Perioperative Management of Renal Dysfunction

Rakesh Garg
MD, DNB, MNAMS, FCCS, PGCHM
Assistant Professor
Department of Anaesthesiology and Intensive Care
PGIMER and Dr RML Hospital, New Delhi.
Table 1 | KDIGO definition of CKD

Structural or functional abnormalities of the kidneys for ≥3 months, as manifested by

1. Kidney damage, with or without decreased GFR, as defined by
   Pathologic abnormalities
   Markers of kidney damage
     Urinary abnormalities (proteinuria)
     Blood abnormalities (renal tubular syndromes)
     Imaging abnormalities
   Kidney transplantation
2. GFR < 60 ml/min/1.73 m², with or without kidney damage

CKD, chronic kidney disease; GFR, glomerular filtration rate; KDIGO, Kidney Disease Improving Global Outcomes.

# Severity of CKD by GFR Levels

Normal GFR 125 ml/min/1.73 m$^2$

<table>
<thead>
<tr>
<th>Stage</th>
<th>Degree of renal failure</th>
<th>GFR ml/min/1.73 m$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Kidney damage</td>
<td>≥ 90</td>
</tr>
<tr>
<td>2.</td>
<td>Mild</td>
<td>60 – 89</td>
</tr>
<tr>
<td>3.</td>
<td>Moderate</td>
<td>30 – 59</td>
</tr>
<tr>
<td>4.</td>
<td>Severe</td>
<td>15 - 29</td>
</tr>
<tr>
<td>5.</td>
<td>Kidney failure</td>
<td>&lt; 15</td>
</tr>
</tbody>
</table>

Stages of Chronic Renal Failure

• Diminished renal reserve
• Renal insufficiency
• End-stage renal disease
CHRONIC RENAL FAILURE (C.R.F)

-DIMINISHED RENAL RESERVE-

NORMAL BUN &
SERUM CREATININE

ABSENCE OF
SYMPTOMS

CHRONIC RENAL FAILURE (C.R.F)

RENEWAL INSUFFICIENCY

HEADACHES
NOCTURIA
POLYURIA

WEAKNESS
FATIGUE

GFR - 25% OF
NORMAL

CHRONIC RENAL FAILURE (C.R.F)

END STAGE (UREMIA)

GFR ↓ 10%

POST RENAL INSUFFICIENCY

SLOWLY YELLOW
DISCOLORATION
PRURITUS (UREMIC FROST)
CNS DEPRESSION
PERIPHERAL NEUROPATHY
BP - CHF - ASHD
PERICARDITIS

ANOREXIA
NAUSEA - VOMITING
GI BLEEDING
PEPTIC ULCER
DISEASE

HYPERGLYCEMIA
HYPERLIPIDEMIA
GOUT

HYPERPARATHYROID
ANEMIA - BLEEDING
HYPERPARATHYROID
UREMIA
HYPERPARATHYROID
AMENORRHEA
HYPERPARATHYROID
INFERTILITY
IMPOTENCE

PSYCHOLOGICAL CHANGES
WITHDRAWAL
DEPRESSION
PSYCHOSIS

EVALUATE ACCESS SITE FOR:
PATENCY & SIGNS OF INFECTION
DO NOT TAKE BP OR OBTAIN
BLOOD SAMPLES FROM EXTREMITIES
THAT HAS ACCESS SITE.

RENAL OSTEODYSTROPHY

HEMODIALYSIS

© 1984 Nursing Education Consultant
Assessment of Renal Function
Blood Urea Nitrogen

• Protein catabolism: Amino acid $\rightarrow$ Ammonia $\rightarrow$ (liver) $\rightarrow$ Urea $\rightarrow$ (kidney)

• BUN related to protein catabolism, inversely related to glomerular filtration

• Not a reliable indicator of GFR

• Normal: 10 - 20 mg/dL

• Lower: starvation, liver disease

• Elevation: ↓GFR, ↑protein catabolism (trauma, sepsis, degradation of blood, high-protein diet)

• > 50 mg/dL: Renal impairment
Serum Creatinine

- Muscle metabolism → Creatinine
- Creatinine production (M: 20-25 mg/kg, F: 15-20 mg/kg): related to muscle mass, inversely related to glomerular filtration
- Reliable indicator of GFR
- Normal: M: 0.8 - 1.3 mg/dL, F: 0.6 - 1 mg/dL
- Increases: large meat meals, Cimetidine therapy, ↑acetoacetate (ketoacidosis)
- GFR declines with age (5% / decade), muscle mass also declines → creatinine relative normal
Serum Creatinine...

