Special issues in the management of the critically ill obese

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Outline

- Definitions and epidemiology
- Physiological aspects
- Practical management issues

Classification: WHO 2000

BMI	Classification
< 18.5	underweight
18.5–24.9	normal weight
25.0–29.9	overweight
30.0–34.9	class I obesity
35.0–39.9	class II obesity
≥ 40.0	class III obesity

Definitions

- Current WHO definition:
  - a BMI greater than or equal to 25 is overweight
  - a BMI greater than or equal to 30 is obesity

http://www.who.int/mediacentre/factsheets/fs311/en/index.html

CDC

Height	Weight Range	BMI	Considered
5' 9"	124 lbs or less	Below 18.5	Underweight
	125 lbs to 168 lbs	18.5 to 24.9	Healthy weight
	169 lbs to 202 lbs	25.0 to 29.9	Overweight
	203 lbs or more	30 or higher	Obese

http://www.cdc.gov/obesity/adult/defining.html

Obesity epidemic (WHO statistics)

- Worldwide, obesity has more than doubled since 1980
- In 2008, more than 1.4 billion adults were overweight
- Of these over 200 million men and nearly 300 million women were obese

http://www.who.int/mediacentre/factsheets/fs311/en/index.html

United States

- 66% of the United States population is currently overweight (BMI greater than 25), and the figure is expected to rise to 75% by 2015

Wang Y, et al. Epidemiol Rev 2007;29:6.

NFHS 2007: Obese or overweight

States	Males (%)	Males rank	Females (%)	Females rank
India	**12.1**	**14**	**16**	**15**
Punjab	30.3	1	37.5	1
Kerala	24.3	2	34	2
Goa	20.8	3	27	3
Tamil Nadu	19.8	4	24.4	4
Andhra Pradesh	17.6	5	22.7	10
Sikkim	17.3	6	21	8
Mizoram	16.9	7	20.3	17
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Incidentally, Kerala and Punjab rank number 1 and 2 in per capita alcohol consumption: IAPA India Alcohol Atlas

Review Article

Consensus Statement for Diagnosis of Obesity, Abdominal Obesity and the Metabolic Syndrome for Asian Indians and Recommendations for Physical Activity, Medical and Surgical Management

A Misra*, P Chowbey**, BM Makkar***, NK Vikram****, JS Wasir+, D Chadha++, Shashank R Joshi+++, S Sadikot++++, R Gupta+, Seema Gulati#, YP Munjal## for Consensus Group

Abstract

Asian Indians exhibit unique features of obesity; excess body fat, abdominal adiposity, increased subcutaneous and intra-abdominal fat, and deposition of fat in ectopic sites (liver, muscle, etc.). Obesity is a major driver for the widely prevalent metabolic syndrome and type 2 diabetes mellitus (T2DM) in Asian Indians in India and those residing in other countries. Based on percentage body fat and morbidity data, limits of normal BMI are narrower and lower in Asian Indians than in white Caucasians. In this consensus statement, we present revised guidelines for diagnosis of obesity, abdominal obesity, the metabolic syndrome, physical activity, and drug therapy and bariatric surgery for obesity in Asian Indians after consultations with experts from various regions of India belonging to the following medical disciplines: internal medicine, metabolic diseases, endocrinology, nutrition, cardiology, exercise physiology

For Indians…

- Normal BMI: 18.0-22.9 kg/m^2
- Overweight: 23.0-24.9 kg/m^2
- Obesity: >25 kg/m2

Misra A, et al. J Assoc Physicians India 2009 Feb;57:163-70.

Obesity and critical illness

Prevalence

- Prevalence of obesity may be as high as 25% in medical/surgical intensive care units

Joffe A, et al. Curr Opin Anaesthesiol 2007;20:113

Mortality in ICU

Author	Journal/Year	Country	N	Type of ICU	Mortality in obese
Bercault N	Crit Care Med 2004	France	340	Medical/ surgical	OR=2.1 (95% CI, 1.2-3.6)
El-Solh A	Chest 2001	US	117 obese	Medical	Obese-30% Non-obese-17%
Goulenok C	Chest 2004	France	813	Medical	Obese-32% Non-obese-18%
Nasraway SA	Crit Care Med 2006	US	1373	Surgical	No difference

Largest meta-analysis

- A total of 62,045 critically ill subjects. 15,347 obese patients representing 25% of the pooled study population

Akinnusi M, et al. Crit care med 2008;36:151–8.

Mortality

Outcome: mortality

Study	obese n/N	nonobese n/N	Weight %	RR (random) 95% CI
El-Solh A	35/117	22/132	5.45	1.79 [1.12, 2.88]
Marik PE	1180/12011	4057/36165	11.61	0.88 [0.82, 0.93]
Bercault N	54/170	29/170	6.45	1.86 [1.25, 2.77]
Garrouste-Orgeas	41/227	327/1471	8.15	0.81 [0.61, 1.09]
Neville A	20/63	29/179	5.20	1.96 [1.20, 3.21]
Ray D	36/550	158/1598	7.21	0.66 [0.47, 0.94]
Brown C	62/283	148/870	8.65	1.29 [0.99, 1.68]
Alban R F	8/135	63/783	3.22	0.74 [0.36, 1.50]
Aldawood	86/540	222/1295	9.30	0.93 [0.74, 1.17]
Bochicchio G	13/62	166/1105	5.07	1.40 [0.84, 2.31]
Nasraway S	18/366	64/1007	5.00	0.77 [0.47, 1.29]
O'Brien J M	104/457	329/1031	9.93	0.71 [0.59, 0.86]
Peake S L	20/129	46/304	5.31	1.02 [0.63, 1.66]
Morris A E	72/237	231/588	9.48	0.77 [0.62, 0.96]
Total (95% CI)	15347	46698	100.00	1.00 [0.86, 1.16]

Total events: 1749 (obese), 5891 (nonobese)
Test for heterogeneity: Chi² = 53.38, df = 13 (P < 0.00001), I² = 75.6%
Test for overall effect: Z = 0.03 (P = 0.97)

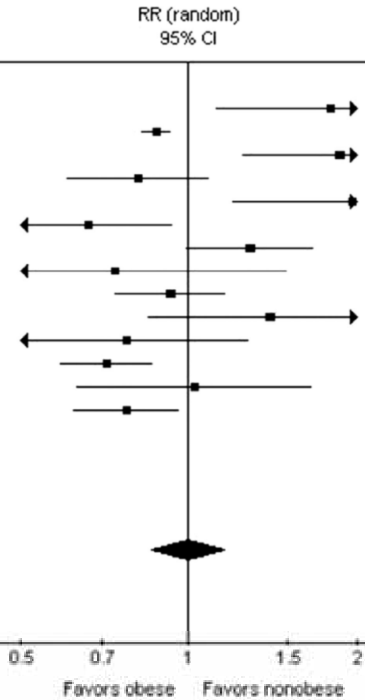


Figure 2. Forest plot examining the risk of intensive care unit mortality among obese vs. nonobese critically ill patients. *Horizontal lines* represent 95% confidence intervals (*CI*); *RR*, relative risk.

