OBESITY AND LUNG
INTRODUCTION

- Sedentary lifestyles and increased pollution brought about by industrialization pose major challenges to the prevention of both obesity and chronic respiratory diseases.

- Obesity and respiratory illness – interaction – results in change in phenotype of these diseases.

- Obesity – major risk factor for obstructive sleep apnea and obesity hypoventilation syndrome.

- Review of current understanding of the influence of obesity on chronic respiratory diseases.
Section I: Overweight and obesity

Section II: Effects of obesity on chronic respiratory diseases

Section III: Diagnosis and treatment of obesity

Section IV: Therapeutic implications of obesity
GLOBAL BURDEN

- More than one billion people around the world are overweight or obese.

- At least 300 million are obese.

- National Center for Health Statistics – United states.
  - 70% of adult population are overweight.
  - 30% of them are obese.
  - Approx. 400,000 deaths / year attributed to obesity related morbidity.
  - 7% of health care expenditures.
Obesity epidemic in Europe, Middle east, the Pacific islands, Australasia and China.

More than 3 fold increase in the prevalence rate of obesity and overweight, since 1980.
Burden in developing countries

- Obesity epidemic is not restricted to industrialized societies.

Special features:
- Faster increase in prevalence rate of obesity and overweight.
- Coexistence with problems of malnutrition and underweight.
- Nutrition transition.
As countries develop, they face many of the problems common in industrialized nations. Obesity is one of the most worrisome.

Underweight and overweight in selected developing countries

A calculation of body mass index, or BMI, determines whether a person isn't eating enough or is tipping the scales. Many developing countries are facing both problems simultaneously.

Obesity and overweight
OBESITY AND OVERWEIGHT

- Obesity refers to an excess of body fat.

- Body fat usually constitute 15 - 20% of the body mass in healthy men and 25 - 30% in healthy women.

- Frequently used methods for measuring body fat:
  - Body mass index
  - Percentage of ideal body weight
  - Weight to height ratio
  - Waist circumference
  - Waist to hip circumference ratio
  - Skin fold thickness
**Body mass index**: an index of weight to square of height. (kg/m²)

- Most useful indicator of health risk related to overweight & obesity.
- Measures magnitude of obesity.
- Very easy to use in clinical practice.
- Provides no information about the distribution of fat in the body.
### Figure 1: Body mass index chart.

