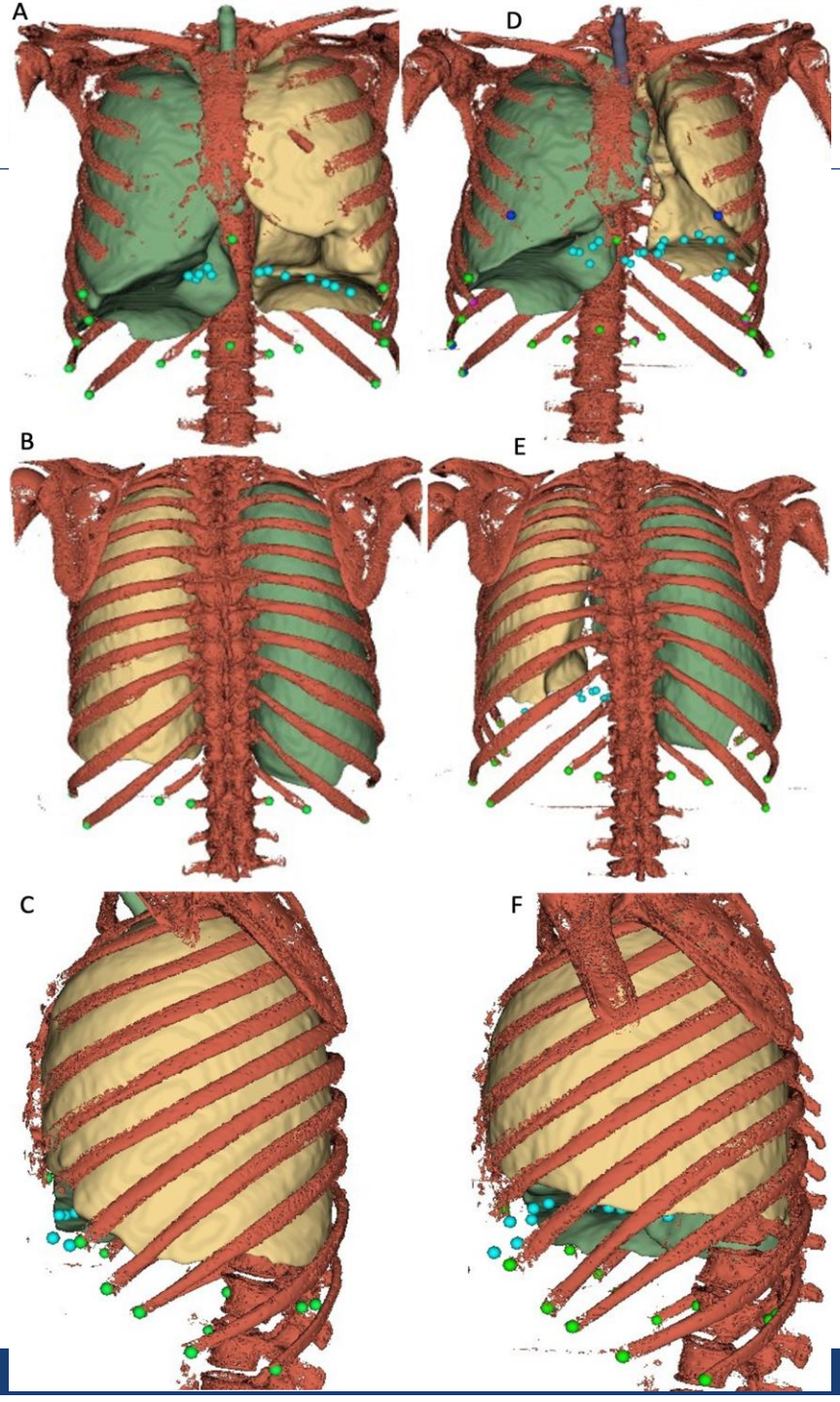
Mise en place :



Valves endobronchiques

Mise en place :