Duration of mechanical ventilation

Outcome: Days on mechanical ventilation (MVD)

Study	obese N	obese Mean (SD)	nonobese N	nonobese Mean (SD)	Weight %	WMD (random) 95% CI
El-Solh A	117	7.70(9.60)	132	4.60(7.10)	15.26	3.10 [0.98, 5.22]
Ray D	550	5.20(6.70)	1598	5.20(6.00)	22.30	0.00 [-0.63, 0.63]
Brown C	283	8.00(14.00)	870	6.00(9.00)	17.22	2.00 [0.26, 3.74]
Aldawood	1295	9.00(13.67)	540	9.00(13.00)	19.34	0.00 [-1.33, 1.33]
Bochicchio G	62	16.00(16.00)	1105	8.00(10.00)	8.01	8.00 [3.97, 12.03]
Morris A E	237	9.55(10.55)	588	9.43(11.03)	17.87	0.12 [-1.49, 1.73]
Total (95% CI)	2544		4833		100.00	1.48 [0.07, 2.89]

Test for heterogeneity: $Chi^2 = 25.12$, df = 5 (P = 0.0001), $I^2 = 80.1\%$

Test for overall effect: Z = 2.06 (P = 0.04)

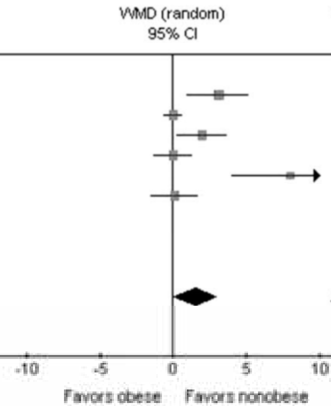
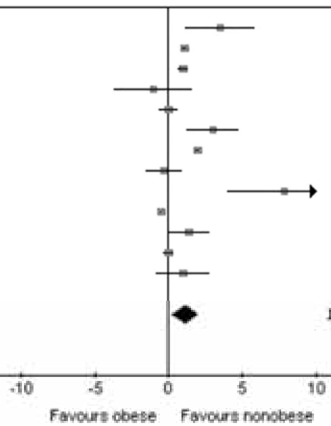


Figure 4. Forest plot depicting the association between obesity and duration of mechanical ventilation (*MVD*). *Horizontal lines* represent 95% confidence intervals (*CI*). *MVD*, days of mechanical ventilation. *WMD*, weighted mean difference.

Length of Stay



Outcome: length of stay (LOS)

Study	obese N	obese Mean (SD)	nonobese N	nonobese Mean (SD)	Weight %	WMD (random) 95% CI	Order
El-Solh A	117	9.30(10.50)	132	5.82(8.20)	5.34	3.48 [1.12, 5.84]	0
Marik PE	12011	5.20(8.80)	36165	4.10(6.50)	9.78	1.10 [0.93, 1.27]	0
Garrouste-Orgeas	227	7.00(2.50)	1471	6.00(1.54)	9.66	1.00 [0.67, 1.33]	0
Neville A	63	10.00(9.00)	179	11.00(10.00)	4.75	-1.00 [-3.66, 1.66]	0
Ray D	550	4.60(6.45)	1598	4.60(6.50)	9.28	0.00 [-0.63, 0.63]	0
Brown C	283	13.00(14.00)	870	10.00(10.00)	6.70	3.00 [1.24, 4.76]	0
Alban R F	135	6.80(0.90)	783	4.80(0.30)	9.79	2.00 [1.85, 2.15]	0
Aldawood	540	8.00(12.00)	1295	8.33(12.66)	8.01	-0.33 [-1.55, 0.89]	0
Bochicchio G	62	19.40(15.00)	1105	11.60(9.00)	3.13	7.80 [4.03, 11.57]	0
Nasraway S	366	2.10(0.58)	1007	2.60(0.88)	9.82	-0.50 [-0.58, -0.42]	0
O'Brien J M	457	13.00(13.30)	1031	11.60(11.60)	7.56	1.40 [-0.01, 2.81]	0
Peake S L	75	2.70(1.34)	304	2.70(1.35)	9.66	0.00 [-0.34, 0.34]	0
Morris A E	237	13.00(12.05)	588	12.03(12.40)	6.52	0.97 [-0.86, 2.80]	0
Total (95% CI)	15123		46528		100.00	1.08 [0.27, 1.88]	

Test for heterogeneity: $Chi^2 = 987.16$, $df = 12$ ($P < 0.00001$), $I^2 = 98.8\%$

Test for overall effect: $Z = 2.61$ ($P = 0.009$)

Figure 5. Forest plot depicting the association between obesity and intensive care unit length of stay (*LOS*). *Horizontal lines* represent 95% confidence intervals (*CI*). *WMD*, weighted mean difference.

Subgroup Analysis

Study	Obese(non-morbid) n/N	Nonobese n/N	Weight %	RR (random) 95% CI
Marik PE	902/9338	4057/36165	77.69	0.86 [0.80, 0.92]
Garrouste-Orgeas	41/227	327/1471	4.24	0.81 [0.61, 1.09]
Ray D	24/396	158/1598	2.11	0.61 [0.40, 0.93]
Alban R F	7/92	63/812	0.65	0.98 [0.46, 2.08]
Aldawood	75/447	222/1295	6.39	0.98 [0.77, 1.24]
Nasraway S	9/272	64/1007	0.78	0.52 [0.26, 1.03]
Peake S L	20/129	46/304	1.56	1.02 [0.63, 1.66]
Morris A E	58/183	231/588	6.58	0.81 [0.64, 1.02]
Total (95% CI)	11084	43240	100.00	0.86 [0.81, 0.91]

Total events: 1136 (Obese(non-morbid)), 5168 (Nonobese)
Test for heterogeneity: Chi² = 6.78, df = 7 (P = 0.45), I² = 0%
Test for overall effect: Z = 5.06 (P < 0.00001)