| Height | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| 4'10"  | 91 | 98 | 100| 105| 110| 115| 119| 124| 129| 134| 138| 143| 148| 153| 158| 162| 167| 172| 177| 181| 185| 189|
| 5'     | 97 | 102| 107| 112| 118| 123| 128| 133| 138| 143| 148| 153| 158| 163| 168| 173| 178| 183| 188| 193| 198| 204|
| 5'1"   | 100| 108| 111| 116| 122| 127| 132| 137| 143| 148| 153| 158| 163| 168| 173| 178| 183| 188| 193| 198| 204| 209|
| 5'2"   | 104| 109| 115| 120| 125| 130| 135| 140| 145| 150| 155| 160| 165| 170| 175| 180| 185| 190| 195| 200| 205| 210|
| 5'3"   | 107| 113| 118| 123| 128| 133| 138| 143| 148| 153| 158| 163| 168| 173| 178| 183| 188| 193| 198| 203| 208| 213|
| 5'4"   | 110| 118| 122| 128| 134| 140| 145| 151| 157| 163| 169| 175| 181| 187| 192| 198| 204| 210| 216| 222| 228| 234|
| 5'5"   | 114| 120| 126| 132| 138| 144| 150| 156| 162| 168| 174| 180| 186| 192| 198| 204| 210| 216| 222| 228| 234| 240|
| 5'6"   | 118| 124| 130| 136| 142| 148| 155| 161| 167| 173| 179| 186| 192| 198| 204| 210| 216| 222| 228| 234| 240| 246|
| 5'7"   | 121| 127| 134| 140| 146| 153| 159| 166| 172| 178| 185| 191| 198| 204| 211| 217| 223| 229| 235| 241| 247| 253|
| 5'8"   | 125| 131| 138| 144| 151| 158| 165| 171| 177| 184| 190| 197| 203| 209| 216| 222| 229| 235| 241| 247| 253| 259|
| 5'9"   | 128| 135| 142| 149| 156| 163| 170| 177| 184| 190| 197| 204| 211| 218| 224| 231| 238| 244| 251| 257| 263| 269|
| 5'10"  | 132| 139| 146| 153| 160| 167| 174| 181| 188| 195| 202| 209| 216| 223| 230| 237| 244| 251| 258| 265| 272| 279|
| 5'11"  | 136| 143| 150| 157| 164| 171| 178| 185| 192| 199| 206| 213| 220| 227| 234| 241| 248| 255| 262| 269| 276| 283|
| 6'     | 140| 147| 154| 161| 168| 175| 182| 189| 196| 203| 210| 217| 224| 231| 238| 245| 252| 259| 266| 273| 280| 287|
| 6'1"   | 144| 151| 158| 166| 174| 182| 189| 197| 204| 212| 219| 227| 234| 241| 248| 255| 262| 269| 276| 283| 290| 297|
| 6'3"   | 152| 160| 168| 176| 184| 192| 200| 208| 216| 224| 232| 240| 248| 255| 263| 271| 279| 287| 294| 302| 309| 316|
| 6'4"   | 156| 164| 172| 180| 189| 197| 205| 213| 221| 229| 237| 245| 253| 261| 269| 277| 285| 293| 301| 309| 317| 325|
Waist circumference: measured at the level of the top of the right iliac crest.

Highly correlates with visceral adipose tissues.

A high-risk waist circumference:
- 35 inches or greater for women
- 40 inches or greater for men.
<table>
<thead>
<tr>
<th>Category</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>less than 18.5</td>
</tr>
<tr>
<td>Normal</td>
<td>18.5 - 24.9</td>
</tr>
<tr>
<td>Overweight</td>
<td>25.0 - 29.9</td>
</tr>
<tr>
<td>Obesity</td>
<td>more than 30</td>
</tr>
</tbody>
</table>
Classification

Magnitude of obesity

- Overweight: more than 25
- Obesity type I: more than 30
- Obesity type II: more than 35
- Obesity type III: more than 40
Fat distribution in the body

Android obesity:
- Fat deposition in upper parts of the body and abdomen
- Male predominance
- Vital organs affected (heart, liver, kidneys and lungs)

Gynoid obesity:
- Fat deposition in hips, thighs and legs
- Female predominance
- Vital organs affected (kidneys, uterus, intestine and bladder)
Etiopathogenesis

- Metabolically determined obesity
- Environmentally induced obesity
- Endocrinopathies
- Appetite regulation disorders
- Compulsive eating disorders
- Pharmacologically induced obesity
Health risks of overweight and obesity

- Above a BMI of 20 kg / m2, morbidity for a number of health conditions increases as BMI increases.

- The nature of the obesity related health risks is similar in all population.

- The specific level of health risk associated with a given level of overweight or obesity may vary with:
  - Race / ethnicity
  - Age, gender
  - Societal conditions

- For a given level of overweight or obesity, Indian population has higher level of risk for obesity related conditions than the western population.
# Symptoms, diseases and special problems associated with obesity

