Clinical Approach to the Morbidly Obese Patient with Respiratory Failure

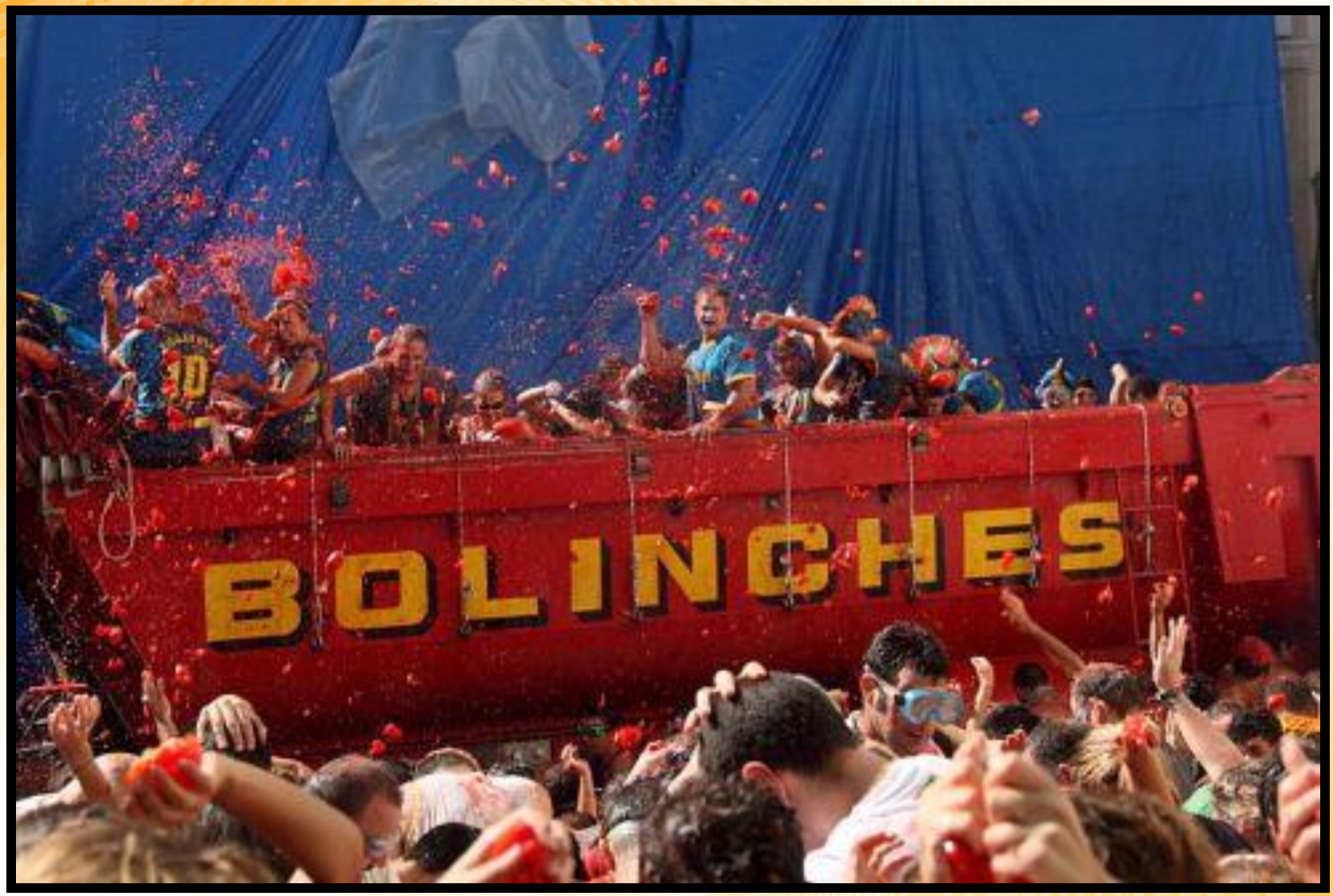
Kenneth Miller, MEd, RRT-NPS, RRT-ACCS, AC-E
Educational/Research Coordinator
Respiratory Care Services
Lehigh Valley Health Network

Clinical Objectives

- Describe the incidence and presence of obesity in America
- Define the respiratory clinical pathophysiology germane to the obese patient population
- Describe the clinical challenges the obese patient presents with respiratory compromise

Is Obesity a Problem?

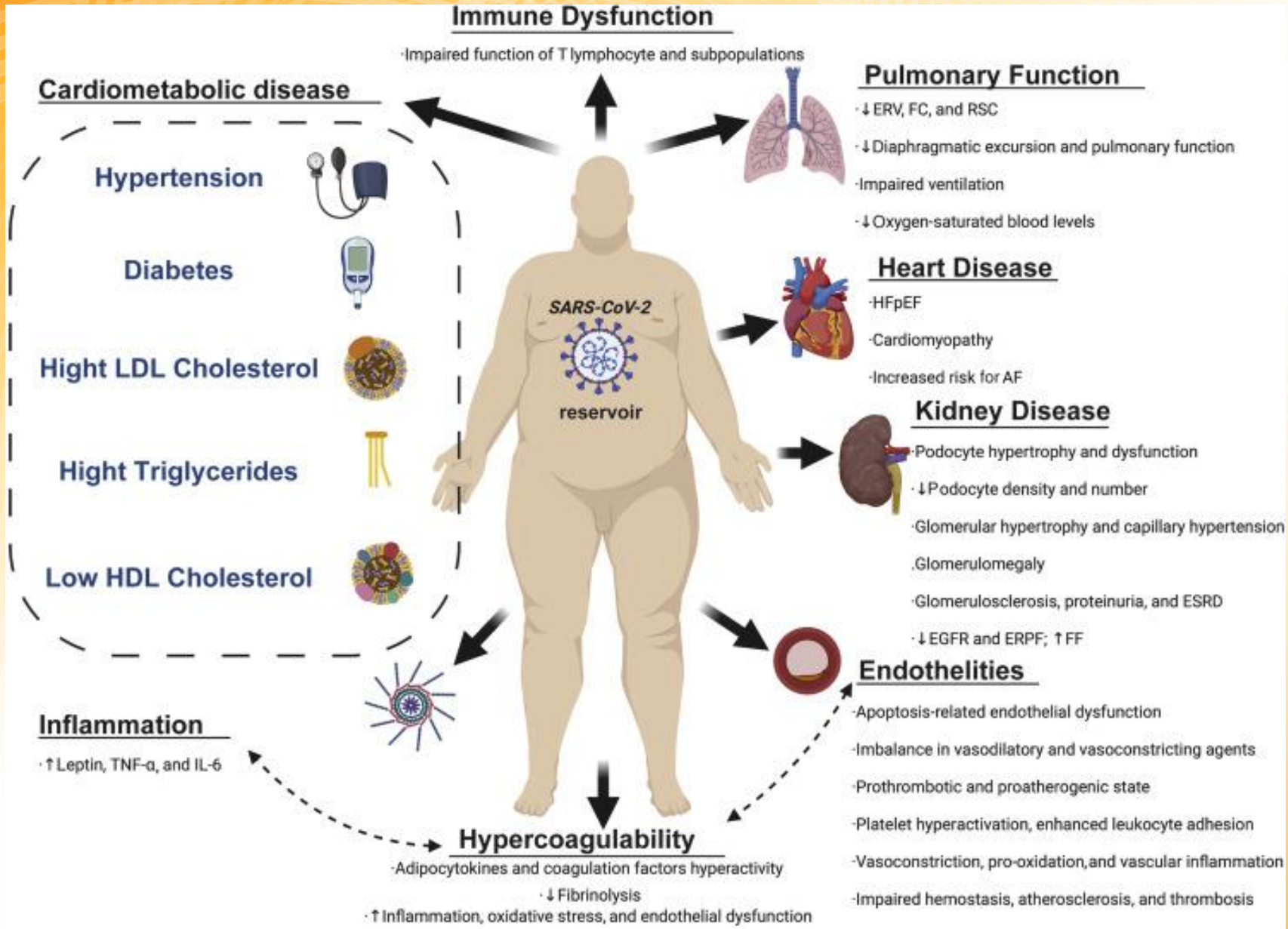
I am speaking to the choir??



Or do I have to convince you!!!

Why the Concern?

- Approximately 65% of American adults either are either overweight or obese.
- Illness of morbid obese exceeds 25 billion dollars nation-wide.
- Life expectancy is reduce by eight years.
- Ten percent of the population listed as morbid obese (BMI>40%) and account for **14 cases per 1,000 ICU admissions.**
- As more of these patients are admitted to critical care units, the RRT needs to understand the scope of care and interventions that are required to optimize clinical outcomes.


Immune Dysfunction
·Impaired function of T lymphocyte and subpopulations
Cardiometabolic disease
Hypertension
Diabetes
Hight LDL Cholesterol
Hight Triglycerides
Low HDL Cholesterol
SARS-CoV-2
reservoir
Pulmonary Function
·↓ERV, FC, and RSC
·↓Diaphragmatic excursion and pulmonary function
·Impaired ventilation
·↓Oxygen-saturated blood levels
Heart Disease
·HFpEF
·Cardiomyopathy
·Increased risk for AF
Kidney Disease
·Podocyte hypertrophy and dysfunction
·↓Podocyte density and number
·Glomerular hypertrophy and capillary hypertension
.Glomerulomegaly
·Glomerulosclerosis, proteinuria, and ESRD
·↓EGFR and ERPF; ↑FF
Endothelities
·Apoptosis-related endothelial dysfunction
·Imbalance in vasodilatory and vasoconstricting agents
·Prothrombotic and proatherogenic state
·Platelet hyperactivation, enhanced leukocyte adhesion
·Vasoconstriction, pro-oxidation,and vascular inflammation
·Impaired hemostasis, atherosclerosis, and thrombosis
Inflammation
·↑Leptin, TNF-α, and IL-6
Hypercoagulability
·Adipocytokines and coagulation factors hyperactivity
·↓Fibrinolysis
·↑Inflammation, oxidative stress, and endothelial dysfunction

Is Obesity a Problem?

Yes!

Like our weight, the cost of health care is rising!!!

Questions?

How Do We Define Obesity?

Methods of Measurement

- Body Mass Index (BMI) - **calculation**
- Hydrostatic weight
- Body calipers

} **% Body Fat**

General Body Fat Percentage Categories		
Classification:	**Women:**	**Men:**
Essential Fat	10 - 12%	2 - 4%
Athletes	14 - 20%	6 - 13%
Fitness	21 - 24%	14 - 17%
Acceptable	25 - 31%	18 - 25%
At Risk	32% plus	25% plus

Body Mass Index

$$\frac{\text{Body Weight (kg)}}{\text{Height (m}^2\text{)}}$$

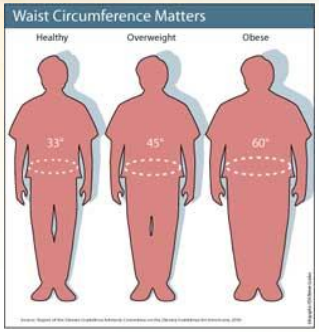
Flaws	Strengths
•Indirect Measurement •Doesn't take muscle into account	•Noninvasive •Simple and effective when used in context

BMI – NIH/NHLBI Table

BMI	
< 18.5	Below normal weight
19-24	Normal weight
25-29	Overweight
30-34	Class I Obesity
35-39	Class II Obesity
40+	Class III Obesity

National Institutes of Health (NIH), National Heart, Lung, and Blood Institute (NHLBI). The practical guide: identification, evaluation, and treatment of overweight and obesity in adults. Bethesda: National Institutes of Health. 2000, NIH publication 00-4084.

Definition of Obesity



WEIGHT IN POUNDS

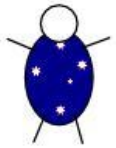
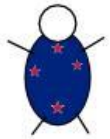
HEIGHT IN FEET AND INCHES	120	130	140	150	160	170	180	190	200	210	220	230	240	250
4' 6"	29	31	34	36	39	41	43	46	48	51	53	56	58	60
4' 8"	27	29	31	34	36	38	40	43	45	47	49	52	51	56
4' 10"	25	27	29	31	34	36	38	40	42	44	46	48	50	52
5' 0"	23	25	27	29	31	33	35	37	39	41	43	45	47	49
5' 2"	22	24	26	27	29	31	33	35	37	38	40	42	44	46
5' 4"	21	22	24	26	28	29	31	33	34	36	38	40	41	43
5' 6"	19	21	23	24	26	27	29	31	32	34	36	37	39	40
5' 8"	18	20	21	23	24	26	27	29	30	32	34	35	37	38
5' 10"	17	19	20	22	23	24	26	27	29	30	32	33	35	36
6' 0"	16	18	19	20	22	23	24	26	27	28	30	31	33	34
6' 2"	15	17	18	19	21	22	23	24	26	27	28	30	31	32
6' 4"	15	16	17	18	20	21	22	23	24	26	27	28	29	30
6' 6"	14	15	16	17	19	20	21	22	23	24	25	27	28	29
6' 8"	13	14	15	17	18	19	20	21	22	23	24	25	26	28

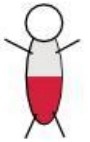
Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000)

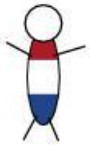
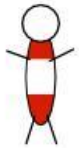
Obese Overweight Healthy Weight

OBESITY:

The percentage of the population older than 15 with a body-mass index greater than 30.

USA	Mexico	UK	Slovak Republic	Greece	Australia	New Zealand	Hungary	Czech Republic
								
31%	24%	23%	22%	22%	22%	21%	19%	15%

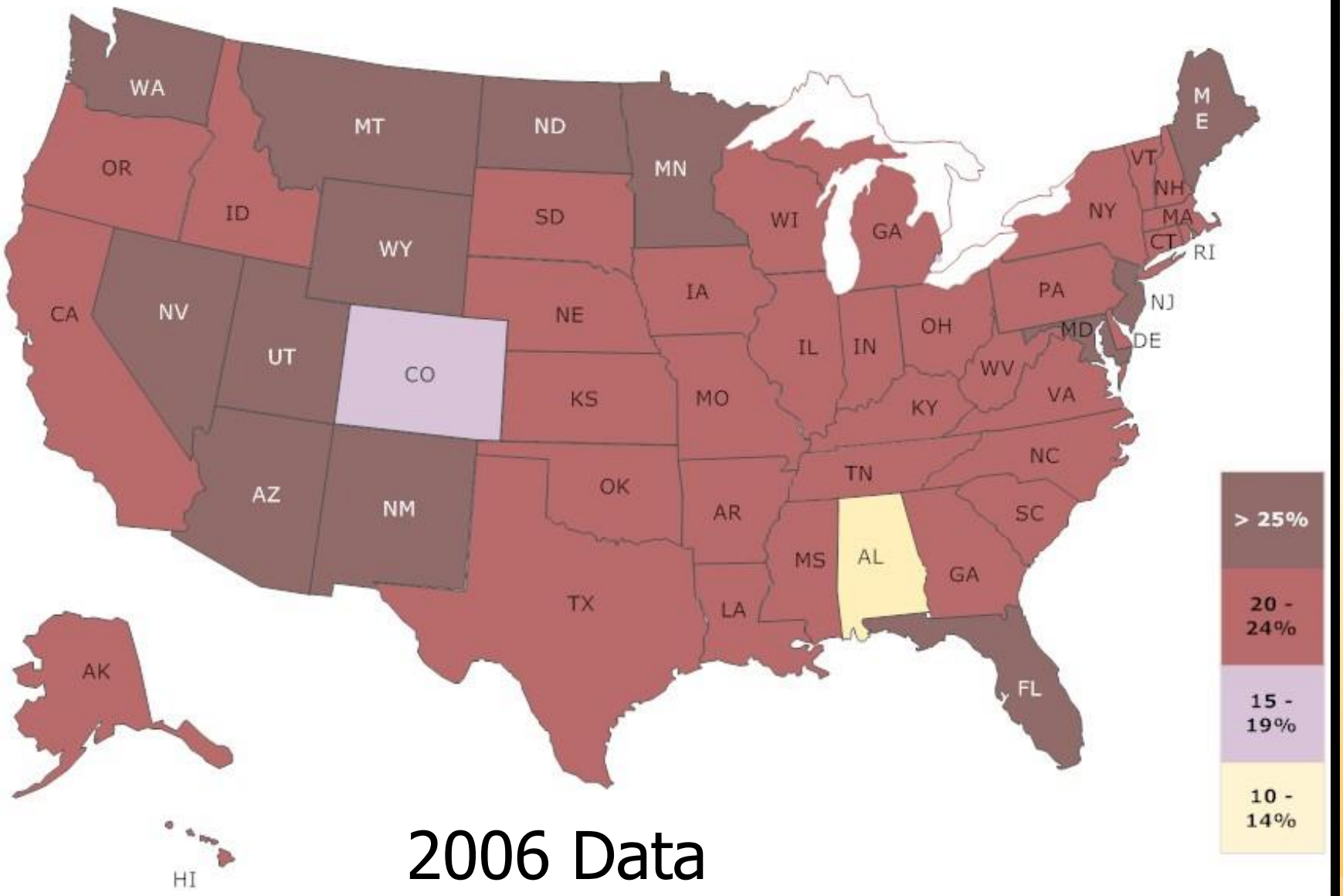
Canada	Spain	Ireland	Germany	Portugal	Finland	Turkey	Belgium	Poland
								
14%	13%	13%	13%	13%	13%	12%	12%	11%

Netherlands	Sweden	Denmark	France	Austria	Italy	Norway	Japan	Korea
								
10%	10%	10%	9%	9%	9%	8%	3%	3%

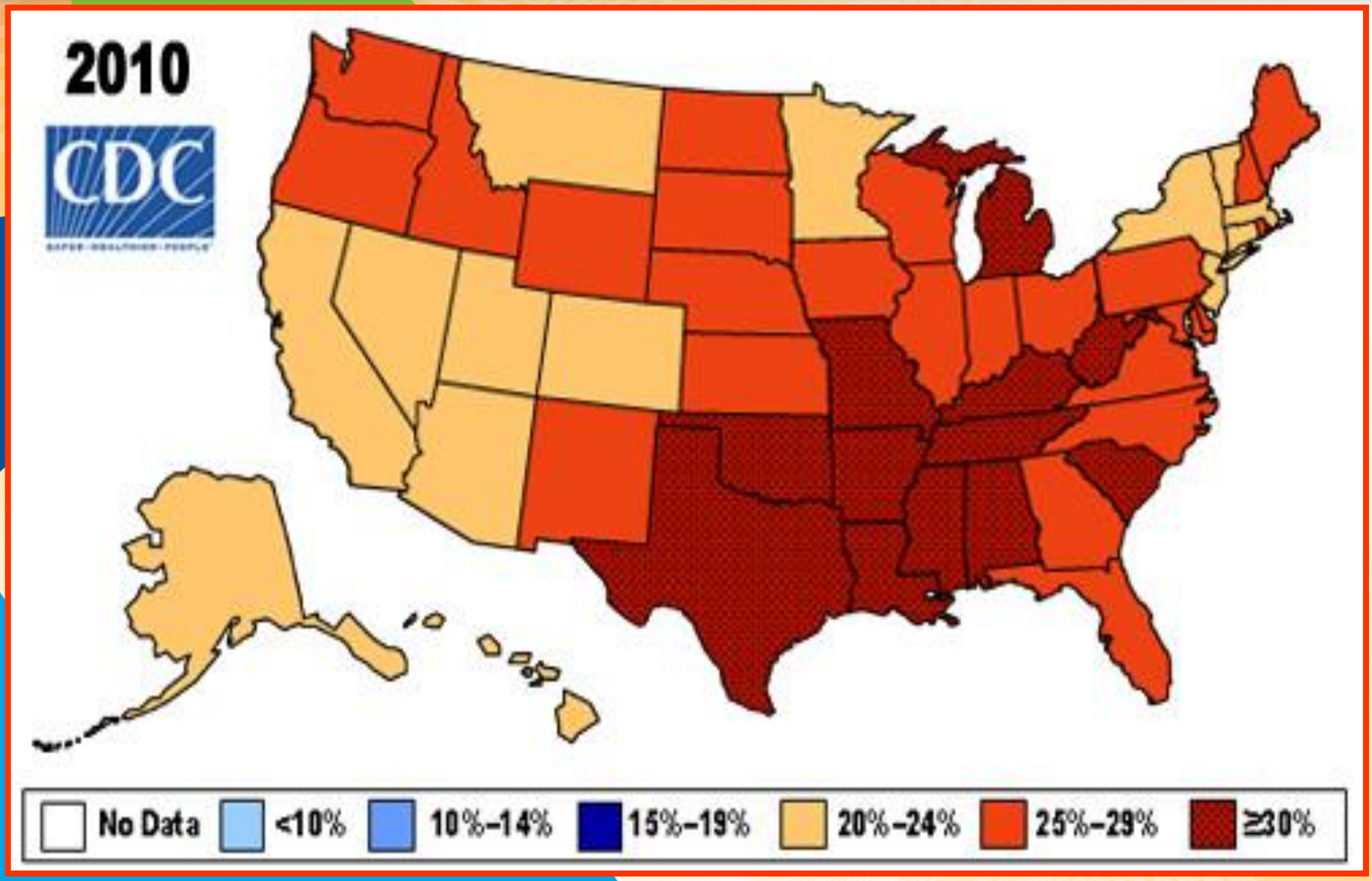
Data taken from:
http://en.wikipedia.org/w/index.php?title=Image:Bmi30chart.png&oldid=107854217