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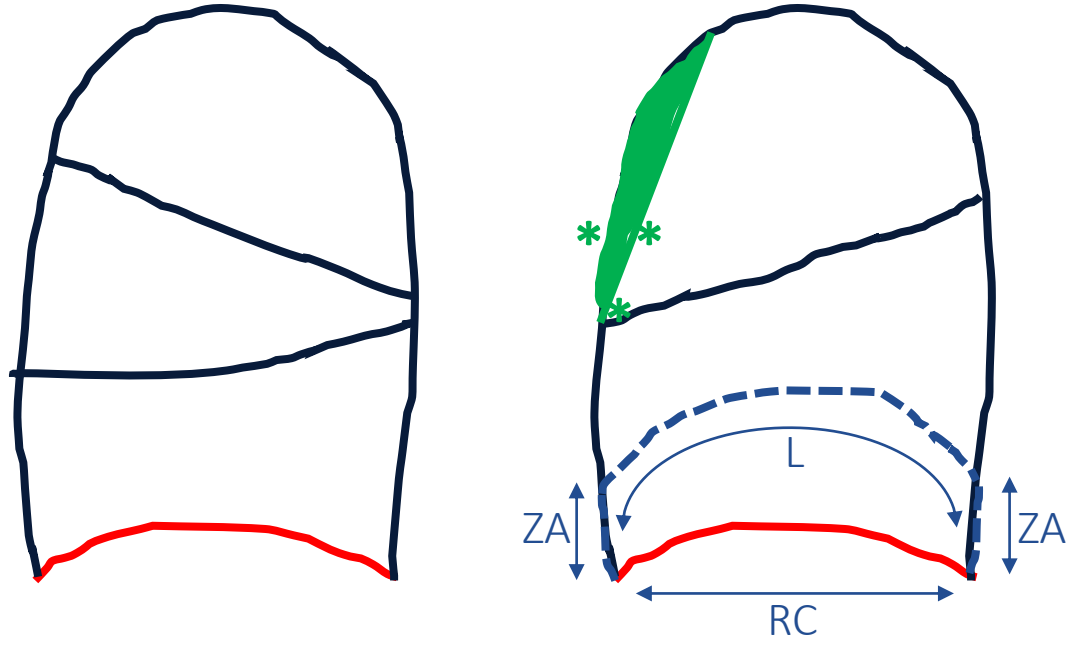
En résumé : effets de la réduction endoscopique de volume pulmonaire sur la forme du diaphragme



- Mise en place de valves dans le lobe cible
- Perte de volume du lobe cible
- Majoration du volume du lobe adjacent

- Amélioration de la forme du diaphragme du côté traité :
  - ↑ de l'aire de la zone d'apposition
  - ↓ du rayon de courbure
  - ↑ de la longueur des fibres musculaires

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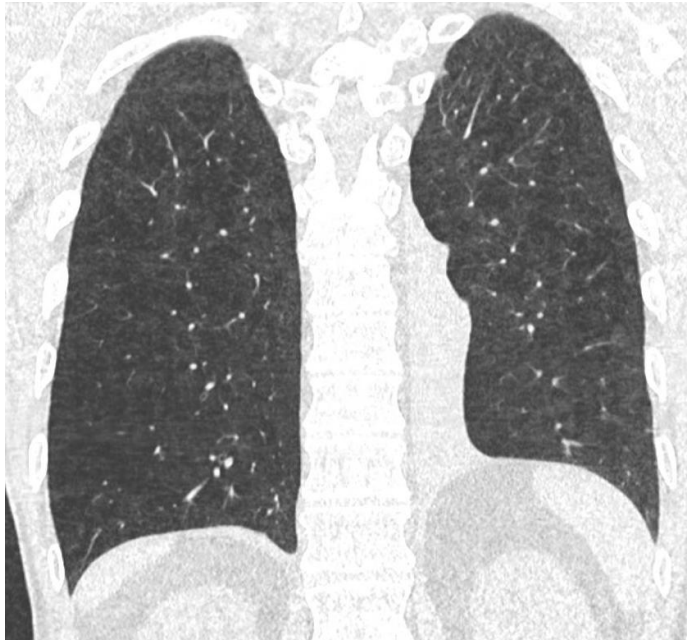
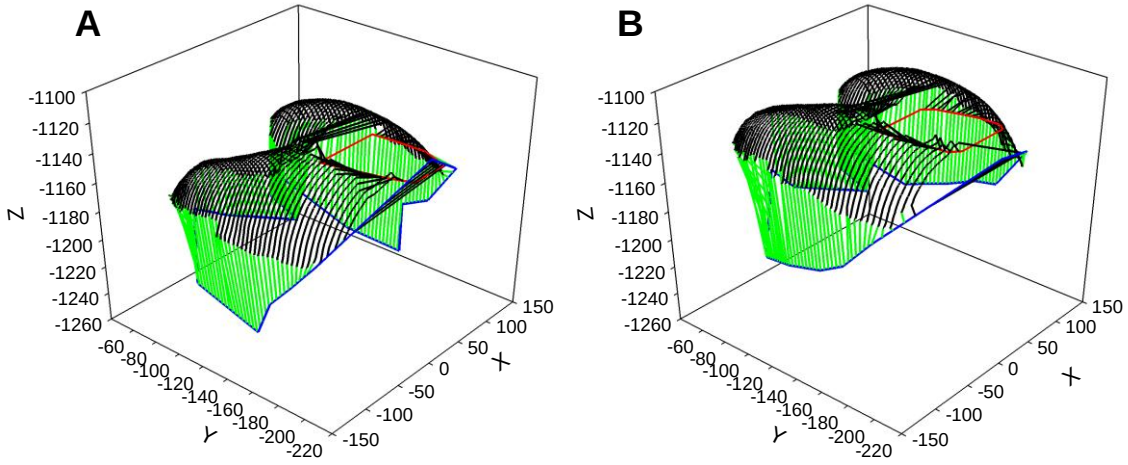
VALVES ENDOBRONCHIQUES





