Nutrition and Sedation in ICU

DR.ABOLFAZL MOZAFARI

PULMONOLOGIST, INTENSIVIST

ASSOCIATED PROFESSOR OF ISLAMIC AZAD UNIVERSITY OF QOM

Introduction

- Nutritional Support has become a routine part of the care of critically ill patients
- Nutritional Support refers to enteral, parenteral provision of calories, proteins, electrolytes, vitamins, minerals, trace elements and fluids.
- These patients are hyper metabolic and have increased nutritional requirements.
- In critically ill patients malnutrition develop rapidly due to the presence of acute phase responses, which not only promote catabolism but also alter the response to nutritional support.
- Malnutrition once established exerts well-known deleterious effects by altering immunity, increasing susceptibility to nosocomial infections, decreasing wound healing and promoting organ failure.

Carbohydrates are believed to be the preferred energy source during this period because fat mobilization is impaired.

Supplementary protein is recommended for critically ill patients, The basis of protein prescriptions is the hope for mitigation of the breakdown of muscle proteins into amino acids, which then serve as the substrate for gluconeogenesis, as reflected in a favorable nitrogen balance.

The phase of recovery which begins as critical illness (catabolism exceeding anabolism) resolves is characterized by anabolism exceeding catabolism. Nutrition support provides substrate for the anabolic state, during which the body corrects hypoproteinemia, repairs muscle loss, and replenishes other nutritional stores.

Casaer MP, et al. Am J Respir Crit Care Med 2013; 187:247.

A Practical Approach During Nutrition.

- When should nutrition supplementation be initiated .
- Which route should be used for the delivery of nutrient.
- What special precaution should be taken before initiating supplementation in the patients (Diabetic background, Cardiac Diseases, Chronic Renal Failure).
- Termination of Parenteral Nutrition

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- ***Biochemical tools***: Hemoglobin
  Albumin
  Transferrin
  Pre-albumin
  Lymphocyte Count
- *Clinical Assessment*: It is simplest and most practical method.
  Good nutritional History
  General physical examination
  Loss of subcutaneous fat(chest and triceps)
  Oedema
  Ascitis
- *Dietary Assessment*: It can be assessed by 24 hrs dietary recall
  Food frequencies
  Food daily Technique
  Observed food consumption

Nutritional Requirements:

To actually measure energy requirements we need sophisticated equipment.

Requirements are most often calculated using formulae.

One such formula is the Harris-Benedict Equation which estimates the basal energy expenditure (BEE) in Kcal/day

Harris Benedict equation (BEE)

For men: 66+(13.7xwt)+(5xht)-(6.7xAge)

For Women: 655+(9.6xwt)+(1.8xht)-(4.7xAge)

Resting energy expenditure (REE) in Kcal/24hr

REE=BEEX1.2→ [(3.9x$VO_{2)}$+(1.1xVCO_2)-61] X1440

Dosing weight — When prescribing enteral or parenteral nutrition, the appropriate body weight from which to calculate caloric and protein intake (ie, the dosing weight) must first be determined.

For patients who are underweight (body mass index [BMI] <18.5 kg/m), normal (BMI 18.5 to 24.9 kg/m) or who are overweight (BMI 25 to 29.9 kg/m) we suggest using the current weight as the initial dosing weight

For patients who are obese (BMI ≥30 kg/m), we suggest that the dosing weight be adjusted
dosing weight = IBW + 0.4 (ABW - IBW)
dosing weight = 1.1 * IBW

Ideal body weight is computed in men as 50 + (0.91 × [height in centimeters − 152.4]) and in women as 45.5 + (0.91 × [height in centimeters − 152.4]). A simple alternative would be to compute ideal body weight as the weight corresponding to an ideal body mass index of 22 kg/m^2.

We believe that a safe starting point for most critically ill patients is approximately 8 to 10 kcal/kg per day(20-30% total calories). Attempting to achieve a goal of 25 to 30 kcal/kg of dosing weight per day after one week is reasonable for most stable patients.

A goal of 35 kcal/kg per day is an acceptable goal if weight gain is desired in a relatively stable patient; weight gain should not be attempted until the patient is stable and in a lower inflammatory state. We keep the caloric goal at 25 kcal/kg per day or less if extubation is imminent.

Rice TW, et al. JAMA 2012; 307:795.

- A careful balance of macro-nutrients (protein, lipids and carbohydrates) provide the energy requirements whilst micronutrients (Vitamins and minerals) are required in very small amounts to maintain health .

- Proteins: Proteins provide 10-15% of total calories. Daily requirements of proteins-
- .8-1.2 g/kg→ Normal Metabolism
- 1.2-1.6gm/Kg-→ Hypercatabolism

- Nitrogen Balance:-2/3rd of nitrogen derived from protein is excreted in the urine.

- Because protein is 16% Nitrogen, each gm of urinary nitrogen represents 6.25gm of degraded proteins.
- N Balance(g)=(Protein intake(g)/6.25)-(UUN+4)
- Positive Nitrogen Balance:Provide enough non-protein calories
- Negative Nitrogen Balance: insufficient intake of non-protein calories
- The goal of nitrogen balance is to maintain a positive balance of 4-6gms

- **Carbohydrate**: It Provides upto 50-60% of total calories or 70-90% of non-protein calories
- It provides 3.4 Kcal /g of glucose
- The total glucose load may be limited to 3.5-5gm/Kg/24hr depending upon severity of stress
- **Lipids**: Lipid emulsion provides 25-30% of total energy.

Maximum dose should be limited to 1gm/kg/24hr

It provides 9.3 Kcal/gm

Micronutrients:

Usually act as co-factors for enzymes, involved in metabolic pathway or structurally integral part of enzymes and are often involved in electron transfer. Their daily requirements given in table

Indications: Our usual approach to selecting critically ill patients for nutrition support is as follows

For patients without contraindications to enteral nutrition, we begin early enteral feeding (ie, within 48 hours) because we believe that the potential benefits of early enteral feeding (eg, fewer infections and pneumonia, possibly lower mortality) outweigh its risks .

During the first five to seven days of critical illness, we do not exceed 20 to 30 percent of feeding goal, unless the patient is quite stable.

For adequately nourished patients who have contraindications or intolerance to enteral nutrition, we do NOT initiate early parenteral nutrition and typically do not start feeding parenterally before one to two weeks have elapsed.

This reflects the evidence that early parenteral nutrition may increase the risk of infection and prolong mechanical ventilation, intensive care unit (ICU) stay, and hospital stay

Reintam Blaser A, et al. Intensive Care Med 2017;43:380

Contraindications of enteral and parentral nutrition

Guidelines discourage early enteral nutrition in critically ill patients who are both hemodynamically unstable and have not had their intravascular volume fully resuscitated, since such patients may be predisposed to bowel ischemia

Other contraindications to enteral nutrition include bowel obstruction, severe and protracted ileus, major upper gastrointestinal bleeding, intractable vomiting or diarrhea, severe hemodynamic instability, gastrointestinal ischemia, and a high output fistula.

