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General principles

- obese have ↑ energy expenditure compared to lean people
- BMR corrected for body surface area is the same
- but obese have ↑ bsa ⇒ ↑O2 consumption & CO2 production

Causes

- multifactorial incl genetic & environmental factors which are not fully understood
- resting energy expenditure is ↑ed but also see ↑↑↑ calorie intake
- balance of appetite & satiety is complex centrally processed by hypothalamus:
  - hormones eg
    - lepin:
      - made in adipose
      - function to ↓ appetite
      - obese have ↑ed circulating levels but lepin insensitivity
      - long term hunger level
    - adiponectin:
      - similar signalling role to lepin
    - insulin:
      - controls short term appetite by working on hypothalamus
    - ghrelin
      - from wall of stomach
      - stretching ⇒ ↓ release ⇒ ↓ appetite
  - neuro mechanisms

BMI

weight(kg)/height (m)^2

- <20 = underweight
- 20-25 = normal
- 25-30 = overweight
- 30-40 = obese
- 40-50 = morbidly obese (>35 with comorbidities)
- 50-60 = super obese
- 60-70 = super super obese
- >70 = hyperobese

Issues

- Medical co-morbidities
- airway/ventilation
- OSA
- Metabolic complications
- positioning/handling
- drug dosing

Medical Co-Morbidities

- Obesity paradox:
  - outcome data shows equal or lower mortality in obese than normal weight critically ill patients (eg sepsis, heart failure)
  - no surgical evidence that outcomes in obese worse than normal weight pts
  - Ting ICU admissions for obese

Summary

- associations:
  - HTN
dyslipidaemia
IHD
DM
OA
liver disease
asthma
OSA & obesity hypoventilation syndrome

OSA
- apnoea definition =
  - cessation of airflow @ mouth/nose (apneic episodes) for >10s despite effort with hypoxaemia
  - >5/hr
- interruption of REM sleep
- strong association with obesity but other causes:
  - adeno-tonsillar hypertrophy
  - craniofacial abnormalities
- undiagnosed in ~80%

- different causes (strong overlap between them):
  - obstructive (pharyngeal wall collapse) (85%):
    - balance during inspiration:
      - -ve pressure created by diaphragm & intercostals
      - contractor of oropharyngeal dilator & abductor mms to maintain patent upper airway
    - alteration in balance caused by:
      - ↑fat in pharyngeal wall ⇒ ↑compliance
      - change airway geometry so axis of open part is AP rather than lateral ⇒ ineffective
genioglossus tone during inspiration
    - intermittent desat on PSG but full recovery from nadir
  - centrally driven aka obesity hypoventilation syndrome (5%):
    - severe disease with marked end organ damage
    - desensitisation of resp centres - ?leptin insensitivity
    - chars:
      - diurnal variation in ventilation
      - PaCO2 > 45 (type II failure)
      - ↓sensitivity to CO2
      - hypoventilation
      - ↑O2 consumption & ↑CO2 production:
        ‣ ↑ed metabolically active adipose
        ‣ mm work to support weight & respiration
    - BiPaP effective despite ↓drive
    - see prolonged desat with no recovery on PSG
  - mixed

- Pathophys:
  - hypoxaemia ⇒ secondary polycythaemia
  - systemic vasoC ⇒ HTN
  - pulmonary vasoC ⇒ RV failure

- STOP BANG OSA screening score for presence of OSA:
  - S nore loudly
  - T ired with daytime somnolence
  - O served apneic episodes
  - P ressure = HTN
  - B MI >35
  - A ge >50
  - N eck circumference >40cm
  - G ender = Male
  - score:
    - ≥3 = high risk; sensitive but low specificity
    - ≥5 = high risk OSA; high sensitivity & specificity

Obesity - 3
- Epworth Sleepiness Score:
  - good tool to decide who to send to sleep clinic for formal Ix
  - no point sending for sleep study if not sleepy

- Sleep service
  - perform polysomnography (PSG) - includes ECG, EEG, eye movements, EMG, snoring volume, oronasal airflow, SpO2s