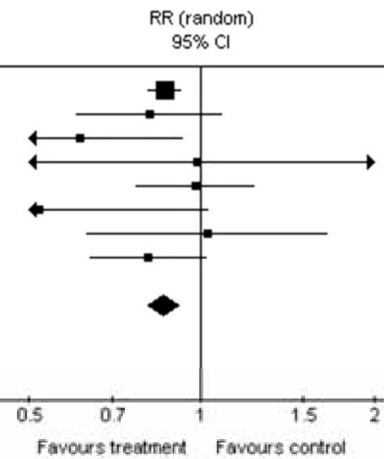


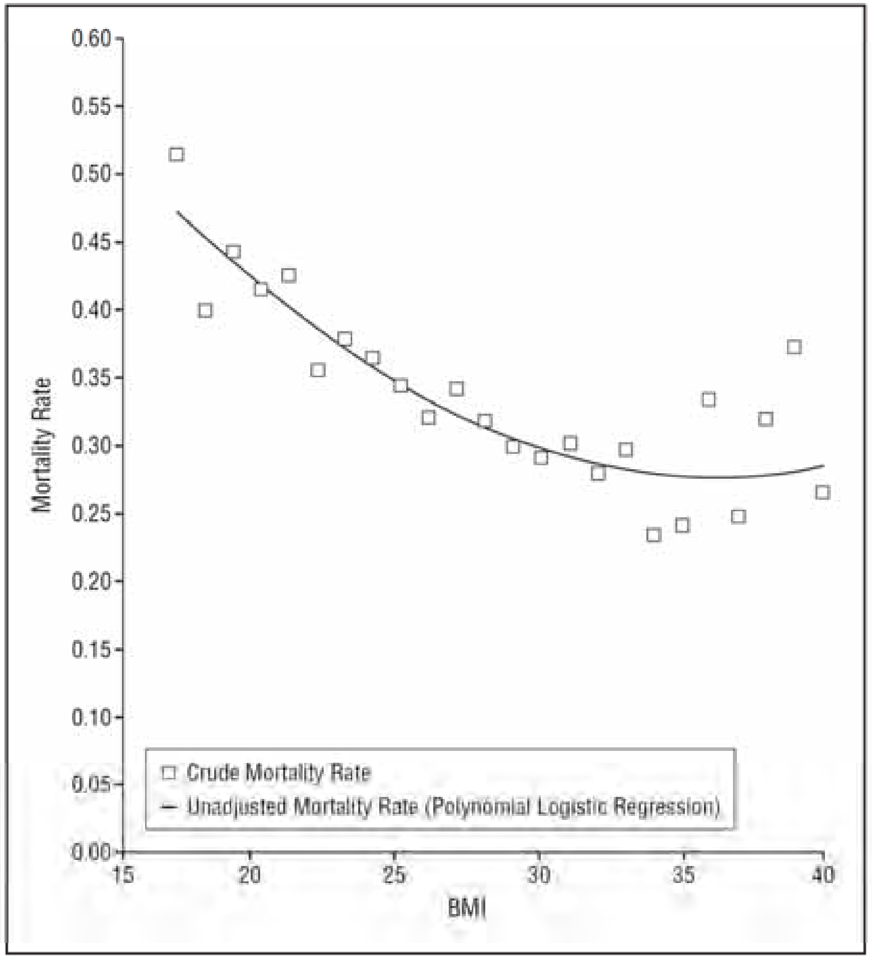
Figure 8. Forest plot examining the risk of mortality among nonobese (body mass index [*BMI*] of <30 kg/m²) vs. obese with BMI of 30–39.9 kg/m². *Horizontal lines* represent 95% confidence interval (*CI*). *RR*, relative risk.

Obesity Paradox

What is it?

- Observations that, although obesity is a major risk factor in the development of cardiovascular and peripheral vascular disease, when acute cardiovascular decompensation occurs, for example, in myocardial infarction or congestive heart failure, obese patients may have a survival benefit

BMI and Mortality in stable outpatients with heart failure



Curtis J, et al. Arch Intern Med 2005;165: 55–61.

How do you explain this?

Obese vs Non-obese

- Better and more aggressive medical care and enhanced observation than normal-weight populations
- Tend to be on more, and perhaps better, cardioprotective medical therapy than other groups of patients
- Tend to be younger at the time of the acute cardiovascular event, which may confer an age benefit
- How we measure obesity is unsatisfactory (body mass index (BMI) may not accurately reflect the risk of complications in all obese individuals)

Physiological aspects

Pathophysiologic Effects of Obesity relevant to Critical Illness

Effects on Pulmonary Physiology

Chest Wall Compliance

Obese have reduced respiratory compliance

TRUE

Reduced respiratory compliance is due to reduced chest wall compliance

Probably a myth……

Effects of Obesity on Respiratory Resistance*

Françoise Zerah, M.D.; Alain Harf, M.D.; Léon Perlemuter, M.D.; Hubert Lorino, Ph.D.; Anne-Marie Lorino, Ph.D.; and Guy Atlan, M.D.

To assess the effects of obesity on pulmonary function, 46 healthy subjects exhibiting various degrees of obesity underwent lung function tests. Subjects were divided into three groups according to body mass index (BMI): 13 had minimal obesity (BMI, 25 to 29 kg/m^2, group 1); 24 had a BMI in the 30 to 40 range (group 2); and 9 displayed to morbid obesity (BMI >40, group 3). Respiratory resistance was estimated by the forced random noise oscillation technique and airway resistance was determined by body plethysmography. Lung volumes and expiratory flows were also determined and significant negative correlations with BMI were found. Expiratory flows diminished in proportion to lung volumes, and the ratio of forced expiratory volume in 1 s to forced vital capacity was within normal limits. Although expiratory flows did not suggest bronchial obstruction, both respiratory resistance and airway resistance rose significantly with the level of obesity ($p<0.005$ and $p<0.025$, respectively), from 3.2 ($\pm$0.02) and 3.2 ($\pm$0.02) cm $H_2O \cdot s \cdot L^{-1}$, respectively, in group 1, to 5.5 ($\pm$0.06) and 5.0 ($\pm$0.05), respectively, in group 3. Evaluation of the factors responsible for this increased resistance disclosed a significant linear correlation between airway conductance and functional residual capacity ($r=0.70$, $p<10^{-4}$), but specific airway conductance was found to be independent of the degree of obesity. The difference between respiratory resistance and airway resistance did not widen significantly according to the level of obesity, suggesting that chest wall resistance was not a factor enhancing these resistances. Taken together, these findings suggest that in addition to the elastic load, obese subjects have to overcome increased respiratory resistance resulting from the reduction in lung volumes related to being overweight.