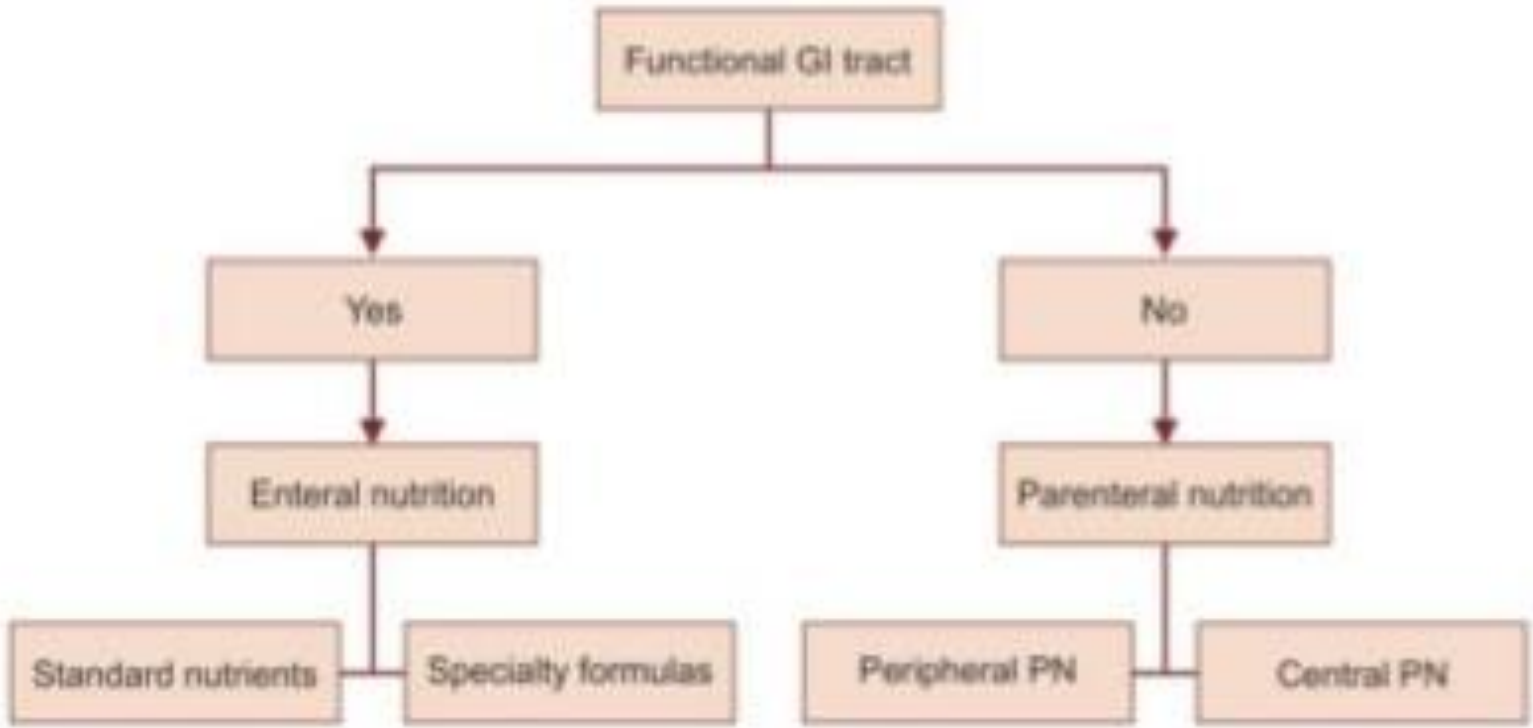
Contraindications to parenteral nutrition include hyperosmolality, severe hyperglycemia, severe electrolyte bnormalities, volume overload, inadequate IV access, and inadequate attempts to feed enterally.

Relative contraindications to parenteral nutrition are not well defined. However, parenteral nutrition is often avoided in sepsis, systemic inflammatory response syndrome, minor vomiting, gastrointestinal bleeding, short-term mechanical ventilation, and conditions expected to reverse quickly that temporarily preclude enteral feeding.

Enteral and parenteral nutrition must be initiated slowly and with strict monitoring in patients at risk for "refeeding syndrome." Patients with chronic undernourishment should receive supplemental thiamine prior to initiation of artificial nourishment to prevent Wernicke syndrome

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

NUTRITIONAL PLAN



How to give enteral nutrition?

- Confirm tube position: Clinically and radiographically if possible.
- Secure the tube well.
- Sit patient up- At least 30° to minimize the risk of reflux and aspiration of gastric contents
- Aspirate regularly (e.g. 4 hourly) to ensure that gastric residual volume is less than 200ml.
- Avoid bolus feeding: Large volume of feed in stomach will increase the risk of aspiration of gastric content
- Use-Pro-kinetics : If patient not tolerated enteral feed then prokinetics given : Metoclopramide 10mg iv tds

Disease specific formulae:

- These are usually polymeric and feed designed for :

- **Liver diseases**: Low sodium and altered amino-acids contents
  (to reduce encephalopathy)

- **Renal Disease:** Low phosphate and Potassium 2kcal/ml
  (to reduce fluid intake)

- **Respiratory Disease:** High fat Content reduce CO_2 production

COMPLICATIONS OF ENTERAL NUTRITION

- Aspiration can be reduced by continuous feeds and checking for gastric residue.

Diarrhea due to:

- Gastric hypersecretion
- Lactose intolerance
- Altered bowel flora
- Hyperosmolar feeding
- Malabsorption

- Mechanical problems due to
  - Tube dislodgment
  - Malposition
  - Blocked tubes

Peripheral Parenteral Nutrition PPN:

- The maximum osmolarity that can be tolerated by peripheral vein is 900 mosm/L.

- The concentration of various solutions that can be given safely via peripheral veins are –

  Glucose-5-10%

  Amino-acids- 2-4%

  Lipids-10-20% as both concentration are iso-osmolar.

- PPN is unsuitable for patients –

  Poor peripheral venous access

  High energy and nitrogen requirements

  High Fluid requirements

  Requiring nutrition for longer time.

Central Parenteral Nutrition: CPN

- IV catheter should be inserted under all aseptic conditions
- It should be used only for purpose of parenteral nutrition.
- Confirm the position of catheter by X-ray Chest .