- Each doubling of serum creatinine $\rightarrow$ 50% reduction in GFR

*Figure 32–1. The relationship between the serum creatinine concentration and the glomerular filtration rate.*
BUN / Cre Ratio

- ↓renal perfusion, or obstruction of urinary tract → ↓renal tubular flow rate → enhance urea reabsorption, not affect creatinine → BUN/Creatinine ratio > 10:1

- Volume depletion, edematous disorders (heart failure, cirrhosis, nephrotic syndrome), or obstructive uropathies → BUN/Creatinine ratio > 15:1
**GFR**

- Estimation of the GFR is used to assess, define, and classify renal function in CKD
- Quantitative assessment of GFR, by
  - Exogenous marker
    - Inulin
    - I-iothalamate
    - Cr-EDTA etc.
  - Endogenous marker
    - Creatinine
    - cystatin C
Disadvantages

Creatinine Clearance - Imprecise:

• At high values of GFR
• Patients with a grossly abnormal muscle mass
• Patients with a very low BMI
• Pregnant patients
• Where renal function is changing rapidly

• In most cases, measurement of creatinine clearance using a timed (e.g. 24-hour) urine collection for assessment of the GFR is not more reliable than estimation using a prediction equation

Creatinine Clearance

• The most accurate method for assessing renal function (GFR)

\[
\text{Creatinine clearance} = \frac{(140 - \text{age}) \times \text{lean body weight}}{72 \times \text{plasma creatinine}}
\]

• Compensatory hyperfiltration in the remaining nephrons and increases in glomerular pressure in early renal disease \(\rightarrow\) relative preservation of GFR \(\rightarrow\) Ccr overestimates the true GFR

• Important to look for other signs: hypertension, proteinuria...
Urinalysis

• The most common test routinely for evaluating renal function
• Routine urinalysis: pH, specific gravity, glucose, protein, bilirubin, urinary semident
• Urinary pH > 7.0 + systemic acidosis → renal tubular acidosis
• Specific gravity > 1.018 after overnight fast → adequate renal concentrating ability
Preoperative concerns...
Concerns due to . . .

• Multisystem organ involvement
• Anemia, Platelet dysfunction, coagulopathy
• Cardiovascular:
  • Congestive heart failure (primary or secondary)
  • Hypertension
  • CAD
  • Uremic pericarditis
  • Dysrhythmias
• Muscle weakness, neuropathy
Concerns due to . . .

• CNS dysfunction
  • Behaviour change
    • Myoclonus, seizures, coma (encephalopathy)
• Fluid, electrolyte and acid base disturbances
• Uremic gastritis, bleeding
• Secondary hyperparathyroidism
• Dialysis related problems
Co morbidities [>50%]

- Diabetes mellitus
- Hypertension
- CAD
- CHF
- Pulmonary disease
- Previous malignancy
- Vasculitis
- SLE
Cardiovascular Risks

• History - DOE, angina, previous MI, PCI, CABG, diabetes, smoking, HTN, drugs

• **Complications of CKD In CVS:**
  – Salt and water retention, hypertension, and LVH
  – Cardiomyopathy, CCF, and pulmonary oedema
  – Accelerated atherosclerosis and stiffening of large capacitative arteries
  – Altered lipoprotein metabolism
  – Complications of AVF/shunts, e.g. heart failure, limb ischaemia, steal syndrome, pulmonary atheroembolism
  – Uraemic pericarditis
Cardiovascular death after elective surgery under general anaesthesia more – Patients were diagnosed as having renal failure with serum creatinine on admission >150 µmol /litre [1.69mg/dl]


Preoperative serum creatinine > 176.8 µmol /litre (2 mg/dl) independent predictor of cardiac complications, and was associated with major cardiac complications in 9% of cases


A serum creatinine > 200 mmol /litre [2.26mg/dl] is considered an objective risk factor, and contributes an added 2% to the predicted mortality

• Cardiovascular disease accounts for approximately 40% of deaths in patients undergoing dialysis [ >60% LVH, RVH, pericarditis]

• Cardiac screening should be performed before transplantation in all symptomatic or high risk patients / asymptomatic patients with diabetes [exercise test or DSE > dipyridamole thallium stress test]

