Syllabus of training objectives for nephrology trainees

Medical Expert Role

Table of Contents:

Colour coding:
Blue: pediatric content

Physiology

At the end of their rotation in Consultative Nephrology, the nephrology subspecialty resident should be able to:

1. General Anatomy and Physiology
    a Describe the embryology of the kidney with particular emphasis on nephron development.
    b Describe basic renal anatomy
    c Describe the effects of pore size and electrical charge of the glomerular filtration barrier on the filtration of various solutes.
    d Describe the regulation of renal blood flow under both normal and hypoperfused states.
    e Describe how variations in glomerular capillary hydrostatic pressure, plasma flow rate, plasma protein concentration, and ultrafiltration coefficient affect GFR.
    f Describe the effects of changes in afferent and efferent arteriolar resistance, and colloid osmotic pressure, on GFR.
    g Describe the effects of the renin-angiotensin-aldosterone system, prostaglandins, and the sympathetic nervous system on renal hemodynamics and GFR.
    h Define the concept of transport maximum.
    i State the major principles of handling of organic substances, including glucose and amino acids, protein, urea, organic anions and cations.
    j Describe sodium, chloride, and water handling at each segment of the nephron under normal conditions, and during hyper- and hypovolemia.
    k Describe the factors that govern renal potassium excretion and extrarenal transcellular movement of potassium.
    l Describe potassium handling at each segment of the nephron.
    m Describe bicarbonate, proton, ammonium, and titratable acid handling at each segment of the nephron.
    n Describe the general regulation of the carbon dioxide and bicarbonate buffer system.
    o Describe anticipated changes in renal histology with aging
    p Know and understand the renal physiologic changes that occur at birth, during the neonatal period (for both pre-term and term infants) and in early infancy, including maturational changes in changes in GFR, vasoregulatory mechanisms, water, sodium, potassium, bicarbonate and hydrogen ion transport
2. Edema
    a Describe the physiology of edema formation, including Starling's forces, capillary permeability, and role of the kidney.
    b Generate a differential diagnosis, and demonstrate a diagnostic approach for both localized and generalized edema.
    c Describe the signs, symptoms, pathogenesis and management of neonatal hydrops fetalis
    d Describe the goals and principles of edema management, including diet, pharmacotherapy, and plasma expanders.

3. Electrolyte and Free Water Disorders
    a Salt and water
        i Describe the physiology of salt and water homeostasis in health.
        ii Describe the physiology of salt and water homeostasis in volume disorders and sodium concentration disorders (hypo/hypernatremia).
        iii Generate a differential diagnosis for hypo/hypernatremia that categorizes the various entities according to volume status and osmolality status. This list should include:
            1 Hypovolemic hyponatremia
            2 Euvolemic hyponatremia – SIADH, medications, endocrine
            3 Hypervolemic hyponatremia
            4 Hypovolemic hypernatremia
            5 Euvolemic hypernatremia – nephrogenic and central diabetes insipidus (partial and complete)
            6 Hypervolemic hypernatremia
        iv Demonstrate a diagnostic approach to salt and water disorders.
        v Describe the complications of salt and water disorders.
        vi Describe the acute and chronic management of salt and water disorders, including the complications of therapy.

    b Potassium

        i Describe the physiology of potassium homeostasis in health and hypo/hyper-kalemic states.
        ii Generate a differential diagnosis for hypo/hyperkalemia that categorizes the various entities according to mechanism (intake, loss, transcellular shift). This list should include:
            1 Hypokalemia with decreased intake
            2 Hypokalemia with shift – medications, alkalosis
            3 Hypokalemia with increased GI loss
            4 Hypokalemia with increased renal loss – renal artery stenosis, reninoma, Conn's, Cushing's, Liddle, Bartter, Gitelman and Fanconi syndromes, diuretics, anionuria, hypomagnesemia, renal tubular acidosis (RTA) types 1 and 2
            5 Hyperkalemia with increased intake (in conjunction with other factors)
            6 Hyperkalemia with shift – medications, acidosis, insulin deficiency
            7 Hyperkalemia with decreased renal loss – hypoaldosteronemic states, Gordon's, RTA type 4, potassium sparing diuretics
        iii Demonstrate a diagnostic approach to potassium disorders.
        iv Describe the complications of potassium disorders.
        v Describe the acute/emergent management of potassium disorders, with specific reference to electrocardiographic changes.
        vi Describe the chronic management of potassium disorders.

c Acid Base Disorders

i Describe the physiology of acid/base homeostasis in health, metabolic acidosis and alkalosis, and respiratory acidosis and alkalosis.
ii Demonstrate a diagnostic approach to simple and complex acid/base disorders. This list should include:
    1 Wide anion gap metabolic acidosis
    2 Normal anion gap metabolic acidosis
        a GI
        b Renal tubular acidosis
    3 Chloride responsive metabolic alkalosis
    4 Chloride resistant metabolic alkalosis
    5 Respiratory acidosis and alkalosis
    6 Mixed acid-base disturbances
iii Generate a differential diagnosis for the etiologies of the various acid/base disorders.
iv Describe the complications of the various acid/base disorders.
v Describe the acute and chronic management of the various acid/base disorders.

d Calcium Phosphate and Magnesium Disorders

i Describe the physiology of calcium/phosphate/magnesium homeostasis in health and in disease states such as hypo/hypercalcemia, hypo/hypermagnesemia, and hypo/hyperphosphatemia, including the hereditary disorders: X linked dominant hypophosphatemic rickets, autosomal dominant hypophosphatemic rickets, autosomal recessive hypophosphatemic rickets, hereditary hypophosphatemic rickets with hypercalciuria, vitamin D dependent rickets and vitamin D resistant rickets.
ii Demonstrate a diagnostic approach to calcium, magnesium, and phosphate disorders.
iii Generate a differential diagnosis for each of the calcium, magnesium, and phosphate disorders.
iv Describe the complications of each of the calcium, magnesium, and phosphate disorders.
v Describe the management of each of the calcium, magnesium, and phosphate disorders.