<table>
<thead>
<tr>
<th><strong>Cardiovascular system</strong></th>
<th><strong>Integumental system</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary artery disease</td>
<td>Cellulitis</td>
</tr>
<tr>
<td>Hypertension</td>
<td>Carbuncles</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>Intertigo</td>
</tr>
<tr>
<td>Varicose veins</td>
<td>Venous stasis of legs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Gastrointestinal system</strong></th>
<th><strong>Respiratory system</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholelithiasis</td>
<td>Dyspnoea &amp; fatigue</td>
</tr>
<tr>
<td>GERD</td>
<td>Obesity hypoventilation syndrome</td>
</tr>
<tr>
<td>Colonic cancer</td>
<td>Obstructive sleep apnea</td>
</tr>
<tr>
<td>Hernias</td>
<td></td>
</tr>
<tr>
<td>Nonalcoholic steatohepatitis</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Musculoskeletal system</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Immobility</td>
</tr>
<tr>
<td>Osteoarthritis</td>
</tr>
<tr>
<td>Low back pain</td>
</tr>
<tr>
<td>Genitourinary system</td>
</tr>
<tr>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Hypogonadism</td>
</tr>
<tr>
<td>Prostatic cancer</td>
</tr>
<tr>
<td>Urinary incontinence</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Neurological system</td>
</tr>
<tr>
<td>Idiopathic intracranial hypertension</td>
</tr>
<tr>
<td>Meralgia paresthetica</td>
</tr>
<tr>
<td>Stroke</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Psychosocial problems</td>
</tr>
<tr>
<td>Depression</td>
</tr>
<tr>
<td>Social / employment discrimination</td>
</tr>
<tr>
<td>Work disability</td>
</tr>
</tbody>
</table>
Table 2. Classification of overweight and obesity by BMI, waist circumference, and associated disease risk

<table>
<thead>
<tr>
<th></th>
<th>BMI (kg/m²)</th>
<th>Obesity class</th>
<th>Disease risk* (relative to normal weight and waist circumference)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>&lt;18.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal†</td>
<td>18.5 to 24.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>25.0 to 29.9</td>
<td>I</td>
<td>Increased</td>
</tr>
<tr>
<td>Obesity</td>
<td>30.0 to 34.9</td>
<td>II</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>35.0 to 39.9</td>
<td>III</td>
<td>Very high</td>
</tr>
<tr>
<td>Extreme obesity</td>
<td>≥40</td>
<td>III</td>
<td>Extremely high</td>
</tr>
<tr>
<td>Men ≤ 40 in (102 cm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women ≤ 35 in (88 cm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;40 in (102 cm)</td>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>&gt;35 in (88 cm)</td>
<td></td>
<td></td>
<td>Very high</td>
</tr>
</tbody>
</table>

Adapted from the World Health Organization (5).
BMI, body mass index.
* Disease risk for type 2 diabetes, hypertension, and coronary heart disease.
Effects of obesity on chronic respiratory diseases
Effects of obesity on chronic respiratory disease

- Obesity and lung function
- Obesity and Asthma
- Obesity and COPD
- Obstructive sleep apnea
- Obesity hypoventilation syndrome
- Post operative pulmonary complications
Obesity and lung function

In regards to effects on pulmonary function, obese subjects can be categorized as those exhibiting either:

Simple obesity:
- Eucapnic
- Does not exhibit alveolar hypoventilation
- May or may not have obstructive sleep apnea

or

Obesity hypoventilation syndrome:
- Hypercapnic
- Exhibit alveolar hypoventilation
- May or may not have obstructive sleep apnea
Increasing BMI is typically associated with a reduction in:

- TLC
- FVC
- FEV1
- FRC
- ERV
Total lung capacity (TLC)

- A clinically significant restrictive pattern (TLC <85%) is usually seen only in massive obesity.

- This change in TLC is more pronounced in subjects with central fat deposition.

- When obesity is less than massive, a restrictive defect should not be attributed to fat accumulation until other causes of restrictive impairment have been excluded.
**Functional residual capacity (FRC)**

- Reduction in FRC – most consistent finding in obese subjects.

- Reduction in expiratory reserve volume (ERV)
  
  No change in residual volume.

- Changes are prominent in supine position.

- Reduced ventilation in lung bases.
FIGURE 97-3 Representative values of TLC and its subdivisions for varied disorders of the chest wall, including ankylosing spondylitis (AS), kyphoscoliosis (KS), pectus excavatum (PE), thoracoplasty (TP), flail chest (FC), simple obesity (SO), and obesity hypoventilation syndrome (OHS).
Fig. 1. Postural changes in total lung capacity (TLC) and subdivisions as measured by multibreath helium dilution. See text for further details of volume changes. FRC, functional residual capacity; RV, residual volume.
Vital capacity (VC) #

- Vital capacity in obese subjects is related inversely to BMI.

