Anesthesia for Bariatric Surgery

Jay B. Brodsky, MD

Professor (Anesthesiology)

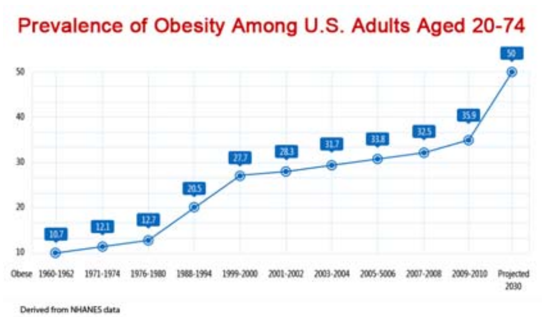
Stanford University Medical Center
Stanford, California

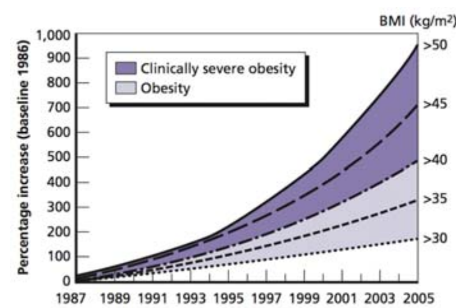
jbrodsky@stanford.edu

February 26, 2018

Anesthesia for Bariatric Surgery: Goals and Objectives

- Define "ideal" and "lean" body weight for appropriate drug dosing and ventilator management.
- Select the optimal position for an obese surgical patient for direct laryngoscopy and to maximize "safe apnea time".
- Recognize the risk factors for a "difficult" airway in obesity.
- Identify which morbidly obese patients require a rapid sequence induction and which do not.
- Choose the safest airway management technique for the obese patient.





Why is "Ideal Body Weight" Important?

- Controlled ventilation (Vt) is based on "Predicted" or Ideal Body Weight (IBW)
- Anesthetic drugs are administered by IBW or Lean Body Weight (LBW); Not actual total body weight (TBW)

Vecuronium	IBW
Rocuronium	IBW
Cis-Atracurium	IBW
Propofol (induction)	LBW
Fentanyl	LBW
Sufentanil	LBW
Remifentanil	LBW
Succinylcholine	TBW
Sugammadex	TBW (IBW, LBW)

There is a no physiologic basis for IBW

"Ideal Body Weight" – in 1942 Metropolitan Life Insurance Co. published height and weight tables associated with lowest mortality rates …..***among policy holders!***

Uninsured (with health problems) were excluded *

* Met Life not representative of general population - between 1911-1937 life expectancy for Met Life policyholders increased +17.0 years vs +11.5 years for entire US population

Met Life - Ideal Body Weight Tables

- Data only from insured, healthy adults 25-59 year old
- Height and weight obtained while applicants wore shoes and clothing
- No standardized measuring equipment
- Self-reported height and weight accepted
  - women underestimated weight
  - men overestimated height

Ideal Body Weight Tables

Metropolitan Life Insurance Company (1942-1943)

Table 1 Proposed range of ideal weights for women, ages 25 and over, Metropolitan Life Insurance Company

Height (with shoes)	Weight in pounds (as ordinarily dressed) Small frame	Medium frame	Large frame
5' 0"	105-13	112-20	119-29
5' 1"	107-15	114-22	121-31
5' 2"	110-18	117-25	124-35
5' 3"	113-21	120-28	127-38
5' 4"	116-25	124-32	131-42
5' 5"	119-28	127-35	133-45
5' 6"	123-32	130-40	136-50
5' 7"	126-36	134-44	142-54
5' 8"	129-39	137-47	145-58
5' 9"	133-43	141-51	149-62
5' 10"	136-47	145-55	152-66
5' 11"	139-50	148-58	155-69
6' 0"	141-53	151-63	160-74

Source: Metropolitan Life Insurance Company 1942.

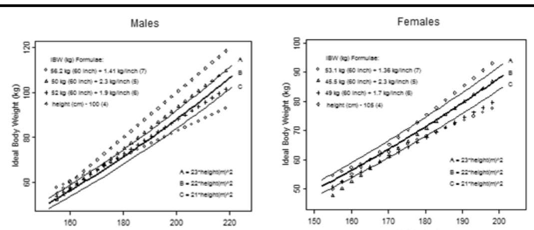
Table 2 Ideal weights for men, ages 25 and over, Metropolitan Life Insurance Company

Height (with shoes)	Weight in pounds (as ordinarily dressed) Small frame	Medium frame	Large frame
5' 2"	116-25	124-33	131-42
5' 3"	119-28	127-36	133-44
5' 4"	122-32	130-40	137-49
5' 5"	126-36	134-44	141-53
5' 6"	129-39	137-47	145-57
5' 7"	133-43	141-51	149-62
5' 8"	136-47	145-56	153-66
5' 9"	140-51	149-60	157-70
5' 10"	144-55	153-64	161-75
5' 11"	148-59	157-68	165-80
6' 0"	152-64	161-73	169-85
6' 1"	157-69	166-78	174-90
6' 2"	163-75	171-84	179-96
6' 3"	168-80	176-89	184-202

Source: Metropolitan Life Insurance Company 1943.

