MGH Critical Care COVID Update

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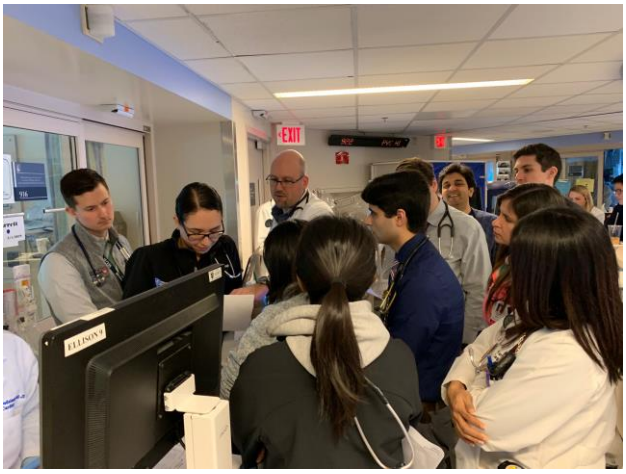
Current as of 3-25-2020 noon

no disclosures

MGH Critical Care COVID Update

- Capacity Scenario
- MGH Critical Care Surge Outline
- Overview of COVID ICU Management
  - Focus on ARDS

Ellison 9: March 5, 2019, 855 AM

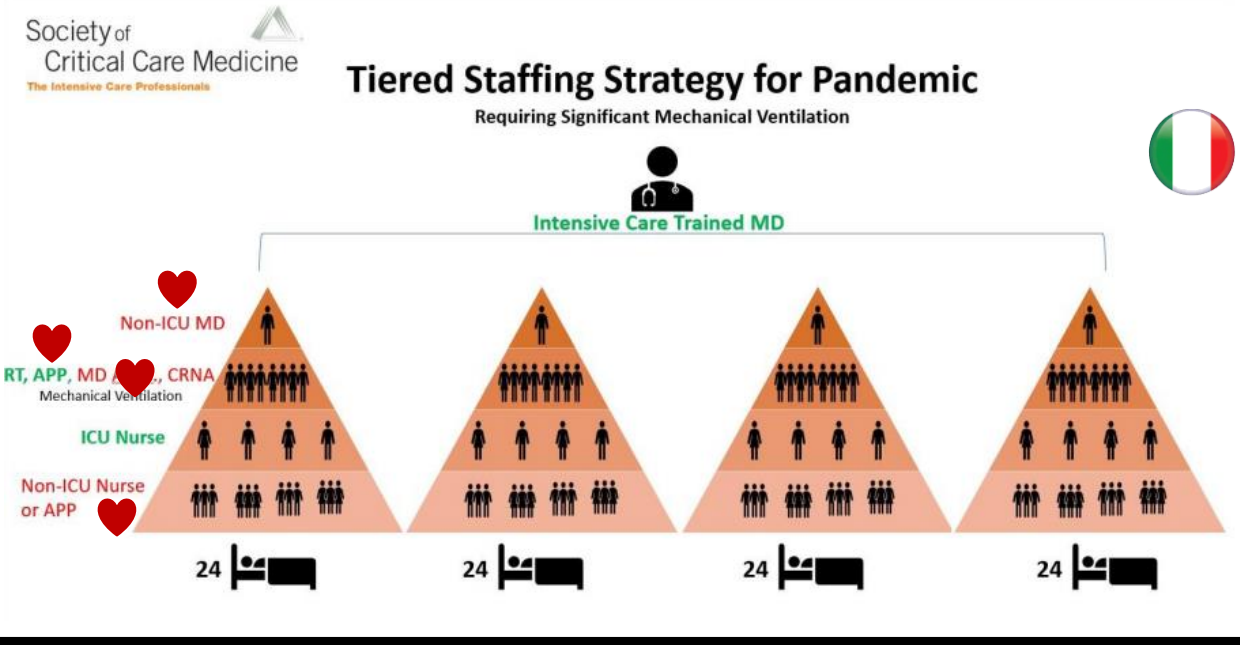


Ellison 9: March 23, 2020, 1021 AM

- Focused, quick rounds w/ RN
- Distancing
  - ↓ team contact
  - ↓ patient contact
- Preserve PPE
- Virtual teaching, RTL, work rounds
- Role of technology
- Corona~~ry~~ Care Unit

MGH ICU Staffing

- **Standard staffing** - each ICU group will continue to staff their own patients and provide internal backup
  - *Consolidated COVID units, adjust non-COVID volume*
- **Enhanced staffing** - critical care providers from across the hospital will provide backup to other units as staff become furloughed or volume and acuity increases significantly
- **Surge staffing** - in addition to the above layers of staffing, new ICU units will open and *de novo* ICU teams will be formed