Drawing by:
http://www.WellingtonGrey.net

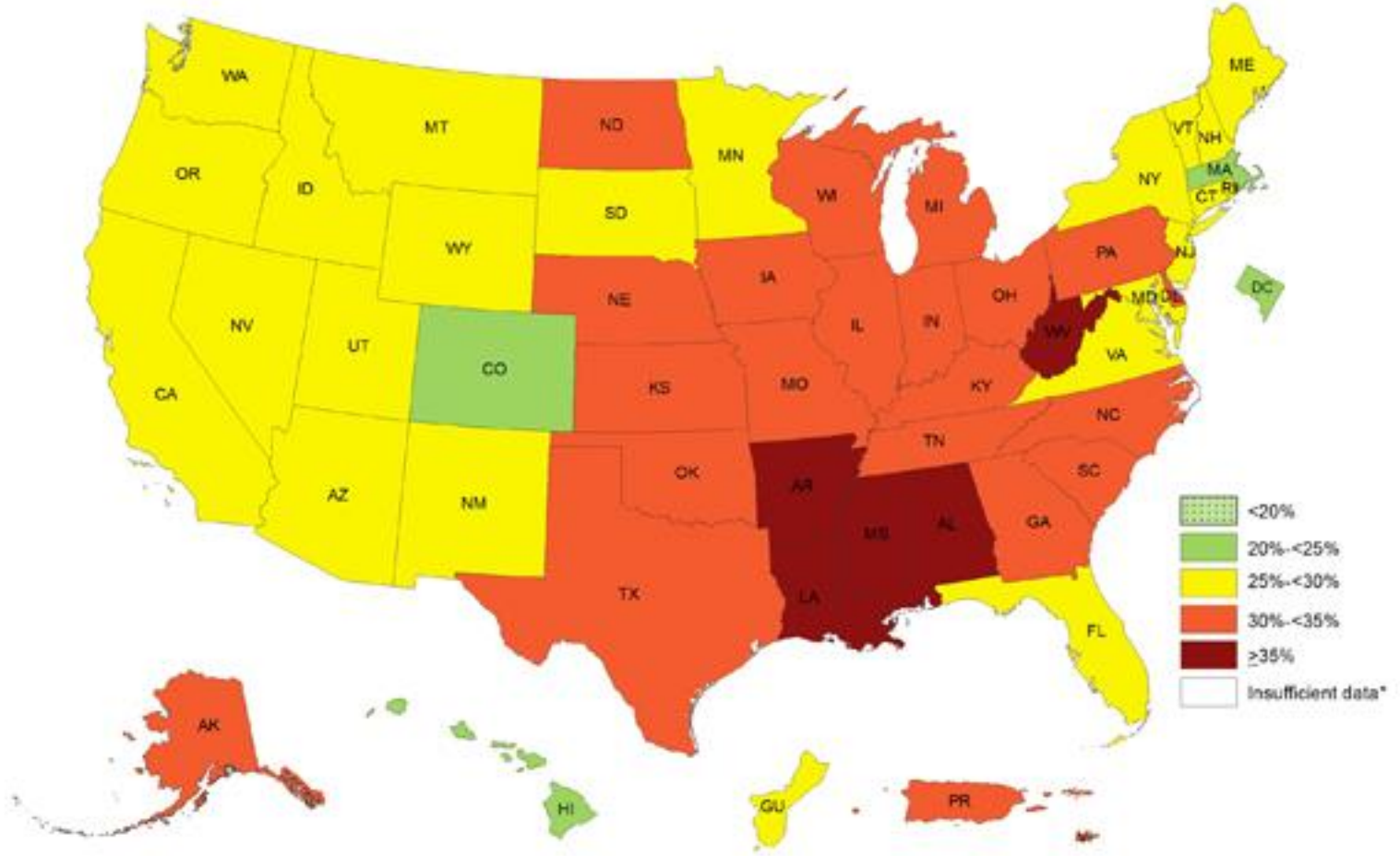
OBESITY IN THE USA

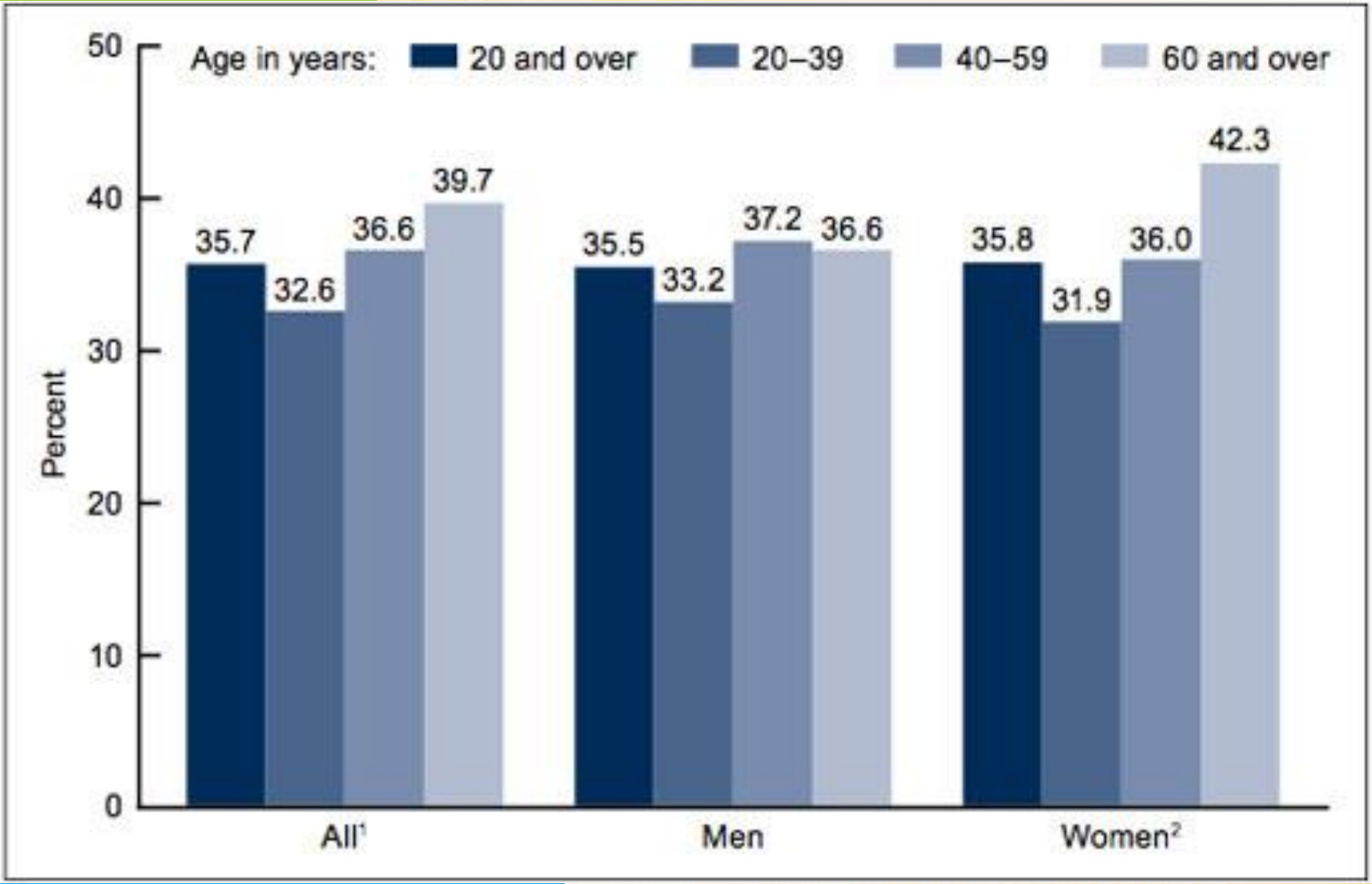


2006 Data

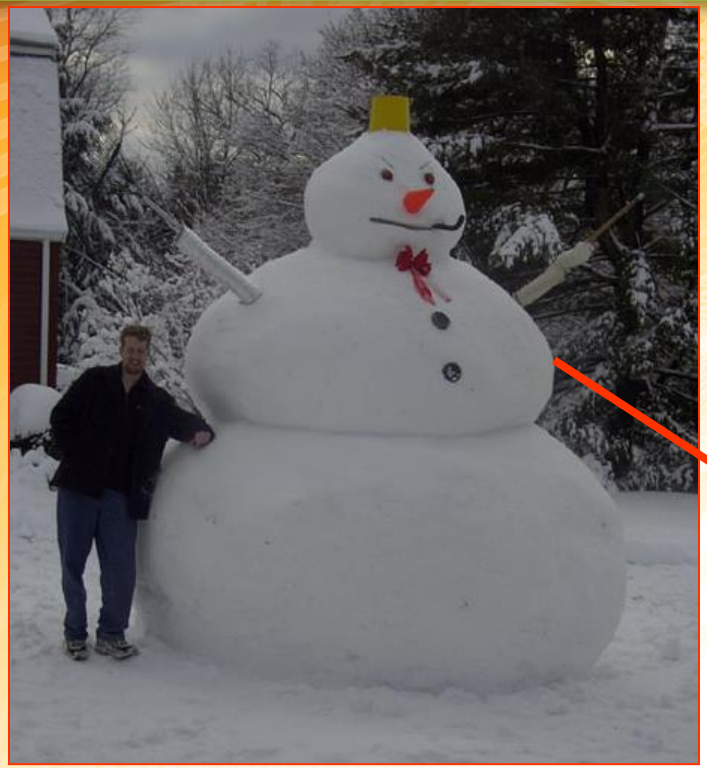

2010
CDC
No Data
<10%
10%–14%
15%–19%
20%–24%
25%–29%
≥30%

Self-reported Obesity Prevalence by US State and Territory, BRFSS, 2016.





Aging and Obesity




I'll Be
Dead Soon

Morbid Obesity in Our Society

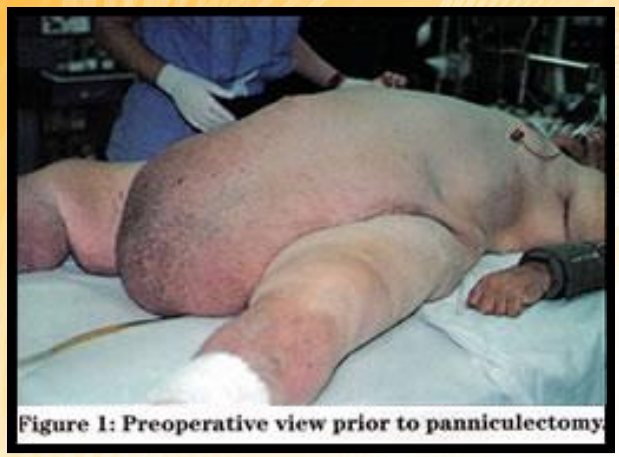


Figure 1: Preoperative view prior to panniculectomy.

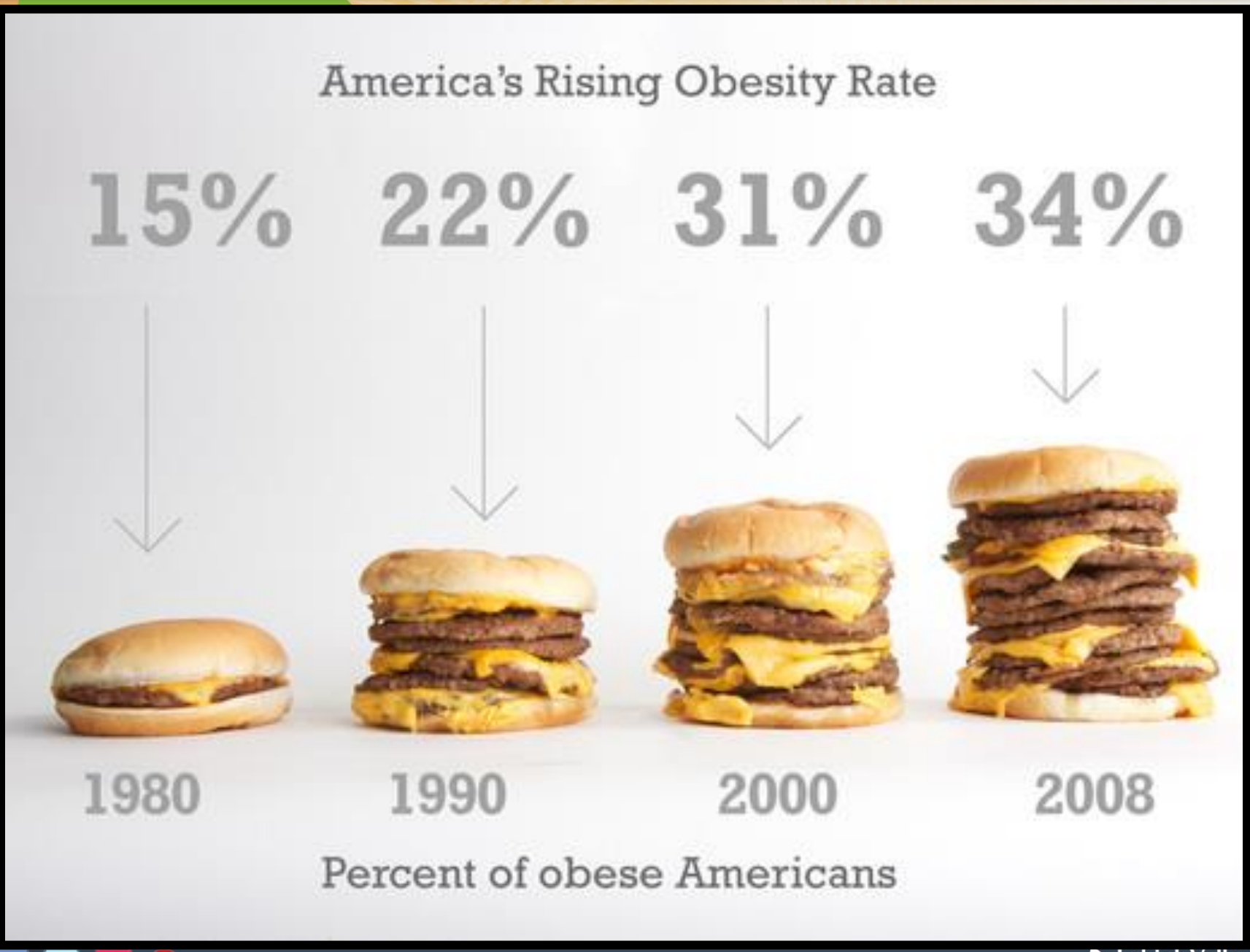
increased health costs

childhood obesity

increased consumption

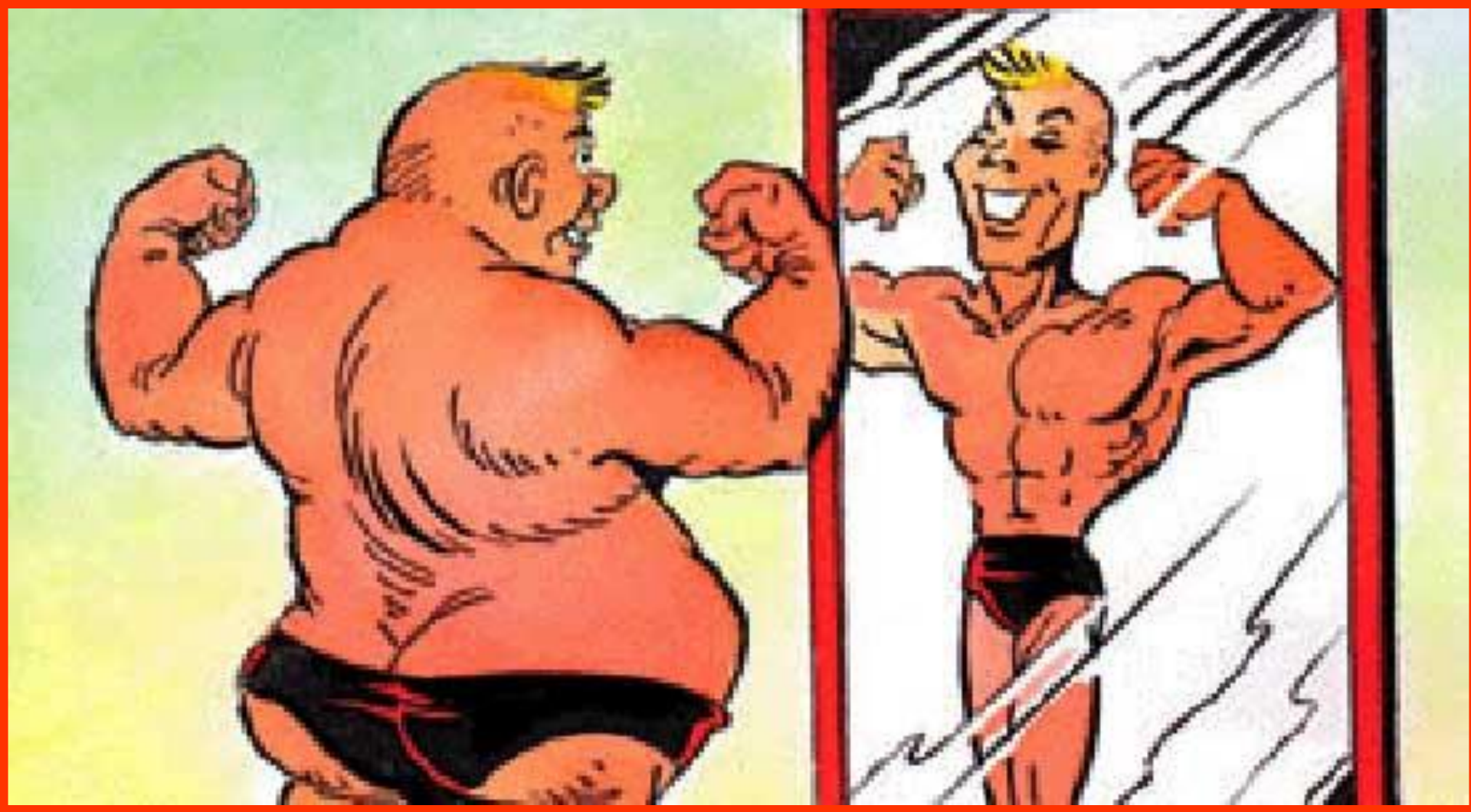
increased asthma

Super Sizing It!


America's Rising Obesity Rate
15%
22%
31%
34%
1980
1990
2000
2008
Percent of obese Americans

AND IF YOU ORDER
THE LARGER PORTION
REGULARLY
AFTER
ONE YEAR
YOU'D BE

8.3
POUNDS
FATTER.



Altered Image

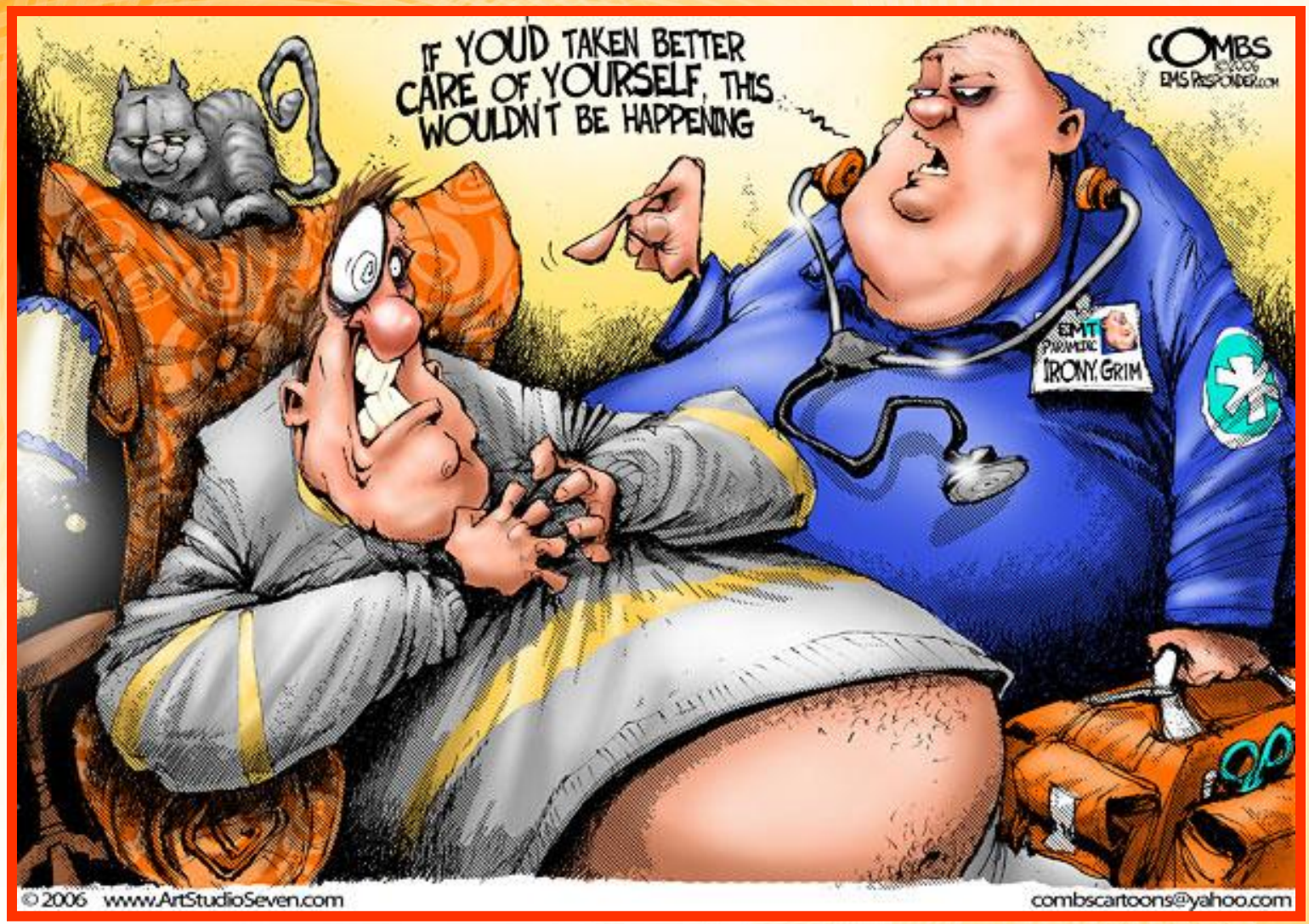
TABLE 2

EXAMPLES OF POOR QUALITY OF LIFE IN ADOLESCENT OBESITY

Domain	*Examples*
Emotional	Patient is withdrawn, sullen, and self-critical. He or she has poor self-esteem and partakes in suicidal ideation.
Physical	Patient has limited mobility and exertional dyspnea. He or she does not participate in sports or exercise and is chronically fatigued.
Academic	Patient falls asleep in school, submits incomplete homework assignments, and receives poor grades. He or she is frequently absent and struggles to concentrate.
Social	Patient is socially insecure and lacks social and leadership skills. He or she is often isolated, rejected, and bullied, indicating inadequate social support, few reciprocal friendships, and neither a best friend nor a romantic partner.