Ideal Body Weight (kg) Formulas

MEN	WOMEN
Height (cm) – 100	Height (cm) – 110
Height (cm) -102	Height (cm) - 105
50 kg (60 in) + 2.3 kg/in	45.5 kg (60 in) + 2.3 kg/in
52 kg (60 in) + 1.9 kg/in	49 kg (60 in) + 1.7 kg/in
56.2 kg (60 in) + 1.41 kg/in	53.1 kg (60 in) + 1.36 kg/in
22 x M^2	22 x M^2



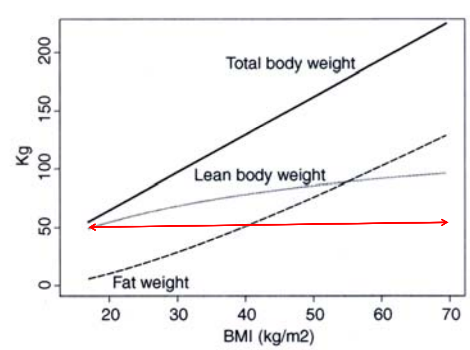
Ideal Body Weight (kg) (IBW) = (22)(m^2)

Lemmens H, Brodsky JB. Estimating Ideal Body Weight. Obes Surg (2005) 15:1082-3

Lean Body Weight (LBW) in a normal weight patient

(Men) LBW = 80% IBW

(Women) LBW = 75% IBW



Janmahasatian Formula

$$\text{LBW (kg)} = \frac{9270 \times \text{TBW (kg)}}{6680 + (216 \times \text{BMI (kg.m}^{-2}))} \text{(men)}$$

$$\text{LBW (kg)} = \frac{9270 \times \text{TBW (kg)}}{8780 + (244 \times \text{BMI (kg.m}^{-2}))} \text{(women)}$$

LBW in Obesity (BMI > 30 kg/m^2)

IBW + 20 - 30%

What is "OBESITY"?

Fat comprises *greater than* ***normal*** percentage of body weight

Why are 2 out of 3 American women "overweight"?

Body Mass Index (BMI = kg/m^2)

18.5 - 25	**Ideal, Normal**, Desirable, Predicted, Healthy
25 - 29	Overweight
30 - 39	Obese
$\geq$ 40	Morbid Obesity
> 50	Super-Obese
> 60	Super-Super-Obese

Average Weight for American Adults (1998)

Body Mass Index values for males and females aged 20 and over, and selected percentiles by age: United States, 2007–2010. Source: "Anthropometric Reference Data for Children and Adults: United States" from CDC DHHS[31]

Age	Percentile								
	5th	10th	15th	25th	50th	75th	85th	90th	95th
	Men BMI (kg/m^2)								
20 years and over (total)	20.7	22.2	23.2	24.7	27.8	31.5	33.9	35.8	39.2
20–29 years	19.4	20.7	21.4	22.9	25.6	29.9	32.3	33.8	36.5
30–39 years	21.0	22.4	23.3	24.9	28.1	32.0	34.1	36.2	40.5
40–49 years	21.2	22.9	24.0	25.4	28.2	31.7	34.4	36.1	39.6
50–59 years	21.5	22.9	23.9	25.5	28.2	32.0	34.5	37.1	39.9
60–69 years	21.3	22.7	23.8	25.3	28.8	32.5	34.7	37.0	40.0
70–79 years	21.4	22.9	23.8	25.6	28.3	31.3	33.5	35.4	37.8
80 years and over	20.7	21.8	22.8	24.4	27.0	29.6	31.3	32.7	34.5
Age	Women BMI (kg/m^2)								
20 years and over (total)	19.5	20.7	21.7	23.3	27.3	32.5	36.1	38.2	42.0
20–29 years	18.8	19.9	20.6	21.7	25.3	31.5	36.0	38.0	43.9
30–39 years	19.4	20.6	21.6	23.4	27.2	32.8	36.0	38.1	41.6
40–49 years	19.3	20.6	21.7	23.3	27.3	32.4	36.2	38.1	43.0
50–59 years	19.7	21.3	22.1	24.0	28.3	33.5	36.4	39.3	41.8
60–69 years	20.7	21.6	23.0	24.8	28.8	33.5	36.6	38.5	41.1
70–79 years	20.1	21.6	22.7	24.7	28.6	33.4	36.3	38.7	42.1
80 years and over	19.3	20.7	22.0	23.1	26.3	29.7	31.6	32.5	35.2

World Health Organization Classification by BMI (1998)

Classification	BMI (kg/m^2)	Risk of co-morbidities
Underweight	< 18.5	Low
NORMAL range	18.5 – 24.9	Average
Overweight (pre-obese)	25.0 – 29.9	Increased
Obese	≥ 30.0	
Class I	**30.0 – 34.9**	**Moderate**
Class II	**35.0 – 39.9**	**Severe**
Class III	**≥ 40.0**	**Very severe**

June 17, 1998

National Heart, Lung, and Blood Institute (NHLBI) declared previous BMI standards too lenient

Changed “over-weight” cutoffs from BMI (> 27.8 men, > 27.3 women) to ≥ 25 for both men and women

Overnight prevalence of “overweight” increased from 33% to 59% (men) and 36% to 51% (women)

Czerniawski AM. From Average to Ideal. The evolution of the height and weight table in the United States, 1836-1943. Social Science History (2007) 31: 273-296

Without gaining a pound, Americans with a ***“normal”*** BMI on June 16, 1998 woke up the next day to learn that their health was now in danger

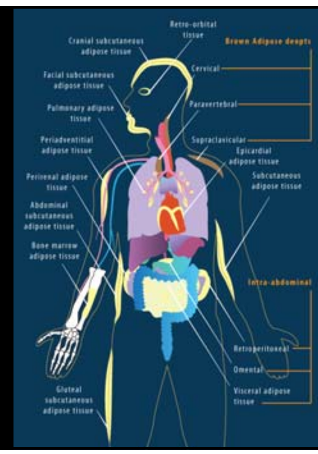
By simply changing the definition, the number of over-weight adults in USA increased by **35.4 million** in one day!

Kucmarski RJ, Flegel KM. Criteria for definition of overweight in transition: background and recommendations for the United States. Am J Clin Nutr 2000; 72: 1074-81

BMI measures weight

BMI is not a direct measure of obesity!

