La ventilation unipulmonaire

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EIUA

Le 21 janvier 2023

Cliniques universitaires SAINT-LUC UCL BRUXELLES

UNIVERSITAS CATHOLICA LOVANIENSIS SEDES SAPIENTIAE 1425

INDICATIONS

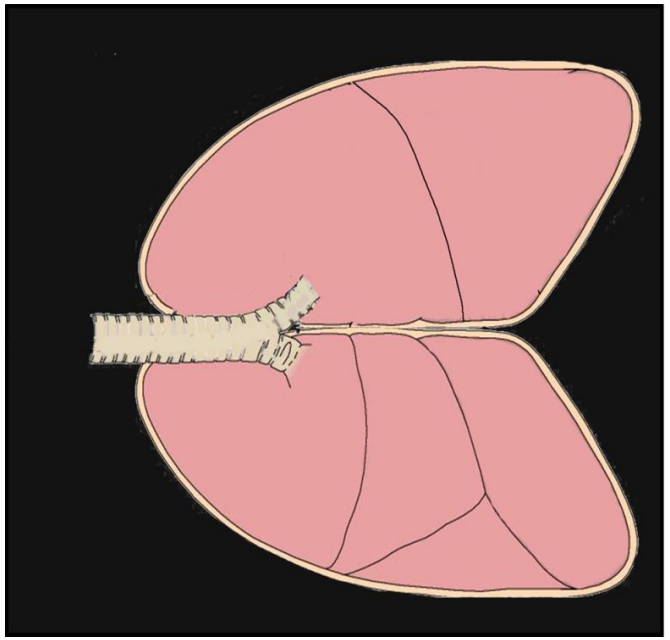
- Exposition chirurgicale
  - Lobectomie, segmentectomie
  - VATS
  - Thoracoscopie
  - Biopsie pulmonaire
  - Chirurgie médiastinale
  - Chirurgie œsophagienne
  - Chirurgie aorte thoracique
  - Chirurgie cardiaque par voie robotique

- Protection pulmonaire
  - Pathologies néoplasique
  - Pathologies infectieuses (abcès, pneumopathie)
  - Hémoptysie massive

- Lavage pulmonaire unilatéral: Protéinose alvéolaire
- Oxygénation: Fistule broncho pleurale, trauma pénétrant pulmonaire, contusion pulmonaire etc

Physiologie de la ventilation unipulmonaire

Poumon non dépendant



Perfusion 40%

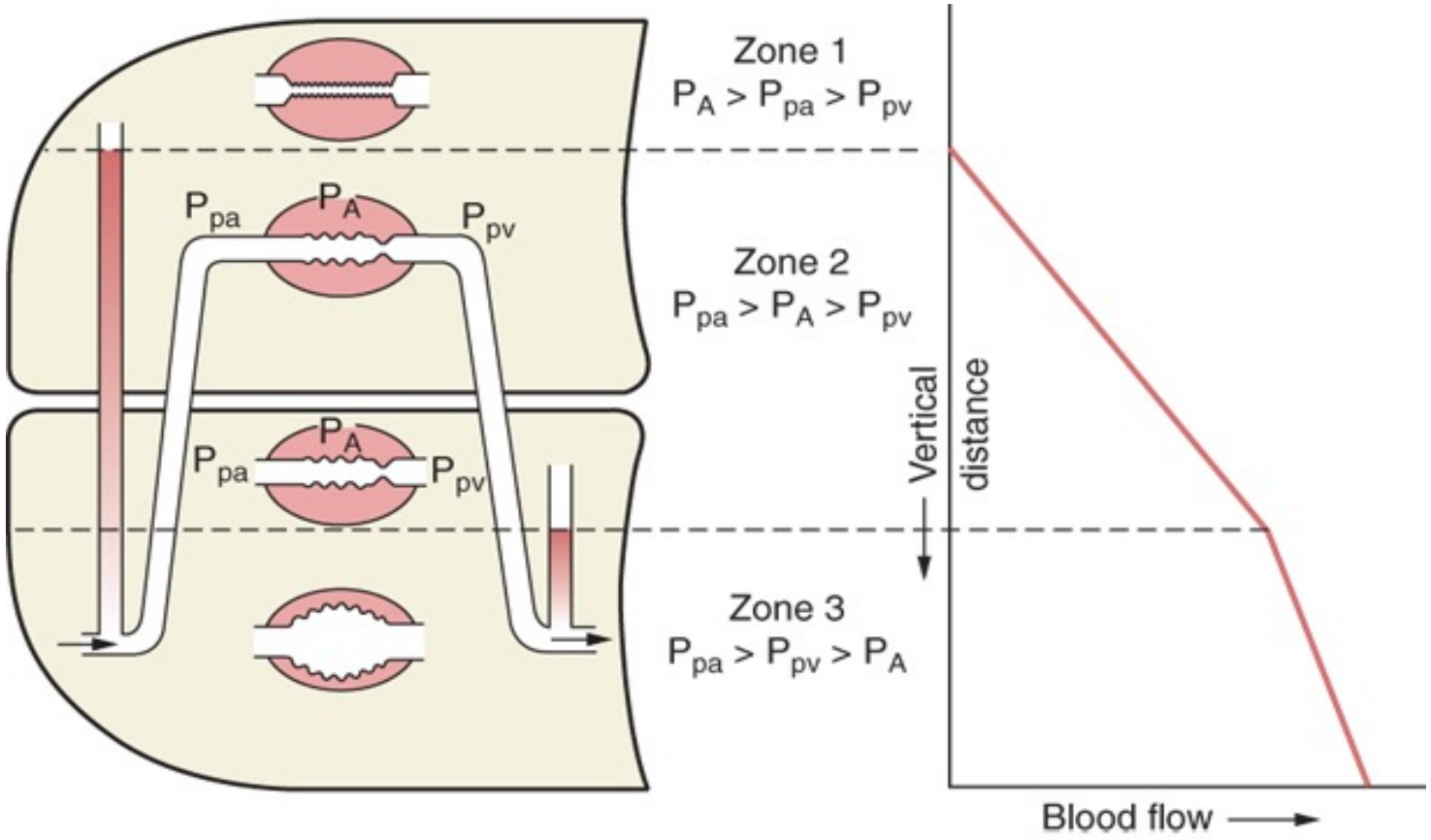
Poumon dépendant

Perfusion 60%

Campos JH, Feider A: JCVA 2018 Oct;32(5):2330-2338

Physiologie de la ventilation unipulmonaire

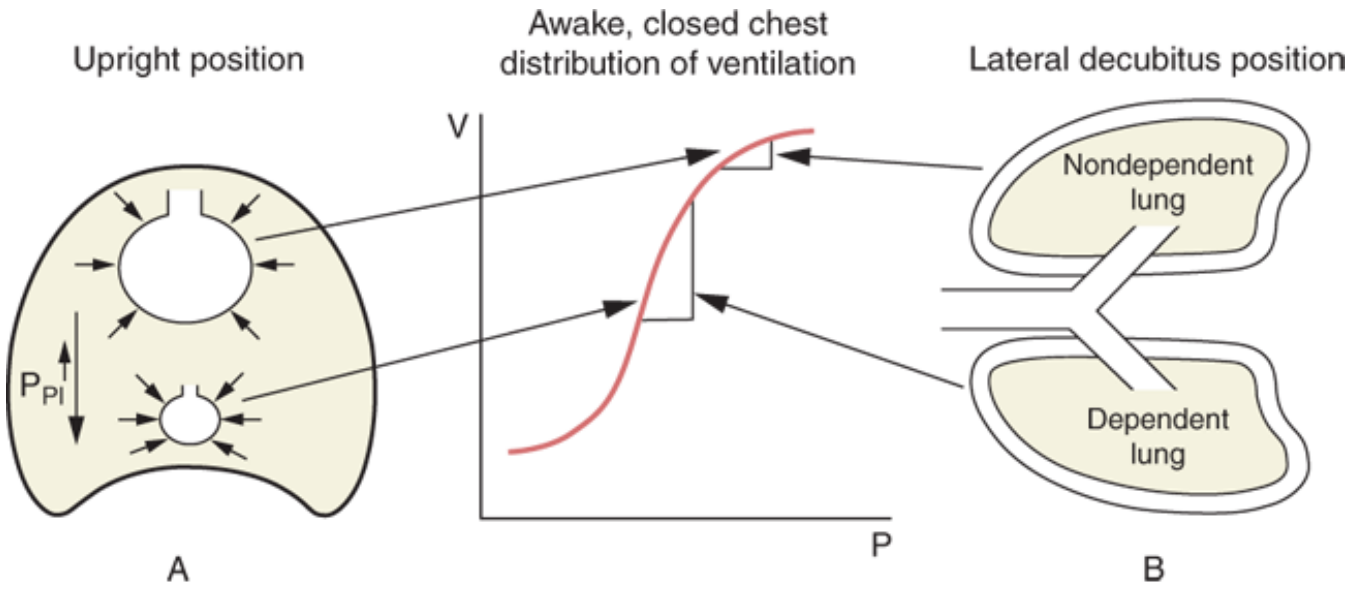
Effets de la gravité sur la perfusion pulmonaire en DL



Anesthesiology, 3e edition, 2018 McGraw Hill: David E. Longnecker et al

Physiologie de la ventilation unipulmonaire DL, VS, thorax fermé

- Le poumon dépendant: meilleure compliance
- Hémidiaphragme dépendant: meilleure contraction

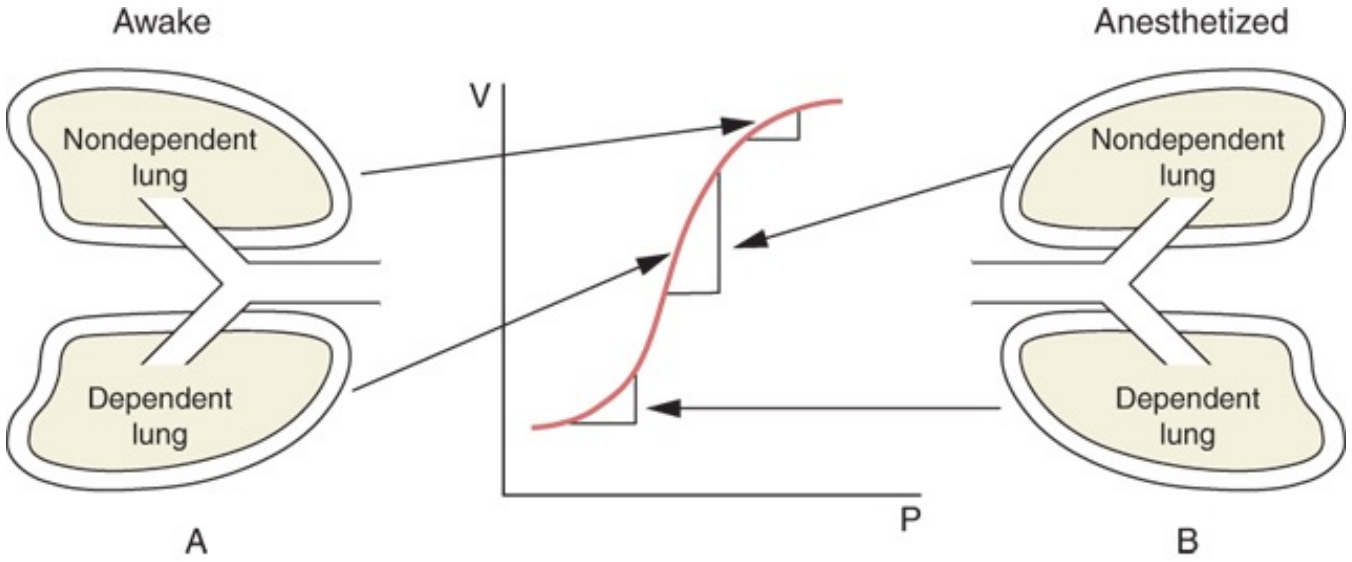


Source: D.E. Longnecker, S.C. Mackey, M.F. Newman, W.S. Sandberg, W.M. Zapol: Anesthesiology, Third Edition