Management of Coronavirus Patients

- ***Personal protection***
  - *Watch videos and/or attend a session on PPE*
  - *Get or update fit testing* *(*may not be available)*
  - *OHS online form*
  - ***Strict isolation (contact/airborne/eye)**; observed don/doff*
  - *Minimum necessary patient and HCW contacts*
  - *Room entry logging*
  - *Conserve PPE (batch testing, procedures, visits)*
  - *Minimize unnecessary testing (CXR, labs, cardiac imaging)*
  - ***There is no emergency in a pandemic* (EM literature)**

COVID19 Update

Responding to CODES and RAPID RESPONSES

March 20, 2020

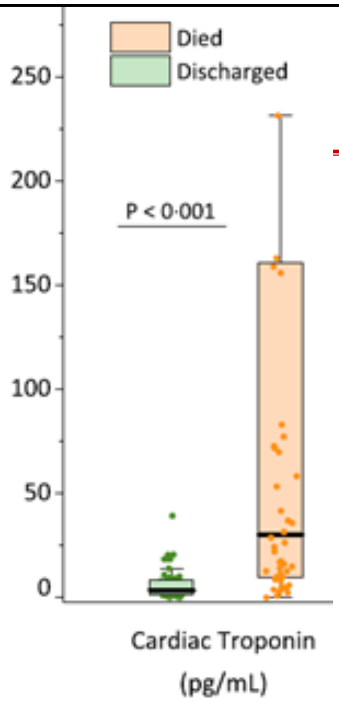
Only necessary staff **should enter the room for clinician safety and to conserve supplies. Police & Security and Clinical Supervisors will assist with crowd control.**

CODE Responders entering the room - Essential code team members and staff *only*:

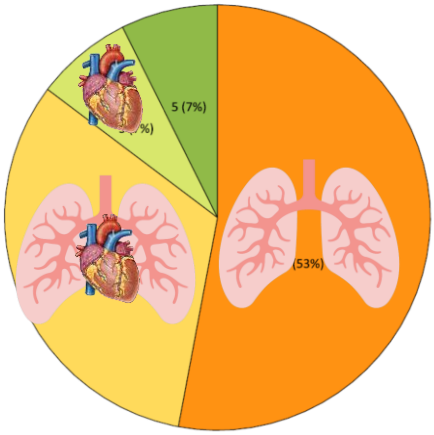
- **Protect yourself FIRST!**
  - **Aerosol-generating procedures such as intubation are HIGHLY LIKELY to occur during a code**
  - **Use N95 + Contact + Eye protection for all CODES**
  - **Staff who are NOT entering the room *DO NOT* need to don PPE**

Rapid Response Responders:

- **Protect yourself FIRST!**
  - **PAUSE and consult with staff before entering room to obtain patient status and determine if PPE is needed.**



Organ Failures



Intensive Care Med 3/3/2020 epub

Respiratory Failure
Respiratory Failure with Myocardial Damage/Heart Failure
Myocardial Damage/Heart Failure
Unknown

	Total (n=191)	Non-survivor (n=54)	Survivor (n=137)	p value
Outcomes				
Sepsis	112 (59%)	54 (100%)	58 (42%)	<0·0001
Respiratory failure	103 (54%)	53 (98%)	50 (36%)	<0·0001
ARDS	59 (31%)	50 (93%)	9 (7%)	<0·0001
☆ Heart failure	44 (23%)	28 (52%)	16 (12%)	<0·0001
☆ Septic shock	38 (20%)	38 (70%)	0	<0·0001
☆ Coagulopathy	37 (19%)	27 (50%)	10 (7%)	<0·0001
☆ Acute cardiac injury	33 (17%)	32 (59%)	1 (1%)	<0·0001
☆ Acute kidney injury	28 (15%)	27 (50%)	1 (1%)	<0·0001
☆ Secondary infection	28 (15%)	27 (50%)	1 (1%)	<0·0001
Hypoproteinaemia	22 (12%)	20 (37%)	2 (1%)	<0·0001
Acidosis	17 (9%)	16 (30%)	1 (1%)	<0·0001

COVID Severity

	Mild	Moderate	Severe	Critical
Symptoms	+/-	+	++	++
Chest Imaging	(-)	Lung inflammation	Lung inflammation	Lung inflammation
Syndrome		▪ URI symptoms	▪ Dyspnea ▪ Tachypnea ▪ Hypoxemia ▪ P/F < 300	▪ Ventilator ▪ Shock ▪ Other organ failures

SOFA score, DM, HTN, age, **lymphopenia**, leucocytosis, and elevated ALT, LDH, hsTnI, CPK, **D-dimer**, serum ferritin, IL-6, prothrombin time, creatinine, and procalcitonin were also associated with death. ↓ALC (76% v. 26%, < ~0.9)

Lancet 3/9/2020

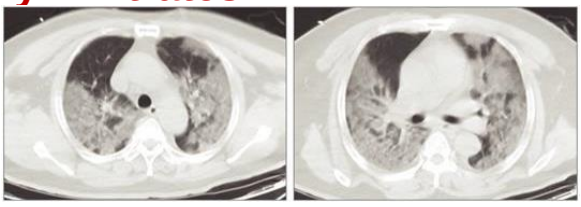
The risk factors related to the development of ARDS and progression from ARDS to death included older age, neutrophilia, and organ and coagulation dysfunction (eg, higher LDH and D-dimer).