• Patients with abnormal screening tests or with symptomatic IHD should undergo CAG and revascularization, if indicated

• CHF – if present before dialysis , it is an independent prognostic indicator of mortality [Uremic Cardiomyopathy – Echo]

• Anemia & AVF may contribute to LV abnormalities [improved by erythropoietin]
• Patients on dialysis with residual renal function [24 h urine volume >100 ml]
  
  – Lower mortality risk
  – Reduced intradialytic weight gain
  – Improved solute clearance in haemodialysis

Hypertension

• Goals of therapy for hypertension:
  – To slow the progression of the kidney disease itself
  – Prevent the extrarenal complications of high blood pressure, such as cardiovascular disease and stroke

• Antihypertensives -
  – If SBP $\geq$140 mm Hg, DBP $\geq$ 90 mm Hg, or both
  – Unless the urine protein : creatinine ratio is $>$100 mg / mmol, when a threshold of 130/80 mm Hg is advocated.
  – $<125/75$ mm Hg - patients with proteinuria of $\geq$ 1 g/24 h

• ACEI and ARBs have a major prognostic benefit in proteinuric renal disease

• Erythropoietin increases blood viscosity and vascular resistance - may aggravate hypertension

• Cyclosporine and corticosteroids may also induce hypertension in renal transplant recipients
Diabetes mellitus

- Patients with type – II DM & H/o myocardial infarction, stroke, stroke, peripheral gangrene have a worse prognosis than who did not have a h/o vascular complications

- Other problems with diabetes
  - Stiff joint syndrome
  - Autonomic neuropathy
  - Peripheral neuropathy
  - Electrolyte imbalance
  - Diffuse atherosclerosis
  - Hypo/ hyper glycemia
  - ketoacidosis
Haemostasis and Coagulation

• Platelet dysfunction (uraemic thrombocytopeny or thrombasthenia)
• Preoperative dialysis improves platelet function
• Residual anticoagulation after HD
• Impaired prothrombin consumption contribute to the clotting defects
Haemostasis and Coagulation...

- Thromboelastography - show that all aspects of coagulation are increased, including initial fibrin formation, fibrin–platelet interaction, and qualitative platelet function, also a reduction in fibrinolysis.

- Vascular access thrombosis is of particular importance in patients with Stage 5 CKD on HD as it is associated with an increased mortality.

- In emergent procedures:
  - Intense dialysis
  - Conjugated estrogen -0.6mg/kg/day IV or PO 3hrs before surgery - more effective than FFP, Cppt, desmopressin
  - Desmopressin [DDAVP] – 0.3µ/kg iv or nasal spray , 1hr before surgery , peak – 1-2 hrs, duration – 6-12 hrs
  - Cryoprecipitate 10 units IV over ½ hr , effect
Anemia

- Normocytic, normochromic anemia - observed when the GFR falls below 30 mL/min and is due to insufficient production of erythropoietin
- Other factors:
  - iron deficiency
  - repeated laboratory testing
  - blood retention in the dialyzer
  - gastrointestinal bleeding
  - ↓ RBC survival due to toxic radicals
  - Uremic marrow suppression
Anemia...

• Human recombinant erythropoietin (50 to 75 IU/kg subcutaneously triweekly) normalizes the haematocrit, avoids repetitive red cell transfusion, reduces the requirement for hospitalization, and decreases cardiovascular mortality by about 30%

• Many patients on dialysis with 25% Hct. tolerate treadmill exercise, suggesting compensatory mechanisms
  • ↑ cardiac output
  • Right shift of $O_2$- Hb dissociation curve due to ↑ 2,3-DPG

• Avoid blood transfusion – if Hct >25%
Respiratory System

• Pulmonary edema
  – Hypoalbuminemia
  – Fluid overload
  – Increased permeability of alveolar capillary membranes ["low-pressure" pulmonary edema]- characterized radiologically by peripheral vascular congestion giving rise to a "butterfly wing" distribution

• Pleural effusion

• ↑ incidence of atelectasis - ↓ surfactant production

• Abdominal distension and diaphragmatic elevation[ ascites, CAPD] compromise ventilation

• Immunosuppression predisposes to tuberculosis and bacterial pneumonia
Autonomic neuropathy

- Common in patients with CKD and may have significant effect on arterial pressure perioperatively

- A prevalence of 65% in non-diabetic predialysis CKD patients has been noted, whereas studies of patients with CKD on HD have revealed a prevalence of 38% - 87.5%