Distribution and type of fat



Distribution (and type) of fat is most important

Peripheral
hips
buttocks thighs
(female)

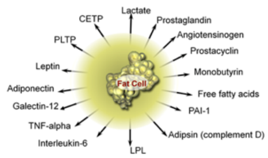
Central
upper body
waist
(male)

Metabolic Syndrome

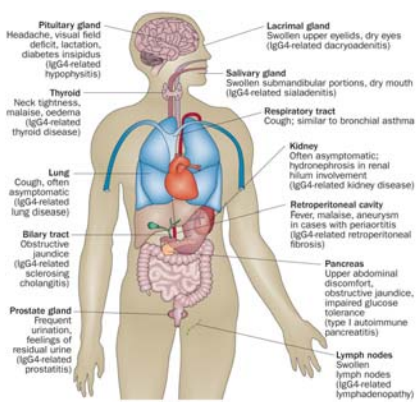
Waist circumference
>102 cm (men) and >88 cm (women)
Serum triglycerides
≥150 mg/dl
HDL cholesterol
<40 mg/dl (men) and <50 mg/dl (women)
Systolic blood pressure
≥130 mmHg and/or diastolic ≥85 mmHg or on treatment for hypertension
Fasting serum glucose
≥110 mg/dl or on treatment for diabetes

CENTRAL OBESITY

Visceral (central) fat is an endocrine organ releasing peptides, metabolites, hormones, FFA, cytokinase, and other compounds throughout the body



BMI		Waist less than or equal to 40 in. (men) or 35 in. (women)	Waist greater than 40 in. (men) or 35 in. (women)
18.5 or less	Underweight	---	N/A
18.5 - 24.9	Normal	---	N/A
25.0 - 29.9	Overweight	Increased	High
30.0 - 34.9	Obese I	High	Very High
35.0 - 39.9	Obese II	Very High	Very High
40 or greater	Obese III	Extremely High	Extremely High



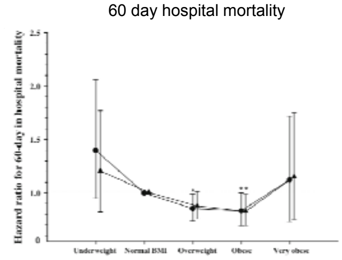
MYTH:

Being overweight/obese is ***always*** bad for your health

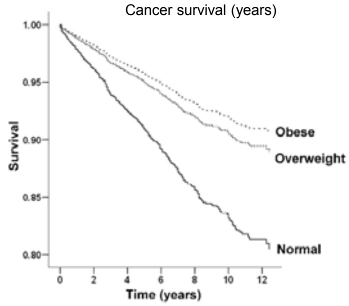
Obesity Paradox is the medical hypothesis that obesity may be protective and associated with greater survival in certain groups of people.

Obesity Paradox

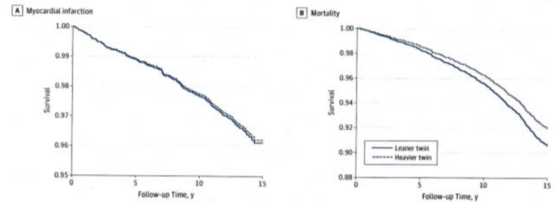
60 day hospital mortality



Cancer survival (years)



Lennon H, et al. The Obesity Paradox in Cancer: a Review. Curr Oncol Rep. 2016 18:56

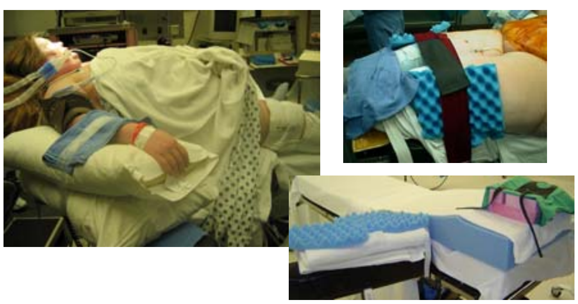


4046 MZ twin pairs
discordant BMIs (difference > 0.01)

Obesity ***was not*** associated with increased risks of MI or death in genetically identical patients

Nordstrom P, et al. Risks of myocardial infarction, death, and diabetes in identical twin pairs with different body mass indexes. JAMA Internal Medicine (2016) doi:10.1001/jamainternmed. 2016.4104

Pad all pressure points and support extremities



Br. J. Anaesth. (1983), 55, 801

THE LARYNGEAL MASK—A NEW CONCEPT IN AIRWAY MANAGEMENT

A. I. J. BRAIN

"**LMA** is an ***alternative*** to a **face mask or endotracheal tube** for achieving and maintaining control of the airway"

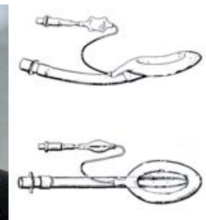


FIG. 1. Prototype of the laryngeal mask.

Indications - LMA

- Short (<1 hr) elective procedures
- ASA-PS 1 or 2 patients

To be used in:

- **Spontaneously breathing** patients
- **Supine** or **lithotomy positions** only

Brain AIJ (1983) The laryngeal mask- a new concept in airway management. Br J Anaesth 55: 801

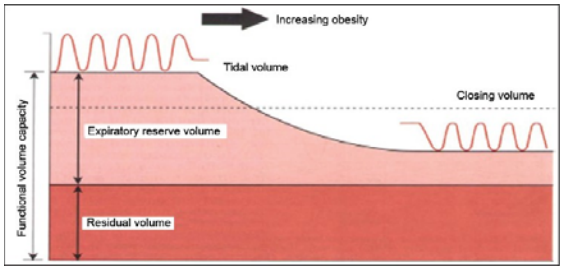
LMA: Contra-indications

- **Decreased pulmonary compliance (present in all obese patients)**

- **High risk of aspiration**

Brain AIJ (1983) The laryngeal mask- a new concept in airway management. Br J Anaesth 55: 801

FRC (ERV) decreases with increasing BMI



Published May 16, 2011 :
A comment on NAP4 from The Society of Bariatric Anaesthetists (SOBA) Nightingale CE, et al.