Hypertension:

1. Definition:
    a. Describe the criteria for diagnosis of hypertension
        i. as per the JNC7 classification scheme in adults
        ii. As per the National High Blood Pressure Education Working Group on High Blood Pressure in Children and Adolescents
        iii. In preterm and term neonates and early infancy
        iv. Using ambulatory blood pressure monitoring (ABPM)
    b. Differentiate primary vs. secondary causes of hypertension
    c. **Differentiate** hypertensive urgency and emergency

2. Etiology:
    a. Demonstrate an understanding of proposed mechanisms of essential hypertension.
    b. Demonstrate understanding of the physiology behind secondary causes of hypertension including:
        i. Hyperaldosteronism
        ii. Renal artery stenosis
        iii. Pheochromocytoma
        iv. Hypertension induced via cortisol or desoxycorticosterone, including inherited disorders
        v. Hypertension associated with pregnancy
        vi. Renal failure
        vii. Coarctation
        viii. Renal parenchymal disease
    c. Know and understand the complications of sustained hypertension

3. Diagnosis:
    a. Demonstrate correct technique for measurement of BP, including ABPM
    b. Assess the hypertensive patients for evidence of end organ damage
    c. Demonstrate the selection and interpretation of appropriate tests for routine evaluation of non-urgent hypertension in end organ damage
    d. Demonstrate selection and interpretation of special tests used in the evaluation for secondary causes of hypertension

4. Therapy:
    Demonstrate understanding of
    a. The therapeutic targets for BP lowering and their rationale
    b. Lifestyle maneuvers that may be effective in treatment of hypertension
    c. Indications for initiation of drug therapy and appropriate selection of specific agents based on clinical criteria.
    d. Mechanisms of action and side-effects of the major anti-hypertensive drug classes
    e. Unique challenges of hypertension treatment in the newborn
    f. Appropriate therapy and targets for hypertensive urgencies and emergencies
    g. The role of interventional radiology and surgical therapy in hypertension treatment

Acute Renal Failure and ICU Nephrology:

1. Definition:
    a. The trainee will be able to define acute renal failure and will understand current accepted classification schemes of staging for severity

2. Epidemiology:
    a. The trainee will have an understanding of the most common causes of acute renal failure in Canada and differentiate based on ambulatory or hospitalized occurrences.
    b. The trainee will recognize risk factors predisposing patients to acute renal failure.
    c. The trainee will appreciate prognostic implications of episodes of acute renal failure on long term renal function and patient survival

3. The trainee will be able to describe the pathophysiology of acute renal failure and provide an appropriate differential diagnosis in each setting, including:
    a. Mechanisms of pre-renal failure, including volume depletion, cardio-renal syndrome, hepatorenal syndromes.
    b. Intrinsic renal disease
        i. Acute glomerulonephritis: including causes of rapidly progressive glomerulonephritis (e.g. ANCA, complement, anti-glomerular basement membrane antibody mediated)
        ii. Acute tubular necrosis
            - Ischemic: e.g. hypovolemic, sepsis
            - Nephrotoxic: contrast, light chain, myoglobin, drug-induced (i.e. aminoglycoside) nephropathies
        iii. Acute interstitial nephritis
        iv. Vascular: e.g. cholesterol emboli, scleroderma renal crisis, TTP/HUS, malignant hypertension
        v. Post renal causes: prostatism, stones, neurogenic bladder, etc.

4. The trainee will be able to describe a differential diagnosis for a patient with acute renal failure.

5. The trainee will be able to describe and interpret appropriate investigation of acute renal failure including:
    a. Biochemistry
    b. Appropriate use of vasculitic screening serologies
    c. Evaluation of urine sediment
    d. Radiologic investigations
    e. Indications for renal biopsy

6. The trainee will be able to discuss the metabolic consequences/complications of acute renal failure including:
    a. Electrolyte and acid base imbalances
    b. Volume overload
    c. Nutritional complications of acute renal failure.

7. Risk Factors and Prevention:
    a. The trainee will recognize clinical factors predisposing patients to acute renal failure
    b. The trainee will understand interventions that may be undertaken to reduce occurrence of acute renal failure.

8. Treatment:
    a. The trainee will have an approach to treatment of major complications of acute renal failure including:
        i. Volume overload
        ii. Electrolyte imbalances
        iii. Acidemia
        iv. Nutritional requirements
    b. The trainee will be able to recognize indications and complications of acute renal replacement therapies including continuous renal replacement therapy (CRRT), and write appropriate acute hemodialysis and peritoneal dialysis prescriptions
    c. The trainee will be able to differentiate the advantages and disadvantages for each of the modalities of acute renal replacement therapy.
    d. The trainee will understand the appropriate prescription of modified hemodialysis techniques including sustained low efficiency dialysis and CRRT.
    e. The trainee will learn the techniques for insertion of temporary hemodialysis central venous catheters and potential complications of insertion
    f. The trainee will know how to modify drug dosages in acute renal failure
    g. The trainee will understand the unique challenges of providing acute renal replacement therapy for neonates, infants, and small children including choices of access, flow rates, extracorporeal circuit and dialyzer sizes.

9. Poisonings

    The trainee will have a diagnostic and therapeutic approach to a patient of suspected overdose of:
    a. Lithium
    b. Salicylates
    c. Alcohols, i.e. methanol, ethylene glycol
    d. Theophylline

    These should include:
    a. Focused history on physical examination directed at identifying etiology and consequences of poisoning.
    b. Interpretation of toxicology screens – anion and osmolal gaps, recognizing products of alcohol in the metabolism, and potential clues in urinalysis.
    c. Understand the pharmacokinetics of removal by hemodialysis or hemoperfusion of these agents.
    d. Identify the indications for acute dialysis in the poisoned patient and appropriate monitoring.