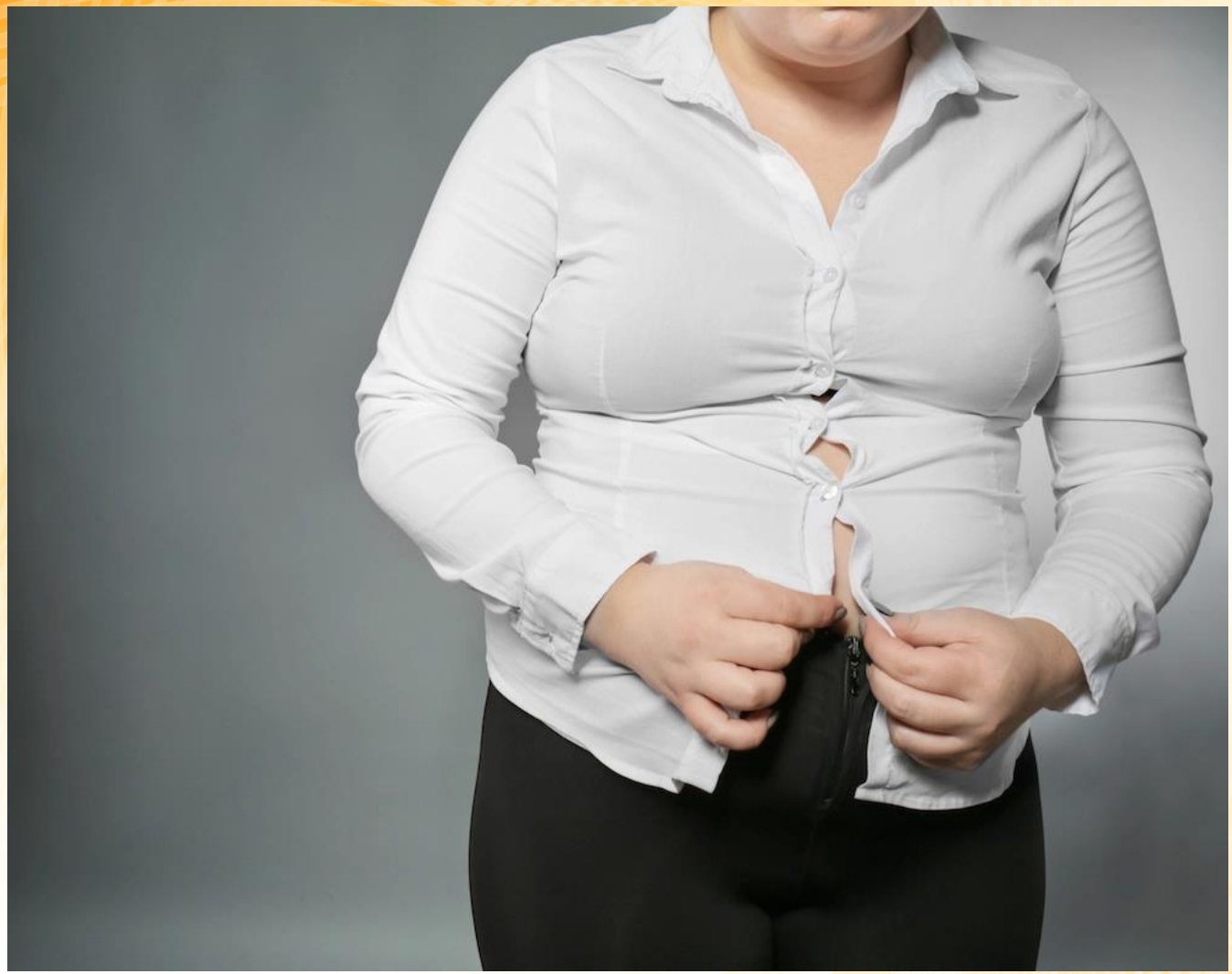
Vazzana AD. *Primary Psychiatry*. Vol 15, No 8. 2008.

Social consequences of obesity



Are we part of the problem!!—40% of health care workers are obese


NHS
NHS

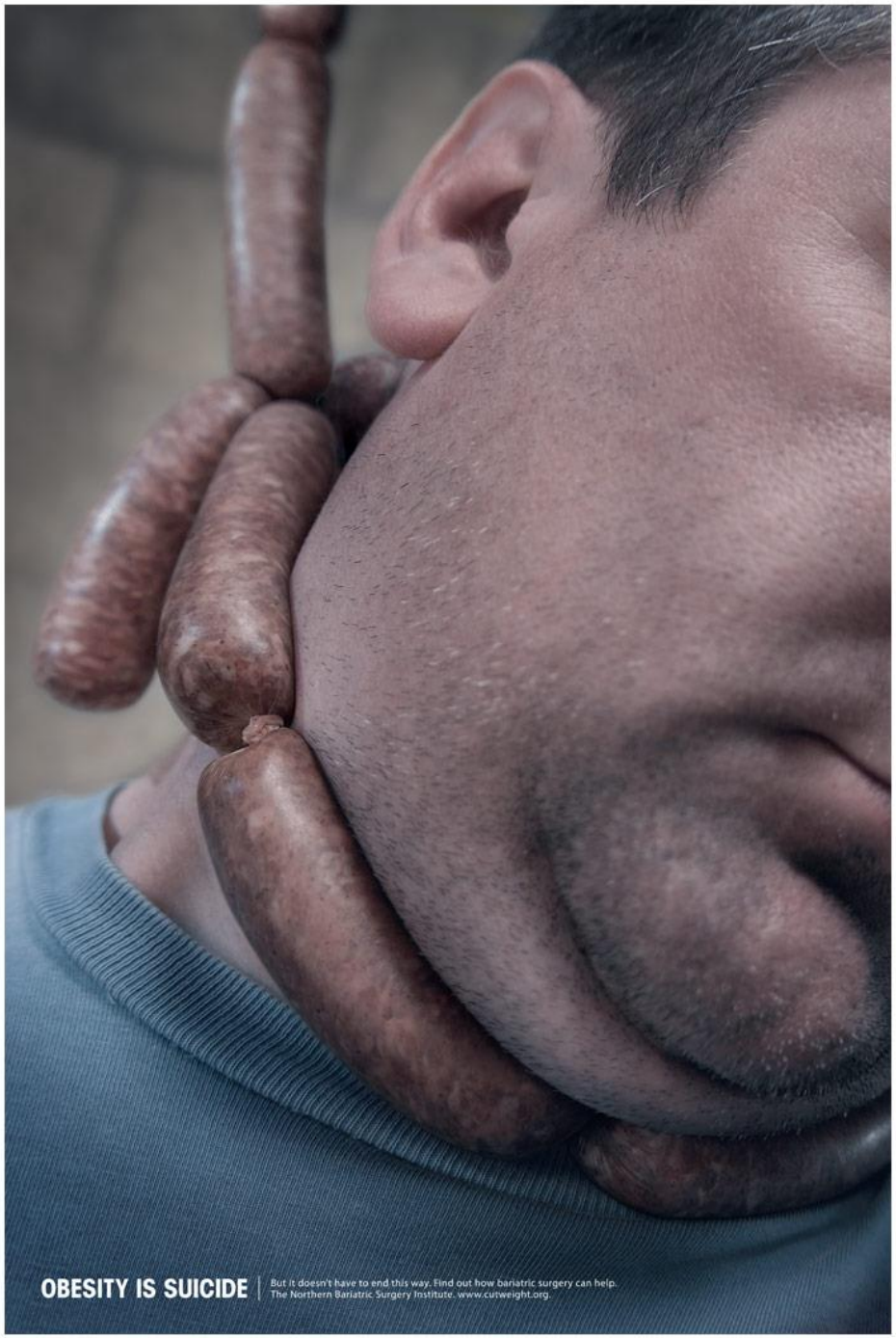


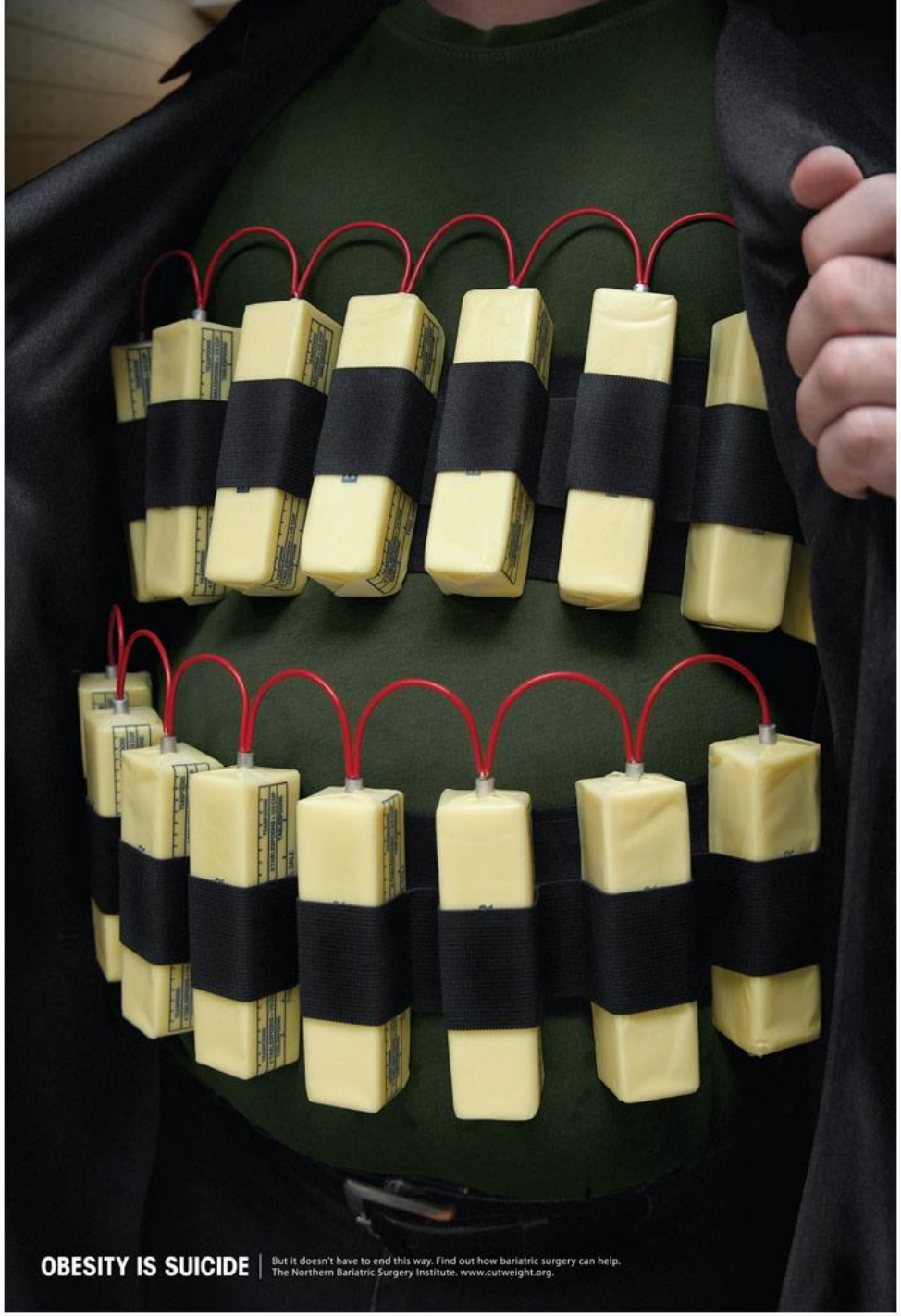
Obese RNs are more apt to be on LOAs or sick time>6 times a year

How To Reduce Obesity?

Scare Tatics!!

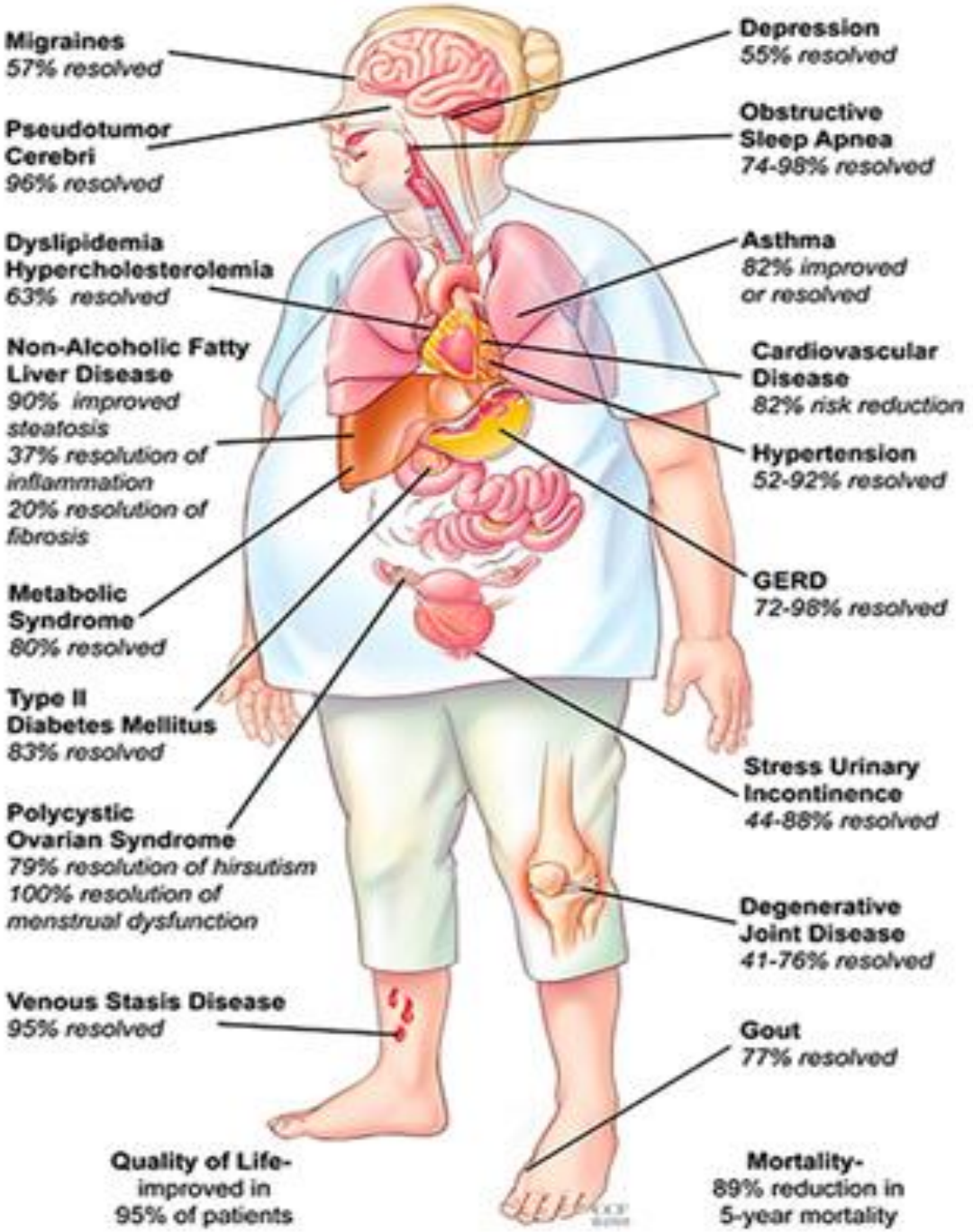

OBESITY IS SUICIDE
But it doesn't have to end this way. Find out how bariatric surgery can help.
The Northern Bariatric Surgery Institute. www.cutweight.org.


OBESITY IS SUICIDE
But it doesn't have to end this way. Find out how bariatric surgery can help.
The Northern Bariatric Surgery Institute. www.cutweight.org.


OBESITY IS SUICIDE
But it doesn't have to end this way. Find out how bariatric surgery can help.
The Northern Bariatric Surgery Institute. www.cutweight.org.

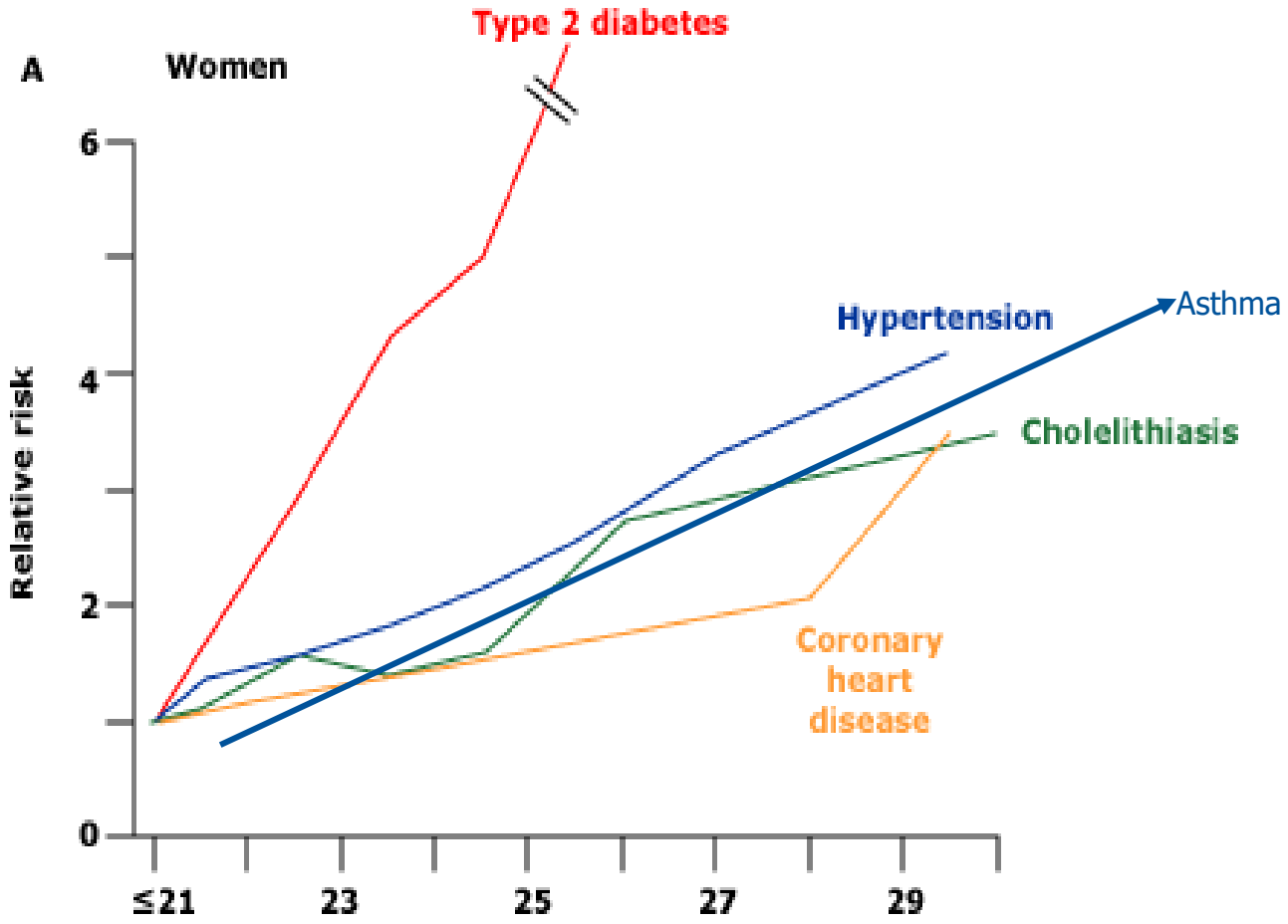
Physical Consequences of Obesity

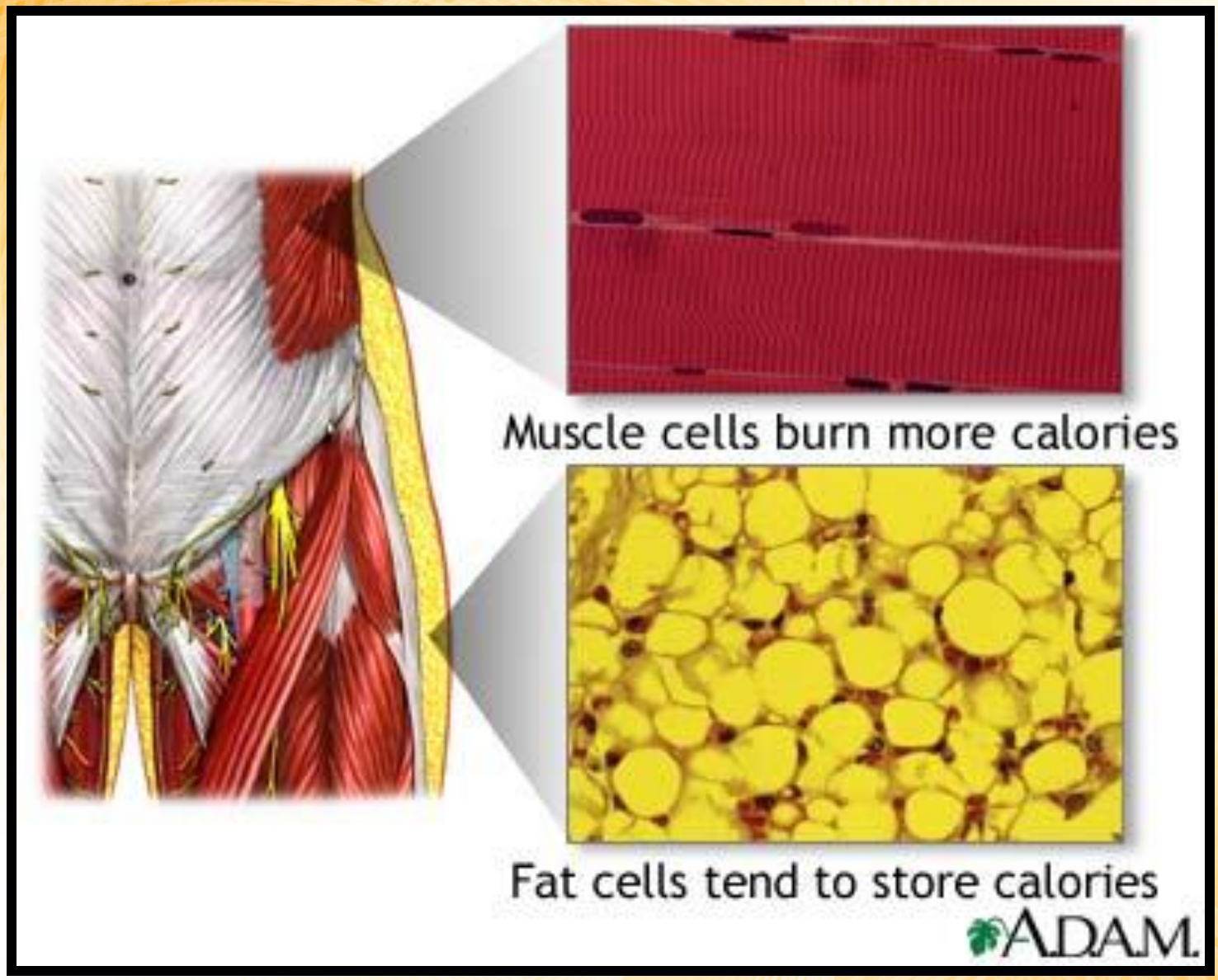
- Diabetes
- Hypertension
- Arthritis
- Sleep Apnea
- Increased risk of colon, breast, pancreas, and kidney cancer
- Increased burden on all abdominal organs
- Adipose tissue releases proinflammatory cytokines- SIRS response.
- Lost of anatomic landmarks