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Variable	Trial			
	STELVIO[1]	IMPACT[7]	TRANSFORM[6]	LIBERATE[5]
Patients, No./No.	EBV34/SoC34	EBV43/SoC50	EBV65/SoC32	EBV128/SoC62
Follow up, mo	6	3	6	12
Target lobar volume reduction, mL	−1366	−1195	−1090	−1142
Between group difference				
FEV_1, %	+18	+17	+29	+18
Residual volume, mL	−831	−480	−700	−522
6-Minute walk distance, m	+74	+40	+79	+39
St. George's Respiratory Questionnaire, points	−14.7	−9.7	−6.5	−7.1

Klooster K, et al. Chest 2021

RIZIV/INAMI REIMBURSEMENT

Since 01/02/2020

AZ Delta, Roeselare
ULB Erasme Bruxelles
UZ Leuven
CHU Liège

UZ Gent
UZ Antwerpen
CHU/UCL Namur
Ghd Charleroi

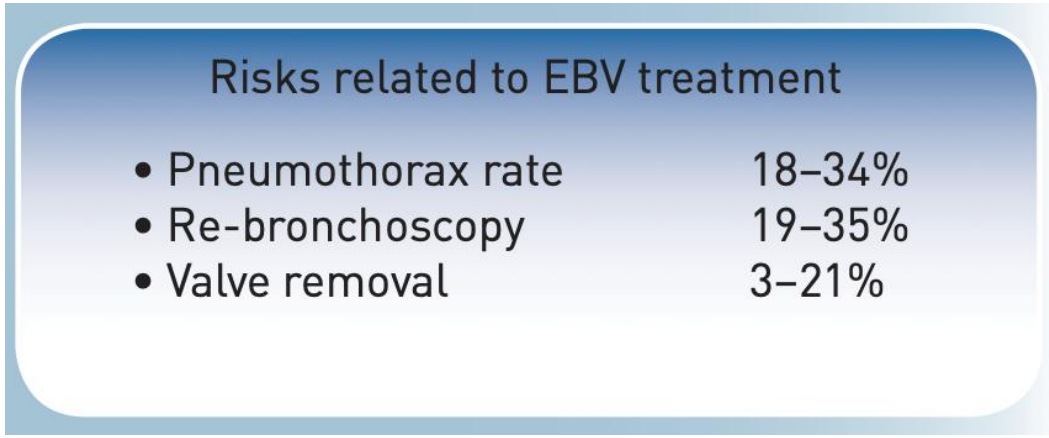
Outcomes

Trial	n treated	Follow-up, months	FEV_1, %	RV, ml	6MWD, m
Belgian Registry, 2020-2023	146	6	+17	-827	+20*
STELVIO, 2015	34	6	+18	-831	+74
IMPACT, 2016	43	3	+17	-480	+40
TRANSFORM, 2017	65	6	+29	-670	+79
LIBERATE, 2018	128	12	+18	-522	+39

*Missing data were entered as « 0 »

Safety

	n (%)
Patients on ICU	15 (10.3%)
ICU stay > 24h	6 (4%)
Pneumothorax	22 (15%)
Chest drainage	17 (77%)
Need for surgical intervention	1 (5%)
Other	4 (18%)
Infection	12 (8.2%)
Exacerbation	11 (7.5%)
Revisions	46 (31%)



Hartman JE, et al. Eur Respir Rev. 2019

→ Safety is good and adverse events are as expected from RCTs

SAFETY OF LUNG VOLUME REDUCTION

Table 1 Baseline characteristics of patients in the UKLVR registry

	All LVR patients n=541	LVRS n=244	EBVs n=219	Missing data
Gender n (%Female)	222 (41.8)	94 (38.5)	91 (41.6)	3 (0.6%)
Age (years)	64.8 (8.54)	63.4 (8.58)	65.9 (8.31)	18 (3.9%)
BMI kgm^{-2}	24.2 (4.4)	24.6 (4.6)	2	
FEV_1%predicted	31.8 (12.1)	32.1 (12.1)	3	
RV% predicted	224.2 (51.3)	220.2 (51.5)	2	
TLco% predicted	36.1 (18.0)	37.0 (16.2)	3	
MRC dyspnoea score	4.0 (0.89)	3.7 (0.85)	3	
Pattern of emphysema				
Heterogeneous	386 (71.0)	190 (77.9)	1	
Homogeneous	155 (28.5)	54 (22.1)	6	
Alpha1-antitrypsin deficiency Yes	69 (13.0)	26 (10.7)	3	