Chronic Kidney Disease

1. Definition of CKD
    a. Define the different stages of CKD
    b. Describe different methods to assess renal function
        i. eGFR determinations based on creatinine (Cockcroft-Gault, MDRD study, Schwartz (children)**)**
        ii. eGFR determinations employing plasma cystatin C levels
        iii. Creatinine clearance
        iv. DPTA GFR
        v. Inulin clearance

2. Etiology
    a. Describe the etiologies and pathogenesis for CKD including
        i. Congenital
            1. Structural anomalies
                a. Dysplasia
                b. Multi-cystic dysplastic kidney
                c. Posterior urethral valves/obstructive uropathy
                d. Hypoplasia
            2. Congenital nephrotic syndrome

        ii. Inherited
            1. Autosomal recessive polycystic kidney disease
            2. Autosomal dominant polycystic kidney disease
            3. Alport Syndrome
            4. Hereditary nephrotic syndromes
                a. Familial FSGS
                b. Congenital nephrotic syndromes
                c. Nail-patella syndrome
            5. Juvenile nephronophthisis/medullary cystic disease
            6. Glomerulocystic disease
            7. Cystinosis
            8. Primary hyperoxaluria
            9. Hereditary forms of haemolytic uremic syndromes
        iii. Acquired
            1. Glomerular
                a. FSGS
                b. IgA nephropathy/Henoch Schonlein Purpura
                c. Lupus
                d. Membranoproliferative glomerulonephritides
                e. Cryoglobulinemia
                f. Membranous nephropathy
                g. Amyloidosis
                h. Dysproteinemias

2. Vascular
    a. Cholesterol atheroembolic disease
    b. Hypertension – nephrosclerosis
    c. Renovascular disease
    d. Vasculitis
        i. Wegener's disease
        ii. Good pasture's disease/ anti-GBM disease
        iii. Microscopic polyarteritis
3. Interstitial
    a. Drug induced
        i. NSAIDs
        ii. Lithium
    b. Immune-mediated
4. Diabetes
5. Hypertension
6. Hemolytic uremic syndrome/Thrombotic thrombocytopenic purpura
7. Chronic pyelonephritis
8. Secondary to systemic disease
    a. Liver disease
    b. Heart failure
    c. HIV infection
    d. Sickle cell disease
    e. Cancer and /or its therapies (chemotherapy, radiation)

3. Epidemiology
    a. Describe the epidemiology of CKD in Canada and internationally including incidence, prevalence/etiology/survival using CORR, KDOQI data and NAPRTCS data in children
    b. Screening for CKD in the general population methods

4. Management
    a. General management
        i. Treating reversible causes of CKD including hypoperfusion, nephrotoxic medications, obstruction
        ii. Management to slow progression to ESRD including control of proteinuria, hypertension, diabetes, smoking cessation, metabolic acidosis and hyperlipidemia
        iii. Management of complications of CKD
            1. Describe CSN/KDOQI guidelines for management of anemia in renal disease including:
                a. Appropriate investigation of anemia
                b. Appropriate iron management
                c. Guidelines for initiation of monitoring/dosing of erythropoietic agents, therapeutic targets
                d. Complications of medications used for anemia management

e. Possible alternative treatments for anemia

2. Describe Calcium-Phosphate metabolism in CKD including:
    a. Comprehensive knowledge of renal bone disease – pathophysiology, phosphate binders, vitamin D and analogues, parathyroidectomy, calcimimetics
3. Describe the unique nutritional issues in CKD including
    a. Diagnosis and management of malnutrition and its effect on survival
    b. Renal dietary modifications and limitations
    c. Nutritional and vitamin supplements
    d. Obesity effects on CKD
4. Describe fluid overload and hypertension management in CKD patients
    a. Dietary modifications
    b. Diuretic therapy
    c. Blood pressure targets in different disease states
    d. Anti-hypertensive management
    e. Complications of hypertension in CKD patients
5. Describe the cardiovascular disease in CKD patients
    a. CVD outcomes in CKD patients
    b. Relationship of CKD in childhood to development of vascular disease and atherosclerosis in early adulthood
    c. CVD risk factors
        i. Lipid management
        ii. Vascular calcification
        iii. Hypertension
        iv. DM control
        v. Smoking

b. Pediatric specific management
    i. Growth and endocrine disturbances in children with CKD
        1. *Recognize and understand*
            a. The pathogenesis of impaired linear growth with CKD
            b. Evaluation of growth patterns and growth potential
            c. The differential roles of nutrition and growth hormone on linear growth at different ages
            d. How to evaluate sexual maturation
            e. Treatment options and potential complications of rhGH

    ii. Nutrition
        1. *Recognize and understand*
            a. The impact of CKD on appetite
            b. Abnormalities of gastrointestinal system which accompany CKD in children

c. Role of sodium supplementation in infants with renal dysplasia or obstructive nephropathy
d. Indications for nasogastric or gastrostomy feeding
e. Clinically and age-appropriate dietary requirements and manipulations for children with progressive CKD

iii. Neurocognitive development
1. Recognize and understand
a. The potential impact of CKD on neurodevelopment
b. Risk factors for developmental dysfunction
c. Educational issues in the child with CKD

iv. Psychosocial and ethical issues in children with CKD

v. Vaccinations
1. Understand the differing vaccination requirements and doses in children with CKD in terms of
a. Immune function and responsiveness
b. Accelerated vaccine schedules pre- transplantation
c. Vaccines which are contraindicated post transplant

vi. Transition to adult care: know and understand
1. The difference between transition and transfer
2. The steps involved and timing for transition preparation, readiness assessment and the transfer process, including
a. Roles of the parent, health care team and patient in the process
b. Adequate verbal communication with and a written documentation for the adult team
c. Adequate written documentation for the patient (personal health care summary or "passport")
3. Factors which may influence adherence in the adolescent patient with CKD or ESRD
4. Special considerations for the pediatric patient with multiple disabilities or cognitive delay, including preparation for surrogate decision making

5. Prognosis
a. Describe the long-term prognosis of CKD including progression to ESRD and mortality
b. Describe risk factors for progression to ESRD

6. Indications for renal replacement therapy
    a. Describe the options for RRT including LRD/DD transplant, peritoneal dialysis, hemodialysis, no treatment
    b. Describe the indications for chronic dialysis including GFR estimates, "uremic" symptoms (such as pericarditis, pleuritis, CNS involvement (confusion, motor neuropathy, comatose, seizures, tremor, asterixis), persistent nausea/vomiting) , fluid overload, persistent metabolic derangements, malnutrition/failure to thrive, impaired growth
    c. Describe situations in which dialysis may not be offered

7. Preparation for dialysis
    a. Describe the advantages and disadvantages of each dialysis modality including: dietary restrictions, access, location of dialysis centre, travel, comorbid conditions, convenience, patient age, home situation
    b. Describe contraindications to dialysis modalities
    c. Preparation for dialysis modality including modality selection, securing access, psycho-social assessment
    d. Describe the special considerations in modality selection for children, particularly infants and small children who live far from a pediatric dialysis centre

Hemodialysis

1 Describe the epidemiology of ESRD in your province vs. Canada vs. World – incidence/prevalence/etiology/survival/CORR data. Demonstrate understanding of the cost of therapy.