- In non-obese subjects VC increases with BMI.

- Changes in VC more pronounced in subjects with abdominal obesity.

Vital capacity vs BMI

VC

FFM

BMI
## Compliance of respiratory system

<table>
<thead>
<tr>
<th></th>
<th>Simple obesity</th>
<th>OHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest wall compliance</td>
<td>80% of normal</td>
<td>37% of normal</td>
</tr>
<tr>
<td>Lung compliance</td>
<td>75% of normal</td>
<td>60% of normal</td>
</tr>
<tr>
<td>Total respiratory system compliance</td>
<td>90% of normal</td>
<td>44% of normal</td>
</tr>
</tbody>
</table>
Chest wall compliance reduction is due to
- Excess soft tissue weight compressing the thoracic cage.
- Fatty infiltration of the chest wall.

Lung compliance reduction is due to:
- Increased pulmonary blood volume.
- Closure of dependent airways.

Airway resistance

- Increased in obese subjects, in part because of the reduction in lung volume.

- The specific airway conductance may be normal or reduced to 50 – 70% of the normal.

- Source of increased airway resistance appears to lie in the lung tissue and small airways rather than in the large airways.
Work of breathing

- Increased in both simple obesity and OHS.

<table>
<thead>
<tr>
<th></th>
<th>Non obese subjects</th>
<th>Simple obesity</th>
<th>Obesity hypoventilation syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work of breathing (Joules / litre)</td>
<td>0.43</td>
<td>0.74</td>
<td>1.64</td>
</tr>
<tr>
<td>Oxygen cost of breathing</td>
<td>1</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

Attributed to decreased compliance and increased resistance of the respiratory system.

Metabolism

- Increased metabolic rate

- Increased oxygen consumption (> 25% of normal) #

  Increased carbon dioxide production.

- On breath holding:
  - \( \text{PaO}_2 \) decreases faster than normal.
  - magnitude of fall of \( \text{PaO}_2 \) correlates with severity of obesity.

- Increase in \( \text{O}_2 \) consumption per kg body wt. in obese subjects lower than increase per kg body wt of a non obese subject. # Salvadori A et al, Chest 1992.
Gas exchange

- Often impaired in obese patients.
- Widened alveolar-arterial tension gradient.
- Hypoxemia absent or mild in simple obesity.
- PaO2 lower than normal in obesity hypoventilation syndrome.
- Hypoxemia more pronounced in supine position.

Mechanisms:
- Ventilation-perfusion mismatching
- Shunting
- Hypoventilation (OHS)
The single breath diffusing capacity usually normal in simple obesity and slightly reduced in OHS.

The physiological dead space (\(V_D\)) and the ratio of dead space to tidal volume (\(V_D / V_T\)) are normal.
**Respiratory drive**

- May be increased in simple obesity but clearly abnormal in obesity hypoventilation syndrome.

<table>
<thead>
<tr>
<th></th>
<th>Ventilatory drive to increased CO₂</th>
<th>Ventilatory drive to decreased O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple obesity</td>
<td><img src="#" alt="Decrease" /></td>
<td><a href="#">↑ or normal</a></td>
</tr>
<tr>
<td>Obesity hypoventilation syndrome</td>
<td><img src="#" alt="Decrease" /> <img src="#" alt="Decrease" /></td>
<td><img src="#" alt="NA" /></td>
</tr>
</tbody>
</table>
Respiratory muscle strength

- Inspiratory and expiratory muscle strength is generally normal in simple obesity.

