SOLUNUM MEKANİKLERİ

Dr Gül Gürsel

Gazi Üniversitesi Tıp Fakültesi Göğüs Hastalıkları AD YBÜ

Solunum mekanikleri

Akciğer fonksiyonlarının basınç ve akım olarak ifade edilmesi.

Bunlardan volum, komplians, elastans, direnç, WOB hesaplanabilir

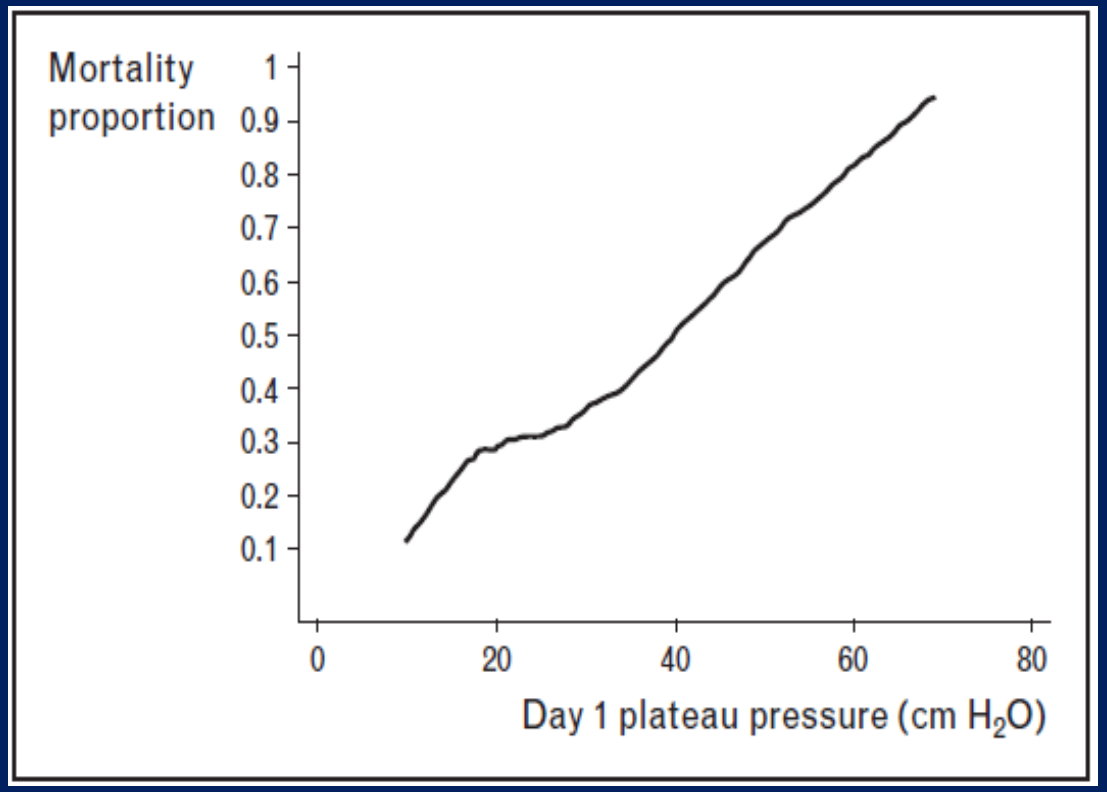
Bu parametreler zamana karşı veya birbirlerine karşı çizdirilebilir

Spontan solunum & paralitik hasta
İnspiryum & ekspiryum

EFFECT OF A PROTECTIVE-VENTILATION STRATEGY ON MORTALITY IN THE ACUTE RESPIRATORY DISTRESS SYNDROME

MARCELO BRITTO PASSOS AMATO, M.D., CARMEN SILVIA VALENTE BARBAS, M.D., DENISE MACHADO MEDEIROS, M.D., RICARDO BORGES MAGALDI, M.D., GUILHERME DE PAULA PINTO SCHETTINO, M.D., GERALDO LORENZI-FILHO, M.D., RONALDO ADIB KAIRALLA, M.D., DANIEL DEHEINZELIN, M.D., CARLOS MUNOZ, M.D., ROSELAINE OLIVEIRA, M.D., TERESA YAE TAKAGAKI, M.D., AND CARLOS ROBERTO RIBEIRO CARVALHO, M.D.

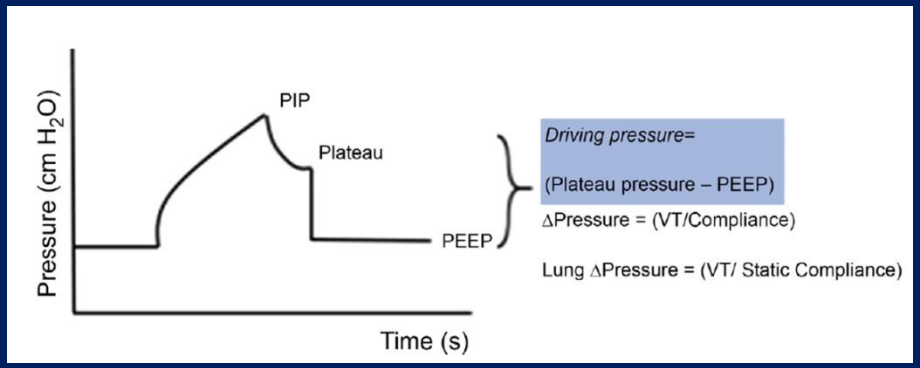
Hager DN, Krishnan JA, Hayden DL, Brower RG. Tidal volume reduction in patients with acute lung injury when plateau pressures are not high. Am J Respir Crit Care Med 2005; 172:1241–1245.

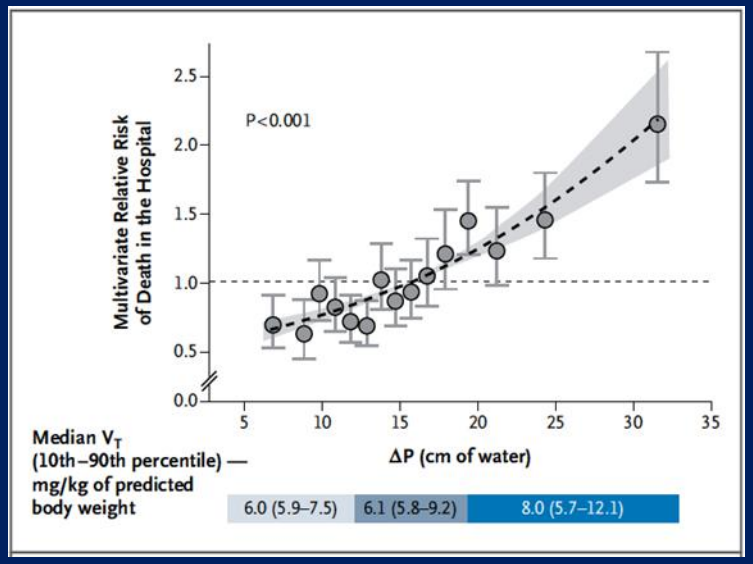


Driving Pressure and Survival in the Acute Respiratory Distress Syndrome

Marcelo B.P. Amato, M.D., Maureen O. Meade, M.D., Arthur S. Slutsky, M.D., Laurent Brochard, M.D., Eduardo L.V. Costa, M.D., David A. Schoenfeld, Ph.D., Thomas E. Stewart, M.D., Matthias Briel, M.D., Daniel Talmor, M.D., M.P.H., Alain Mercat, M.D., Jean-Christophe M. Richard, M.D., Carlos R.R. Carvalho, M.D., and Roy G. Brower, M.D.