Data are presented as n (%) and mean (SD). Where numbers do not add up to 100% these missing
carried out but due to small numbers and to ensure these individuals remain non-identifiable, have r
BMI, body mass index; EBCs, endobronchial coils; EBVs, endobronchial valves; FEV_1, forced expira
reduction surgery; MRC, Medical Research Council; RV, residual volume; TLco, carbon monoxide tra

Table 3 Complications per treatment

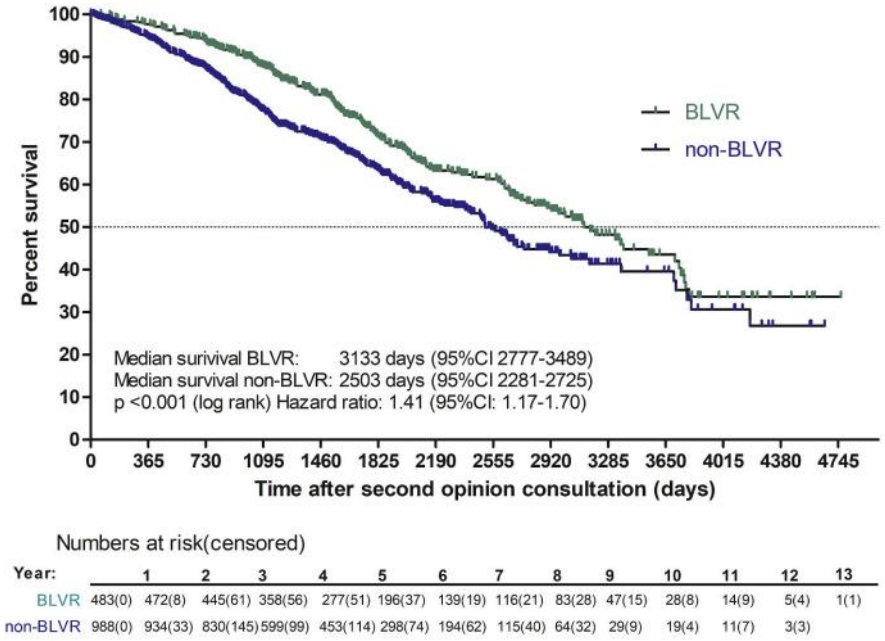
Complication	Whole cohort (n=289)	LVRS (n=118)	EBVs (n=171)	P value
Haemoptysis	12 (2.6)	0 (0)	12 (5.5)	0.002
Pneumonia	33 (7.1)	12 (4.9)	21 (9.6)	0.568
Pneumothorax	31 (6.7)	11 (4.5)	20 (9.1)	0.518
Pneumothorax occurring after hospital discharge	9 (1.9)	3 (0.8)	8 (3.2)	0.534
Valve expiration, aspiration or migration	10 (2.2)	n/a	10 (4.6)	n/a
Bronchospasm	1 (0.2)	0 (0)	1 (0.5)	1.000
Exacerbation of COPD	75 (16.2)	26 (10.7)	49 (22.4)	0.198
Post-operative pain	13 (2.8)	11 (4.5)	2 (0.9)	<0.001
Hospitalisations (up to 12 months postprocedure)	42 people (12.5)/52 admissions	13 people (14.3)/17 admissions	29 people (22.3)/35 admissions	0.120
Hospitalisations requiring NIV (up to 12 months postprocedure)	5 people (1.1) 7 NIV admissions	0 (0)	5 people (2.3)/7 admissions	0.059
Hospitalisations requiring intubation (up to 12 months postprocedure)	6 (1.3)	1 (0.4)	5 (2.3)	0.215
Survival analysis	Whole cohort (n=367)	LVRS (n=201)	EBVs (n=166)	
Death	95 (25.9)	50 (24.9)	45 (27.1)	0.298*
Death within 0–90 days of procedure	14 (3.8)	11 (5.5)	3 (1.8)	0.068

Data are presented as n (%) p values represent $\chi 2$ or Fisher's exact test.
*Log rank test.
COPD, chronic obstructive pulmonary disease; EBVs, endobronchial valves; LVRS, lung volume reduction surgery; NIV, non-invasive ventilation.