JAMA IM 3/13/2020

Berlin Criteria: Acute Respiratory Distress Syndrome and COVID

Timing **Acute** (≤7d of insult)

Imaging **Bilateral pulmonary infiltrates**



Etiology **Non-cardiogenic**

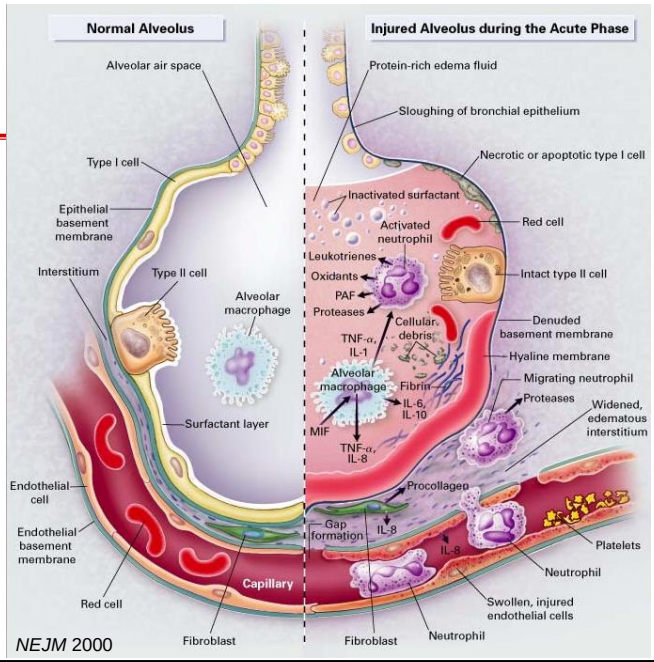
Oxygenation **Marked hypoxemia**

	Reference	COVID19 ICU
Pao_2, mm Hg	83-108	68 (56-89)
Pao_2:Fio_2, mm Hg	400-500	136 (103-234)

Pathophysiology

- Inflammation*
- Vascular permeability / interstitial edema*
- Surfactant dysfunction
- Alveolar edema
- Mucous plugging

Histologically: Pulmonary consolidation, fibrinous exudates (macrophages, giant cells), hyaline-membranes, desquamation of bronchial mucosa, focal hemorrhages, mucous plugs

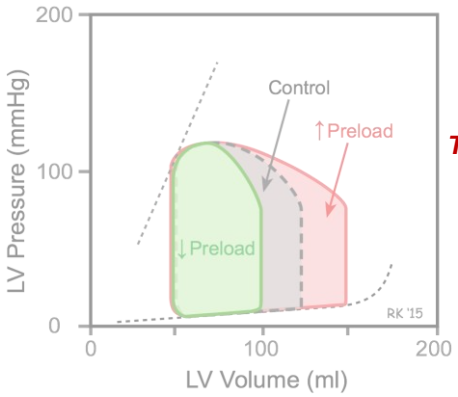


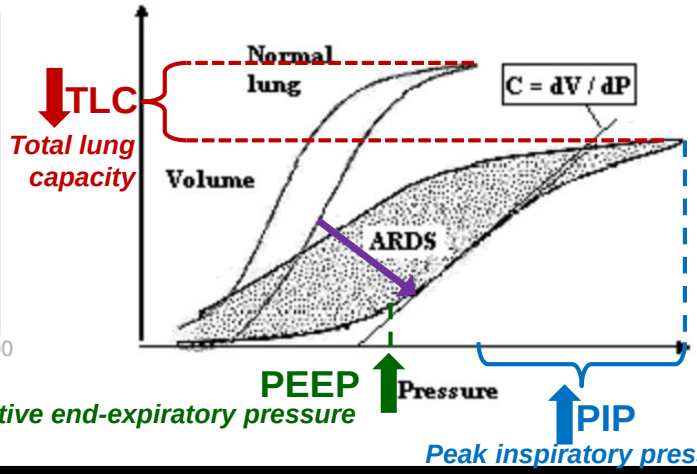
NEJM 2000

Lancet Res Med 2018;6:691.
AJRCCM 2017:195:331.