- In OHS, inspiratory muscle strength may be reduced by 40%.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Nl</th>
<th>SO</th>
<th>OHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW</td>
<td>(% ideal)</td>
<td>105</td>
<td>195</td>
<td>201</td>
</tr>
<tr>
<td>BW/Ht</td>
<td>(Kg/cm)</td>
<td>0.42</td>
<td>0.75</td>
<td>0.78</td>
</tr>
<tr>
<td>BMI</td>
<td>(Kg/m²)</td>
<td>24</td>
<td>45</td>
<td>46</td>
</tr>
<tr>
<td>TLC</td>
<td>% predicted</td>
<td>100</td>
<td>95</td>
<td>83</td>
</tr>
<tr>
<td>C_{RS}</td>
<td>L/cm H₂O⁻¹</td>
<td>0.11</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>R_{RS}</td>
<td>cm H₂O L⁻¹ sec⁻¹</td>
<td>1.2</td>
<td>4.0</td>
<td>7.8</td>
</tr>
<tr>
<td>Work</td>
<td>J/L</td>
<td>0.43</td>
<td>0.74</td>
<td>1.64</td>
</tr>
<tr>
<td>MVV</td>
<td>L/min</td>
<td>159</td>
<td>129</td>
<td>89</td>
</tr>
<tr>
<td>P_{max}</td>
<td>cm H₂O</td>
<td>100</td>
<td>95</td>
<td>60</td>
</tr>
</tbody>
</table>

**Note:** Nl = normal; SO = simple obesity; OHS = obesity hypoventilation syndrome; BW = body weight; Ht = height; BMI = body mass index; TLC = total lung capacity; C_{RS} = respiratory system compliance; R_{RS} = respiratory system resistance; MVV = maximal voluntary ventilation; P_{max} = maximal inspiratory pressure.
Obesity and asthma

- Prevalent disorders with a significant public health impact.

- Asthmatics have tendency to gain weight.

- Obesity:
  - Increases the risk of incident asthma.
  - Alters the phenotype of prevalent asthma.
Obesity and asthma prevalence

- An increased prevalence of asthma in the obese.

- Significant association between BMI levels and asthma prevalence.

- Confounding factors:
  - Obstructive sleep apnea
  - Gastro-esophageal reflux disease

**Obesity and asthma incidence**

- Obesity – risk factor for development of a new diagnosis of asthma.

- Dose-response relationship with incident asthma and increasing BMI.

- Effect stronger in women than men but the difference is usually small.

- Similar relationship seen in pediatric population.

**Mechanism:**
- BMI does not measure adiposity equally well in children vs adults and men vs women.
- Gender difference in lung development and growth.
- Pre vs post pubertal sex hormone difference.

**Obesity and atopy**

**NHAENS III survey**: prevalence of asthma and atopy increased with increasing BMI.

After adjusting for confounding factors, only the relationship between BMI and asthma remained significant.

**New Zealand study**: BMI was significantly associated with positive skin tests and elevated IgE.

Association was modest { OR 1.14 (1.10 – 1.30) }.

Not seen in boys.


Diagnosing asthma in obesity

- Obesity causes reduction in FEV1 and FVC but results in a preserved FEV1 / FVC ratio.
- Obese individuals breathe shallowly, near to their closing volume.

**Overdiagnosis of asthma in obese individuals?**

- Schachter et al. (1971 adults): obesity was associated with diagnosis of asthma and symptoms of dyspnoea and wheeze but not associated with airflow obstruction or airway hyperresponsiveness.#
- Bibi et al. (5984 children): obesity was associated with asthma symptoms and inhaler use but not airway hyperresponsiveness (AHR).$

Obesity and asthma phenotype

Obesity is associated with “difficult to control” asthma.

Childhood asthma management program – CAMP study:

- Asthma defined by symptoms, lung function and testing for atopy and AHR.
- No statistically significant relationship between BMI and many markers of asthma control.
- Weak relationship with exertional cough and wheeze.
- Weak inverse relationship between BMI and bronchodilator reversibility.
- No impact of BMI on AHR to Methocholine.

CAMP on extended follow-up phase.