Buttery SC, et al. BMJ Open Respir Res 2024

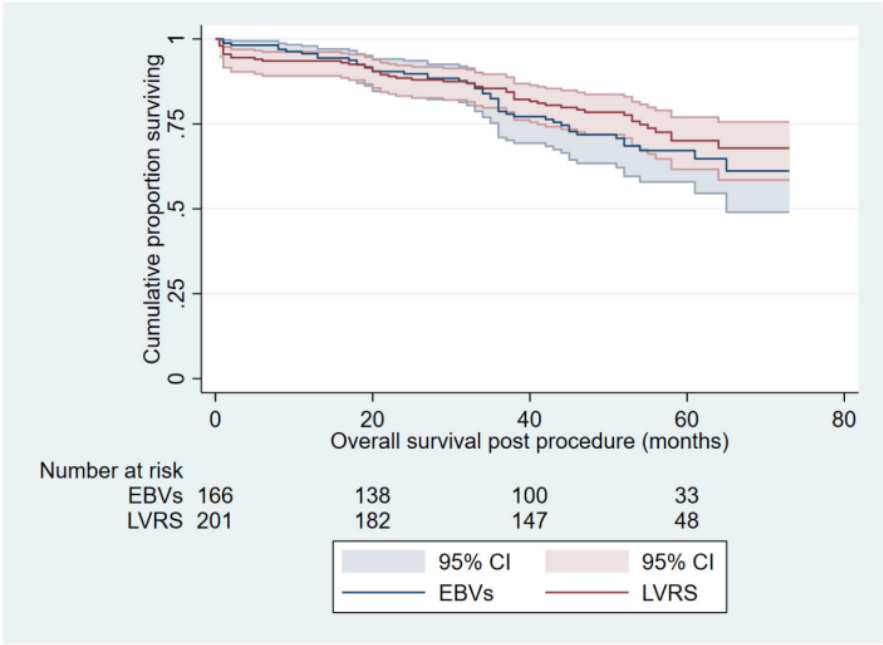
SURVIVAL AFTER LONG VOLUME REDUCTION

Survival improvement



Numbers at risk(censored)

Year:	1	2	3	4	5	6	7	8	9	10	11	12	13
BLVR	483(0)	472(8)	445(61)	358(56)	277(51)	196(37)	139(19)	116(21)	83(28)	47(15)	28(8)	14(9)	5(4)	1(1)
non-BLVR	988(0)	934(33)	830(145)	599(99)	453(114)	298(74)	194(62)	115(40)	64(32)	29(9)	19(4)	11(7)	3(3)	



Hartman JE, et al. Resp Med 2022
Buttery SC, et al. BMJ Open Respir Res 2024

GLOBAL INITIATIVE FOR CHRONIC OBSTRUCTIVE LUNG DISEASE™

Interventional Therapy in Stable COPD

Figure 3.27

Bronchoscopic Interventions

- In select patients with advanced emphysema, bronchoscopic interventions reduce end-expiratory lung volume and improve exercise tolerance, health status and lung function at 6-12 months following treatment. Endobronchial valves **(Evidence A)**; Lung coils **(Evidence B)**; Vapor ablation **(Evidence B)**

ALTERNATIVE FOR OR BRIDGING TO LTX?

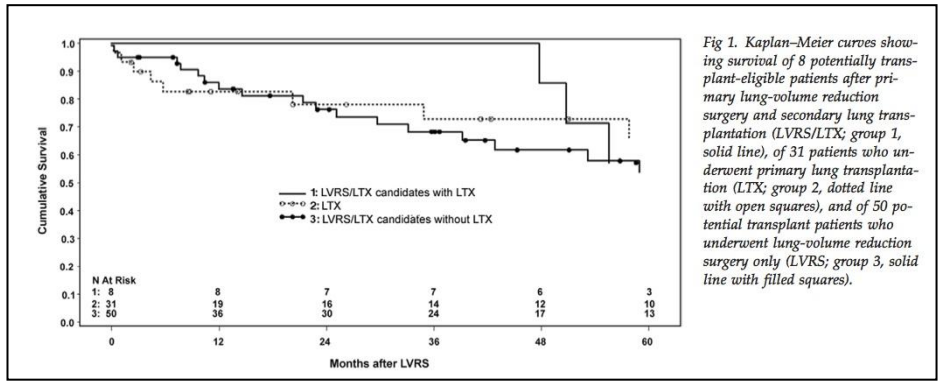


Fig 1. Kaplan–Meier curves showing survival of 8 potentially transplant-eligible patients after primary lung-volume reduction surgery and secondary lung transplantation (LVRS/LTX; group 1, solid line), of 31 patients who underwent primary lung transplantation (LTX; group 2, dotted line with open squares), and of 50 potential transplant patients who underwent lung-volume reduction surgery only (LVRS; group 3, solid line with filled squares).