N Engl J Med 2015;372:747-55.
DOI: 10.1056/NEJMsa1410639





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ESTABLISHED IN 1812 NOVEMBER 13, 2008 VOL. 359 NO. 20

Mechanical Ventilation Guided by Esophageal Pressure in Acute Lung Injury

Daniel Talmor, M.D., M.P.H., Todd Sarge, M.D., Atul Malhotra, M.D., Carl R. O'Donnell, Sc.D., M.P.H., Ray Ritz, R.R.T., Alan Lisbon, M.D., Victor Novack, M.D., Ph.D., and Stephen H. Loring, M.D.

Intensive Care Med (2012) 38:395–403
DOI 10.1007/s00134-012-2490-7

ORIGINAL

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ECMO criteria for influenza A (H1N1)-associated ARDS: role of transpulmonary pressure

	ECMO	No ECMO	
	Conventional Ventilation	Conventional ventilation	Conventional ventilation and higher PEEP
VT (mL/kg PBW)	5.0 ± 0.9	5.0 ± 0.8	5.0 ± 0.8
PEEP (cmH_2O)	17.1 ± 1.6	17.9 ± 1.2	22.3 ± 1.4#
RR (breaths/min)	32.8 ± 2.4	31.1 ± 0.3	30.3 ± 2.4
Oxygenation index	34 ± 5	37 ± 4	16 ± 1#
PaO_2/FiO_2	75 ± 10	67 ± 5	180 ± 9##
$P_{AO,\ mean}$	25.2 ± 2.7	25.1 ± 1.8	29.1 ± 1#
$PaCO_2$ (mmHg)	54.3 ± 7.4	54.6 ± 8.4	42.9 ± 8.0##
pH	7.386 ± 0.035	7.371 ± 0.094	7.405 ± 0.089
$PPLAT_{RS}$ (cmH_2O)	31.0 ± 1	31.5 ± 0.5	38.4 ± 1.0#
$PPLAT_{CW}$ (cmH_2O)	4.0 ± 1.4*	14.7 ± 2.5	13.5 ± 0.8#
$PPLAT_L$ (cmH_2O)	27.2 ± 1.2*	16.6 ± 2.9	25.3 ± 1.7#
E_{RS} (cmH_2O/L)	38.4 ± 5.2	37.4 ± 4.2	43.8 ± 3.3#
E_L (cmH_2O/L)	32.3 ± 5.3**	20.2 ± 4.7	28.6 ± 2.3#
E_{CW} (cmH_2O/L)	6.1 ± 0.7*	17.2 ± 1.7	15.2 ± 2.6
E_{CW}/E_{RS}	0.16 ± 0.03*	0.47 ± 0.08	0.35 ± 0.04
Stress index	1.071 ± 0.032	0.922 ± 0.033	1.052 ± 0.032#

Chiumello et al. Critical Care (2017) 21:240
DOI 10.1186/s13054-017-1820-0

Critical Care

REVIEW Open Access

Respiratory support in patients with acute respiratory distress syndrome: an expert opinion

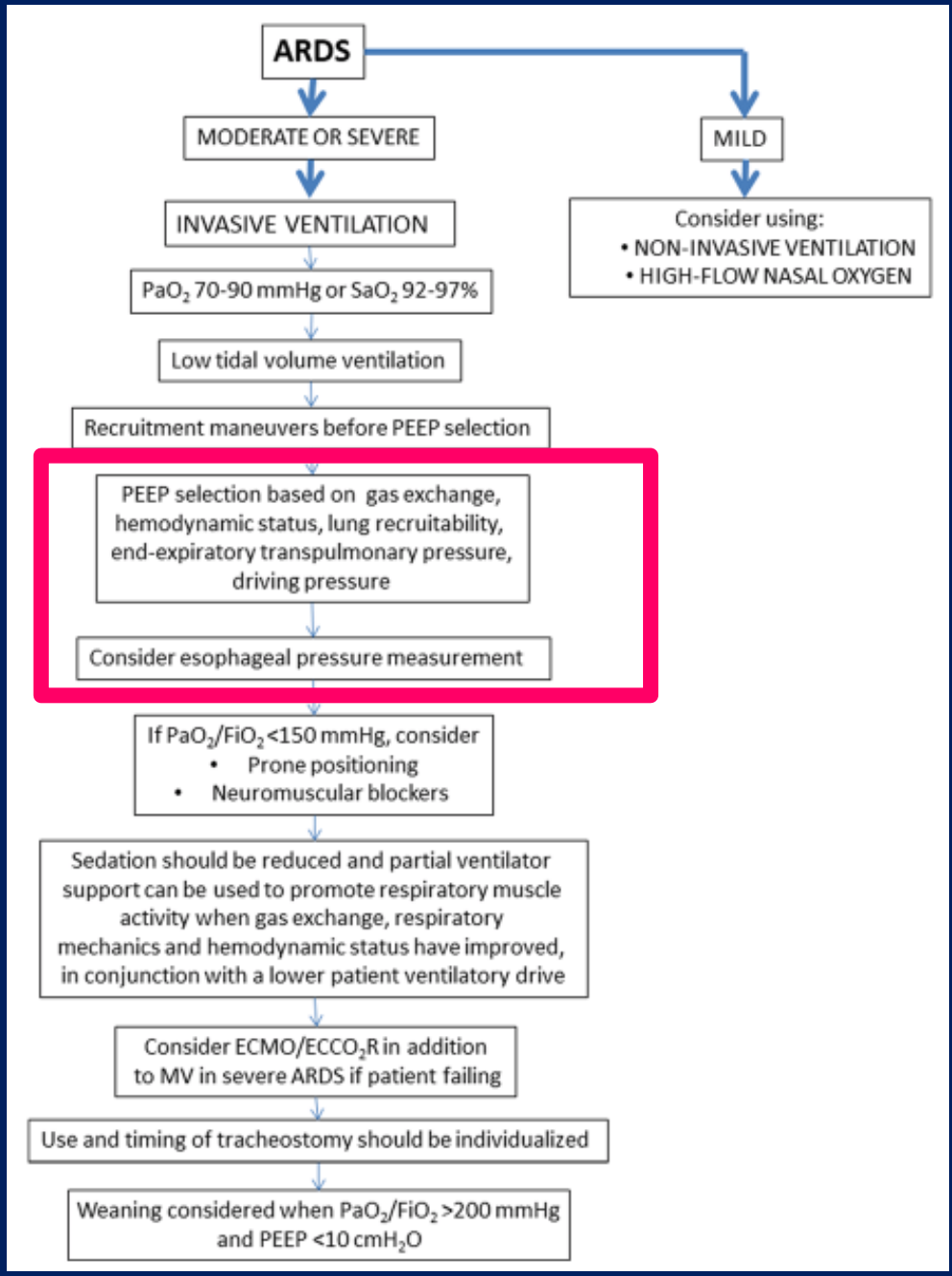
Davide Chiumello[1], Laurent Brochard[2,3], John J. Marini[4], Arthur S. Slutsky[2,3], Jordi Mancebo[5], V. Marco Ranieri[6], B. Taylor Thompson[7], Laurent Papazian[8], Marcus J. Schultz[9], Marcelo Amato[10], Luciano Gattinoni[11], Alain Mercat[12], Antonio Pesenti[13,14], Daniel Talmor[15] and Jean-Louis Vincent[16*]