Anesthesiology, 3e edition, 2018 McGraw Hill: David E. Longnecker et al

Physiologie de la ventilation unipulmonaire DL, AG, VM, curarisation, thorax fermé

- Diminution de la CRF
- Meilleure Perfusion poumon dépendant
- Meilleure Compliance poumon non dépendant



Anesthesiology, 3e edition, 2018 McGraw Hill: David E. Longnecker et al

Physiologie de la ventilation unipulmonaire DL, AG, VM, curarisation, thorax ouvert

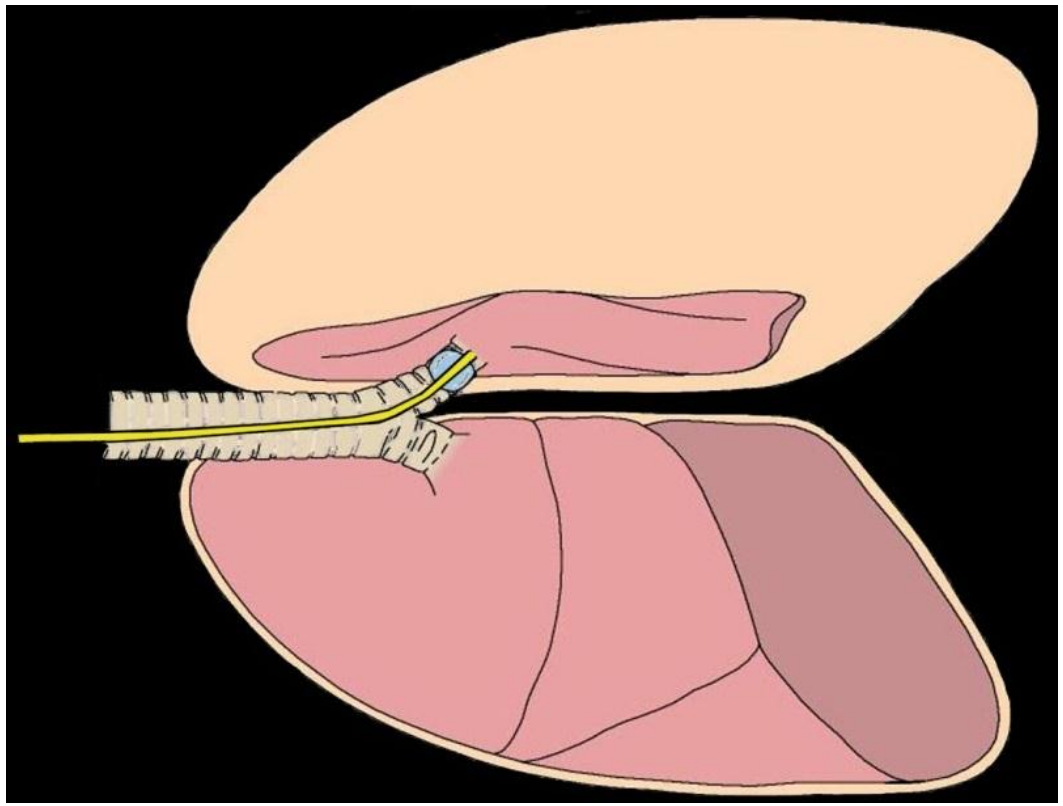
- Meilleure compliance poumon dépendant
- Amélioration perfusion poumon non dépendant (diminution des pression, meilleur DC)

  => diminution de l'effet shunt

Physiologie de la ventilation unipulmonaire Vasoconstriction pulmonaire hypoxémique

- Seul le poumon dépendant participe à la ventilation
- Changement distribution V/P
- Majoration shunts droite-gche

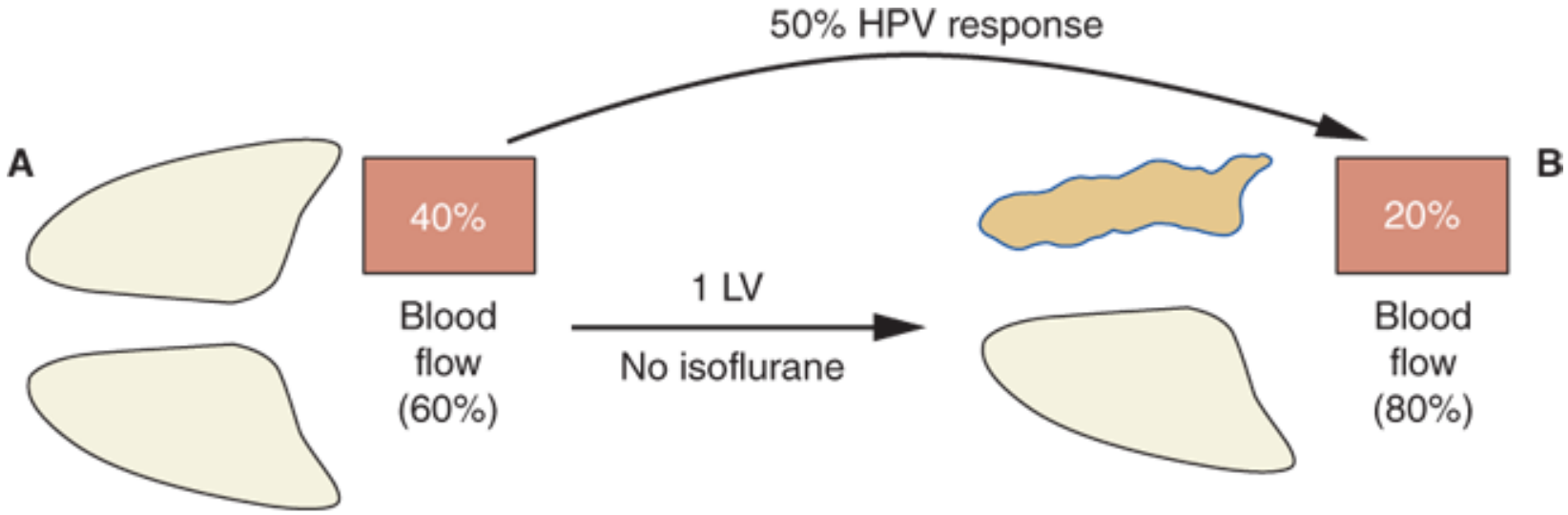
=>Hypoxémie



Campos JH, Feider A: JCVA 2018 Oct;32(5):2330-2338

Vasoconstriction pulmonaire hypoxémique

- Hypoxémie
  - => activation VPH
  - => augmentation RVP
  - => diminution du shunt
  - $\Rightarrow$ meilleure paO2



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Anesthesiology, 3e edition, 2018 McGraw Hill: David E. Longnecker et al

Vasoconstriction pulmonaire hypoxémique

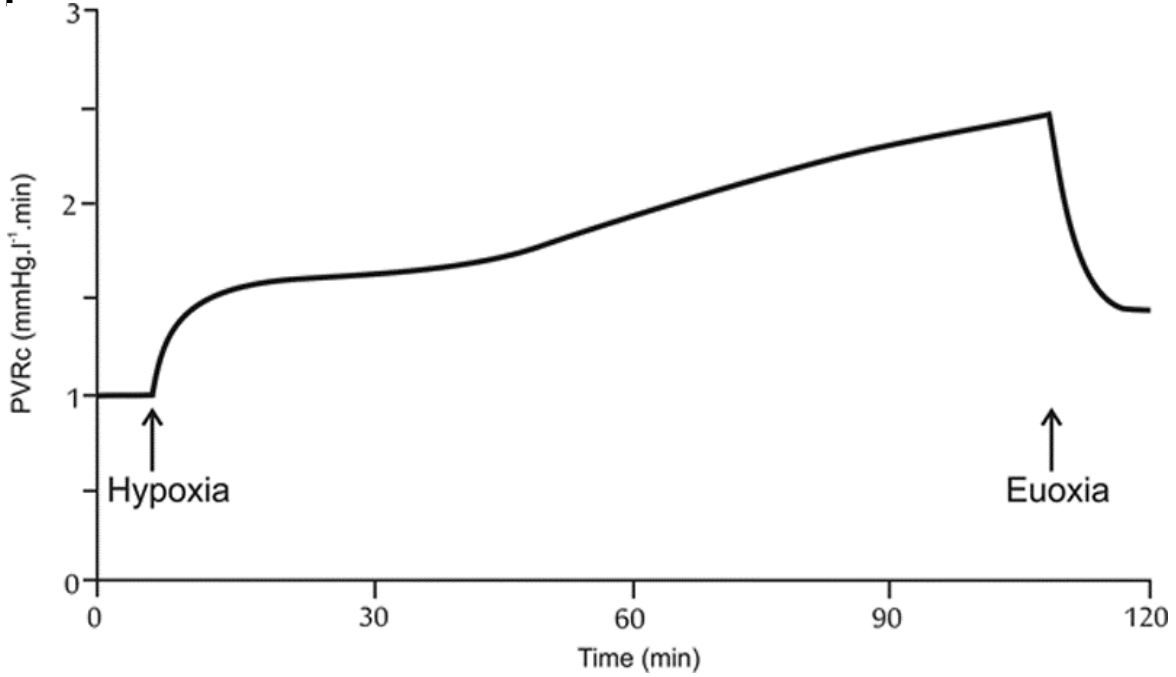
- Phénomène réflexe adaptatif autorégulé en réponse à une hypoxémie
- Vasoconstriction cellules musculaires lisses circulation pulmonaire
- Diminutions perfusion 40-50% du poumon non dépendant

=> Diminution du shunt

=> Amélioration paO2

Vasoconstriction pulmonaire hypoxémique

- Réflexe biphasique: une phase d'installation rapide (20-30 min) suivie d'une phase plus lente avec un effet maximum à 100 min

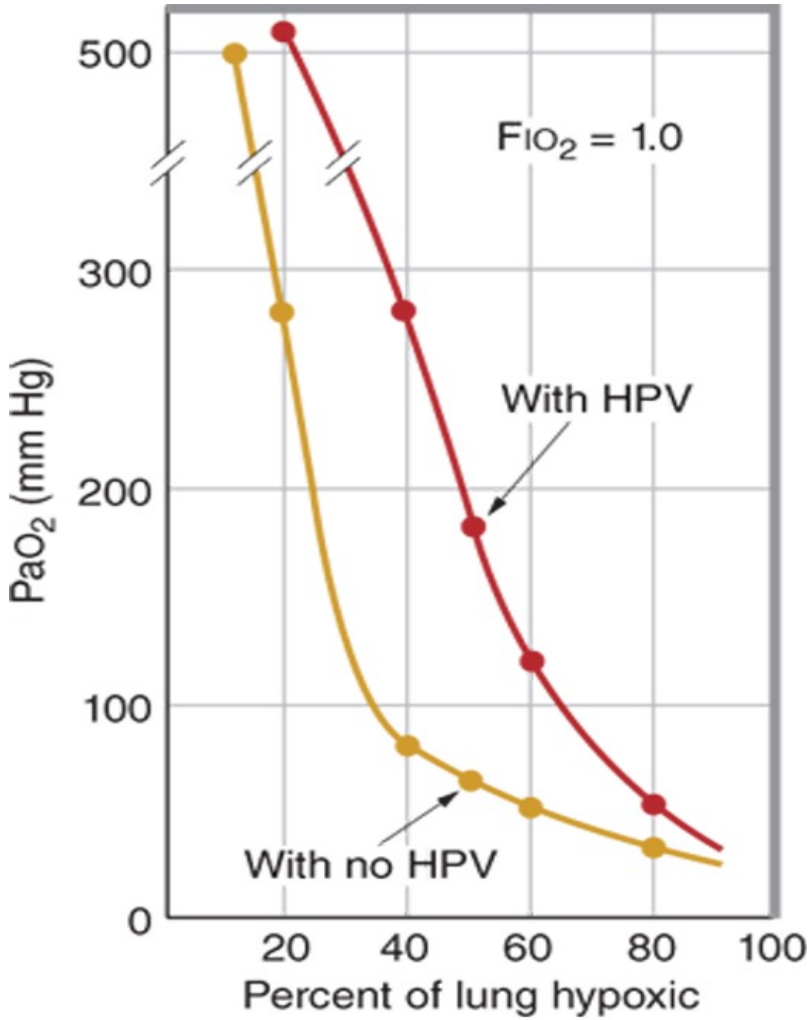


The biphasic nature of hypoxic pulmonary vasoconstriction in hypoxic healthy subjects (end-tidal Po_2 of 50 mmHg). Phase 1 of the response is complete within minutes, with a second phase occurring approximately 40 min later. Po_2 = partial pressure of oxygen. PVRc = pulmonary vascular resistance corrected for cardiac output. (Based on data from reference 7.)