Lehigh Valley Health Network

Body-mass index and the risk of disease

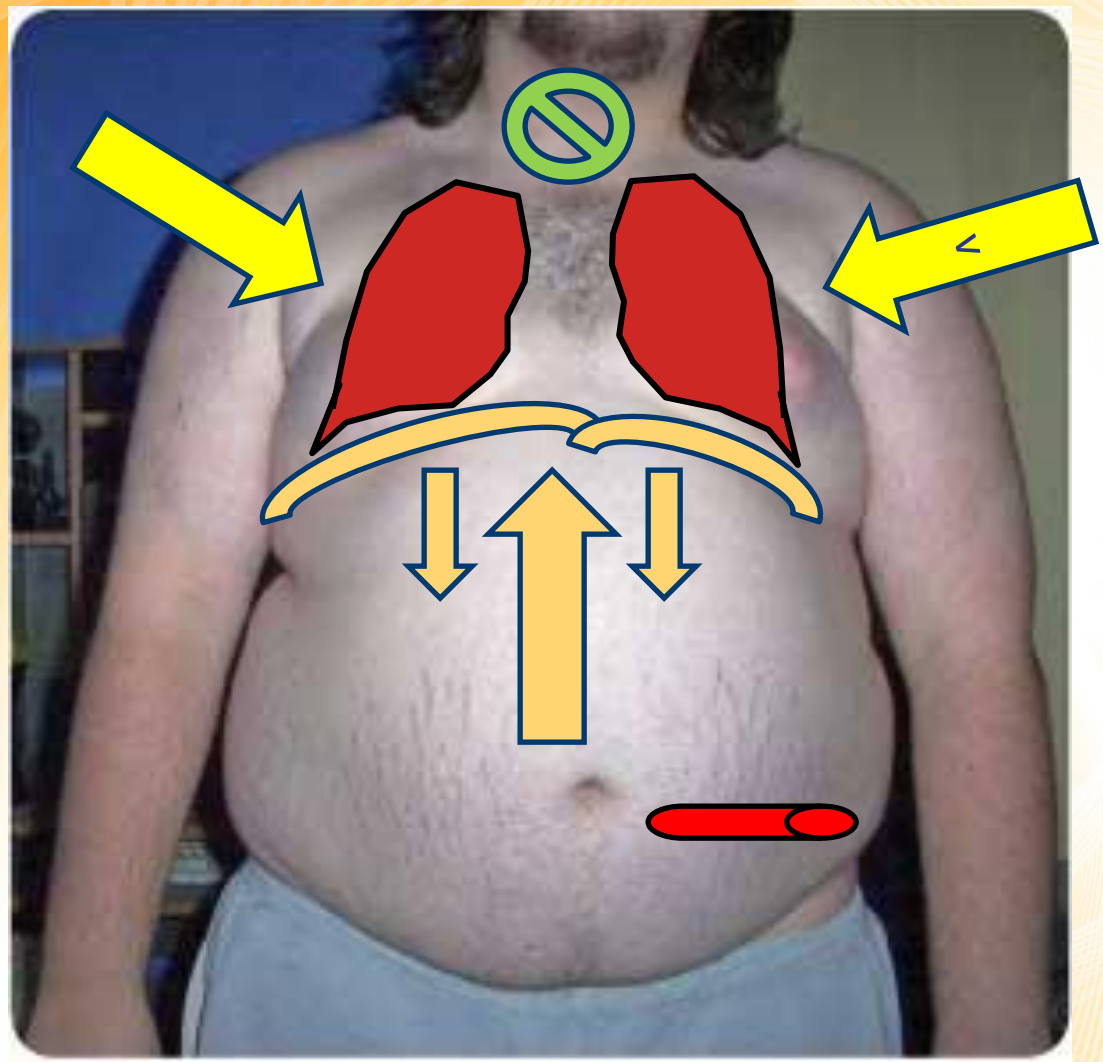



Muscle cells burn more calories
Fat cells tend to store calories
A.D.A.M.

Lung Mechanics and Obesity

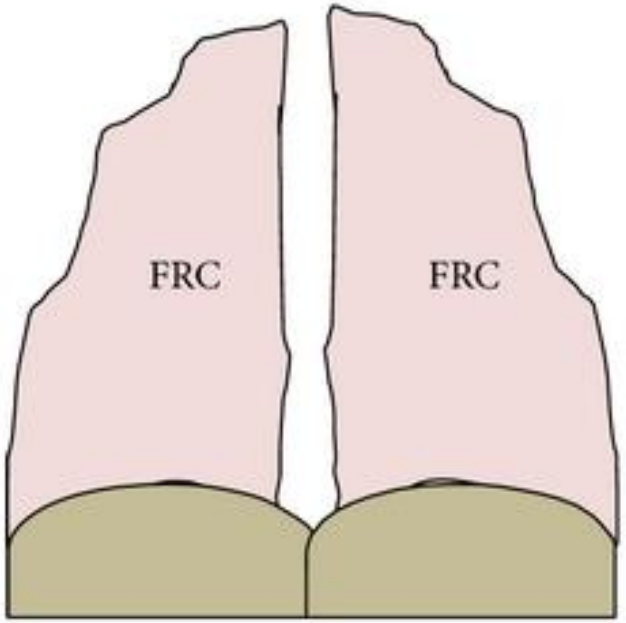
Respiratory Complications

- Restrictive load on thoracic cage and diaphragm.
- Increased airway resistance and lowered FRC.
- Increased pulmonary blood volume
  - increased risk of pulmonary embolus
- Increased dyspnea with work, reduced pulmonary reserve.
- Elevated $PaC0_2$ at rest

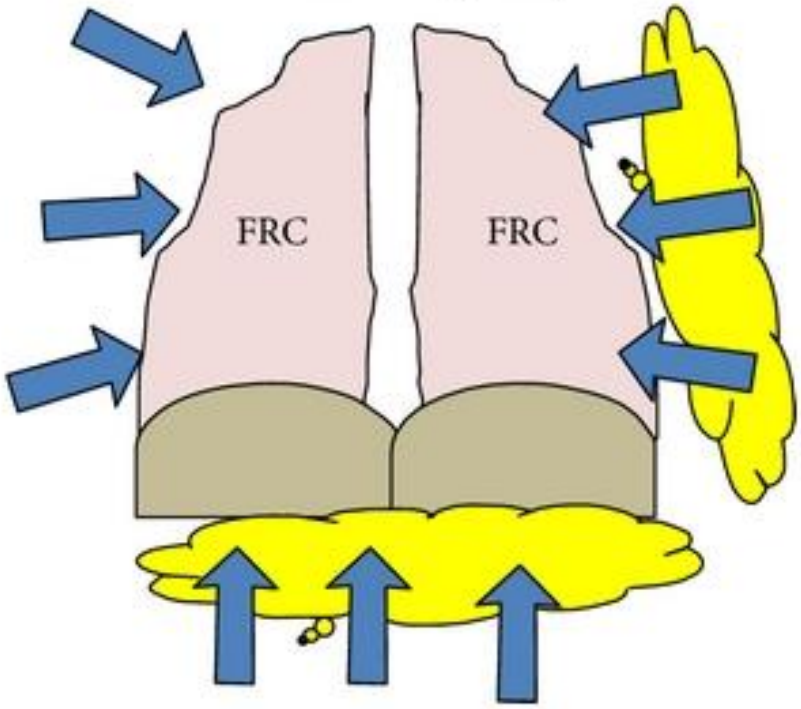


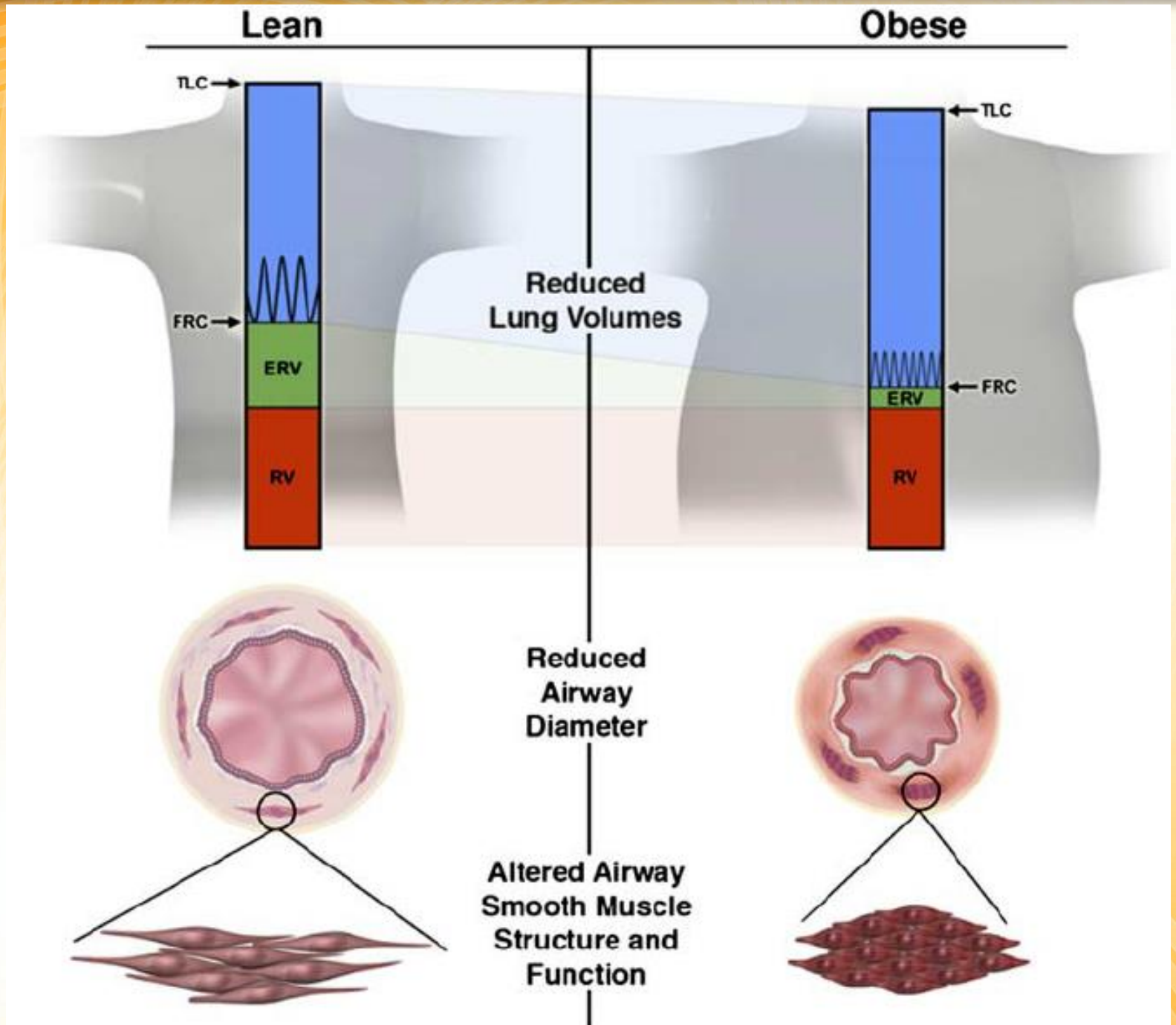
- Diaphragm is pushed upward
- Weight on chest wall restricts, and prevents diaphragmatic excursion
- Adipose requires blood/oxygen
- Increased risk of obstructed upper airway

Resting lung volumes (FRC) in nonobese lungs with good lung compliance



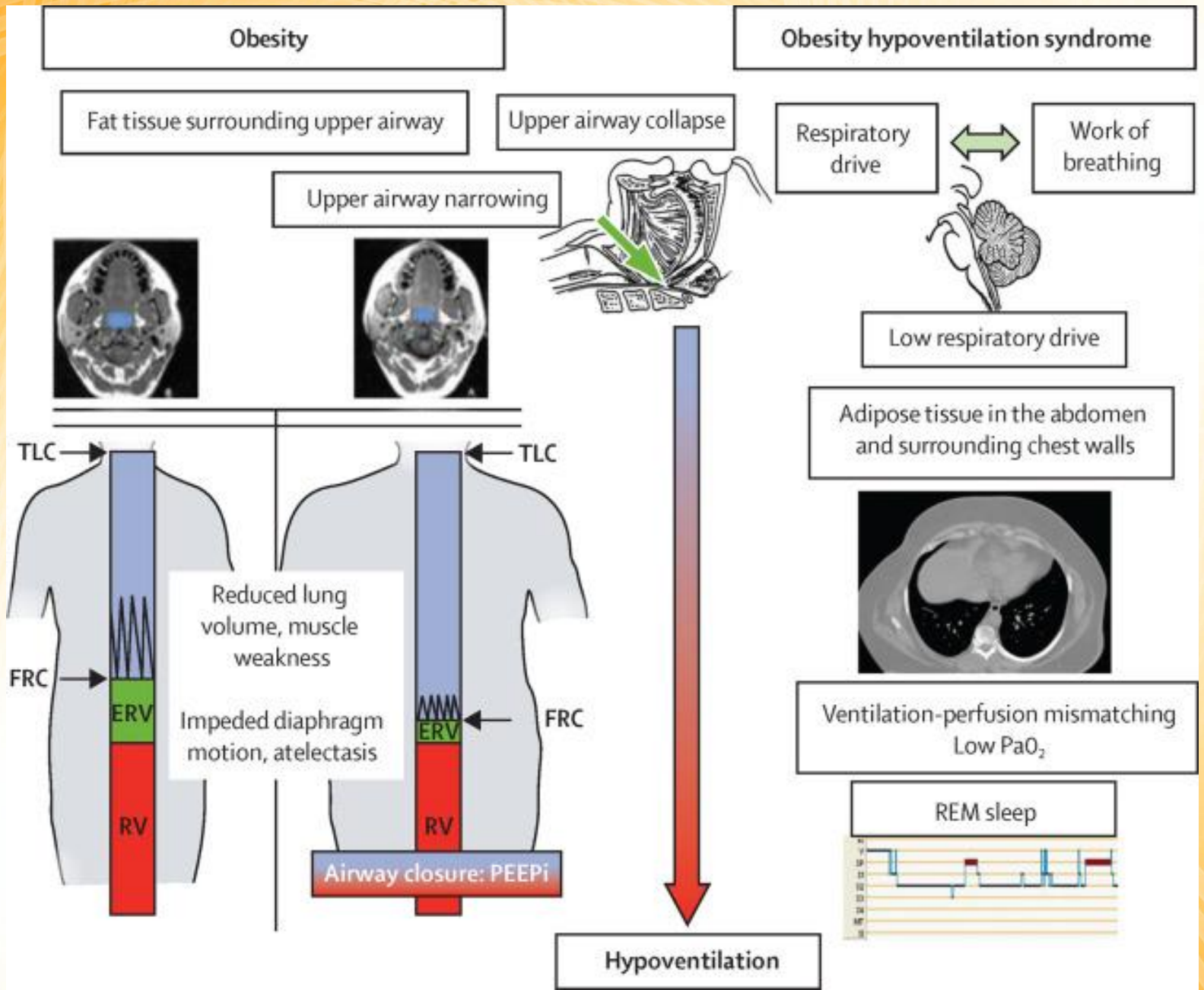
Reduced resting lung volumes (FRC) in obese lungs due to restriction from surrounding adipose tissue and reduction in lung compliance

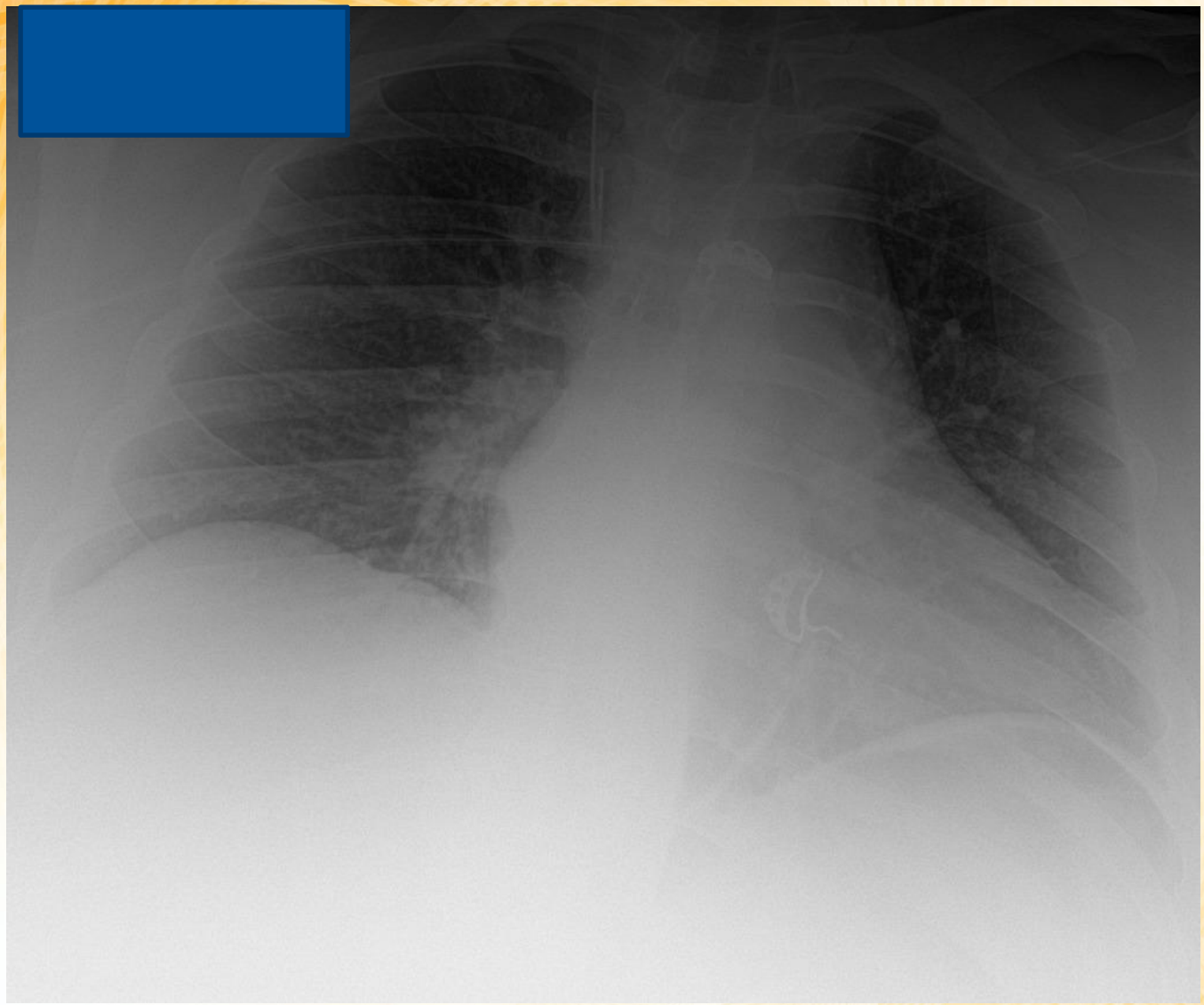



Lean
Obese
TLC
FRC
ERV
RV
TLC
FRC
ERV
RV
Reduced Lung Volumes
Reduced Airway Diameter
Altered Airway Smooth Muscle Structure and Function

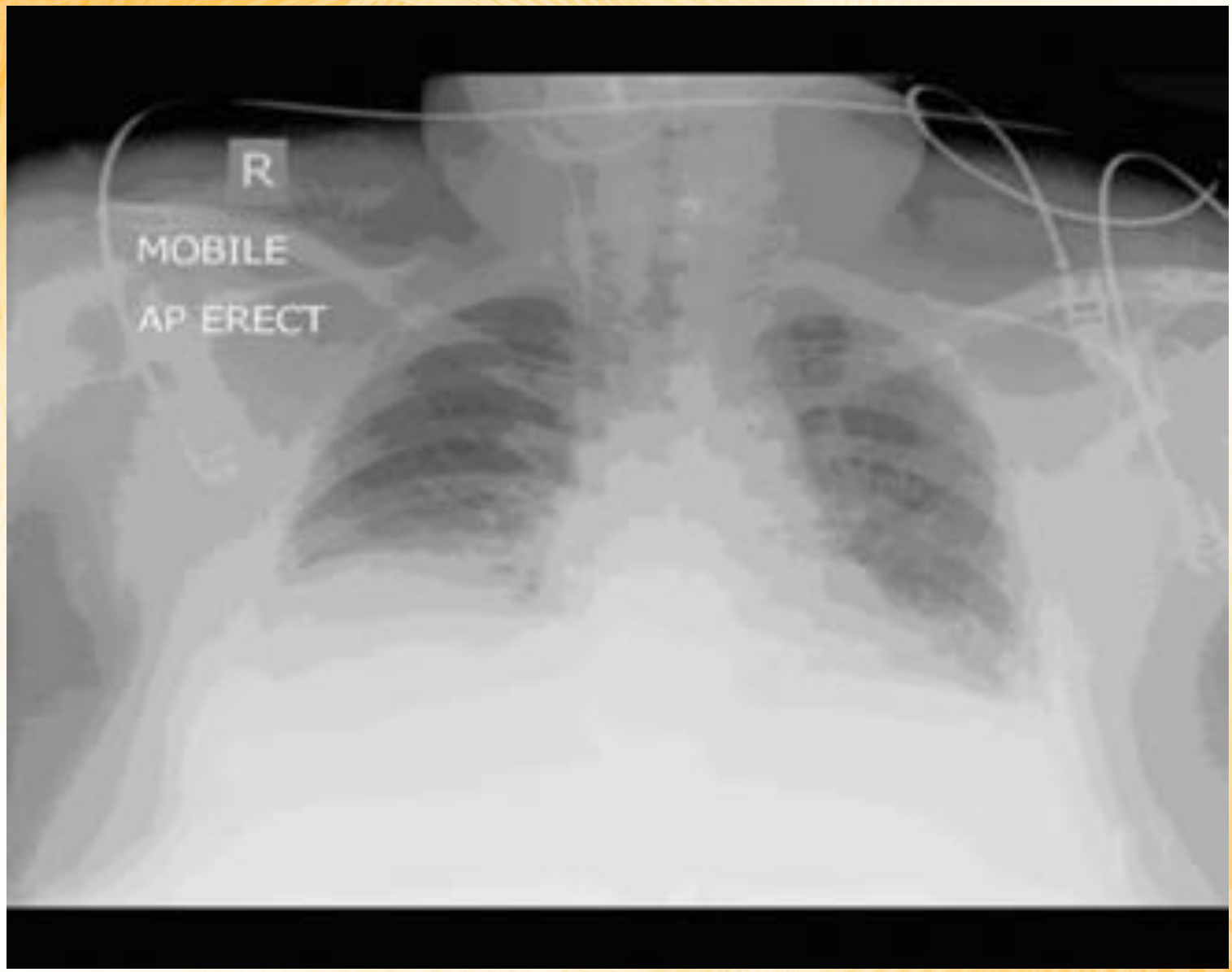
Pulmonary Mechanics

- Increased Ventilator PIP/PLT
- Increased chest wall compliance
- Reduce FRC
- Increased resistance and weight on airway structures