(Chest 1993; 103:1470-76)

ANOVA = analysis of variance; Crs = respiratory compliance; ERV = expiratory reserve volume; Gaw = airway conductance; IC = inspiratory capacity; Irs = respiratory inertance; OSA = obstructive sleep apnea; Raw = airway resistance; Rrs = respiratory resistance; RV = residual volume; S = slope of the linear relationship of resistive impedance vs frequency; SGaw = specific airway conductance; TLC = total lung capacity

Rrs and Raw

- The average values found for Rrs were only slightly higher than the values for Raw
- In the group with morbid obesity the difference between Rrs and Raw was not significantly greater than for the subjects with minimal obesity
- The change in FRC therefore appears to be the main factor explaining the increase in Rrs

J Appl Physiol. 1995 Oct;79(4):1199-205.

Effects of posture on respiratory mechanics in obesity.

Yap JC, Watson RA, Gilbey S, Pride NB.

Department of Medicine, Royal Postgraduate Medical School, Hammersmith Hospital, London, United Kingdom.

Abstract

Increased abdominal mass in obesity should enhance normal gravitational effects on supine respiratory mechanics. We have examined respiratory impedance (forced oscillation over 4-26 Hz applied at the mouth during tidal breathing), maximum inspiratory and expiratory mouth pressures (MIP and MEP), and maximum effort flow-volume curves seated and supine in seven obese subjects (O) (mean age 51 yr, body mass index 43.6 kg/m2) and seven control subjects (C) (mean age 50 yr, body mass index 21.8 kg/m2). Seated mean total lung capacity was smaller in O than in C (82 vs. 100% of predicted); ratio of functional residual capacity (FRC) to total lung capacity averaged 43% in O and 61% in C ($P < 0.01$). Total respiratory resistance (Rrs) at 6 Hz seated was higher in O (4.6 cmH2O.l-1.s) than in C (2.2 cmH2O.l-1.s; $P < 0.001$); total respiratory reactance (Xrs) at 6 Hz was lower in O than in C. In C, on changing to the supine posture, mean Rrs at 6 Hz rose to 2.9 cmH2O.l-1.s, FRC fell by 0.68 liter, and Xrs at 6 Hz showed a small fall. In O, despite no further fall in FRC, supine Rrs at 6 Hz increased to 7.3 cmH2O.l-1.s, and marked frequency dependency of Rrs and falls in Xrs developed. Seated, MIP and MEP in C and O were similar; supine there were small falls in MEP and maximum expiratory flow in O. The site and mechanism of the

- In obese individuals as compared to controls, on changing posture from sitting to supine there is a larger rise on Rrs despite significantly lesser change in FRC
- The site and mechanism of the increase in supine Rrs and the mechanism maintaining supine FRC in obesity all need further investigation

The Effects of Body Mass on Lung Volumes, Respiratory Mechanics, and Gas Exchange During General Anesthesia

Paolo Pelosi, MD, Massimo Croci, MD, Irene Ravagnan, MD, Stefano Tredici, MD, Alessia Pedoto, MD, Alfredo Lissoni, MD, and Luciano Gattinoni, MD

Istituto di Anestesia e Rianimazione, Universita' di Milano and Servizio di Anestesia e Rianimazione, Ospedale Maggiore, Istituto di Ricovero e Cura a Carattere Scientifico, Milan, Italy

We investigated the effects of body mass index (BMI) on functional residual capacity (FRC), respiratory mechanics (compliance and resistance), gas exchange, and the inspiratory mechanical work done per liter of ventilation during general anesthesia. We used the esophageal balloon technique, together with rapid airway occlusion during constant inspiratory flow, to partition the mechanics of the respiratory system into its pulmonary and chest wall components. FRC was measured by using the helium dilution technique. We studied 24 consecutive and unselected patients during general anesthesia, before surgical intervention, in the supine position (8 normal subjects with a BMI

compliance of the chest wall was only minimally affected ($r = 0.45$; $P < 0.05$)

3. the resistance of the total respiratory system and of the lung increased ($r = 0.81$; $P < 0.01$ and $r = 0.84$; $P < 0.01$, respectively), whereas the chest wall resistance was unaffected ($r = 0.06$; P = not significant)
4. the oxygenation index (Pa_{O_2}/PA_{O_2}) decreased exponentially ($r = 0.81$; $P < 0.01$) and was correlated with FRC ($r = 0.62$; $P < 0.01$), whereas Pa_{CO_2} was unaffected ($r = 0.06$; P = not significant)
5. the work of breathing of the total respiratory system increased, mainly due to the lung component ($r = 0.88$; $P < 0.01$ and $r = 0.81$; $P < 0.01$, respectively).

BMI and compliance

- With increasing BMI, the compliance of the total respiratory system and of the lung decreased exponentially whereas the compliance of the chest wall was only minimally affected

Total Respiratory System, Lung, and Chest Wall Mechanics in Sedated-Paralyzed Postoperative Morbidly Obese Patients*

Paolo Pelosi, MD; Massimo Croci, MD; Irene Ravagnan, MD; Pierluigi Vicardi, MD; and Luciano Gattinoni, MD

Objective: To study the relative contribution of the lung and the chest wall on the total respiratory system mechanics, gas exchange, and work of breathing in sedated-paralyzed normal subjects and morbidly obese patients, in the postoperative period.
Setting: Policlinico Hospital, University of Milan, Italy.
Methods: In ten normal subjects (normal) and ten morbidly obese patients (obese), we partitioned the total respiratory mechanics (rs) into its lung (L) and chest wall (w) components using the esophageal bal-

$p<0.01$) and the chest wall (0.39 ± 0.13 J/L vs 0.18 ± 0.04 J/L; $p<0.01$); and (5) a reduced pulmonary oxygenation index (PaO_2/PAO_2 ratio).
Conclusion: Sedated-paralyzed morbidly obese patients, compared with normal subjects, are characterized by marked derangements in lung and chest wall mechanics and reduced lung volume after abdominal surgery. These alterations may account for impaired arterial oxygenation in the postoperative period.

(CHEST 1996; 109:144-51)

- Reduced respiratory system total compliance
- Reduced chest wall compliance

Journal of Clinical Investigation
Vol. 43, No. 4, 1964

The Total Work of Breathing in Normal and Obese Men *

J. T. Sharp, J. P. Henry, S. K. Sweany, W. R. Meadows, and R. J. Pietras

(From the Cardiopulmonary Laboratory of the Veterans Administration Hospital, Hines, Ill., and the Departments of Medicine of the University of Illinois College of Medicine and the Stritch School of Medicine of Loyola University, Chicago, Ill.)