INTRAVENOUS NUTRIENT SOLUTIONS:

- **Carbohydrates:**These are provided by dextrose solutions. These are available as 5%,10%,20%,50%,70%
- **Proteins:** These are given as amino acid solution . They Contain 50% essential and semi-essential amino acid
- **Lipids:** Intravenous Lipid Emulsions consists of submicron droplets of cholesterol and phospholipids surrounding a core of Long Chain Triglycerides. It is available in 10% and 20% Strength.
- It provides a source of essential fatty acids –linolenic acid (w-3 fatty acid) and linoleic(w-6 fatty acid)
- **Electrolytes and micronutrients** As given in Table.

MONITORING OF PATIENTS:

- Vital Signs: Temperature, blood pressure, pulse, respiratory rate
- Fluid balance- Weight , edema, input-output.
- Delivery equipment: Nutrient Composition, tubing, pumps, catheter, dressing
- On first day measure blood sugar every 6hrs for 24hrs
- During first week measure serum electrolytes, blood urea, sugar and serum triglycerides daily.
- Unstable patients may require blood sugar and serum electrolytes measurements twice daily.
- Serum Calcium, AST, bilirubin, alkaline phosphate, phosphorus magnesium and blood counts at least twice a week.
- Prothrombin time and albumin once a week
- Once the desired infusion rate of TPN has been achieved and blood chemistry is Normal monitoring may be reduced to once a week.

TERMINATION OF PARENTERAL NUTRITION

- Goal: to restart oral/ enteral feeding as soon as gastro-intestinal function improves.
- Gradual transition from PN to oral/ enteral nutrition
- Reduce infusion rate upto 50% for 1-2hrs before stopping
- When 60% of total energy and protein requirements are taken orally/ enterally. PN may be stopped.

COMPLICATION OF TPN:

- **Catheter related:** Pneumothorax, Hemothorax, Chylothorax, Air embolism, Cardiac Tamponade, Catheter sepsis.

- **Metabolic:**Azotemia, Hepatic Dysfunction, Cholestasis, Hyperglycemia/ Hypoglycemia, excessive CO_2 production, metabolic acidosis/alkalosis, electrolyte imbalances.

- **Refeeding Syndrome**

- **Overfeeding**

In SUMMARY

Nutrition support refers to the enteral or parenteral provision of calories, protein, electrolytes, vitamins, minerals, and fluids.

Critically ill patients are selected for nutrition support on the basis of whether they have contraindications to enteral nutrition, as well as whether the patient is adequately nourished or malnourished

For critically ill patients without contraindications to enteral nutrition, we recommend early (eg, within 48 hours) enteral nutrition (Grade 1B).

For critically ill medical patients without contraindications to enteral nutrition, we suggest early enteral nutrition

For critically ill patients who are hemodynamically unstable and have not had their intravascular volume fully resuscitated early enteral nutrition is Contraindicated

In SUMMARY

For adequately nourished patients who have contraindications to enteral nutrition, we recommend NOT initiating early parenteral nutrition (Grade 1A).

While the optimal time for starting parenteral nutrition in these patients is unknown, we typically do not start parenteral feeding before one to two weeks have elapsed.

For patients with malnutrition who have contraindications to enteral nutrition that are expected to persist one week or less, we suggest NOT initiating parenteral nutrition (Grade 2C).

For patients with malnutrition who have contraindications to enteral nutrition that are expected to persist greater than one week, we suggest parenteral nutrition

An acceptable initial nutritional goal is 8 to 10 kcal of calories/kg per day and then 18 to 25 kcal and 1.5 grams of protein/kg per day after five to seven days,

Sedation and pain control in ICU

Clinical Practice Guidelines for the Prevention and Management of Pain, Agitation/Sedation, Delirium, Immobility, and Sleep Disruption in Adult Patients in the ICU

John W. Devlin, PharmD, FCCM (Chair)[1,2]; Yoanna Skrobik, MD, FRCP(c), MSc, FCCM (Vice-Chair)[3,4]; Céline Gélinas, RN, PhD[5]; Dale M. Needham, MD, PhD[6]; Arjen J. C. Slooter, MD, PhD[7]; Pratik P. Pandharipande, MD, MSCI, FCCM[8]; Paula L. Watson, MD[9]; Gerald L. Weinhouse, MD[10]; Mark E. Nunnally, MD, FCCM[11,12,13,14]; Bram Rochwerg, MD, MSc[15,16]; Michele C. Balas, RN, PhD, FCCM, FAAN[17,18]; Mark van den Boogaard, RN, PhD[19]; Karen J. Bosma, MD[20,21]; Nathaniel E. Brummel, MD, MSCI[22,23]; Gerald Chanques, MD, PhD[24,25]; Linda Denehy, PT, PhD[26]; Xavier Drouot, MD, PhD[27,28]; Gilles L. Fraser, PharmD, MCCM[29]; Jocelyn E. Harris, OT, PhD[30]; Aaron M. Joffe, DO, FCCM[31]; Michelle E. Kho, PT, PhD[30]; John P. Kress, MD[32]; Julie A. Lanphere, DO[33]; Sharon McKinley, RN, PhD[34]; Karin J. Neufeld, MD, MPH[35]; Margaret A. Pisani, MD, MPH[36]; Jean-Francois Payen, MD, PhD[37]; Brenda T. Pun, RN, DNP[23]; Kathleen A. Puntillo, RN, PhD, FCCM[38]; Richard R. Riker, MD, FCCM[29]; Bryce R. H. Robinson, MD, MS, FACS, FCCM[39]; Yahya Shehabi, MD, PhD, FCICM[40]; Paul M. Szumita, PharmD, FCCM[41]; Chris Winkelman, RN, PhD, FCCM[42]; John E. Centofanti, MD, MSc[43]; Carrie Price, MLS[44]; Sina Nikayin, MD[45]; Cheryl J. Misak, PhD[46]; Pamela D. Flood, MD[47]; Ken Kiedrowski, MA[48]; Waleed Alhazzani, MD, MSc (Methodology Chair)[16,49]

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The Need for Sedation

- Anxiety
- Pain
- Acute confusional status
- Mechanical ventilation
- Treatment or diagnostic procedures
- Psychological response to stress