"… obese patients ***should not*** be allowed to breathe spontaneously for anything other than the shortest procedure."

Potential Risk Factors for Gastric Aspiration in Obesity

- Delayed gastric emptying (???)
- Decreased pH gastric fluid (???)
- Increased gastric fluid volume (???)
- High incidence hiatal hernia and GERD
- Diabetic with gastroparesis
- Increased abdominal pressure (laparoscopy, lithotomy)
- Previous gastric banding

- Keller C, et al. Aspiration and the laryngeal mask airway: three cases and a review of the literature. Br J Anesth 2004; 93: 579-82
- Abdi W, et al. Evidence of pulmonary aspiration during difficult airway management of a morbidly obese patient with the LMA CTrach. Br J Anaesth 2008, 100: 275-7

4th National Audit Project of
The Royal College of Anaesthetists and The Difficult Airway Society
Major complications of airway management in the UK
NAP4 Report and findings March 2011

Approximately 2.9 million anaesthetics in UK

- 42% pts who experienced a major airway complication (death, brain damage, emergency surgical airway, or ICU admission) were obese
- Obese pts had 2X risk of serious airway problems during anesthesia
- "Severe" obesity 4X more likely to have airway problems

4th National Audit Project of
The Royal College of Anaesthetists and The Difficult Airway Society
Major complications of airway management in the UK
NAP4 Report and findings March 2011

- Morbidly obese at increased risk of regurgitation and aspiration (50% of deaths in NAP-4)
- Obese patients had increased frequency of aspiration associated with use of supraglottic devices (LMAs)….

BJA **Major complications of airway management in the UK:**
Results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society
British Journal of Anaesthesia
Cook TM ,et al. BJA (2011) 106:617-31

- ETT achieves the best protection against aspiration and can enable increased pressure during ventilation
- …. second-generation SGAs with improved seal ***may be safer*** in obesity – but (in 2011) no evidence available

Role of 2nd Generation SGAs in Obesity?

Published May 16, 2011

A comment on NAP4 from The Society of Bariatric Anaesthetists (SOBA)
Nightingale CE, et al.

- SOBA recommends tracheal intubation for patients with BMI > 35 kg/m^2
- ETT should be the default airway (in obesity) with justification for the use of a SGA

Are the airways of morbidly obese patients are "difficult"

Answer: Yes and No!

What is a Difficult Airway?

"difficult airway …. clinical situation in which a conventionally trained anesthesiologist experiences ***problems*** with ***face mask ventilation*** and/or ***tracheal intubation***"

ASA Task Force: Practice Guidelines for the Management of the Difficult Airway.

Shiga T, et al. Predicting Difficult Intubation in Apparently Normal Patients: A Meta-analysis of Bedside Screening Test Performance. Anesthesiology 2005; 103: 429-37

… intubation *"problems"* are 3 times more likely to occur in obese compared to normal weight patients!

Juvin P, et al. Difficult tracheal intubation is more common in obese than in lean patients. Anesth Analg 2003; 97:595–600

Brodsky JB, et al. Morbid obesity and tracheal intubation. Anesth Analg 2002; 94:732–6

Voyagis GS, et al. Value of oropharyngeal Mallampati classification in predicting difficult laryngoscopy among obese patients. Eur J Anaesthesiol 1998; 15:330–4

Ezri T, et al. Prediction of difficult laryngoscopy in obese patients by ultrasound quantification of anterior neck soft tissue. Anaesthesia 2003; 58:1111–4

Face Mask Ventilation (MV)

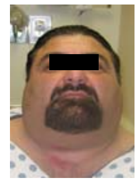
Grade	Description
1	Ventilated by mask
2	Ventilated by mask with oral airway/ adjuvant with or without muscle relaxant
3	Difficult ventilation (inadequate, unstable, or requiring two providers) with or without muscle relaxant
4	Unable to mask ventilate with or without muscle relaxant
	Total cases

Grade 3

Kheterpal S, et al. Incidence and predictors of difficult and impossible mask ventilation. Anesthesiology (2006) 105:885-91

Grade 3 MV – Unstable, inadequate and/or requiring 2 providers

Grade 3 mask ventilation	
Body mass index ≥ 30 kg/m^2	< 0.0001
Beard	< 0.0001
Mallampati III or IV	< 0.0001
Age ≥ 57 yr	0.002
Jaw protrusion—severely limited	0.018
Snoring	0.019



Kheterpal S, et al. Incidence and predictors of difficult and impossible mask ventilation. Anesthesiology 2006; 105: 885-891

Incidence and Predictors of Difficult and Impossible Mask Ventilation

Sachin Kheterpal, M.D., M.B.A.,* Richard Han, M.D., M.P.H.,* Kevin K. Tremper, Ph.D., M.D.,† Amy Shanks, M.S.,‡ Alan R. Tait, Ph.D.,§ Michael O'Reilly, M.D., M.S.,|| Thomas A. Ludwig, M.D., M.S.*

Table 5. Airway Outcome Independent Predictors

Factor	*P* Value
Grade 3 mask ventilation	
Body mass index ≥ 30 kg/m^2	< 0.0001
Beard	< 0.0001
Mallampati III or IV	< 0.0001
Age ≥ 57 yr	0.002
Jaw protrusion—severely limited	0.018
Snoring	0.019
Grade 3 or 4 mask ventilation and difficult intubation	
Jaw protrusion—limited or severely limited	< 0.0001
Thick/obese neck anatomy	0.019
Sleep apnea	0.036
Snoring	0.049
Body mass index ≥ 30 kg/m^2	0.053

"Intubation" Difficulty Score (IDS)

1. Number of additional attempts at intubation
2. Number of additional operators
3. Number of alternate intubation techniques used
4. Glottic exposure (Grade 2-4 Cormack-Lehane view)
5. "Lifting force" applied during laryngoscopy
6. Need to apply external laryngeal pressure
7. Position of the vocal cords at intubation