It has been long suspected that the increased work required to move the ponderous thoracic wall and abdomen during breathing was responsible for hypoventilation and retention of carbon dioxide in the obesity-hypoventilation or "Pickwickian" syndrome (1–4). Increased oxygen cost of ventilation, decreased lung compliance, increased pressure-volume work done on the lung, and increased intra-abdominal pressure have been reported in the extremely obese (5–8), and compliances of the thorax and the total respiratory

136 to 208 lbs. in weight. Of the 14 obese subjects, who ranged from 253 to 370 lbs. and 29 to 60 years, four had the obesity-hypoventilation syndrome. Two of the remaining ten obese subjects, to be referred to as the "obese normal" group, had mild arterial hypoxemia without hypercapnia. Table I gives conventional pulmonary function data on all subjects; Table II presents their respiratory mechanics.

In the four patients with the obesity-hypoventilation syndrome, the diagnosis was based upon the following criteria: *1*) repeated demonstration of P_{CO_2} levels in arterial blood above 48 mm Hg; *2*) absence of definite clinical or physiologic evidence of other respiratory disorders

- Thoracic compliance significantly reduced in patients with OHS as compared to comparable obese subjects without OHS

Conclusions

- Lung compliance reduced in obese
- Chest wall compliance reduced in supine position, in sedated paralyzed morbidly obese and in patients with OHS

Increased airway resistance

- Breathing at low FRC
- Upper airway obstruction
- Small airway resistance due to edema and inflammation

Cardiovascular changes in obesity

- Increased blood volume
- Increased cardiac output (with a constant cardiac index)
- Increased stroke volume (heart rates remain constant)
- Reduced SVR (in normotensive obese)

Alexander JK, et al. Cardiovasc Res Cent Bull 1962;1:39.

Obesity and HF

- Obesity itself may lead to diastolic dysfunction
- Higher propensity toward the development of pulmonary edema during high cardiac output states or conditions of fluid loading in critical illness

Ku CS, et al. Am J Cardiol 1994;73:613

Obesity and HF

- Increased left ventricular chamber size (due to elevations in cardiac output and circulating blood volume)[1]
- Compensatory development of eccentric left ventricular hypertrophy to decrease wall stress
- If the degree of hypertrophy does not keep pace with the degree of chamber dilation, systolic dysfunction or so-called ‘‘obesity cardiomyopathy’’ may ensue (prevalence of 10%)[2]

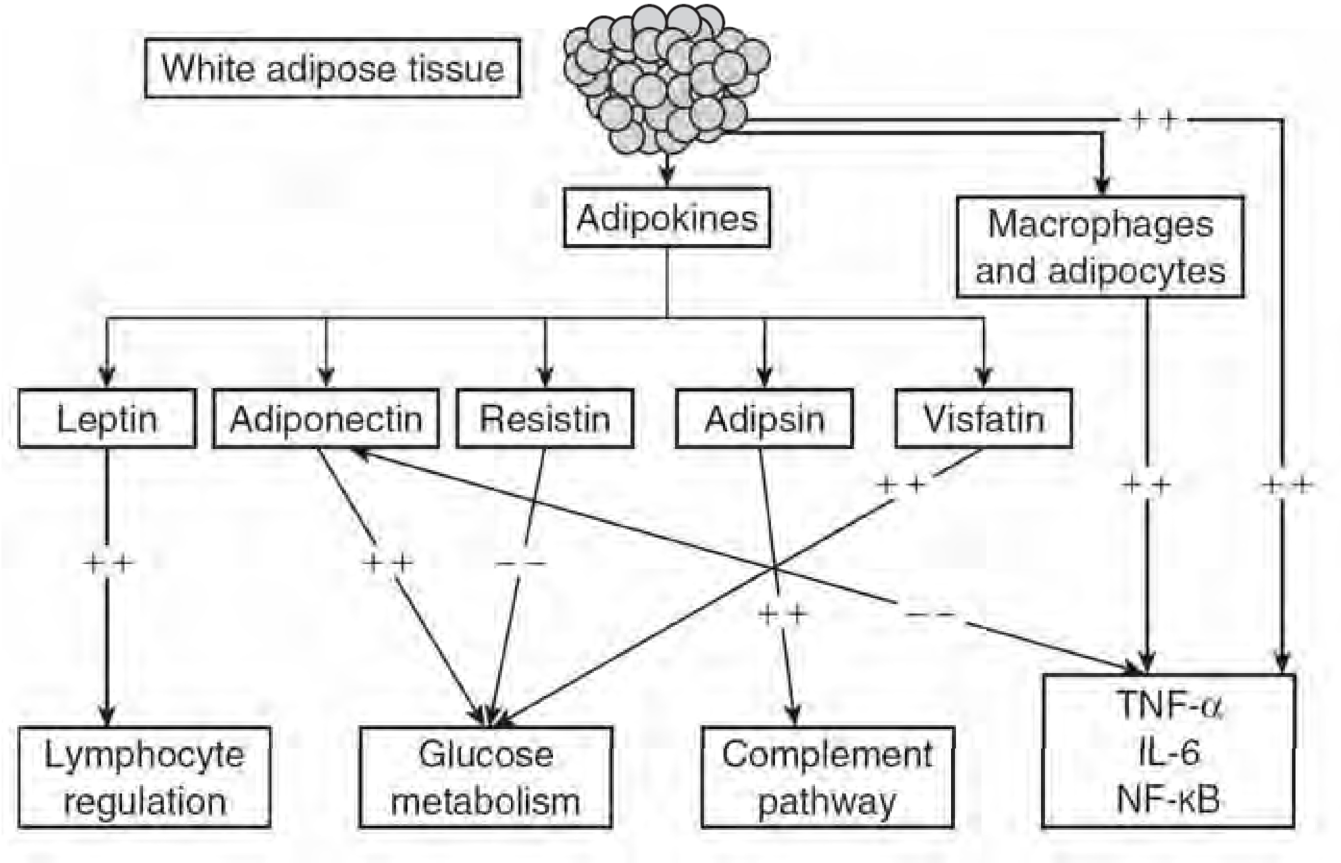
[1]Alpert MA, et al. Am J Cardiol 1995;76:1198
[2]Alpert MA, et al. Am J Med Sci 2001;321:225

Obesity and HTN

- Increased risk for systemic hypertension
- Diastolic dysfunction is common in obese patients, and coexistent hypertension increases the risk for overt systolic dysfunction

Alpert MA, et al. Am J Med Sci 1993;306:117

Immunologic effects



Vachharajani V, et al. Intensive Care Med 2006 21: 287

Obesity, sepsis and ALI/ARDS

- Sepsis and ARDS are known to have a "hypercytokinemic" millieu
- The cytokine link
  - ET-1
  - vWF
  - ICAM-1
  - IL-1, TNF-α, IL-6, IL-8
  - Increased oxidative stress

Other common disorders in critically ill obese

Venous thromboembolism

- Increased risk of VTE in obese[1,2]
- Increased PAI-1 and reduced fibrinolytic activity in obese patients may contribute to their increased risk for venous thromboembolism[3]

[1]Goldhaber SZ, et al. JAMA 1997;277:642.