- Apnoea = as defined prev
- Hypopnoea = ↓ airflow through airways ⇒ disturbance of sleep measured over total sleep time
- AHI (Apnoea or hypopnoea index) = total episodes in night/number of hours slept
  - ↑ not universally defined but ↓ airflow by 30% or >4% desat an example
  - index represents severity of OSA
  - grading:
    - <5 = normal
    - 5-15 = mild
    - 15-30 = moderate
    - >30 severe

- The point of PSG is to decide who to offer CPAP:
  - Symptomatic patients: ⅓ compliant, ⅓ semi compliant, ⅓ non-compliant
  - Asymptomatic patient: only 3% compliant with CPAP
  - but PSG ca be useful for peri-op risk stratification

**Independent co-morbidities assoc with OSA:**
- Airway: ↑ risk of difficult airway
- Neuro:
  - ↑ stroke
  - ↓ quality of life, ↓ cognitive function, depression
  - childhood OSA ⇒ ↓ IQ, ↓ memory, ↓ learning skills, bed wetting
- Endocrine:
  - impaired glucose tolerance & dyslipidaemia/DM
  - ↑ TACTH & ↑ cortisol
  - testicular & ovarian dysfunction
  - hypothyroid
- CVS:
  - HTN
  - arrhythmias
  - pHTN & heart failure
  - polycythaemia
- Paeds - assoc with adeno-tonsillar hypertrophy - but severity is not proportional

- Treated with
  - lifestyle factors: weight loss, stop smoking, stop alcohol, ↑ physical activity
  - Rx co-morbidities
  - CPAP
  - surgical uvulo-palato-pharyngoplasty
  - mandibular advancement devices
  - plan for difficult BMV +/- intubation
- If new diagnosis:
  - limited evidence CPAP 1-3months prior to surgery effect outcome
  - General benefit = well being, functional status, alertness

**Anaesthetic Considerations**
- ↑ risk of periop airway obstruction

**PreOperative**
- stratify pt risk based on:
  - patient factors:
    - severity of OSA
    - craniofacial abnormalities
    - compliance with CPAP
- obesity
  - surgical factors:
    - duration of surgery
    - laparoscopically possible or likely to be very painful post op
    - regional technique possible
  - if use to guide need for PSG preop, day case, HDU/ICU post op

- consider OSA in all paeds T&A's
- optimise co-morbidities

- Ix's
  - FBC
  - SpO2 - if resting hypoxia in clinic ⇒ ABG
  - ECG - if R heart strain ⇒ ECHO to exclude RVH
  - ABGs baseline - if normal HCO3 than can r/o OHS
  - if heart failure or hypercapnia >50 then defer elective surgery until 3/12 of CPAP

Intra-Operative
- avoid sedative pre-meds
- short acting agents - avoid opioids where able
- pre-oxygenate ++
- ETT preferred to sedation or GA with spont vent
- maximise non-opioid analgesia
- ↑ monitoring post op
- regional where possible

Post Op
- full NMB reversal
- high sitting
- extubate to CPAP
- target preop SpO2 - must have continuous monitoring overnight
- prolonged PACU stay - +1 hr on top normal protocol
- HDU

Other Respiratory problems

Lung Biomechanics
- ↓ FRC:
  - ↓ed in awake
  - ↓ for further post induction
- ↓ pulmonary compliance:
  - ↑ weight of chest wall
  - ↑ pulmon blood volume
- closing volume encroaches on FRC during VT
- rapid O2 desat

Asthma
- may have signs similar to asthma
- commonly bronchoconstrictive symptoms due to airway closure not hyperreactive airways affecting calibre
- closure = direct effect of obesity rather than intrinsic disease
- non-reversible with bronchodilators

CardioVascular
- physiology:
  - ↑ CO - to deliver ↑ metabolic tissue demands
  - ↑ MAP ⇒ LV dilation & hypertrophy ⇒ ↓ ventricular compliance ⇒ ↓ diastolic dysfunction & ↑ LVEDP
  - ↑ blood volume - 2nd to:
    - RAAS
    - polycythaemia
- ↑ risk of heart failure - caused by:
  - ↑ blood volume & ↑ LVEDP
  - chronic hypercapnia ⇒ pHTN ⇒ ↑ heart pressures ⇒ RV dilatation ⇒ cor pulmonale
- ↑ risk arrhythmias - caused by:
  - ↑ catecholamines 2nd to OSA
  - ventricular hypertrophy
  - fat infiltration of conducting systems
  - +/- hypokalaemia from diuretics
- ↑ ed risk of IHD:
  - ↑ DM
  - ↓ level of activity

