Hemodinamik destek olarak Mekanik Ventilasyon

Dr. İsmail Cinel

Anesteziyoloji ve Reanimasyon Anabilim Dalı

Marmara Üniversitesi Tıp Fakültesi

Nerden Başlasam?
Nasıl Anlatsam?

Sitasyon = 13701

h indeks = 57

Michael R. Pinsky, MD.

Sitasyon = 13701

h indeks = 57

The Lancet, Volume 228, Issue 5904, 1936, Pages 981–983

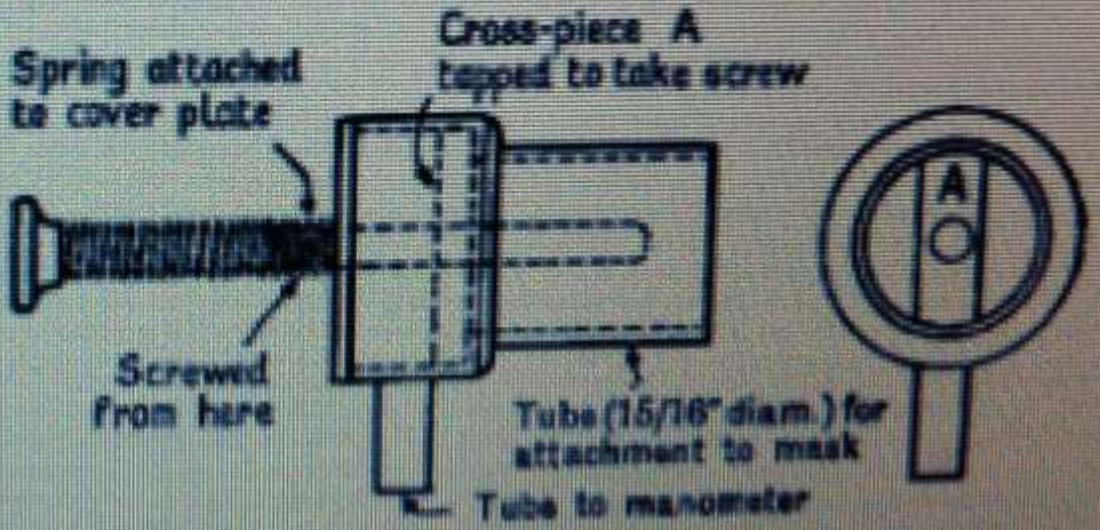
LEFT-SIDED HEART FAILURE WITH PULMONARY ŒDEMA

ITS TREATMENT WITH THE "PULMONARY PLUS PRESSURE MACHINE"

BY E. P. POULTON, D.M. Oxon., F.R.C.P. Lond.
PHYSICIAN TO GUY'S HOSPITAL, LONDON

ACUTE pulmonary œdema of circulatory origin must be due to incoördination between the right and left ventricle such that the volume of blood delivered per minute into the pulmonary circulation is not completely passed on into the systemic circulation by the left ventricle. Congestion of the pulmonary circulation with local rise of blood pressure must follow, leading to acute pulmonary œdema. A case of this kind with myocardial degeneration was investigated about ten years ago by Campbell and Poulton[1 2] in which evidence was brought forward that during muscular exercise there was acute pulmonary congestion lasting some minutes. Further, Crowden[3]

it will be better to try half this amount. The ordinary vacuum cleaner used as a blower usually gives too big a flow; it is cut down by an adjustable resistance or a machine of oversize voltage may be used. When the household vacuum cleaner is employed the machine should be run for some minutes first of all to get rid of dust; then a new flexible tube should be fitted, and there should be a cotton-wool filter. If



the stream of air is too rapid the patient may complain of the air being cold. Apart from cutting down

CHEST editorials

VOLUME 85 / NUMBER 1 / JANUARY, 1984

Mechanical Breath

Non-pharmacologic Support for a Failing Heart?

Mali Mathru, M.D., F.C.C.P.
Jacksonville, Florida

- 1. Ppl ↑ preload ↓
- 2. PaO_2 ↑ PCO_2 ↓ PAP ↓
- 3. Alveolar kapillerlerin mekanik olarak kompresyonu ile sol ventrikül preloadı düşer. Yüklenmiş kalpte LVEDV azalma CO’u artırır.
- 4. Transmural basınç ↓ LV afterload ↓
- 5. Kardiyojenik şok gibi oksijen sunumunun azalmış olduğu durumlarda, zaten sınırlı olan sunumun solunum kasları tarafından tüketilmesi önlenmiş olur.
- 6. Genellikle uygulanan sedasyon sempatik deşarjı önleyerek sol ventrikülü rahatlatır.

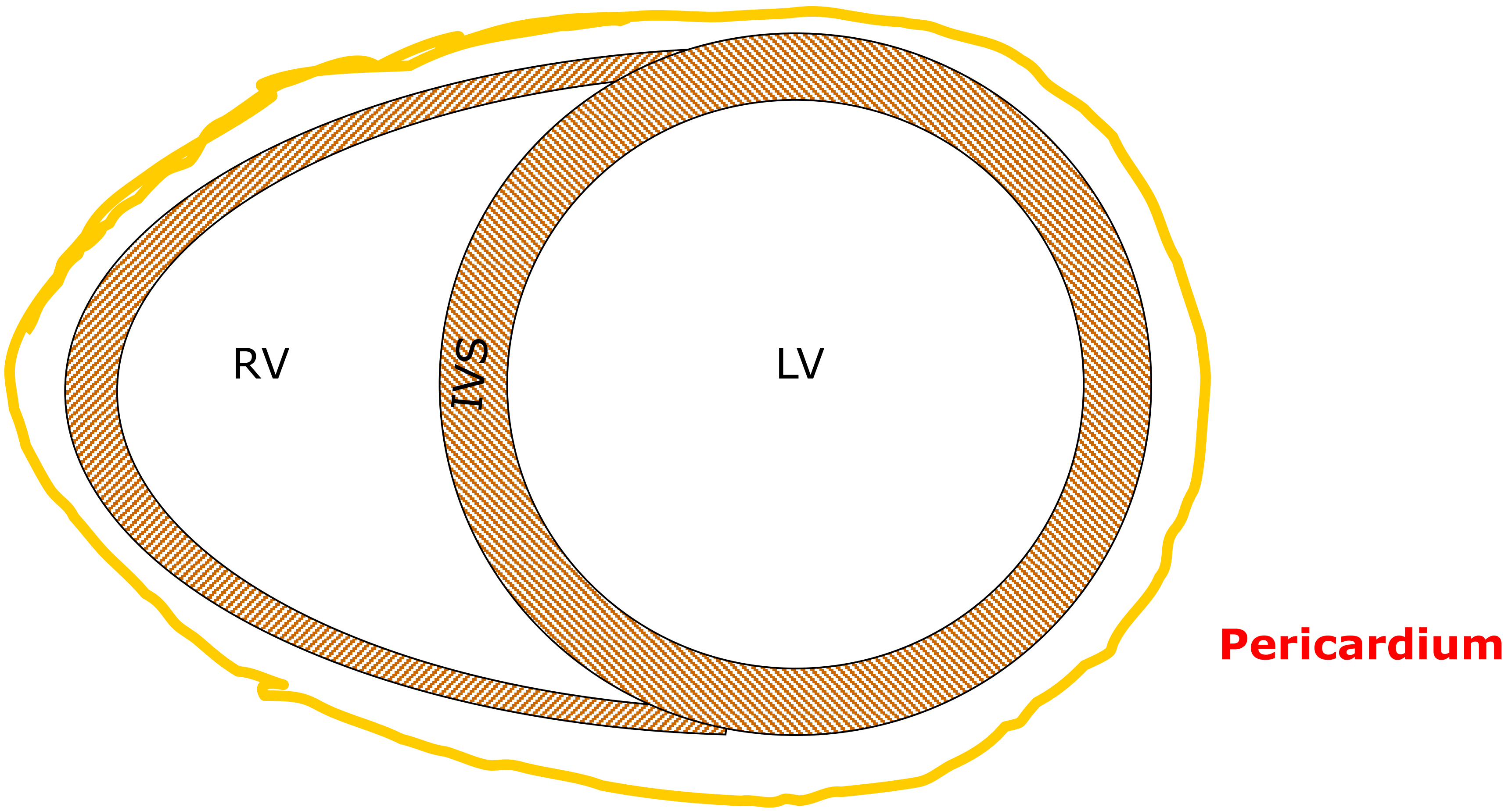
Solunum ⟷ **Dolaşım**

1. **Mekanik (Hidrolik)**
2. **Nöral**
3. **Humoral**

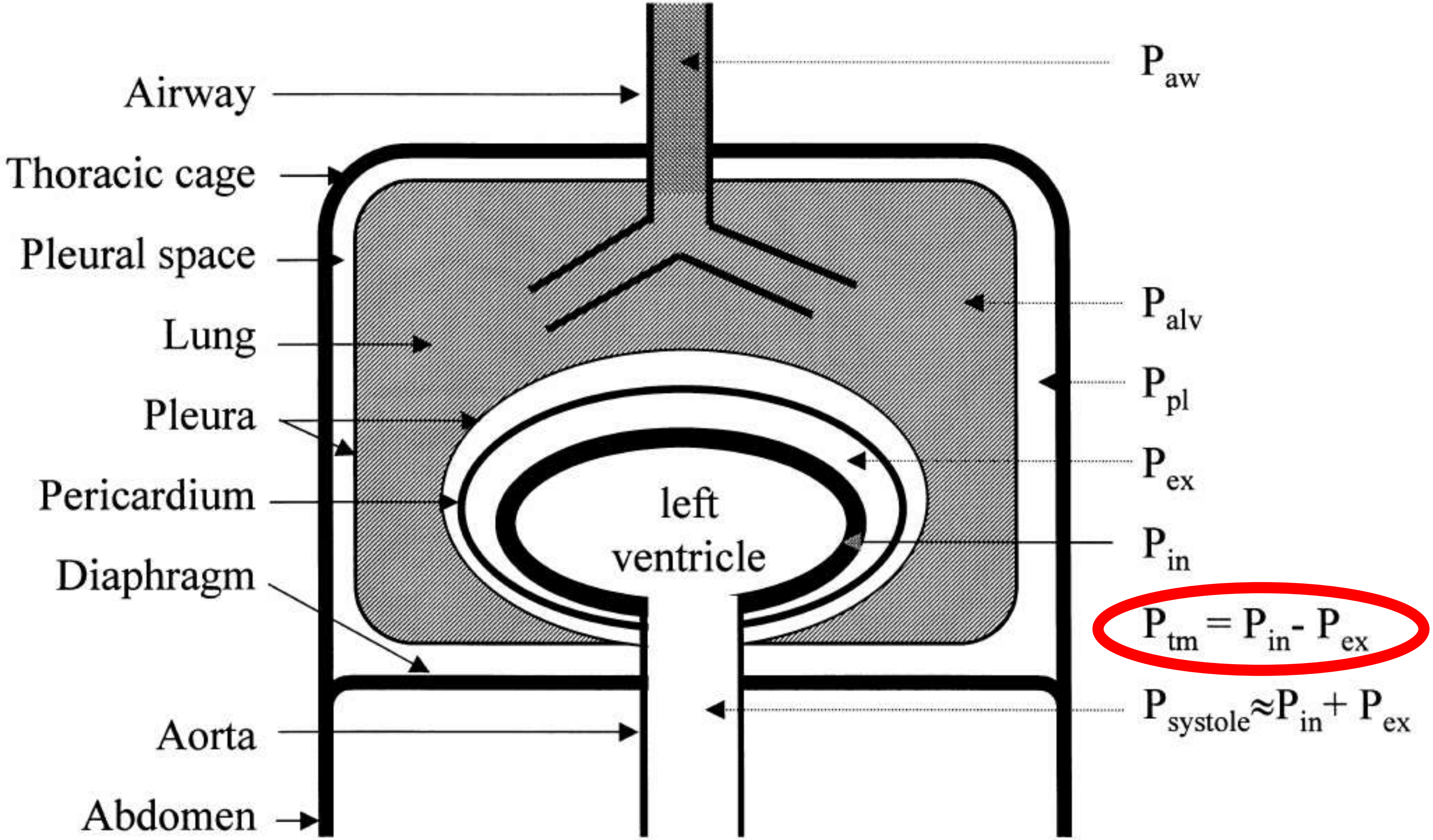
Bitişik akciğer
Perikard
Kalp

} Volum ve kompliyans

'Ventricular Interdependence'



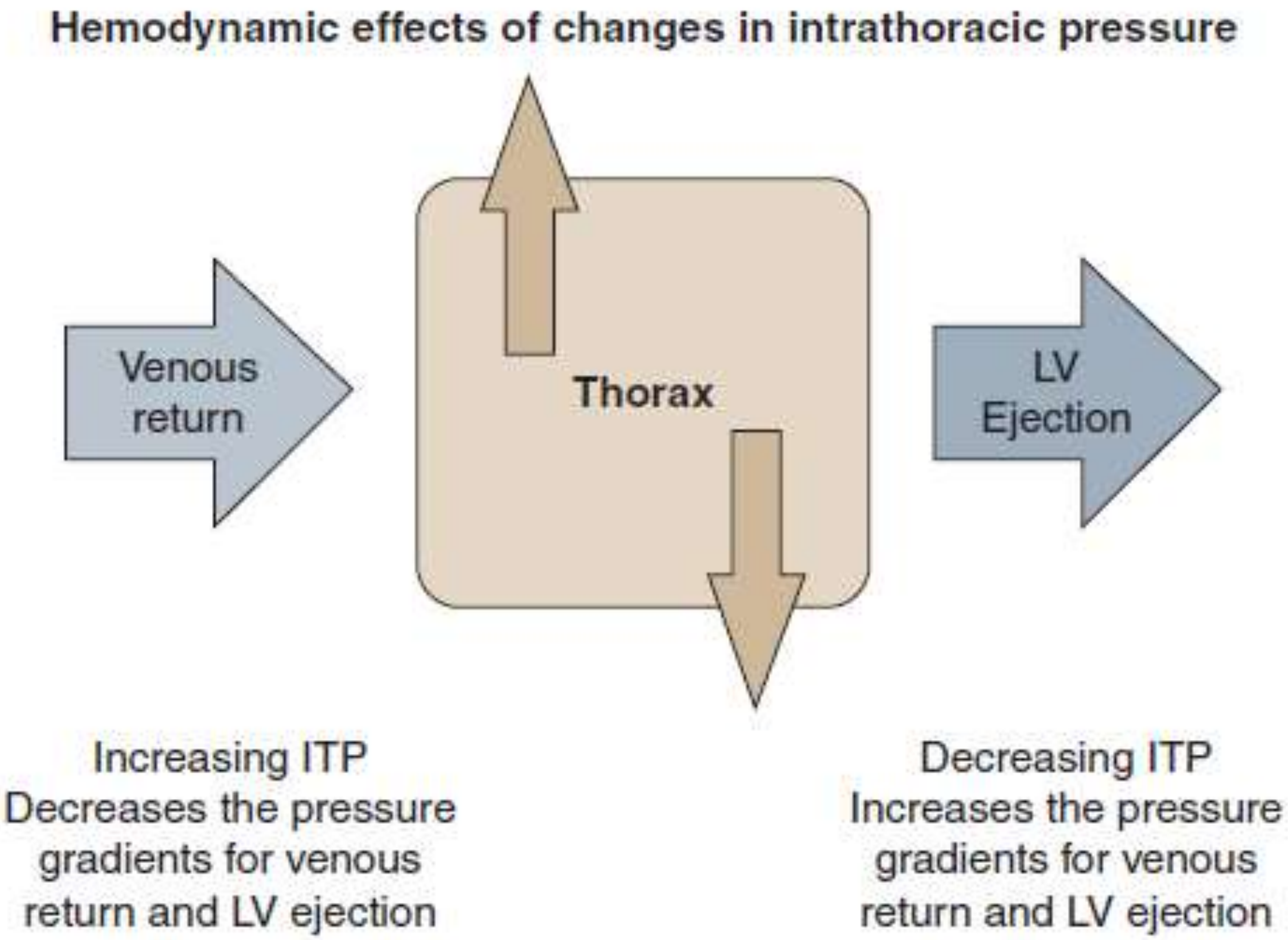
P/V……RV……LV



Airway
Thoracic cage
Pleural space
Lung
Pleura
Pericardium
Diaphragm
Aorta
Abdomen
left ventricle
P_{aw}
P_{alv}
P_{pl}
P_{ex}
P_{in}
$P_{tm} = P_{in} - P_{ex}$
$P_{systole} \approx P_{in} + P_{ex}$