[2]Stein PD, et al. Am J Med 2005;118:978.

[3]Loskutoff DJ, et al. Arterioscler Thromb Vasc Biol 1998;18:1.

Gastrointestinal abnormalities

- Increased risk of GERD due to:
  - increased intra-abdominal pressure
  - decreased lower esophageal sphincter pressure
  - increased frequency of hiatal hernia
  - alterations in esophageal motility and gastric emptying in the obese

Friedenberg FK, et al. Am J Gastroenterol 2008; 103: 2111

Gastrointestinal abnormalities

- Increased risk of abdominal compartment syndrome (mean IAP in nonobese patients -- 0 cm H_2O, in morbidly obese patients -- 12 cm H_2O)

Lambert DM, et al. Obes Surg 2005;15:1225.

Practical management issues

Airway management

Difficult airway

- ‘‘The clinical situation in which a conventionally trained anesthesiologist experiences difficulty with face mask ventilation of the upper airway, difficulty with tracheal intubation or both.’’

American Society of Anesthesiologists Task Force on Management of the Difficult Airway.
Anesthesiology 2003;98:1269–77.

DMV

- Difficult mask ventilation (DMV) is defined as the inability of an unassisted anesthesiologist to maintain the measured oxygen saturation as measured by pulse oximetry greater than 92% or to prevent or reverse signs of inadequate ventilation during positive-pressure mask ventilation under general anesthesia.

DI

- Difficult intubation has been defined by the need for more than three intubation attempts or attempts at intubation that last more than 10 minutes.

Predictors of DMV

Table 3. Identification of Risk Factors for Difficult Mask Ventilation with Multivariate Analysis (n = 1,502)

Variables	Odds Ratio (95% CI)	*P* Value
Presence of beard	3.18 (1.39–7.27)	0.006
Body mass index > 26 kg/m^2	2.75 (1.64–4.62)	<0.001
Lack of teeth	2.28 (1.26–4.10)	0.006
Age > 55 yr	2.26 (1.34–3.81)	0.002
History of snoring	1.84 (1.09–3.10)	0.02

Langeron O, et al. Anesthesiology 2000;92: 1229–36.

Difficult MV-MOANS

- M-mask seal
- O-obesity
- A-age >55 years
- N-no teeth
- S-stiffness

Murphy M, et al. Manual of emergency airway management. Philadelphia: Lippincott Williams and Wilkins; 2004. p. 70–2.

Predictors of difficult intubation

Table 2. Multivariate Predictors of Difficulty with Tracheal Intubation

Variable	Incidence (%)	Laryngoscopy grades III and IV combined: Odds ratio	Laryngoscopy grades III and IV combined: *P*	Laryngoscopy grade IV alone: Odds ratio	Laryngoscopy grade IV alone: *P*
Mouth opening			0.00005		0.00005
≥4 cm	93.6				
<4 cm	6.4	2.70	0.00005	4.09	0.00005
Thyromental distance			0.00005		0.00005
>6.5 cm	89.0				
6.0–6.5 cm	9.9	2.03	0.00005	2.31	0.0008
<6.0 cm	1.1	4.33	0.00005	5.81	0.00005
Mallampati class			0.00005		0.00005
I	46.2				
II	40.8	3.32	0.00005	2.18	0.0295
III	13.0	8.91	0.00005	7.27	0.00005
Neck movement			0.00005		0.00005
>90°	91.4				
80–90°	6.4	2.19	0.00005	2.71	0.0001
<80°	2.2	3.13	0.00005	2.72	0.0029
Ability to prognath			0.00005		0.0004
Yes	95.1				
No	4.9	2.48	0.00005	2.56	0.0004
Body weight			0.00005		0.0049
<90 kg	77.6				
90–110 kg	16.6	1.94	0.00005	1.45	0.1647
>110 kg	5.8	2.42	0.00005	2.87	0.0014
History of difficult intubation			0.00005		0.0020
None	98.2				
Questionable	1.4	2.48	0.00005	2.15	0.0367
Definite	0.4	9.46	0.00005	4.02	0.0021

El-Ganzouri AR, et al. Anesth Analg 1996;82:1197–204.

More recently (N=90,000)

Table 4. Multivariate Model for the Prediction of Difficult Intubation

	OR	95 % CI	*P*
35 ≤ BMI	1.34	1.19–1.51	< 0.0001
25 ≤ BMI < 35	1.11	1.04–1.18	< 0.0016
Mallampati III and IV	3.70	3.41–4.00	< 0.0001
Male	1.35	1.27–1.44	< 0.0001
Age, year	1.01	1.01–1.01	< 0.0001
Surgical Priority = Scheduled	1.34	1.24–1.44	< 0.0001
Previous difficult intubation = Yes	6.32	5.11–7.84	< 0.0001
Previous difficult intubation = Unknown	1.26	1.15–1.39	< 0.0001
NMBA = No relaxation	1.59	1.49–1.70	< 0.0001

Lundstrom LF, et al. Anesthesiology 2009;110:266–74.

- Extended Mallampati score and DM can predict difficult laryngoscopy[1]
- Hyperglycemia leads to glycosylation of joints resulting in limited mobility[2]

[1]Mashour GA, et al. Anesth Analg 2008; 107(6):1919–23.

[2]Riessell E, et al. Anaesthesia 1990;45:1024–7.

Key to proper airway management

- Anticipate
- Proper positioning
- Pre-oxygenation
- Intubating devices
- Alternate airway tools