**Endocrine**

- Insulin resistance & DM:
  - post onset obesity see:
    - ↓ glucose removal
    - insulin resistance
    - ➔ hyperinsulinaemia
  - later:
    - ↑ VLDL synthesis
    - ↑ plasminogen activator inhibitor 1 synthesis
    - ↑ SNS activity
    - ↑ Na reabsorption
    - ➔ hyperlipidaemia & HTN
  - development of type II DM = ↑ BSL later
- bariatric surgery (esp gastric bypass) can improve DM ii control immediately ie before weight loss
  - 80% complete resolution DM II within 1 yr post surgery

**Metabolic Syndrome**

- = occurrence of metabolic RFs for type II DM & CVS disease
- criteria - any 3 of 5:
  - abdo obesity (waist >102cm men; 88cm women)
  - serum triglycerides >1.7, or on Rx
  - HDL <1 men; <1.3 women, or on Rx
  - bp >130/85, or on Rx
  - fasting glucose >5.6, or on Rx
- risk of atherosclerotic CVS disease:
  - vasc endothelial dysfunction
  - abnormal lipids
  - HTN
  - vasc inflammation

**Gastrointestinal**

- ↑ intra-abdo pressures ⇒ ↑ reflux, ↑ aspiration

**VTE**

- ↑ risk of DVT & PE
- ↑ risk of recurrent VTE if anticoag withdrawn
- risk also ↑ ed if presence of:
  - smoking
  - air travel
  - women on OCP

**Risk Scoring**

**Peri-Operative Practicalities**
### Preoperative

- Assess for high risk:
  - STOPBANG
  - poor functional capacity
  - abnormal ECG:
    - low voltage
    - LVH
    - QTc prolonged
    - inflat T abnormalities
    - R axis dev or RBBB
    - P pulmonale
  - uncontrolled bp
  - SpO2 <94% on RA
  - poorly controlled asthma/COPD
  - prev DVT/PE
  - if any should consider
    - ABGs/sleep studies
    - pre-op CPAP
    - ECHO
    - cardio-resp consult
- should perform CVS exam
- check whether can lie flat
- ABG as baseline for CO2 control
- consider gastric acid prophylaxis peri-op

### Perioperative

- get pt to walk into OR
- lie on pre-prepared hover mattress
- standard monitoring:
  - bp cuff - acceptable to use forearm cuff
  - invasive A lines - only indicated for specific CVS problems
- cannulation - US guided periph or central lines
- SCDs on all
- careful Ul positioning to prevent brachial plexus shld ext/abduction injuries
- epidural analgesia:
  - advs:
    - ↓reduction in vital capacity & other spirometric values
    - lung volumes recovered quicker post op
  - disadv:
    - ↓abdo wall mm tone ↓ing forced expiration power
    - difficult to get in place

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**Table 21.1 Obesity Surgery Mortality Risk Score**

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt;45 yr</td>
<td>1</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1</td>
</tr>
<tr>
<td>Gender</td>
<td>1</td>
</tr>
<tr>
<td>Risk factors for PE</td>
<td>1</td>
</tr>
<tr>
<td>BMI ≥30 kg/m²</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total:**

<table>
<thead>
<tr>
<th>Risk group (score)</th>
<th>Post-operative mortality risk (deaths/total number of patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A (0 or 1 points)</td>
<td>0.2%</td>
</tr>
<tr>
<td>Class B (2 or 3 points)</td>
<td>1.2%</td>
</tr>
<tr>
<td>Class C (4 or 5 points)</td>
<td>2.4%</td>
</tr>
</tbody>
</table>

*Previous VTE, pulmonary hypertension, preoperative vena cava filter, or hyperventilation due to obesity.*
Induction
- ramped position sniffing morning air (tragus above sternum)
- pre-oxygenation in this position essential to >80% (>90% better)
- airway:
  - NAP 4 - difficult airway x2 of non-obese:
    - aspiration with LMAs
    - diff tracheal intubation (13%)
    - airway obstruction during emergence
    - rescue techniques failed more commonly
  - preoxygenate ramped ⇒ ↑FRC, ↓aspiration risk
  - AFOI may be routine in some bariatric centres
  - good airway plan - weak assoc with ↑difficult intubation
  - assistant to pull breasts down
  - IPPV should be used (avoid SV):
    - ↑WOB
    - early airway closure
    - rapid desat
  - avoid LMAs BMI >35
  - extubate head up awake