2 Describe the provision of renal care and in particular Renal Replacement Therapy in your province.

3 Describe the indications for acute and chronic dialysis.

4 Demonstrate comprehensive knowledge of hemodialysis prescription to include:
- Various modalities/descriptive terms – diffusion, convection, ultrafiltration, CRRT, IHD.
- Compare and contrast acute and chronic dialysis modalities.
- Dialysis membranes – material, surface area, KUF, KOA, cost, re-use, sterilization, adverse effects.
- Dialysate – including temperature, fluid composition
- Anticoagulation.
- Assessing dry weight.
- Delivery system/circuit.
- The principles of water treatment for dialysis.

  How to calculate dialyzer and extracorporeal circuit size, blood flow rate, and dialysate flow rate and temperature and ultrafiltration rate for patients of different sizes and different ages, including the newborn and infant

5 Describe vascular access management including:
- Knowledge of different types of vascular access. Strengths and weaknesses of each type.
- Understand all aspects, including principles, of vascular access monitoring – recirculation, dynamic venous pressure monitoring, access flow, etc.
- Current management guidelines for thrombolytics, and treatment of vascular access infections.
- Consider attending OR with surgeon or radiology suite with interventional radiologist.

6 Describe CSN/DOQI guidelines for management of anemia in renal disease including:
- Appropriate investigation of anemia.
- Appropriate iron management.
- Guidelines for initiation of monitoring/dosing of Erythropoietic agents (EPO or Darbepoetin).
- Alternative treatment options – Vitamin C, Carnitine, Deca-Durabolin.

7 Describe Calcium – Phosphate metabolism in renal failure including:
- Comprehensive knowledge of renal bone disease – pathophysiology, extensive reading of literature dealing with phosphate binders, Vitamin D and analogues, surgical parathyroidectomy, calcimimetics, etc.
- Aluminum toxicities – diagnosis and management.

8 Describe how adequacy of Dialysis adequacy is determined including:
- Definitions of adequacy (toxin clearance, acid-base status, etc.)
- Describe how Kt/V is measured.
- Define urea kinetic modeling including an explanation for URR, Kt/v (single & double pool), and its limitations.
- Management strategies to improve Kt/v, and/or dialysis adequacy.
- Contrast clearance and assessment of small molecules vs. middle molecules.

9 Describe the role of nutrition in the management of ESRD patient including:
- Diagnosis and management of malnutrition/effect on survival.
- Intradialytic TPN.
- Renal diet content and limitations.
- Vitamin supplements.
- Linear growth for infants and children (See details in Pediatric CKD section)

10. Describe the complications of dialysis treatment, their prevention and management, including:
A) Hypotension and hypertension.
- Causes and complications.
-Therapies (sodium/fluid profiling, dialysate temperature modification, pharmacotherapy, etc.).
B) Dialyzer reactions.
C) Arrhythmias.
D) Disequilibrium.
E) Symptomatic Issues: headache, nausea, muscle cramps
F) Air embolism
G) Hypoxemia
H) Blood leak

11 Describe hypertension/cardiovascular disease in ESRD including unique modifications for renal function:
- Antihypertensive therapy.
- Lipid lowering.
- Other traditional and non-traditional risk factors.

12 Describe the systemic complications of ESRD including:
- Uremic bleeding.
- Serositis (pericarditis, pleuritis, and ascites).
- Sexual dysfunction.
- Amyloid.
- Depression/sleep disorders.
- Movement disorders.
- Screening for neoplasms.

13 Describe the management of systemic diseases in ESRD patients including modifications for renal function:
- Diabetes mellitus.
- Arthritis.
- Pain management.
- Infections.

14 Describe the role of Allied Health Personnel in the management of ESRD patients. In particular, describe their roles in assessment of quality of life, life skill assessment and modification, vocational rehab, anxiety management, and initiation/cessation of RRT.

15 Describe principles of drug dosing in renal failure.

16. Describe the indications, potential benefits and associated risks, and prescription of extended hours/home hemodialysis.

17. Describe the role of hemodialysis in the treatment of neonatal metabolic disorders

Peritoneal Dialysis

1. The resident will understand evaluation and selection of patients for peritoneal dialysis.

2. The resident will demonstrate knowledge of the principles of peritoneal dialysis (PD):
   a) understand the principles of ultrafiltration, diffusion, and convective solute transport
   b) understand peritoneal membrane structure and physiology, including the layers, pore sizes, and relationships to dextrose concentration, dwell time, and clinical outcomes
   c) describe how the peritoneal equilibration test is performed and its results applied to the clinical situation to assist in the choice of modality and dialysis prescription
   d) Understand the use of intra-peritoneal pressure measurement to help select the optimal fill volume

3. The resident will understand concepts of adequacy of peritoneal dialysis including:
   a) the importance of residual renal function and management strategies to maintain residual renal function
   b) the importance and clinical assessment of volume control and its management
   c) the importance and clinical assessment of nutritional status and its management
   b) the measurement of dialysis adequacy, including Kt/V and creatinine clearance
   d) current guidelines for adequate dialysis

4. The resident will demonstrate knowledge of the mechanical aspects of peritoneal dialysis:
   a) describe the indications, technique, limitations, and prescriptions for the peritoneal dialysis options (CAPD, NIPD, tidal PD and CCPD)
   b) describe how the various procedures available are performed and taught to the patient
   c) prescribe the appropriate dialysis (number of exchanges, volume/exchange, length of dwell time, dialysis dextrose and calcium concentration) for each clinical situation.
   d) discuss the constituents of commercial dialysis solutions and the effects (short and long-term) on peritoneal membrane function

5. The resident will demonstrate knowledge of the peritoneal dialysis catheter
   a) describe the different types of dialysis catheters available and the standard insertion techniques - the resident is not required to demonstrate proficiency in the actual insertion of the catheters.
   b) Compare /contrast the different types of PD catheters in terms of shape, cuff(s), placement for all pediatric age groups (neonates, infants, children, adolescents)
   c) manage patients with a newly placed catheter, including the options of delay of dialysis, low volumes, cycler dialysis, or temporary hemodialysis
   d) describe the indications for catheter removal

6. The resident will be able to describe the pathophysiology, investigation and management of the following complications of peritoneal dialysis:
   a) exit site and tunnel infections
   b) peritonitis
   c) leaks
   c) hernias

d) inadequate drain
e) ultrafiltration failure
f) sclerosing peritonitis
g) altered bowel function
h) obesity and cachexia
i) Shoulder pain
j) Blood in dialysate effluent
k) Metabolic abnormalities

7. The resident will be able to describe the pathophysiology and management of long-term complications of PD including: renal osteodystrophy, hypertension, lipid abnormalities, anemia, cardiac dysfunction, nervous system dysfunction and hypercalcemia.