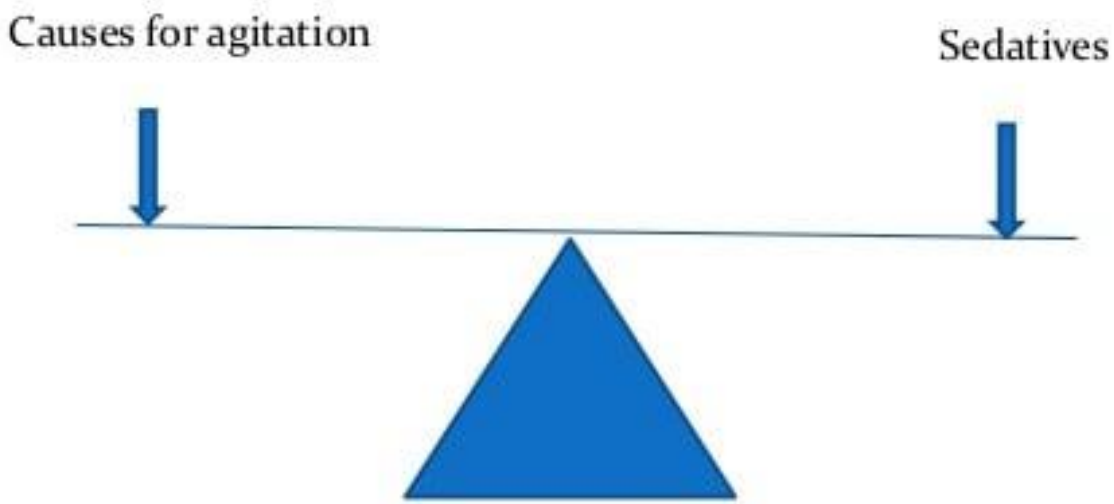
Goals of sedation in the ICU

- Patient comfort
- Control of pain
- Anxiolysis and amnesia
- Adverse autonomic and hemodynamic responses
- Facilitate nursing management
- Facilitate mechanical ventilation
- Avoid self extubation
- Reduce oxygen consumption

Characteristics of an ideal sedation agents for the ICU

- Lack of respiratory depression
- Rapid onset, titratable with a short elimination half-time
- Sedation with ease of orientation and arousability
- Anxiolytic
- Hemodynamic stability
- No accumulation in renal/ hepatic dysfunction

Sedation



A sedation holiday involves stopping the sedative infusions and allowing the patient to wake. this strategy has been shown to decrease the duration of mechanical ventilation and the length of stay in ICU

Table 1 – Ramsay scale[4]

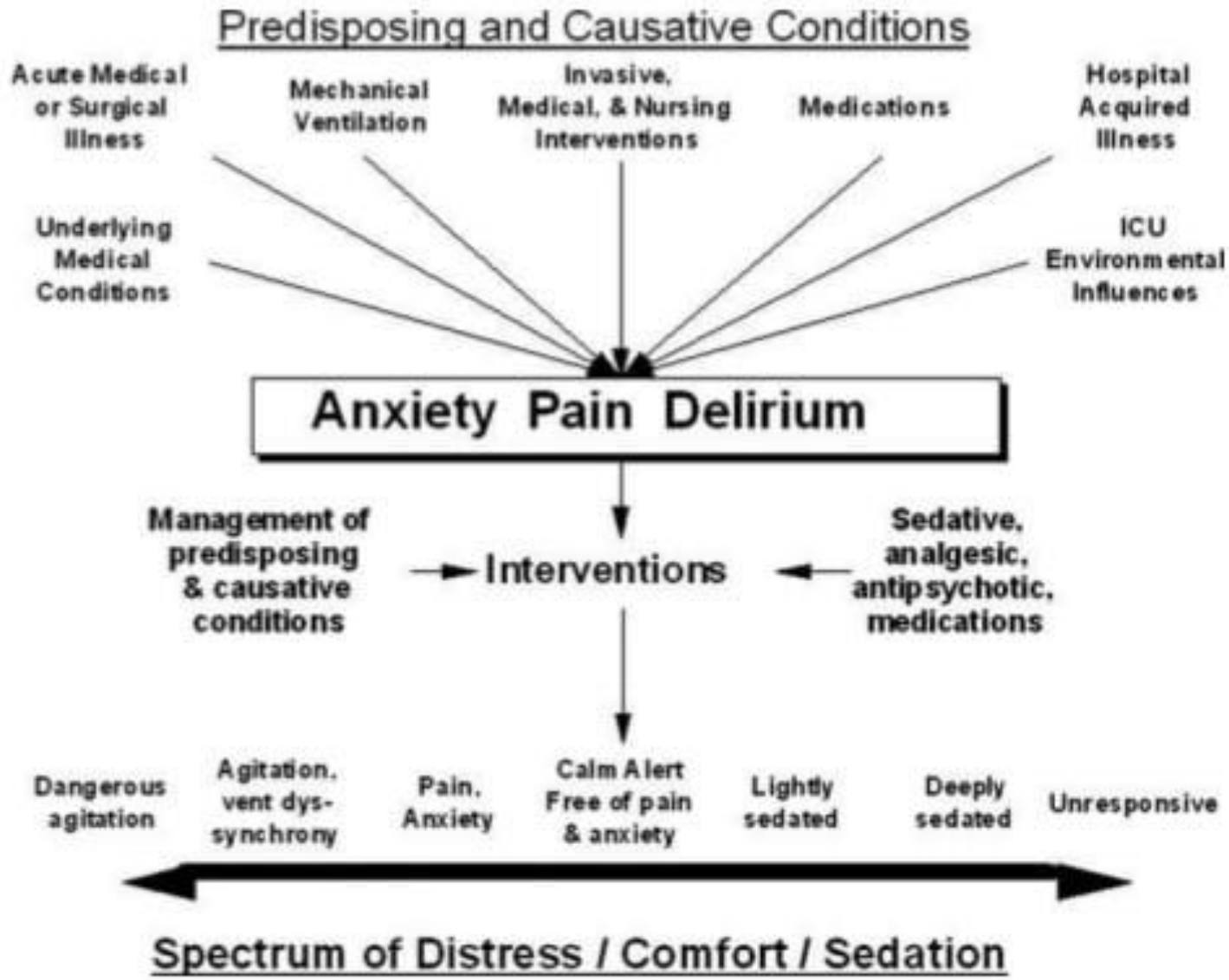
1	Patient anxious and agitated or restless, or both
2	Patient co-operative, orientated, and tranquil
3	Patient responds to commands only
4	Brisk response to a light glabellar tap or auditory stimulus
5	Sluggish response to a light glabellar tap or auditory stimulus
6	No response to the stimuli mentioned in items 4 and 5