IDS < 5 = not difficult
IDS ≥ 5 = difficult

Juvin P, et al. Difficult ***tracheal intubation*** is more common in obese than lean patients. Anesth Analg (2003) 97:595-600

IDS	Lean (BMI < 30) (n=134)	Obese (BMI > 35) (n=129)
> 1	61.9%	43.3%
< 5	35.8%	41.1%
≥5	2.3% (n=3)	**15.5% (n=20)**

- Cormack-Lehane (III/IV) views identical

  10.4% (lean group) vs 10.1% (obese group)
- All patients in both groups were intubated by direct laryngoscopy
- BMI was not an independent risk factor for difficult intubation

AIRWAY
Juvin P, et al. Difficult ~~tracheal intubation~~ is more common in obese than in lean patients. Anesth Analg (2003) 97: 595–600

Potential "Difficult" Tracheal Intubation Predictors

ABNORMAL FACIAL ANATOMY and/or DEVELOPMENT
- Small mouth and/or large tongue
- Dental abnormality, prominent incisors, poor dentition
- Prognathia
- Acromegaly
- Congenital syndrome (eg Treacher-Collins)

INABILITY TO OPEN MOUTH
- Masseter muscle spasm
- Temporo-mandibular joint dysfunction
- Facial burns
- Post-radiation fibrosis
- Scleroderma

CERVICAL IMMOBILITY/ABNORMALITY
- Short neck/ or obesity + large neck circumference
- Poor cervical mobility (eg ankylosis spondylitis)
- Previous cervical spine and/or neck surgery
- Presence of cervical collar
- Post-radiation fibrosis

PHARYNGEAL and/or LARYNGEAL ABNORMALITY
- High or anterior larynx
- Deep vallecula (inability to reach base of epiglottis with blade)
- Anatomic abnormality of epiglottis/hypopharynx (eg tumor)
- Subglottic stenosis
- ? Obstructive Sleep Apnea

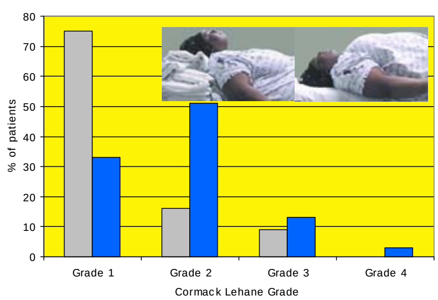
Stanford Anesthesia Residents – Direct Laryngoscopy
100 Consecutive Morbidly Obese Patients

1st attempt	92%	(92/100)
2nd attempt	5%	(5/100)
3rd attempt	2%	(2/100)
Failed	1%	(1/100)

Brodsky JB, et al. Morbid Obesity and Tracheal Intubation. Anesth Analg 2002; 94: 732

Head Elevated Laryngoscopy Position (HELP)

Direct Laryngoscopy (Cormack-Lehane View)



Collins JS, et al. Laryngoscopy and morbid obesity: a comparison of the "sniff" and "ramped" positions. Obes Surg. (2004) 14:1171-5

Shiga T, et al. Predicting Difficult Intubation in Apparently Normal Patients: A Meta-analysis of Bedside Screening Test Performance. Anesthesiology 2005; 103: 429-37

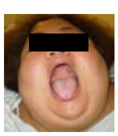
- Ezri T, et al. Anaesthesia 2003;58:1111–4
- Juvin P, et al. Anesth Analg 200397:595–600
- Brodsky JB, et al. 2002;94:732–6
- Voyagis GS, et al. Eur J Anaesthesiol 1998;15:330–4

378/379 pts (4 studies) successfully intubated by conventional direct laryngoscopy!

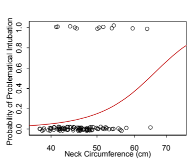
All 4 studies stated…"**magnitude of obesity *did <u>not</u>* influence laryngoscopy difficulty**!"

What Should You Look For?

Mallampati Score III/IV

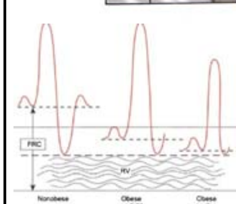


Always be prepared for a difficult tracheal intubation



Neck Circumference > 60 cm

Routine Position Anesthetic Induction – Supine

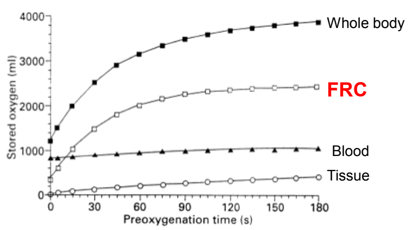


- Increased intra-abdominal pressure
- Reduced chest wall compliance
- Decreased lung volumes

Pre-oxygenation

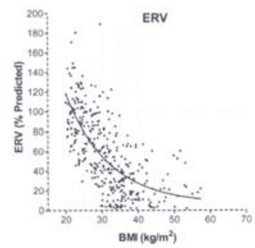
Normally patients are pre-oxygenated with 100% oxygen via a tight-fitting facemask for:

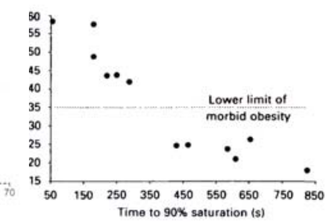
- 3 min at tidal volume ventilation
- 8 vital capacity breaths within 60 s



Benumof JL. Preoxygenation: Best Method for Both Efficacy and Efficiency? *Anesthesiology 1999;91:603*

FRC and SAP inversely proportional to BMI



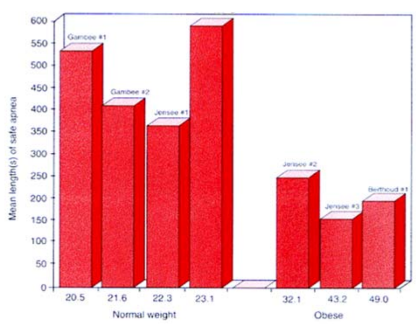


Jones RL, et al (2006) The effects of body mass index on lung volumes. Chest 130: 827-833