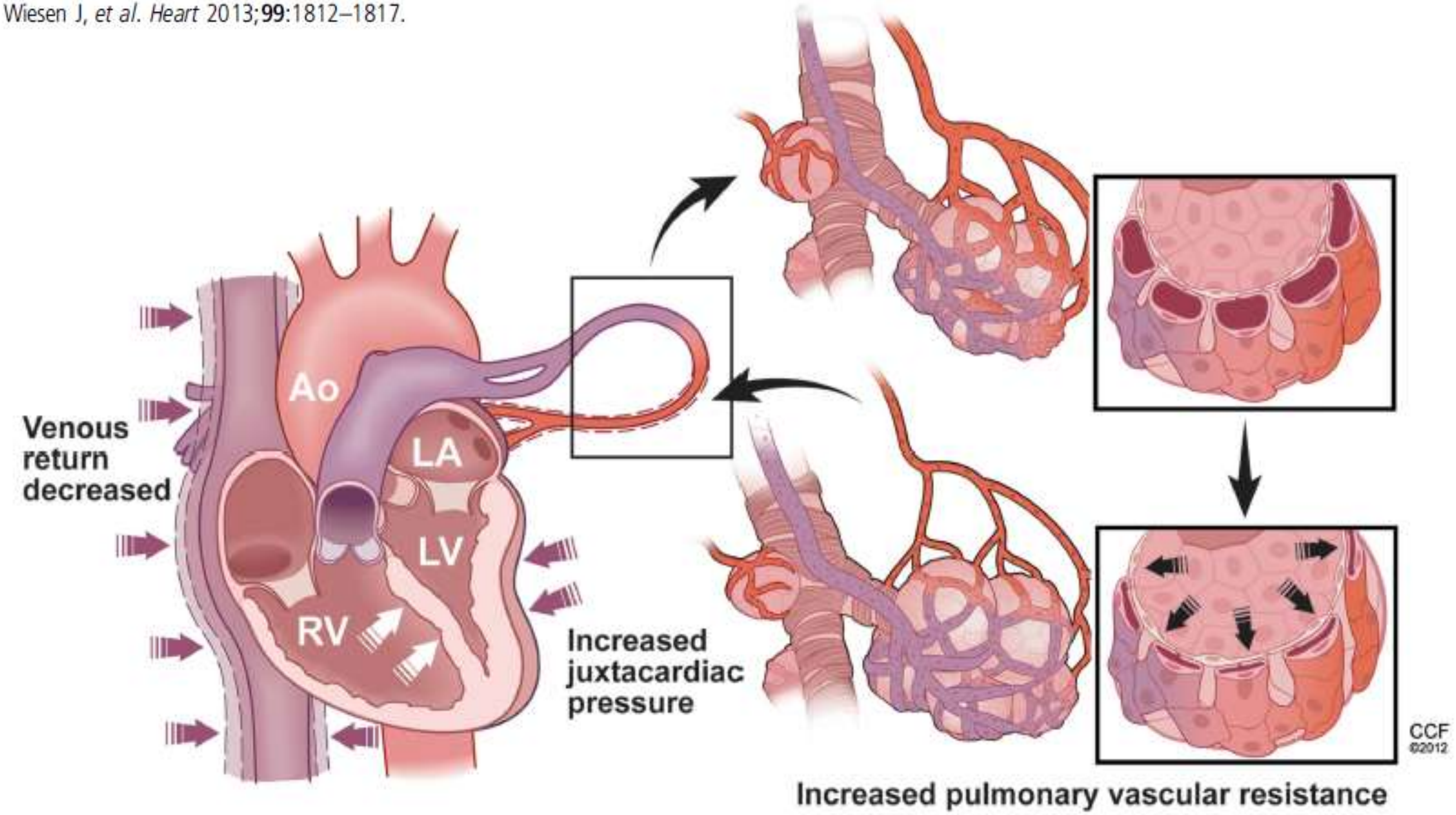
EFFECT OF MECHANICAL VENTILATION ON HEART–LUNG INTERACTIONS

Hernando Gomez
Michael R. Pinsky

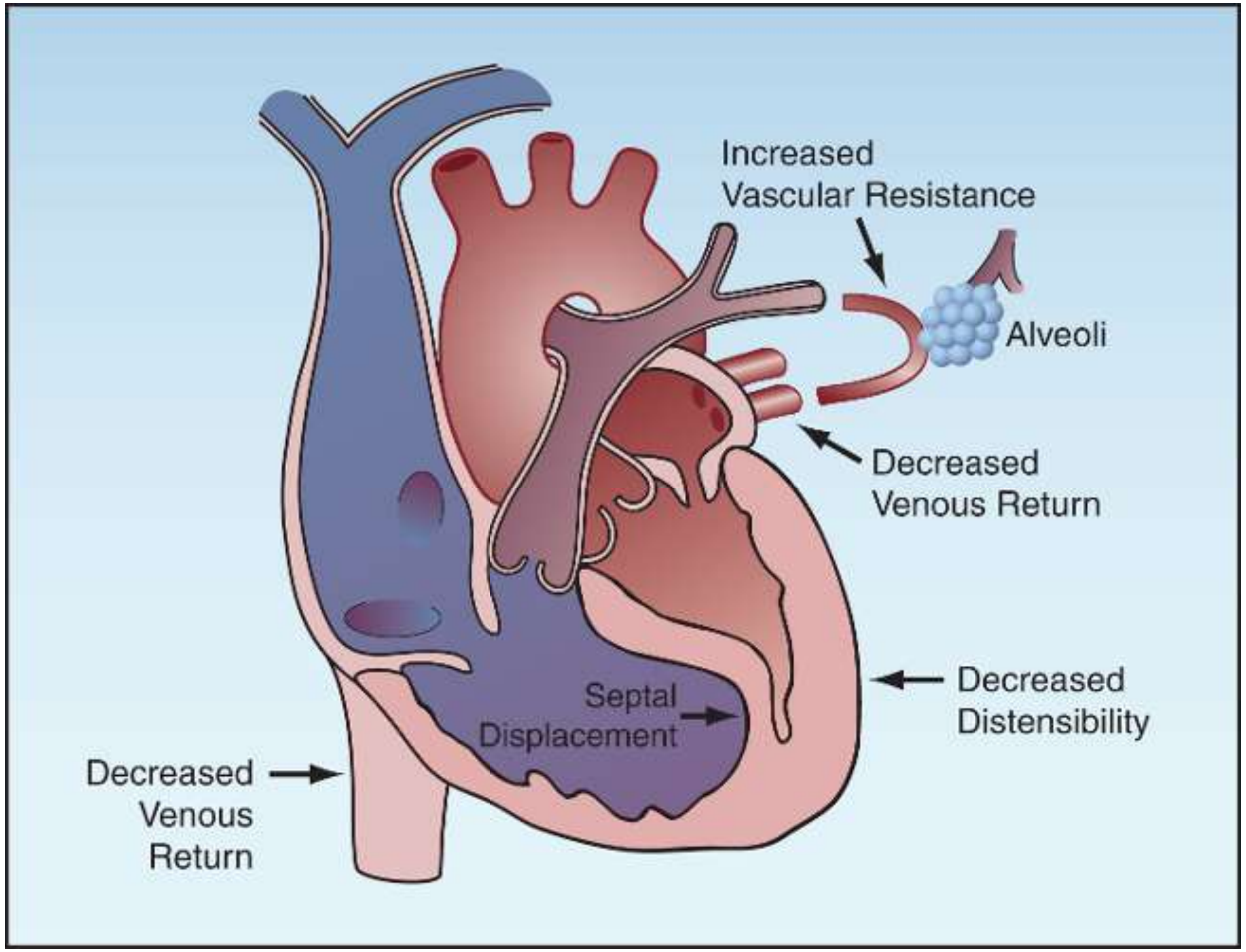


Mekanik ventilasyonun sağlıklı kalbe etkisi

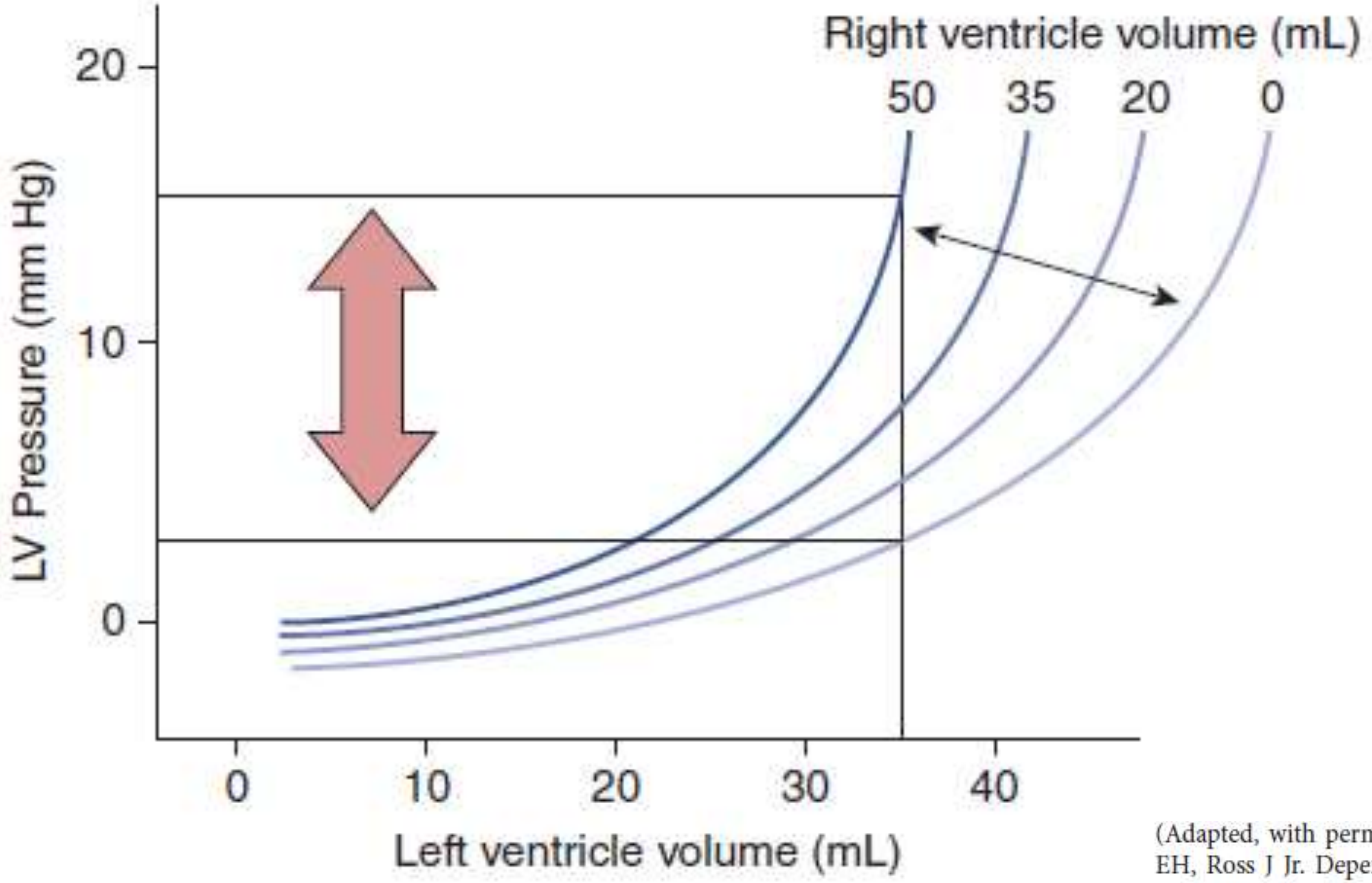
Wiesen J, *et al*. *Heart* 2013;**99**:1812–1817.



Mekanik ventilasyonun sağlıklı kalbe etkisi



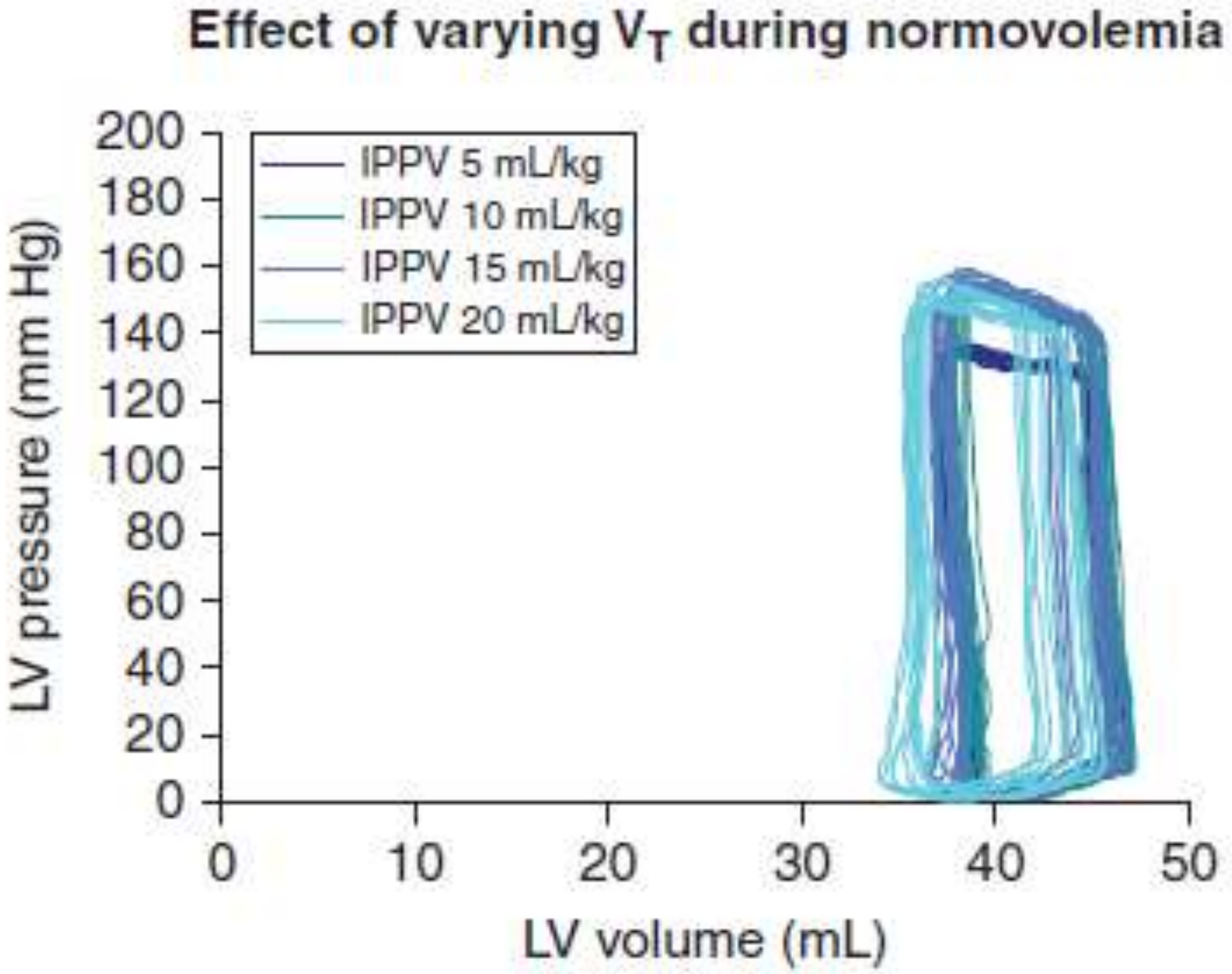
Changing RV end-diastolic volume changes LV diastolic compliance

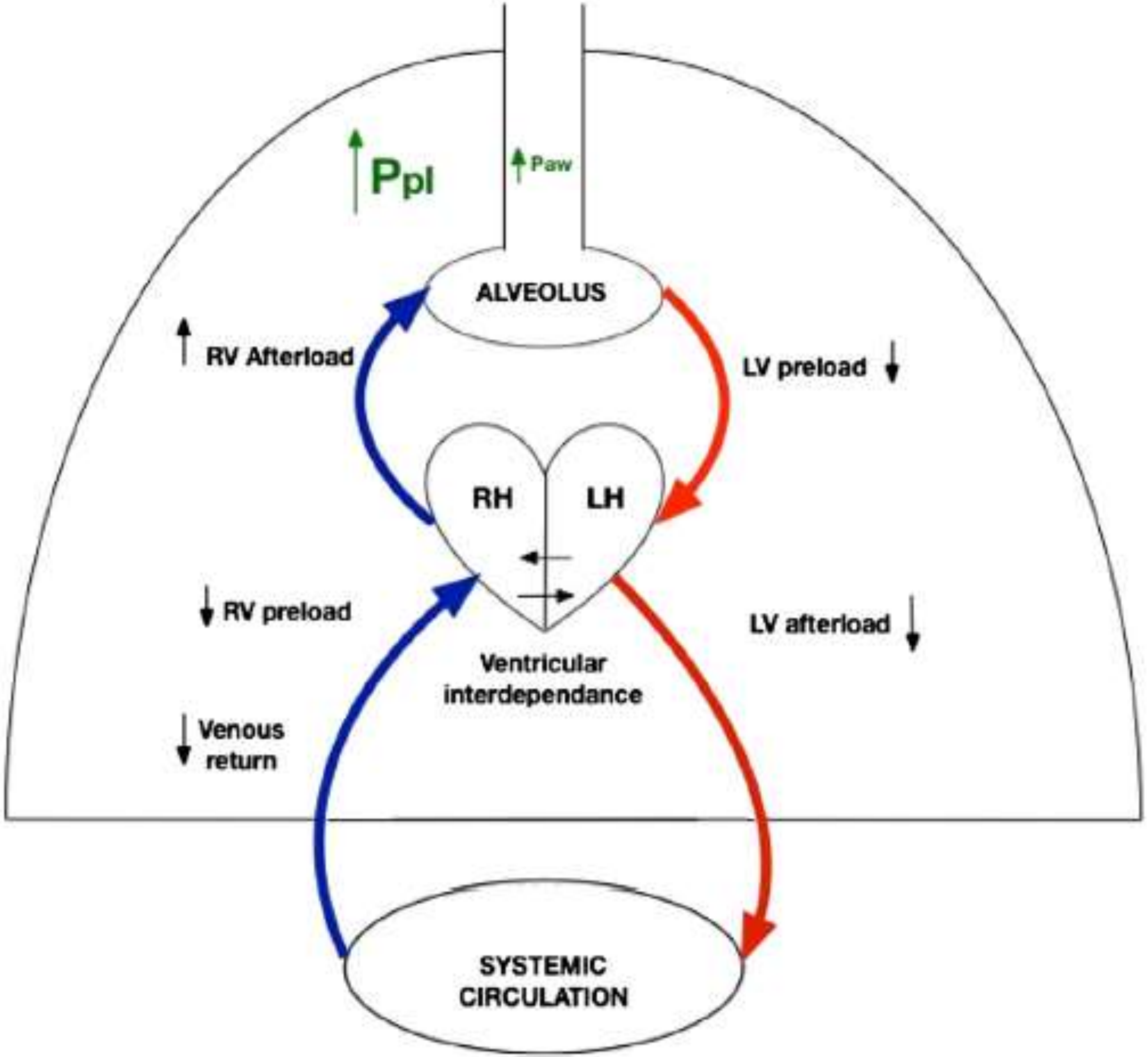


(Adapted, with permission, from Taylor RR, Covell JW, Sonnenblick EH, Ross J Jr. Dependence of ventricular distensibility on filling the opposite ventricle. *Am J Physiol*. 1967;213:711–718.)