Andrew B. Lumb, Peter Slinger. *Anesthesiology* 2015; 122:932–946

Vasoconstriction pulmonaire hypoxémique

- L'effet de la VPH sur la paO2



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Anesthesiology, 3e edition, 2018 McGraw Hill: David E. Longnecker et al

Vasoconstriction pulmonaire hypoxémique: facteurs inhibiteurs directs

- HYPOCAPNIE et Alcalose
- pvO2 élevée
- Vasodilatateurs: nitroprussiat de sodium, nitroglycérine, inhibiteurs calciques, adénosine, NO, prostaglandines
- Hémodynamique: HTAP, DC élevé
- Halogénés > 1 MAC
- Hypothermie
- Manipulation chirurgicale (libérations PG)

Anesthesiology, 3e edition, 2018 McGraw Hill: David E. Longnecker et al

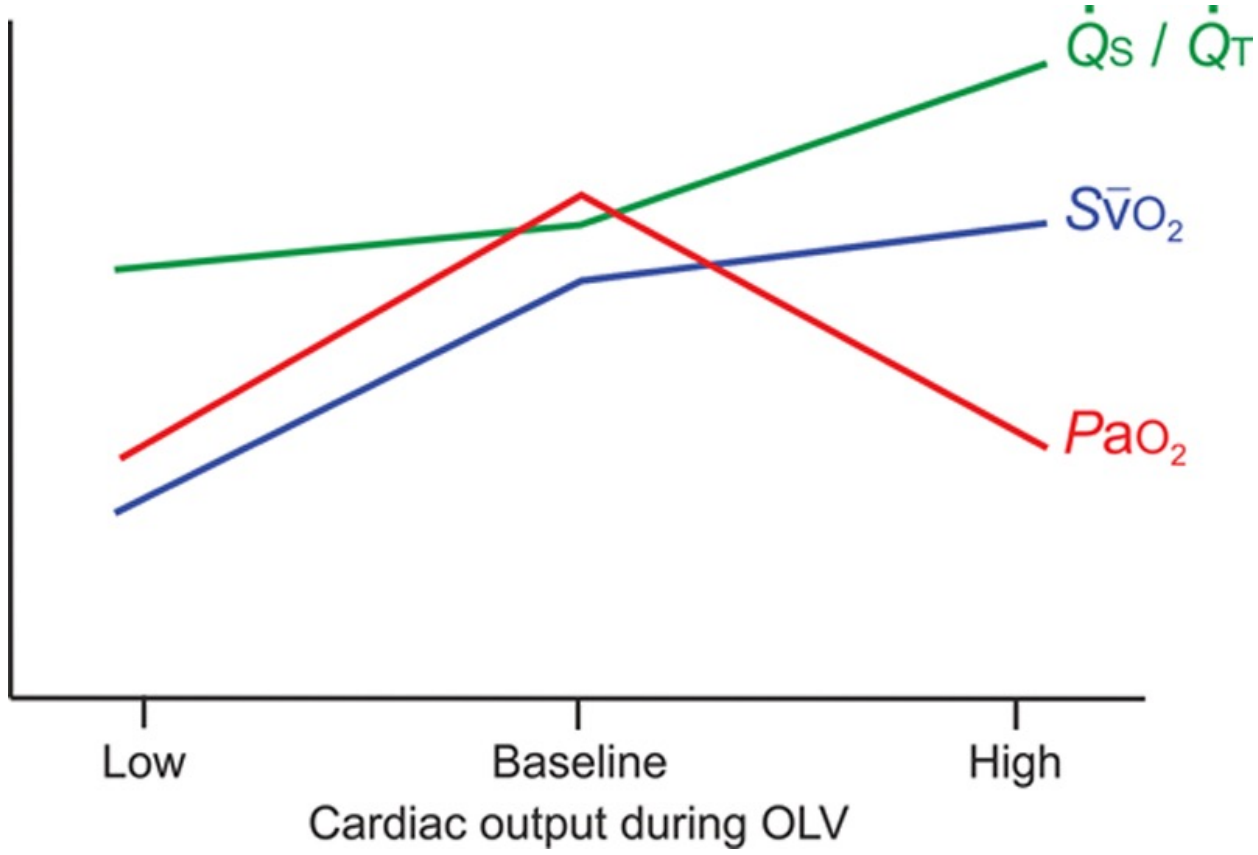
Vasoconstriction pulmonaire hypoxémique: facteurs inhibiteurs indirects

Diminution du débit sanguin vers le poumon dépendant

- Ventilation à pression élevées
- PEEP excessive sur le poumon dépendant
- FiO2 basse
- vasopresseurs

Anesthesiology, 3e edition, 2018 McGraw Hill: David E. Longnecker et al

Vasoconstriction pulmonaire hypoxémique
Influence du débit cardiaque



Andrew B. Lumb, Peter Slinger. *Anesthesiology* 2015; 122:932–946

Vasoconstriction pulmonaire hypoxémique: Agents Halogénes

Inhibition dose dépendante et agent dépendante:

(études animales)

Halotane > isoflurane >>> sévoflurane

Halotane: inhibiteur puissant

0.5 MAC Halotane = ↓50% VPH chez le rat

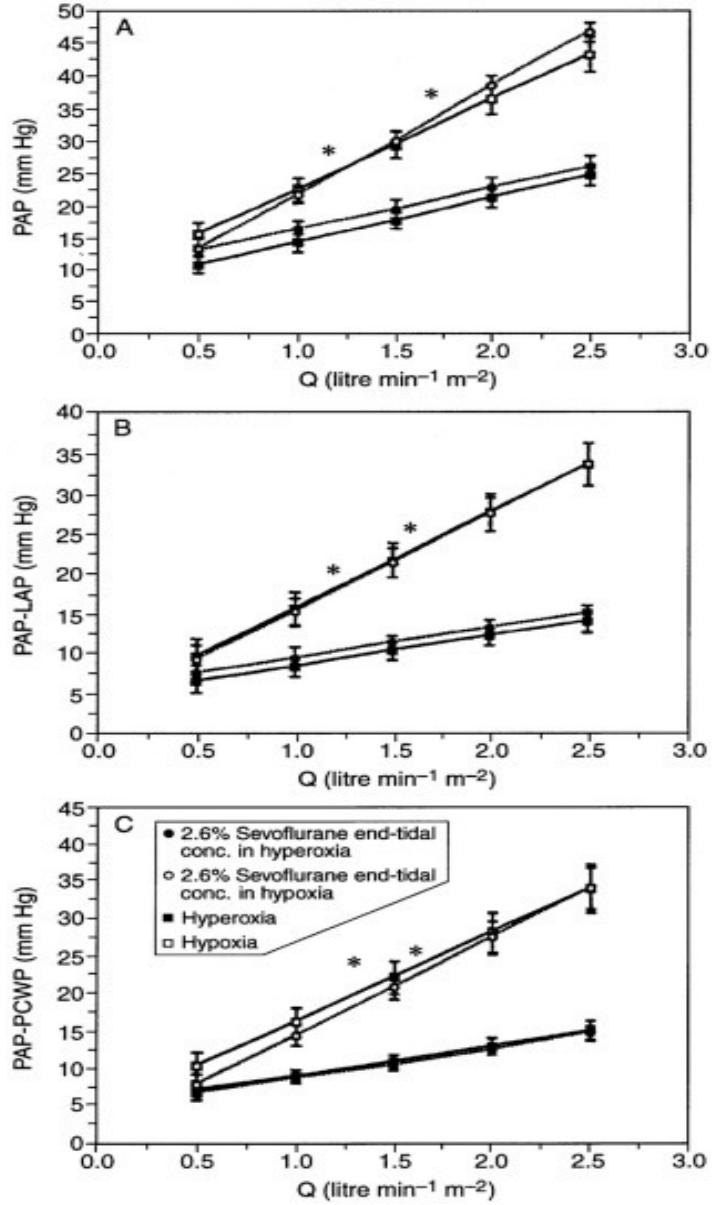
1.3 MAC Isoflurane ? 1 MAC Halotane sur la VPH

Marshall C et al. Anesthesiology 1984; 60:304–8

Vasoconstriction pulmonaire hypoxémique: Agents Halogénes: sévoflurane

Sevoflurane at a clinically relevant concentration (1 MAC)

no significant effect on HPV in anaesthetized piglets.

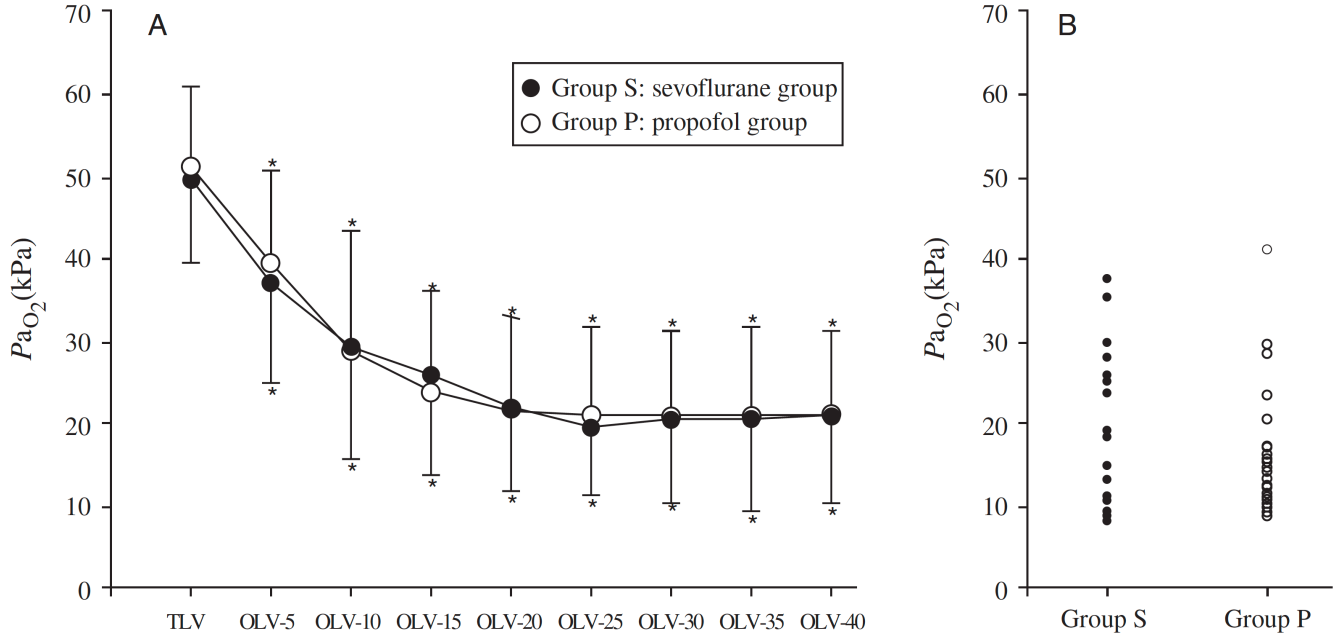


Kerbaul F et al. Br J Anaest 2000; Vol 85 Pages 440-5

Vasoconstriction pulmonaire hypoxémique: propofol vs sévoflurane

Effects of propofol vs sevoflurane on arterial oxygenation during one-lung ventilation:

Sevoflurane and propofol **similar effect** on PaO2 during OLV



Pruszkowski O et al Br J Anaesth 2007; 98: 539–44

Hypoxémie et OLV

- Incidence 4 – 10 %
- littérature hétérogène sur les facteurs prédictifs

Guenoun T et al. J Cardiothorac Vasc Anesth 2002; 16:199–203

Hypoxémie et OLV

- Facteurs prédictictifs:
  - paO2 pendant TLV ou VS (*Slinger P et al. Can J Anaesth 1992;39:1030-5*)
  - EFR préop nles vs BPCO : effet paradoxal (*Bardoczky GI et al. Chest 110:180-84,1996*)
  - Latéralité: chir. pulmonaire droite (*Katz et al. J Cardiothor Vasc Anesth 1996; 10:207-9*)
  - % perfusion poumon opéré (*Schwarzkopf et al. Anesth Analg 2001;92:842-75*)
  - Ht > 45% (*Guenoun T et al J Cardiothorac Vasc Anesth. 2002;16(2):199–203)*

Hypoxémie et OLV

Intraoperative Anesthetic Management of the Thoracic Patient

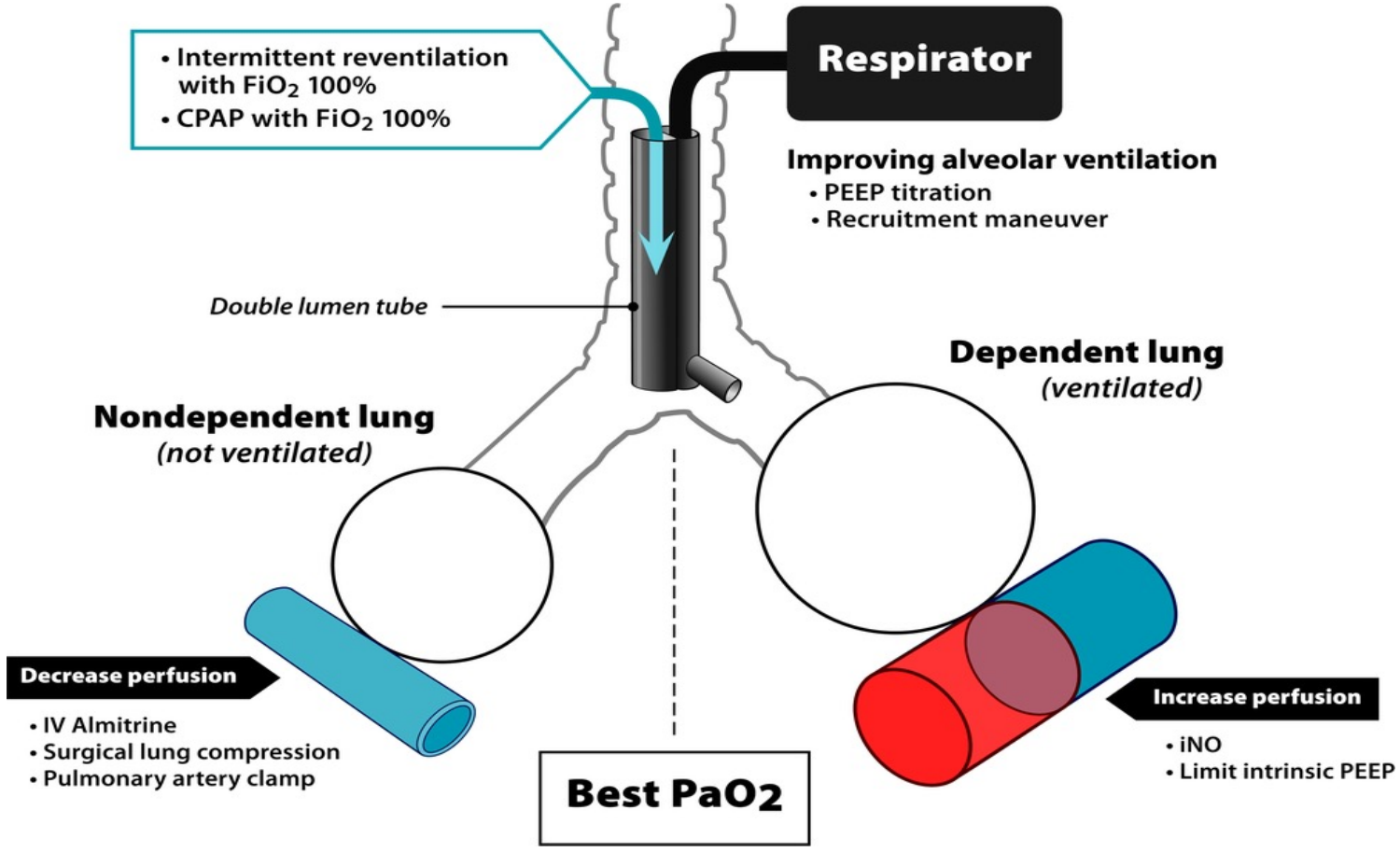
Melina Shoni, MD[a], Gerardo Rodriguez, MD[b,*]

Table 3
Risk factors for developing hypoxemia during one-lung ventilation can be classified as patient specific and surgery specific

Patient-Specific Risk Factors	Surgery-Specific Risk Factors
• Normal preoperative spirometry • Body mass index >30 kg/m^2 • Low baseline Pao_2 • History of lung-reducing operation	• Large, central lung mass • Right-sided thoracic surgery • Surgery performed in the supine position

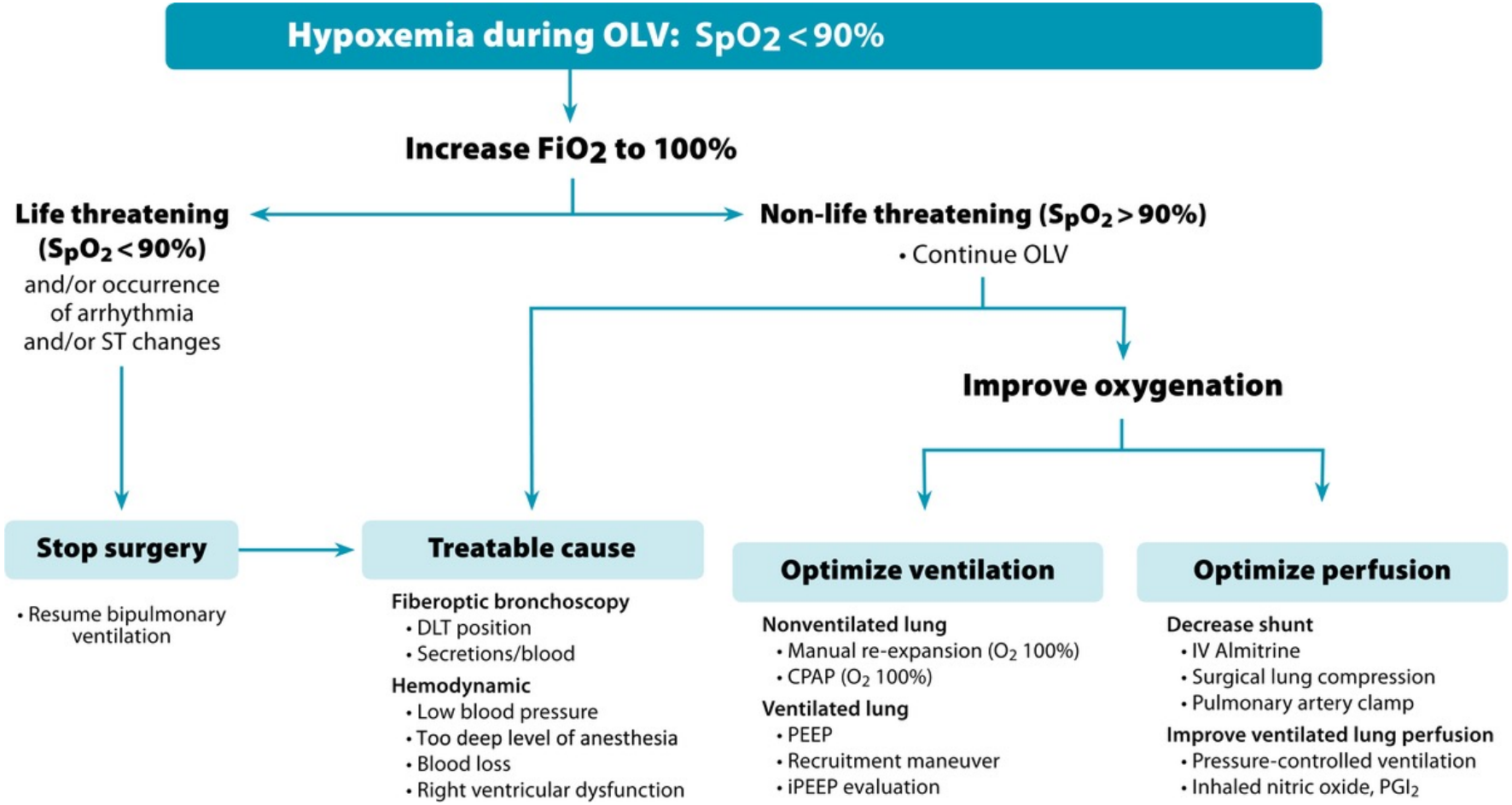
Shoni M, Rodriguez G. Thorac Surg Clin 30 (2020) 279-291

Hypoxémie et OLV: stratégies thérapeutiques



Rozé Hadrien et al: Management of Intraoperative Hypoxemia during One-lung Ventilation
Anesthesiology. 2011;114(1):167-174. doi:10.1097/ALN.0b013e3182023ed3

Hypoxémie et OLV: algorythme



Rozé Hadrien et al: Management of Intraoperative Hypoxemia during One-lung Ventilation
Anesthesiology. 2011;114(1):167-174. doi:10.1097/ALN.0b013e3182023ed3

Ventilation protectrice et OLV

Contents lists available at ScienceDirect

Journal of Cardiothoracic and Vascular Anesthesia

journal homepage: www.jcvaonline.com

Original Article

The Effects of an Open-Lung Approach During One-Lung Ventilation on Postoperative Pulmonary Complications and Driving Pressure: A Descriptive, Multicenter National Study

iPROVE Network investigators, Javier Belda, MD, PhD*, Carlos Ferrando, MD, PhD*,†,[1], Ignacio Garutti, MD, PhD‡

Belda J, et al. (2018), https://doi.org/10.1053/j.jvca.2018.03.028

Ventilation protectrice et OLV

- Étude prospective, descriptive
- Multicentrique
- 690 patients, thoracotomies (wedges, segmentect, lobectomies)

- *VT 5 - 6 ml/kg IBW*
- *Optimal PEEP: 8 +/- 2 cm H2O (meilleure C dyn)*
- *DP 11 +/- 3 cm H2O*

Belda J, et al. (2018), https://doi.org/10.1053/j.jvca.2018.03.028

Ventilation protectrice et OLV

Complications postopératoires 11.8%

(18-32% dans la littérature)

Postoperative Pulmonary Complications

Incidence of PPC	% (n)
Atelectasis	5.3 (24)
Acute respiratory failure	6.0 (27)
Reintubation	2.7 (12)
ARDS	0.9 (4)
Pneumonia	4.4 (20)
Empyema	0.7 (3)
Bronchospasms	1.1 (5)
Pneumothorax	1.1 (5)
Pneumonitis	0 (0)
Bronchopleural fistula	0 (0)
Patients stratified by number of complications	
0	88.2 (398)
1	6.6 (30)
2	3.5 (16)
3	0.8 (4)
≥ 4	0.6 (3)

NOTE. Only atelectasis requiring bronchoscopy was included as a PPC. For the acute respiratory failure diagnosis, a SpO_2 value of less than 92% was used instead of the usual 90%.
Abbreviations: ARDS, acute respiratory distress syndrome; PPC, postoperative pulmonary complications; SpO_2, oxyhemoglobin saturation.