8. Infectious complications of peritoneal dialysis: the resident will know
   a) How to prevent, diagnose and treat PD infectious complications
   b) Different drug dosing methods for peritonitis in adult and pediatric patients
   c) Short and long-term complications of infection
   d) Significance of elevated peritoneal leukocyte count in context of negative culture

9. The resident will know PD outcome, including rates of mortality and technique failure.

10. The resident will understand diabetic patient management on PD, including their insulin

11. Nutrition and growth in children: *the resident will know and understand*
   a) The assessment of nutritional status and electrolyte balance
   b) The nutritional management of infants treated with peritoneal dialysis (value of nasogastric and gastrostomy feeding and potential complications on PD)
   c) Also see section on nutrition in pediatric CKD section

12. The resident will understand the impact of PD upon the individual and their family and be able to determine the functional status of the patient with respect to the capability of performing PD. They should be able to discuss social, ethical, and legal issues around the appropriate initiation and withdrawal of peritoneal dialysis.
   The resident will understand the psychological and behavioural adjustments of the child on dialysis, including
   a) Potential alterations in normal cognitive development
   b) Problems imposed by dialysis upon school attendance and performance
   c) Peer group activities.

13. Drug therapy and clearances: The resident *will know and understand*
   a) Drug dosage adjustment methods to achieve appropriate levels in the dialyzed child and adult
   b) The impact of intra-peritoneally administered antibiotics upon blood concentrations in the child or adult receiving peritoneal dialysis
   c) The importance of drug binding and partition characteristics upon their removal by dialysis

Renal Transplantation

1. Basic Sciences
    a. Transplant immunology
        i. Describe the HLA system and its relevance to transplantation
        ii. Describe mechanisms of cell-mediated and antibody-mediated rejection including mechanisms of allo-recognition and the processes involved in the effector arms of the immune system
        iii. Transplant immunology laboratory
            1. Describe the techniques for HLA typing and their significance
            2. Describe techniques for anti-HLA antibody screening including PRA testing and cross matching
            3. Demonstrate the ability to interpret the results of tissue typing, antibody screening and cross match procedures

    b. Transplant pathology
        i. Develop a knowledge of the Banff schema of allograft pathology
        ii. Describe the histologic findings in cell-mediated and antibody-mediated rejection, chronic allograft injury processes (IF/TA, transplant glomerulopathy and transplant vasculopathy) as well as causes of allograft dysfunction other than rejection such as drug toxicity, recurrent disease and infection
        iii. Interpret renal allograft biopsy findings in a clinical setting

    c. Immunosuppressive therapy
        i. Develop an understanding of immunosuppressive therapy including drug mechanisms of action, side effects and toxicities, drug interactions, indication and clinical practice of induction and maintenance immunosuppression, therapeutic drug monitoring and management, issues associated with generic immunosuppressive agents and relevant intra-class differences of the following:
            1. Calcineurin inhibitors (cyclosporine and tacrolimus)
            2. Anti-metabolites (mycophenolate and azathioprine)
            3. Corticosteroids
            4. mTOR inhibitors
            5. Anti-IL2 receptor monoclonal antibodies (basiliximab)
            6. OKT3 and polyclonal depleting antibodies (Thymoglobulin and ATG)
            7. anti-CD20 monoclonal antibody treatment
            8. IVIG
            9. Plasmapheresis / plasma exchange
            10. Newly approved therapies for transplantation

2. Pre-transplant
    a. Recipient evaluation
        i. Describe the evaluation for a potential kidney transplant recipient

ii. Describe the recipient risks and benefits and contraindications of transplantation
iii. Describe how previous malignancies, co-morbid cardiovascular disease and other specific conditions or patient variables affect eligibility and outcomes in transplantation
iv. Describe the indications and contraindications, advantages and disadvantages of kidney-pancreas and liver-kidney transplantation
v. Identify diseases with possible recurrence risk post-transplantation and counsel recipient on these risks

b. Special Pediatric Recipient Evaluation Issues
i. Bladder assessment for underlying urologic causes of CKD and urologic abnormalities that may need correction prior to renal transplantation
ii. Relative indications for nephrectomy of native kidneys
iii. Vaccinations and viral risk factors to be addressed pre-transplant
iv. Particular issues related to infant recipient preparation
v. Minimum size requirements related to vascular anastomosis and extra- or intra-peritoneal cavity space
vi. Unique management of children with primary hyperoxaluria

c. Living Donor Evaluation **(adult only)**
i. Describe what comprises an LRD evaluation including relative and absolute contraindications
ii. Describe the operative procedure, short and long term risks and outcomes of transplant donor nephrectomy

d. Deceased Donor Evaluation
i. Explain who may be considered an eligible DD donor including the diagnosis of brain death, non-heart beating death and expanded criteria donors
ii. Describe the absolute and relative contraindications to DD donation
iii. Describe the ICU care of the brain dead donor

e. Donor Selection (LD or DD)
i. Know and understand the Health Canada regulations concerning donor screening for transmissible diseases

f. Organ Allocation
i. Describe the issues regarding wait lists and donor supply
ii. Describe the relative advantages and disadvantages of LRD versus DD donor transplantation
iii. Describe the issues of allosensitization including how this occurs, its impact on patient and transplant outcomes and how it affects recipient access to transplant

iv. Define a highly sensitized recipient and possible strategies to manage these patients including National Organ Allocation systems, highly sensitized recipient wait lists, paired exchange programs, pre-transplant desensitization (IVIG, splenectomy, plasmapheresis, rituximab)