- Delayed gastric emptying may be present in up to 69% of patients

- Etiology - uraemia, diabetes mellitus, hyperparathyroidism

- Autonomic dysfunction associated with CKD is characterized by
  - reduced baroreceptor sensitivity
  - sympathetic overactivity
  - parasympathetic dysfunction

- ↑angiotensin II and deafferentation of the baroreceptors may be responsible for the increase in sympathetic tone. Treatment with ACE inhibitors corrects this sympathetic overactivity
**Fluid and electrolytes**

- Patients with CKD develop fluid overload early and this may be a stimulus for inflammation and accelerated progression of renal disease.
- Impaired ability to excrete a sodium load predisposes these patients to volume overload.
- Infusion of large volumes of saline will also result in hyperchloreaemic metabolic acidosis – depression of myocardial contractility, reduced cardiac output, and reduced renal blood flow.
- If access to free water is restricted in the perioperative period, the inability to concentrate urine will result in hypernatraemia and hypertonicity.
- In managing patients on dialysis, the anaesthetist should establish the patient’s dry weight and compare it with their weight immediately before coming to OR.
Electrolyte Disturbance

• Hyponatremia-Urinary loss, Salt restriction, Vomiting
• Hyperpotassemia- esp. if oliguria +
• Hypermagnesemia – mild, sec to antacids, \( \downarrow \) renal exc., (CNS & myoc & N-M depression)
• Hyperphosphatemia- (Ca X PO4 = >60)
• Hypocalcaemia – (sec to \( \uparrow \) PO4 & \( \downarrow \) GI absorption)& Metastatic deposition- common, no s/s (except if alkalosis+)
• Metabolic acidosis - H+ retention

Most disturbances improve with dialysis
Potassium balance

• Plasma potassium concentration usually remains normal until the onset of Stage 5 CKD - due to
  – an increase in the excretion of potassium per functioning nephron
  – increased output in the stool

• Risk of developing hyperkalemia
  – Acidaemia
  – Insulin deficiency
  – Hypertonicity
  – Drugs
Anti Hyperkalemic Measures

- In emergent procedures, if there is no time to dialysis – anti hyperkalemic measures can be started

- Calcium gluconate –
  - decreases membrane excitability
  - dose - 10 mL of 10% solution infused over 2–3 min
  - The effect begins within minutes but is short-lived (30–60 min)
  - can be repeated if no change in the electrocardiogram is seen after 5–10 min

- Insulin –
  - 10–20 U regular insulin and 25–50 g of glucose [hyperglycaemic patients should not be given glucose]
  - plasma $K^+$ will fall by 0.5–1.5 mmol/L in 15–30 min
  - the effect will last for several hours

- NaHCO$_3$ -
  - IV 3 ampoules per liter (134 mmol/L NaHCO$_3$) reserved for severe hyperkalemia associated with metabolic acidosis
  - Patients with end-stage renal disease seldom respond to this intervention and may not tolerate the Na$^+$ load and resultant volume expansion

- $\beta_2$-adrenergic agonists –
  - parenterally or nebulized form $\beta_2$-adrenergic agonists
  - onset of action is 30 min
  - lowering the plasma $K^+$ concentration by 0.5 to 1.5 mmol/L
  - the effect lasts 2–4 h
Anti Hyperkalemic Measures

• Removal of $\text{K}^+$ can be achieved with
  – Diuretics
  – cation-exchange resin
  – dialysis

• Sodium polystyrene sulfonate –
  – cation-exchange resin
  – 25–50 g mixed with 100 mL of 20% sorbitol to prevent constipation
  – $\downarrow \text{K}^+$ by 0.5–1.0 mmol/L within 1–2 h and last for 4–6 h
  – also be administered as a retention enema 50 g of resin and 50 mL of 70% sorbitol mixed in 150 mL of tap water
  – The sorbitol should be omitted from the enema in postoperative patients due to the increased incidence of sorbitol-induced colonic necrosis, especially following renal transplantation

• Hemodialysis –
  – most rapid and effective way of lowering the plasma $\text{K}^+$ concentration is hemodialysis
  – This should be reserved for patients with renal failure and those with severe life-threatening hyperkalemia unresponsive to more conservative measures

• Peritoneal dialysis
  – only 15–20% effective as hemodialysis
Other problems

• Airway –
  – SLE
  – Rheumatoid arthritis

• Vascular access
  – permanent
    • arteriovenous fistulae (AVF)
    • arteriovenous grafts (AVG)
  – temporary
    • short-term non-cuffed catheters <1 week, right internal jugular vein is the preferred
    • long-term tunnelled cuffed catheters
Goals

• Preoperative period
  – Optimize fluid, acid-base & electrolyte status: dialysis
  – Hematocrit of at least 25%
  – Correct coagulopathy
  – Optimal blood pressure control
  – Aspiration prophylaxis
Goals . . .