Belda J, et al. JCVA 2018 Dec;32(6):2665-2672

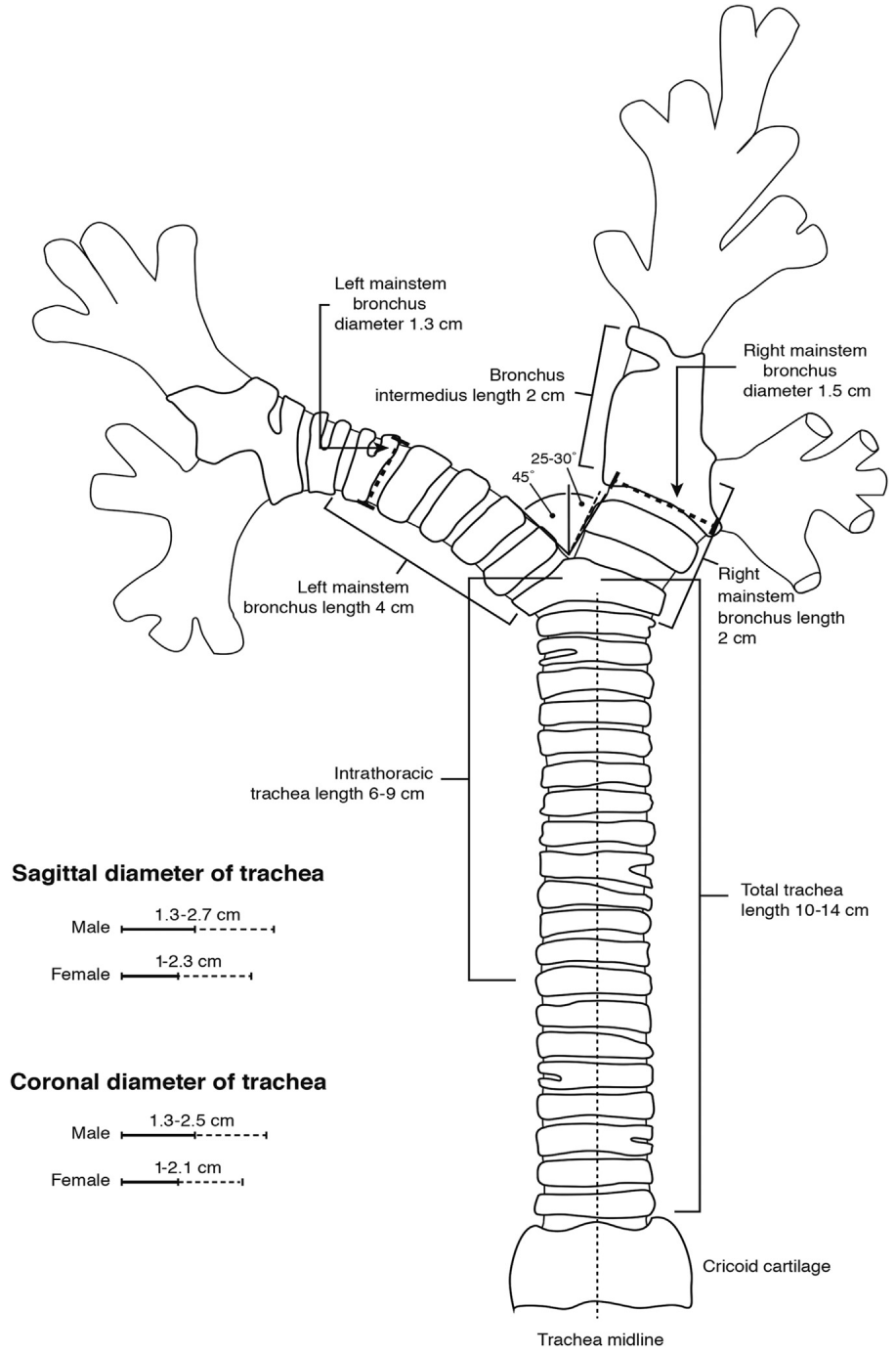
Techniques de ventilation unipulmonaire

- 2 techniques principales

- Tubes double lumière

- Bloqueurs bronchiques

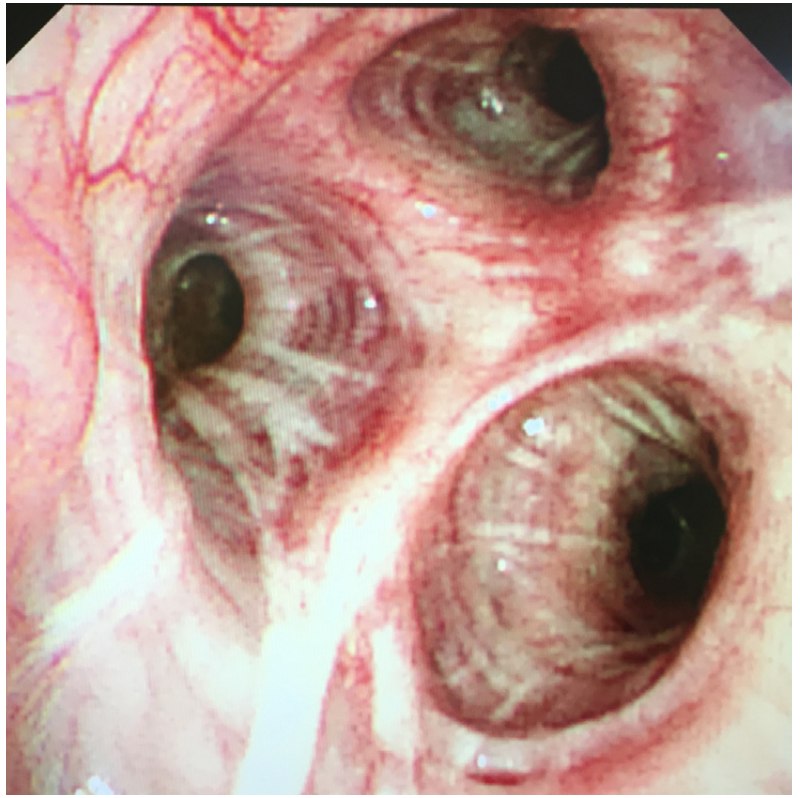
Anatomie arbre trachéo-bronchique



D. Falzon et al. JCVA 31, 2017: 678–693

Anatomie endo trachéo-bronchique

Carène



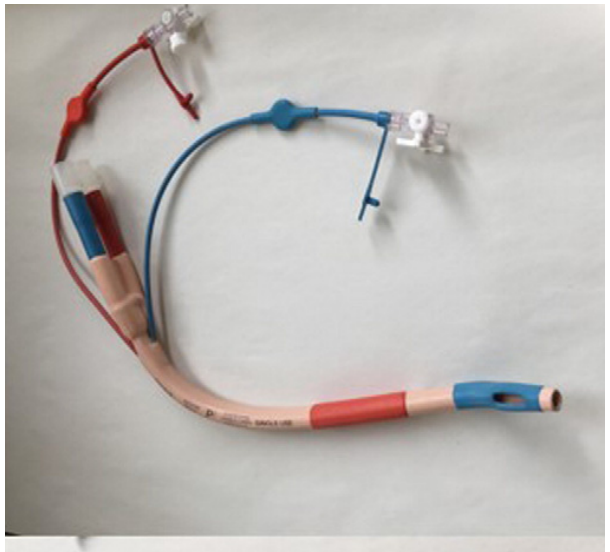
Lobaire supérieure droite
(apical, antérieur, postérieur)

D. Falzon et al. JCVA 31, 2017: 678–693

TDL: historique

- 1949 Carlens:
  - tube flexible, latex,
  - double lumière
  - ergot
  - orientation antéropostérieure