JAMA IM 3/13/2020

PV Aberrations in ARDS





Ventilator Goal

- **Support oxygenation when patient cannot**

while

- **Minimizing ventilator induced/associated harms**

Table 1
Selected clinical trials of ALI and ARDS

Intervention	Reference	Study phase	Study population[A]	Results
Lung-protective ventilation	96	Phase III	ARDS (N = 53)	Decrease in mortality
Lung-protective ventilation	97	Phase III	ARDS (N = 861)	Decrease in mortality
Lung-protective ventilation	98	Phase III	ARDS (N = 103)	Decrease in mortality
High PEEP	108	Phase III	ARDS (N = 549)	No difference in mortality
High PEEP	109	Phase III	ARDS (N = 385)	No difference in mortality
High PEEP	110	Phase III	ARDS (N = 382)	No difference in mortality
High-frequency ventilation	116	Phase II	ARDS (N = 148)	No difference in mortality
Prone position	111	Phase III	ALI and ARDS in children (N = 102)	No difference in mortality
Prone position	112	Phase III	ARDS (N = 342)	No difference in mortality
Neuromuscular blockade	113	Phase III	ARDS (N = 340)	Decrease in mortality
Esophageal pressure to adjust PEEP	114	Phase II	ARDS (N = 61)	Improved oxygenation
Surfactant	125	Phase III	ARDS (N = 448)	No difference in mortality
Methylprednisolone	126	Phase III	ARDS (N = 99)	No difference in mortality
Methylprednisolone				rease in mortality, but small study
Methylprednisolone				difference in mortality
Methylprednisolone				uction in duration of mechanical entilation, but major limitations elated to study design
Liposomal prostaglandin E				difference in mortality for results
Antioxidants				difference in mortality
Nitric oxide				difference in mortality
β_2-Agonist (aerosolized)				difference in mortality
β_2-Agonist (intravenous)				difference in mortality
ω-3 Fatty acid supplement				difference in mortality
Pulmonary artery versus c				difference in mortality
Fluid-conservative versus				e ventilator-free days with luid-conservative therapy
Extracorporeal membrane oxygenation	115	Phase III	ARDS (N = 90)	Decrease in mortality, but results not conclusive
APC	134	Phase III	Nonseptic ARDS (N = 75)	No difference in mortality
APC	133	Phase III	Sepsis (N = 1,697)	No difference in mortality
GM-CSF	131	Phase II	ARDS (N = 130)	No difference in mortality

[A]Physiologic criteria for ALI and ARDS varied among these trials.

No therapies have durably altered outcome in ARDS

Only "lung protective" ventilator strategies

MGH TREATMENT GUIDE FOR CRITICALLY ILL PATIENTS WITH COVID-19

PRESENTATION

NOTABLE SX
- ~65-80% Cough • ~45% Febrile initially
- ~15% URI Sx • ~10% GI Sx
- Acute worsening after early mild sx

HIGH RISK FOR SEVERE DZ
- Age >55
- Comorbid diseases:
  - Pulm, cardiac, renal
  - Diabetes, HTN
  - Immunocompromise

LABS INDICATING SEVERE DZ
- D-dimer >1000
- CPK > 2x ULN
- CRP>100, LDH >245
- Troponin elevated/uptrending
- Abs lymphocyte count <0.8
- Ferritin >300

DIAGNOSTICS

DAILY LABS
- CBC with diff (trend lymphocyte ct)
- CMP
- CPK

RISK STRAT Q2-3 DAY PRN
- D-dimer
- Ferritin/CRP/ESR
- LDH
- Troponin, EKG

ONE TIME TEST FOR ALL PTS
- HBV, HCV, HIV testing
- Influenza A/B, RSV
- Additional resp viral per ID guide
- COVID-19 (if not already performed)

RESPIRATORY FAILURE

CONSIDER EARLY INTUBATION
Avoid using HFNC or NIPPV
Warning signs: inc FiO_2, dec SaO_2, CXR worse

LUNG PROTECTIVE VENTILATION
- Vt 4-6 ml/kg predicted body weight
- Plateau pressure <30
- Driving pressure (Pplat-PEEP) <15
- Target SaO2 90-95%, PaO2>60
- Starting PEEP 8-10 cmH20

↓

CONSERVATIVE FLUID STRATEGY
No maintenance fluids, diuresis as tolerated by hemodynamics/Creatinine

↓

PEEP TITRATION
Best PEEP by tidal compliance or ARDSnet low PEEP table

↓

PRONE
Early consideration if cont. hypoxemia or elevated airway pressures

↓

ADDITIONAL THERAPIES
- Paralytics for vent dysynchrony, not routine
- Inhaled NO: up to 80 ppm (no epoprostenol)

IF WORSENING / **IF IMPROVING**

ECMO CONSULT
if continued hypoxemia or elevated airway pressures

VENT LIBERATION
- Daily SAT/SBT when appropriate
- ABCDE bundle

PAGER NUMBERS
ICU CONSULT:26955 ECMO:24252 BIOTHREATS:26876

HEMODYNAMICS
- MAP >65
- Norepinephrine first choice pressor
- IF WORSENING:
  - Consider myocarditis/cardiogenic shock
  - Obtain POCUS echo, EKG, trop, CVO2 (formal TTE if high concern)

CHANGE TO USUAL CARE
- **MINIMIZE** staff contact in room
- **NO** routine daily CXR
- **HIGH THRESHOLD** for bronchoscopy
- **HIGH THRESHOLD** to travel
- **BUNDLE** bedside procedures
- Appropriate guideline-based isolation for aerosol generating procedures:
  - bronchoscopy
  - intubation/extubation
  - AVOID nebs, prefer MDIs