Obesity
Obesity hypoventilation syndrome
Fat tissue surrounding upper airway
Upper airway collapse
Upper airway narrowing
Respiratory drive
Work of breathing
Low respiratory drive
Adipose tissue in the abdomen and surrounding chest walls
Ventilation-perfusion mismatching
Low $Pa0_2$
REM sleep
TLC
TLC
FRC
FRC
ERV
ERV
RV
RV
Reduced lung volume, muscle weakness
Impeded diaphragm motion, atelectasis
Airway closure: PEEPi
Hypoventilation



Bi-basilar atelectasis


R
MOBILE
AP ERECT

Systemic Proinflammatory State

Oversimplified:

Proinflammatory molecules lead to a number of **metabolic** and **cardiovascular** complications of obesity, which *may* lead to **airway inflammation** (think Asthma and COVID)

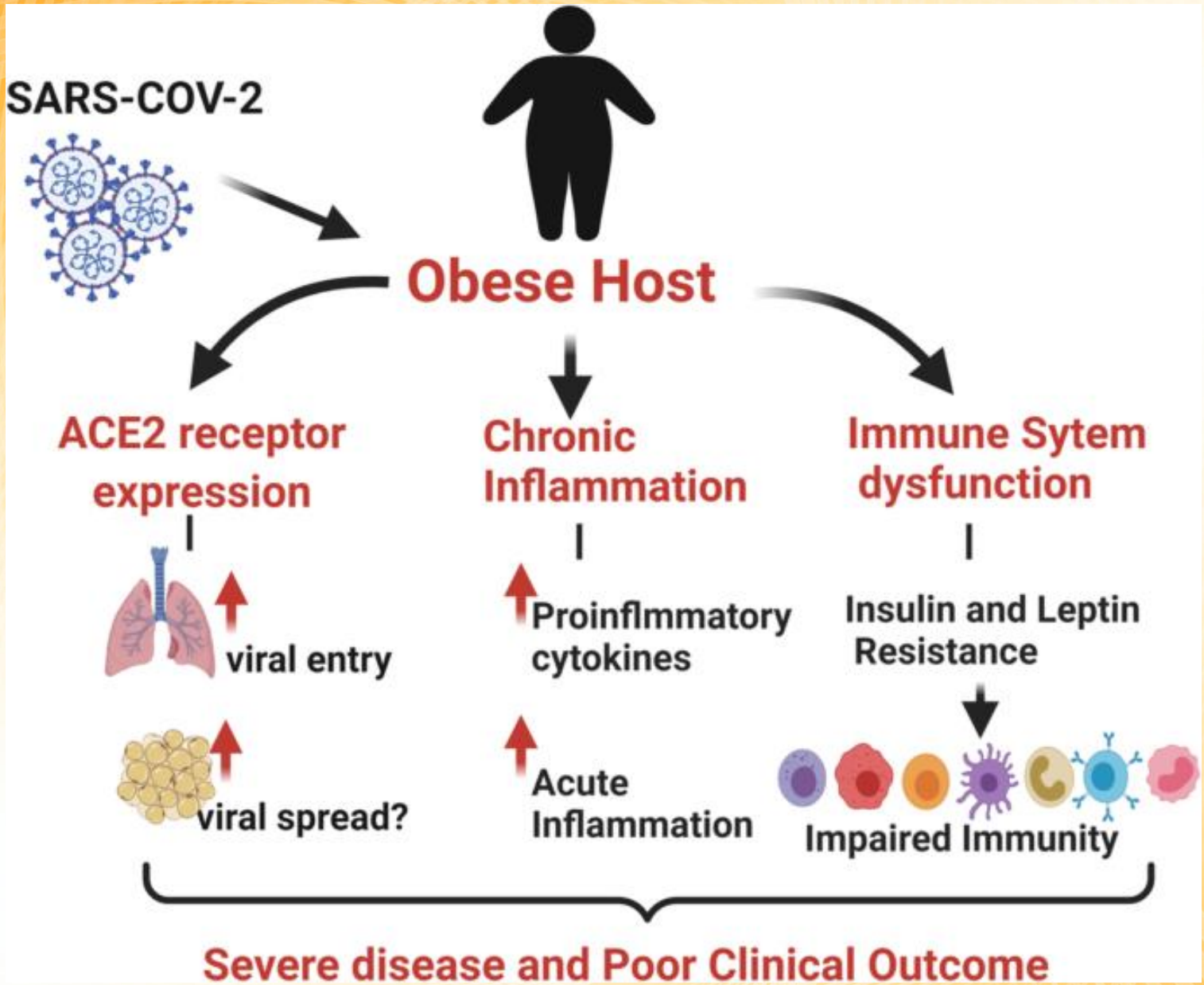
Obesity and Asthma

- Increase in Asthmatics proportional to increase in obesity???
- Obesity leads to increased of pro-inflammatory hormones and cytokines.
- Asthmatics that are obese often not controlled well and have lower scores on Asthma Control Questionnaires.

Symptom Control

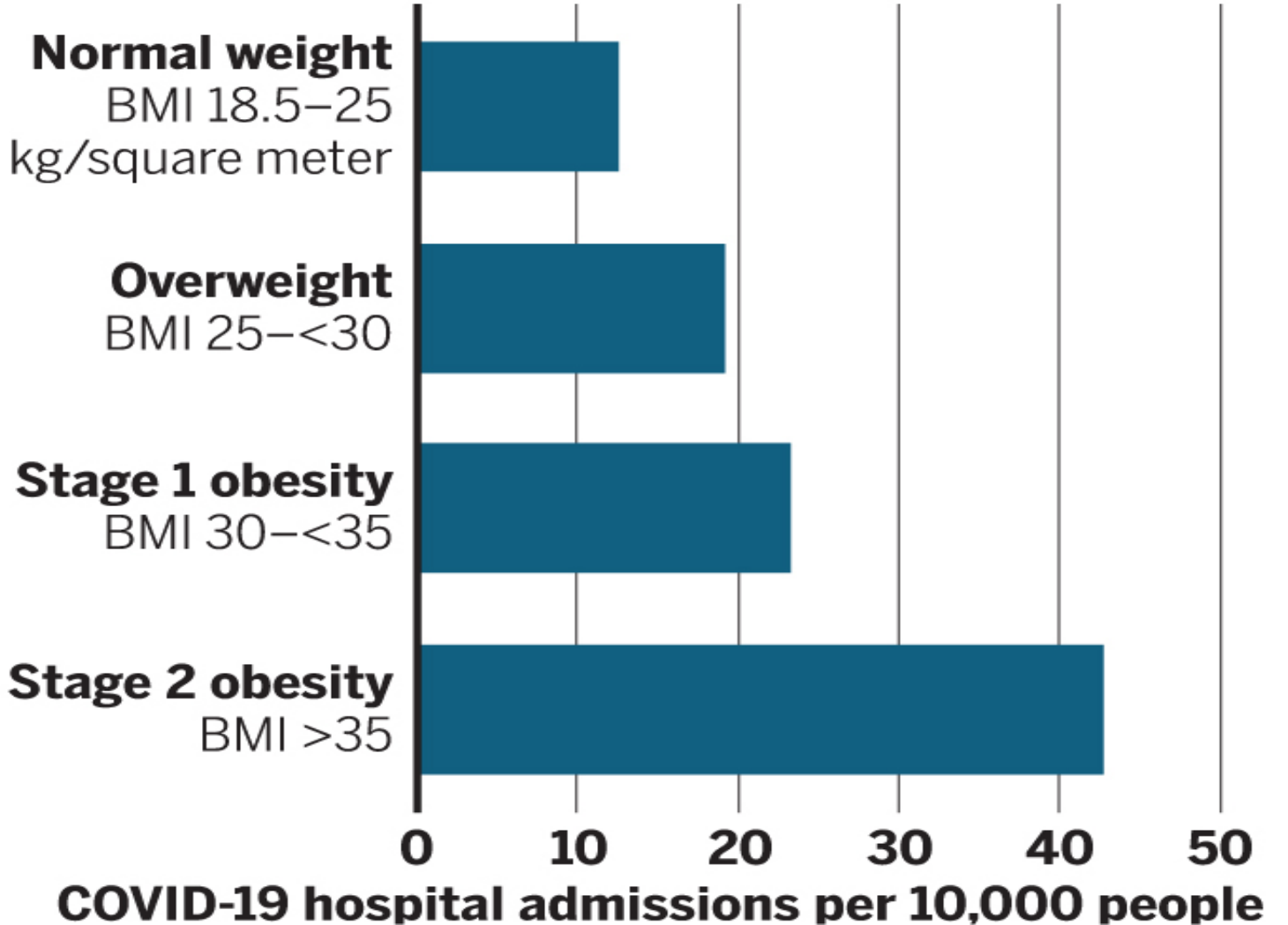
- Linear increase in asthma severity and BMI
- More reports of the severe persistent classification, especially in females>BMI 40
- More systemic corticosteroid use
- Increased ED and physician visits
- Increased night time wakening
- Negative Methacoline challenge???

Obesity And COVID


SARS-COV-2
Obese Host
ACE2 receptor expression
Chronic Inflammation
Immune Sytem dysfunction
viral entry
Proinflmmatory cytokines
Insulin and Leptin Resistance
viral spread?
Acute Inflammation
Impaired Immunity
Severe disease and Poor Clinical Outcome

The danger of extra kilos

Among 334,000 people in England this spring, the chances of being hospitalized with COVID-19 increased steadily with their body mass index (BMI).

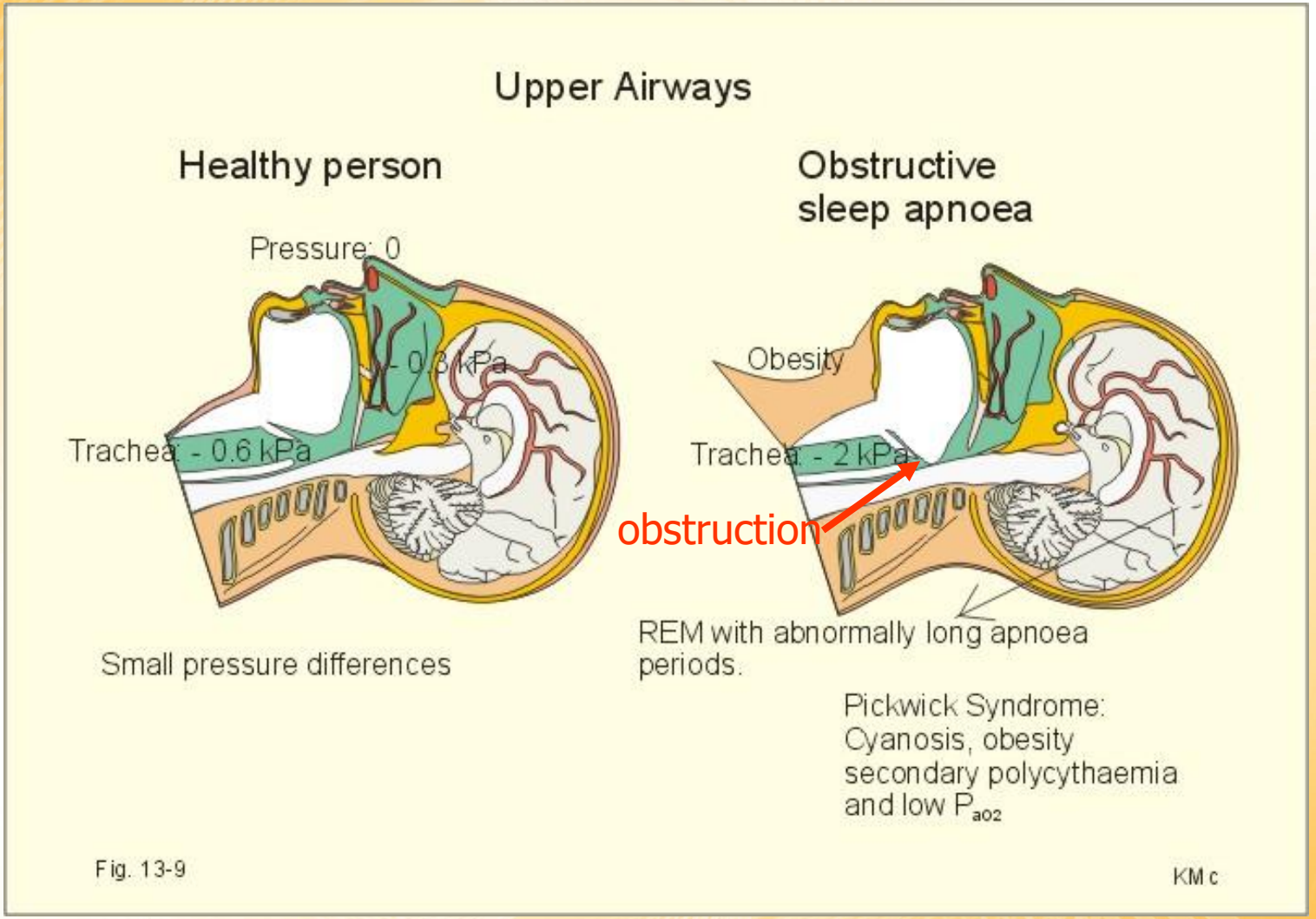


Questions?

Airway Difficulties in the Obese Patient

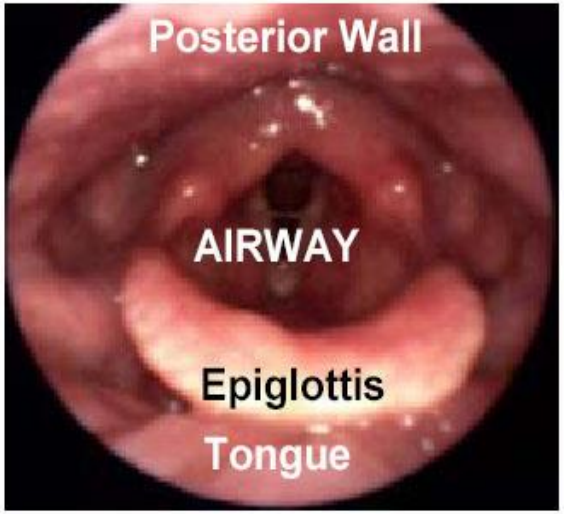
Sleep Apnea

15% of sleep apnea found on admission



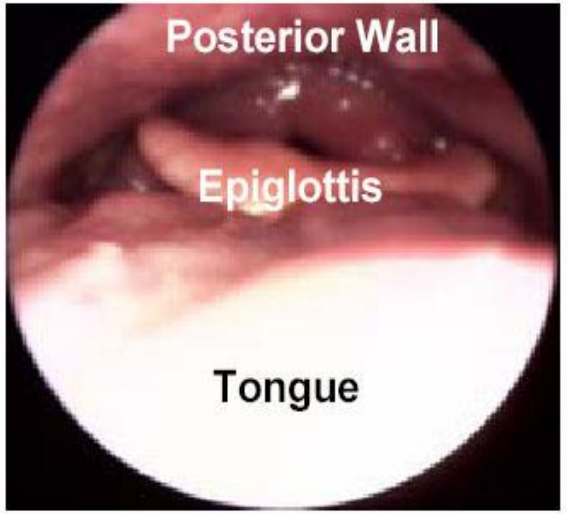
Obstructive Sleep Apnea

Mouth Opening Compromises the Retrolingual Airway.



Mouth Closed

Mouth Half Open



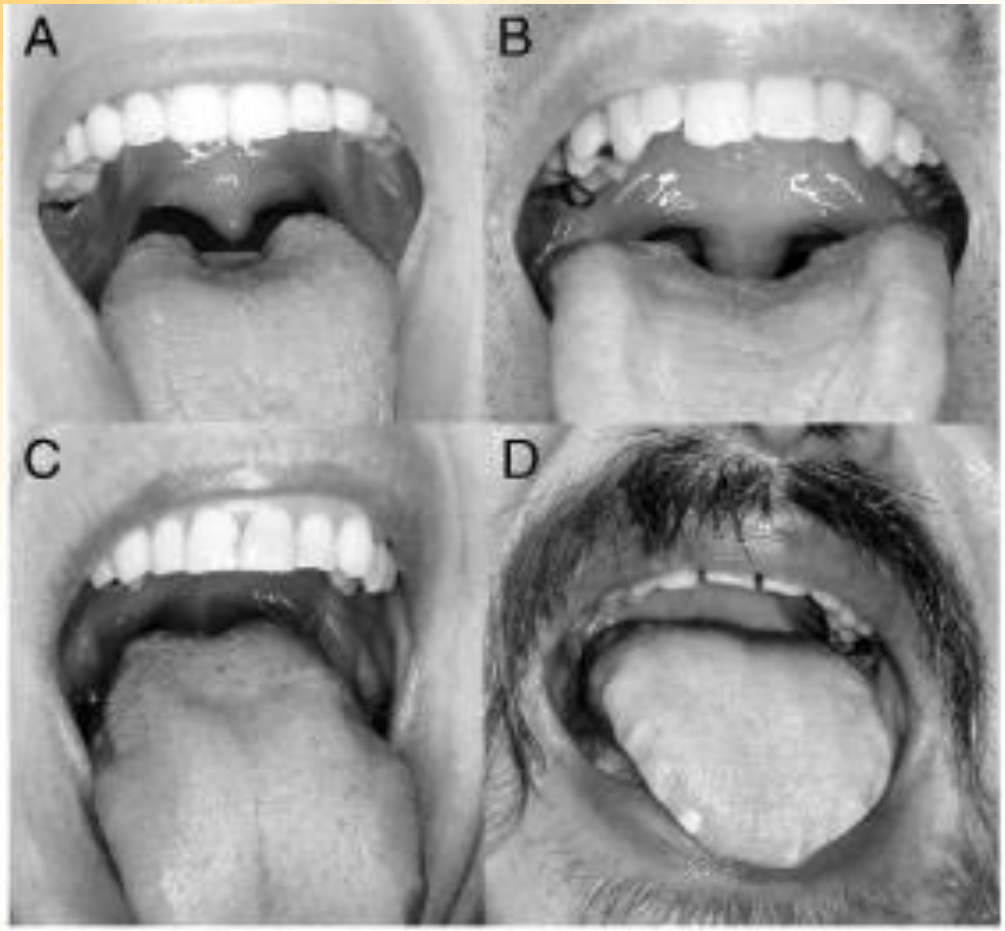
Mouth Open

From Washington.edu

The Airway

Class 1

Class 3



Class 2

Class 4

The Ideal Airway

Difficult Intubation

Bull neck

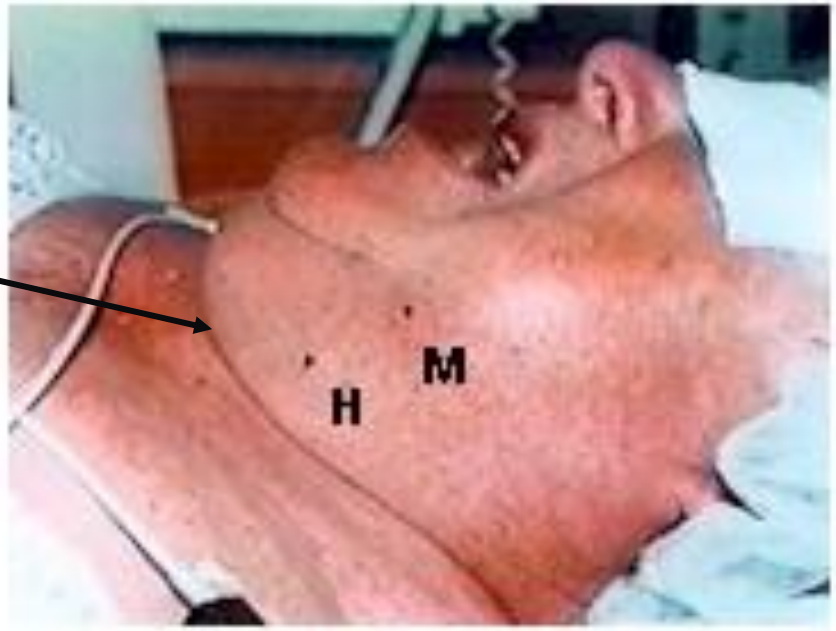
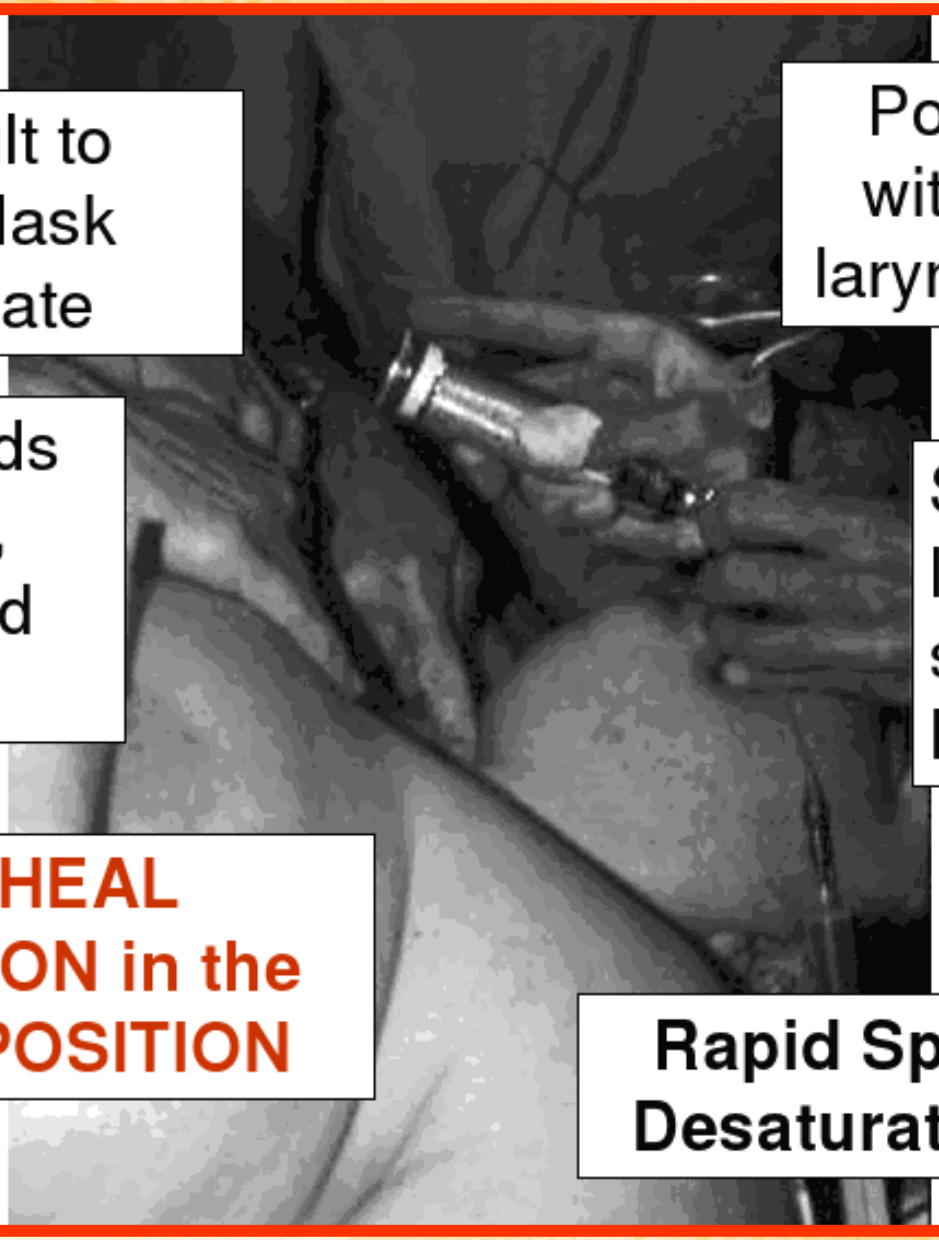