Obesity and airway inflammation

Enhancement of normal adipose tissue function in obesity leads to a systemic proinflammatory state.

Proinflammatory molecules from adipocytes:
- Leptin
- Tumour necrosis factor – A
- Interleukin – 6
- Tissue growth factor – B1
- C-reactive proteins.

Implications in airway inflammation and other metabolic and cardiovascular complications.

Candidate genes have been identified, that are associated with both obesity and asthma.

### TABLE 1. CANDIDATE GENES OF POTENTIAL RELEVANCE TO BOTH OBESITY AND ASTHMA

<table>
<thead>
<tr>
<th>Locus</th>
<th>Candidate Genes</th>
<th>Relevance to Asthma</th>
<th>Relevance to Obesity</th>
</tr>
</thead>
<tbody>
<tr>
<td>5q</td>
<td>ADRB2</td>
<td>Controls airway tone</td>
<td>Controls metabolic rate</td>
</tr>
<tr>
<td></td>
<td>NR3C1</td>
<td>Modulates inflammation</td>
<td>Modulates inflammation</td>
</tr>
<tr>
<td>6p</td>
<td>TNF, HLA gene cluster</td>
<td>Modulates immune and inflammatory responses</td>
<td>Modulates immune and inflammatory responses</td>
</tr>
<tr>
<td>11q13</td>
<td>UCP2, UCP3</td>
<td>Unknown</td>
<td>Controls metabolic rate</td>
</tr>
<tr>
<td></td>
<td>IgE (FceRII)</td>
<td>Th2 inflammatory response</td>
<td>Unknown</td>
</tr>
<tr>
<td>12q</td>
<td>STAT6, IGF1, IL1A, LTA4H</td>
<td>Modulates inflammatory responses</td>
<td>Modulates inflammatory responses</td>
</tr>
</tbody>
</table>

*Definition of abbreviations: ADRB2 = β2-adrenergic receptor; IGF = insulin-like growth factor; IL1A = interleukin 1α; LTA4H = leukotriene A4 hydroxylase; NR3C1 = glucocorticoid receptor; STAT6 = signal transducer and activator of transcription gene; TNF = tumor necrosis factor; UCP = uncoupling protein.*
Obesity and COPD

- More sedentary lifestyle in COPD patients contribute to the development of obesity.

- BMI > 24 kg/m² is associated with better survival.

- Copenhagen city heart study: overweight and obesity in COPD was associated with decrease in risk of death compared with normal weight. (hazard ratio 0.9; 95% confidence interval 0.7 – 1.0)

“Obesity paradox” (well documented in patients with heart failure)#

Oversimplification?

- Preferential loss of muscle tissue.
- Compounding risk of comorbidities.

Obesity and post operative pulmonary complications

Obesity – major risk factor for post operative complications.

Pulmonary complications:
- Pneumonia
- Atelectasis
- Pulmonary embolism
- Pulmonary edema

Additional risk factors:
- Increased duration of surgery
- Prolonged intubation
- Mechanical ventilation
- Prolonged immobilization
- Coexisting illnesses.
Obstructive sleep apnea

- Intermittent upper airway obstruction due to inability of pharyngeal musculature to maintain upper airway patency in the presence of alterations in airway shape and diameter.

- Fall in PaO2
- Rise in PaCO2
  Increased inspiratory efforts leading to sleep fragmentation.

Clinical features:
- Loud, habitual snoring
- Witnessed apneas
- Nocturnal awakening
- Gasping or choking episodes during sleep changes
- Nocturia
- Unrefreshing sleep, morning headache
- Excessive daytime sleepiness
- Automobile/ work related accidents
- Irritability, memory loss, personality changes
- Decreased libido
Obesity – well recognized risk factor.

About 70% of people with OSA are obese. #

Prevalence of OSA among obese people is approx. 40% #

Almost all men with class III obesity have OSA.

Mechanisms: $
- Increased fat deposition in pharyngeal region.
- Reduced lung volumes.

Diagnosis of obstructive sleep apnea

- Nocturnal polysomnography – gold standard diagnostic tests.