THERAPEUTICS

ALL ICU ADMISSIONS:
- Low threshold for empiric abx
- Tracheal aspirate for intubated pts
- **WITH ID GUIDANCE:**
  - Consider hydroxychloroquine and statin
  - Remdesivir through clinical trial

IMMUNE MODULATION
- Immunomodulatory therapies only in consultation with ID and critical care attending
- **NO STEROIDS** for resp failure, consider only in s/o additional indication

MGH Protocol 3/25/2020

ARDS Ventilator Strategy

Independent Variables*

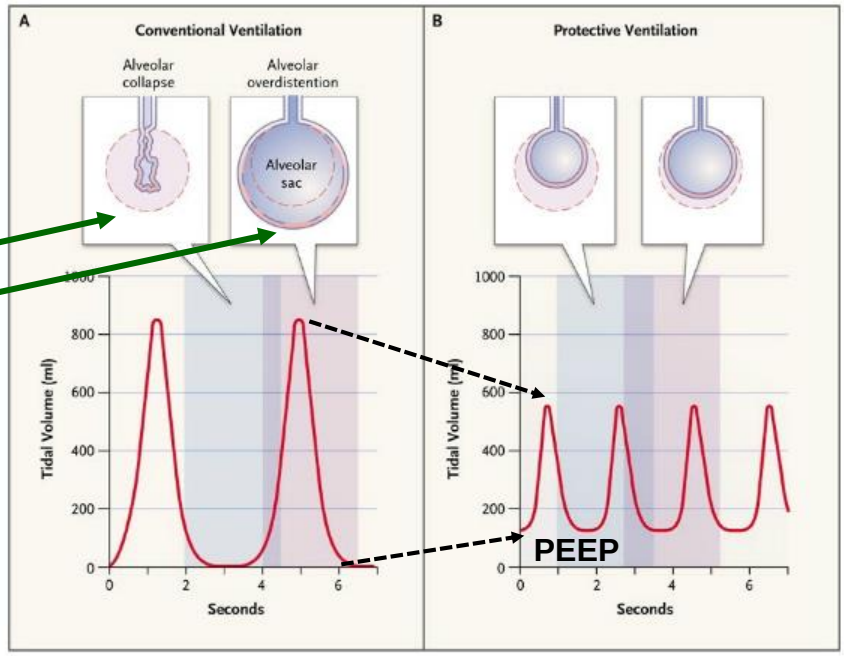
- **Tidal volume (6 cc/kg PBW)**
- **Respiratory rate (~16-20s)**

$\dot{V}_E = TV \times rr$

*Volume control ventilator mode

Lung Protection

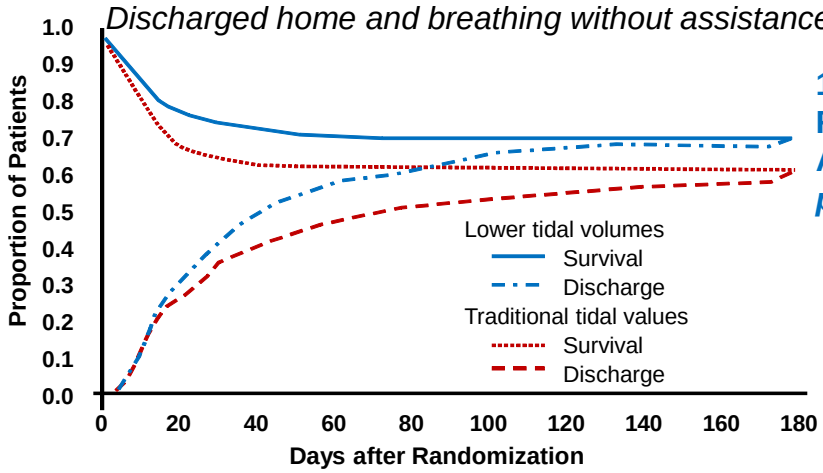
- Maintain $\dot{V}_E$
- ↓ atelectrauma
- ↓ volutrauma



Malhotra A, NEJM 2007

ARDSNet: Low Tidal Volume (6 v. 12 cc/kg)

NHLBI
n=861
P/F ~130s



180d
RRR 22%
ARR 8.8%
p=0.007

Of interest, LTV ↓IL-6 by △0.3pg/mL/2.5pg/mL day 0→3

ARMA, ARDSNet NEJM 2000

Tidal Volume

- PBW

Inches to kg

♀ 45.5+2.3(H-60)

♂ 50+2.3(H-60)