EFFECT OF MECHANICAL VENTILATION ON HEART–LUNG INTERACTIONS

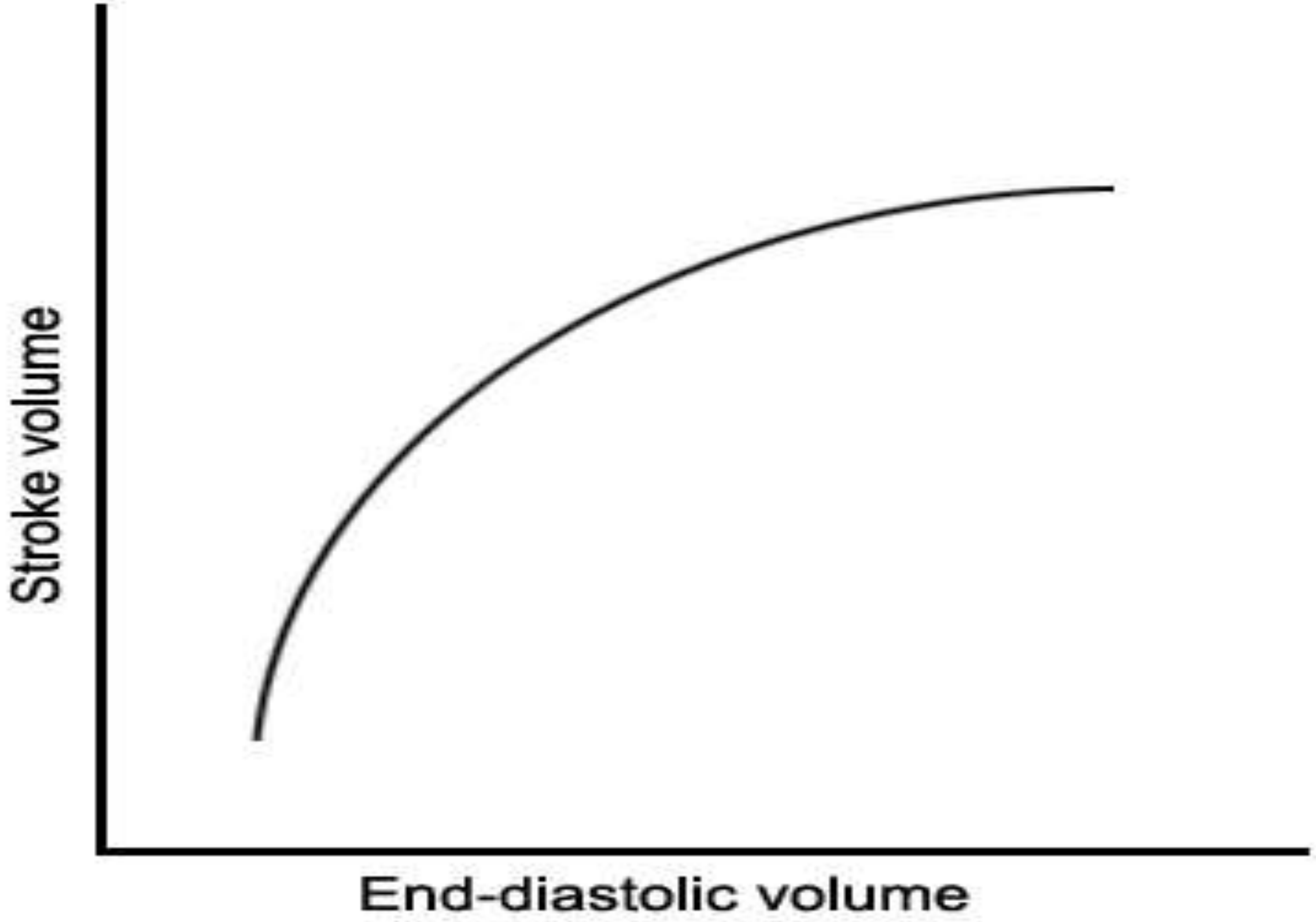
Hernando Gomez
Michael R. Pinsky

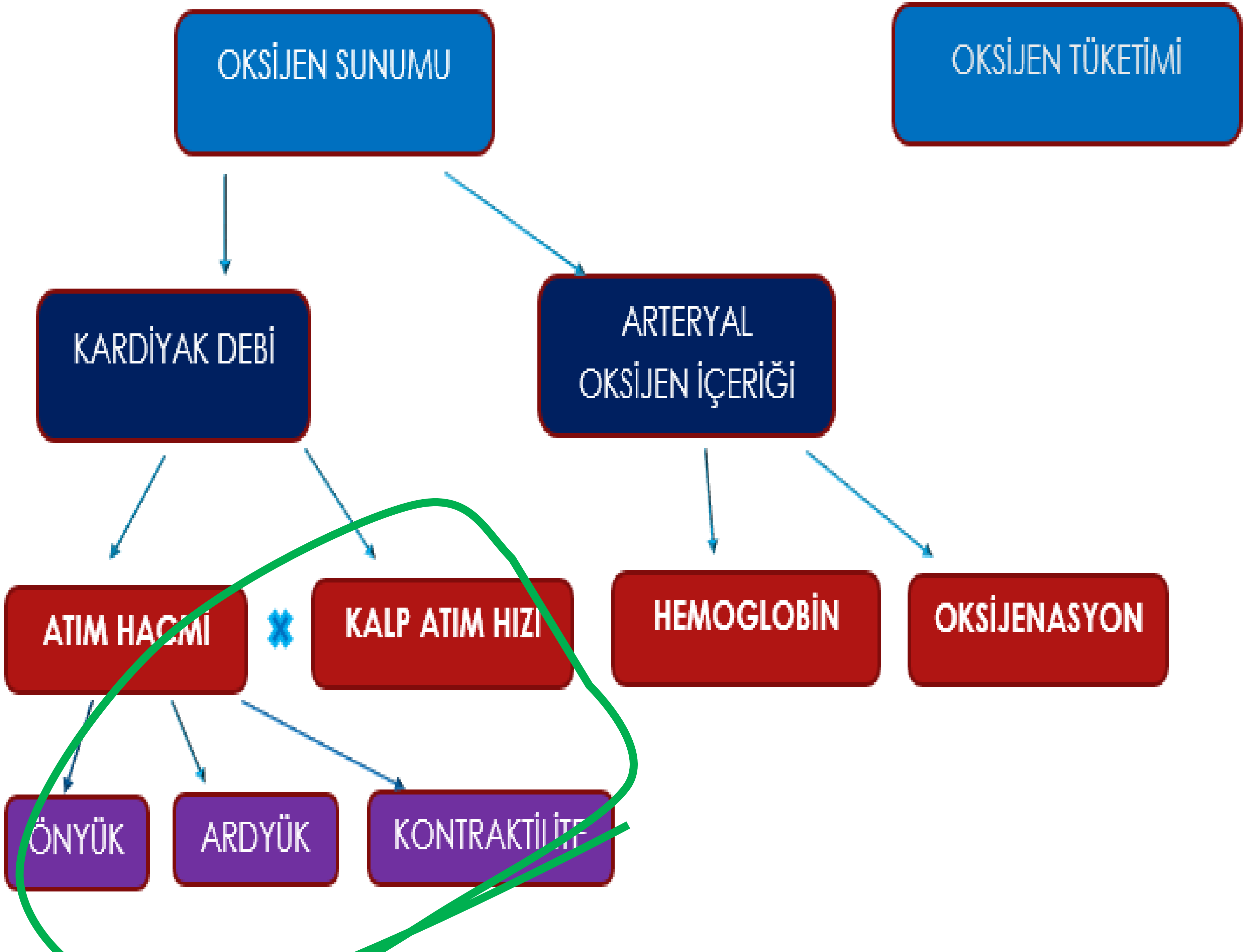




Ppl
Paw
ALVEOLUS
RV Afterload
LV preload
RH
LH
RV preload
LV afterload
Ventricular
interdependance
Venous
return
SYSTEMIC
CIRCULATION

Frank-Starling



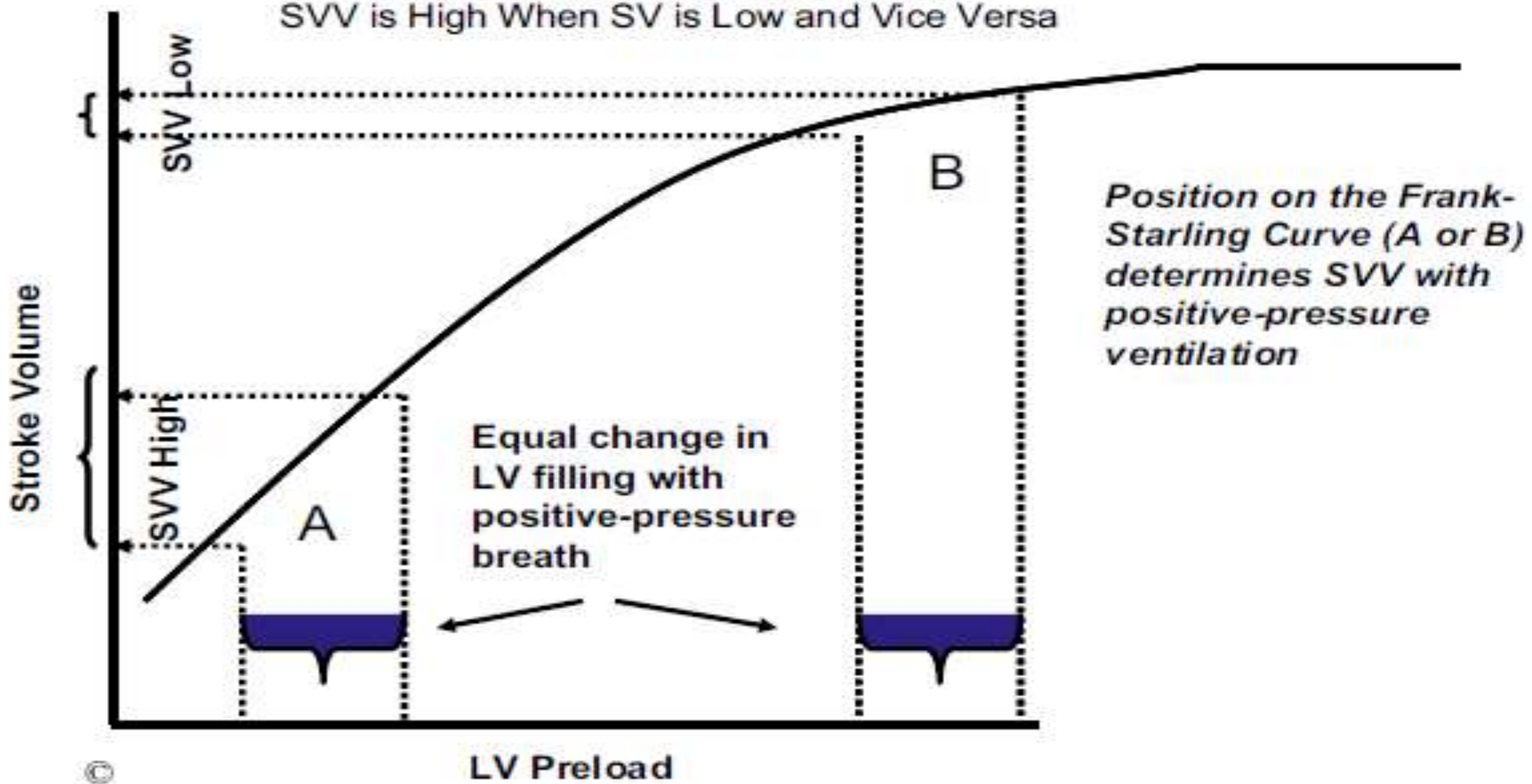

OKSİJEN SUNUMU
OKSİJEN TÜKETİMİ
KARDİYAK DEBİ
ARTERYAL OKSİJEN İÇERİĞİ
ATIM HACMİ
x
KALP ATIM HIZI
HEMOGLOBİN
OKSİJENASYON
ÖNYÜK
ARDYÜK
KONTRAKTİLİTE

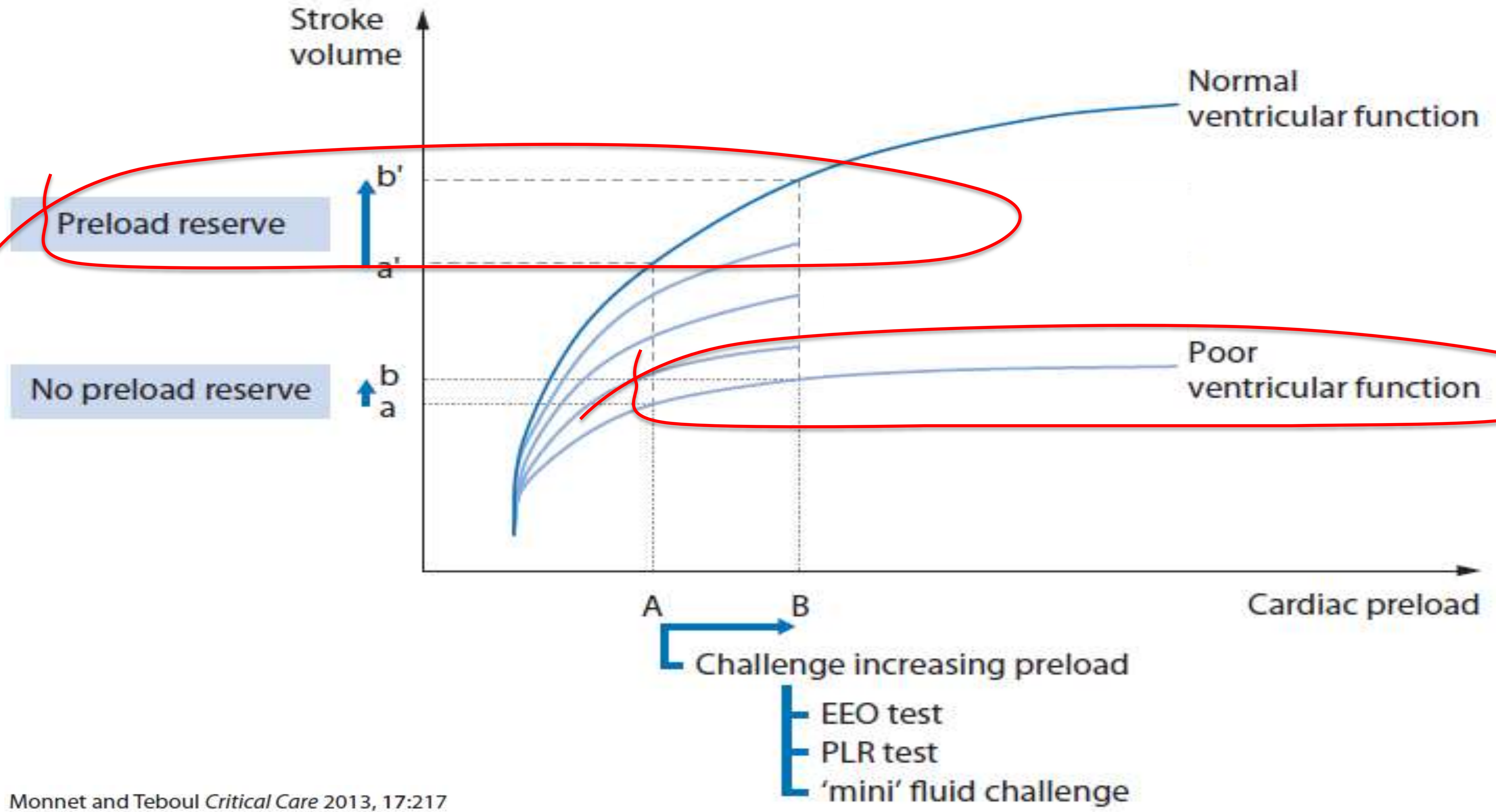
Physiologic Goal-Directed Therapy in the Perioperative Period: The Volume Prescription for High-Risk Patients

William T. McGee, MD,* and Karthik Raghunathan, MD†

Journal of Cardiothoracic and Vascular Anesthesia, Vol [redacted], No [redacted] (Month), 2013: pp [redacted]

Magnitude of SVV
Is Related to Location of Individual Patients on
Their Frank-Starling Curve
For the Same Change in LV Filling
SVV is High When SV is Low and Vice Versa

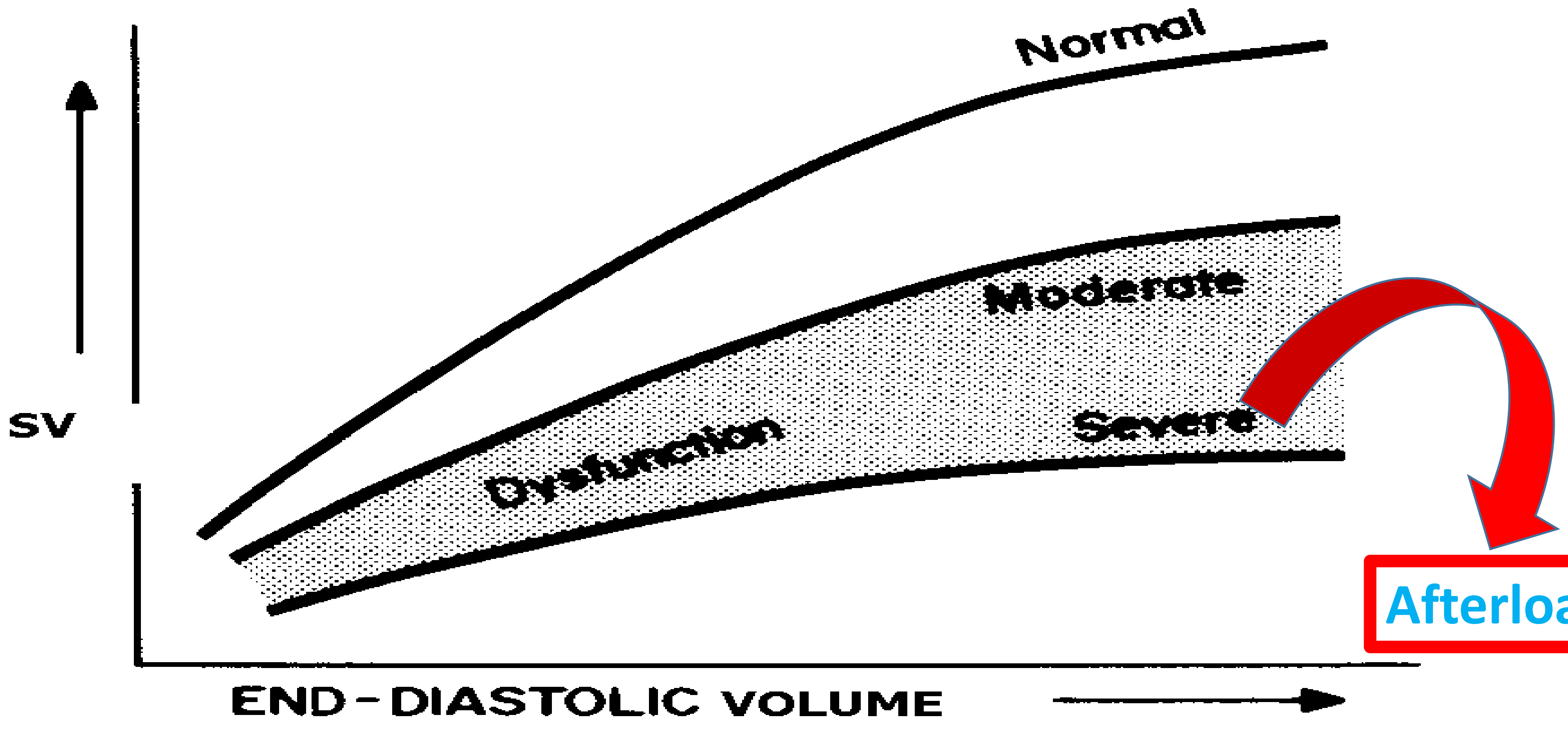




Monnet and Teboul *Critical Care* 2013, 17:217

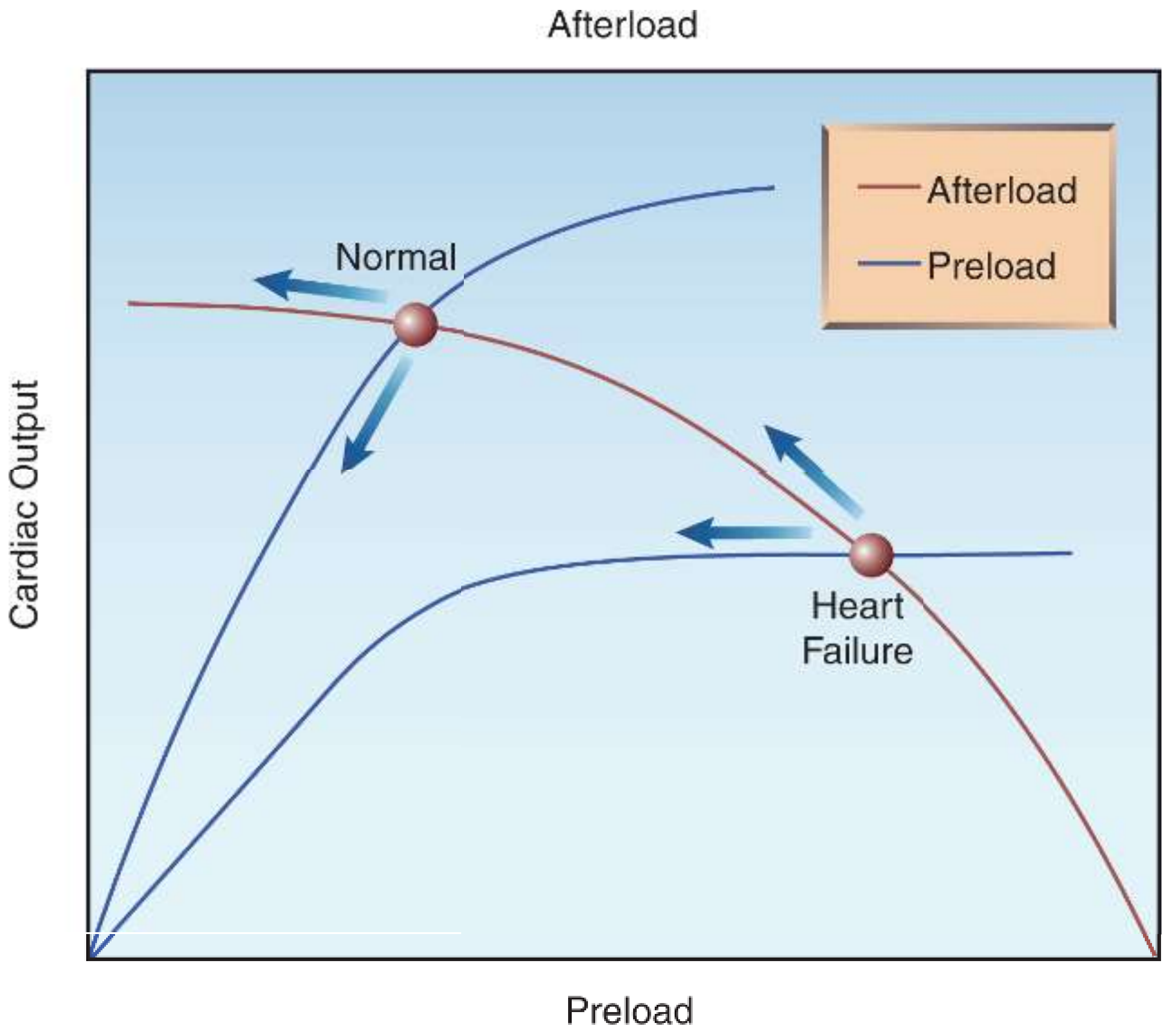
Hangisinde? Hangi Noktasında?