1962 Robertshaw
- suppression de l'ergot
- orientation plan coronal lumière bronchique
- marqueurs radio-opaques

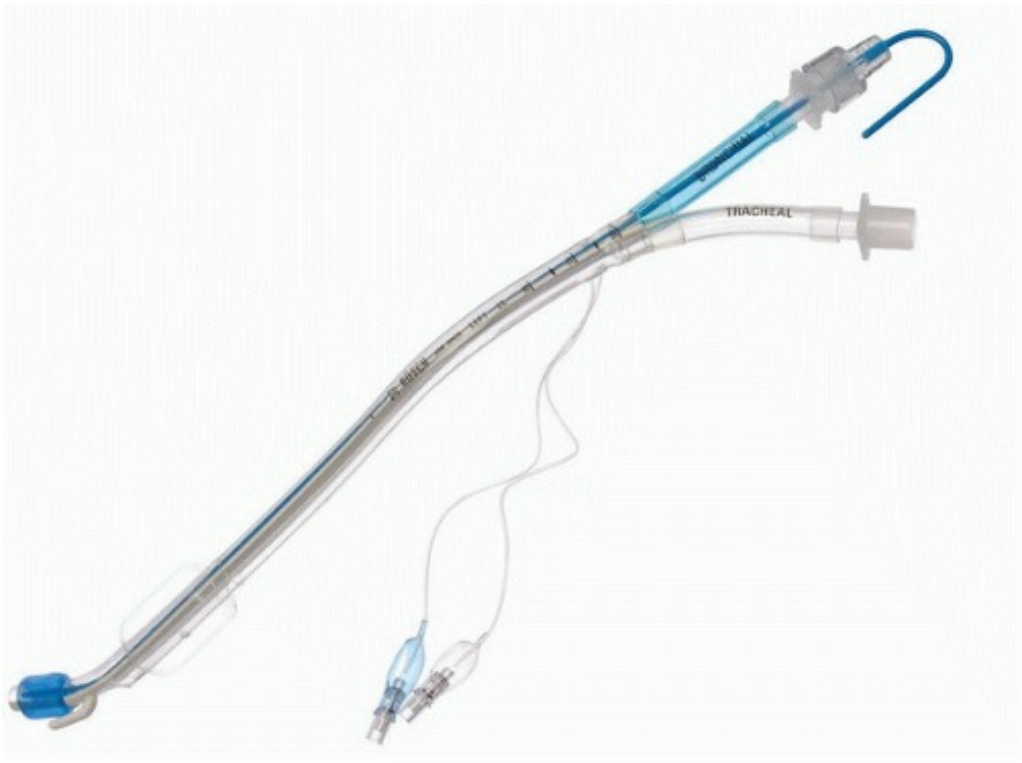


McGrath B et al. J Anesth Hist. 2017 Jul;3(3):76-86

TDL: design Carlens

- Ergot carinal
- Lumières plus étroites
- Résistances plus élevées

modèle TDL dte Sumi



modèle TDL gche Rüsch

TDL: design Robertshaw

- Moins traumatique
- Diamètres internes plus grands

  gauche: angle 45°

  droit: angle 20°
- Stabilité

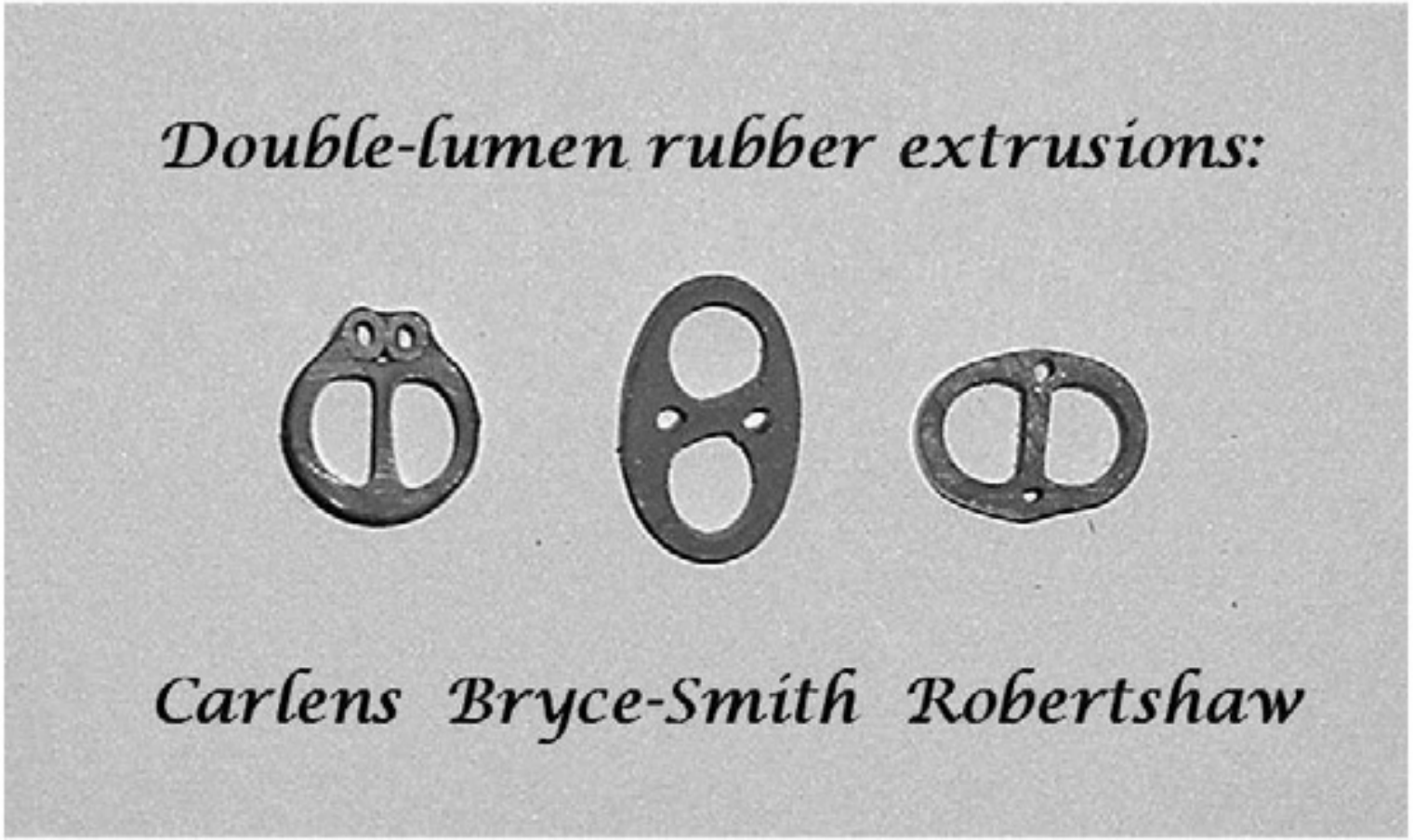
Mallinckrodt, Portex, Rüsch, Sheridan

TDL: design Robertshaw

- Modèle de TDL droit: forme et taille du ballonnet différents selon fabriquant
- Dimensions œillet bronche LSD

Mallinckrodt, Portex, Rüsch, and Sheridan

TDL: section transversale



McGrath B. et al. Journal of Anesthesia History 3 (2017); 76-86

TDL vidéoassisté

- VivaSight DLT
  - seul modèle gauche
  - pas de contrôle fibroscopique nécessaire
  - coût

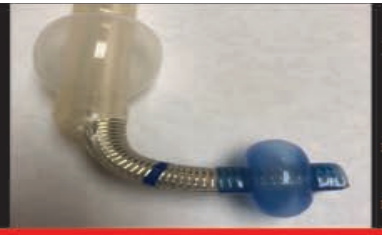
TDL: modèle pour trachéostomie

- Modèle droit ou gauche
- 3 tailles disponibles (7, 8, 9)

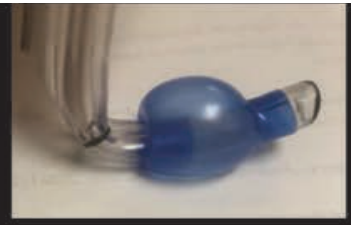
TDL droit, Sumi

TDL: nouveaux modèles

Silbroncho

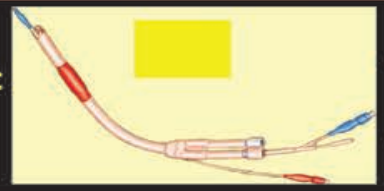


- Can be inserted at > 50° angle without kinking of the bronchial lumen
- A divided single-lumen tube
- Flexible wire-reinforced bronchial tip

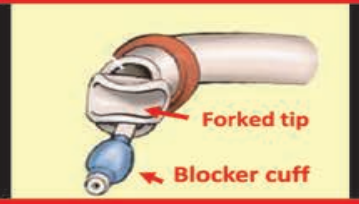


Conventional DLT stiffness prevents it passing through >50° angle into the left main bronchus without kinking the bronchial lumen

Papworth BiVent Tube

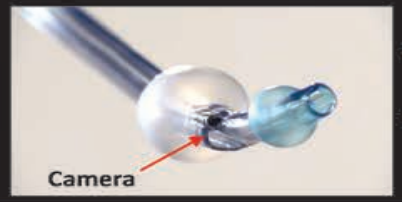


- Eliminates the need for endobronchial intubation
- Can achieve lung isolation without the need for FB

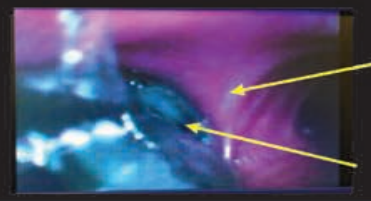


A forked tip that rests on the carina

ET View DLT



- An integrated video camera
- Provides a continuous real-time view of tube position



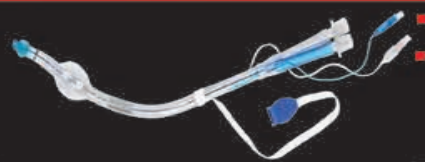
L- DLT image through the ET view

A single use Robertshaw DLT

- Single use replica of the original red rubber Robertshaw DLT
- Less likely displaced intraoperatively

The right sided version has a longer ventilating slot. Increases the chance of alignment with the right upper lobe orifice

ECOM DLT



- Continuous CO Monitoring
- Potentially be useful during lung transplantation, off-pump cardiac surgery

Electrodes on the Bronchial Cuff

Cohen E. Anesth Analg 2021 Dec 1;133(6):1520-1531

TDL: Choix de la taille

- Pas de formule magique
  - en général, selon la taille/sexe du(la) patient(e)
  - cas particuliers: mesures radiologiques

Table 2. The Selection of DLT Size Based on Adult Patients' Sex and Height

Sex	Height (cm)	Size of DLT (F)
Female	<160 (63 in)*	35
Female	>160	37
Male	<170 (67 in)†	39
Male	>170	41

*For females of short stature (<152 cm or 60 in), examine bronchial diameter on computed tomography scan, consider 32F.

†For males of short stature (<160 cm), consider 37F.

Slinger P. JCVA, Vol 22, No 6 (December), 2008: pp 925-929

TDL: choix de la taille

- comparatif avec tube simple lumière
- diamètre fibroscope bronchique correspondant

Table 1. Comparative Diameters of Single- and Double-Lumen Tubes

Single-Lumen Tubes		DLTs			
ID (mm)	ED (mm)	French Size (F)	Double-Lumen ED (mm)	Bronchial Lumen ID (mm)	FOB Size (mm)
6.5	8.9	26	8.7	3.2	2.4
7.0	9.5	28	9.3	3.4	2.4
8.0	10.8	32	10.7	3.5	2.4
8.5	11.4	35	11.7	4.3	≥3.5
9.0	12.1	37	12.3	4.5	≥3.5
9.5	12.8	39	13.0	4.9	≥3.5
10.0	13.5	41	13.7	5.4	≥3.5

NOTE. Double-lumen ED = approximate external diameter of the double-lumen portion of the tube. FOB size = maximal diameter of fiberoptic bronchoscope that will pass through both lumens of a given size of DLT.

Abbreviations: ED, external diameter; ID, internal diameter.

Slinger P. JCVA, Vol 22, No 6 (December), 2008: pp 925-929

TDL choix taille

- Sous estimation:
  - Échec exclusion pulmonaire
  - Incidence plus grande de malposition
  - Surinflation ballonnet bronchique
  - Hyperinflation pulmonaire dynamique

- Surestimation:
  - Traumatique
  - Hernie ballonnet bronchique
  - Échec intubation, lésions glottiques etc

TDL: indications TDL droite

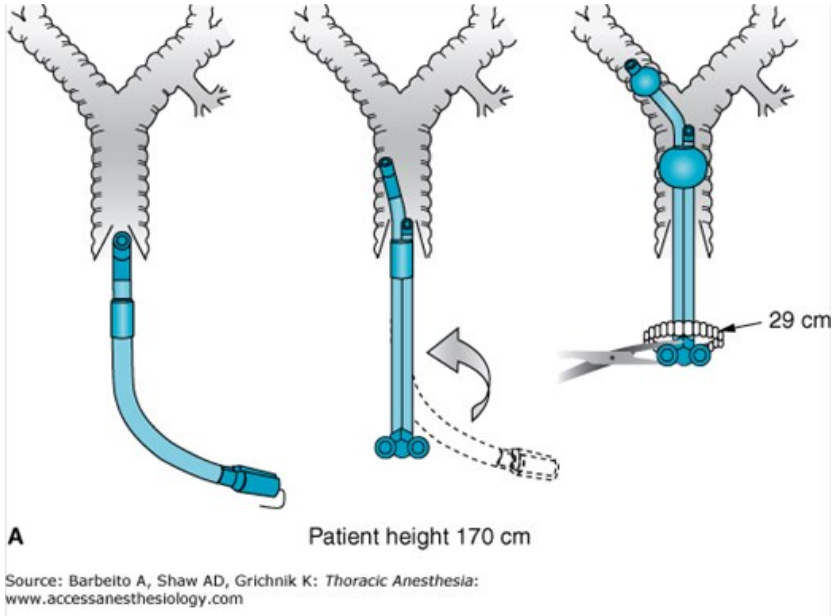
Table 3. Indications for a Right-Sided DLT*

Distorted anatomy of the entrance of the left mainstem bronchus
External or intraluminal tumor compression
Descending thoracic aortic aneurysm
Site of surgery involving the left mainstem bronchus
Left lung transplantation
Left-sided tracheobronchial disruption
Left-sided pneumonectomy†
Left-sided sleeve resection