Richmond Agitation-Sedation Scale

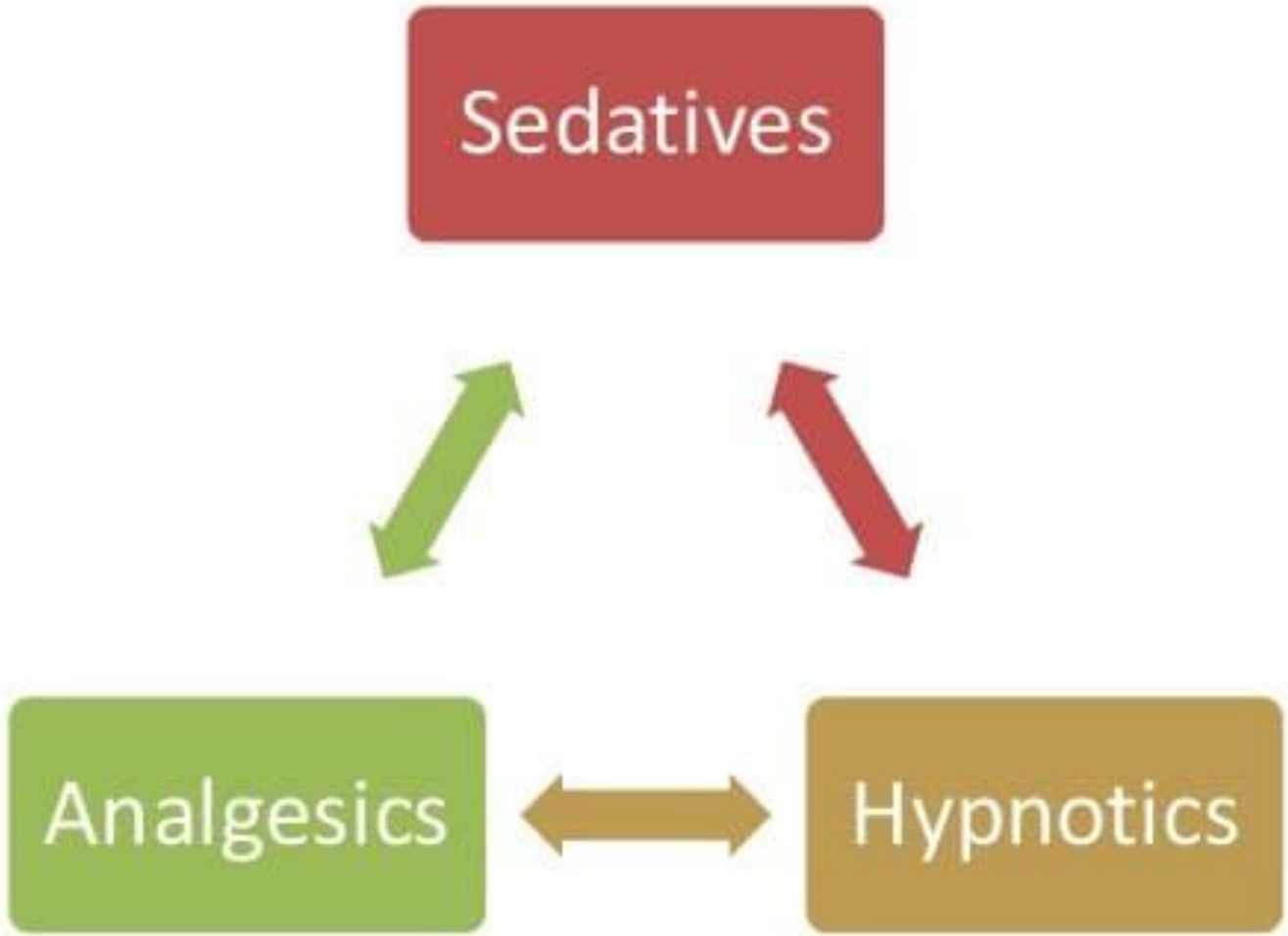
Score	Term	Description
+4	Combative	Overtly combative or violent, immediate danger to staff
+3	Very agitated	Pulls on or removes tube(s) or catheter(s) or has aggressive behavior toward staff
+2	Agitated	Frequent nonpurposeful movement or patient-ventilator dyssynchrony
+1	Restless	Anxious or apprehensive but movements not aggressive or vigorous
0	Alert and calm	
−1	Drowsy	Not fully alert, but has sustained (>10 s) awakening, with eye contact, to voice
−2	Light sedation	Briefly (<10 s) awakens with eye contact to voice
−3	Moderate sedation	Any movement (but no eye contact) to voice
−4	Deep sedation	No response to voice, but any movement to physical stimulation
−5	Unarousable	No response to voice or physical stimulation