Frank – Starling Eğrisi



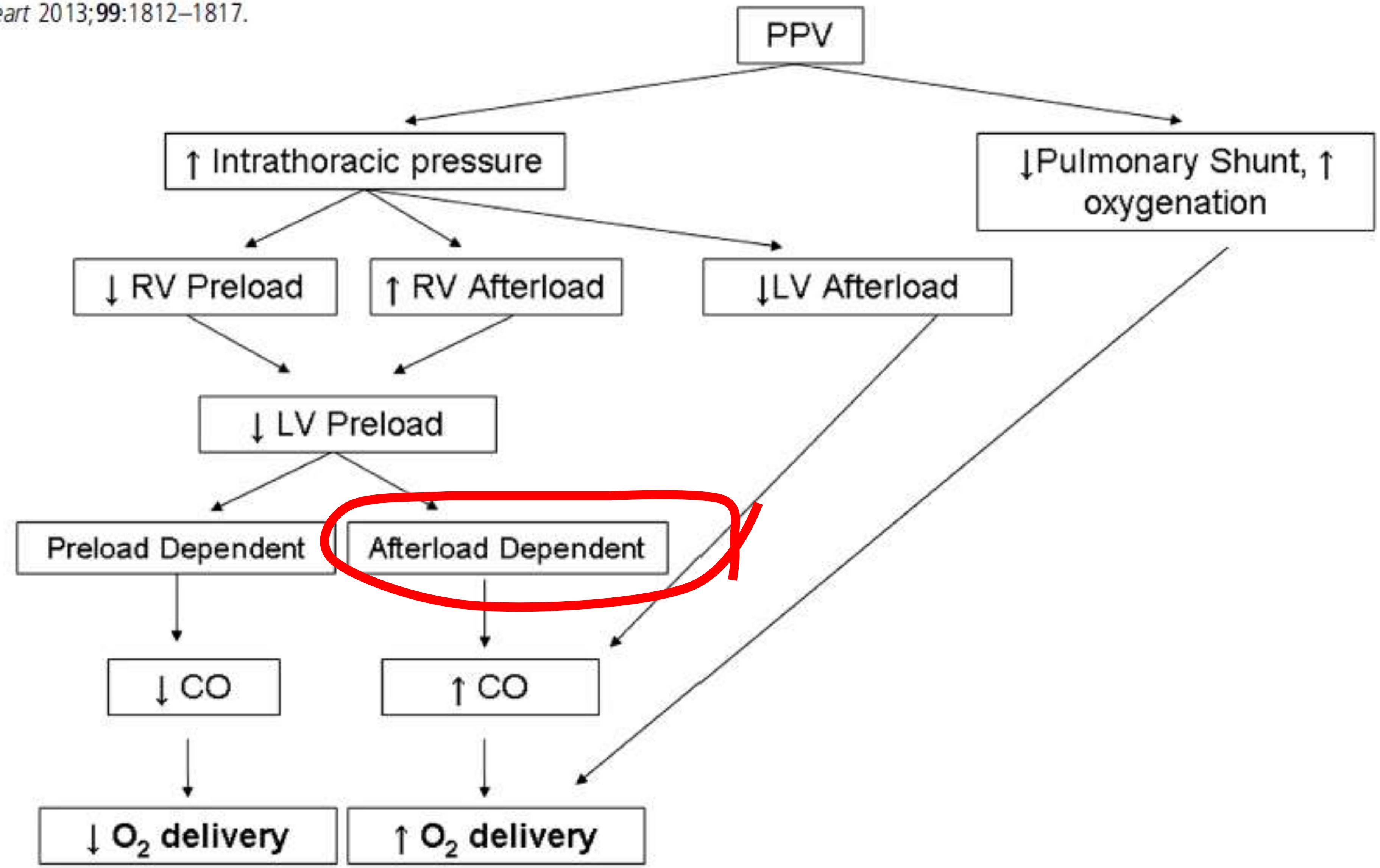
Afterload duyarlı !

Pozitif Basınçlı Ventilasyonun Kalp Debisine Etkisi



‘Preload dependent’ vs ‘Afterload dependent’

Wiesen J, *et al*. *Heart* 2013;**99**:1812–1817.



‘Preload-dependent’

- Hipovolemi
- İskemi
- Restriktif kardiyomyopati
- Tamponad
- Kapak darlığı

‘Afterload-dependent’

A. Sol ventrikül disfonksiyonuna bağlı akut solunum yetersizliği

- Kardiyojenik Pulmoner Ödem

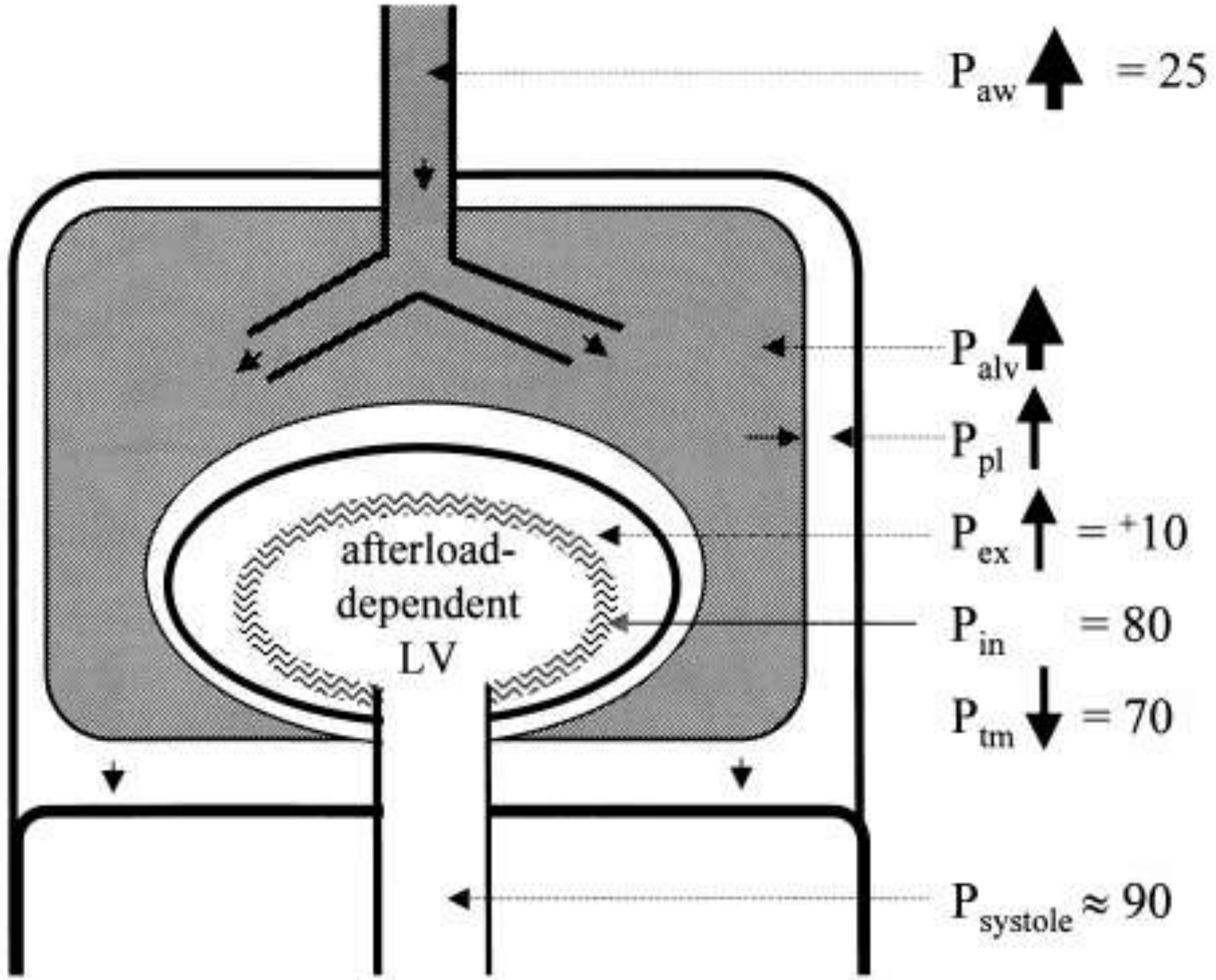
B. Solunum sisteminin indüklediği kalp yetersizliği (sistolik disfonksiyon varlığında)

- Şiddetli kardiyomyopati
- İskemik kalp hastalığı

Pozitif Basınçlı Ventilasyonun 'Preload', 'Afterload' ve Kalp Debisi Üzerine Etkileri

Haemodynamic effect of positive pressure ventilation	Likely effect on cardiac output: Preload dependent	Likely effect on cardiac output: Afterload dependent
RV preload ↓	↓	↑
RV afterload ↑	↓	↓
LV preload ↓	↓	↑
LV afterload ↓	↑	↑

Wiesen J, *et al. Heart* 2013;**99**:1812–1817.



Sistolik disfonksiyon varlığında PPV'nun etkisi

Hemodynamic Effects of Noninvasive Bilevel Positive Airway Pressure on Patients With Chronic Congestive Heart Failure With Systolic Dysfunction*

Brick Acosta, MD; Robert DiBenedetto, MD, FCCP; Ali Rahimi, MD; Maria Francesca Acosta, MD; Orlando Cuadra, MD; An Van Nguyen, RRT, RCP; and Lee Morrow, MD

CHEST 2000; 118:1004

- Ağır sistolik disfoksiyona (EF<%35) sekonder KKY olan 14 hasta

	Başlangıç	1 saat BIPAP	p
SKB	136	124	0.008
KAH	85	75	0.002
SS	23	15	0.001
SVR	1671	1236	0.001
CO	5.09	6.37	0.004
EF	28.7	34.4	0.001
LVED	224	246	0.045

Does Continuous Positive Airway Pressure by Face Mask Improve Patients With Acute Cardiogenic Pulmonary Edema Due to Left Ventricular Diastolic Dysfunction?*

Variables	Baseline	CPAP
RR, breaths/min	37 ± 5	28 ± 4†
Arterial blood pH	7.41 ± 0.07	7.41 ± 0.04
Pa_{O_2}, mm Hg	70 ± 10	126 ± 27†
Pa_{CO_2}, mm Hg	39 ± 3	40 ± 3
Sp_{O_2}, %	89 ± 2	97 ± 1†
Heart rate, beats/min	104 ± 15	91 ± 18
MAP, mm Hg	76 ± 16	67 ± 7
LV end-diastolic volume, mL	128 ± 23	113 ± 17
LVEF, %	39 ± 12	45 ± 8†
VTIAo, cm	17.5 ± 5	16.9 ± 2
E, cm	0.93 ± 0.5	0.83 ± 0.4
A, cm	0.7 ± 0.18	0.7 ± 0.19
E/A ratio	1.4 ± 0.6	1.2 ± 0.5

*Values given as mean ± SD.

†$p < 0.05$ compared to baseline.

CHEST / 127 / 3 / 2005

Variables	Preserved LV Systolic Function (n = 4)		Decreased LV Systolic Function (n = 5)	
	Baseline	CPAP	Baseline	CPAP
RR, breaths/min	37 ± 5	28 ± 4†	32 ± 5	24 ± 4†
Arterial blood pH	7.41 ± 0.07	7.41 ± 0.04	7.38 ± 0.03	7.39 ± 0.02
Pa_{O_2}, mm Hg	71 ± 8.5	134 ± 25†	69 ± 12	120 ± 30†
Pa_{CO_2}, mm Hg	39 ± 3	40 ± 3	37 ± 3	38 ± 2
Sp_{O_2}, %	89 ± 2	97 ± 1†	87 ± 3	96 ± 1†
Heart rate, beats/min	101 ± 19	83 ± 11	105 ± 13	98 ± 21
MAP, mm Hg	91 ± 13	72 ± 6†	64 ± 4	63 ± 3
LV end-diastolic volume, mL	107 ± 4	98 ± 3†	148 ± 4	128 ± 8†
LVEF, %	49 ± 2	51 ± 2	29 ± 6	38 ± 6†
VTIAo, cm	21.3 ± 4.6	17.9 ± 2.4	14.4 ± 2	16.2 ± 2
E, cm	0.59 ± 0.17	0.66 ± 0.11	1.19 ± 0.52	0.98 ± 0.5
A, cm	0.6 ± 0.1	0.65 ± 0.08	0.71 ± 0.23	0.67 ± 0.26
E/A ratio	1 ± 0	1 ± 0.22	1.7 ± 0.7	1.5 ± 0.6

*Values given as mean ± SD.

†$p < 0.05$ compared to baseline.

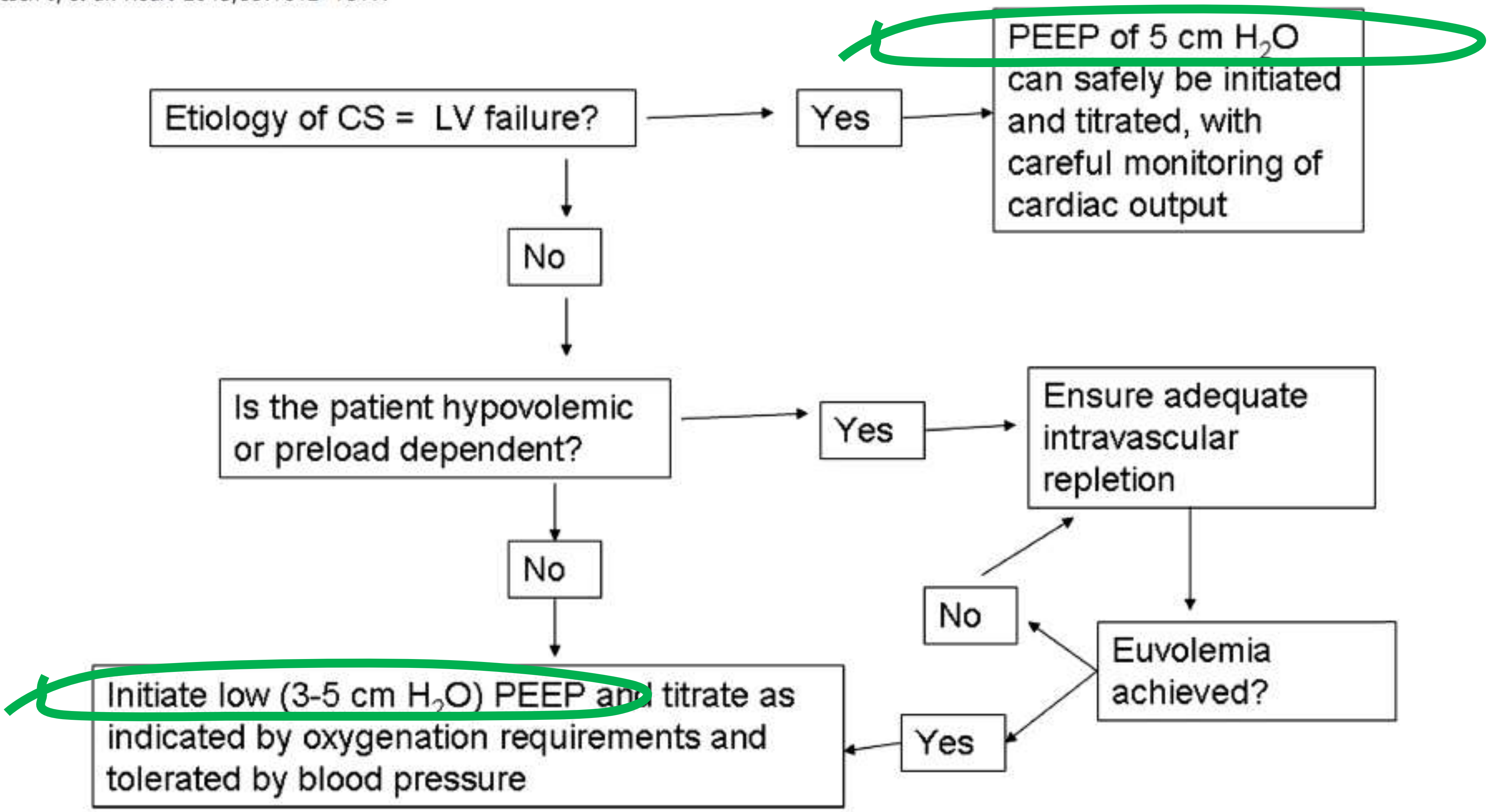
Sol Ventrikül Disfonksiyonu olan hastalarda PEEP Kullanımı

Study	n	Description of study	Patient groupings	Definition of LV dysfunction	Amount of PEEP (cm H_2O)	Cardiopulmonary changes with PEEP
Grace and Greenbaum[38]	21	Medical ICU; titration of PEEP to maximal CO	Divided by PCWP (≤12, 14–18, ≥19)	AMI, CS or CHF requiring MV	0–8	CO increase in 12/13 of patients with PCWP ≥19
Mathru *et al*,[54]	290	Surgical ICU, post CABG; MV by CMV, IMV or IMV +PEEP	Divided by EF and LVEDP	EF <60% (mean 34%) and LVEDP >16 Torr (mean 19)	5	Improvement in RAP, PCWP, CI, SI
Dongelmans, 1986[10]	121	Surgical ICU, post CABG; MV with high versus low PEEP	High (10) versus Low (5) PEEP	None provided	5–10	Improved lung compliance, PaO_2 and decreased need for supplemental O_2 on discharge, but longer duration of MV
Malbouisson *et al*,[55]	10	Surgical ICU, post CABG; recruitment manoeuvres with high PEEP	–	Requirement of inotropic support for CS (CI <2.5)	Up to 40	Improved PaO_2/FIO_2, reduced intrapulmonary shunting, no decrease in MAP or CI
Kontoyannis *et al*,[39]	28	Medical ICU; patients with myocardial infarction complicated by CS requiring IABP	IABP alone versus IABP plus elective MV+PEEP	Systolic blood pressure <80 mm Hg with end organ damage	10	Improved ability to wean mechanical support (90% vs 56%), PCWP, CI, UO and discharge survival (80% vs 28%)

Wiesen J, *et al*. *Heart* 2013;**99**:1812–1817.

Kardiyojenik Şok ve Sol Ventrikül Yetersizliği

Wiesen J, *et al*. *Heart* 2013;**99**:1812–1817.



Mekanik Ventilasyonun Kardiyak Etkileri

	Preload-Related Ventricular Dysfunction	RV Dysfunction	LV Dysfunction
Examples	Hypovolemia Ischemia Restrictive cardiomyopathy Cardiac tamponade Valvular stenoses	Severe pulmonary hypertension COPD Acute PE RV Infarct	Ischemic cardiomyopathy Cardiogenic pulmonary edema
Effect of mandatory ventilation on cardiac function	↓LVEDV (preload) ↓Cardiac output	↑RV afterload ↑RV O_2 demand	↓Afterload ↓Myocardial O_2 demand ↑Cardiac output
Measures to prevent adverse cardiovascular effects	Fluid loading Minimize airway pressure	Treat hypoxia and acidosis Ensure adequate coronary perfusion Ensure adequate intravascular volume	PEEP/CPAP beneficial

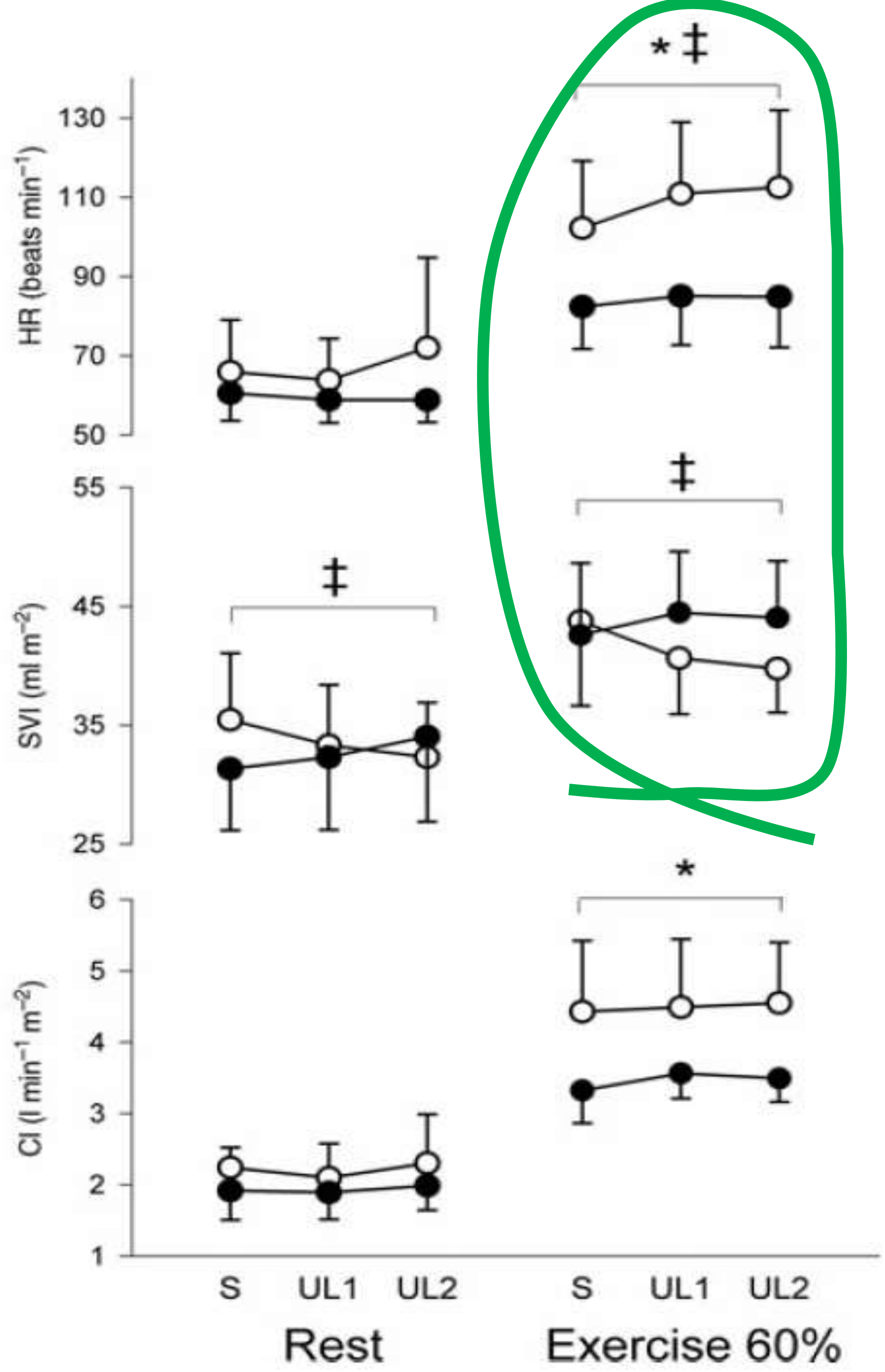
Effect of changes in intrathoracic pressure on cardiac function at rest and during moderate exercise in health and heart failure

Sophie Lalande, Charles E. Luoma, Andrew D. Miller and Bruce D. Johnson

Exp Physiol 2012, 97, 248

Division of Cardiovascular Diseases, Mayo Clinic, Rochester, MN 55905, USA

- Sağlıklı 11 ve EF<%40 11 hasta, ağızlık ile spirometreye bağlı olarak solutulmuş
- İnspiratuar yükü ortadan kaldırmak için BIPAP
- EKO ile SV



Conclusion

In conclusion, inspiratory unloading improved SVI at rest and during moderate exercise in patients with heart failure, possibly due to a reduction in LV afterload.