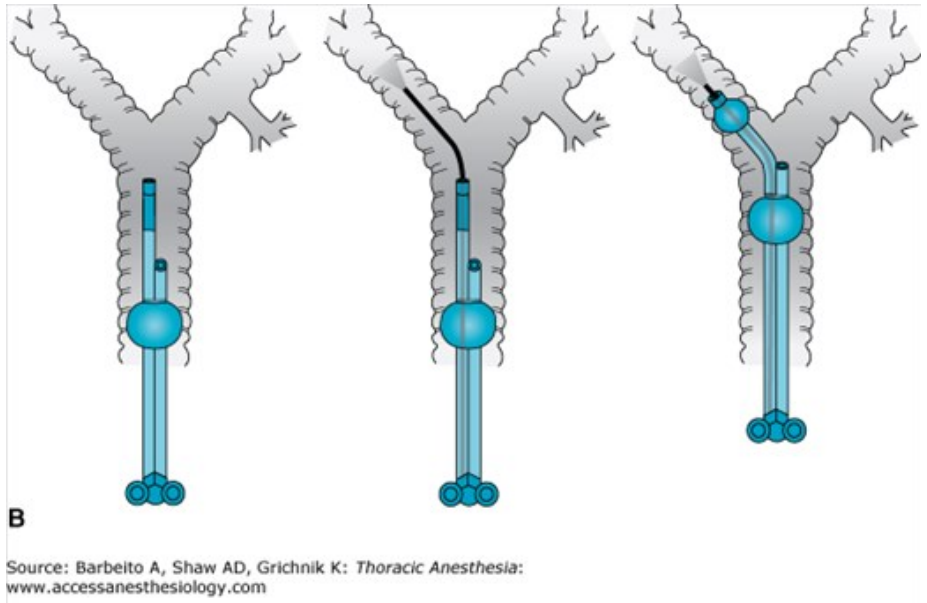
Slinger P. JCVA, Vol 22, No 6 (December), 2008: pp 925-929

TDL placement: 2 méthodes

- à l'aveugle par laryngoscopie directe
- contrôle fibroscopique second temps

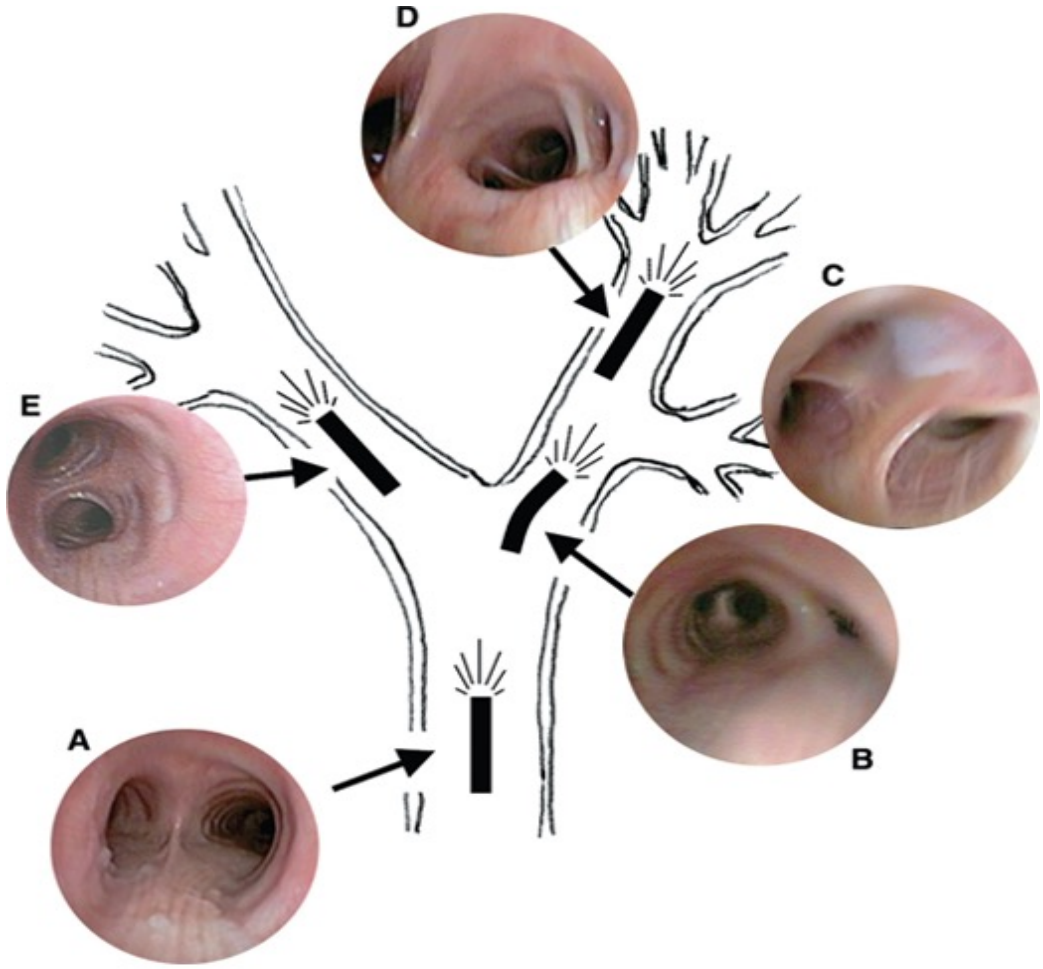


- guidée par fibroscopie bronchique d'emblée



Andrew D. Shaw et al Thoracic Anesthesia McGraw Hill 2012. Chapter 5 Lung Separation Techniques

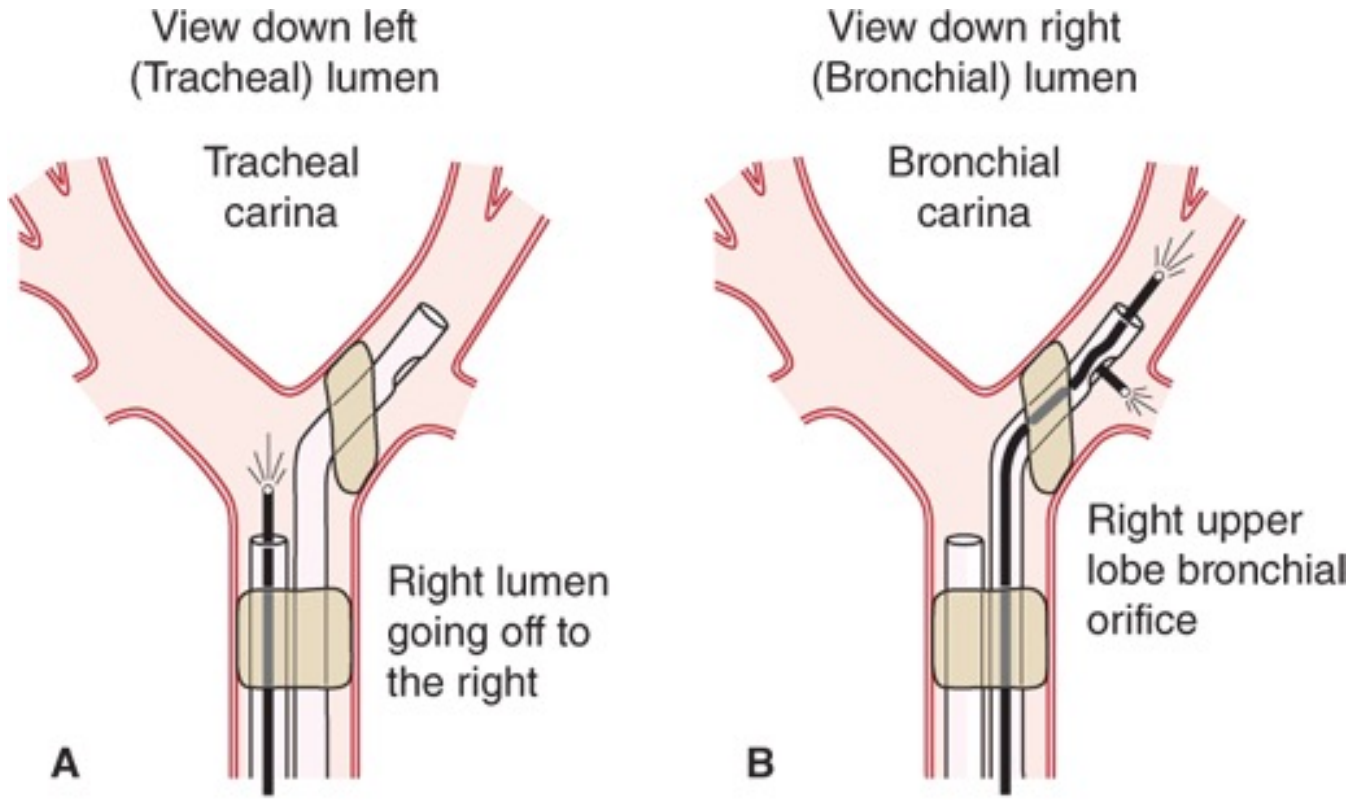
TDL: contrôle fibroscopique



Anesthesiology, 3e edition, 2018 McGraw Hill: David E. Longnecker et al

TDL droit: particularités

- Choix du tube
- Ventilation du LSD
- Stabilité lors des manipulations, du positionnement
- Contrôle fibroscopique indispendable



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TDL: complications de positionnement

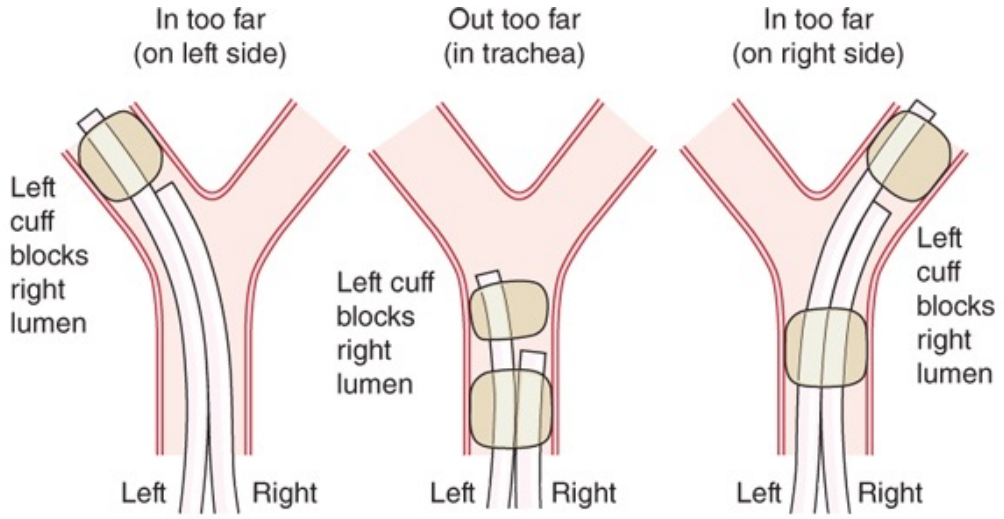
Malposition

- Échec exclusion
- Exclusion partielle poumon dépendant, exclusion LSD
- Obstruction trachéale

  => hypoxémie

Causes

- Hyperinflation ballonnet bronchique
- Extension cervicale à la mise en DL
- Manipulation chirurgicale



Procedure	Breath sounds heard		
Clamp right lumen (both cuffs inflated)	Left	Left and right	Right
Clamp left lumen (both cuffs inflated)	None or very ↓↓	None or very ↓↓	None or very ↓↓
Clamp left lumen (deflate left cuff)	Left	Left and right	Right

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TDL: complications traumatiques

- Lésions du larynx
- Lésions trachéales (partie membraneuse)
- Lésions bronchiques