• Intraoperative period
  – Prevent aspiration
  – Careful positioning
  – Avoid potential fistula sites while securing venous access
  – Select appropriate drugs
  – Use neuromuscular monitoring
  – Blunt intubation response
  – Maintain hemodynamic stability, euvolemia, careful fluid management
  – Hyperventilation to maintain baseline carbon dioxide levels
Goals.

- Postoperative period
  - Prevent aspiration
  - Blunt extubation response
  - Avoid respiratory depression
  - Ensure complete reversal of neuromuscular blockade
  - Extubate fully awake
Surgical procedures

1. Routine surgery
2. Laparoscopic surgery
3. AV fistula
4. Emergency surgery
5. Orthopedic procedures
6. Pregnancy
7. Renal Transplant
DIALYSIS

• Indications:
  – GFR <10ml/min or sr. creatinine of 8mg/dl
  – GFR <15ml/min or sr. creatinine of 6mg/dl [in diabetes patients]
  – Uremic symptoms {pericarditis, encephalopathy, Coagulopathy}
  – Fluid overload unresponsive to diuretics
  – Refractory hyperkalemia
  – Severe metabolic acidosis [pH <7.20]
  – Neurologic symptoms {seizures, neuropathy}
Dialysis concerns

• Hypotension
• Electrolyte deficit [hypokalemia, hyponatremia]
• ↓LVEF and new perfusion defects
• Hypoproteinemia
• Dementia
• Aluminum toxicity
• Dialysis disequilibrium syndrome
Ideal timing of dialysis

• Preop dialysis
  – Best scheduled the day before the surgery
• Goals
  – To optimize fluid status
  – To optimize electrolyte status
  – To decrease BUN < 100 mg/dl
Ideal timing of dialysis ...

• Avoid elective surgery on the same day of dialysis due to
  – Anticoagulation
  – Fluid shifts
  – Hypokalemia

• Delay in surgery > 48 hours of dialysis
  – Fluid overload
  – Hyperkalemia, acidosis
Preop Transfusion

• Indicated when hematocrit < 25%
• Transfuse during dialysis
• Problems
  – Infection
  – Fluid overload
  – Pulmonary oedema
Premedication

- Anxiolysis
- Aspiration prophylaxis
- Antihypertensives
- Antibiotics
Premedication...

• Anxiolysis
  – Benzodiazepines: most are highly protein bound, hypoalbuminemia → ↑sensitivity
  – Diazepam (Lipid soluble, bound to albumin)
    • Increased sensitivity due to increased free fraction
    • Longer t ½ of desmethyl diazepam, oxazepam (excreted in urine)
  – Midazolam
    • Water soluble
    • Vd, clearance and elimination t ½ are largely unaffected
Anxiolysis. . .

• Alprazolam
  – Decreased protein binding
  – Increased free fraction
  – Increased sensitivity

• Dexmedetomidine
  – Reduced protein binding
  – Longer lasting sedative effect
Aspiration prophylaxis – why?

• Gastro paresis
Aspiration prophylaxis – How?

• H2 blockers- dose has to be reduced
• Metoclopramide
  – Accumulates in renal failure
• Sodium citrate
Antihypertensives

• Continued perioperatively
  – Calcium channel blockers
  – Alpha 2 agonist clonidine
  – Beta blockers
  – Alpha blockers
  – ACE inhibitors
Monitoring

- Care of AV fistula
- 5 lead ECG
- NIBP
- Pulse oximetry - which hand?
- EtCO$_2$
- Neuromuscular monitoring

- ABG
- Temperature
- CVP, Invasive arterial pressure
- Urine output in non oliguric renal failure
Pulse oximetry

- Upper extremity arteriovenous fistula does not affect pulse oximetry readings

  *Avitsian R et al, Nephrology 2006*
Role of RSI

- CRF with diabetes or other risk factors for aspiration
Altered Renal Function and the Effects of Anesthetic Agents