AMERICAN THORACIC SOCIETY DOCUMENTS

An Official American Thoracic Society/European Society of Intensive Care Medicine/Society of Critical Care Medicine Clinical Practice Guideline: Mechanical Ventilation in Adult Patients with Acute Respiratory Distress Syndrome

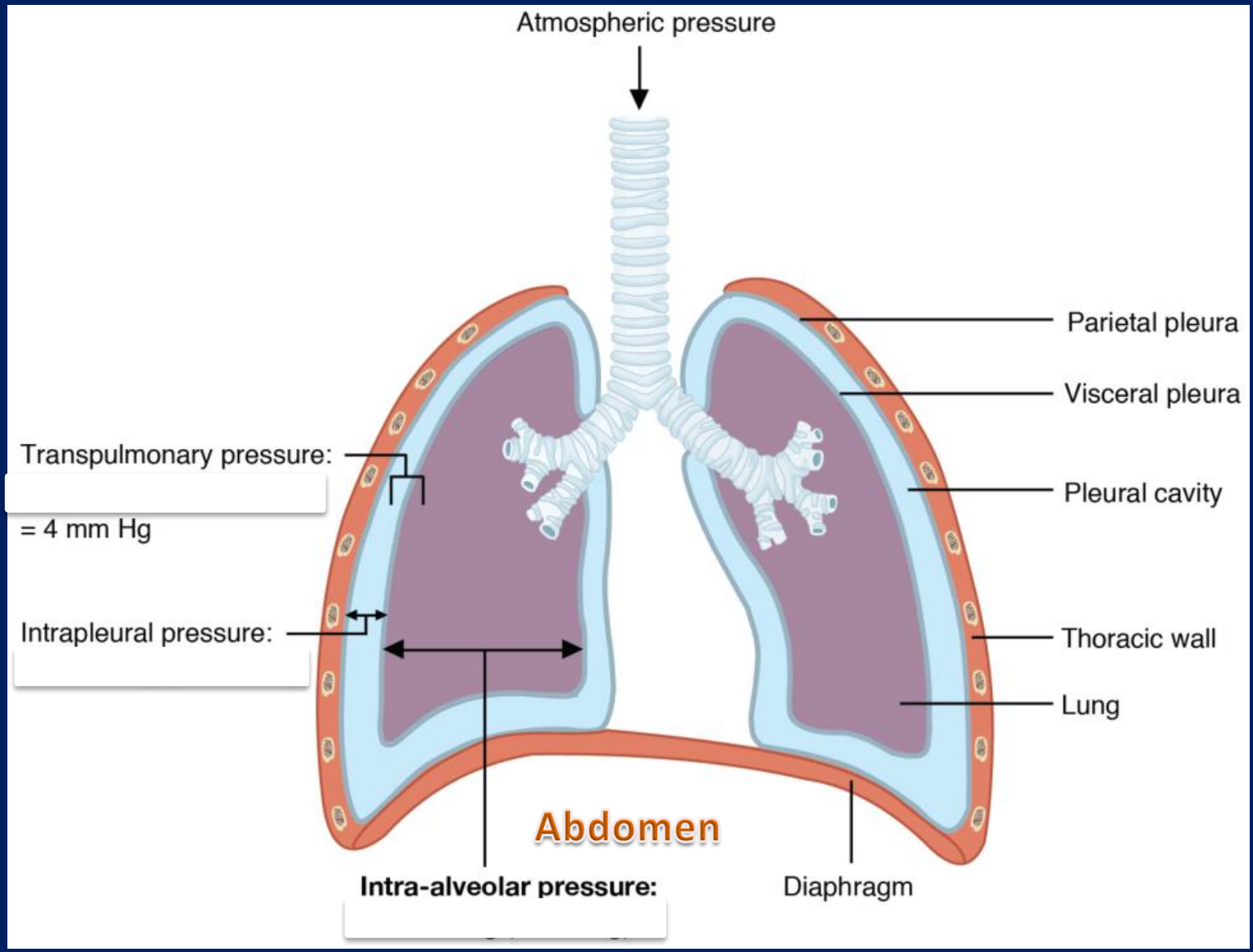
Eddy Fan, Lorenzo Del Sorbo, Ewan C. Goligher, Carol L. Hodgson, Laveena Munshi, Allan J. Walkey, Neill K. J. Adhikari, Marcelo B. P. Amato, Richard Branson, Roy G. Brower, Niall D. Ferguson, Ognjen Gajic, Luciano Gattinoni, Dean Hess, Jordi Mancebo, Maureen O. Meade, Daniel F. McAuley, Antonio Pesenti, V. Marco Ranieri, Gordon D. Rubenfeld, Eileen Rubin, Maureen Seckel, Arthur S. Slutsky, Daniel Talmor, B. Taylor Thompson, Hannah Wunsch, Elizabeth Uleryk, Jan Brozek, and Laurent J. Brochard; on behalf of the American Thoracic Society, European Society of Intensive Care Medicine, and Society of Critical Care Medicine

This official clinical practice guideline of the American Thoracic Society (ATS), European Society of Intensive Care Medicine (ESICM), and Society of Critical Care Medicine (SCCM) was approved by the ATS, ESICM, and SCCM, March 2017