3. Peri-transplant
    a. Describe the operative technique of a kidney transplant
        i. Know how the operative technique may differ for small infants
        ii. Understand the intra-operative monitoring and fluid and inotropic drug support for pediatric recipients of different sizes

    b. Describe the etiology and management strategies for the following causes of delayed graft function
        i. Hyperacute and acute antibody mediated rejection
        ii. ATN
        iii. Atheroemboli
        iv. Graft thrombosis
        v. Urinary tract obstruction

    c. Describe strategies for prevention and screening of common or serious post-transplant infectious complications
        i. CMV, EBV, BKV, PCP, fungal infection

    d. Describe the management of other immediate post-transplant complications including
        i. Electrolyte abnormalities
        ii. Hypertension
        iii. Fluid overload
        iv. Immunosuppression related complications

4. Early post-transplant
    a. Manage immunosuppression including adjustment of drug doses to maximize effectiveness, recognize and respond appropriately to toxicities and side effects and describe the role of individualizing protocols for a particular patient's needs

    b. Describe the frequency and management for causes of early graft dysfunction including
        i. Volume depletion
        ii. Acute antibody mediated rejection
        iii. Acute vascular rejection
        iv. Acute cellular rejection
        v. Infection – pyelonephritis, EBV, CMV, BK nephritis
        vi. Thrombosis
        vii. CNI toxicity
        viii. Obstruction
        ix. Renal artery stenosis

x. Recurrence of primary disease
xi. New renal disease

c. Describe the management of acute rejection including pathology, immunobiology and clinical science

d. Describe the impact of various infectious complications post-transplantation including their typical time course, monitoring, prophylaxis and treatment
   i. EBV
   ii. CMV
   iii. Polyoma viruses (BK, JC)
   iv. UTIs
   v. PCP
   vi. Parvovirus
   vii. Community acquired, including fungi and arthropod borne infections (e.g. WNV, dengue fever, malaria, etc.)

e. Describe the complications of a renal allograft biopsy and management of these complications

5. Late post-transplant
   a. Describe the long-term patient and allograft survival outcomes of renal transplant, and risk factors associated with these outcomes.

   b. Describe the issues involved in prescribing immunosuppression including
      i. Risks of inadequate or excessive immunosuppression
      ii. Long term toxicities of individual immunosuppressive agents
      iii. Strategies to minimize long term exposure to immunosuppressive agents

   c. Describe the pathogenesis, importance and clinical management of long term post-transplant complications including
      i. Cardiovascular disease, hypertension, dyslipidemia
      ii. Diabetes
      iii. Malignancies – PTLD, skin cancer, cervical cancer
      iv. Opportunistic infections (e.g. PCP)
      v. Fertility and pregnancy in transplant recipients
         1. Outcomes
         2. Teratogenicity of medications
      vi. Transplant RAS
      vii. Post-transplant erythrocytosis and anemia
      viii. Bone and mineral metabolism
      ix. Gout
      x. Obesity

   d. Describe the clinical presentation of recurrent renal disease post-transplantation and its management in the recipient

e. Transplant graft failure
    i. Describe the determinants of declining allograft function associated with IF/TA (interstitial fibrosis and tubular atrophy)
    ii. Describe the determinants of declining allograft function associated with transplant glomerulopathy
    iii. Describe management strategies of a patient with a failing graft including those to optimizing graft survival and managing complications of CKD
    iv. Describe the management of a failed graft including return to dialysis, withdrawal of immunosuppression, graft nephrectomy and re-transplantation

f. Pediatric issues post renal transplant
    i. Growth/sexual maturation: recognize and understand
        1. Factors /mechanisms which retard growth post transplantation
        2. Ways to maximize growth in the child, including different immunosuppression regimens and risks and benefits of rhGH
        3. Patterns of sexual development following renal transplantation
        4. Pregnancy and fertility issues, including natural history, potential teratogenicity of medications, possible complications to mother and fetus, and need for specialized prenatal care
    ii. Rehabilitation / psychosocial adaptation: recognize and understand
        1. The principles in successful rehabilitation of the child or adolescent after renal transplantation (including physical fitness, school reintegration, peer relationships)
        2. The predictive factors, psychological processes, and management approaches to non-adherence
    iii. Transition to adult care:
        1. See section under CKD

Nephrolithiasis

1. Epidemiology
    a. **Describe the incidence and prevalence of nephrolithiasis in children and adults including the different types of stones formed**

2. Etiology
    a. Describe the different types of stones including
        i. Calcium phosphate
        ii. Calcium Oxalate
        iii. Struvite
        iv. Uric acid
        v. Cystine

    b. Describe risk factors for stone formation including
        i. Hypocitrituria
        ii. Hypercalcuria **and nephrocalcinosis**
        iii. Urinary tract infections
        iv. Urinary tract structural anomalies
        v. Hyperoxaluria
        vi. Cystinuria
        vii. Hyperuricosuria
        viii. Tumour lysis syndrome

3. Diagnosis
    a. Describe the work-up for a stone including radiological investigations, urinalysis for crystals, blood and urine testing and stone analysis

    b. Know the conditions in which a genetic work-up for stones might be warranted such as for cystine stones and hyperoxaluria

4. Management
    a. Describe the basic principles of acute stone management including pain management and if required lithotripsy and surgery

    b. Describe the management for stone prevention including fluid intake, dietary modifications

    c. Describe specific management strategies for the different types of stones including medications and targeted dietary modifications

5. Prognosis
    a. Describe the complications associated with stones both acute and chronic

    b. Describe the risk of recurrence for each type of stone

Renal implications of Pregnancy:

1. The trainee will understand the changes in the anatomy of the urinary tract during normal pregnancy

2. The trainee will appreciate the renal physiologic changes in normal pregnancy including:
    a. Renal hemodynamics: Renal plasma flow, GFR
    b. Volume homeostasis including normal gestational changes in weight, intravascular, intra and extra cellular volume status, sodium balance and production of volume regulating hormones
    c. Regulation of plasma osmolality
    d. Acid base metabolism
    e. Course of anticipated BP changes in normal pregnancy.
    f. Changes in tubular function and protein excretion.
    g. Implications of the aforementioned changes on standard measurements of renal function

3. The trainee will be familiar with diagnosis and treatment of renal disorders related to pregnancy including:
    a. UTI
    b. Nephrolithiasis
    c. Etiologies of acute renal failure including pre-eclampsia, acute fatty liver, acute cortical necrosis

4. The trainee will be aware of the implications of pregnancy upon the course of pre-existing glomerular diseases or chronic renal insufficiency.