- Most drugs employed during anesthesia partly dependent on renal excretion
- The systemic effects of azotemia potentiate the pharmacological actions
- Causes: decreased protein binding, greater brain penetration due to breach of blood-brain barrier, synergistic effect with toxins retained in renal failure
Barbiturates

- Renal disease $\rightarrow$ decreased protein binding
  $\rightarrow$ ↑free circulating barbiturates
  $\rightarrow$ ↑sensitivity

- Acidosis $\rightarrow$ ↑nonionized fraction $\rightarrow$ more rapid entry into the brain
Induction Agents

Thiopentone

- Drug of Choice
- Free drug fraction ↑ (56% vs 28%), altered protein binding, due to ↓ in albumin
- Slow administration
- No difference in sleep dose
- Total drug T1/2 el unaltered
- Free drug VDss, Clp unaltered
Induction agent

Propofol

• No change T1/2el, Clp
• 0.3% excreted unchanged, Hepatic & extrahepatic metabolism
• Induction dose of propofol associated with a bispectral index value of 50 is significantly higher in patients with established renal failure compared with controls
• The time interval between cessation of a propofol infusion and eye opening is significantly shorter in renal failure patients than in controls
Others ...

• **Etomidate**
  – Increased free fraction, Hypoalbuminemia → decreased protein binding of Etomidate → may enhance its effects

• **Ketamine**
  – Increase in heart rate & blood pressure
  – Elimination of norketamine reduced.
# Opioids

<table>
<thead>
<tr>
<th>Parent drug</th>
<th>Metabolite</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine</td>
<td>Morphine -3-glucuronide (70%)&lt;br&gt;Morphine -6-glucuronide (5%)</td>
<td>Antanalgesic&lt;br&gt;Potent analgesic- delayed onset sedation and respiratory depression</td>
</tr>
<tr>
<td>Pethidine</td>
<td>Norpethidine</td>
<td>Seizure, myoclonus, altered mental state</td>
</tr>
<tr>
<td>Oxycodone</td>
<td>Oxymorphone&lt;br&gt;Noroxycodeone</td>
<td>Prolonged half life</td>
</tr>
<tr>
<td>Codeine</td>
<td>-</td>
<td>Prolonged half life</td>
</tr>
</tbody>
</table>
## Opioids

<table>
<thead>
<tr>
<th>Parent drug</th>
<th>Metabolite</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fentanyl</td>
<td>Nil active</td>
<td>Reduced clearance, reduce dose 30-50%</td>
</tr>
<tr>
<td>Alfentanil</td>
<td>Nil active</td>
<td>Increased free fraction, reduce dose 30-50%</td>
</tr>
<tr>
<td>Remifentanil</td>
<td>Minimally active metabolite</td>
<td>Reduced clearance and prolonged elimination half life, reduce infusion rate</td>
</tr>
</tbody>
</table>
Neuromuscular blocking agents

• The initial dose required to provide neuromuscular blockade is higher than in controls
• The dose required to maintain the block is lower than in controls, except for atracurium & cisatracurium
Neuromuscular blocking agents

Vecuronium
• Active metabolites - 3, 17, & 3,17-desacetyl vec. excreted by kidneys
• 3-desacetyl vec → prolonged action
  – No difference in onset time or recovery index
Long duration of action - use with caution

Atracurium
• Elimination not dependent on liver, kidneys
• Pharmacokinetics unaltered
• Continuous infusion - prolonged action
• Metabolite laudanosine- seizures in dogs, not in man
Neuromuscular blocking agents

Rocuronium
- Metabolised in liver, 9% exc. by kidneys
- Altered drug distribution
- Systemic clearance normal

Mivacurium
- Metabolised by SChE
- Duration 1.5 times longer

Succinylcholine
- Avoid in hyperkalaemia (K$^+$ $>$ 5.5)
- Repeat doses - marked hyperkalaemia
- $\downarrow$ SChE - insignificant
Neuromuscular blocking agents

Cisatracurium

- 3-4 times more potent than atracurium
- No histamine release
- Weaker autonomic effects
- More CV stability than atracurium
- Undergoes Hofmann elimination
- 16% eliminated by kidneys
- In ESRD, slower onset of action, Clp ↓ by 13%
  T1/2 el ↑ by 14%
Volatile Agents