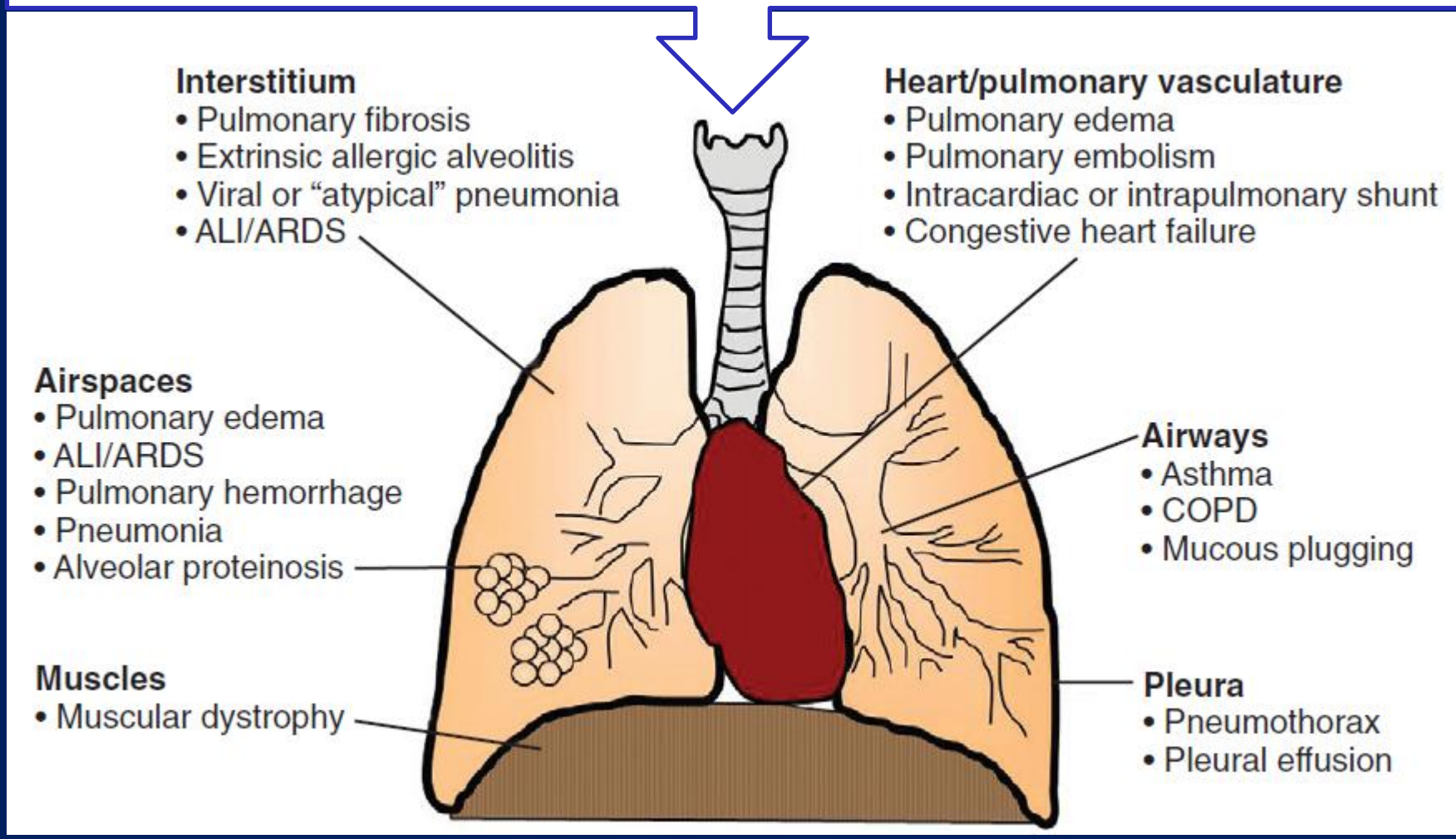


Equation of motion

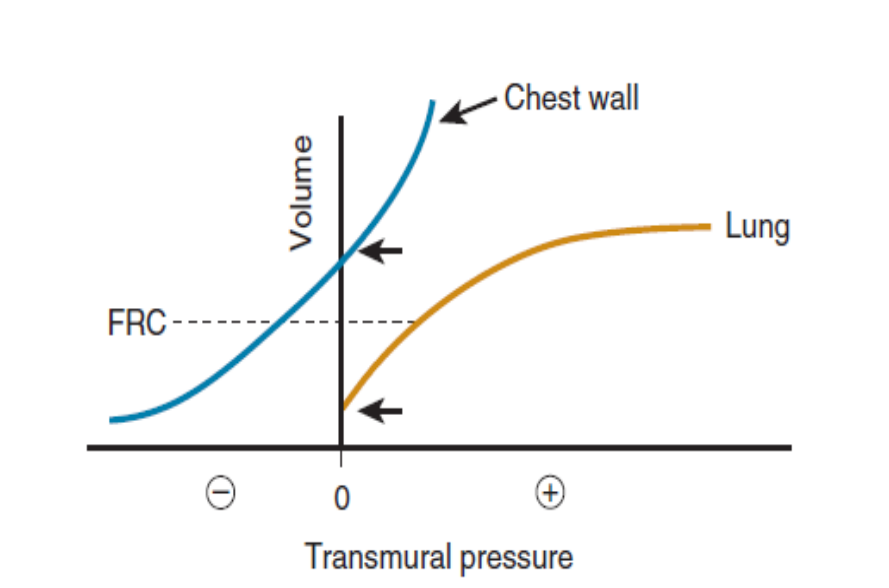
$$P = R\,(flow) + Vt/2C + PEEPi$$


Atmospheric pressure
Parietal pleura
Visceral pleura
Transpulmonary pressure:
= 4 mm Hg
Pleural cavity
Intrapleural pressure:
Thoracic wall
Lung
Abdomen
Intra-alveolar pressure:
Diaphragm

YÜKSEK HAVAYOLU BASINCI



KOMPLİANS



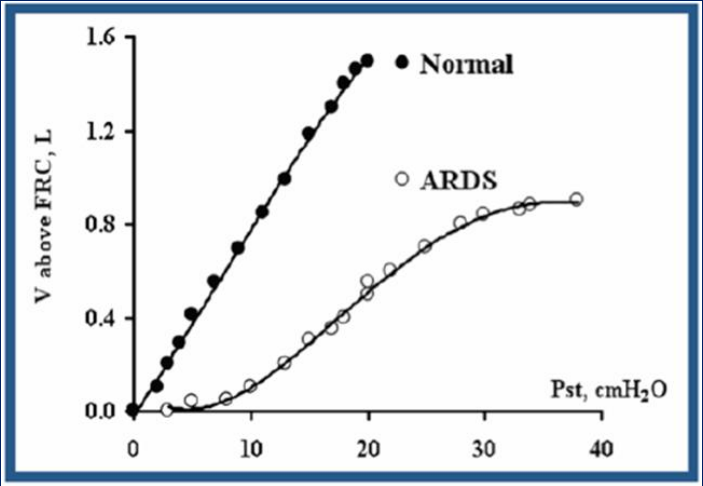


Fig. 4: Static airway pressure (Pst) vs. lung- volume relationship in normal and low- compliance lungs

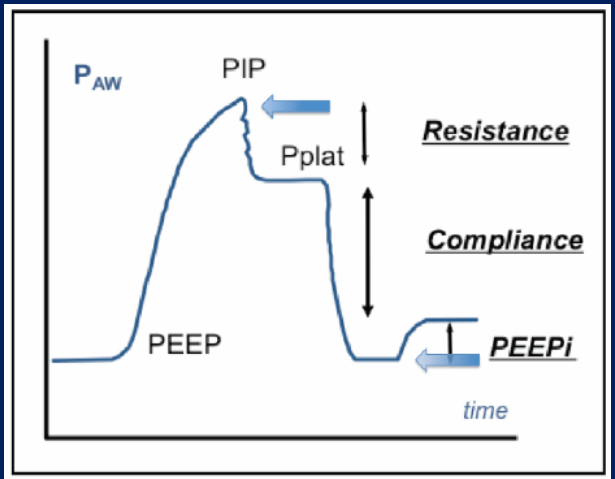
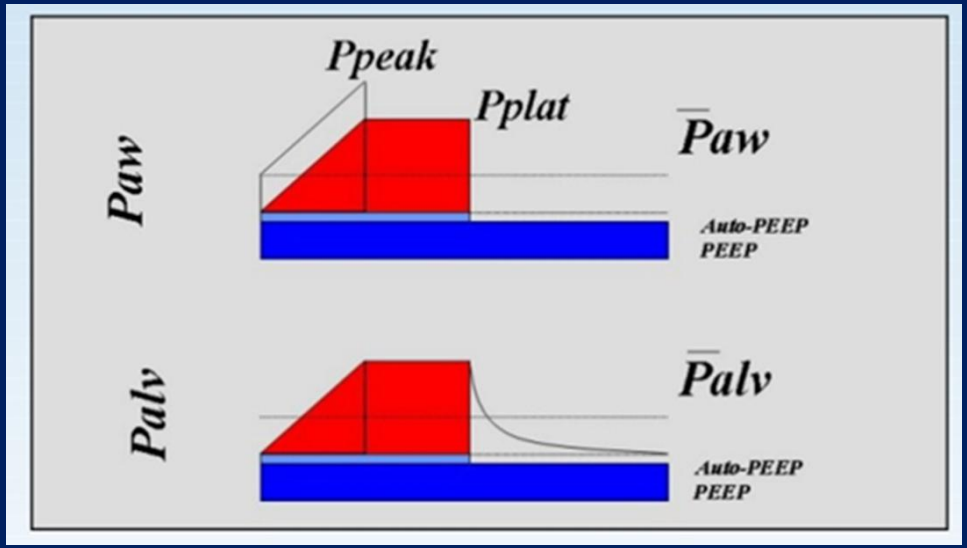