HEIGHT	PBW	4 ml	5 ml	6 ml	7 ml	8 ml
4' 0" (48)	17.9	72	90	107	125	143
4' 1" (49)	20.2	81	101	121	141	162
4' 2" (50)	22.5	90	113	135	158	180
4' 3" (51)	24.8	99	124	149	174	198
4' 4" (52)	27.1	108	136	163	190	217
4' 5" (53)	29.4	118	147	176	206	235
4' 6" (54)	31.7	127	159	190	222	254
4' 7" (55)	34	136	170	204	238	272
4' 8" (56)	36.3	145	182	218	254	290
4' 9" (57)	38.6	154	193	232	270	309
4' 10" (58)	40.9	164	205	245	286	327
4' 11" (59)	43.2	173	216	259	302	346
5' 0" (60)	45.5	182	228	273	319	364
5' 1" (61)	47.8	191	239	287	335	382
5' 2" (62)	50.1	200	251	301	351	401
5' 3" (63)	52.4	210	262	314	367	419
5' 4" (64)	54.7	219	274	328	383	438
5' 5" (65)	57	228	285	342	399	456
5' 6" (66)	59.3	237	297	356	415	474
5' 7" (67)	61.6	246	308	370	431	493
5' 8" (68)	63.9	256	320	383	447	511
5' 9" (69)	66.2	265	331	397	463	530
5' 10" (70)	68.5	274	343	411	480	548
5' 11" (71)	70.8	283	354	425	496	566
6' 0" (72)	73.1	292	366	439	512	585
6' 1" (73)	75.4	302	377	452	528	603
6' 2" (74)	77.7	311	389	466	544	622
6' 3" (75)	80	320	400	480	560	640
6' 4" (76)	82.3	329	412	494	576	658
6' 5" (77)	84.6	338	423	508	592	677
6' 6" (78)	86.9	348	435	521	608	695
6' 7" (79)	89.2	357	446	535	624	714
6' 8" (80)	91.5	366	458	549	641	732
6' 9" (81)	93.8	375	469	563	657	750
6' 10" (82)	96.1	384	481	577	673	769
6' 11" (83)	98.4	394	492	590	689	787
7' 0" (84)	100.7	403	504	604	705	806

PBW and Tidal Volume for Females

HEIGHT	PBW	4 ml	5 ml	6 ml	7 ml	8 ml
4' 0" (48)	22.4	90	112	134	157	179
4' 1" (49)	24.7	99	124	148	173	198
4' 2" (50)	27	108	135	162	189	216
4' 3" (51)	29.3	117	147	176	205	234
4' 4" (52)	31.6	126	158	190	221	253
4' 5" (53)	33.9	136	170	203	237	271
4' 6" (54)	36.2	145	181	217	253	290
4' 7" (55)	38.5	154	193	231	270	308
4' 8" (56)	40.8	163	204	245	286	326
4' 9" (57)	43.1	172	216	259	302	345
4' 10" (58)	45.4	182	227	272	318	363
4' 11" (59)	47.7	191	239	286	334	382
5' 0" (60)	50	200	250	300	350	400
5' 1" (61)	52.3	209	262	314	366	418
5' 2" (62)	54.6	218	273	328	382	437
5' 3" (63)	56.9	228	285	341	398	455
5' 4" (64)	59.2	237	296	355	414	474
5' 5" (65)	61.5	246	308	369	431	492
5' 6" (66)	63.8	255	319	383	447	510
5' 7" (67)	66.1	264	331	397	463	529
5' 8" (68)	68.4	274	342	410	479	547
5' 9" (69)	70.7	283	354	424	495	566
5' 10" (70)	73	292	365	438	511	584
5' 11" (71)	75.3	301	377	452	527	602
6' 0" (72)	77.6	310	388	466	543	621
6' 1" (73)	79.9	320	400	479	559	639
6' 2" (74)	82.2	329	411	493	575	658
6' 3" (75)	84.5	338	423	507	592	676
6' 4" (76)	86.8	347	434	521	608	694
6' 5" (77)	89.1	356	446	535	624	713
6' 6" (78)	91.4	366	457	548	640	731
6' 7" (79)	93.7	375	469	562	656	750
6' 8" (80)	96	384	480	576	672	768
6' 9" (81)	98.3	393	492	590	688	786
6' 10" (82)	100.6	402	503	604	704	805
6' 11" (83)	102.9	412	515	617	720	823
7' 0" (84)	105.2	421	526	631	736	842

PBW and Tidal Volume for Males

ARDS Ventilator Strategy

Independent Variables

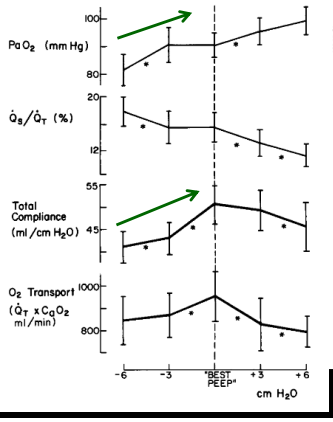
- **Tidal volume (6 cc/kg PBW)**
- **Respiratory rate (~16-20s)**
- **FiO_2**
- **PEEP**
- (inspiratory time, flow)