RANDOMIZED TRIAL OF BILEVEL VERSUS CONTINUOUS POSITIVE AIRWAY PRESSURE FOR ACUTE PULMONARY EDEMA

Timothy Liesching, MD,* David L. Nelson, RRT,† Karen L. Cormier, RRT,† Andrew Sucov, MD,‡ Kathy Short, RN, RRT,§ Rod Warburton, BA,|| and Nicholas S. Hill, MD||

*Division of Pulmonary, Critical Care and Sleep Medicine, Lahey Clinic, Burlington, Massachusetts, †Department of Respiratory Care, ‡Division of Emergency Medicine, Rhode Island Hospital, Providence, Rhode Island, §Department of Respiratory Care, University of North Carolina, Chapel Hill, North Carolina, and ||Division of Pulmonary, Critical Care and Sleep Medicine, Tufts Medical Center, Boston, Massachusetts

The Journal of Emergency Medicine, Vol. 46, No. 1, pp. 130–140, 2014

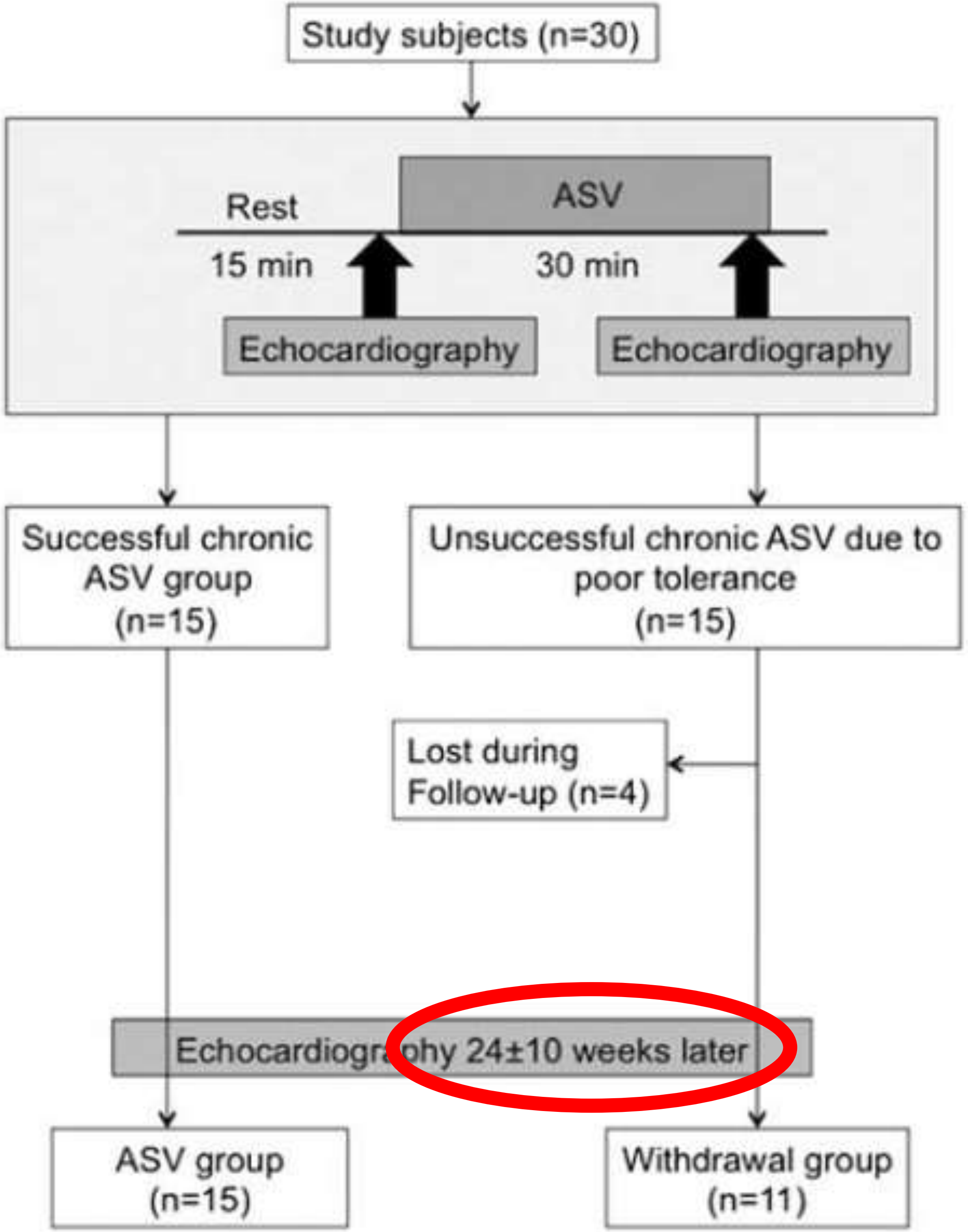
	CPAP	BPAP	*p* Value
ICU admission	91.67%	38.46%	0.008*
ICU length of stay	4.63	3.43	0.143
Hospital length of stay	6.64	6.50	0.623
Hospital mortality	14.28%	7.69%	0.084

EUROPEAN SOCIETY OF CARDIOLOGY®

European Journal of Heart Failure (2011) **13**, 1140–1146
doi:10.1093/eurjhf/hfr103

Comparison of acute and chronic impact of adaptive servo-ventilation on left chamber geometry and function in patients with chronic heart failure

Nobuhiko Haruki[1], Masaaki Takeuchi[1*], Kyoko Kaku[1], Hidetoshi Yoshitani[1], Hiroshi Kuwaki[1], Masahito Tamura[1], Haruhiko Abe[1], Masahiro Okazaki[1], Akizumi Tsutsumi[2], and Yutaka Otsuji[1]



	Baseline	ASV 30 min	*P* value
Heart rate (bpm)	72 ± 14	69 ± 13	<0.0001
Systolic blood pressure (mmHg)	124 ± 21	111 ± 20	<0.0001
Diastolic blood pressure (mmHg)	74 ± 14	68 ± 14	<0.005
Stroke volume (mL)	45 ± 15	54 ± 18	<0.0001
Cardiac output (L/min)	3.1 ± 1.0	3.6 ± 1.1	<0.0001
LV/LA volumes			
LV end-diastolic volume (mL)	150 ± 56	149 ± 55	NS
LV end-systolic volume (mL)	102 ± 52	96 ± 52	<0.0001
LV ejection fraction (%)	34 ± 11	39 ± 13	<0.0001
Maximum LA volume (mL)	105 ± 46	100 ± 45	NS
Minimum LA volume (mL)	66 ± 45	68 ± 44	NS
LV diastolic function			
E wave (cm/s)	91 ± 37	89 ± 38	NS
A wave (cm/s)	62 ± 37	61 ± 34	NS
e′ (cm/s)	4.2 ± 1.4	4.2 ± 1.4	NS
a′ (cm/s)	4.7 ± 2.4	4.5 ± 2.6	NS
E/e′	23.3 ± 10.8	22.8 ± 10.1	NS
Mitral regurgitation vena contracta width (mm)	3.3 ± 1.5	3.2 ± 1.4	NS
Systemic arterial compliance (mL/mmHg)	0.96 ± 0.36	1.29 ± 0.51	<0.0001
Systemic vascular resistance (dyne/s/cm^5)	2539 ± 860	2026 ± 702	<0.0001

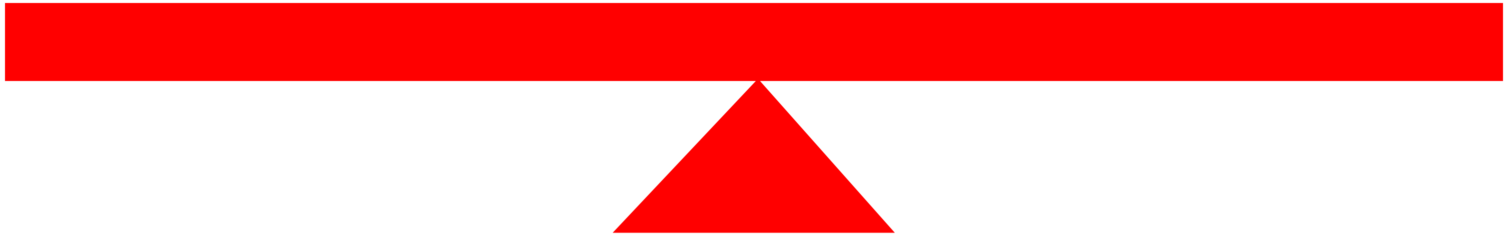
European Journal of Heart Failure (2011) **13**, 1140–1146

	ASV group			Withdrawal group		
	n = 15			*n* = 11		
	Baseline	Follow-up	*P* value	Baseline	Follow-up	*P* valu
NYHA class	2.4 ± 0.5	1.5 ± 0.5	<0.01	2.3 ± 0.5	2.0 ± 0.8	NS
Heart rate (bpm)	74 ± 16	70 ± 13	NS	70 ± 12	67 ± 13	NS
Systolic BP (mmHg)	117 ± 22	123 ± 31	NS	128 ± 16	121 ± 14	NS
Diastolic BP (mmHg)	72 ± 16	66 ± 15	NS	75 ± 11	67 ± 13	NS
Stroke volume (mL)	43 ± 15	56 ± 16	0.0010	49 ± 15	54 ± 12	NS
Cardiac output (L/min)	3.13 ± 1.06	3.83 ± 0.85	0.0037	3.35 ± 0.88	3.52 ± 0.65	NS
SAC (mL/m^2/mmHg)	0.63 ± 0.22	0.69 ± 0.26	NS	0.63 ± 0.20	0.65 ± 0.11	NS
SVR (dyne/s/cm^5)	2483 ± 965	1837 ± 490	0.0005	2338 ± 600	1991 ± 477	NS
E wave (cm/s)	90 ± 35	81 ± 42	NS	105 ± 46	90 ± 40	NS
A wave (cm/s)	64 ± 43	63 ± 45	NS	75 ± 41	68 ± 49	NS
e′ (cm/s)	3.8 ± 1.5	5.3 ± 1.5	0.0013	4.0 ± 1.2	4.0 ± 1.5	NS
a′ (cm/s)	4.2 ± 1.7	5.1 ± 2.8	0.0266	5.6 ± 2.0	5.7 ± 4.0	NS
s′ (cm/s)	3.7 ± 1.1	5.3 ± 1.9	0.0218	4.6 ± 2.0	4.4 ± 1.7	NS
E/e′	27.1 ± 16.1	16.3 ± 8.7	0.0075	27.2 ± 10.0	25.8 ± 16.6	NS
LVEDV (mL)	169 ± 66	129 ± 61	<0.0001	171 ± 60	158 ± 73	NS
LVESV (mL)	122 ± 63	79 ± 60	<0.0001	117 ± 58	106 ± 71	NS
LVEF (%)	30 ± 11	43 ± 14	0.0001	33 ± 11	38 ± 13	NS
Max LAV (mL)	113 ± 54	85 ± 61	0.0006	100 ± 36	95 ± 50	NS
Min LAV (mL)	70 ± 56	50 ± 49	0.0111	61 ± 31	60 ± 46	NS
MR VCW (mm)	3.5 ± 1.3	1.6 ± 2.4	0.0005	3.1 ± 2.4	3.0 ± 2.7	NS

European Journal of Heart Failure (2011) **13**, 1140–1146

(-) (++)

Preload'un azalması **Afterload'un azalması**



1. Kalp hızının azalması;

-Kardiyak sempatik aktivitenin azalması

-Pulmoner 'stretch' res.'lerin uyarılması ile parasempatik aktivitenin artışı

2. 'Reverse remodeling'

Circulation Journal
Official Journal of the Japanese Circulation Society
http://www.j-circ.or.jp

RAPID COMMUNICATION

Short-Term Prognosis of Adaptive Servo-Ventilation Therapy in Patients With Heart Failure

Takashi Koyama, MD; Hiroyuki Watanabe, MD; Gen Igarashi, MD;
Shigenori Terada, MD; Shin Makabe, MD; Hiroshi Ito, MD

Circulation Journal Vol.75, March 2011

Background: This study tested the hypothesis that adaptive servo-ventilation (ASV) therapy improves the prognosis of heart failure (HF) patients, regardless of the severity of sleep-disordered breathing (SDB).

Methods and Results: 88 consecutive patients were divided into 4 groups based on ASV therapy and SDB severity. The incidence of HF, brain natriuretic peptide (BNP) levels, and left ventricular ejection fraction (LVEF) were followed for 12 months. Fewer HF events, together with an increase in LVEF and a decrease in BNP, occurred in ASV-treated patients with both non-to-mild and moderate-to-severe SDB.

Conclusions: ASV therapy improves the short-term prognosis in HF-patients, regardless SDB severity. (*Circ J* 2011; **75:** 710–712)

Sonuç

- MV ve PEEP uygulamasının hemodinamik sonuçları değişkendir ve **hangi klinik kondüsyondaki** hastaya uygulandıklarına bağlıdır.
- Ağır sistolik kalp yetmezliği, AMI, kardiyojenik şok tablolarında PEEP kullanılarak MV uygulanması hala tartışılan bir konudur.
- Oksijenasyonun optimizasyonu için kullanılmasının bir sakıncası olmadığı gibi LV fonksiyonuna faydalı olabileceği bilinmelidir.

Sonuç

- **Hasta seçimi çok önemlidir.**
- Mevcut klinik ve kardiak kondüsyonu ne olursa olsun hipovolemik, 'preload dependent' hastalarda ve sağ ventrikül infarktı olanlarda MV ve PEEP'in ciddi hemodinamik negatif etkileri olabilir.
- RV disfonksiyonu olanlarda PEEP'e bağlı afterload artışı tolere edilemeyebilir.
- Alveolar rekruitment ve PEEP uygulanmadan önce preload optimize edilmelidir.

Teşekkürler…

LV disfonksiyonunda PPV'nun etkisi

- Stres altındaki ve disfonksiyone miyokard afterload artışına ve metabolik ihtiyacın altındaki oksijen sunumuna oldukça duyarlıdır.
- PPV:
  - Oksijenasyonu düzeltir
  - Transmural pulmoner basıncın azalmasına bağlı LV afterloadında azalma
  - LV preload'ında azalma, konjesyon yükünün azalması
  - LV performansının iyileşmesi
  - Solunum işinin azalması
  - İnspiryumda ITP'nin aşırı negatifleşmesini önler
  - Hipoksiye bağlı pulmoner vazokonstrüksiyonun düzelmesi
  - Miyokarda oksijen sunumunun artması

Heart. 2013;99(24):1812

- Kalp yetmezlikli hastalarda stres ile aşırı solunum gayreti oluşur, tidal volümden daha çok solunum frekansı artar.
- Azalmış kardiak rezerv ve artmış solunum yükü kalp akciğer etkileşimini olumsuz yönde etkiler.
- Büyümüş kalp toraks içinde yer kaplaması kalp akciğer etkileşiminin daha da olumsuzlaşmasına neden olur.
- ITP'de dalgalanma artar
- Kalp yetmezlikli hastalar derin solunum yapmaktan kaçınarak end ekspiratuar akciğer volümünü muhafaza etmeye çalışırlar.
- Bu anormal solunum paterni kalp yetmezlikli hastalarda solunumun kardiak negatif etkilerini minimize etmek için oluşan bir fizyolojik yanıt olabilir.

Chest **117**, 321, 2000,
Med Hypotheses **74**, 416, 2009
Chest **130**, 164, 2006

- Sağlıklı kalpte ITP'ın daha da negatifleşmesi sistemik venöz dönüşü artırarak LVED artırır ve SV artar
- Fakat LV kontraktilitesi bozulmuş kalp yetmezlikli hastalarda LVED artışı SV'ü artırmadığı gibi, LV transmural basıncı artarak afterload artışına neden olur. Sonuçta negatif ITP ile SV azalabilir.

Prog Cardiovasc Dis **24**, 375, 1982

- Akut sol kalp yetmezliğinde sıklıkla mekanik ventilasyon (invazif ya da non invazif) gerekir:
  - Akut hipoksik solunum yetmezliği (Şant ve V/Q uygunsuzluğu)
  - Artmış solunum iş yükü (Azalmış kompliyans)
  - Ritm bozuklukları
  - Perkütan ya da cerrahi girişimler için sedasyon gerekliliği

*Am J Cardiol*2006;97:13F–25F.