Fig. 3: Airway pressure trace showing end-inspiratory and end-expiratory pauses (thick arrows)



Komplians,

$C = \Delta$ volüm / Δ basınç

$Cst = V_T/Pplat\text{-}PEEP$

$1/C_{TA} = 1/C_A + 1/C_{GK}$

$Cdyn = V_T/Ppeak\text{-}PEEP$

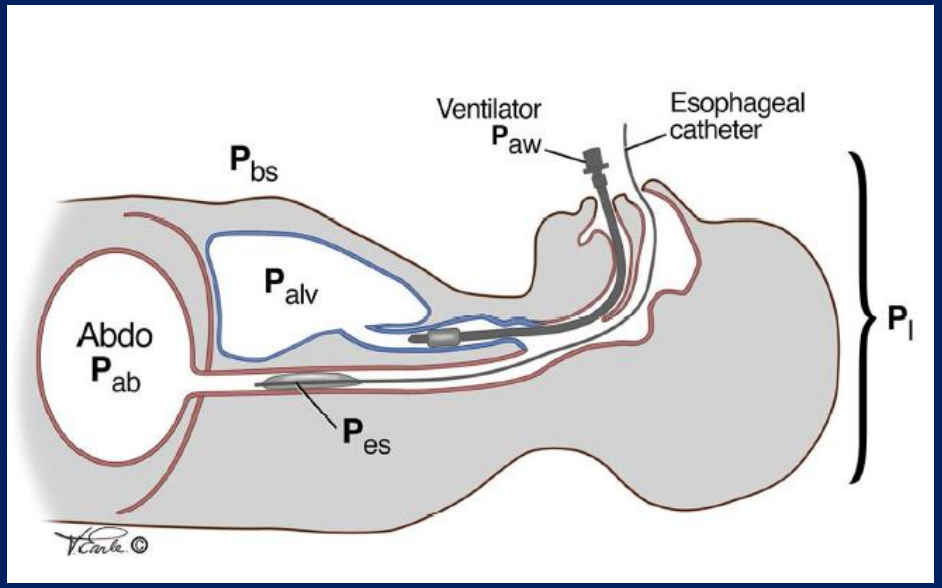
Elastans

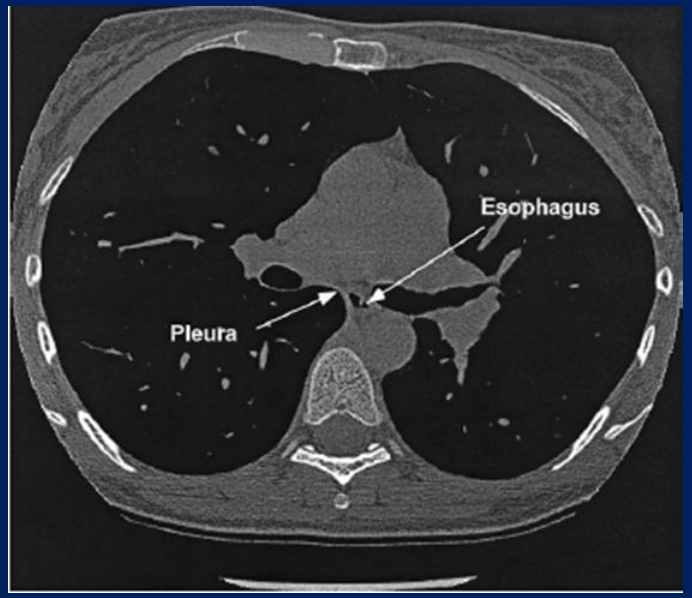
$E = 1/C$

$E = Pplat - PEEP / VT$

$E_{TA} = E_A + E_{GK}$

Pes=Pplevra


Ventilator
P_{aw}
Esophageal
catheter
P_{bs}
P_{alv}
Abdo
P_{ab}
P_{es}
P_l


Esophagus
Pleura

Akciğer kompliansının azaldığı durumlar

- ARDS
- Kardiyojenik pulmoner ödem
- Konsolidasyon
- Atelektazi
- Pulmoner fibrozis
- Pnömonektomi
- Bronşiyal entübasyon
- Overdistansiyon

Göğüs Duvarı kompliansının azaldığı durumlar

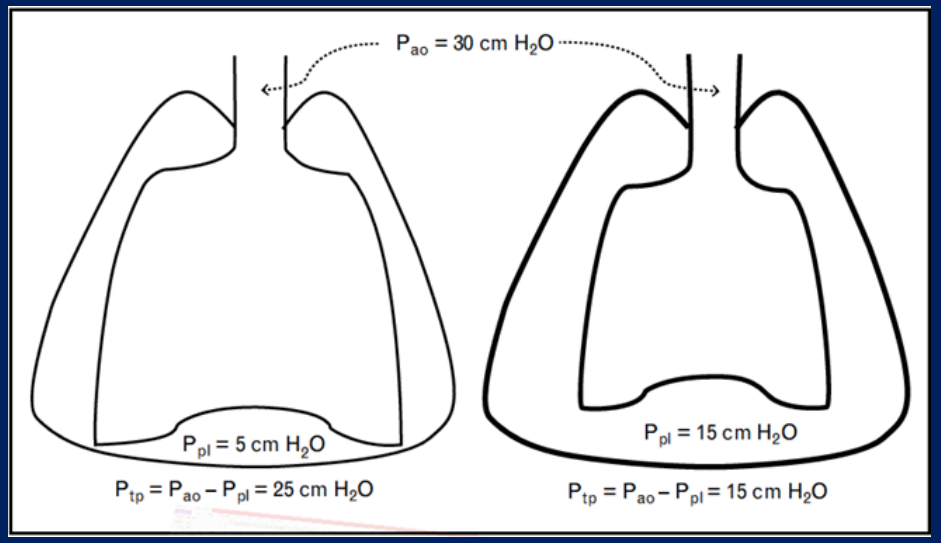
- Göğüs duvarı ödemi, deformiteleri
- Abdominal hipertansiyon
- Obezite
- Asit
- Kostal kıkırdakların kemikleşmesi
- Kostovertebral eklemlerin artriti
- Yanık sonrası cilt skarları
- Plevral effüzyon