Figure 2

Airway Management

- Endotracheal intubation
  - Limited neck mobility and mouth opening
  - Short neck distance
  - When placed supine lost of FRC and desaturation
- Tracheotomy
  - Standard trach sizes to small and often too curved
  - High degree of airway obstruction
  - Percutaneous tracheostomy not optimal *choice-13 patient case series*



Difficult to Bag/Mask Ventilate

Poor view with direct laryngoscopy

Assistant holds back breasts, applies cricoid pressure

Short laryngo-scope handle

TRACHEAL INTUBATION in the SUPINE POSITION

Rapid SpO_2 Desaturation

Extended size
Trach tubes

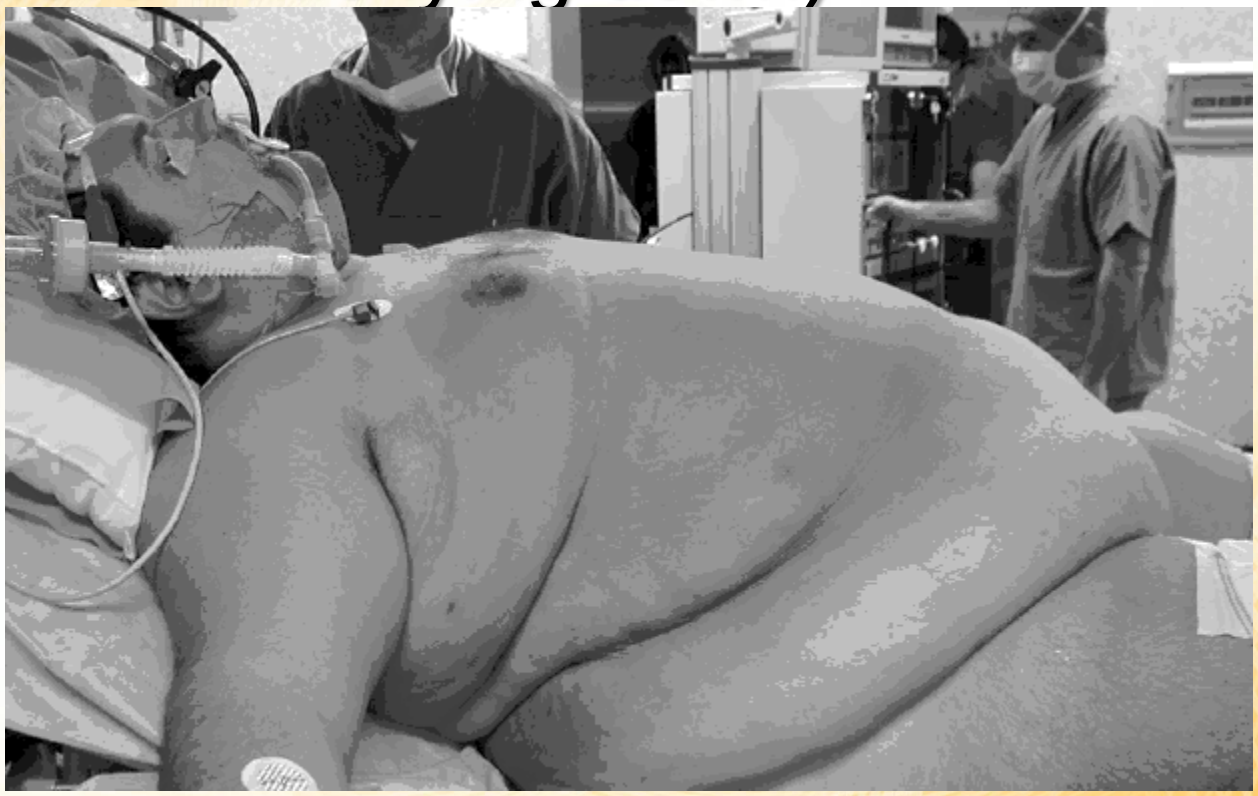
tions?

Airway Strategies

- Assess the physiology
- Proactive use of “difficult airway equipment”
- Consider back-up plan – what will you do if you cannot intubate?
- Consider ***NOT*** using paralytics or heavy sedation if possible
- Consider **trial** of noninvasive ventilation

Positioning

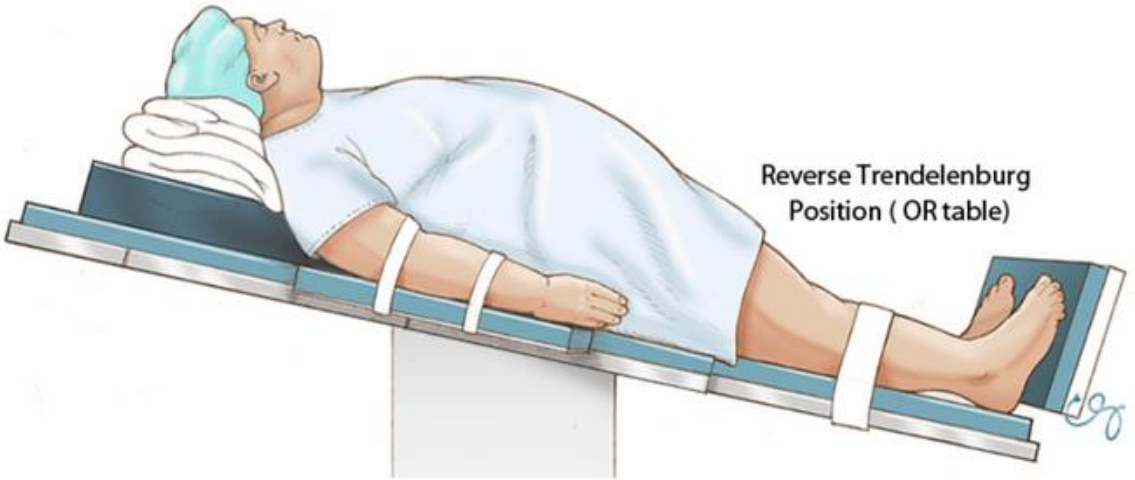
- Consider Reverse Trendelenberg (sitting upward while lying down)



EMNote

RSI in Morbidly Obese Patients

- Ramped position better than sniff position
- Reverse Trendelenberg position also helpful
- Ear-to-sternal-notch in same horizontal plane
- Patient's face parallel to the ceiling



@ jackcfchong

EMNote

RSI in Morbidly Obese Patients

MNEMONIC: *build a BIG RAMPPPP*

B: BUY TIME: Increase FiO2, NIV, Optimise Medical Rx

I: INDICATION FOR INTUBATION: do you really need to do it & do it now?

G: GET HELP: Anaesthetics, ICU, ENT, Nurses, Orderlies

R: RAMP: Build a big ramp!

A: APNOEIC OXYGENATION: use nasal prongs to maintain diffusion of O2

M: MINIMAL DRUGS: local anaesthetic spray/neb, ketamine/ketofol +/- sux/roc

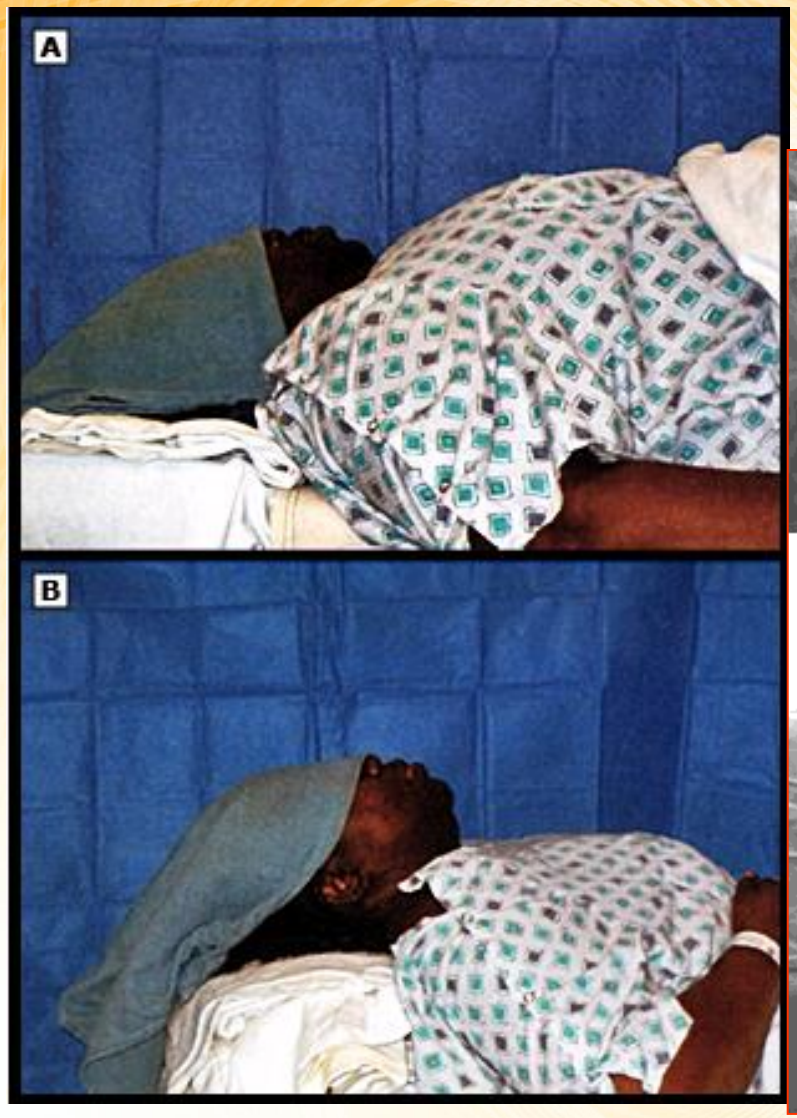
P: PRE-OXYGENATE WITH NIV

P: PARALYSIS – ONLY IF NEEDED

P: PLAN FOR FAILURE: Surgical airway kit by the bedside

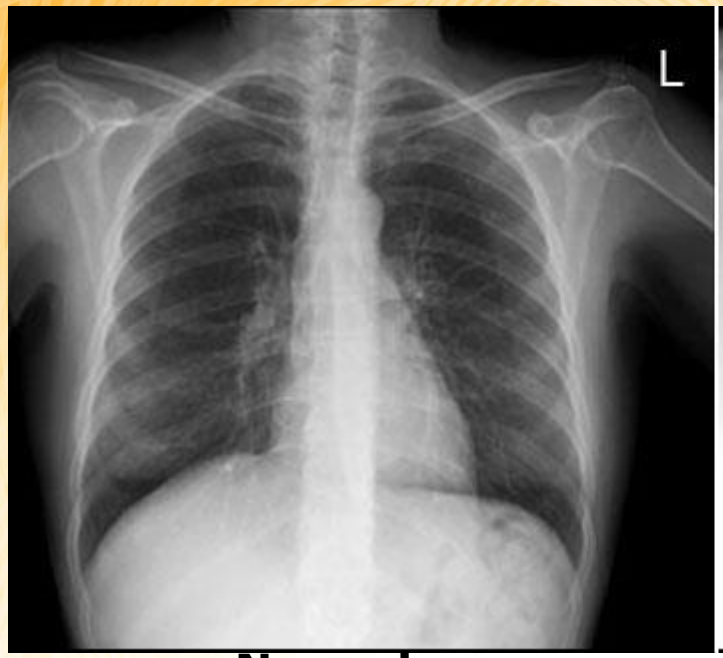
P: POST INTUBATION CARE

@ jackcfchong

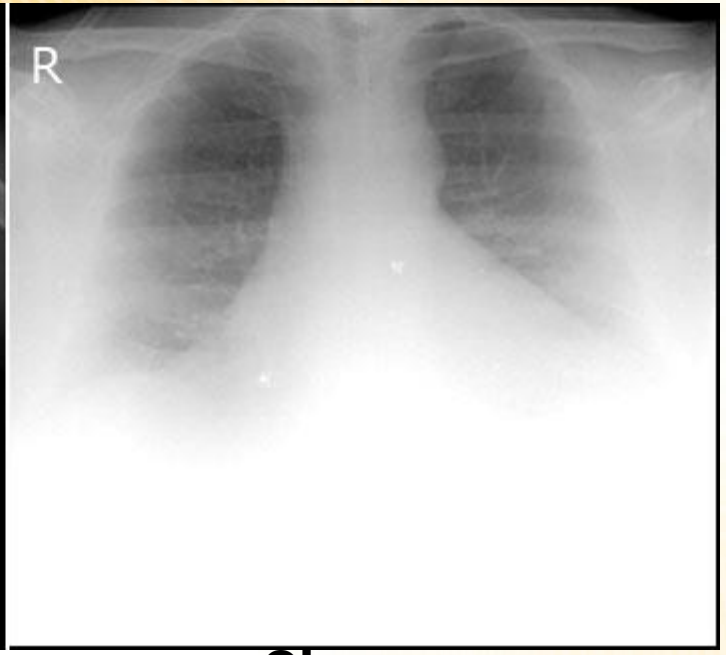

A
B

Imaging Issues!!!