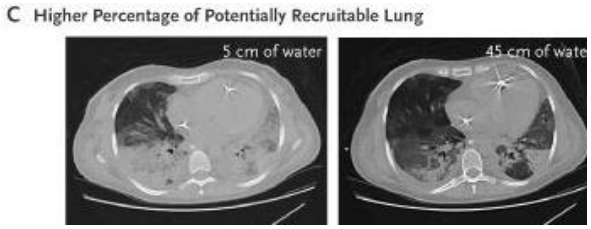
CO_2

O_2

Positive End-Expiratory Pressure

- Benefits:
  - Prevents end-expiratory derecruitment
  - Optimizes lung volumes and C_{RS}

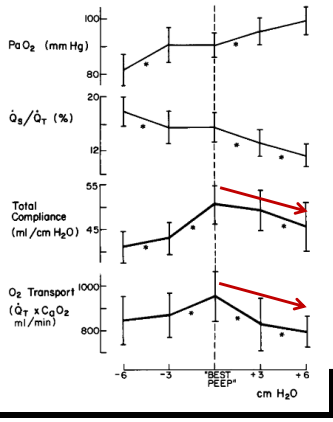


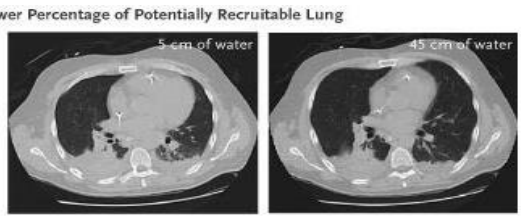


Suter PM, *et al.* NEJM 1975
Gattinoni L, *et al*. NEJM 2006

Positive End-Expiratory Pressure

- Downsides:
  - Overdistention of already open lung units
  - Adverse hemodynamic effects (venous return, RV)





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ARDS Ventilator Strategy

Independent Variables

- **Tidal volume (6 cc/kg PBW)** — CO_2
- **Respiratory rate (~16-20s)** — CO_2
- **FiO_2** — O_2
- **PEEP (start ~8-10 cmH_2O)†** — O_2
- (inspiratory time, flow)

"Lungs appear like *sponges* . . . they are completely wet . . . exquisitely PEEP responsive"
~14 cmH_2O

†MGH differs from SCCM guidance
ART JAMA 2017;318:1335

ARDS Ventilator Strategy

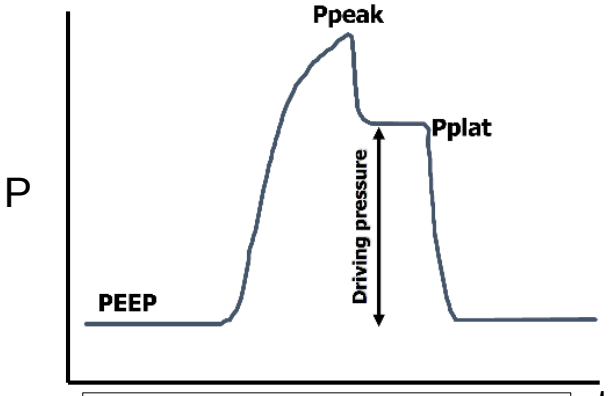
Independent Variables

- **Tidal volume (6 cc/kg PBW)** — CO_2
- **Respiratory rate (~16-20s)** — CO_2
- **FiO_2** — O_2
- **PEEP (start ~8-10 cmH_2O)** — O_2
- (inspiratory time, flow)

Reported Variables

- pH > 7.25
- SaO_2 90%-96%
- PaO_2 55-80 mmHg
- P/F ratio
- P_{plat} <30 (†pressure on alveoli)
- Driving Pressure:
  (P_{plat} – PEEP) < 15
- Compliance (resp system)

ARDS Ventilator Strategy



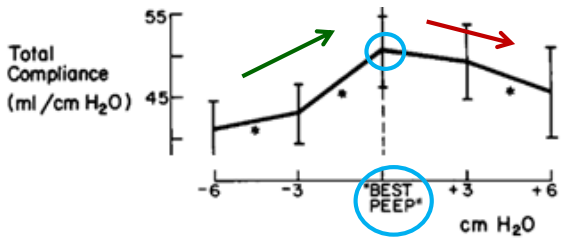
$C_{RS} = V_T / (P_{Plat} - PEEP)$

Reported Variables

- pH > 7.25
- SaO_2 90%-96%
- PaO_2 55-80 mmHg
- P/F ratio
- P_{plat} <30 (†pressure on alveoli)
- **Driving Pressure:**
  (P_{plat} – PEEP) < 15
- **Compliance (resp system)**

**Volume control ventilator mode*

Finding the "Best PEEP": Tidal Compliance



Bedside maneuver
Perform after recruitment
No special equipment

PEEP	Pplat	Plat-PEEP	Tidal Volume	Compliance	SpO2	BP
24	33	9	400	44.4	96	92/58 75
22	31	9	400	44.4	95	106/61 75
20	27	7	400	57.1	96	106/62 75
18	25	7	400	57.1	96`	112/63 77
16	23	`7	400	57.1	96	117/64 78
14	22	8	400	50	96	117/65 79