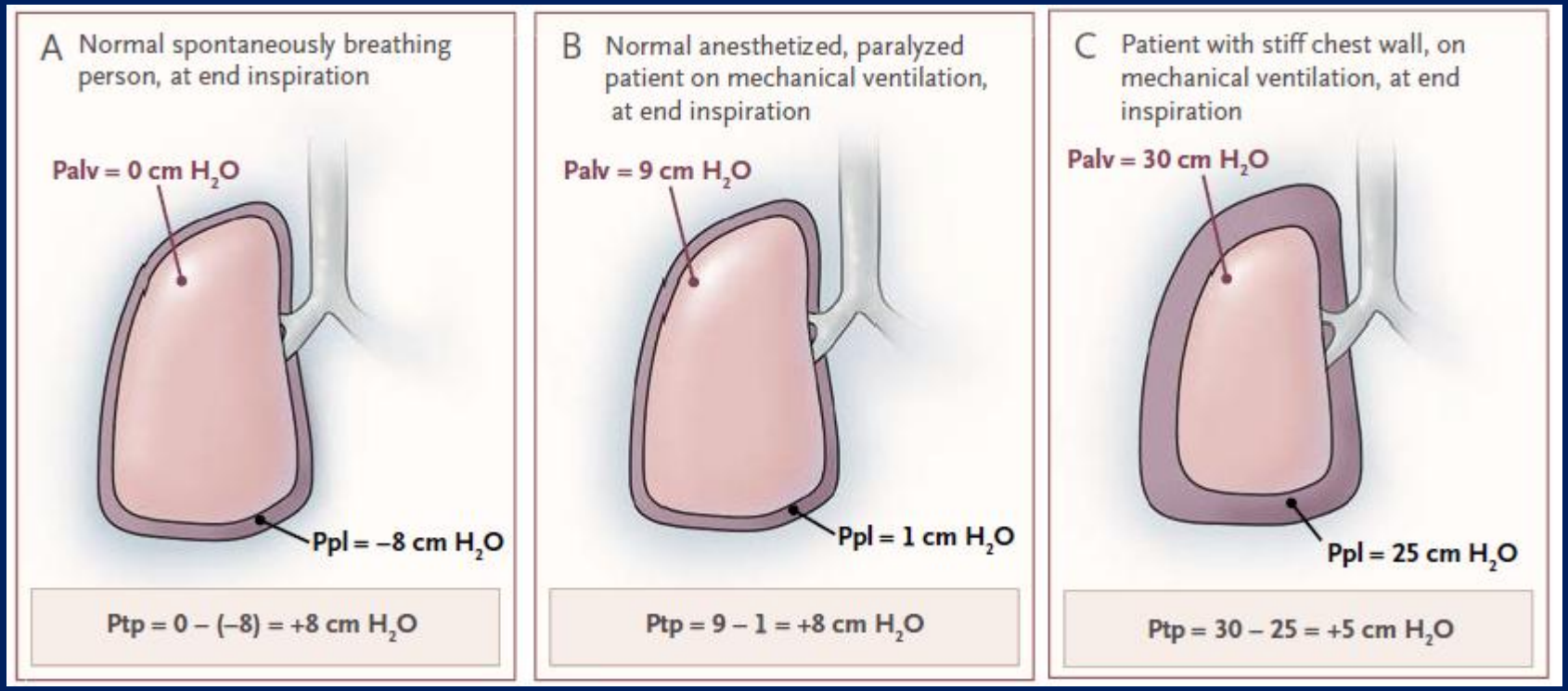
Parametre	Normal	ARDS	KOAH
C_{AKC}, ml/cmH2O	90-140	55	
C_{GD}, ml/cmH2O	100-200	125	
C_{TA}, ml/cmH2O(statik)	64	38	
C_{SS}, ml/cmH2O(dinamik)	50-80		
E_{AKC}, cmH2O/L	9	18	8
E_{GD}, cmH2O/L	7	8	5
E_{TA}, cmH2O/L	16	26	13
E_{AKC}/E_{SS}	0.55	0.70	
Resistans cmH2O.L-1.s	2	4	7
Resistans	8-12 60L/dk akımla of square inspiratory flow		

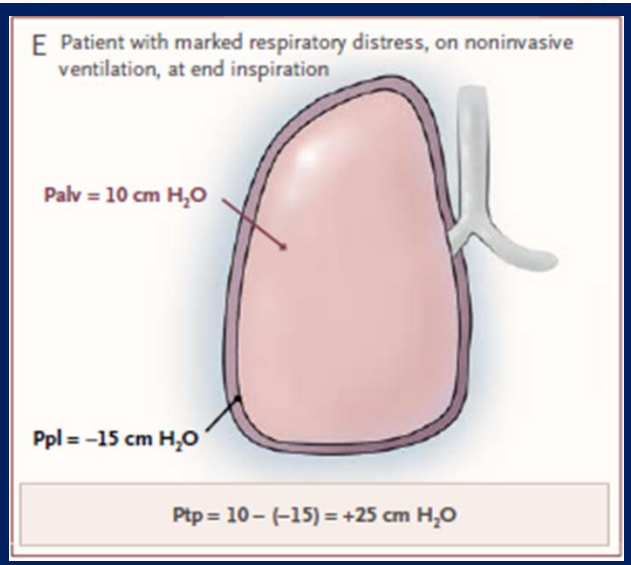
ALVEOL GERİLİMİNİN DEĞERLENDİRİLMESİ

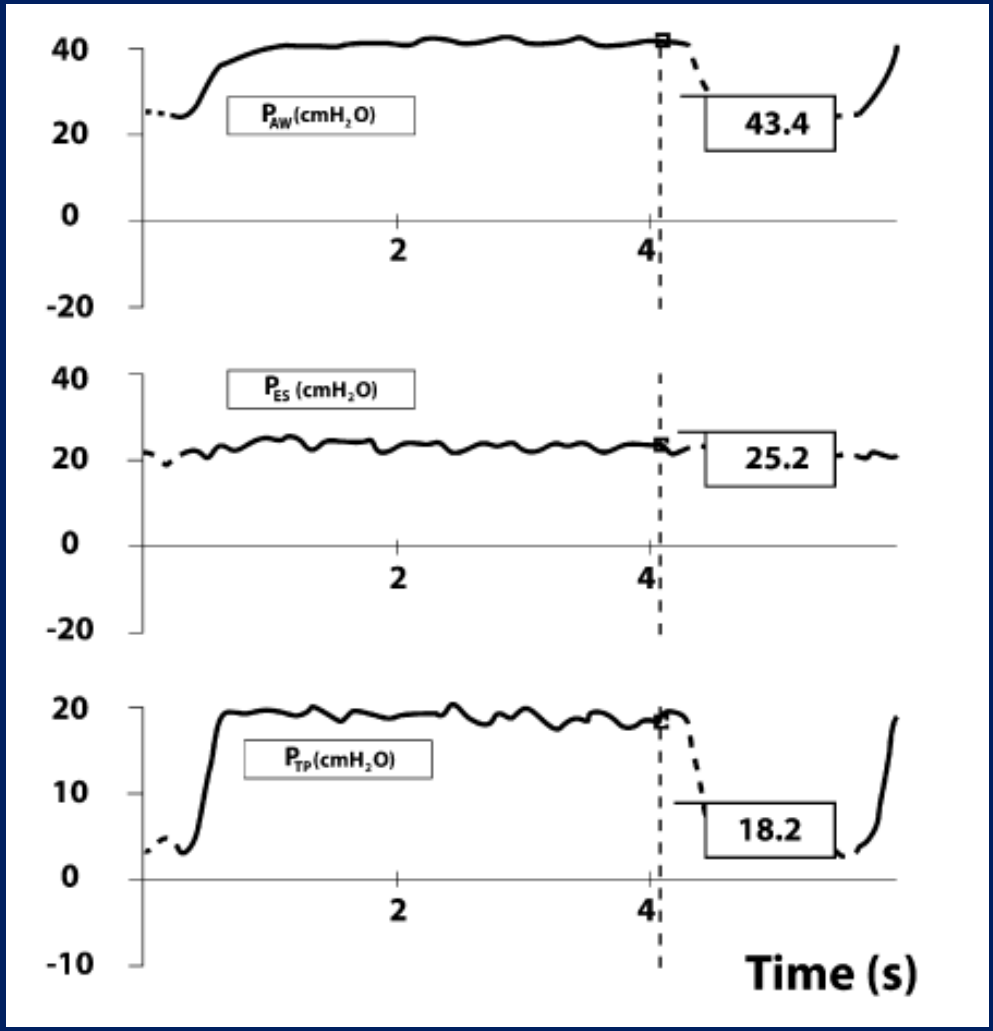
Transpulmoner Basınç
Akciğerleri ekspanse eden basınç