• Not dependent on kidneys for elimination
• Chronic renal failure with severe anemia (Hb < 5) $\rightarrow$ ↓blood:gas partition coefficient $\rightarrow$ accelerated induction
• Enflurane and Sevoflurane (with < 2 L/min gas flows) $\rightarrow$ fluoride accumulation $\rightarrow$ undesirable for patients with renal disease undergoing long procedures
Volatile Agents

Sevoflurane:

- Compound A – dose related nephrotoxin in rats
- < 4 MAC hours is NOT associated with increased risk of renal toxicity, serum inorganic fluoride levels & rate of elimination did not differ from controls
- Indices of renal tubular function do not significantly change after sevoflurane anesthesia

*Nishiyama et al, Anesth Analg 1996*
Volatile Agents

• Negligible fluoride production
  – halothane
  – Desflurane
  – Isoflurane

• Methoxyflurane > sevoflurane > enflurane > isoflurane > desflurane > 0
Volatile Agents

• Enflurane, methoxyflurane – flouride toxicity
• Desflurane, sevoflurane – safe
• Halothane – reduces RBF, cardiac depressant effect
• Isoflurane – preserves RBF, mild cardiodepressive effect, low renal toxicity

Anesthetic of choice
Reversal agents

• Neostigmine
  – renal excretion is the principle route of elimination, clearance is reduced and its half life is prolonged
  – This might result in bradycardia and AV block when used in combination with atropine rather than glycopyrrolate

• Sugammadex
  – Recurrence of NMB was not observed in any patient
  – No sugammadex-related serious adverse events were reported

*Staals et al, BJA oct 2008*
Anticholinergic Agents

Atropine & Glycopyrrolate

• Eliminated by the kidneys (20-50%)
• Single dose - accumulation insignificant but accumulation exists following repeated doses
• Can be used safely in renal impairment
Crystalloids: fluid overload
Fluid management

1. Assess preoperative volume status
2. Replacement of insensible loss
3. Replacement of blood loss
Assess volume status

- Look for oedema, elevated jugular venous pressure
- Examine chest x-ray – CT ratio and vascular pedicle width
- Compare current weight to pre and post dialysis weights to assess intravascular volume trends
- Estimate 24 hr urine volume
- Dialysis 12-24 hr prior to surgery
Fluid management...

- Avoid large volume of IV fluids
- Replace insensible loss
- Avoid potassium containing fluids in stage 5 CKD
- Ringer’s lactate - used till stage 4 CKD
- CVP guided fluid management
- No specific guidelines on target CVP for non transplant surgery
Use of HES

• Avoid high molecular weight and/or highly substituted HES (HES 450/0.7, HES 200/0.62)

• Medium molecular weight starches HES 200/0.5, 130/0.4 are more easily renally excreted

• Mean residual plasma concentration after 24 hours of infusion of HES 200/0.5 in normal volunteers was 1.5 mg/dl as compared to 4 mg/dl after infusion of HES(450/0.7)
Voluven (HES 130/0.4)

- Study in 19 volunteers with non-oliguric mild to severe renal dysfunction
- HES (130/0.4) can be safely administered to patients even with severe renal impairment, without risk of plasma accumulation

Jungheinrich et al, Anesth Analg 2002
# Fluid management...

<table>
<thead>
<tr>
<th>Maintenance fluid</th>
<th>30% of the calculated fluid rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Third space loss</td>
<td>1-2 ml /kg/hr</td>
</tr>
<tr>
<td>Blood loss</td>
<td>replace with colloid or RBC</td>
</tr>
</tbody>
</table>

*Miller’s textbook of anesthesia*
Fluid management...

Normal Saline

- $\text{Na}^+ - 154, \text{Cl}^- - 154$ mEq/L, pH – 6.0
- Osmolality – 308 mOsm/Kg
- Osmotic pressure – 5944 mmHg (plasma – 5620)
- Volume of distribution – PV+ ISFV (ECFV)
- 20% remains intravascular after equilibrium
- Out of 500 ml, 100 ml remains in PV, 400 ml shifts to ISFV
- Initial distribution of equilibrium time is 15-20 mins
Regional Anaesthesia

General Anaesthesia
Recommended Anaesthetic Technique

Induction
• Thiopentone/ propofol
• Fentanyl/ morphine
• Atracurium/ Vecuronium/ rocuronium/ succinylcholine
• ETT

Maintenance
• O₂ - N₂O, isoflurane, relaxant, opioids, IPPV

Reversal
• Glycopyrrolate - Neostigmine
Regional anesthesia

• No consensus on regional anesthesia in CRF
• Use of brachial plexus block for AV fistula
• Use of spinal, epidural for renal transplantation
• Prolonged bleeding time (> 15 minutes) is a contraindication
Neuraxial blocks...