Invasive PPV in Severe Systolic Heart Failure

- PPV ve PEEP’in hemodinamik etkilerinden çekinildiği için KKY’li hastalarda solunum desteği olarak genel eğilim NIMV’dur.
- Fakat ağır LV disfonksiyonu olanlarda bile PEEP ve invazif MV’nun zararlı olmadığı hatt afaydalı olabileceğine yönelik deliller vardır.
- LV disfonksiyonlu 21 hastada (KKY’li AMI 7, kardiojenik şok 8, KKY 6) invazif MV uygulanırken PEEP açılmasıyla hastaların çoğunda CO düşmüş. Fakat olgular PCWP yüksek ve normal olarak ayrıldıklarında PCWP> 19 mmHg olan 13 hastanın 12’sinde CO’un arttığı gözlenmiş. *Crit Care Med*1982;10:358
- CABG sonrası LV disfonksiyonu olan MV uygulanan hastalarda 5 cmH2O PEEP açılmasıyla PCWP, CI, SVI değerleri iyileşmiş. Araştırmacılar: Ağır LV disfonksiyonu olan her hastada PEEP kullanılmasını önermişler *Crit Care Med*1982;10:423
- CABG sonrası MV uygulanan kardiyojenik şoktaki hastalarda rekruitment sonrasında 10 cmH_2O PEEP uygulanmasının hemodinamik bozukluğa neden olmadan intrapulmoner şantı azalttığı, akciğer kompliyansını düzelttiği bildirilmiştir. *Rev Bras Anestesiol*2008;58:112

Invasive PPV in Severe Systolic Heart Failure

- PEEP kullanılarak uygulanan MV sadece LV fonksiyonlarını düzeltmekle kalmaz klinik sonuçları da iyileştirebilir.
- IABCP gerektiren kardiyojenik şoklu olgular 10 cmH_2O PEEP ile MV uygulanan ve uygulanmayan olarak randomize edilmişler. MV uygulananlarda idrar çıkışı, PCXP, CI, P/F oranı daha iyi, inotrop ve vazopressör kullanımı daha düşük IABCP'dan weaning daha kolay, hastanede kalış daha kısa survive daha iyi. *Intensive Care Med*1999;25:835
- LV disfonksiyonu olan hastalarda PEEP'in hemodinamik yararlı etkileri olmadığını da bildiren çalışmalar var. Fakat bu çalışmlarda PEEP'in hemodinamik zararlı etkileri olmadığı ve kullanılabileceği not edilmiş. *Intern Emerg Med* 2009;4:249

PEEP

- Kardiyojenik şokta
  - PEEP LV oksijen tüketimini azaltır
  - İskemik miyokarda oksijen sunumunu arttırır
  - İntrakardiak laktat üretimini azaltır
  - LV preload'u azaltarak kalbin yükünü azaltır
  - Transmural basıncı düşürerek LV afterload'u azaltır
  - Oksijenasyonu düzeltir
  - Solunum işini azaltır
  - Hipoksik pulmoner vazokonstriksiyonu ortadan kaldırır
  - Metabolik gereksinimi azaltır

*Clin Physiol*1988;8:287

- Clin Physiol. 1988 Jun;8(3):287-301.
- **Cardiovascular effects of positive end-expiratory pressure during acute left ventricular failure in dogs.**
- Hevrøy O[1], Reikerås O, Grundnes O, Mjøs OD.
- **Author information**
- **Abstract**
- Haemodynamic and metabolic effects of ventilation with positive end-expiratory pressure (PEEP) were studied in closed-chest dogs anaesthetized with sodium pentobarbital during normal cardiac function and during acute left ventricular (LV) failure. LV failure was induced by embolizing the left coronary bed with 50 micron plastic microspheres causing a marked depression of LV function. End-expiratory pressure was set to 0, 5, 10 and 15 cm H2O both before and after coronary embolization. During normal cardiac function PEEP above 5 cm H2O depressed cardiac output (CO) significantly. However, following coronary embolization after which LV function was seriously impaired, CO was maintained as PEEP was applied. This is attributed to reduced sensitivity to the LV pre-load reductions induced by PEEP during LV failure. PEEP reduced MBF both during normal and impaired LV function. This did not result in ischaemic myocardial metabolism assessed by lactate extraction either in normal hearts or following coronary embolization. The reduced MBF was, however, associated with reduced MVO2 both during normal cardiac function and during LV failure. It is suggested that

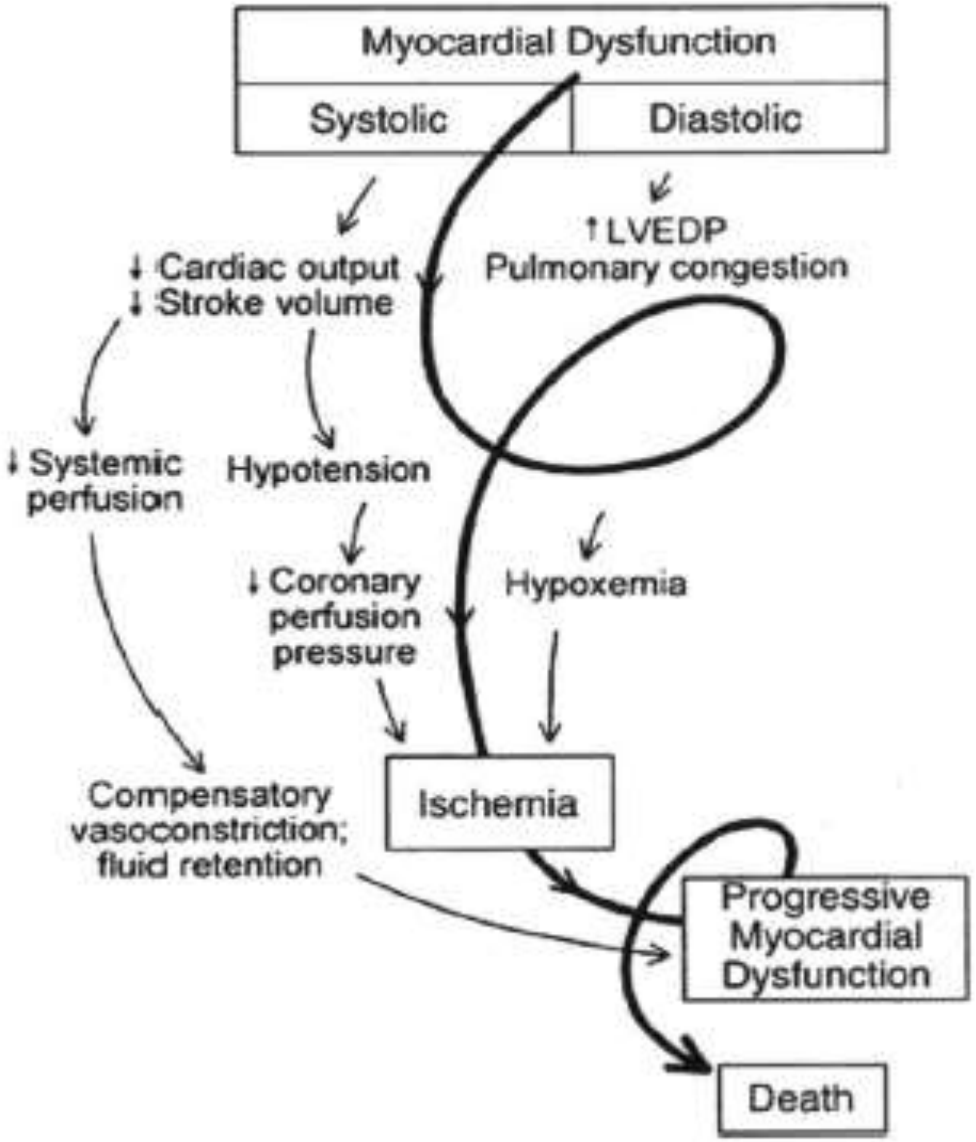
- Am Rev Respir Dis. 1981 Aug;124(2):121-8.
- **Positive end-expiratory pressure (PEEP) does not depress left ventricular function in patients with pulmonary edema.**
- Calvin JE, Driedger AA, Sibbald WJ.
- **Abstract**
- We evaluated the effects of positive end-expiratory pressure (PEEP) on left ventricular function in 15 patients with acute respiratory insufficiency secondary to pulmonary edema with invasive (pressure; flow) measurements and radionuclide angiography (RA). Using RNA allowed a definition of the left ventricular ejection fraction (LVEF), and then calculation of the left ventricular end-diastolic volume (LVEDV), both before and after PEEP. With a mean PEEP of 14.2 +/- 1.8 cm H2O (mean +/- SD) (range, 10 to 15), a fall in the cardiac index (4.34 +/- 1.5 to 3.84 +/- 1.4 L/min/M2; p less than 0.001) was accompanied by a significant decrease in the stroke volume index (42 +/- 13 to 39 +/- 12 ml/beat M2; p less than 0.01) and pulse rate (103.4 +/- 14.3 to 98 +/- 13.5 beats/min; p less than 0.01). The decrease in the stroke volume index was primarily due to a significant decrease in left ventricular preload (LVEDV) from 85.9 +/- 19 to 71.4 +/- 21.4 ml/m2 (p less than 0.01). Simultaneously, the mean LVEF increased from 0.47 +/- 0.10 to 0.53 +/- 0.08 (p less than 0.05), despite a significant increase in the systemic vascular resistance (1,619 +/- 575 to 1,864 +/- 617 dynes . s. cm-5/M2; p less than 0.01). We concluded that the use of PEEP in patients with acute pulmonary edema, to the degree used in this study, may depress cardiac output by simply decreasing left ventricular preload. We were unable to produce any evidence that would support a change in the contractile state of the left ventricle as a cause of depressed forward flow with the use of PEEP.

- Crit Care Med. 1982 Jun;10(6):358-60.
- **Cardiac performance in response to PEEP in patients with cardiac dysfunction.**
- Grace MP, Greenbaum DM.
- **Abstract**
- The effect of PEEP on cardiac performance was evaluated in 21 patients with left ventricular (LV) dysfunction. Twenty-three data sets were divided into three groups according to pulmonary arterial wedge pressure (PAWP). In three of four group A data sets (PAWP = 12 mm Hg), cardiac output (CO) decreased when PEEP was added. In four of six group B data sets (PAWP = 14-18 mm Hg) and in 12 of 13 group C data sets (PAWP less than or equal to 19 mm Hg), CO increased with addition of PEEP. In group C, the mean increase in CO was 500 ml/min, and the mean level of best PEEP was 3.9 cm H_2O. When PAWP exceeded 18 mm Hg, PEEP was safe and in many instances augmented CO.

Cardiac failure: Mechanical support strategies

(Crit Care Med 2006; 34[Suppl.]:S268–S277)

John P. Boehmer, MD; Eric Popjes, MD



For heart Psur is pericardial pressure (Ppc)

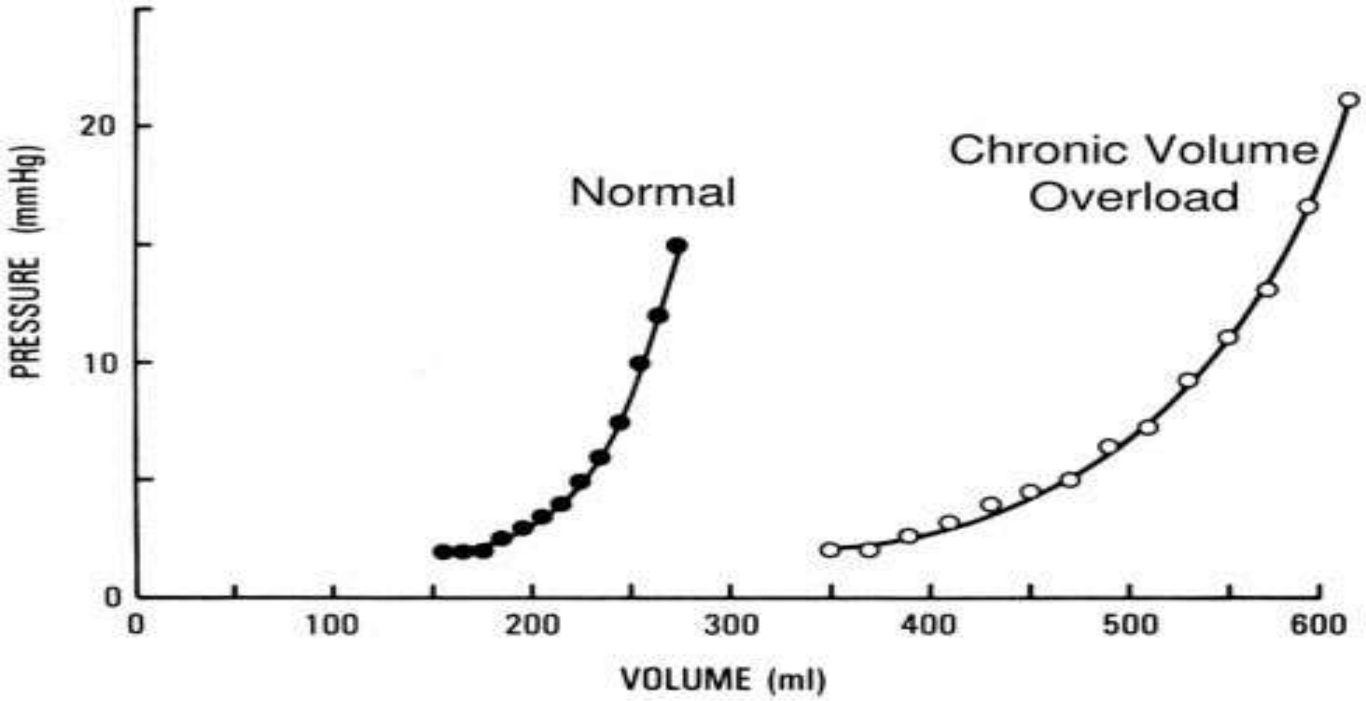
Ttm = Pim – Ppc

Pericardium

high extensibility at low level of stress

with an abrupt transition to relative inextensibility at higher stress

therefore it exerts a restraining effect on volume of heart



Physiologic role of normal pericardium

Matthew W. Watkins, Martin M. LeWinter, annu. Rev. Med 993;44:171-180

RV & LV mechanically coupled

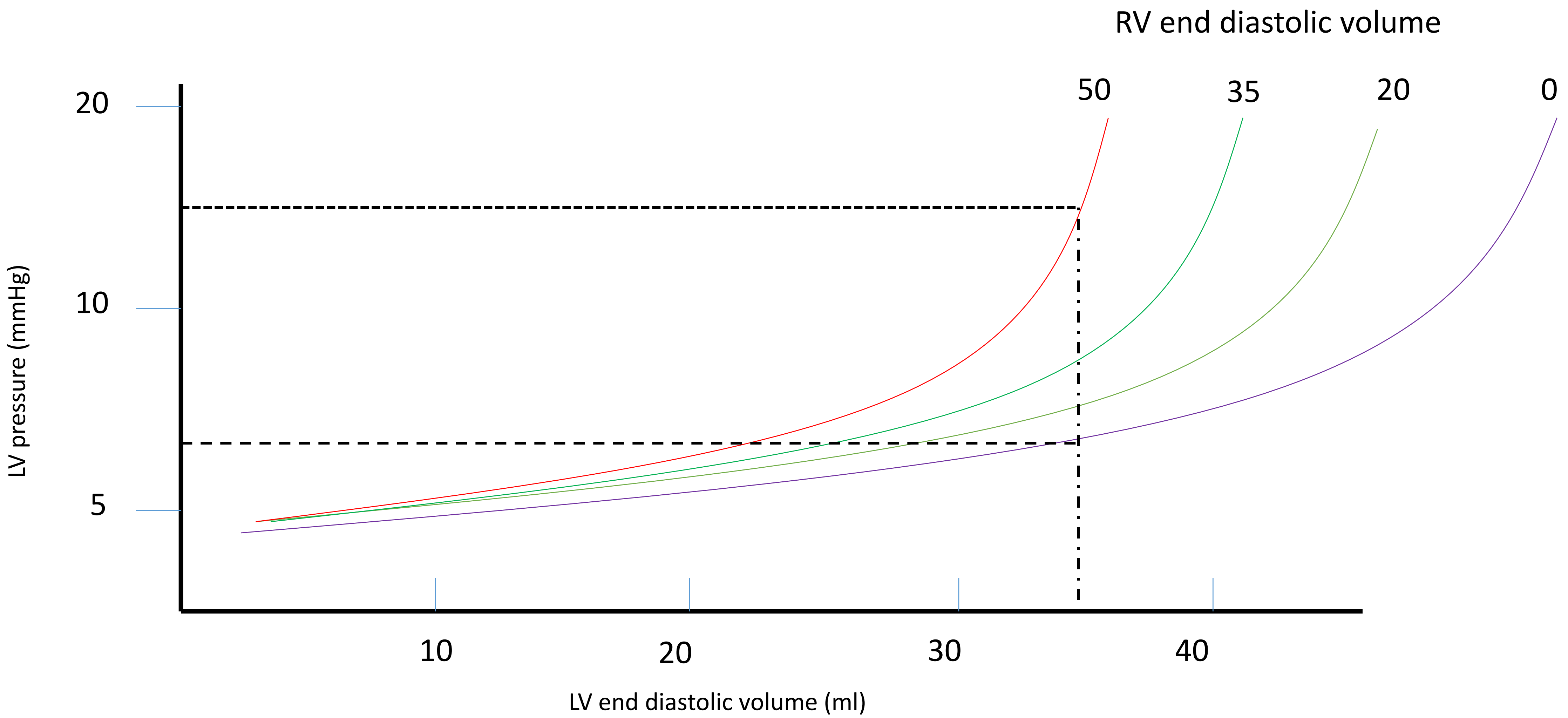
common septum & circumferential fibres

expansion of both ventricles constrained by a common pericardium
(pericardial constraint)

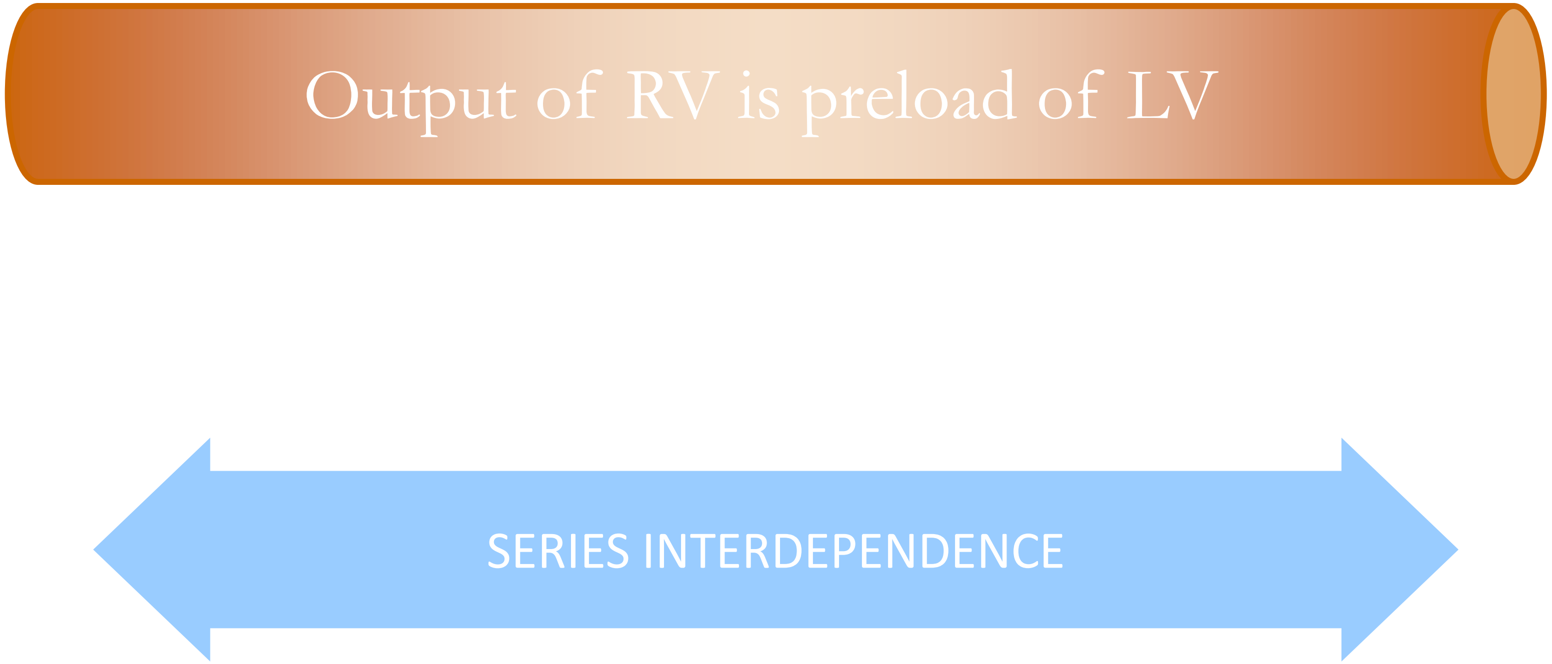
Diastolic filling of one ventricle has to be at the cost of another
diastolic filling of one ventricle will affect the geometry and stiffness of another

PARELLEL INTERDEPENDENCE

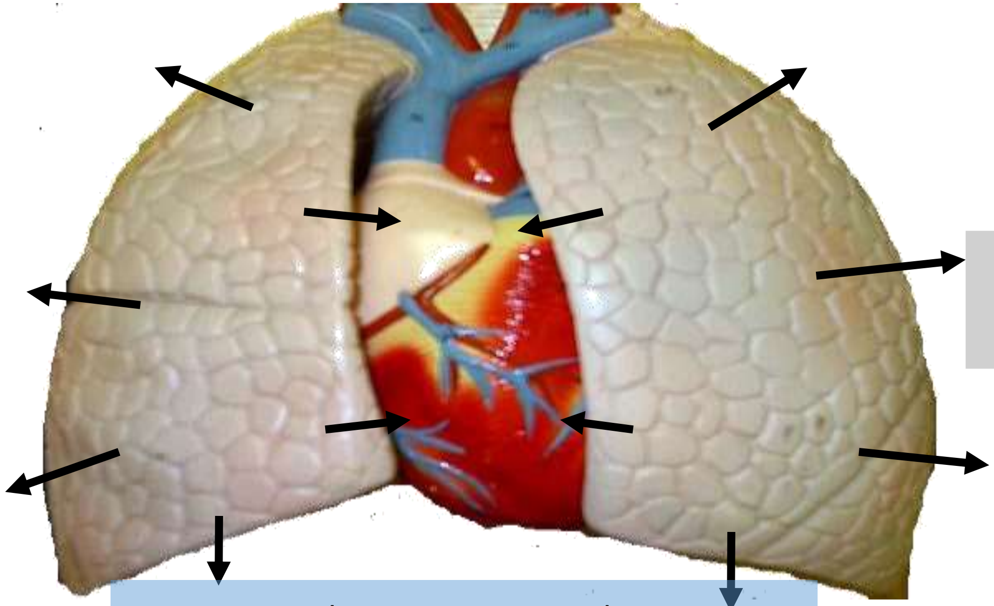
Changes in RVEDV, changed LV diastolic compliance