Tutic 2006 Ann Thorac Surg; 82: 208-13

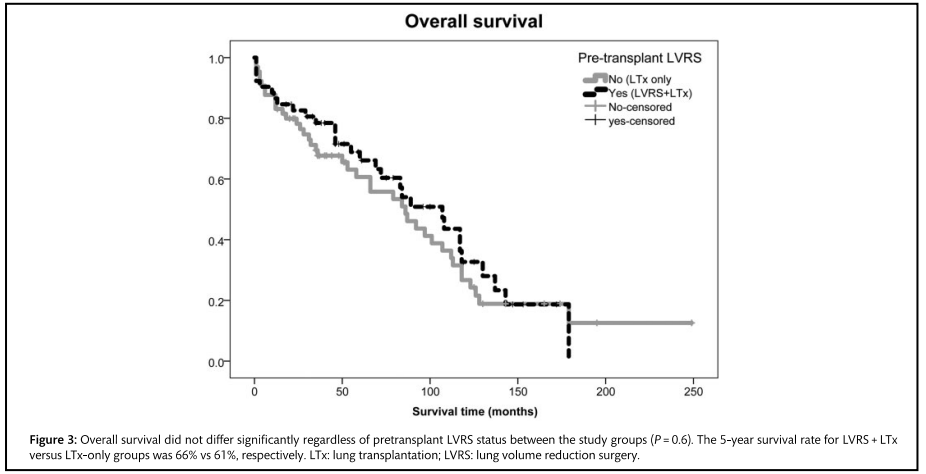
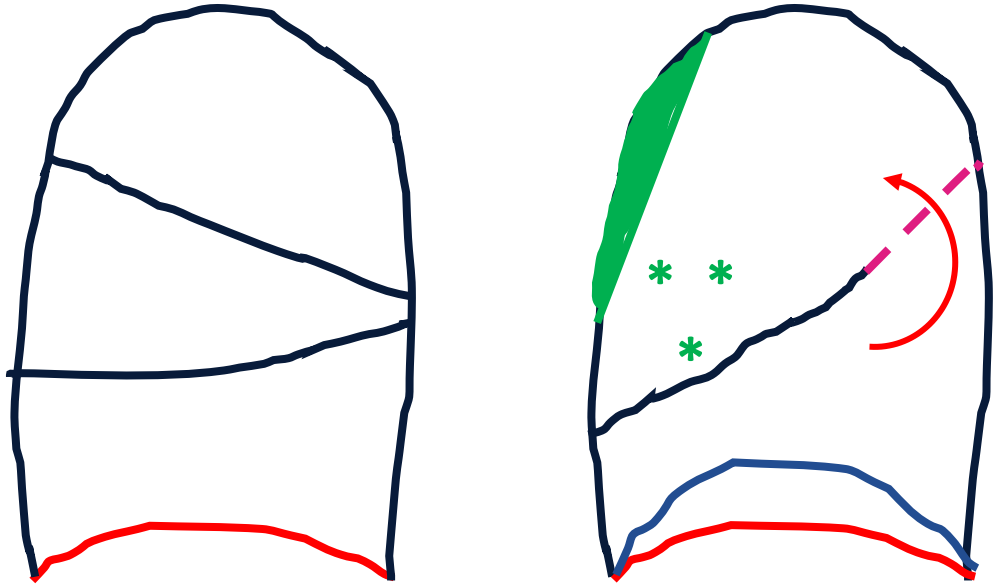


Figure 3: Overall survival did not differ significantly regardless of pretransplant LVRS status between the study groups ($P = 0.6$). The 5-year survival rate for LVRS + LTx versus LTx-only groups was 66% vs 61%, respectively. LTx: lung transplantation; LVRS: lung volume reduction surgery.

Inci et al. Eur J Cardiothorac Surg 2018;53:569-602

- LVRS
  - Postpone LTX 4 to 5 years, without impairing chances of future LTx
  - No negative influence on short-term and long-term outcome of LTx
  - Should not preclude the candidacy for LTx
- BLVR
  - No negative influence on short-term and long-term outcome of LTx
  - Should not preclude the candidacy for LTx

