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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
 - leptin:
 - made in adipose
 - function to ↓appetite
 - obese have ↑ed circulating levels but leptin insensitivity
 - long term hunger level
 - adiponectin:
 - similar signalling role to leptin
 - 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
 - ▶ ↑ing 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:
 - ▶ Snore loudly
 - ▶ Tired with daytime somnolence
 - ▶ Observed apneic episodes
 - ▶ Pressure = HTN
 - ▶ BMI >35
 - ▶ Age >50
 - ▶ Neck circumference >40cm
 - ▶ Gender = Male
- ↳ score:
 - ≥3 = high risk; sensitive but low specificity
 - ≥5 = high risk OSA; high sensitivity & specificity

- 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, oro-nasal 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: 1/3 compliant, 1/3 semi compliant, 1/3 non-compliant
 - ▶ Asymptomatic patient: only 3% compliant with CPAP
 - ↳ but PSG can 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
 - ▶ ↑ACTH & ↑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 paed 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
 - ▶ ↓s 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 ⇒ ↑ R 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

Table 21.1 Obesity Surgery Mortality Risk Score¹⁶

Risk factor	Points
Age >45yr	1
Hypertension	1
♂ sex	1
Risk factors for PE*	1
BMI ≥50kg/m ²	1
Total:	
Risk group (score)	Post-operative mortality risk (deaths/total number of patients)
Class A (0 or 1 points)	0.2%
Class B (2 or 3 points)	1.2%
Class C (4 or 5 points)	2.4%

* Previous VTE, pulmonary hypertension, preoperative vena cava filter, or hypoventilation due to obesity.

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 UI 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

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 \Rightarrow \uparrow FRC, \downarrow aspiration risk
 - AFOI may be routine in some bariatric centres
 - good airway plan - weak assoc with \uparrow difficult intubation
 - assistant to pull breasts down
 - IPPV should be used (avoid SV):
 - \uparrow 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 possible
 - 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 \downarrow 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 \therefore :
 - 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
- ↑blood volume (&↑ed CO)
- altered tissue protein binding
- ↑ed concentration of free fatty acids, cholesterol & α1 acid glycoprotein
- PPB altered:
 - plasma albumin unchanged
 - ↑α1 acid glycoprotein
- Drug clearance:
 - ↑Renal blood flow
 - ↑GFR
 - ↑tubular secretion
 - ↑hepatic blood flow 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
- ↑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

Suggested dosing regimes for anaesthetic drugs	
Lean Body Weight Males 100Kg Females 70Kg	Adjusted Body Weight Ideal plus 40% excess
Propofol induction	Propofol Infusion
Thiopental	Suxamethonium (Max 200mg)
Fentanyl	Alfentanil
Rocuronium	Lidocaine
Atracurium	Neostigmine (5mg)
Vecuronium	Sugammadex (see package insert)
Morphine	Antibiotics
Paracetamol	Low Molecular Weight Heparin
Bupivacaine	

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 dont 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 inflatable

Preoperative

- straightforward laproscopic 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

Gastric Bypass

- = roux-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)
 - malena
 - haemetemesis

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