But routine recruitment / high PEEP may harm: ART, and other trials ALVEOLI, EXPRESS, LOVS

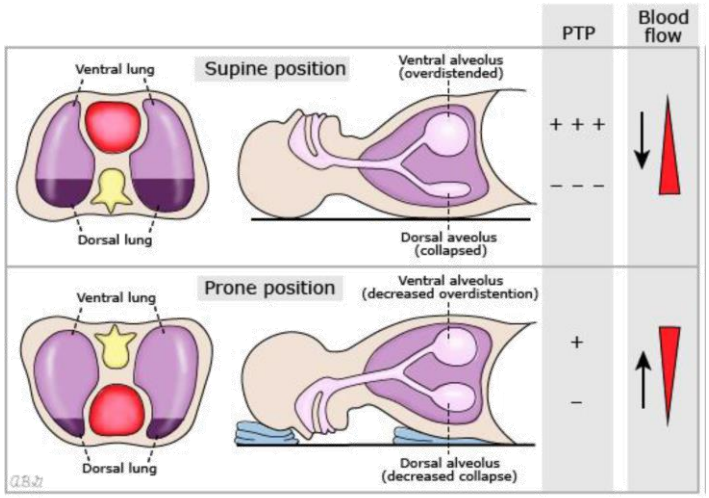
Fluid Management Principles

- Goal to ↓ EVLW*
- Conservative fluid strategy improves
  - Ventilator free days (+2.5)
  - Mechanical vent days (-2.8)
  - ICU free days (+2)
- Fluids
  - Avoid maintenance fluids
  - Limit bolus (crystalloid) to shock
  - Assess fluid responsiveness
- Consider diuretic to normalize CVP until off ventilator
  - Stop based on ↑Cr
- Avoid RIJ access (ECMO)

FACTT *NEJM* 2006; SCCM

Prone Ventilation

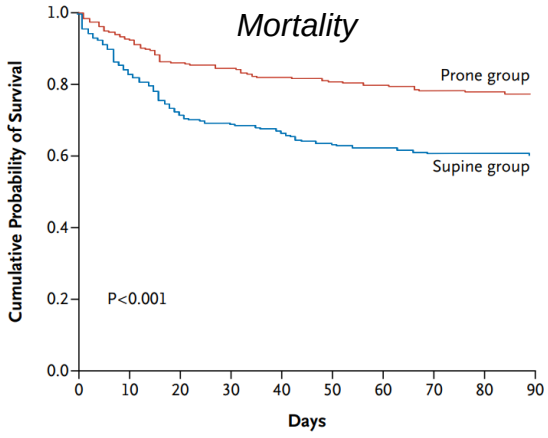
- Mechanisms
  - ↓ lung compression
  - ↑ FRC (recruit **posterior base**, diaphragm)
  - ↑ and more homogenous ventilation (V/Q, reduces ventilator trauma)
- prone↓ FiO2 and ↓ PEEP
- MGH Protocol drafted



Prone Positioning: PROSEVA

France
n=466
P/F 100
PEEP 10
TV 6.1 cc/kg

Prone>16h per day
Sites *highly experienced*



No. at Risk					
Prone group	237	202	191	186	182
Supine group	229	163	150	139	136

At 28d
HR ~ 0.4
ARR 16.8%
p=<0.001

At 90d
HR ~ 0.4
ARR 17.4%
p=<0.001

Of interest, rate of cardiac arrest half in prone patients versus supine

NEJM 2013

Proning: Logistics and Contraindications

Contraindications

- Unstable spine, pelvis, or fractures
- Pregnancy (2nd/3rd trimester)
- Open chest/abdomen
- Elevated ICP
- Hemoptysis
- Facial trauma

- *Vascular/CVVH lines, NGT are not*
- *Arterial line before prone*
- *? Paralytic*

Complications

- ETT dislodged/obstructed
- Corneal abrasion, facial edema
- Atypical sites of pressure ulcers
- EKG leads on back
- Brachial plexopathy
- Hemodynamics (*less* hypotension in PROSEVA)

Recap: ARDS

- **Early intubation**
- **Lung protective ventilation**
- **Prone ventilation**
- **Nitric oxide (iNO)**
- **Conservative fluid strategy**
- **± NMB → Daily SAT**

- Steroids*
- ? Anti-retrovirals
- ? Early antibiotics
- ? Anti-inflammatories, statins
- ? ECMO

20/20 Vision on COVID and ARDS

- **Protect yourself and team**
- **Protect the patient (lung protection)**

References

- PHS/MGH Communication with Italian and Chinese ICUs
- MGH/PHS protocols
  - Critical Care
  - ID (CHANT)
  - Proning Protocol
- PCCM (Hibbert, Hardin, etc) and HCICU intensivists/RRT
- ACC, JAMA, SCCM, ATS, ARDSnet, CDC, CCDC