Berthoud MC, et al (1991) Effectiveness of Preoxygenation in Morbidly Obese Patients. Br J Anaesth 67: 464-6

Safe Apnea Period (SAP)

Time$_{(sec)}$ to SpO_2 90 - 92%

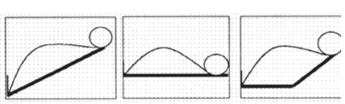


4th National Audit Project of
The Royal College of Anaesthetists and The Difficult Airway Society

Major complications of airway management in the UK

Obese patients desaturate rapidly – time from anesthetic induction to assisted ventilation should be minimised, and efforts should be made to increase "Safe Apnea Period" (SAP)

Position and SAP and SpO_2 Recovery Times in Morbidly Obese Patients



Safe Apnea Period (seconds)	178±55 (1 vs 3:p<0.05)	123±24	153±63
Recovery Time (seconds)	80±30 (2 vs 1:P<0.001)	206±64	97±41 (2 vs 3: P<0.001)
Lowest SaO_2(%)	83±4	82±5	83±4

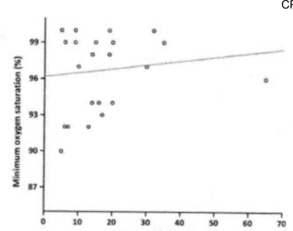
Data is Mean±Standard Deviation.

Boyce et al (2003) A preliminary study of the optimal anesthesia positioning for the morbidly obese patient. Obes Surg 13: 4-9

Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE)

Optiflow™

CPAP continuous delivery 100% O_2 up to 70 L/min



Average SAP (> 90% SpO_2) 17 min until airway secured in 25 difficult airway patients (12 obese)

Patel A, et al. Transnasal humidified rapid-insufflation ventilatory exchange (THRIVE): a physiological method of increasing apnoea time in patients with difficult airways. Anaesthesia (2015) 70: 323-329

Nasal Oxygen Insufflation and SAP

Morbidly obese patients
25° head-up position
Pre-oxygenation with facemask - FiO_2 1.0 at 10L/min for 3 min
Paralyzed with succinylcholine

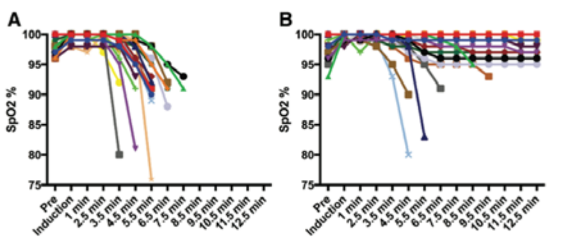
- 5 L/min nasal O_2 during laryngoscopy
- 16/17 pts – SpO_2 100% after 4 mins apnea

Baraka AS, et al. Supplementation of pre-oxygenation in morbidly obese patients using nasopharyngeal oxygen insufflation. Anaesthesia (2007) 62:769–773

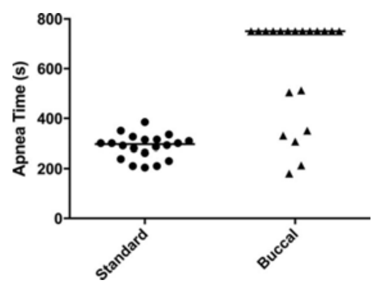
- 40 patients, BMI 30-40 kg m^2
- Face-mask preoxygenation until $ET\text{-}O_2$ = .8
- 20 pts - 10 L/min O_2 via buccal RAE tube
- Intubation with Glidescope 150 secs after paralysis
- Maintained laryngoscopy until SpO2 < 95%, or 750 secs (12.5 mins) elapsed

Heard A, et al. Apneic oxygenation during prolonged laryngoscopy in obese patients: A randomized controlled trial of buccal RAE tube oxygen administration. Anesth Analg (2017) 124: 1162-7

Standard Preoxyenation (N=20) Buccal Oxygenation (N=20)



Heard A, et al. Apneic oxygenation during prolonged laryngoscopy in obese patients: A randomized controlled trial of buccal RAE tube oxygen administration. Anesth Analg (2017) 124:1162-7



Apnea time with $SpO_2 \geq 95\%$ (horizontal line = median)

Heard, A, et al. Apneic Oxygenation During Prolonged Laryngoscopy in Obese Patients: A Randomized, Controlled Trial of Buccal RAE Tube Oxygen Administration. Anesth Analg 2017) 124(4):1162-1167

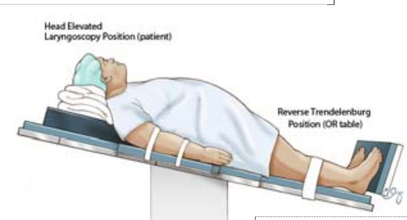
Positive Pressure Face Mask and P-LMA Ventilation and SAP

	FM (n=52)	PLMA (n=48)
SAP (seconds)	205.0±48.2	337.4±61.0
Range	96–320	176–456
Recovery time (seconds)	49.7±6	42.1±5
Range	36–68	30–56
Lowest SpO_2	63.4±7	62.6±6.4
Range	43–79	49–74

Sinha A, et al. ProSeal[TM] LMA Increases Safe Apnea Period in Morbidly Obese Patients Undergoing Surgery under General Anesthesia. Obes Surg (2013) 23: 580–584