5. The trainee will be able to diagnose and treat hypertensive disorders of pregnancy including:
    a. Pre-existing hypertension
    b. Pre-eclampsia eclampsia

6. The trainee will be able to provide appropriate counseling to patients with pre-existing renal insufficiency, chronic renal failure, or end stage renal disease in terms of:
    a. Implications of pregnancy upon the course of their renal disease
    b. Implications of pregnancy upon maternal and fetal health
7. The trainee will be aware of teratogenic side effects of certain medications pertinent to the care of the renal patient and suggested alternatives.

Urologic Aspects of Pediatric Nephrology

1. Anomalies of the urinary tract: *the trainee will understand*
    a. Diagnosis, evaluation, treatment, and long term outcome of anomalies of the upper and lower urinary tract such as
        i. Hydronephrosis, hydroureter, ureterocoele, posterior urethral valves, prune belly triad syndrome, ectopic or fused kidneys,
    b. The pathophysiologic consequences of urinary tract obstruction
    c. Special fetal and neonatal issues genitourinary (GU) issues such as
        i. Evaluation and management GU abnormalities detected in utero
        ii. Indications for prenatal intervention for fetal urinary tract obstruction
        iii. Diagnosis and management of hematuria in neonates

2. Urinary tract infection (UTI) in infancy, childhood, adolescence: *the trainee will know*
    a. The definition, epidemiology, pathogenesis and spectrum of causative organisms
    b. Appropriate diagnostic methods and pitfalls
    c. Modes of therapy
    d. Appropriate follow up and imaging evaluation
    e. The causes of sterile pyuria

3. Vesicoureteral reflux (VUR): *the trainee will understand*
    a. The epidemiology, natural history, appropriate imaging and VUR grading
    b. The clinical management and long term follow up of each grade of VUR reflux

4. Neurogenic bladder: *the trainee will understand*
    a. Normal physiologic phases of micturition
    b. Different types of neurogenic bladder, including “non neurogenic”
    c. Etiologies, pathophysiology, and treatment options

5. Enuresis in Children: *the trainee will understand*
    a. The maturation of bladder function
    b. The definition, incidence and pathogenesis of enuresis
    c. , When and how to evaluate enuresis, and therapeutic modalities for the treatment

6. Urinary tract trauma: *the trainee will recognize*
    a. Predisposing factors, physical, laboratory and imaging findings, and possible sequelae

7. Renal tumours in children: *the trainee will know and understand*
    a. , The clinical features, natural history, evaluation and diagnosis of nephroblastoma (Wilms’ tumour), mesoblastic nephroma, and angiomyolipoma
    b. The genetic implications and associated phenotypic abnormalities

8. Nephrolithiasis *(see general section on nephrolithiasis)*

9. Diagnostic Methods in Nephrology

1. Laboratory evaluation of renal function
    a. Urinalysis and urine collections: <u>The resident will know, understand and interpret</u>
        i. The normal, abnormal, and artifactual features of a urinalysis
        ii. Orthostatic proteinuria, persistent proteinuria and microalbuminuria
        iii. Diagnostic features of the different types of micro and macrohematuria
    b. Biochemical Assessment: *The resident will know, understand and interpret*
        i. Tests of glomerular and tubular function
    c. Serologic studies: *The resident will know indications, specificity and limitations*:
        1. Total haemolytic complement and individual components
        2. Anti neutrophil cytoplasmic antibody, anti-glomerular basement membrane antibody, antinuclear antibody

2. Medical Imaging
    a. The resident will know the indications, limitations, and complications of
        i. Intravenous pyelography, voiding cystourethrography, computed tomography and magnetic resonance imaging of the genitourinary system, and renal arterial and venous angiography
    b. The resident will know and understand the indications for and limitations of
        i. Renal ultrasonography and Doppler study
        ii. Various types of radionuclide scans of the genitourinary system, including imaging, GFR measurement and renal blood flow applications

3. Renal pathology
    a. Light microscopy

    The resident will understand
        i. The use of specific histochemical stains in evaluation of renal biopsies

    The resident will identify
        ii. A normal kidney, minimal lesion, membranous nephropathy, mesangial proliferation, membranoproliferative lesions, diffuse proliferation, extracapillary proliferation /crescents, sclerosing changes, focal segmental sclerosis, focal necrotizing lesions/vasculitis, tubulointerstitial nephritis
        iii. Various forms of cystic disease, renal dysplasia, oligomeganephronia
        iv. Diabetic nephropathy
        v. Acute tubular necrosis, microthrombus, nephrotoxic changes consistent with calcineurin inhibitors, malignant hypertensive changes
    b. Electron microscopy: *The resident will recognize*
        i. Effacement of foot processes, intramembranous, subepithelial, subendothelial, mesangial deposits, reticulo-tubular particles, GBM reticular/lattice lamination and GBM thinning/thickening/splitting
    c. Immunofluorescent microscopy / Immunohistochemistry
        i. *The resident will understand* the basic methodology
        ii. *The resident will recognize* the patterns of immunoglobulin/complement/fibrin deposition and immunoglobulin classes

GLOMERULAR DISORDERS

Nephritis /Nephropathy

The resident should know understand and distinguish for each of the conditions or groups of conditions listed below the following parameters:

- Systemic and renal manifestations
- Laboratory evaluation for the diagnosis and management
- Pathogenesis, immune perturbation (if applicable), pathophysiology and histopathology
- Natural history and epidemiology
- Differential diagnosis for the clinical presentation and histologic lesions
- Therapeutic options and complications and risks of treatment

1. Acute post infectious glomerulonephritis

2. Nephritis with systemic disease
    a. Henoch Schonlein purpura
    b. Systemic lupus erythematosus
    c. Mixed connective tissue disease
    d. Goodpasture syndrome
    e. Wegener granulomatosis, necrotizing vasculitis /polyarteritis
    f. Hemoglobin S disease
    g. Anti phospholipid syndromes
    h. Diabetes
    i. Human immunodeficiency virus associated nephropathy