- Identifies complete cessation of airflow (apnea) and of reduction of airflow (hypopnea) leading to decrease in O2 saturation and arousal.

- Apnea – hypopnea index > 5.

Other methods:
- Nocturnal oximetry and cardiorespiratory monitoring.
- Multivariable apnea prediction questionnaire.
- Epworth sleepiness scale.
FIGURE 102-9 Example of an obstructive apneic episode in a patient with sleep apnea syndrome. The polysomnography traces from the top down are as follows: three EEG channels (C3-A2, C4-A2, OZ-A2); two EOG channels (R and L); submental EMG (EMG); right and left anterior tibialis EMG (RAT, LAT); electrocardiogram (ECG); nasal and oral airflow; chest and abdominal motion (CHEST and ABD). During the apneic episodes, there is abnormal airflow (both oral and nasal), with paradoxical motion of the rib cage and abdomen. At the end of the apneic episode, there is a burst of EMG activity at the arousal. Following arousal, respiration resumes with synchronous movements of the rib cage and abdomen.
Obesity hypoventilation syndrome

Combination of obesity, hypoventilation and daytime hypercapnia.

Clinical presentations:
- Daytime manifestations of hypercapnia.
- Cor pulmonale and right heart failure.

Pickwickian syndrome.

“…………and on the box sat a fat and red-faced boy, in a state of somnolency.”

Charles Dickens

Posthumous papers of the Pickwick club, 1836.
Pathogenesis:
- Impaired central respiratory drive.
- Adverse effects of obesity on
  - Lung function
  - Respiratory muscle function
  - Ventilation and perfusion

Diagnostic criteria:
- BMI > 29.9 kg / m2
- Daytime PaCO2 > 45 mm Hg
- Associated sleep related breathing disorders
- Absence of other known causes of hypoventilation
Diagnosis and treatment of obesity
### Methods of estimating body fat and its distribution

<table>
<thead>
<tr>
<th>Methods</th>
<th>Accuracy</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height &amp; weight</td>
<td>high</td>
<td>no</td>
</tr>
<tr>
<td>Skin fold thickness</td>
<td>low</td>
<td>yes</td>
</tr>
<tr>
<td>Body circumferences</td>
<td>moderate</td>
<td>yes</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>moderate</td>
<td>yes</td>
</tr>
<tr>
<td>Density</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy water (tritiated water, deuterium oxide)</td>
<td>high</td>
<td>no</td>
</tr>
<tr>
<td>Potassium isotope (40 K)</td>
<td>high</td>
<td>no</td>
</tr>
<tr>
<td>Total body electrical conductance</td>
<td>high</td>
<td>no</td>
</tr>
<tr>
<td>Bioelectric impedance (BIA)</td>
<td>high</td>
<td>no</td>
</tr>
<tr>
<td>Fat soluble gas</td>
<td>high</td>
<td>no</td>
</tr>
<tr>
<td>Dual energy x-ray absorptiometry (DEXA)</td>
<td>high</td>
<td>no</td>
</tr>
<tr>
<td>Dual photon absorptiometry (DPA)</td>
<td>high</td>
<td>no</td>
</tr>
<tr>
<td>Computed tomography (CT scan)</td>
<td>high</td>
<td>yes</td>
</tr>
<tr>
<td>Magnetic resonance imaging (MRI)</td>
<td>high</td>
<td>yes</td>
</tr>
</tbody>
</table>
Clinical approach of obese patients with respiratory illnesses

- History, clinical examination and basic investigations.
- Diagnosis of respiratory illness.
- Diagnosis of overweight / obesity and assessment of its magnitude.
  Clinical interpretation of interactions between the obesity and the respiratory illness.
- Screening for obstructive sleep apnea and obesity hypoventilation syndrome.
- Screening for other obesity-related comorbidities (metabolic syndrome)
Diagnosis of metabolic syndrome

Any three of the following:

- Waist circumference > 40 inches (men), > 35 inches (women)
- Triglycerides > 149 mg/dL
- High density lipoproteins < 40 mg/dL (men); < 50 mg/dL (women)
- Blood pressure > 129 / 84 mm Hg
- Fasting plasma glucose > 99 mg/dL.