Heart lung interactions.
Pinsky MR, Textbook of Critical Care, 5th edition, Elsvier Saunders


Output of RV is preload of LV
SERIES INTERDEPENDENCE

Heart and great vessels
In cardiac fossa
TRAPPED AND COMPRESSED
Greater change in Ppl

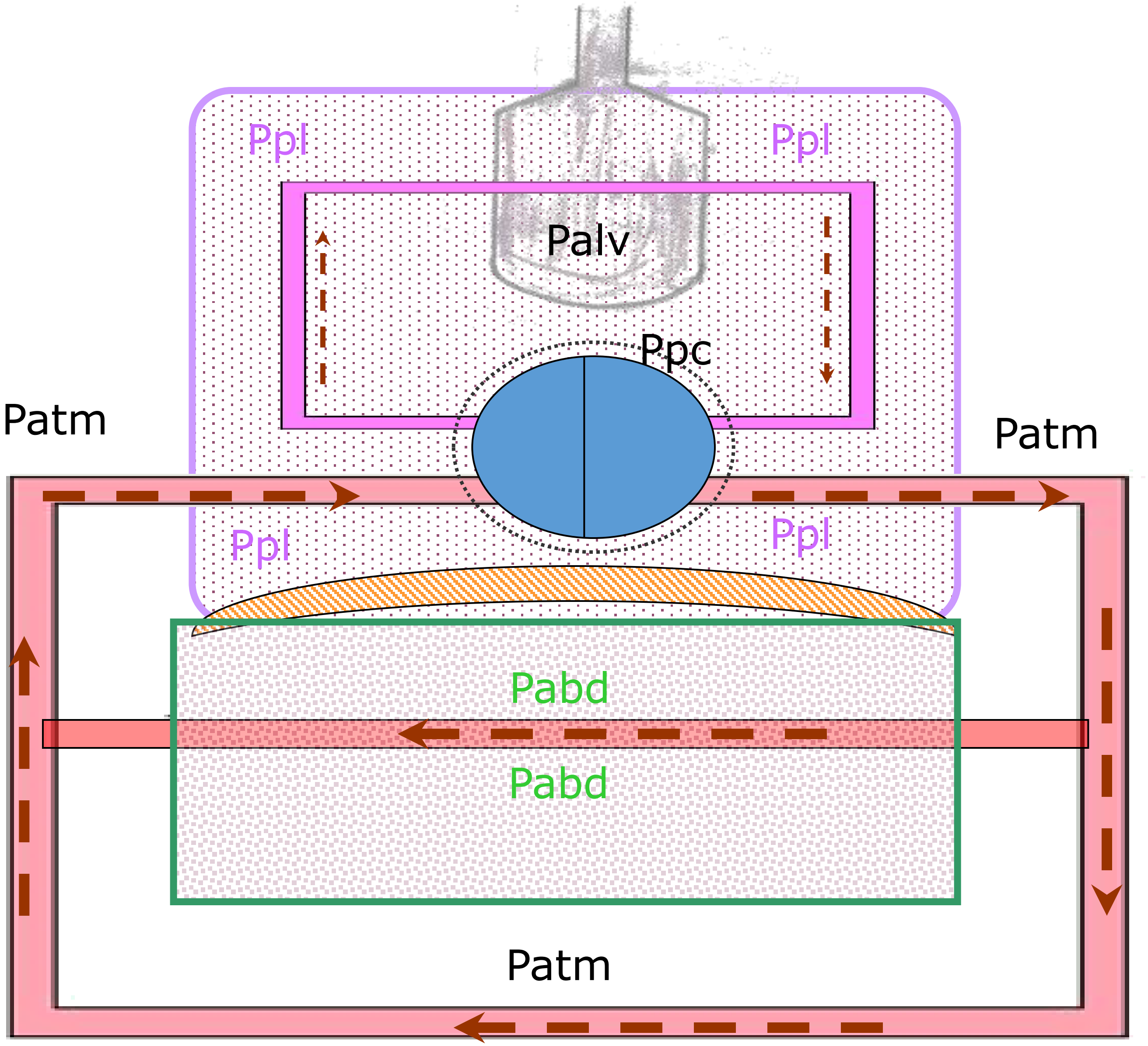


Lateral chest wall moves outward
Less change in Ppl

Diaphragm most compliant
Least change in Ppl

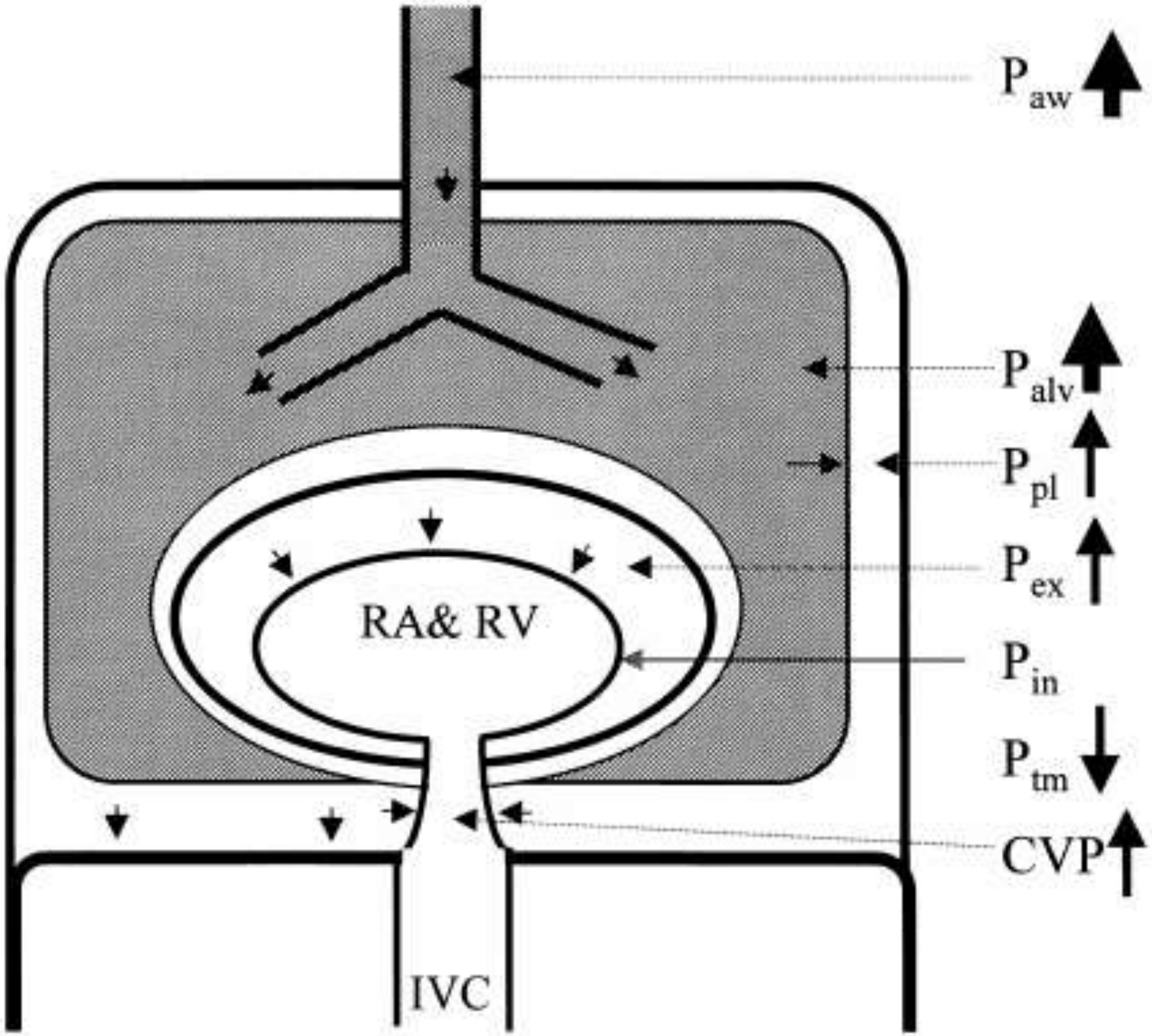
Pleural pressure change
juxta cardiac > lateral chest wall > diaphragm

Surrounding Pressures of Circulatory System



Patm= 0
Ppl= -2 to -5
Pabd = <5

Prof. Dr. Kutay Akpir

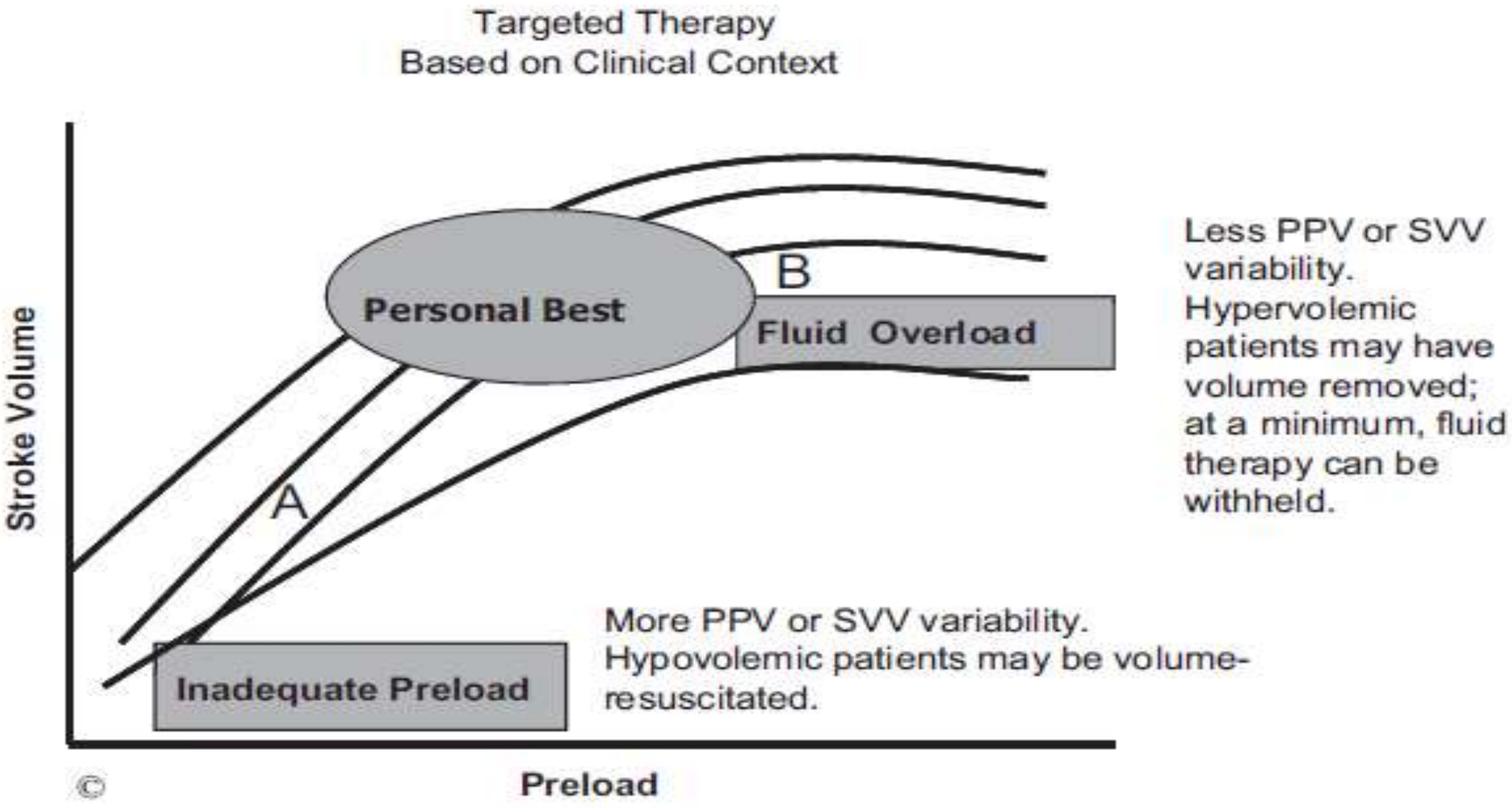


Pozitif basınçlı inspirasyon ve diyastoldeki etkileşim

Physiologic Goal-Directed Therapy in the Perioperative Period: The Volume Prescription for High-Risk Patients

William T. McGee, MD,* and Karthik Raghunathan, MD†

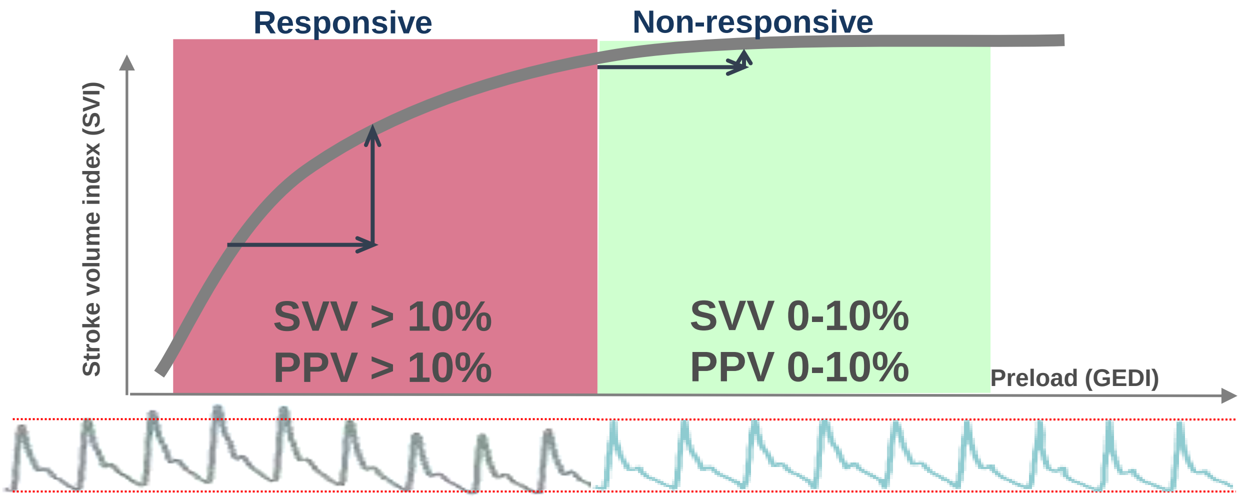
Journal of Cardiothoracic and Vascular Anesthesia, Vol ▮, No ▮ (Month), 2013: pp ▮▮▮–▮▮▮



Sıvı Yanıtı

SVV – 'Stroke Volume Variation'
PPV – 'Pulse Pressure Variation'

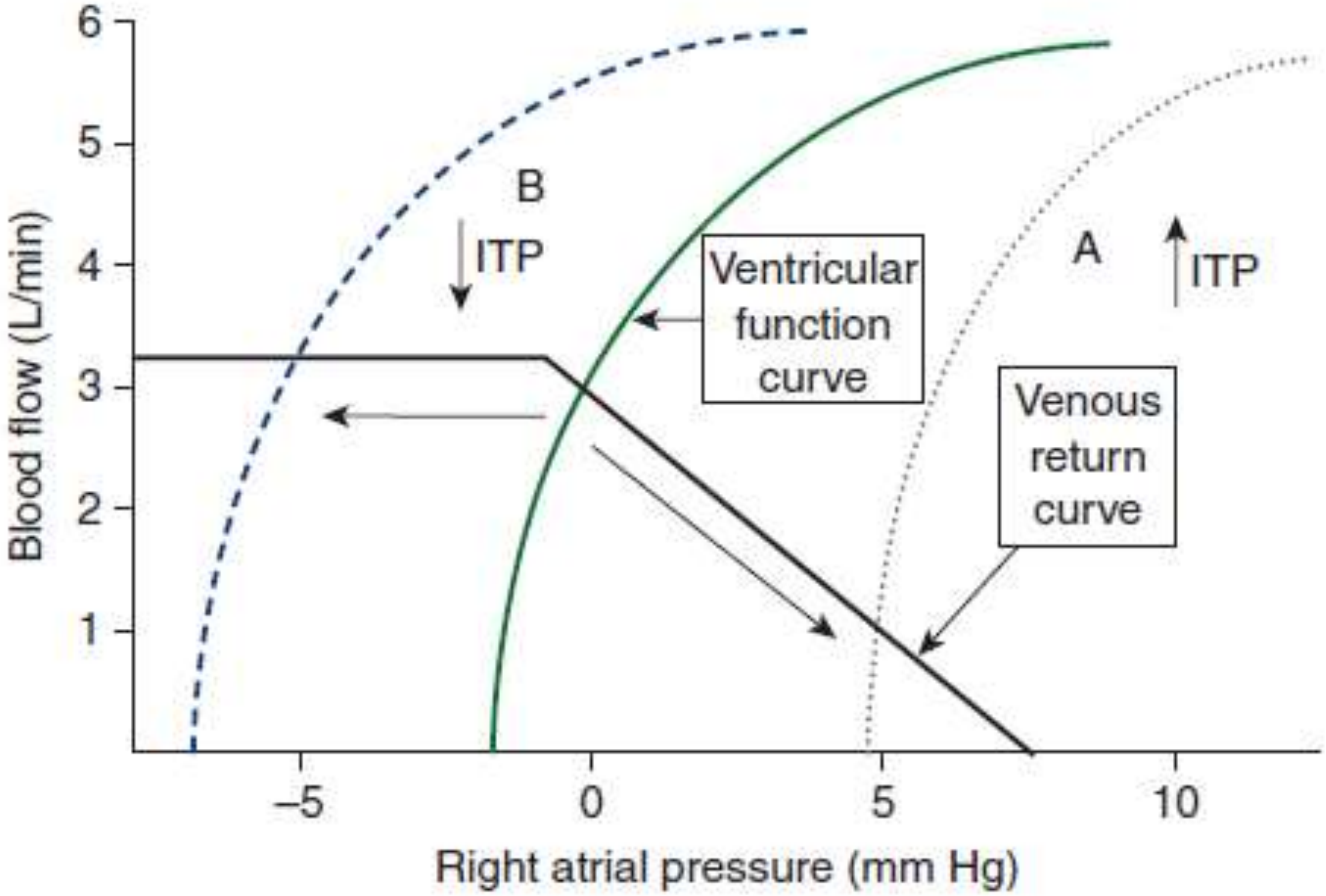
- Sıvı testine CO yanıtı
- Mekanik ventilasyonla arterial basınçta fluktuasyonların kuantifikasyonu
- Gereklilikler:
  - ✓ Mekanik ventilasyon sırasındaki tidal volumler ≥ 8ml/Kg
  - ✓ Sinus ritmi