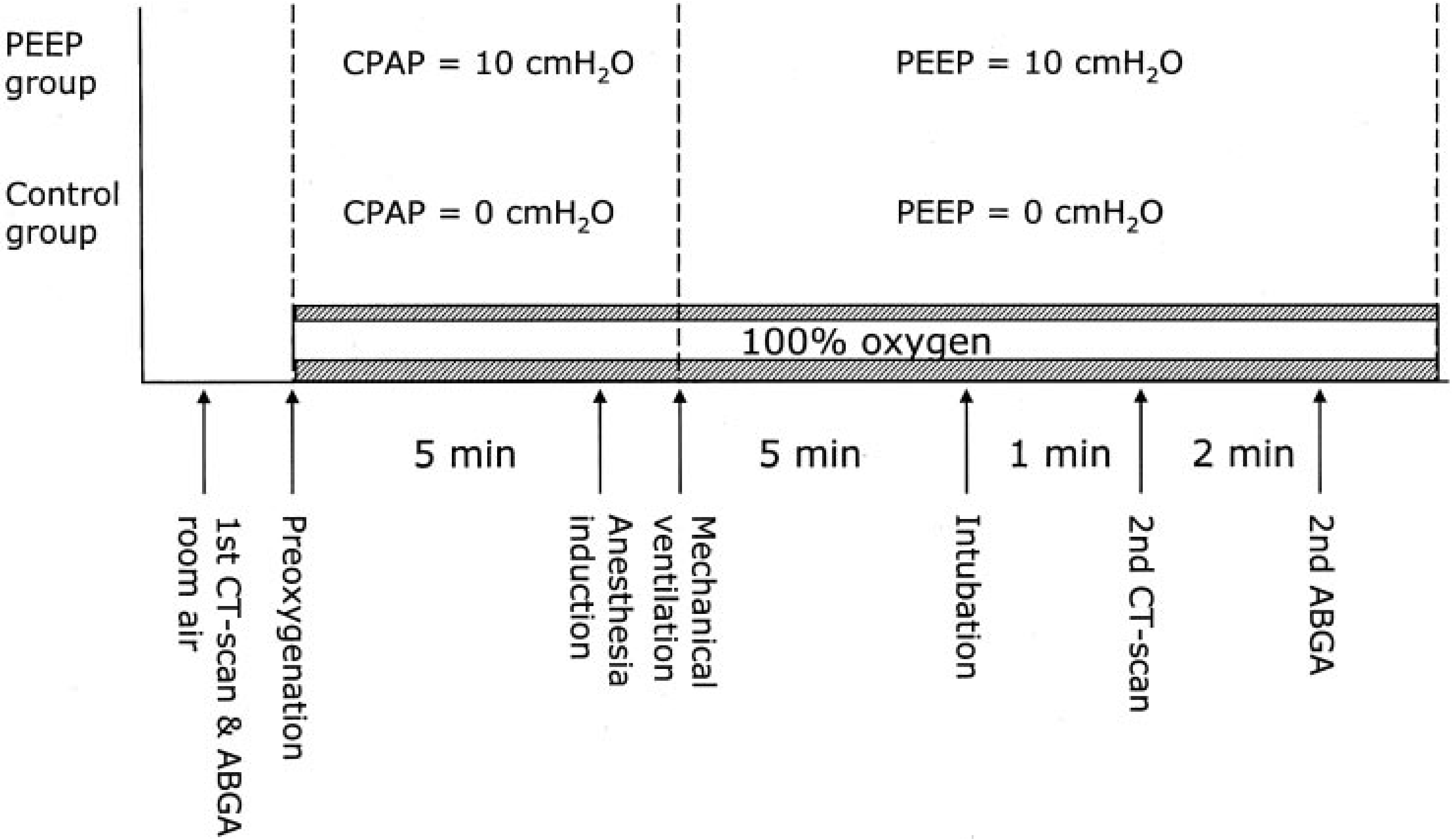
Positioning

Reverse Trendelenburg

Innovations for HELP

HELP-Head Elevated Laryngoscopic Position

Pre-oxygenation



Coussa M, et al. Anesth Analg 2004;98:1491–5.

PCV

- Gander et al used a similar protocol with PCV of 14 cmH_2O and PEEP of 10cmH_2O
- Better oxygenation in test arm

Gander S, et al. Anesth Analg 2005;100:580–4.

FOB

- Awake intubation using a flexible fiber-optic bronchoscope is considered the method of choice when treating an obese patient with an anticipated difficult airway[1]
- However, the significant equipment costs and skill maintenance issues have limited the widespread adoption of this approach

[1]Murphy M, et al. Manual of emergency airway management. 2nd edition. Philadelphia: Lippincott Williams & Wilkins; 2004. p. 127–34.

Video-laryngoscope

- 80 morbidly obese patients undergoing bariatric surgery
- Laryngoscopic vision much better as compared to direct vision
- minimal arterial oxygen saturation reached during the intubation was also higher with the videolaryngoscope

Marrel J, et al. Eur J Anaesthesiol 2007;24(12): 1045–9.

Extraglottic devices--LMA

Esophageal-tracheal combitube

NIV in the obese

- Previous consensus statements have considered obesity as a relative contraindication[1]
- Recent studies have demonstrated success[2,3]

[1] Noninvasive positive pressure ventilation consensus statement. Respir Care 1997;42:364–9.

[2] Duarte A, et al. Crit Care Med 2007;35:732–7.

[3] Rabec C, at al. Rev Mal Respir 1998;15:269–78.

Tracheostomy

- Morbidly obese patients present a unique surgical challenge because of increased submental and anterior cervical adipose tissue.
- Standard tracheotomy tubes are typically too short and angulated

Modifications in technique

- Elastic strap to move chin out
- Cervical lipectomy
- USG guidance

Percutaneous dilatation tracheostomy (PDT)

- Traditionally, obesity has been considered a relative contraindication to the performance of PDT
- No concrete evidence supporting the superiority of standard tracheostomy in this patient group

Standard versus PDT

- Morbidly obese patients were 4.4 times more likely than nonobese patients to suffer complications associated with standard tracheostomy (25% versus 14%, P = .03)
- Complication rate with PDT ranges from 5-44%

FOB guided PDT

- Study analyzing incidence of complications of PDT with and without fiber-optic bronchoscopy assistance
- In the blind-PDT group, the incidence of complications was 16.8%, whereas in the fiber-optic bronchoscopy– assisted PDT group, the incidence of complications was 8.3% (P<.001)

Kost KM, et al. Laryngoscope 2007;115:1–30

Issues in vascular access

CVC

- Surface landmarks traditionally described for jugular (internal and external) and subclavian venous cannulation may be obscured in severely morbidly obese patients
- Large neck circumference, short neck height, skinfolds, and excess adipose tissue in the neck and chest wall are factors that contribute to anatomic complexity

CVC and peripheral access

- Peripheral venous access may be impaired in the upper limbs, especially in the setting of earlier described coexisting conditions, particularly in edematous states
- Effects of an abdominal pannus overlying the inguinal areas prohibit access to the femoral triangle and also pose impediment to smooth procedural operation and infection control measures

Positioning

- Trendelenburg position, the preferred position for CVC placement may lead to hypoxemia

USG

- Ultrasound may be an important tool in CVC placement in the obese
- No study has assessed USG versus blind CVC placement specifically in the obese

Hemodynamic monitoring

- Noninvasive blood pressure monitoring by cuff sphygmomanometer has unpredictable accuracy because of difficulties with cuff size selection.
- Inaccuracies may persist, even when an appropriately sized cuff is available

Maxwell MH, et al. Lancet 1982;2:33.