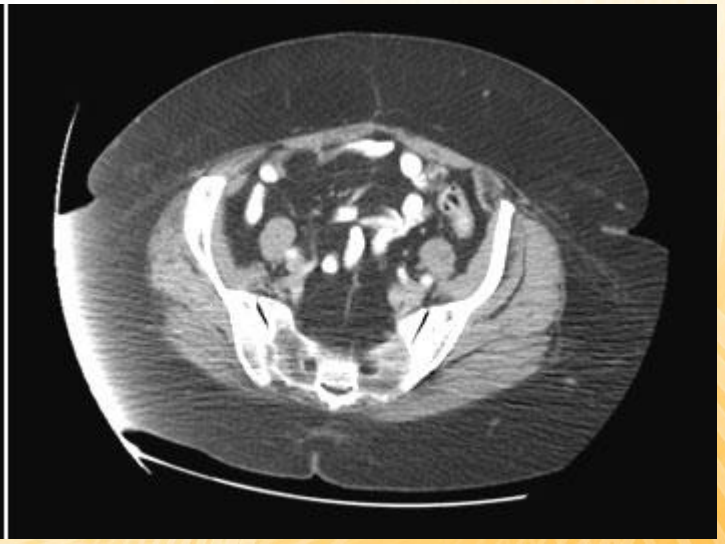
Radiological Difficulties

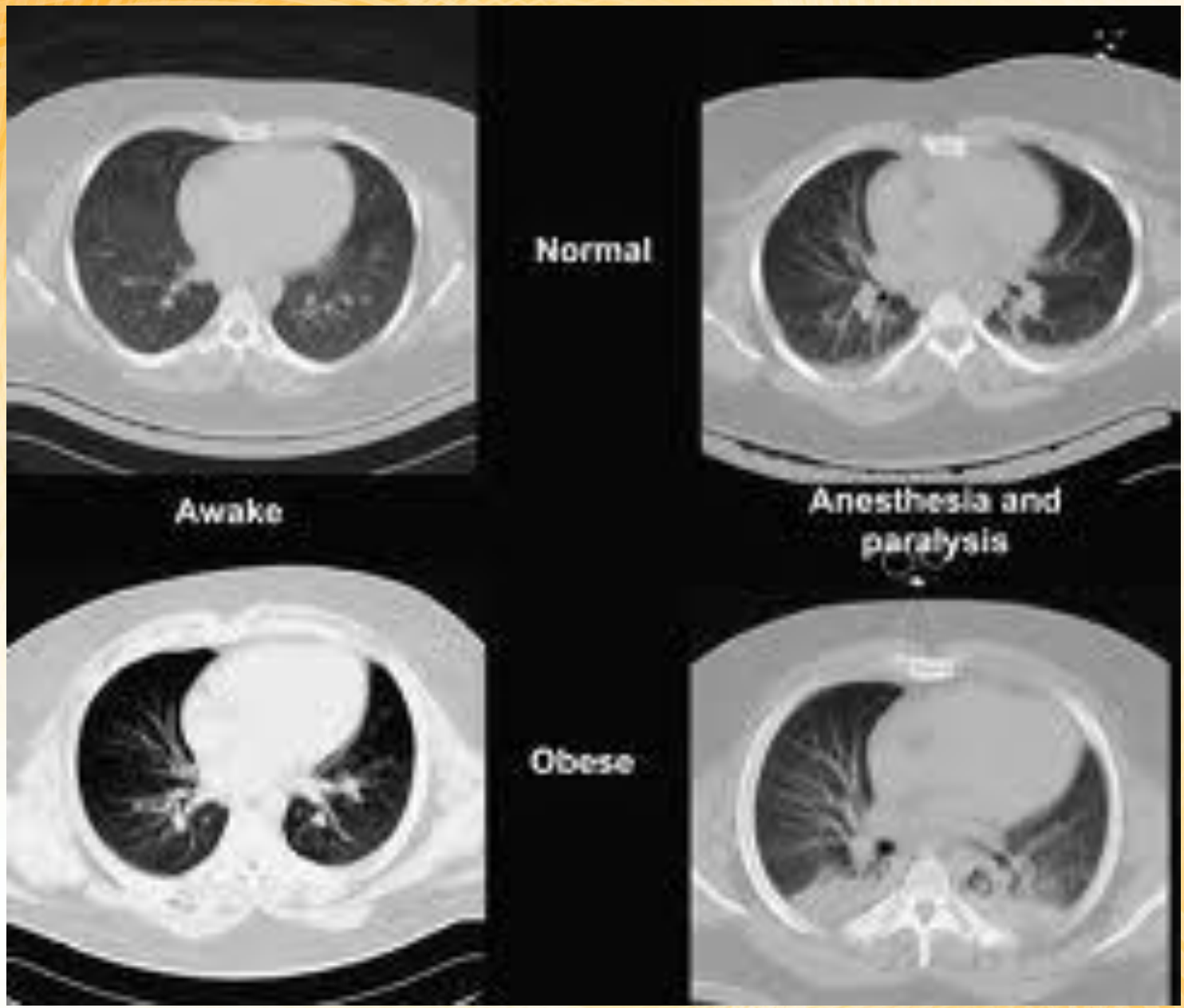


Normal

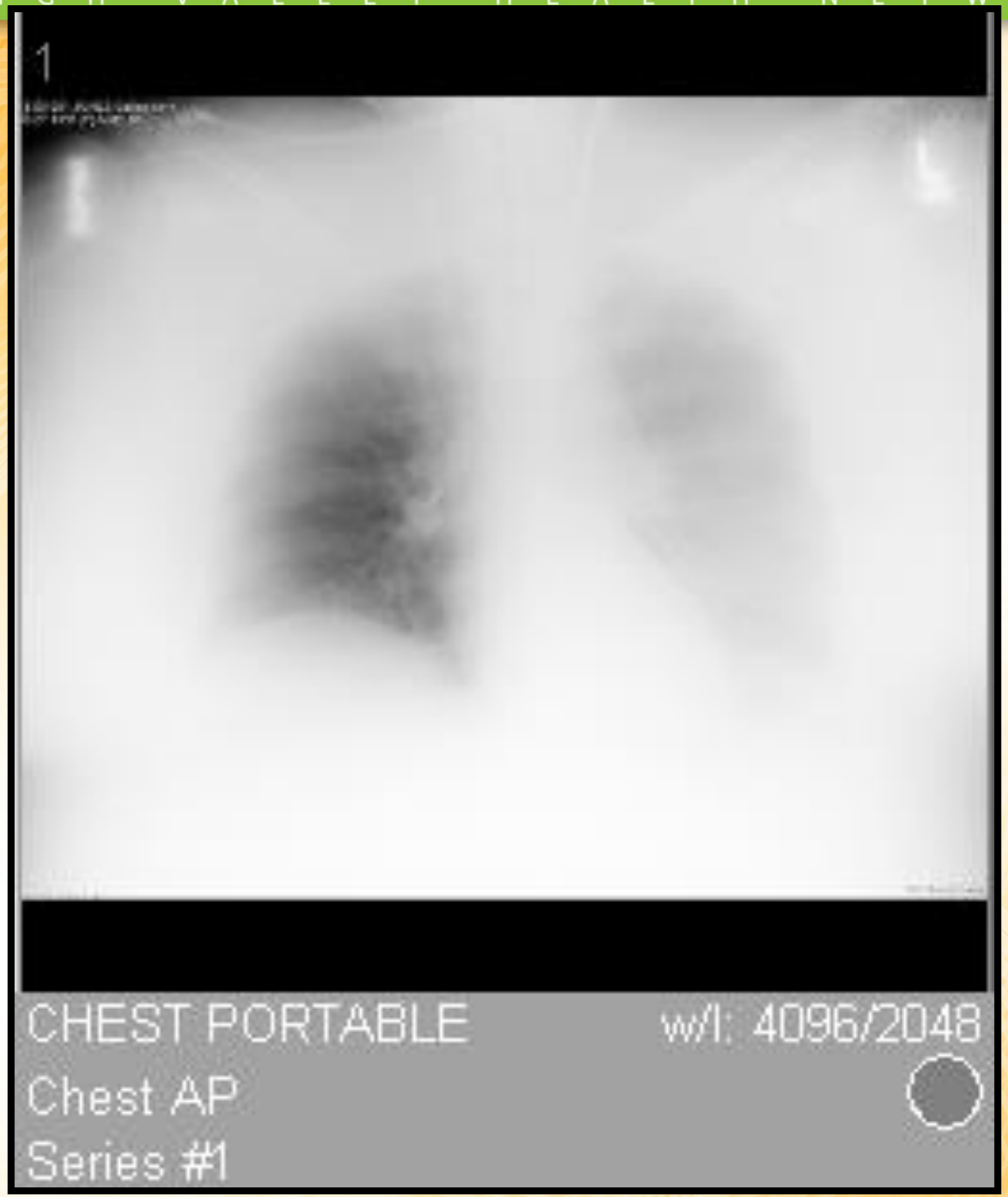


Obese

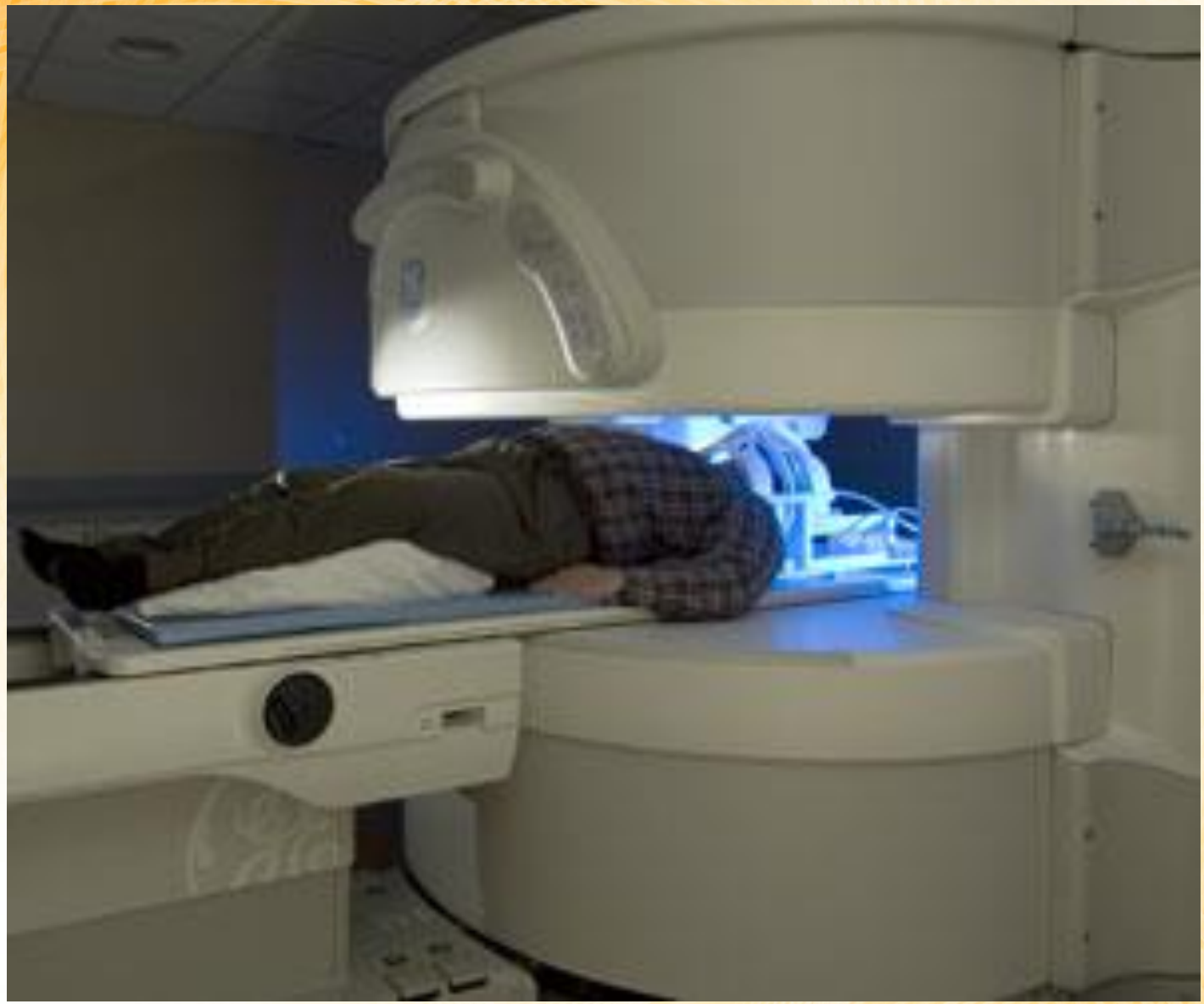



Normal
Awake
Anesthesia and paralysis
Obese

550 lbs..



+



Choosing Image Modality Based on Weight and Girth

350 lbs
45 cm

350 lbs
60 cm

450 lbs
70 cm

550 lbs
55 x 100 cm

No limit

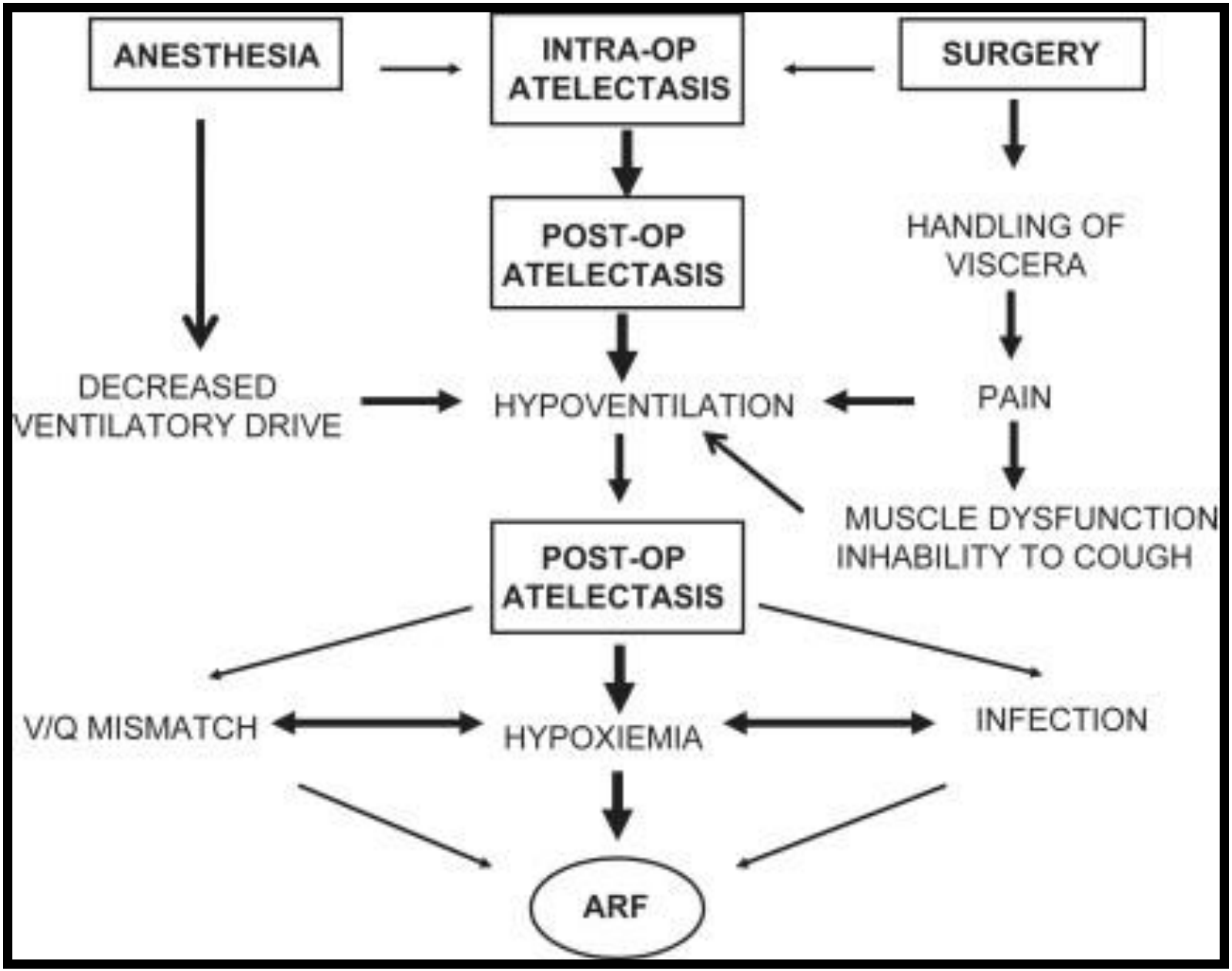
Clinical Monitoring Problems

- Reduced pulse pressure
- Distant heart/breath sounds
- Lack of non-invasive monitoring
- Difficult placement of CVP/Swan-Ganz-A-lines
- Lost of anatomical landmarks


Medscape
Source: Expert Rev of Obstet Gynecol © 2009 Expert Reviews Ltd

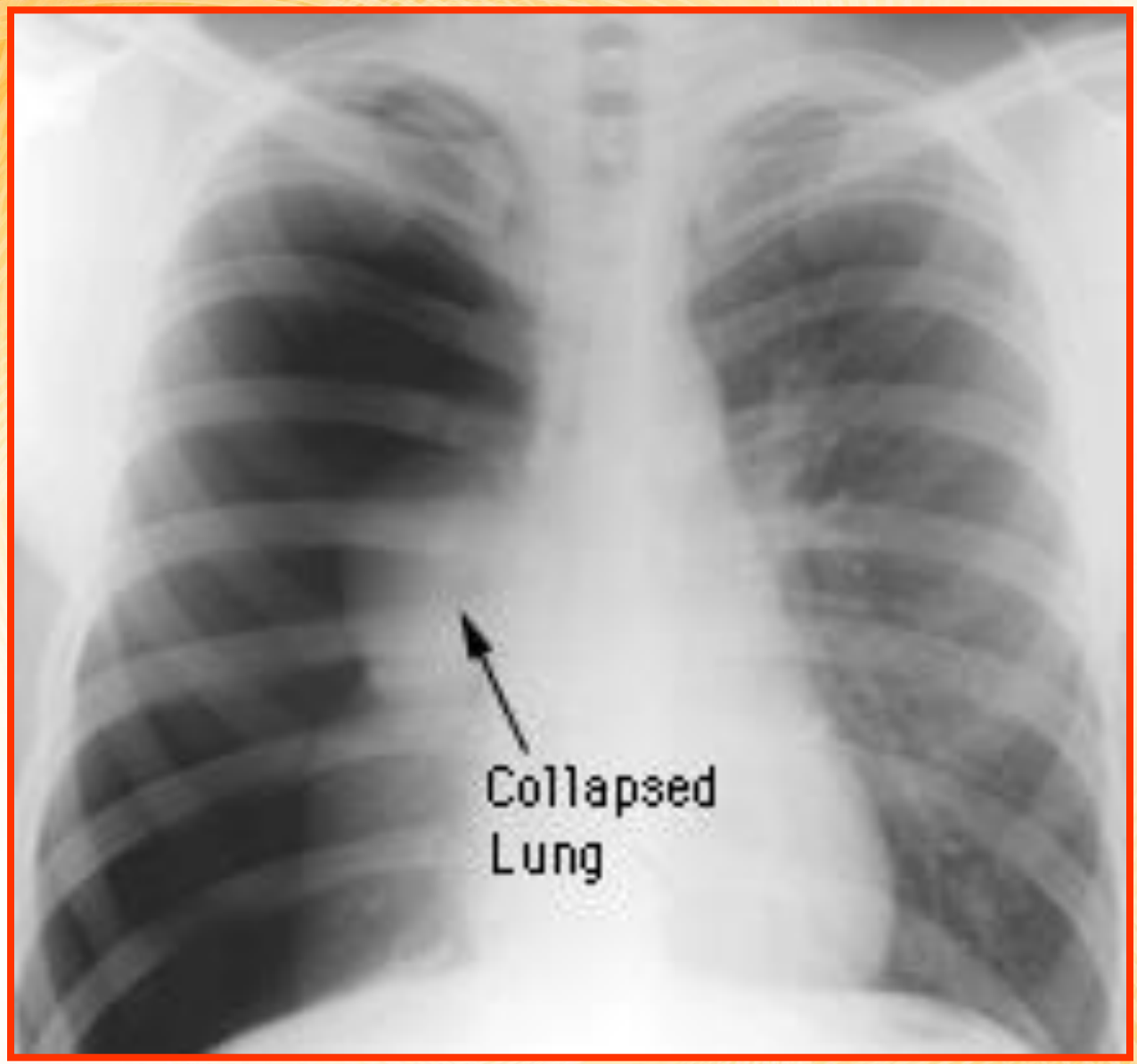
Adipose Tissue=Surgical nightmare

Surgery often takes twice as long


ANESTHESIA
INTRA-OP ATELECTASIS
SURGERY
POST-OP ATELECTASIS
HANDLING OF VISCERA
DECREASED VENTILATORY DRIVE
HYPOVENTILATION
PAIN
MUSCLE DYSFUNCTION
INHABILITY TO COUGH
POST-OP ATELECTASIS
V/Q MISMATCH
HYPOXIEMIA
INFECTION
ARF

The Body is Big
How About the Lungs?

- Ideal body weight based on gender/height
- Lung size determined by ideal body weight not current weight!!!
- Historically tidal volumes in the obese patient population exceed 12cc/kg—**I** place a gastric by-pass patient on a tidal volume of 1500cc!! In 1980s


Collapsed
Lung

Airway Pressures in the Obese Patient

- Ventilator pressures often not seen at the alveolar level
- PIP/PLT higher, often acceptable
  - Chest/abd. impedance
  - Pressure attenuation
- RSBi/PO1 often elevated

Ventilatory Strategies

- Liberate as quick as possible!
- Ventilator duration longer (7.7 ±9.6 days vs 4.6 ±7.1 days)
- Utilize a greater amount of PEEP to unload thoracic and abdominal impedance.
- May need to use recruitment mode to optimize gas exchange for ventilatory duration>48hrs.
- APRV results with this patient population.

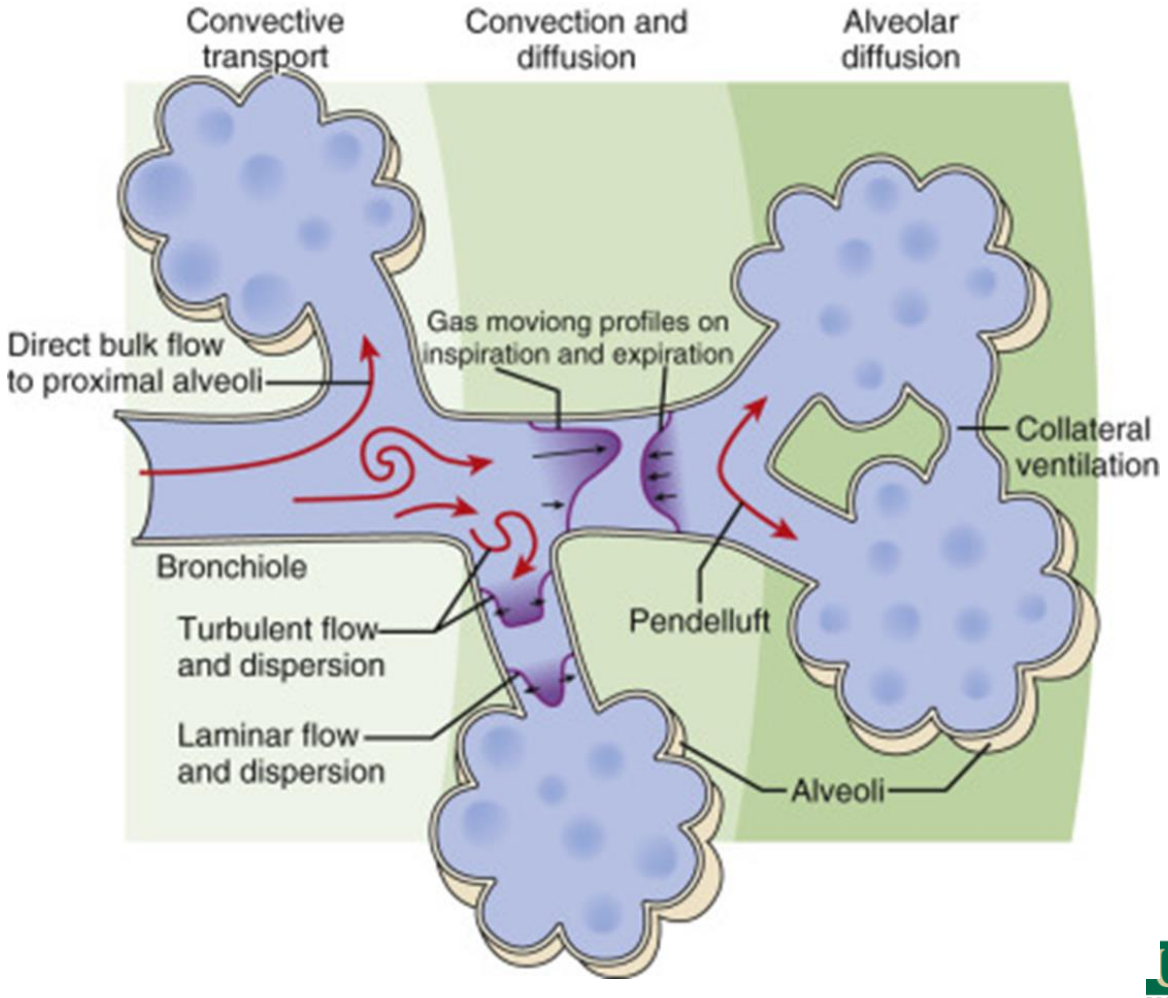
USF HEALTH MORSANI COLLEGE OF MEDICINE UNIVERSITY OF SOUTH FLORIDA

Lehigh Valley Health Network

Airway Pressure Release Ventilation

What is APRV?

- Airway pressure release ventilation (APRV) is a ventilator mode that utilizes a distending pressure along with a long inspiratory phase(> 4 seconds)
- Utilizes collateral alveolar ventilation to increase lung inflation
  - Popcorn in microwave effect
  - Required time to maximize lung inflation >2 hrs.



USF HEALTH MORSANI COLLEGE OF MEDICINE UNIVERSITY OF SOUTH FLORIDA

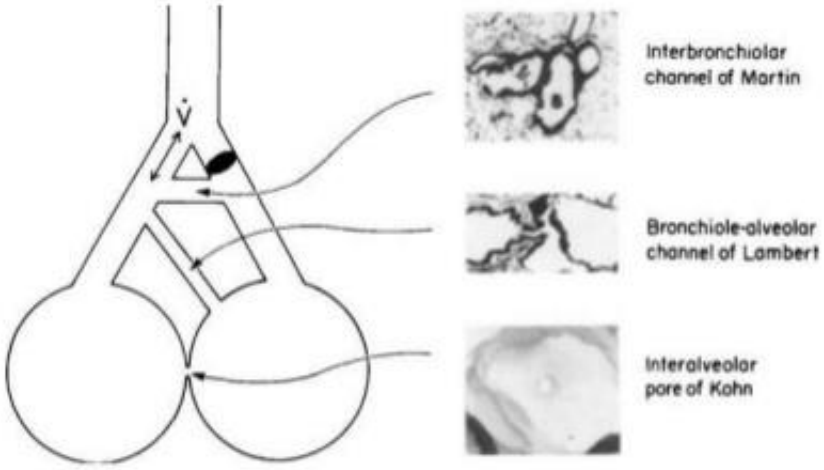
Lehigh Valley Health Network

Definition :

"the ventilation of alveolar structures through passages or channels that bypass the normal airways"

And these are :

- Inter-bronchiolar
- Inter-alveolar
- Bronchiolo-alveolar.
- Interlobar " through fissues "



APRV takes advantage of the collateral channels of ventilation that are barely used at the FRC level in normal, healthy lungs