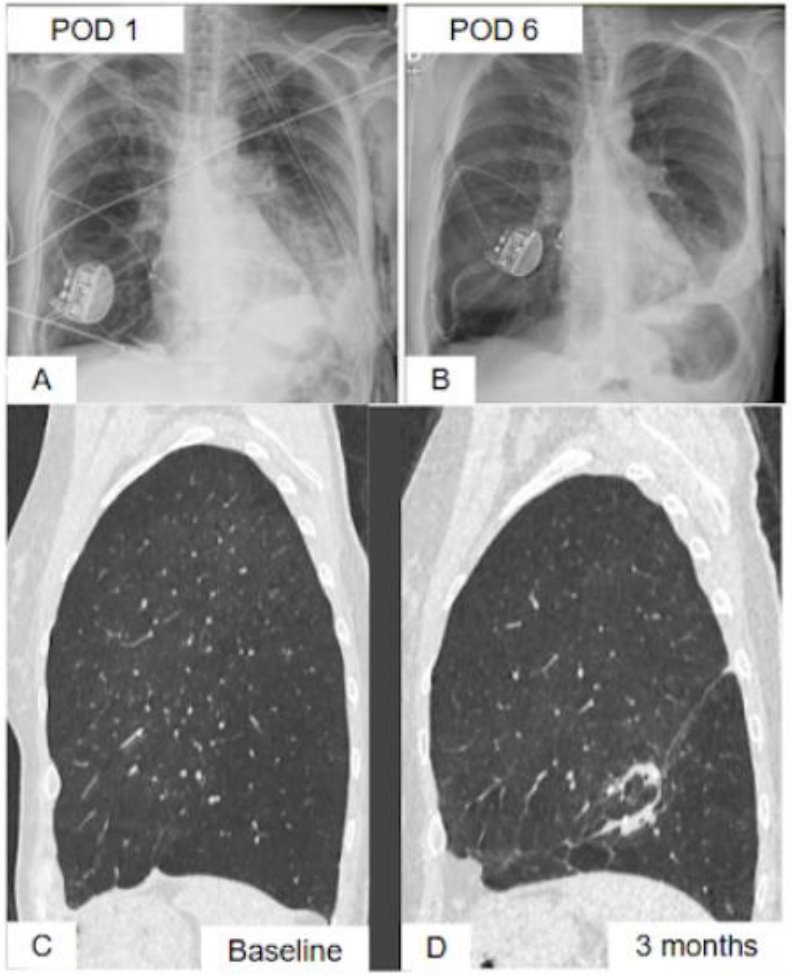
Fermeture chirurgicale de scissure + mise en place de valves



Procédure combinée :

- Bon candidat pour valves mais scissures incomplètes
- fermeture chirurgicale de la scissure
- + Mise en place de valves

Fermeture chirurgicale de scissure + mise en place de valves



Variable	Baseline	3 months	6 months
FEV1 (% predicted)	25	28	28
RV (% predicted)	316	160	180
TLC (% predicted)	143	102	110
DLCO (% predicted)	31	53	50
6MWD (meters)	385	430	415
SGRQ	68/100	50/100	n/a
Oxygen therapy (L/day)	0	0	0