Maintenance
- short acting anaesthetic agents to minimise post op hypovent & hypoxaemia:
  - remi & des
  - TIVA - prop & remi
- NMB monitoring and full reversal
- use high PEEP
- pressure areas
- Left lateral tilt - to minimise aorto-caval compression
- depth anaesthesia monitoring

End of case
- Suggamadex

Postop
- use routine PACU d/c criteria except:
  - aim preop SpO2 with minimal O2 as possibile
  - check no evidence of hypoventilation
  - extubating to BiPAP or CPAP good option
  - VTE prophylaxis - as x2 risk
  - if OSA:
    - reinstate CPAP if using pre-op
    - additional recovery time recommended
    - must be free of apnoeas when not stimulated
    - effective CPAP ↓risk of apnoea to near normal
    - continuous SpO2 monitoring recommended 24hrs post op (level 2 care)

Pharmacology

Calculations
- IBW in kg easily calculated using Broca:
  - Men = height (cm) - 100
  - Women = height (cm) - 105
- Lean body weight - exceeds IBW in obese but then plateaus ∴:
  - Men = 100kg
  - Women = 70kg
- Adjusted Body Weight = IBW + 40% excess

Generic
- VD altered:
- ed % of TBW (but ed actual TBW)
- ed % adipose
- ed lean body mass
- ed blood volume (& ed CO)
- altered tissue protein binding
- ed concentration of free fatty acids, cholesterol α1 acid glycoprotein

- PPB altered:
  - plasma albumin unchanged
  - ed α1 acid glycoprotein

- Drug clearance:
  - Renal blood flow
  - GFR
  - tubular secretion
  - hepatic blood blow in congestive cardiac failure

- hydrophilic drugs (eg NDNMBs):
  - similar VDs, clearance & elim half lives
  - base dose on LBW

- lipophilic drugs (eg prop, opioids (except morphine) & benzo’s):
  - ed VD
  - normal clearance
  - elimination half lives

- ed plasma cholinesterase activity:
  - sux dose on ABW up to max 200mg
  - ideal for obese ⇒ rapid onset & offset but may ⇒ quicker desat compared to roc in RSI

**Specific drugs**
- induction agents = LBW
  - propofol for infusion then change calculation to ABW
- NDNMBs = LBW
- Sux = ABW (max 200mg)
- Neostigmine = ABW (max 5mg)
- Suggamadex - base on total body weight or ABW
- Opioids = LBW (except alfentanil)
- Neuraxial LAs: ↓ dose by 25% as engorged epidural veins & fat impinge on volume of epidural space
- paracetamol - can be dosed more frequently due to ed clearance

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**Suggested dosing regimes for anaesthetic drugs**

<table>
<thead>
<tr>
<th>Lean Body Weight</th>
<th>Adjusted Body Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males 100kg Females 70kg</td>
<td>Ideal plus 40% excess</td>
</tr>
<tr>
<td>Propofol induction</td>
<td>Propofol Infusion</td>
</tr>
<tr>
<td>Thiopental</td>
<td>Suxamethonium (Max 200mg)</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>Alfentanil</td>
</tr>
<tr>
<td>Rocuronium</td>
<td>Lidocaine</td>
</tr>
<tr>
<td>Atracurium</td>
<td>Neostigmine (5mg)</td>
</tr>
<tr>
<td>Vecuronium</td>
<td>Sugammadex (see package insert)</td>
</tr>
<tr>
<td>Morphine</td>
<td>Antibiotics</td>
</tr>
<tr>
<td>Paracetamol</td>
<td>Low Molecular Weight Heparin</td>
</tr>
<tr>
<td>Bupivacaine</td>
<td></td>
</tr>
</tbody>
</table>