Causes of Agitation not to be Overlooked

- Hypoxia
- Hypercarbia
- Hypoglycemia
- Endotracheal tube malposition



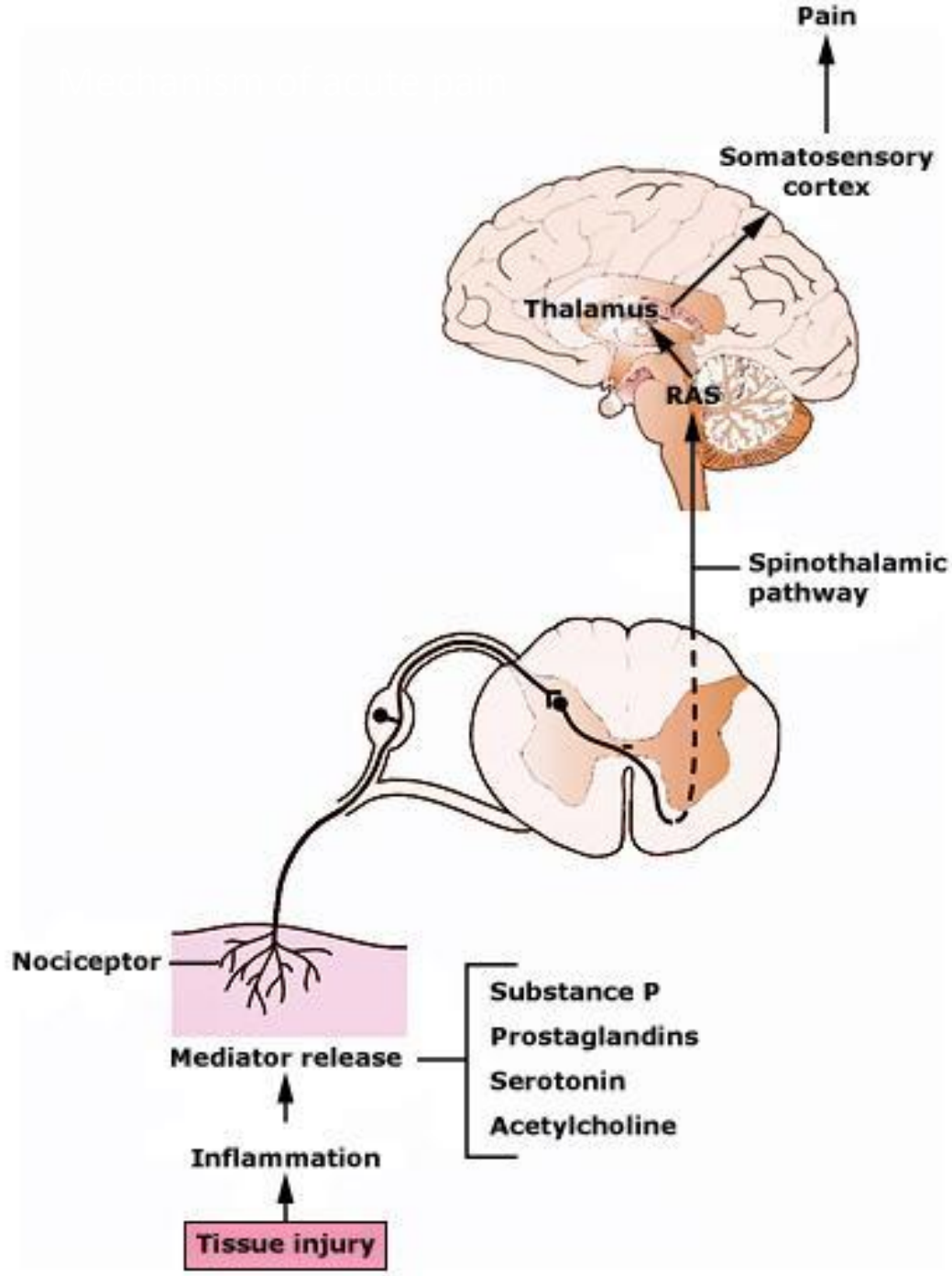
Chest 2008;133;552-565


Sedatives
Analgesics
Hypnotics

PAIN

Unrelieved pain evokes a stress response

- Tachycardia
- Increased myocardial oxygen consumption
- Hypercoagulability
- Immunosuppression
- Persistent catabolism
- Pulmonary dysfunction through localized guarding of muscles


Mechanism of acute pain
Pain
Somatosensory cortex
Thalamus
RAS
Spinothalamic pathway
Nociceptor
Substance P
Prostaglandins
Serotonin
Acetylcholine
Mediator release
Inflammation
Tissue injury

Pain scales for conscious patients

A

B

What does your pain feel like?

0 1 2 3 4 5 6 7 8 9 10

None **Mild** **Moderate** **Very bad** **Unbearable**

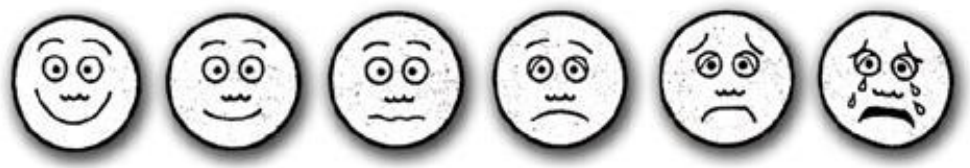
Date: _____

C

Choose the word that best describes your pain:

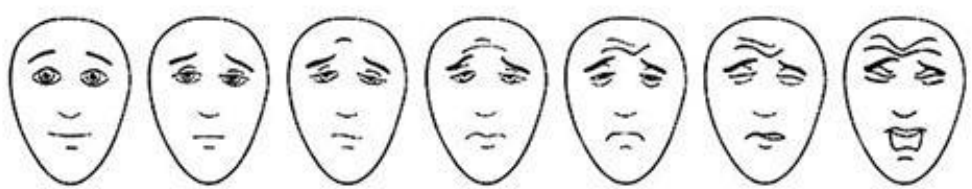
- None
- Mild
- Moderate
- Severe

D



0 1 2 3 4 5

No hurt **Hurts little bit** **Hurts little more** **Hurts even more** **Hurts whole lot** **Hurts worst**



OPIOIDS

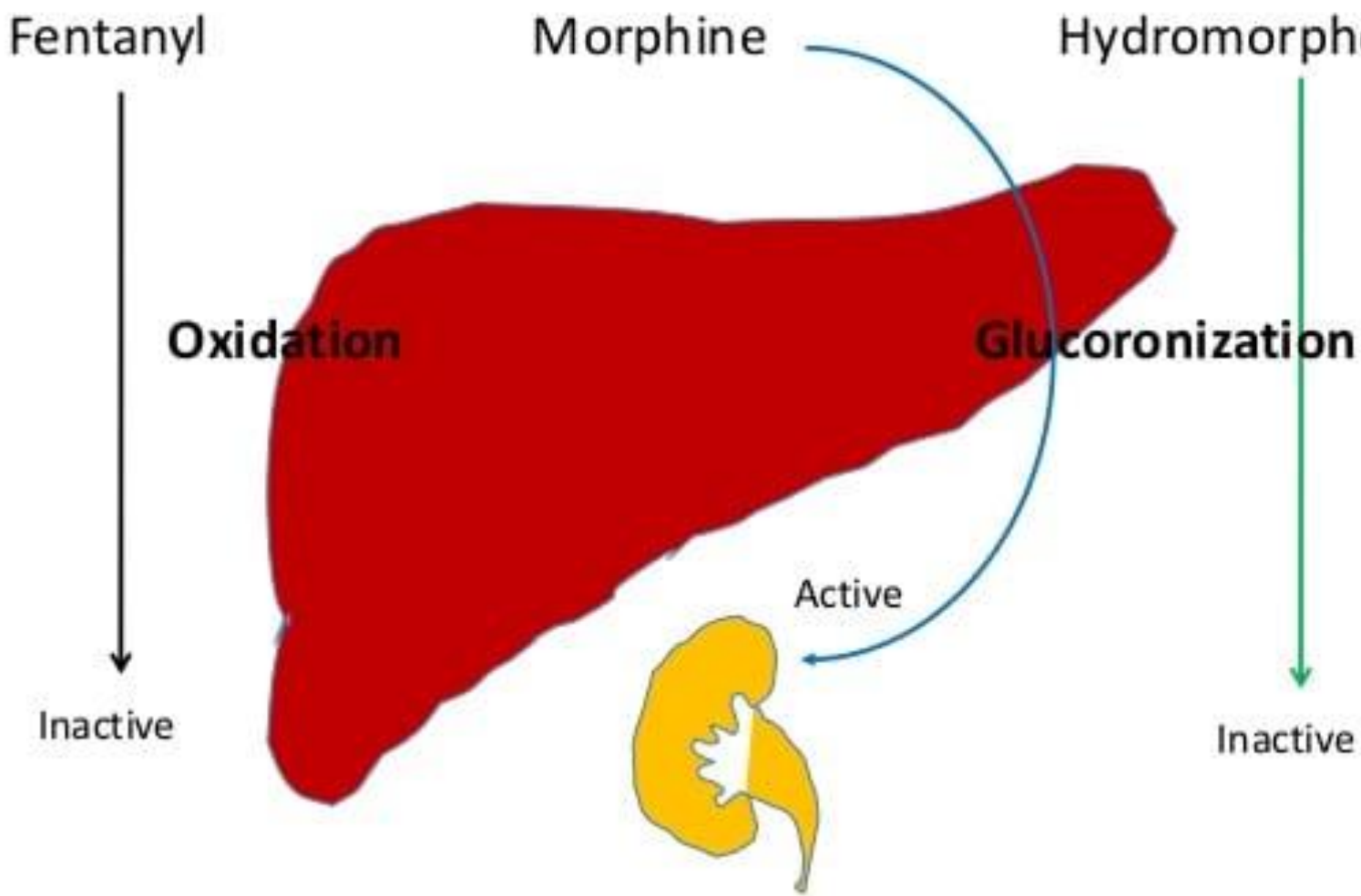
Functions: analgesia, narcosis, and anxiolysis

MOA : Binds with stereospecific receptors at many sides with in the CNS, increases pain threshold, alters pain reception , inhibits ascending pain pathways.