"Ideal" Position for Morbidly Obese Patient

Improves view during direct laryngoscopy



Increases safe apnea time

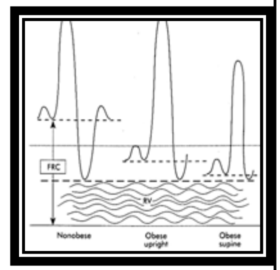
Mechanical Ventilation and Obesity

Reduce atelectasis during and after anesthetic induction

- **FiO2 < 0.8** - may prevent absorption atelectasis/hypoxia
- **Positive-pressure ventilation during induction** - increases "safe apnea period" for intubation
- **Recruitment maneuver (RM) immediately after intubation using a sustained (8-10 seconds) pressure > 50 cm H_2O**

Mechanical Ventilation and Obesity

Supine

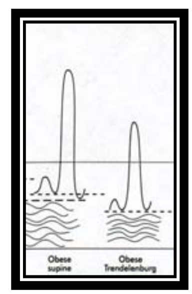


Increased intra-abdominal pressure (IAP) → decreased chest wall compliance and lung volume

Lithotomy

Further reduction in chest wall compliance and lung volumes

Trendelenburg



Greatest reduction in chest wall compliance and lung volumes

Effects of Capnoperitoneum during Laparoscopy

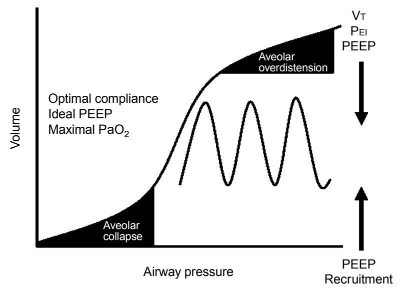
Respiratory Mechanics	
Peak Inspiratory Pressure (PIP)	Increased
Respiratory Compliance	Decreased
Ventilator Changes (to reduce PIP and CO_2)	
Respiratory Rate	Increased
Tidal Volume	Decreased
Minute Ventilation	Increased

Nguyen NT, Wolfe BM. The physiologic effects of pneumoperitoneum in the morbidly obese. Ann Surg 2005; 241:219-226

Avoid Lung Overdistention

- **Tidal volume ventilation (6 - 8 ml/kg/"IBW")**
  - use even smaller VT for "protective lung ventilation"
  - avoid larger VT and/or high ventilatory pressures
- **Increase ventilator rate for excessive hypercapnia**
  - adjust ventilator to maintain physiologic end-tidal CO_2
  - consider "permissive hypercapnia"
- **Keep end-inspiratory (plateau) pressure < 30 cm H_2O**

Pressure-volume Curve Illustrating Lung Protective Ventilation



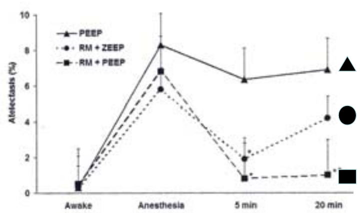
Both overinflation and expiratory collapse should be avoided

Yilmaz M, et al. Optimal ventilator settings in acute lung injury and acute respiratory distress syndrome. Eur J Anaesthesiol 2008; 25: 89-96

Keep lungs expanded

- **PEEP (10 cm H_2O)**
  - Monitor for adverse effects of PEEP
    - bradycardia
    - hypotension
  - Hypotension or decreasing SpO_2 may be due to PEEP increasing pulmonary shunt fraction
- **Prevent re-occurrence of atelectasis with intermittent recruitment maneuvers (RM)**

PEEP alone and RM alone does not improve oxygenation



PEEP 10 cm H_20 only

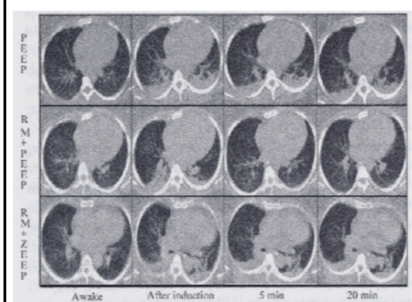
RM alone; zero end-expiratory pressure (ZEEP)

Recruitment maneuver (RM) (55 cm H_2O) + 10 cm positive end-expiratory pressure (PEEP)

Recruitment Maneuver (RM) followed by PEEP (10 cm H_2O) reduces atelectasis and improves oxygenation in morbidly obese patients

Reinius H, et al. Prevention of atelectasis in morbidly obese patients during general anesthesia and paralysis. Anesthesiology 2009; 111: 979-87

30 patients BMI 45 kg/m^2



PEEP (10 cm H_20) only

Recruitment maneuver (RM) (55 cm H_2O) + 10 cm **PEEP**

RM only + zero end-expiratory pressure (ZEEP)

Reinius H, et al. Prevention of atelectasis in morbidly obese patients during general anesthesia and paralysis. Anesthesiology 2009; 111: 979-87

Maintain post-operative lung expansion

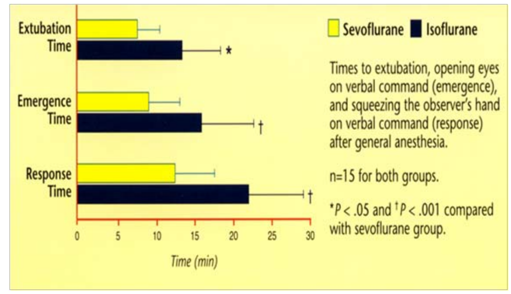
- CPAP or BIPAP immediately after tracheal extubation
- Keep patient's upper body elevated
- Supplemental nasal or mask oxygen
- Maintain good pain control (limit opioids)
- Use incentive spirometry
- Encourage early ambulation

Is there is a "best" anesthetic for morbidly obese patients?