Inspiratory Volume (ml) 915 1184 269 1445 1473 1472

Di Campli MP, accepted Int Med case Rep J

Conclusions : réduction de volume pulmonaire

Réduction du volume pulmonaire

Amélioration de la fonction du diaphragme

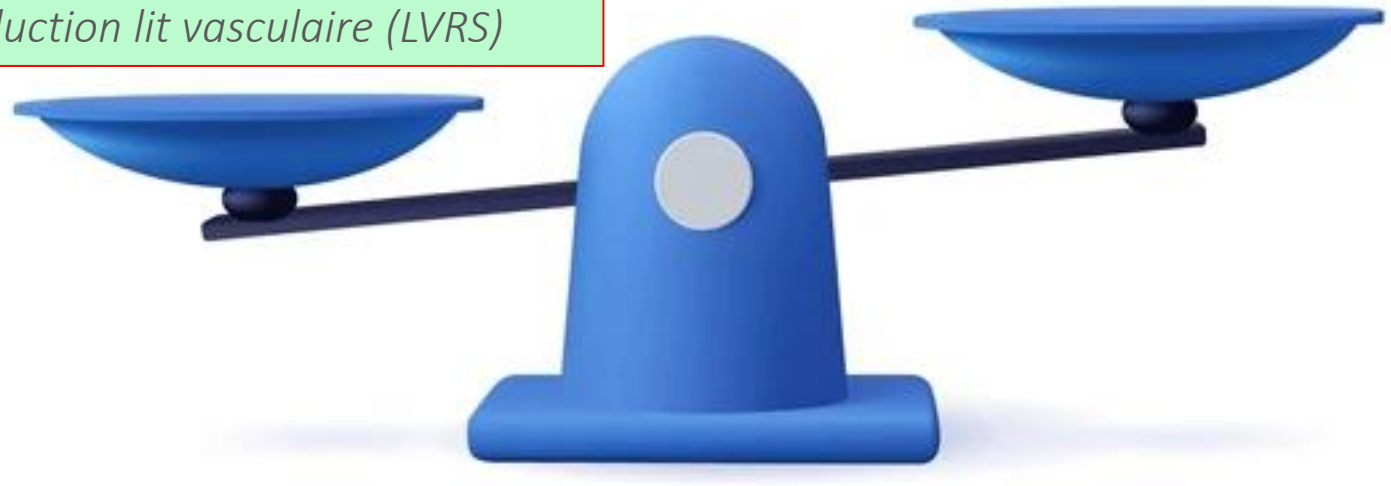
Réduction de l'hyperinflation

Augmente le recul élastique du poumon

…

Perte de parenchyme pulmonaire

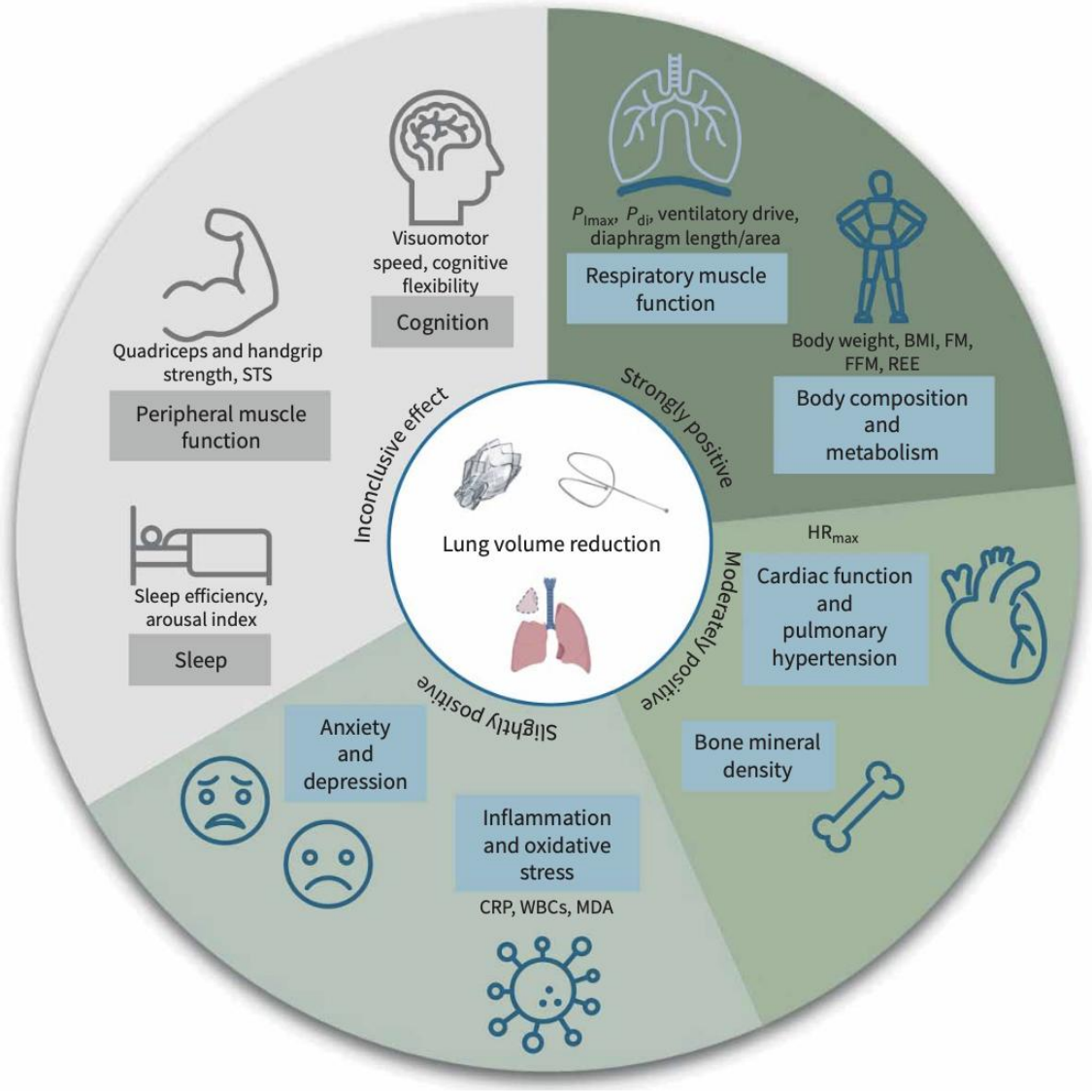
Réduction lit vasculaire (LVRS)



Transplantation pulmonaire

Décision individuelle => Discussion en réunion multidisciplinaire

CONCLUSIONS



Référer les patients !!!

ter Haar. ERJ 2025

Merci pour votre attention