**Midaz = same as propofol**
Thromboprophylaxis
- ↑VTE risk independent of other obesity co-morbidities
- ↑↑risk post surgery
- options:
  - mechanical devices:
    - TED stockings
    - foot impulse devices
    - SCDs
  - continue all options until pt no longer has ↓ed mobility
- pharmacological prophylaxis:
  - for pts with low risk of major bleeding
  - continue until no longer ↓ed mobility (generally 5-7d)
  - no specific guidelines on dosing in obesity

Neuraxial Techniques
- very high failure rare with multiple attempts
- easier insitting position
- use ultrasound prescan to find centre & level
- epidural:
  - ↑risk of dural puncture as epidural space is smaller due to compression by fat & engorged epidural veins
  - use 75% of normal dose
  - dose in sitting position to limit cephalad spread
- spinal:
  - should use less drug (as in pregnant population)
  - CSE attractive & may help find space
By Surgery

Bariatric Surgery
- in UK indication for surgery:
  - BMI >40
  - BMI >35 with significant co-morbidities which could be improved with ↓weight
  - all non-surgical measures have been tried in order to achieve weight loss for >6months
  - BMI >50 as 1st line option
- must go through bariatric MDT Ax

Intragastric Balloon Insertion & Removal
- = insertion of 700ml silicone balloon in stomach via gastroscope
- inflated with saline & methylene blue
- balloons removed after max 6 months
- can be done under sedation/topical or GA with intubation

Preoperative
- indications:
  - BMI 25-35 - weight loss adjunct when don't qualify for bariatric surgery
  - BMI >60-70 - for people too high risk for bariatric surgery

Perioperative
- topical anaesthesia generally enough if cooperative
- L lat position used for insertion ⇒ sedation

Induction
- high risk pts:
  - sedation risk may ⇒ hypoventilation, hypoxia & airway obstruction
- very large patients poorly tolerate side lying ⇒ sit upright

Special Points
- can generally be done as a day case
- high amount of nausea post insertion

Gastric Banding
- = silicone band around top of stomach ⇒ creating small pouch above it
- small injectable port placed subcut & connected to band which is then inflatble

Preoperative
- straightforward laparoscopic procedure
- low mortality rate
- local variance but often used for lower spectrum BMIs
- pre-op paracetamol

Perioperative
- Induction
  - careful positioning
  - 2 IV lines
  - forearm cuff
  - pre-oxygenate in head up position
  - intubation mandatory:
    - VT appropriate for IBW or LBM
    - RSI is not mandatory but quick desat & difficult BMV is likely

Maintenance
- short acting agents: des & TIVA (but correct dosing can be tricky)
- ensure adequate NMB
- give x2 anti-emetics - vomiting is common & risks strain on band sutures
- give minimal intraop opioids
- place adequate LA in port sites

**Extubation**
- in high sitting

**Post op**
- slowly titrate opioids in recovery
- most dont need HDU (except OSA patients)
- early mobilisation

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**Gastric Bypass**

- = rox-en Y bypass
- almost all laproscopic
- involves:
  - small bowel anastomosis
  - formation of a Roux limb
  - creation of gastric pouch
  - gastrojejunal anastomosis
  - lot of surgical variation
- most ask for large NGT passed orogastrically during pouch formation
  - prevents stapling of oesophagus & allow suturing around it during GJ anastomosis

**Perioperative**

**Maintenance**
- double antiemetics

**Post op**
- post op CPAP is safe

**Special Points**
- if surgeon asks for NGT post intubation to decompress stomach: place then remove
  - otherwise risk f NGT stapled into pouch
- leak testing of GJ anastomosis:
  - OG tube passed then air or methylene blue placed into pouch
  - watch for dyed fluid refluxing into mouth - suck
- post op complications:
  - anastomotic leak - signs =
    - post op tachycardia = leak until proven otherwise
    - excessive pain
    - pain on swallowing
  - bleeding: (may just observe initially)
    - melena
    - haematemesis

**Sleeve Gastrectomy**

- stomach divided by stapling to reduce it by 25% of original size
- portion along greater curvature is removed through small incision
- generally laparoscopic

**Preoperative**
- often reserved for higher risk patients as is easier & quicker than bypass

**Perioperative**

**Maintenance**
- large NG tube placed to allow surgeon to staple alongside tube & avoid stapling the oesophagus