- Transpulmoner basınç inspiryum sonunda akciğerlerin ne kadar gerildiğini gösterir
- Ptp=Palv-Ppl
- Ptp=Pplato-Pes




A Normal spontaneously breathing person, at end inspiration
Palv = 0 cm H2O
Ppl = –8 cm H2O
Ptp = 0 – (–8) = +8 cm H2O
B Normal anesthetized, paralyzed patient on mechanical ventilation, at end inspiration
Palv = 9 cm H2O
Ppl = 1 cm H2O
Ptp = 9 – 1 = +8 cm H2O
C Patient with stiff chest wall, on mechanical ventilation, at end inspiration
Palv = 30 cm H2O
Ppl = 25 cm H2O
Ptp = 30 – 25 = +5 cm H2O

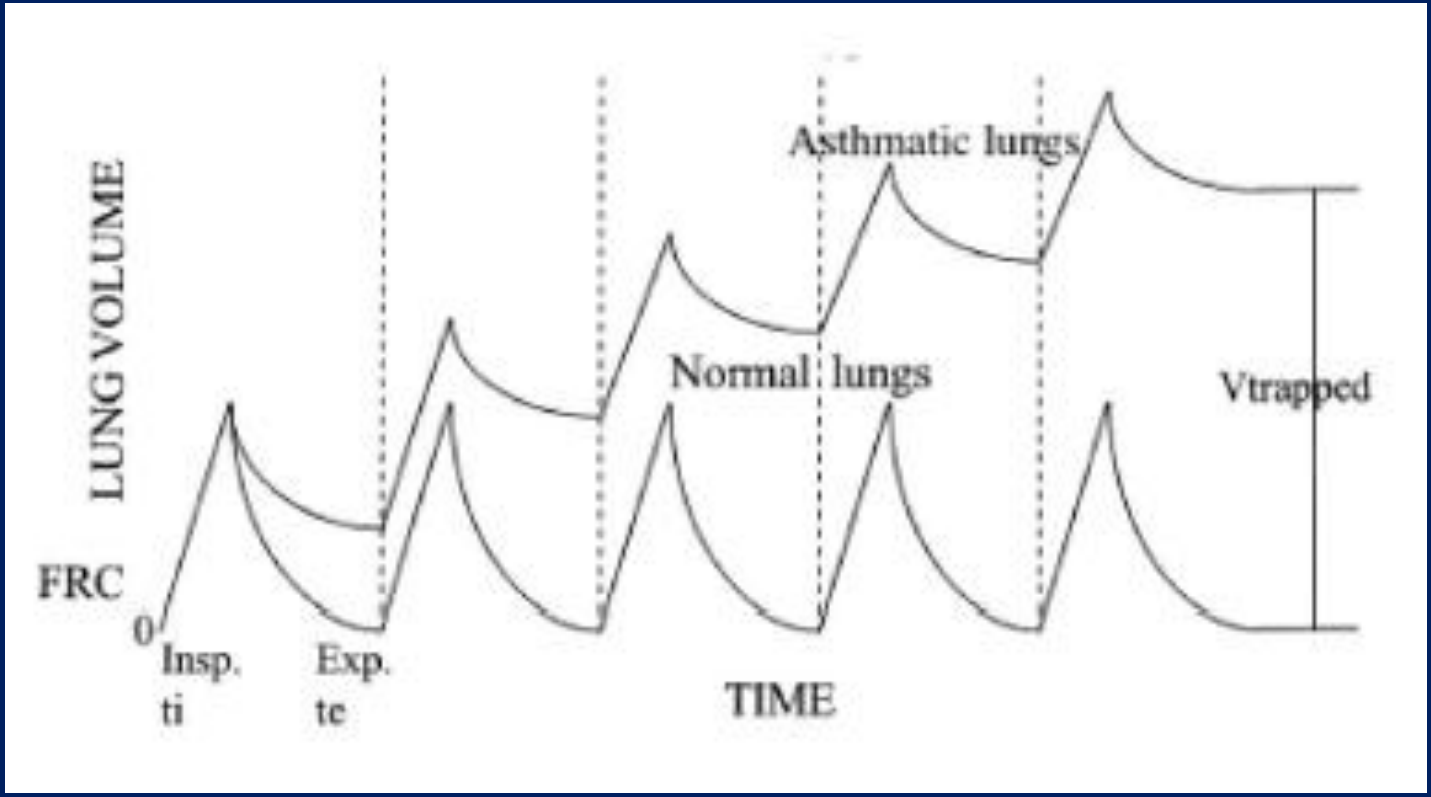

E Patient with marked respiratory distress, on noninvasive ventilation, at end inspiration
Palv = 10 cm H2O
Ppl = –15 cm H2O
Ptp = 10 – (–15) = +25 cm H2O


40
20
0
-20
P_{AW}(cmH$_2$O)
43.4
2
4
40
20
0
-20
P_{ES} (cmH$_2$O)
25.2
2
4
20
10
0
-10
P_{TP}(cmH$_2$O)
18.2
2
4
Time (s)

PEEPi

- Oto-PEEP spontan solunum sırasında olabileeği gibi MV sırasında da olur.
- Entübe KOAH lılarda oto-PEEPi ve dinamik hiperenflasyonun nedenleri
- **Hasta ile ilgili faktörler**
  - Havaakımı sınırlanması
  - Bronkospazm
  - Sekresyonlar
- **Ventilatörle ilgili faktörler**
  - Yüksek VT
  - Kısa Te
- **Ekipmanla ilgili faktörler**
  - Düşük çaplı ET,
  - Ventilatör devresi
  - Ekspiryum valvi