Eg : Morphine, Fentanyl, Alfentanil and Remifentanil .

	Onset	Peaks	Duration
Morphine	2 min	20 min	2 – 7 hrs
Fentanyl	30 sec	5 – 15 min	30 – 60 min

Metabolism of opiates



MORPHINE STANDARD DOSE

Intravenous bolus injection 2.5-5 mg every 15 minutes

Continuous Intravenous Infusion 1-12 mg/ hr

FENTANYL STANDARD DOSE

Analgesia: 1-2 mcg/kg IV/IM q30-60min PRN or 1-3 mcg/kg/hr by continuous IV infusion_

Sedation: 0.5-1 mcg/kg IV/IM q30-60min PRN

Side-effects: respiratory depression, bradycardia, and hypotension (secondary to histamine release), nausea and vomiting, constipation, CNS depression.

Fentanyl

- μ-opioid receptors
- Highly lipophilic
- Rapid onset
- $T_{½}$: 2-4hr
- Repeated dosing may cause accumulation esp. in renal dysfunction
- Less nausea, as well as less histamine-mediated itching, in relation to morphine

Morphine

- Predominantly μ-opioid receptor
- Metabolized primarily in the liver
- Onset: 15-30min
- $T_{½}$: 1.7-4.5hrs
- 60% of morphine is converted to morphine-3-glucuronide (inactive), and 6–10% is converted to morphine-6-glucuronide (1/2 as active).

- Hypotension may result from vasodilatation
- Active metabolite may cause prolonged sedation in the presence of renal insufficiency.

Hydromorphone

- Hydrogenated ketone of morphine
- 6-8 times stronger than morphine
- μ-opioid agonist
- **Lacks a active metabolite (hence drug of choice in ESRD)**
- Minimal histamine release.
- Glucuronidation in the liver
- Strongest of the anti-tussive drugs

Remifentanil

- Specific μ-receptor agonist
- Marketed by GlaxoSmithKline and Abbott as **Ultiva**
- Potent (250 times morphine)

- Onset : 1 minute
- $T_{½}$ = 4 minutes after a 4 hour infusion.

- **Synergism between remifentanil and hypnotic drugs** (such as propofol) the dose of the hypnotic can be substantially reduced → Resulting in more hemodynamic stability

Advantages

- Has ester linkage - rapid hydrolysis by non-specific tissue and plasma esterases to metabolized to remifentanil acid which is almost inactive → excreted in kidneys

- No dose adjustments in renal or liver disease

NSAIDs

- Nonselective, competitive inhibition of cyclooxygenase.
- Significant adverse effects
  - Gastrointestinal bleeding: bleeding secondary to platelet inhibition,
  - renal insufficiency.
  - Increased risk in
    - hypovolemia or hypoperfusion
    - Elderly
    - CKD
- Asthma & Aspirin sensitivity.

Complication of opioid usage:

- depression of consciousness and respiratory drive
-
- Delirium
- Hypotension
- Ileus
- nausea and vomiting
- urinary retention
- Pruritus
- Immunosuppression
- development of tolerance

Considerations for selection of a specific IV opioid agent include

Patients receiving mechanical ventilation and are extubated: fentanyl, morphine, or hydromorphone

Patients with renal and/or hepatic insufficiency – For critically ill patients with renal and/or hepatic insufficiency, we typically select IV fentanyl or hydromorphone and remifentanyl

Patients with hemodynamic instability – For patients with hemodynamic instability, we prefer shorter-acting agents such as fentanyl or remifentanil, rather than a longer-acting agent such as morphine.

Patients with bronchospasm – For patients with known or active bronchospasm, we prefer fentanyl or hydromorphone rather than morphine

Patients requiring frequent neurologic assessments – For patients requiring frequent neurologic assessments, we prefer remifentanil

Patients requiring intermittent bolus opioid doses – For patients with moderate pain we prefer morphine or hydromorphone

Patients who may benefit from oral, enteral, or transdermal opioid administration: methadone, extended-release oxycodone, extended-release morphine sulfate

Ketorolac (toradol)

- Parenteral NSAID
- Prolonged use (> 5 days) of ketorolac has been associated with a two-fold increase in the risk of renal failure and an increased risk of gastrointestinal and operative- site bleeding

Acetaminophen

- Mild to moderate pain at best
- With an opioid, acetaminophen produces a greater analgesic effect than higher doses of the opioid alone

- Potentially hepatotoxic especially in patients with depleted glutathione stores resulting from hepatic dysfunction or malnutrition.

- Acetaminophen should be maintained at
  - less than 2 g per day for patients with a significant history of alcohol intake or poor nutritional status
  - less than 4 g per day for others

Sedative-Hypnotics

- Benzodiazepines
- Propofol
- Dexmedetomidine
- Ketamine
- Etomidate
- Thiopental

BENZODIAZEPINES

Functions: sedation and hypnosis.

MOA: modulating the effects of GABA, the main inhibitory neurotransmitter within the central nervous system.

Eg: Midazolam, Diazepam, Lorazepam

	Onset	Peaks	Duration
Midazolam	2 – 3 min	5 – 10 min	30 – 120 min
Diazepam	2 – 5 min	5- 30 min	> 20 hrs
Lorazepam	5 – 20 min	30 min	10 – 20 hrs

MIDAZOLAM S TANDARD DOSES

IV bolus injection: 1-2.5 mg every two min, max 5 mg.