Invasive monitoring

- Invasive monitoring may be inaccurate as as the parameters are adjusted to BSA
- 40% adjustment for weight above ideal body weight is commonly used as in drug dosing, but no study has rigorously validated this adjustment

Beutler S, et al. Crit Care Med 1981;32:2004.

Renal replacement therapy

- HD—difficulties with vascular access
- PD– may not be feasible due to reduced abdominal capacity

Nutrition of the critically ill obese

Challenges in nutrition of obese

- Use of standard prediction equations to estimate protein and energy requirements is problematic because obesity was not represented among individuals used to generate most of the original equations
- More likely to present with cardiopulmonary and metabolic derangements (eg, obstructive sleep apnea, congestive heart failure, insulin resistance, and type 2 diabetes mellitus) that will influence the composition and rate of delivery of nutrition support

Challenges….

- Obtaining access for enteral and intravenous feeding may be more technically difficult due to the obese body habitus and ensuing mechanical and infectious complications
- Obese patient may be paradoxically malnourished and require special attention to nutrition therapy to avoid compounding this problem

Prediction equations

Table 1. Comparison of Resting Metabolic Rate Prediction Equations

Predictive Equation	Calculation
Harris Benedict[5,a]	Male: 66.5 + (13.8 wt) + (5 ht) – (6.8 age)
	Female: 655.1 + (9.6 wt) + (1.8 ht) – (4.7 age)
Mifflin–St Jeor[6]	Male: (10 wt) + (6.26 ht) – (5 age) + 5
	Female: (10 wt) + (6.26 ht) – (5 age) - 161
Fixed kcal/kg	
ACCP[7]	25 kcal/kg/d actual wt
ESPEN[8]	20–25 kcal/kg/d actual wt
SCCM/A.S.P.E.N.[9]	11–14 kcal/kg/d actual wt

ACCP, American College of Chest Physicians; ESPEN, European Society for Parenteral and Enteral Nutrition; SCCM/A.S.P.E.N., Society of Critical Care Medicine/American Society for Parenteral and Enteral Nutrition.
[a]Body weight value used as actual, adjusted, or ideal.

Kushner RF, et al. J Parenter Enteral Nutr 2011 35: 36S

Adjusted body weight

- Adjusted BW = a X (actual BW − ideal BW) + ideal BW

  a= adjustment factor=ranges from 0.25–0.50

Which one is better?

- Mifflin–St Jeor equation was the most reliable, predicting RMR within 10% measured RMR in more nonobese and obese individuals than any other equation and had the narrowest error rate (systematic review)
- Measuring RMR by indirect calorimetry more accurate andreliable method of assessing energy requirements in critically ill patients (but time consuming and cumbersome)

Frankenfield D, et al. J Am Diet Assoc. 2005;105:775-789.

Hypocaloric feeding

- Intentional administration of calories that are less than predicted energy expenditure
- Rationale???

Nitrogen balance vs Energy intake

Advantages

- Avoid the metabolic complications of overfeeding including
  - Hyperglycemia
  - Fluid overload
  - Increased risk of infections

Evidence

Table 2. Studies Using Hypocaloric Feeding in Hospitalized Obese Patients

Study	Design	No. of Patients	Calorie Intake, kcal/kg/d	Protein Intake, g/kg	Duration of Study, Mean, d	Nutrition Outcome (Nitrogen Balance), g/d	Clinical Outcome
Dickerson et al (1986)[32]	P	13	11.6 actual weight	1.16 actual weight	48.2 ± 31.4	2.4 ± 1.9	Healed wounds, closed fistulae
Burge et al (1994)[33]	PR Hypocaloric vs control	16	14 vs 25 actual weight	2.0 vs 2.18 ideal weight	9.6 ± 3.0	1.3 ± 3.6 vs 2.8 ± 6.9	—
Choban et al (1997)[34]	PR Hypocaloric vs control	30	13.6 vs 22.5 actual weight	2.0 actual weight	10.5 ± 2.6	4.0 ± 4.2 vs 3.6 ± 4.1	Less insulin therapy, no difference in M
Liu et al (2000)[35]	Retro	30 Group 1 (age <60 y) Group 2 (age ≥60 y)	18.2 actual weight	1.6 adjusted weight	13.1 ± 12.9 (group 1) and 12.6 ± 7.8 (group 2)	3.44 ± 3.94 vs 0.2 ± 4.99	No difference in morbidity or mortality
Dickerson et al (2002)[36]	Retro	40 Eucaloric (12) Hypocaloric (28)	<20 vs ≥20 adjusted weight	2.0 ideal weight	26.3 ± 14.8 (eucaloric) 15.4 ± 10.8 (hypocaloric)	Near balance	Decreased intensive care unit days, decreased antibiotic use

M, mortality; P, prospective; R, randomized; Retro, retrospective.

Kushner RF, et al. J Parenter Enteral Nutr 2011 35: 36S

ASPEN guidelines 2009

- For BMI >30, goal of the enteral or parenteral regimen should not exceed 60%–70% of target energy requirements or 11–14 kcal/kg actual body weight per day (or 22–25 kcal/kg ideal body weight per day)
- Protein provided in a range of ≥2.0 g/kg ideal body weight per day for class I and II patients (BMI 30–40), ≥2.5 g/kg ideal body weight for class III (BMI ≥40) (Grade D)

McClave SA, et al. JPEN J Parenter Enteral Nutr. 2009;33:277-316.

It’s different…

- “Permissive” underfeeding -- overall reduction in nutrition therapy delivered, which means there is less energy, protein, and other nutrients
- Hypocaloric feeding means that delivery of total energy is reduced principally by reducing carbohydrate delivery while target protein and other nutrient delivery is achieved

Nursing care

- Skin integrity can be particularly problematic in obese patients
- Multiple skin folds can lead to the buildup of moisture, posing a threat to skin integrity
- Limited mobility, difficulty in nurse-assisted turning, decreased vascularity within adipose tissue, and excessive weight all contribute to pressure ulcer risk
- Involvement of more staff with proper training in repositioning of the obese may help prevent suboptimal mobilization

Issues with imaging and tests

- ECG
- Portable CXR
- CT and MRI machines with weight limits
- USG and Echo

Take home message

- The physiologic effects of obesity make the management of the critically ill patient difficult.
- Despite this, the outcome may not be different from the non-obese
- Probably the most important issues peculiar to the obese in the ICU are management of the airway, ventilation and nutrition

- The super-obese may have overriding logistic issues in management
- Prior planning and a team effort is essential