3. Hereditary glomerular disease
    a. Alport syndrome
    b. Familial nephritis/benign hematuria/thin basement membrane disease
    c. Nail patella syndrome
    d. Fabry disease
    e. Hereditary nephrotic syndromes (see below)

    The resident should also know their molecular defects (if applicable) and genetics

4. IgA nephropathy

5. Rapidly progressive glomerulonephritis

6. Nephritis with low serum complement concentrations

    Also know and understand

    a. Which renal disorders in children are associated with low serum complement concentrations (inherited or acquired)

Nephrotic syndrome

1. Infantile / congenital nephrotic syndrome
   The resident will understand and distinguish
   The various forms including Denys-Drash syndrome/diffuse mesangial sclerosis, Finnish type and infection related, in terms of their histopathology, the cellular/molecular defects (where known), genetic transmission, complications and therapeutic options, and possibility of prenatal diagnosis

2. Primary nephrotic syndrome
   The resident will distinguish clinical, epidemiologic, pathological, genetic aspects and therapies (including differences in pediatric and adult age groups) for
   a. Minimal lesion nephrotic syndrome
   b. Membranous lesion nephrotic syndrome
   c. Focal and segmental glomerulosclerosis
   d. Proliferative lesions
      i. Mesangial proliferative
      ii. Rapidly progressive glomerulonephritis
      iii. Membranoproliferative glomerulonephritis

3. Secondary nephrotic syndrome
   The resident will distinguish epidemiologic, pathological, genetic aspects and therapies

4. Pathophysiology, mechanisms and complications of nephrotic syndrome
   The resident will understand and distinguish
   a. The mechanisms of glomerular injury and production of proteinuria
   Know and understand
   i. The increased thromboembolic tendency, hyperlipidemia and increased bacterial infection risk
   ii. Pathogenesis and consequences of hypoalbuminemia

Hemolytic uremic syndrome

The resident will understand and distinguish

1. The sporadic and inherited forms, in terms of
   a. Etiologies and pathogenesis, including the known genetic defects
   b. The role of complement
   c. The therapeutic options and contraindications of certain therapies
   d. Risks for recurrent episodes
   e. Complications of treatment and outcomes, including
      i. Risks of long-term sequelae (renal and nonrenal)
      ii. Potential for development of endstage renal disease
      iii. Differing risks for recurrence related to etiology and potentially medication use

Cystic/Inherited/Tubular Disorders

1. Specific cystic disorders
   The resident will understand and distinguish the epidemiology, renal and nonrenal features, phenotypic variations, syndromic associations, genetics (if applicable) and clinical management of
   a. Autosomal recessive polycystic kidney disease
   b. Autosomal dominant polycystic kidney disease
   c. Medullary cystic disease
   d. Medullary sponge kidney
   e. Glomerulocystic disease
   f. Multicystic renal dysplasia
   g. Acquired cystic kidney disease
   h. Solitary cysts

2. Multiple malformation syndromes with renal lesions
   The resident will distinguish the initial clinical manifestations, evolution and renal lesions of multiple malformation syndromes, such as
   a. Tuberous sclerosis
   b. Williams syndrome
   c. Neurofibromatosis
   d. Biedl Bardet

3. Tubular disorders
   a. For phosphate wasting syndromes, *the resident will distinguish the*
      i. Clinical and biochemical features, evaluation, pathogenesis, natural history, cellular/molecular defects, genetic implications (where relevant), and appropriate therapy, including potential complications thereof, for:
         1. X linked hypophosphatemic rickets
         2. Autosomal dominant hypophosphatemic rickets
         3. Autosomal recessive hypophosphatemic rickets
         4. Hereditary hypophosphatemic rickets with hypercalciuria
         5. Oncogenous or tumoural rickets with hypophosphatemia
         6. Primary hyperparathyroidism

   b. For other causes of hypophosphatemia, *the resident will distinguish* the differential diagnosis
      i. With normocalcemia
      ii. With hypercalcemia

   c. Fanconi syndromes
      The resident will differentiate and distinguish the different types of Fanconi syndrome including inherited and acquired, in terms of their:
      i. Etiologies, pathogenesis, pathophysiology
      ii. Biochemical features, clinical and laboratory evaluation,
      iii. Appropriate therapies

1. Inherited: *the resident will also differentiate* the cellular/molecular defects and genetic abnormalities, potential complications, of the disease and of therapies and long-term outcomes
    a. Dent disease, cystinosis, Wilson disease
    b. Mitochondrial cytopathies
    c. Other metabolic disorders
2. Acquired: The resident will recognize and distinguish acquired causes due to
    a. Drugs and toxins
    b. Renal disorders –e.g.
        i. Tubulointerstitial nephritis
        ii. Membranous nephropathy with anti-tubular basement membrane antibodies

d. Diabetes insipidus (DI)
    i. The resident will
        1. *Formulate* an approach to evaluation of a patient with polyuria
        2. *Distinguish* the different types of nephrogenic DI including
            a. Etiology, pathogenesis, clinical features and natural history
            b. Genetic implications / defects, molecular abnormalities
            c. Clinical and laboratory evaluation
            d. Appropriate therapy and potential complications of therapy

e. Bartter and Gitelman syndromes
    The resident will understand and distinguish the
        i. Pathogenesis, pathophysiology, cellular/molecular defects, genetic aspects
        ii. Clinical and biochemical features and the natural history
        iii. Evaluation, appropriate therapy and potential complications thereof

4 Disorders of vitamin D metabolism: Vitamin D dependent rickets (VDDR), vitamin D resistant rickets (VDRR), and vitamin D deficiency

The resident will understand and differentiate:

a. The pathogenesis, biochemical and clinical features, and natural history
b. The clinical and laboratory evaluation
c. The genetic molecular basis of hereditary forms (VDDR and VDRR)
d. Treatment and potential complications

5. Tubulointerstitial nephritis (chronic)

The resident will understand and differentiate:

a. The different etiologies, pathogenesis, clinical presentation, renal and systemic manifestations and natural history and epidemiology
b. The laboratory evaluation for diagnosis and management
c. The therapeutic options and complications of therapy for the various types

The resident will understand and differentiate:

a. The diagnostic evaluation for the different clinical presentations
b. Appropriate therapies for the different etiologies