Martin

Kohn

Lambert

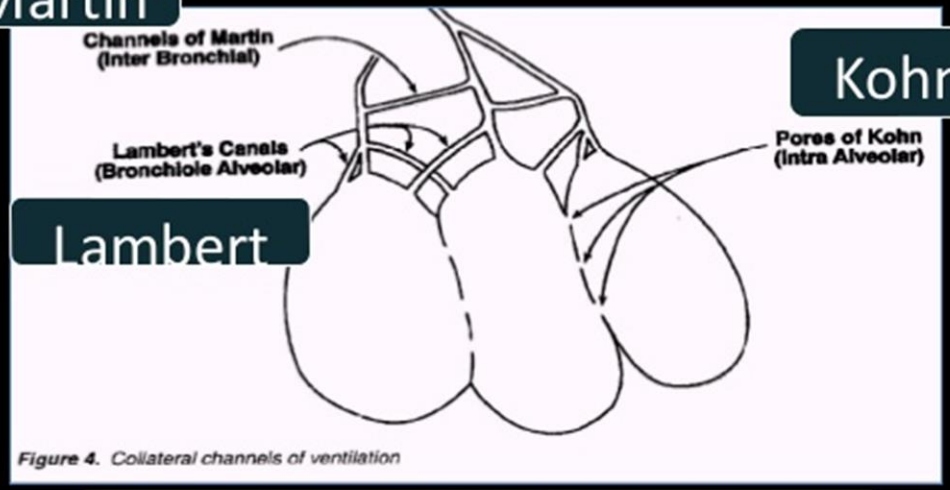


Figure 4. Collateral channels of ventilation

They become important In diseased states

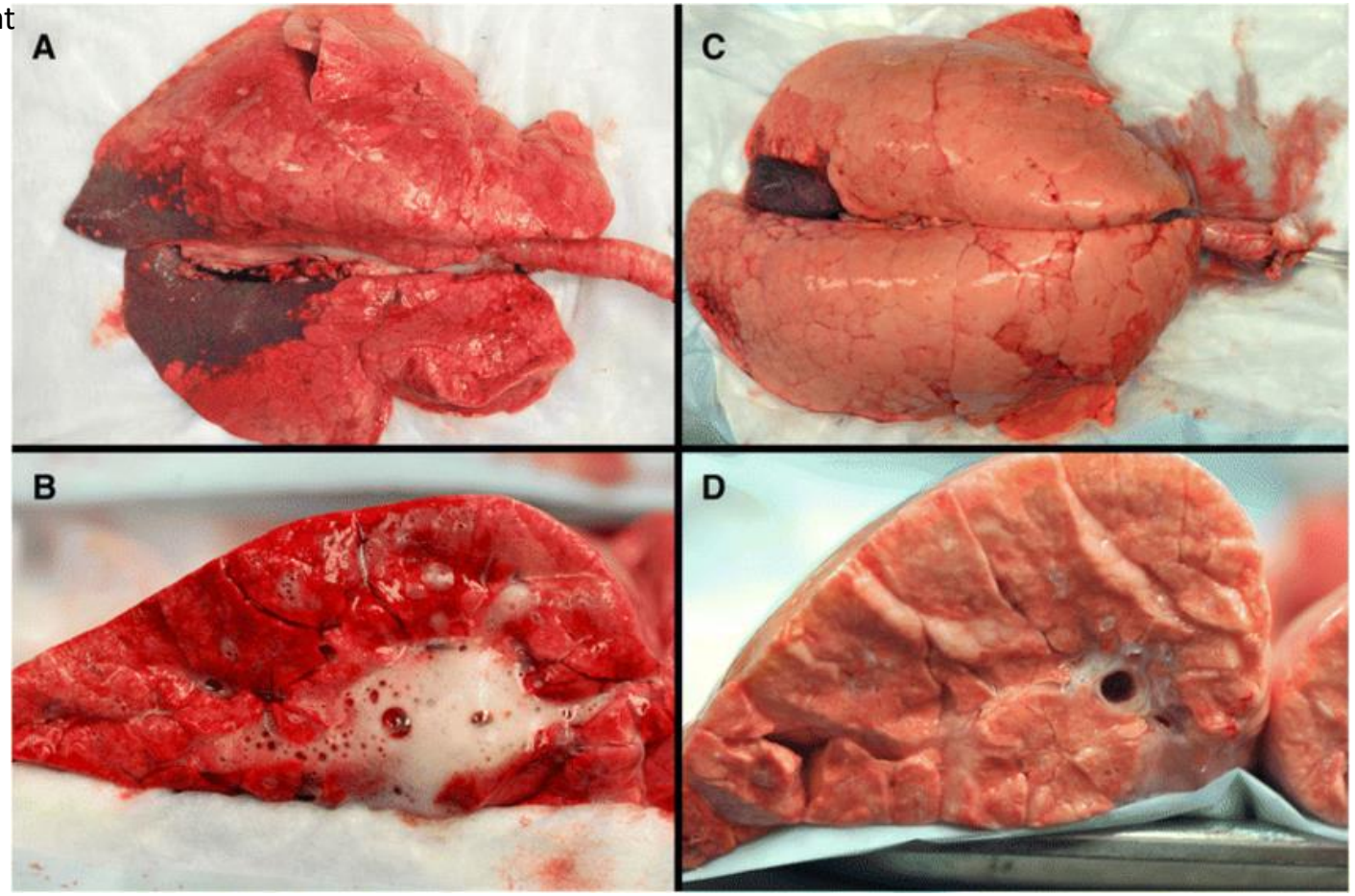
USF HEALTH MORSANI COLLEGE OF MEDICINE UNIVERSITY OF SOUTH FLORIDA

Lehigh Valley Health Network

Animal surfactant wash out model

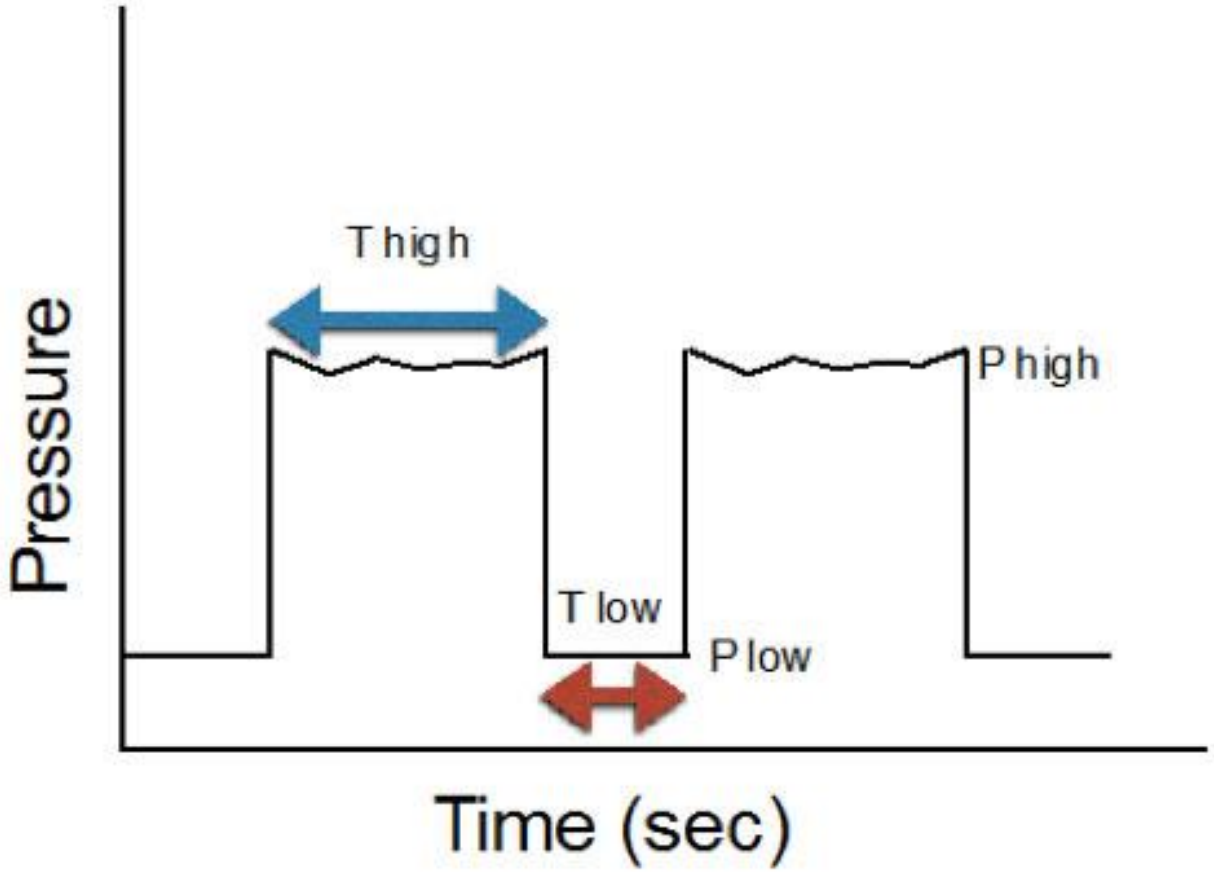
Conventional Mode

APRV



Airway Pressure Release (APRV) Parameters

- Two levels of Pressure
  - P_{high}
  - P_{low}
- Marked by a long inspiratory time and short expiratory time
  - T_{high}
  - T_{low}


T high
P high
T low
P low
Pressure
Time (sec)

Clinician Controlled Parameters

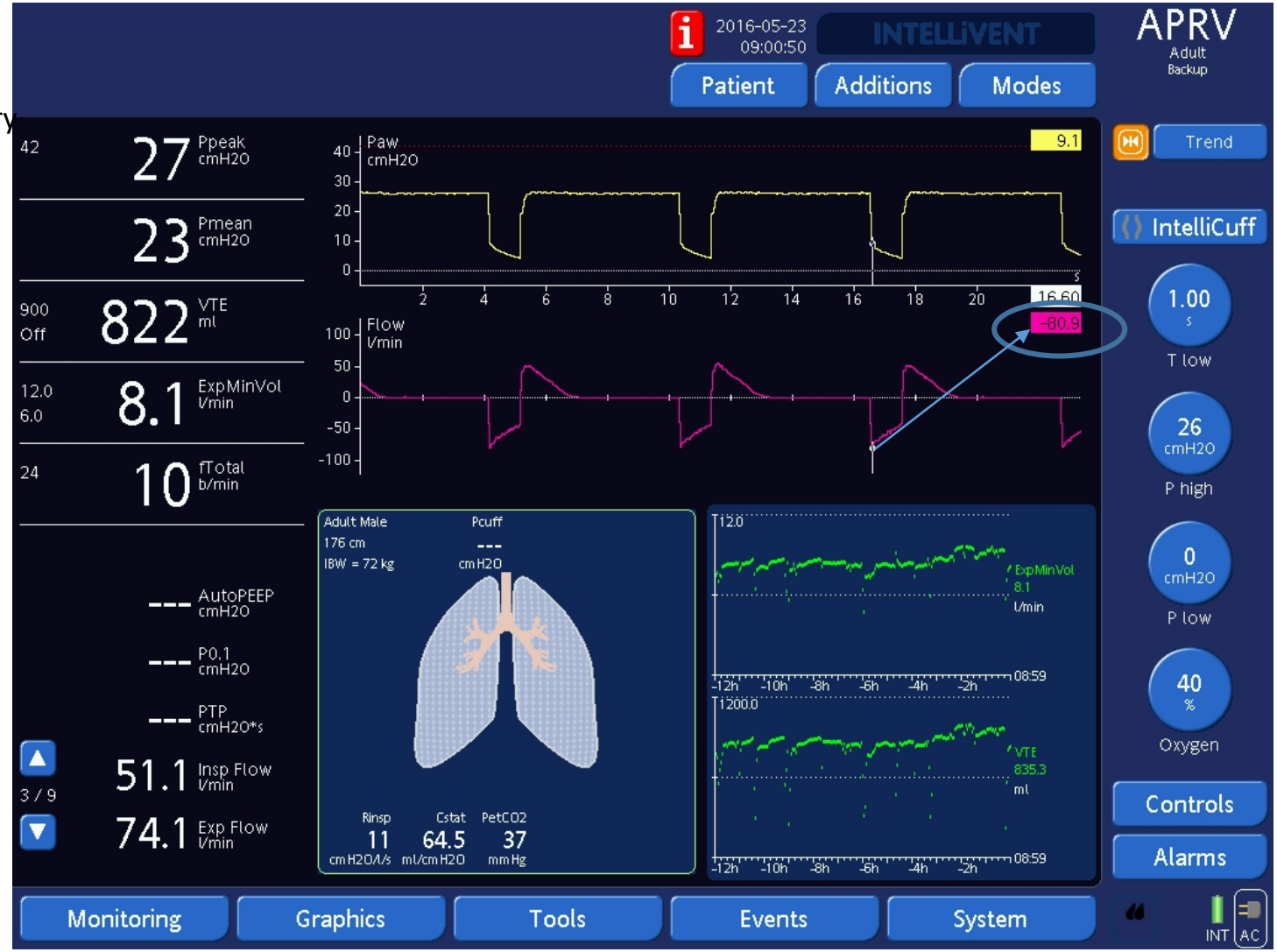
P High
T High
} Recruitment/Oxygenation

P Low
T Low
} Release Phase/Ventilation

USF HEALTH MORSANI COLLEGE OF MEDICINE UNIVERSITY OF SOUTH FLORIDA | Lehigh Valley Health Network

APRV settings
correct
based on
expiratory flow
and lung inflation
Note:
Tlow set at 1.00
based
on exp. flow 50%
(see next 2 slides)
and CLT optimized

Peak expiratory
Flow=80 lpm



End expiratory
Flow=41 liters
80-41=39 lpm
change in expiratory flow
Change in flow = 39/80
expiratory flow change of
48.5%
Goal:
To maintain exp.
flow change
between 33%-66%

Release Volume

- Release volume will reflect the patient's FRC volume and is not a cyclic tidal volume
- Volumes can exceed 1.0 liter

APRV as a Ventilatory Strategy in the Morbid Obese

- Reviewed twenty-four ventilated patients with BMI>30 admitted to the ICU.
- Divided into two groups
  - PRVC
  - APRV
- The APRV group had a reduced ventilatory duration and improved P/F ratio ($P<0.05$) after 24hrs of implementation.
- **Conclusion:** Alveolar gas exchange was augmented in the APRV, ventilatory duration was reduced.

APRV/Obesity Case Study

- A 28 year-old obese white male (BMI >40) presented to an outside hospital with hypotension and vomiting. His past medical history was significant only for an episode of "hepatitis" in 1991 for which he was treated with one "injection" and afterward was told he was "cured". He did not use tobacco, alcohol, or illicit drugs. Family history was significant only for hypertension and diabetes. He was taking no current medications. The patient was admitted to the ICU. Five hours post ICU admission the patient developed respiratory insufficiency requiring intubation and mechanical ventilation.

Case Study

- The patient was placed on volume targeted ventilation. Gas exchange was marginal and chest x-ray revealed bilateral congested. Various ventilator adjustments were made with minimal improvement in gas exchange. The decision was made to place on APRV secondary to large chest wall impedance. Gas exchange was improved along with x-ray; the patient remained on APRV for several days until the diagnosis of sepsis was resolved. Weaning was initiated and the patient was liberated after a SBT on **CPAP of 12cmH_20.**

Questions?

4 hours post admission

2 hrs post ventilation

8 hrs post APRV

Weaning of the Obese patient

- Need to liberate as quick as possible
- May require higher levels of PEEP to address increased thoracic/abdominal impedance
- Positioning is very important
- May be easier to wean in chair or tilt table
- Extubation to BIPIP or high flow oxygen
- Early tracheotomy may facilitate weaning

Weaning Considerations

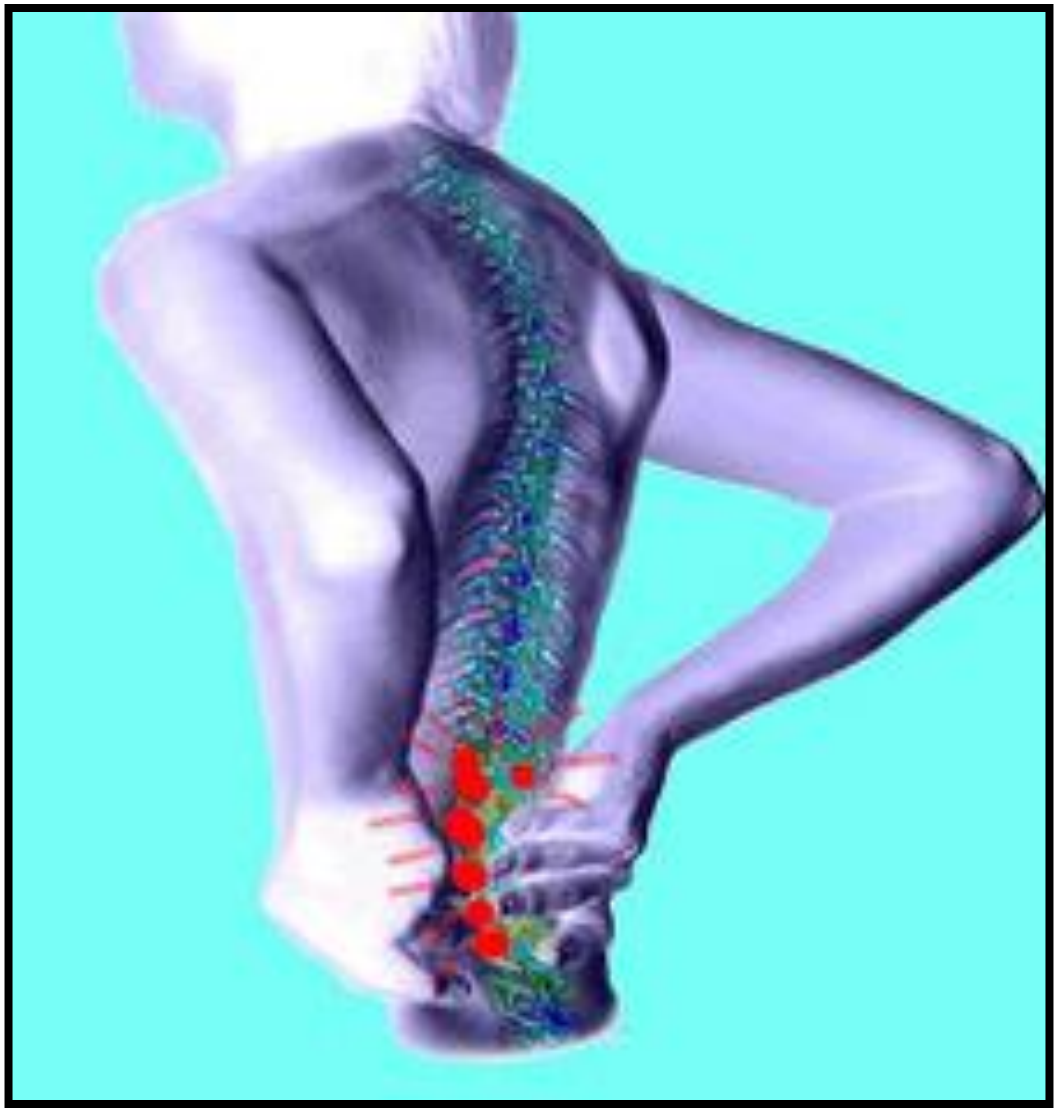
- Adequate Support
- Provide adequate hemodynamic support
- Consider tracheostomy with subsequent wean
- Consider specialized unit and systemized approach
- Future direction of weaning

Early Mobility

- Laying in a hospital bed quickly results in muscle wasting, and it is much more difficult to get it back once it is gone
- Early mobilization is a key (yes, even if the patient is in the ICU, and on a vent, and on high FIO2, and on high PEEP)
- Use of adapted mobility equipment

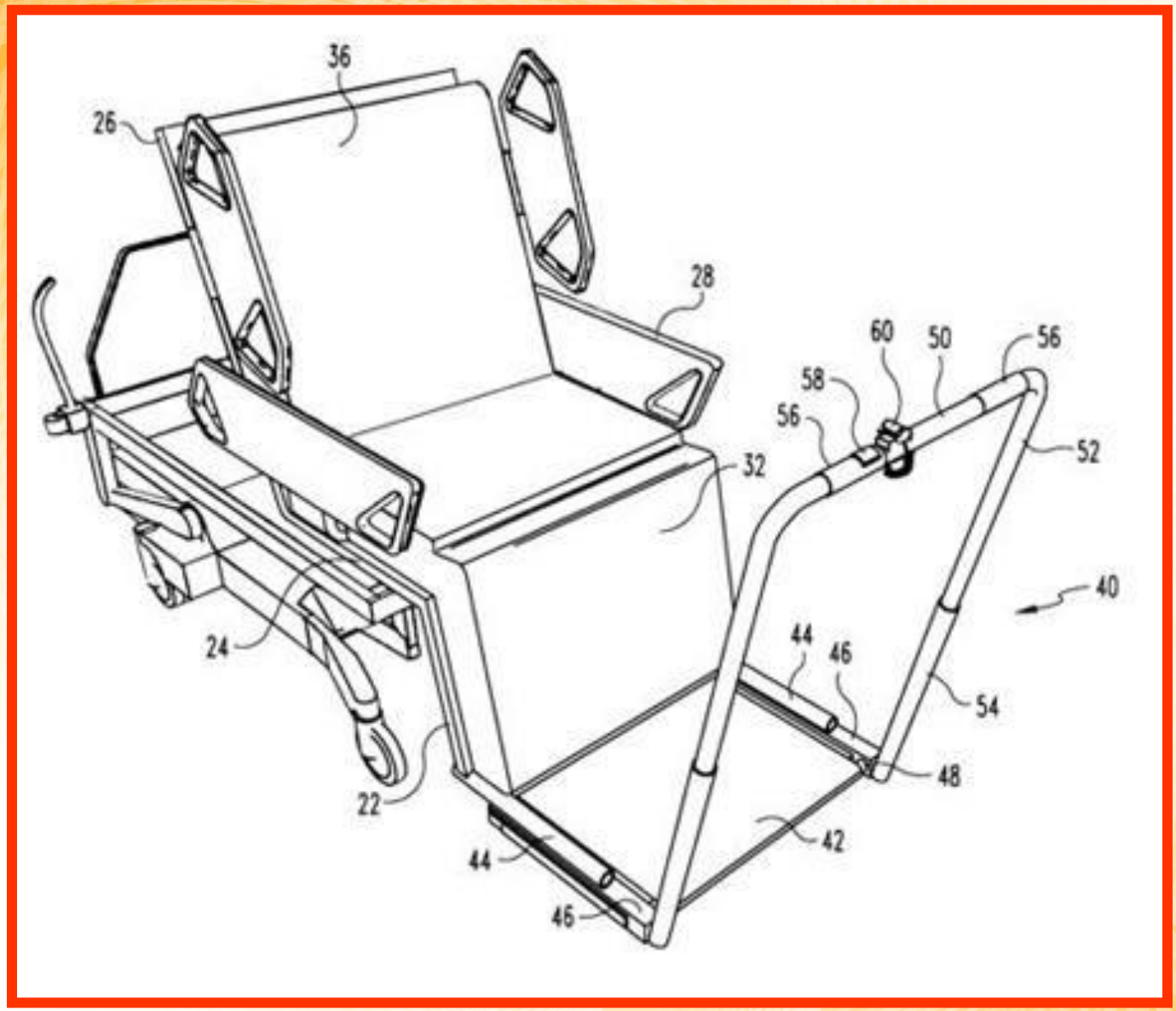
Questions?

Obesity Effect on Health Care Providers



250,000 healthcare workers injured per year caring for the obese patient!!!

Obese man simulator

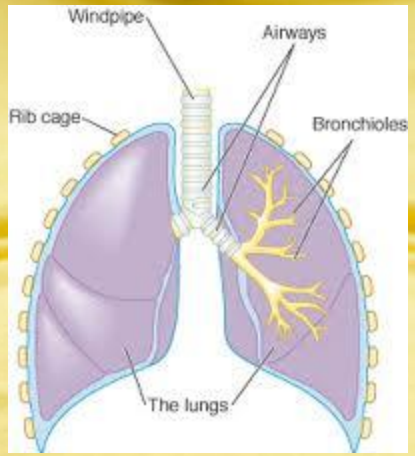

36
26
28
60
50
56
58
56
52
32
40
24
44
46
54
48
22
42
44
46

Tilt Table

Save your back!!


Obesity is not just a comorbidity.
It is a disease.


Clinical Diagnosis is Complicated
So is recovery.



When the body is BIG

The lungs are not!!!

Conclusion

- Obesity is on the rise.
- Will replace tobacco usage as the #1 health concern in the United States.
- Anatomical structures are harder to visualize and manipulate.
- The effect of obesity on the respiratory system is great!
- Clinicians must be aware of the complex interactions between obesity and clinical interventions.
- The cost of obesity may be greater than the disease itself.