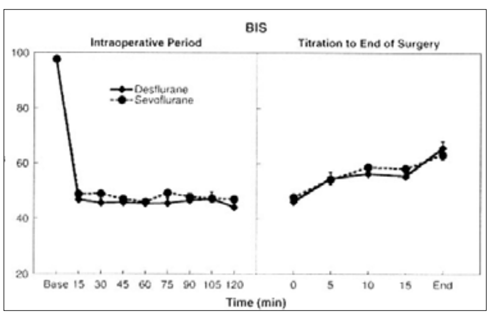
Desflurane is least fat soluble - less deposition in fat - ? faster recovery from anesthesia

	Desflurane	Sevoflurane	Isoflurane	Halothane	N_2O
Fat	27	48	45	51	2.3
Blood	0.42	0.69	1.46	2.54	–
Brain	1.3	1.7	1.6	1.9	1.1
Heart	1.3	1.8	1.6	1.8	–
Liver	1.3	1.8	1.8	2.1	0.8
Kidney	1.0	1.2	1.0	1.2	–
Muscle	2.0	3.1	2.9	3.4	1.2

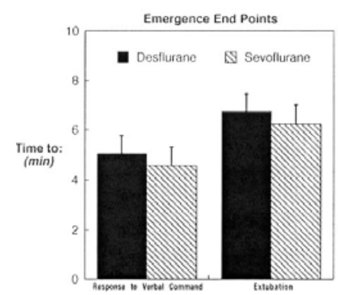
Solubility of Inhaled Anesthetics



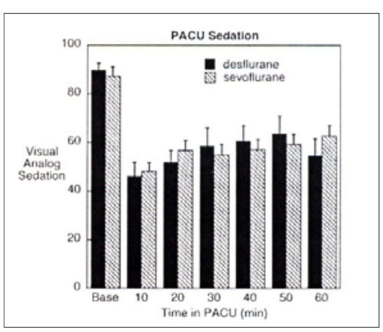
Torri, et al. Randomized comparison of isoflurane and sevoflurane for laparoscopic gastric banding in morbidly obese patients. J Clin Anesth 2001; 13: 565



Arain SR, et al. Choice of volatile anesthetic for the morbidly obese patient: sevoflurane or desflurane. J Clin Anesth 2005; 17: 413-9



Arain SR, et al. Choice of volatile anesthetic for the morbidly obese patient: sevoflurane or desflurane. J Clin Anesth 2005; 17: 413-9



Arain SR, et al. Choice of volatile anesthetic for the morbidly obese patient: sevoflurane or desflurane. J Clin Anesth 2005; 17: 413-9

Remifentanil

Table 2. Recovery profile (min): duration to achieve required stages of post-anesthesia recovery from ending of surgery and discontinuation of propofol infusion

	Group R	Group A	Group F
Response to verbal command	3.00±0.97	3.70±1.78	3.77±1.67
Spontaneous respiration	3.25±1.21*	4.00±1.57	4.16±1.57
Adequate respiration	4.85±1.71*	5.40±2.50	6.36±2.08
Safe extubation	5.60±2.02*	5.90±2.46	7.32±2.15

Values are mean ± SD; *$P<0.05$ compared with Group F.

Gaszynski et al. Post-anesthesia recovery after infusion of propofol with remifentanil or alfentanil or fentanyl in morbidly obese patients. Obes Surg 2004; 14: 498-504

Administered by bolus or infusion

Remifentanil

- Ultra-short acting opioid – half life 3-6 mins - hydrolyzed by non-specific blood and tissue esterases
- → quick recovery – no respiratory depression
- Blunts hemodynamic and cardiac responses to surgery

Remifentanil

Administered with either propofol infusion or inhalational anesthetic (**isoflurane**)

Ideal for MO/OSA patients – eliminates concern about opioid induced post-operative respiratory depression

??? Increased post-operative pain

??? Increased nausea and vomiting

Dexmedetomidine

- Centrally acting alpha-2 agonist - hypnotic/ anxiolytic/ sympatholytic/ analgesic effects
- Minimal respiratory depression
- Cannot be used alone
- Loading dose can cause hypotension, especially when volume depleted
- Causes relative bradycardia
- Long duration (30-90 min)
- Expensive

Table 2. Perioperative Need for Phenylephrine, β-Blocker and Discontinuation of Study Medication Infusion, Time from Turning Off the Desflurane to Patients' Extubation, First Spontaneous Eye Opening, Following Simple Commands, Tracheal Extubation, and the Duration of the Postanesthesia Care Unit (PACU) Stay

	Control (n = 20)	Dex 0.2 (n = 20)	Dex 0.4 (n = 20)	Dex 0.8 (n = 20)
Rescue phenylephrine [n (%)]	4 (20)	2 (10)	4 (20)	10 (50)*
Rescue β-blocker [n (%)]	5 (25)	3 (15)	1 (5)	0 (0)*
Transient discontinuation of study drug [n (%)]	2 (10)	2 (10)	3 (15)	3 (15)
Time to eye opening (min)	6 ± 3	5 ± 3	6 ± 4	8 ± 6
Time to follow simple commands (min)	6 ± 3	6 ± 3	6 ± 4	9 ± 6
Time to tracheal extubation (min)	7 ± 3	5 ± 3	6 ± 4	9 ± 6
Duration of the PACU stay (min)	104 ± 33	81 ± 31*	82 ± 24*	87 ± 24*
Nausea/vomiting in PACU [n (%)]	13/3 (65/15)	5/1 (25/5)*	6/0 (30/0)*	9/2 (45/11)
Required antiemetic therapy [n (%)]	14,70	6,30*	6,30*	2,10*
Nausea score[a]				
Upon arrival in PACU	3 ± 3	1 ± 1*	2 ± 3	1 ± 2
At 30 min	3 ± 3	1 ± 2*	1 ± 2*	1 ± 2*
At 60 min	3 ± 3	2 ± 3	1 ± 2*	1 ± 3

Dexmedetomidine infusion rate of 0.2 g/ kg /h is recommended to facilitate early recovery while minimizing adverse perioperative cardiovascular side effects.

Tufanogullari B, et al. Dexmedetomidine Infusion During Laparoscopic Bariatric Surgery: The Effect on Recovery Outcome Variables. Anesth Analg (2008) 106:1741-8