SVV < 10%
PPV < 10%

EFFECT OF MECHANICAL VENTILATION ON HEART–LUNG INTERACTIONS

Hernando Gomez
Michael R. Pinsky



PEEP ve Şok

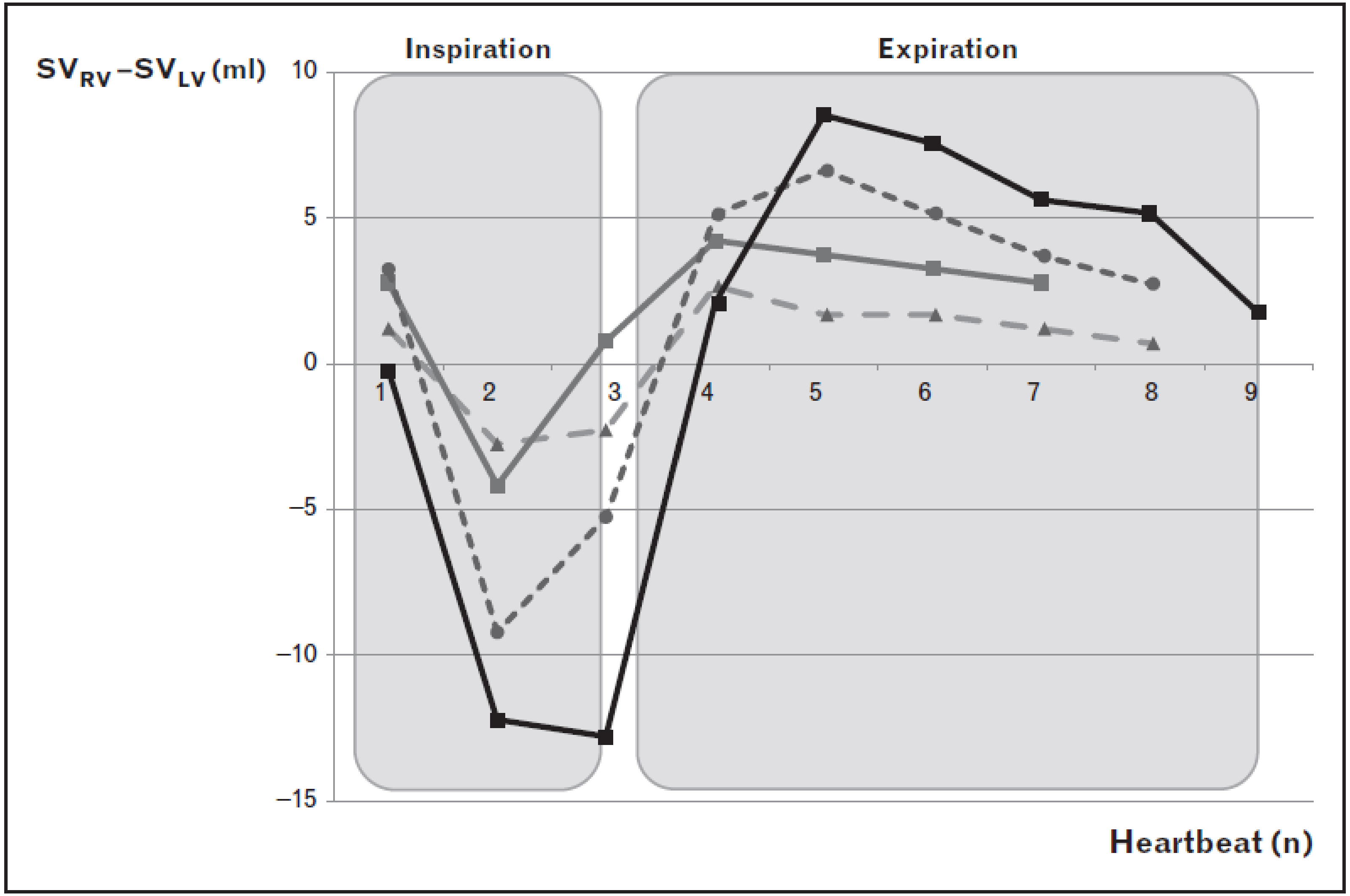
Type of shock	Potential drawback to PEEP	Means of monitoring and compensating
Hypovolemic	↓ RV and LV preload can lead to ↓ CO and worsening of hypotension	Ensure adequate volume resuscitation; carefully monitor BP
Cardiogenic	Although the ↓ LV afterload will ↑CO, the ↓ RV and LV preload may ↓ CO to a greater degree	Ensure that the patient does not have concomitant hypovolaemia
Distributive	↓ RV and LV preload can lead to ↓ CO and worsening of hypotension	Ensure adequate volume resuscitation; carefully monitor BP
Obstructive	↑ RV afterload may precipitously ↓ CO in light of ↓ RV and LV preload	Vigorous hydration and vasopressor support may be necessary to maintain haemodynamic regulation

Wiesen J, *et al. Heart* 2013;**99**:1812–1817.

Heart lung interactions during mechanical ventilation

Michael R. Pinsky

Curr Opin Crit Care 2012, 18:256–260



EFFECT OF MECHANICAL VENTILATION ON HEART–LUNG INTERACTIONS

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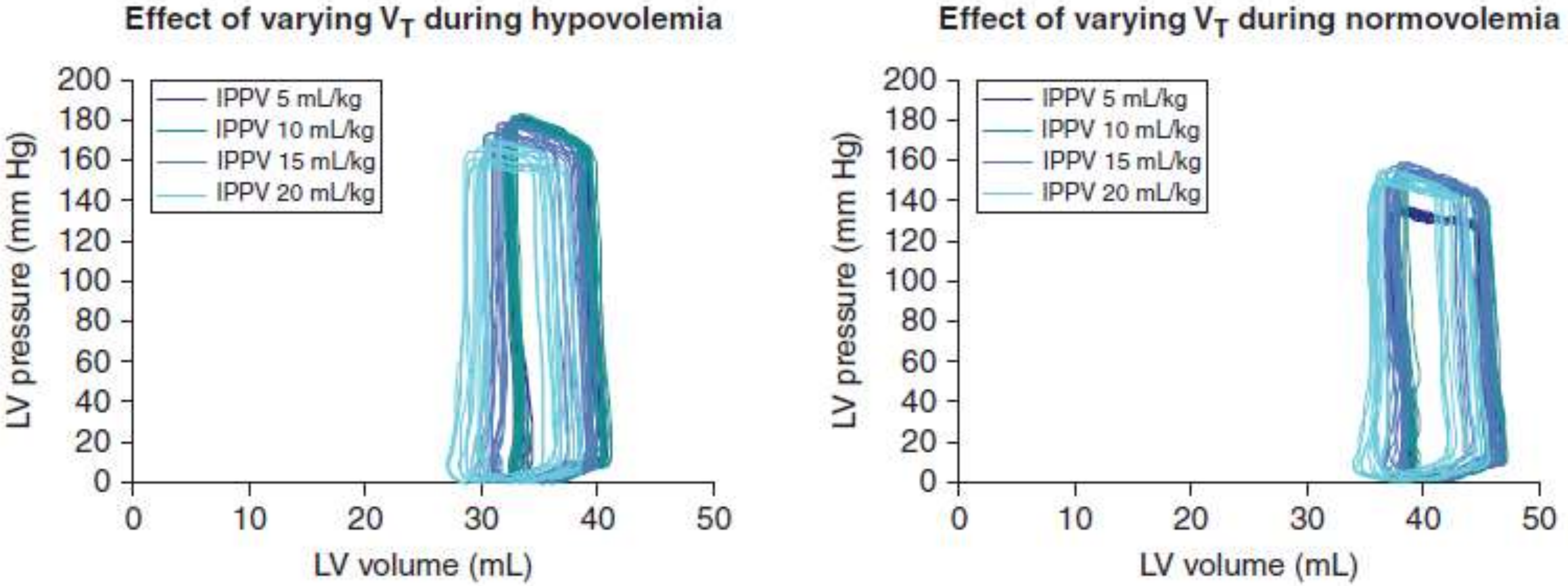
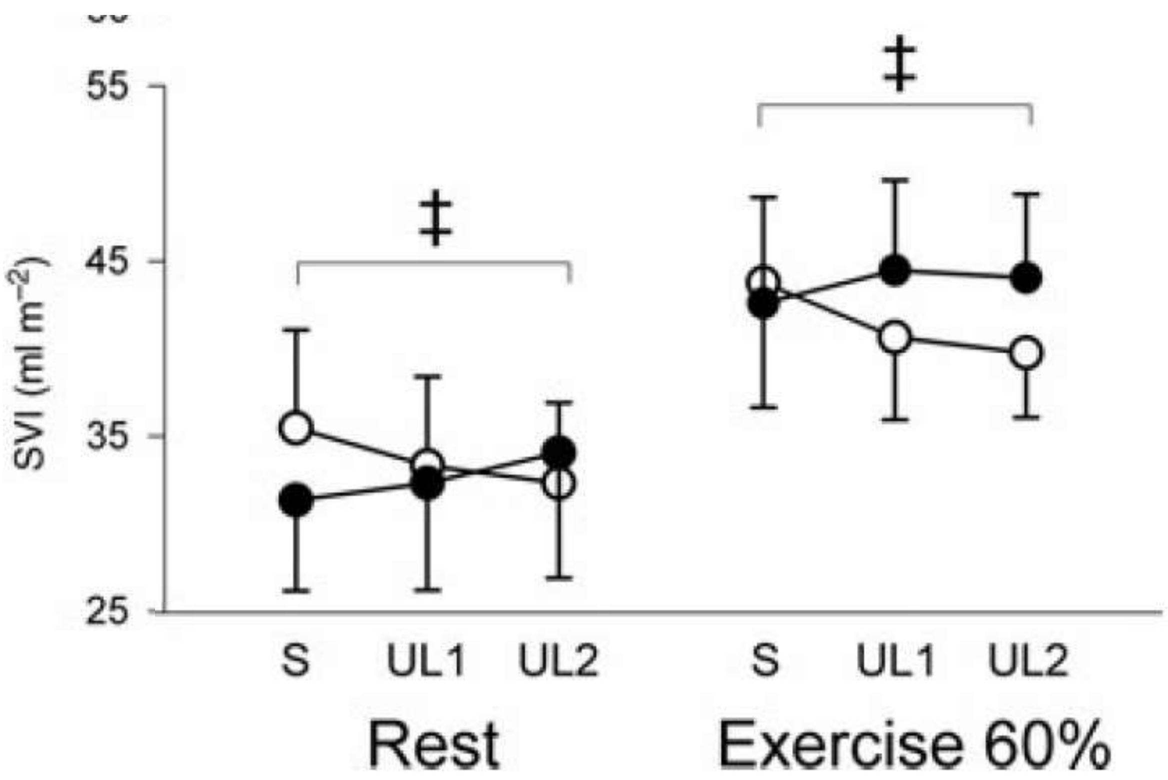


- Endüstri ile çıkar ilişkisi YOK !

Nerden Başlasam?
Nasıl Anlatsam?

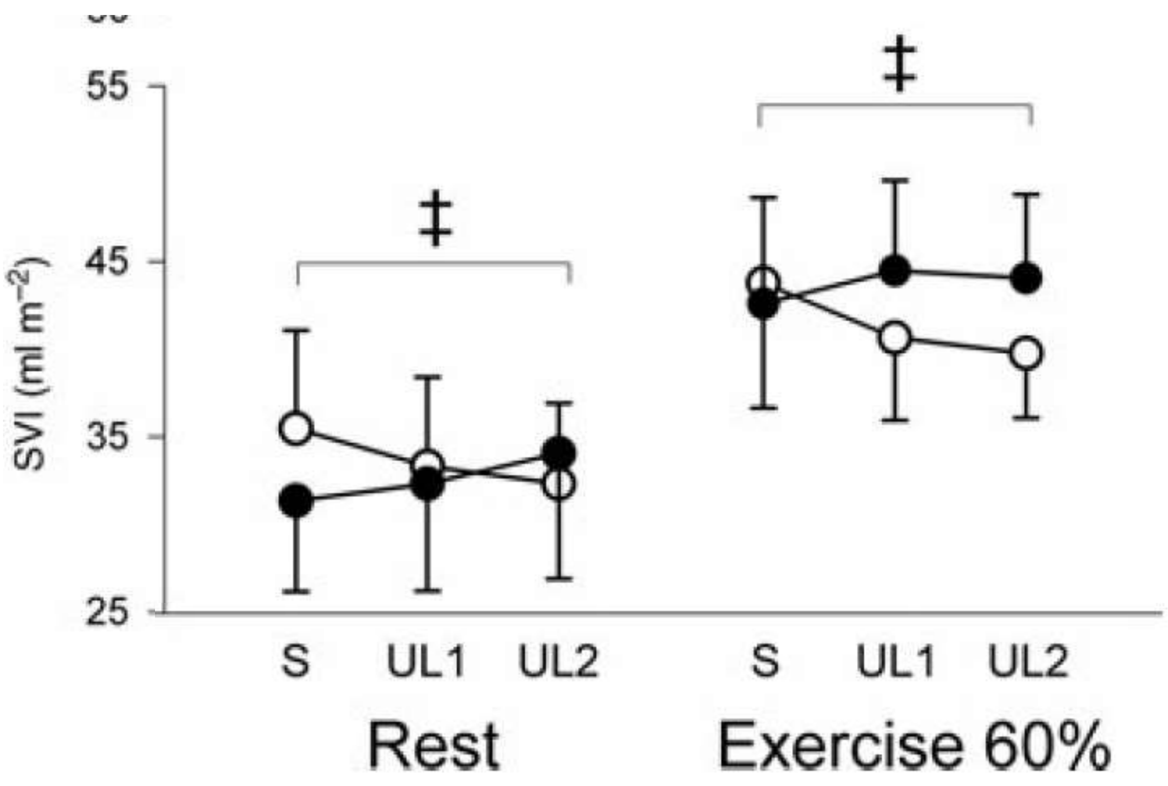
A. Lancet, 1936
B. Frank-Starling
C. Preload-dependency ve Afterload-dependency
D. PEEP
E. CPAP vs BiPAP vs ASV



İnspiratuar yük dinlenme ve egzersizde her iki grupta da SV değiştirmedi !

Conclusion

In conclusion, inspiratory unloading improved SVI at rest and during moderate exercise in patients with heart failure, possibly due to a reduction in LV afterload.



İnspiratuar yük dinlenme ve egzersizde her iki grupta da SV değiştirmedi !

Conclusion

In conclusion, inspiratory unloading improved SVI at rest and during moderate exercise in patients with heart failure, possibly due to a reduction in LV afterload.

Non-invasive PPV in Cardiogenic Pulmonary Edema

- Non-invasive PPV, either via continuous positive airway pressure or bilevel positive pressure support ventilation has been shown to improve haemodynamics, respiratory function and oxygenation in patients with acute systolic heart failure and pulmonary oedema compared with oxygen therapy alone.
- the use of non-invasive ventilation in randomised prospective trials was associated with lower rates of intubation and improved 30-day mortality compared with oxygen therapy alone.
- Results have been similar in patients with systolic heart failure secondary to acute MI or heart failure with preserved ejection fraction.
- Thus, non-invasive PPV has found widespread acceptance in the management of acute symptomatic left heart failure, and would ostensibly have similar haemodynamic effects as its invasive counterpart.

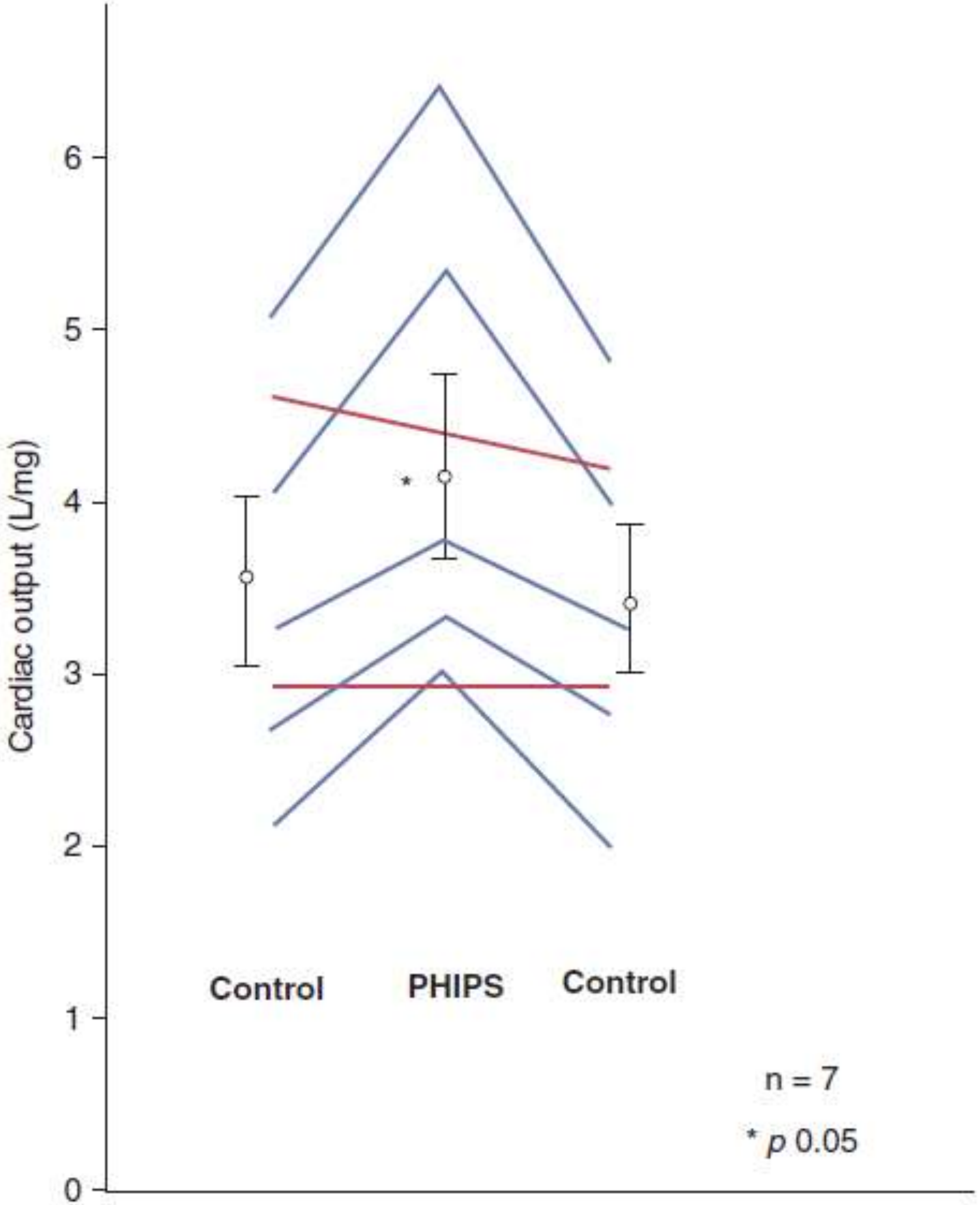
*Chest*1985;87:158

*Crit Care Med*2004;32:2546–8

*Curr Opin Crit Care*2008;14:531

EFFECT OF MECHANICAL VENTILATION ON HEART–LUNG INTERACTIONS

Hernando Gomez
Michael R. Pinsky



with permission, from Pinsky MR, Summer WR. Cardiac augmentation by phasic high intrathoracic pressure support (PHIPS) in man. *Chest*. 1983;84:370–375.)

Variables	Preserved LV Systolic Function (n = 4)		Decreased LV Systolic Function (n = 5)	
	Baseline	CPAP	Baseline	CPAP
RR, breaths/min	37 ± 5	28 ± 4†	32 ± 5	24 ± 4†
Arterial blood pH	7.41 ± 0.07	7.41 ± 0.04	7.38 ± 0.03	7.39 ± 0.02
Pa_{O_2}, mm Hg	71 ± 8.5	134 ± 25†	69 ± 12	120 ± 30†
Pa_{CO_2}, mm Hg	39 ± 3	40 ± 3	37 ± 3	38 ± 2
Sp_{O_2}, %	89 ± 2	97 ± 1†	87 ± 3	96 ± 1†
Heart rate, beats/min	101 ± 19	83 ± 11	105 ± 13	98 ± 21
MAP, mm Hg	91 ± 13	72 ± 6†	64 ± 4	63 ± 3
LV end-diastolic volume, mL	107 ± 4	98 ± 3†	148 ± 4	128 ± 8†
LVEF, %	49 ± 2	51 ± 2	29 ± 6	38 ± 6†
VTIAo, cm	21.3 ± 4.6	17.9 ± 2.4	14.4 ± 2	16.2 ± 2
E, cm	0.59 ± 0.17	0.66 ± 0.11	1.19 ± 0.52	0.98 ± 0.5
A, cm	0.6 ± 0.1	0.65 ± 0.08	0.71 ± 0.23	0.67 ± 0.26
E/A ratio	1 ± 0	1 ± 0.22	1.7 ± 0.7	1.5 ± 0.6

*Values given as mean ± SD.

†$p < 0.05$ compared to baseline.

In summary, the present study shows that CPAP should be used for the management of CPE in patients with diastolic LV dysfunction. In patients with preserved systolic function, CPAP decreases LV end-diastolic volume. Moreover, our data confirm that in patients with altered systolic function, the benefit of CPAP is due to both an increase in LVEF and a decrease in preload.