- Onset of sensory block faster
  - Acidosis – increased free fraction
  - Reduced volume of epidural space – due to distension of epidural and spinal veins by hyperdynamic circulation

- Duration of sensory and motor blocks shorter by 20 %
  - Increased cardiac output causes faster washout of local anesthetic from its site of action
Concerns . . .

- Platelet dysfunction inspite of normal platelet count, PT, PTT, TT
- Residual effect of heparin
- Arrhythmias with epinephrine
- Toxicity due to increased free fraction
- Catheter site infection
- Hypotension with sympathetic block
- Acute pulmonary oedema when sympathetic blockade wears off
• Hypotensive epidural anesthesia in THR
  – 54 CKD patients
  – No patient had renal dysfunction within 24 hours of surgery

  Sharrock et al, BJA 2006

• Renal transplantation under combined general and epidural anesthesia
  • Epidural provided more effective postop pain relief as compared to tramadol
  • Respiratory function was less affected
  • No difference in hemodynamics, renal function

  Dauri M et al, Minerva Anestesiol. 2003
Neuroaxial blockade...

• Spontaneous epidural hematoma
  
  *Shahlaie k et al* *Pediatr nephrol* 2004

• Epidural hematoma following epidural catheter placement in a patient with CRF
  
  *Basta et al, CJA 1999*
Prevention of postop renal dysfunction

1. Maintain adequate oxygen delivery
2. Suppression of renovascular constriction
3. Renal vaso dilatation
4. Maintain renal tubular flow
5. Decrease oxygen demand
6. Attenuate ischemic reperfusion injury
Dopamine and Dopexamine

• Low dose Dopamine has been proved neither a reduction in acute renal failure nor an improvement in renal function in p’t with renal failure.

• It also did not demonstrate improved renal protection when used in cadaveric renal transplantation.

• Dopexamine has been shown some renal protection during aortic surgery but its potential benefit during renal transplant has not been evaluated.
Loop diuretics

- Effective against pigment nephropathy
- Shown to decrease the duration of oliguria and need for dialysis in ARF without effect on mortality
- No renoprotective effect after cardiac surgery

*Lassnigg et al, J Am Soc Nephrol, 2000*
Mannitol

• Osmotic diuretic
• Increased prostaglandin production – renal vasodilatation
• Free radical scavenger
• No difference in postoperative creatinine clearance

Calcium channel blockers

- Renal vasodilatation
- Beneficial effect on postoperative renal function and renal tubular integrity
Fenoldopam

• Selective DA1 agonist
• Vasodilatation, increased renal blood flow, natriuresis, reduced oxygen utilisation
• Renoprotective effect
• Dose : 0.03 – 0.05 µg/kg/min
Pregnancy & CRF

• Concerns in antenatal period
  – Increase dialysis duration
  – Use of low bicarbonate dialysis
  – Double dose of EPO & target Hct 30 – 35%
Pregnancy & CRF . . .

• Concerns during delivery/CS
  – Hypertension/ preeclampsia
  – Fluid overload, pulmonary oedema, CHF
  – Heparin used during dialysis
  – Reduced pseudocholinesterase
  – Use of vasopressors for hemodynamic stability
Pregnancy & CRF…

• Pregnancy in hemodialysis dependent end stage renal disease
  – G3P0, wegener’s, H/O two unsuccessful transplants on 14 hour/week hemodialysis
  – Dialysis duration increased from 14 – 21 hr/wk
  – Serum bicarbonate maintained between 18 – 20 mEq/L using low bicarbonate dialysate
  – Received EPO, iron, calcium, folate
  – Labour analgesia & epidural anesthesia for CS
  
Dhir et al, CJA 2007
Care of Fistula / Shunt

- DO NOT INJECT
- DO NOT CANNULATE VEIN OR ARTERY ON THAT SIDE
- Cover it with a light bandage
- Do not apply BP cuff on the side
- Hypotension can block the fistula/shunt
- Allow adequate circulation in that arm
- Do not flex or over extend
Thank you

Questions
Comments

Dr Rakesh Garg
E Mail: drrgarg@hotmail.com
Mobile - 09810394050