# NHLBI: Clinical guidelines for identification, evaluation and treatment of overweight and obesity.
Treatment of obesity

Strategies:
- Non pharmacological methods
- Pharmacotherapy
- Surgical methods

Non pharmacological approaches:
- Restriction of caloric intake
- Physical activity
- Behavioral treatment (to develop adaptive thinking, eating and exercise habits)

Pharmacotherapy

Four categories:

- Appetite suppressants
- Medications that decrease nutrient absorption
- Medications that increase the energy expenditure
- Investigational drugs
Appetite suppressants

Noradrenergic agents:
- Phentermine
- Diethyl propion
- Phendimetrazine
- benzphetamine

Serotonergic agents:
- Fluoxetine
- Sertraline

Mixed noradrenergic & serotonergic agents:
- Sibutramine
**Medications that decrease nutrient absorption**
- orlistat

**Special category: Dietary supplements and herbal preparations.**
- Chitosan
- Chromium picolinate
- Conjugated linoleic acid
- Ephedra alkaloids (ma huang)
- Garcinia cambogia
Medications currently under clinical trials

Medications approved for indications other than obesity:
- Bupropion
- Topiramate
- metformin

Investigational medications:
- Recombinant human leptin
- Ciliary neutrotrophic factor
- Human growth hormone fragment 177-19
- B3 adrenergic agonists
- Cholecystokinin A receptors
Surgical therapy

- **Indications:**
  - BMI > 40
  - BMI 35 – 40 with coexisting condition

- **Methods:**
  - Jejunoileal shunting
  - Gastric reduction surgery (gastroplasty) with / without intestinal bypass.

- **High success rate**

- **Requires lifelong medical monitoring.**

Difficulties in treatment of obesity

- Achieving targeted weight loss is difficult.
  - Multifactorial etiology
  - Poor treatment compliance
  - Short term efficacy of drugs

- Long-term maintenance of a reduced weight is even more challenging.

- Patients with class III obesity fail to respond to nonpharmacological and pharmacological strategies.

- No specific recommendations exist about weight loss strategies in the presence of respiratory diseases.

# Magali Poulani et al, CMAJ 2006.
Therapeutic implications of obesity
On lung function

- No change or small increase in VC, TLC and Compliance.
- 75% increase in ERV.
- Better ventilation to the lung bases and improved gas exchange.
- Reduction in O2 consumption during exercise.
- Increase in MVV.
In asthma and COPD

- Improvement in lung function and symptoms independent of changes in airway hyperresponsiveness.

- Every 10% relative loss of weight results in #
  - Increase in FVC by 92 ml (p = 0.05)
  - Increase in FEV1 by 73 ml (p = 0.04)

- Improvement in response to pharmacotherapy and better asthma control.

In obstructive sleep apnea

- Improves the symptoms and reduces the breathing disturbances during sleep.

Noseda.A et al. – an average of 9% weight loss is associated with a decrease in apnea-hypopnea index from 66.5 [SD 28.7] to 50.3 [SD 38.4] per hour. (p < 0.05) #

In class III obesity – bariatric surgery markedly improves the symptoms of OSA and CPAP can usually be discontinued after significant weight loss.

# Noseda et al, Chest 1996.
In obesity hypoventilation syndrome

- A return to normal body weight is associated with:
  - Improvement in blood gases
  - Improvement in sleep-related disorders
  - Marked decrease in pulmonary artery pressure.

- Difficult to achieve normal body weight

- Bariatric surgery needed in most cases.

Conclusion

- Influence of obesity on chronic respiratory diseases – controversies still remain.

- An important challenge will be to find efficacious weight-loss strategies for obese patients with chronic respiratory diseases.

- Prevention is better than curing.
All the best..