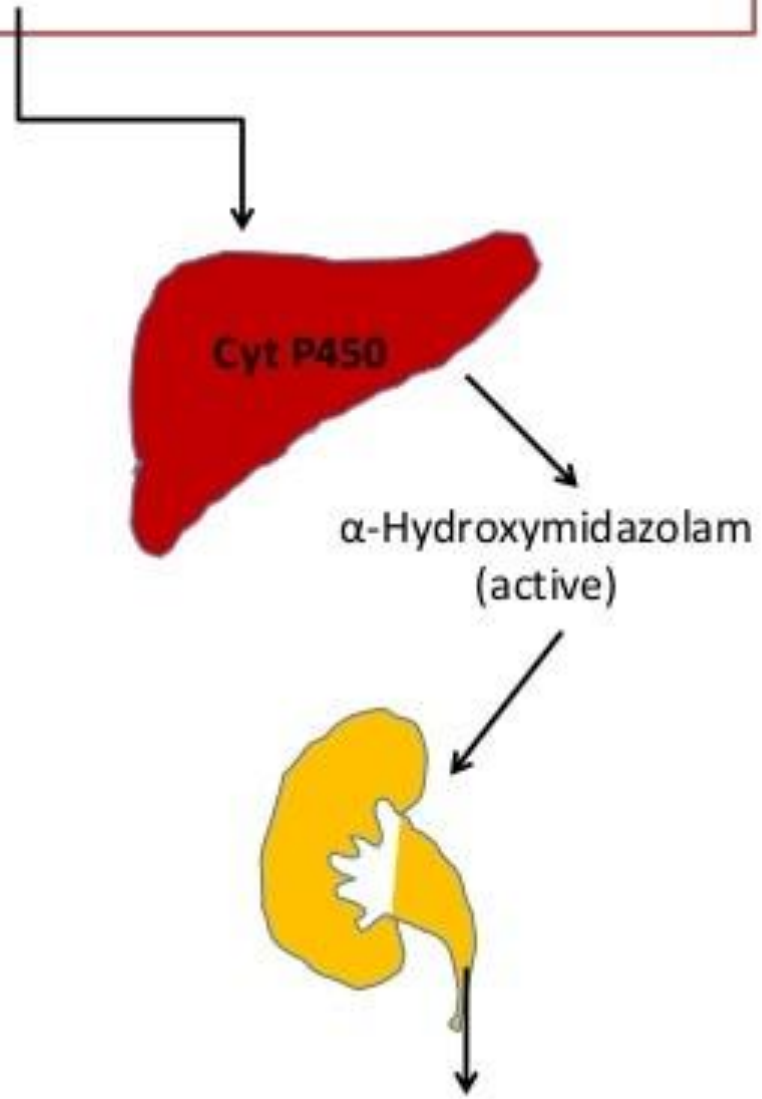
Continuous iv infusion: 1- 10 mg/hr

Sideeffects: Respiratory depression, hypotension, nausea, vomiting.

Midazolam (Versed)

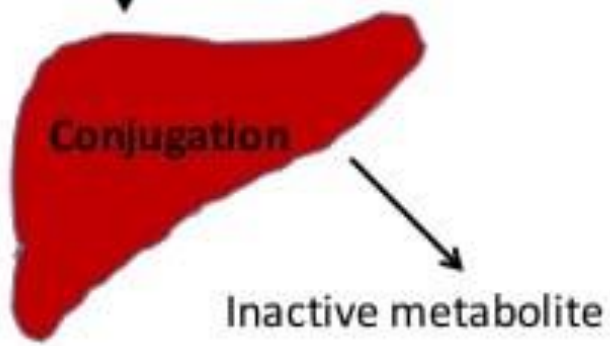
- High lipid solubility
- Onset: 2-3 minutes
- Duration: variable (Accumulates in fats)
- Avoid if hepatic/renal failure
- Inhibition of midazolam metabolism has been reported with inhibitors of cytochrome P_{450}
  - propofol
  - diltiazem
  - Erythromycin
  - Itraconazole

- Obese (high lipid soluble) or patients with reduced serum albumin levels have prolonged sedative effect



Lorazepam (Ativan)

- Less lipid solubility
- Onset: 5-10min
- $T_{½}$: 12- to 15hrs
- Propylene glycol is diluent used to facilitate drug solubility*



In liver failure, lorazepam accumulates lesser than midazolam.

*Crit Care Med 2002 Vol. 30, No. 1

*Lorazepam & Propylene glycol**

- Propylene glycol : hyperosmolarity, acute tubular necrosis, lactic acidosis, metabolic acidosis

- Toxicity is typically observed after*
  - prolonged (>7 d)
  - high-dose (average of >18 mg/h)
  - continuous lorazepam infusion
  - renal and hepatic derangement
  - pregnancy
  - age less than 4 years
  - metronidazole

- An infusion of 2 mg/h of lorazepam will lead to 19.9 g of propylene glycol per day (> 11 times the WHO's recommended daily intake for a 70 kg adult.)

- Monitor a daily serum osmolal gap (if 50 mg or 1 mg/kg)

INTRAVENOUS ANESTHETIC AGENTS - PROPOFOL

Functions: Sedation and anesthetics effect

MOA : Propofol is a sterically hindered alkyl phenolic compound with iv general anaesthetic properties.

IV bolus: 1.5-2.5 mg/kg (less in the elderly) at a rate of 20-40 mg every 10 seconds

Continuous iv infusion: 0.3- 4mg/ kg/ hr

	Onset	Peaks	Duration
Propofol	30 – 60 sec	2 – 5 min	10 min

Adverse Effects:

Propofol Infusion Syndrome:

Severe metabolic acidosis, rhabdomyolysis, hyperkalaemia, hypertriglyceridaemia, renal failure, hepatomegaly and cardiovascular collapse (usually occurs at doses of > 5mg/kg/hr)

Monitor blood-lipid concentration if at risk of fat overload or if sedation used for longer than 3 days. If lipid levels high – change to alternative sedation and consider starting lipid lowering agents.

Ketamine

- NMDA receptor
- Σ opiate receptor
- provides analgesia and apparent anesthesia with relative hemodynamic stability - ‘‘battlefield anesthetic’’
- dissociative anesthesia:
  - unresponsive to nociceptive stimuli, but
  - keep their eyes open and
  - Maintain their reflexes : Blood pressure is maintained, and spontaneous breathing and laryngeal reflexes are preserved.

Pharmacokinetics

- Onset: 1 min
- $T_{½}$: 10-15min
- Actions:
  - Positive inotropic action
  - Induces vasoconstriction
  - Inhibits endothelial nitric oxide production
  - Bronchodilator activity
  - Increase oral secretions

increases myocardial oxygen demand

Advantages

- Provides analgesia + amnestic + sedative effects
- **Preserves respiratory drive** - "awake" intubation
- **Release of catecholamines** –
  - ↑ heart rate,
  - ↑contractility,
  - ↑MAP
  - ↑ cerebral blood flow
  - causes bronchodilation
- *most hemodynamically stable of all of the available sedative induction agents*
- beneficial effects on stunned myocardium
- *minimize the adverse sympathetic stimulation of laryngoscopy*

Disadvantages

- **Re-emergence phenomenon**: experience disturbing dreams
- ↑ intracranial pressure
- Increased oral secretions
- Potential for exacerbating myocardial ischemia.
- ? Risk for elevating ICP – “does not increase cerebral blood flow or ICP if normal carbon dioxide levels are maintained”

Neuromuscular blocking agents

A. Nondepolarizing blockers

1. Long acting: pancuronium, doxacurium, pipecuronium

2. Intermediate acting: atracurium, vecuronium, cisatracurium

3. Short acting: mivacurium

B. Depolarizing blockers: succinylcholine