- Pneumothorax du poumon dépendant

Fitzmaurice and Brodsky, 1999: principales causes

- Sous-estimation taille
- Femmes
- 35 Fr ou 37 Fr

Bloqueurs bronchiques

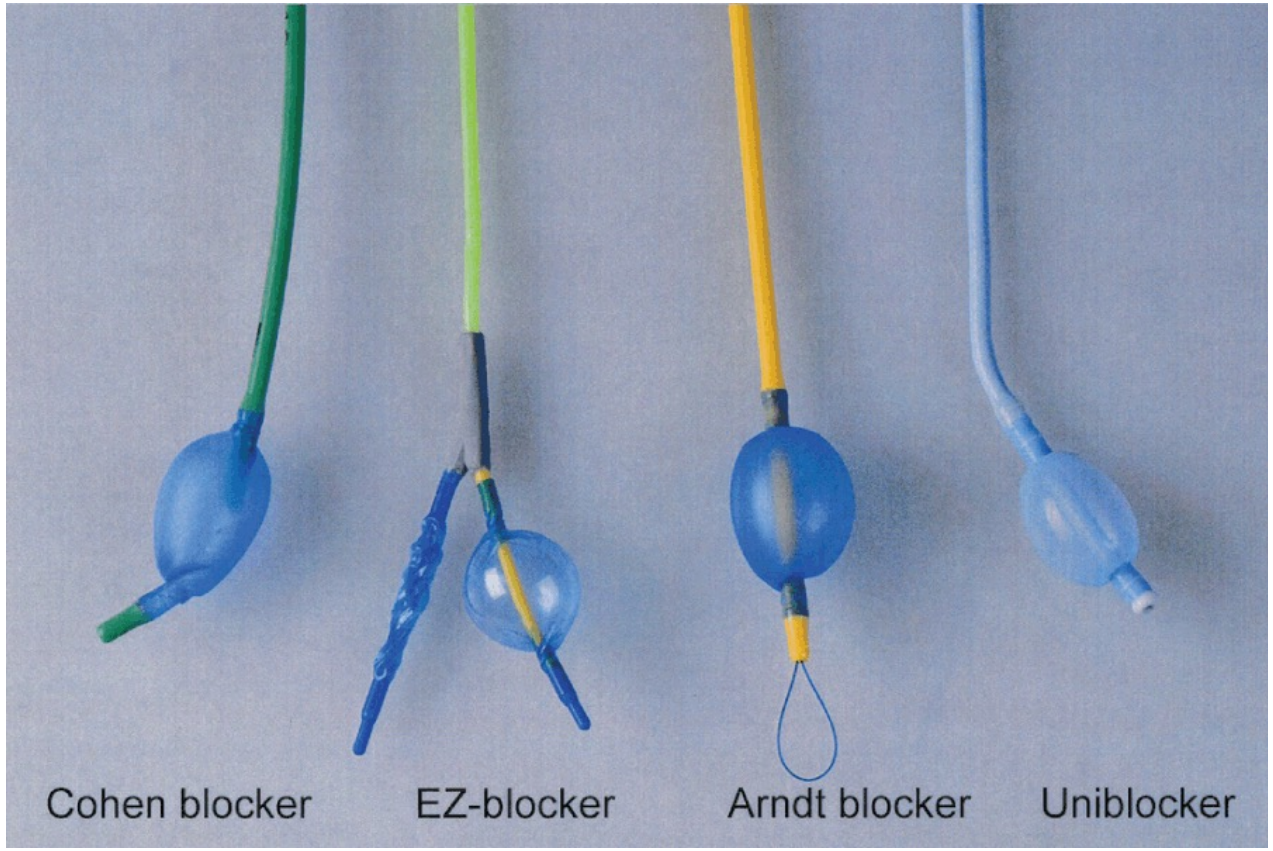
- alternative aux TDL
- utilisation avec un tube monolumière
- occlusion bronche souche
- ballonnet distal
- lumière interne (aspiration, O2)
- fibroscope

Bloqueurs bronchiques: indications générales

- Airway et/ou intubation difficile
- Post laryngectomie
- Trachéostomie
- Immobilisation cervicale
- Obésité morbide
- Pédiatrie

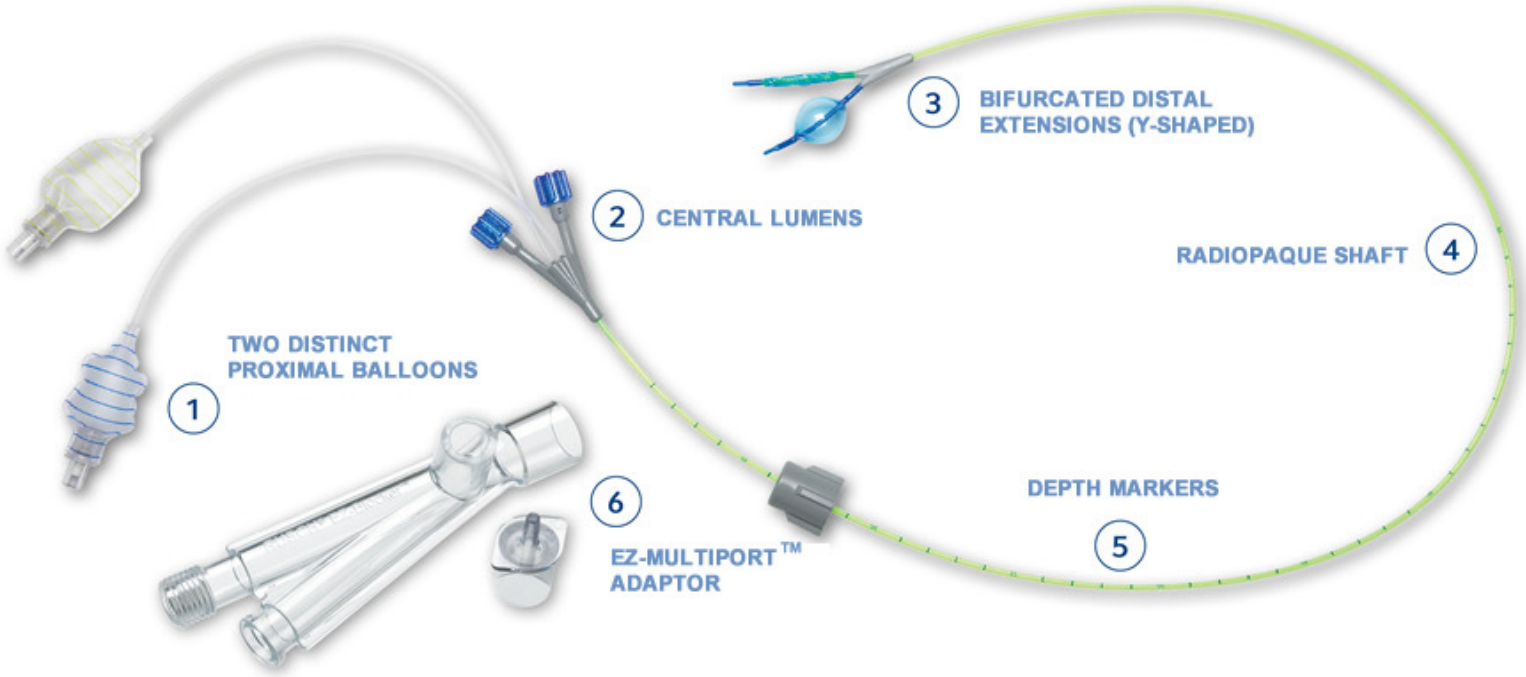
Bloqueurs bronchiques

- 4 modèles
  - Cohen Flex-Tipp blocker (taille 9 Fr)
  - EZ-Blocker (taille 7 Fr)
  - Arndt blocker (taille 5, 7, 9 Fr)
  - Fuji Uniblocker (taille 4, 5 et 9 Fr)



EZ-Blocker

- 4 lumières, 7 Fr
- forme en Y avec double ballonnet, 4 cm
- radio opaque
- facilité
- stabilité



Comparatif: TDL vs BB

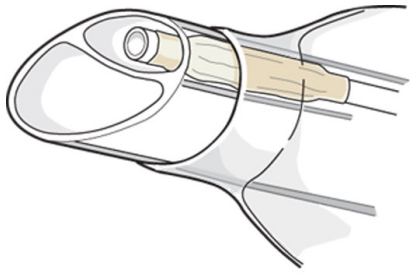
Advantages and Disadvantages of Double-Lumen Endobronchial Tubes and Bronchial Blockers for Lung Isolation

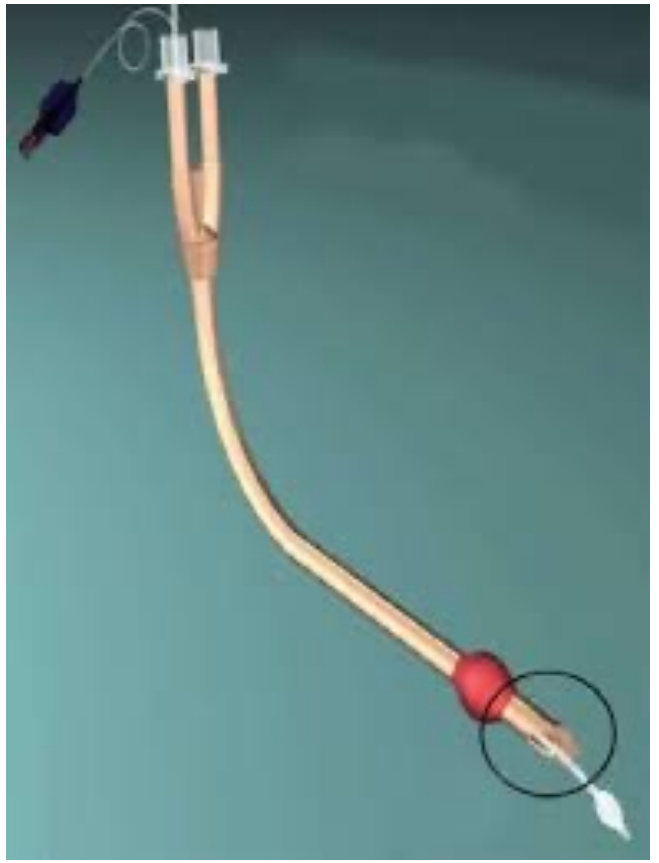
Double-Lumen Endobronchial Tube		Bronchial Blocker	
Advantages	Disadvantages	Advantages	Disadvantages
Easier placement and quicker lung isolation[58,60,61]	Greater incidence of sore throat and hoarseness[61-63]	No requirement to change to tracheal tube if postoperative ventilation required[39]	Correct placement slower[61]
Drainage of isolated lung[61]	Increased risk of airway trauma[61,62]	Use in pediatrics and difficult airways[67]	More frequently misplaced[61]
Less expensive than BBs	Can be difficult or even impossible to place[63]	EZ-Blocker is simpler to place with less risk of intraoperative movement[63]	More expensive than DLTs[61]
Reportedly increased speed of lung deflation[66]	Extra airway procedure to exchange ETT if postoperative ventilation required[66]	One article reported no difference in lung collapse scores between devices[62]	Intraoperative repositioning more frequently required[62,63]
Each lung can be inspected with the bronchoscope[59]	Difficulty with insertion and positioning in patients with abnormal upper or lower airway anatomy[62]	Cohen BB has multiple suction ports that may improve time to lung collapse[62]	Once the stylet is removed from Arndt blockers, reinsertion difficult[66]
Enables independent lung ventilation in ICU[58]		Allows for selective lobar blockade[62]	Most do not allow sequential thoracotomies[66]
Collapsed lung can be deflated and reinflated during the procedure[58]			Modest increase in deadspace and resistance to flow[66]
Continuous positive-pressure ventilation can be applied to contralateral lung during OLV[58]			Significant increase in peak pressures between BB (19 cmH_2O) and DLT (16 cmH_2O)[62]
Allows anesthesiologist to safely collapse and reinflate the operated lung as often as needed during a procedure[58]			

D. Falzon et al. JCVA 31, 2017: 678–693

Papworth BiVent tube

- TDL supracarenal avec BB
  - 1 lumière principale trachéale
  - 1 ballonnet trachéal
  - 1 petite lumière pour le BB





Conclusion

- Physiologie ventilation unipulmonaire
- Ventilation protectrice poumon dépendant
- Algorythme thérapeutique en cas d’hypoxémie
- TIVA ou Anesthésie inhalatoire

Conclusion

- Anatomie et endo anatomie trachéobronchique
- Techniques d’exclusion/isolation pulmonaire
- Fibroscopie bronchique