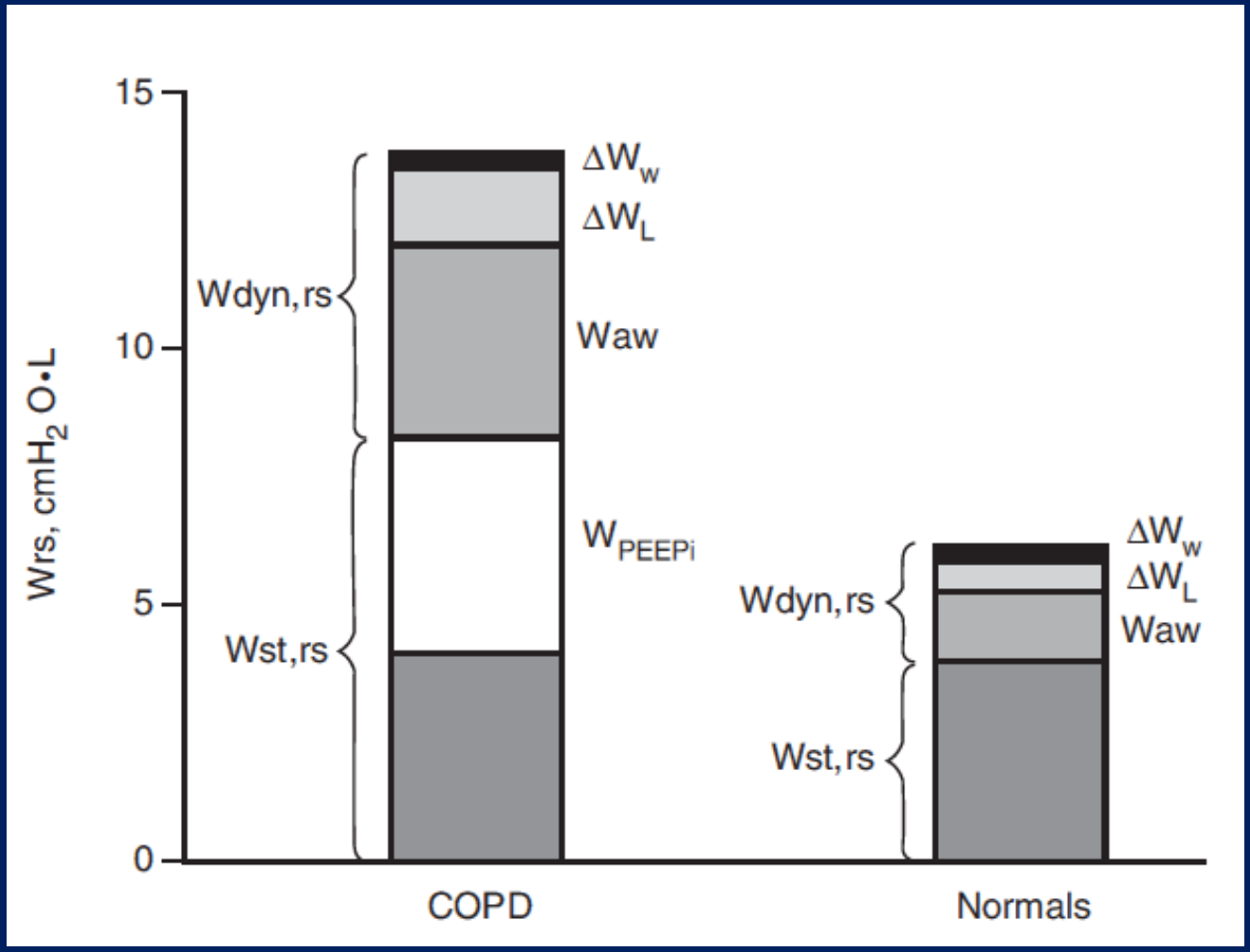
PEEPi oluşum mekanizması



Resistans

Rmax,rs=Ppeak-Pplat/Akım

Normal değerleri:1-8 cmH2O/sn

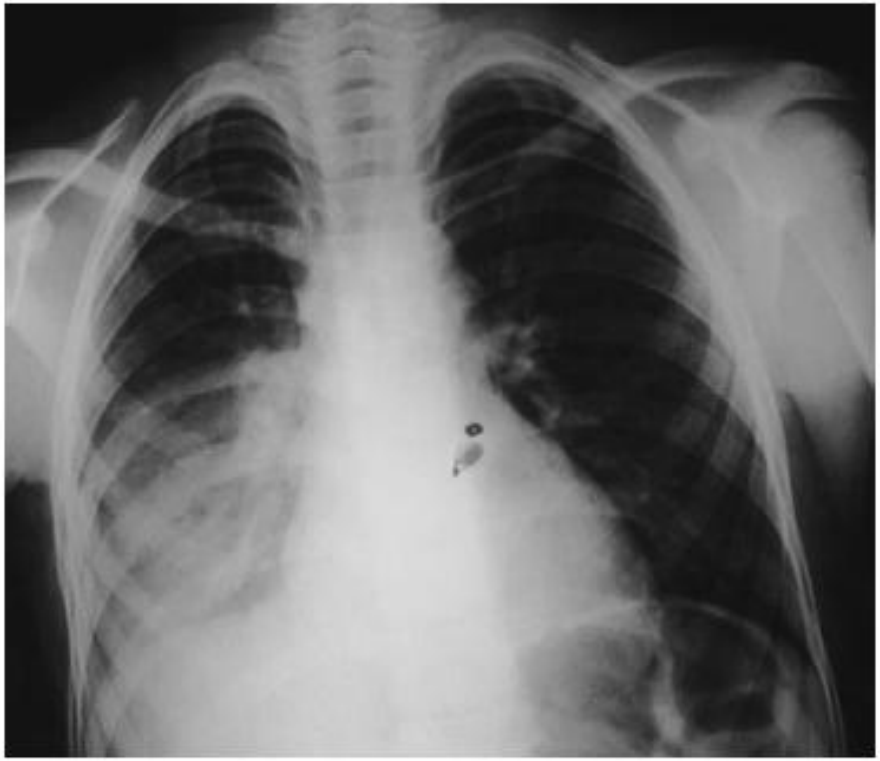

15
10
5
0
Wrs, cmH2O•L
Wdyn,rs
Wst,rs
ΔWw
ΔWL
Waw
WPEEPi
COPD
Wdyn,rs
Wst,rs
ΔWw
ΔWL
Waw
Normals

ZAMAN SABİTİ (Time Constants)

- Bir akciğer ünitesine basınç uygulandığında onu doldurmak için gerekli zaman ünitenin komplians ve resistansına bağlıdır.
- R yüksekse flow düşecek ve doldurmak uzayacak
- C yüksekse doldurmak için daha çok volüm gerekeceğinden daha uzun sürecektir
- ZS R ve C ın ürünü olup TC= RC
- Bir akciğer ünitesine sabit akım uygulandığında onun total volümünün %63 üne ulaşması için gereken zamanı gösterir.

KOAH da Meydana Gelen Değişiklikler

- Periferik havayolu direncinde artma
- Prematür havayolu kapanması
- Akciğer kompliansında artma
- Hava hapsinde artma
- Oto-PEEP
- IC ve IC/TLC azalır
- Hiperenflasyona bağlı olarak diyafram
- kaslarında kısalma ve kasılma yeteneğinde azalma



Resim 1.

Resim 2.


Alan (mm²): 0.0