Part 1
Introduction

The purpose of this part is to provide a brief summary of normal kidney functions that need to be replaced by dialysis, and to place dialysis within the context of integrated management of the patient with chronic kidney disease (CKD).

Chapter 1.1
Normal kidney function

HIGHLIGHTS

- Patients with CKD require comprehensive assessment.
- Assessment and management is guided by the stage of CKD.

The normal kidney helps maintain a stable internal milieu of the body by a range of regulatory, excretory, synthetic and metabolic functions. Dialysis is capable of replacing only some of these functions (see Chapter 1.4). Normal kidney functions include:

1. regulation of:
   (a) ECFV, by excretion or retention of sodium and water
   (b) plasma osmolality, by diuresis or antidiuresis
   (c) acid–base balance, by production and excretion of ammonia, excretion of titratable acids, and reabsorption or excretion of bicarbonate
   (d) potassium balance, especially by its rapid distal tubular secretion
   (e) calcium, phosphate and magnesium balance
2. excretion of:
   (a) solutes of low molecular weight (i.e. <500 Daltons), such as urea and creatinine
   (b) nitrogenous compounds and other 'uraemic toxins'
   (c) solutes of middle-range molecular weight (i.e. 500–20000 Daltons)
3. metabolism of filtered proteins, including hormones

4. synthesis of:
   (a) erythropoietin
   (b) renin–angiotensin
   (c) other locally active, haemodynamic hormones, including prostaglandins, nitric oxide and endothelin
5. activation of 25-hydroxy vitamin D (by 1-hydroxylation)

Reference

1. National Kidney Foundation K/DOQI. Clinical practice guidelines for chronic kidney evaluation, classification and stratification. Am J Kidney Dis 2002; 39 (suppl 1): S17–S31.

Chapter 1.2
Stages of chronic kidney disease

HIGHLIGHT

- The stage of CKD predicts clinical manifestations.

Heading needed

The damaged kidney can undergo a progressive series of structural and functional adaptations that permit the maintenance of useful function even when damage is severe. The extent and effectiveness of these adaptations characterise the five different stages of CKD. The extent to which dialysis is able to subserve normal kidney function is discussed in Chapter 1.4.

CKD may be defined as kidney damage that has persisted for at least 3 months. It may be staged based on the level of the GFR (Table 1.2.1). Clinical evidence of CKD includes abnormal urinalysis and reduced renal size, with or without a reduced GFR.

Table 1.2.1 Stages of CKD

Stage	Clinical definition: kidney damage plus	GFR (mL/min/1.73 m^2)
1	Normal or raised GFR	≥90
2	Mildly reduced GFR	60–89
3	Moderately reduced GFR	30–59
4	Severely reduced GFR	15–29
5	Kidney failure	<15 or dialysis

Staging

Staging is clinically useful as it predicts clinical manifestations, complications and comorbidities of CKD (Table 1.2.2), and can guide assessment and management strategies (see Chapter 1.3).

Table 1.2.2 Clinical manifestations of CKD

Stage	Typical clinical manifestations[(a)]
1	None, or of the primary disease process
2	None; hyperparathyroidism, increased risk of cardiovascular disease
3	Nocturia, anaemia, low 1,25-dihydroxy vitamin D level, raised serum creatinine level, dyslipidaemia, abnormal ECFV
4	Uraemic symptoms, abnormalities of serum electrolyte levels
5	Severe uraemic symptoms, dialysis

(*a*) These may be seen in any stage beyond the first indicated.

Morbidity and mortality

Morbidity and mortality are worse in patients who start dialysis after late referral to nephrological services compared to those who present earlier in the course of CKD. Referral to a nephrologist should occur by stage 3 of CKD, or earlier when dictated by a need for diagnosis or treatment of the primary disease or the presence of risk factors for the rapid progression of CKD (including diabetes, hypertension, smoking, age >65 years, nephritic range proteinuria).

Many patients can remain at early stages of CKD for a number of years. Hence, the majority of patients with CKD die, mainly from cardiovascular disease, prior to the need for dialysis.

Reference

1. National Kidney Foundation K/DOQI. Clinical practice guidelines for chronic kidney evaluation, classification and stratification. Am J Kidney Dis 2002; 39 (suppl 1): S17–S31.

Chapter 1.3
Assessment of the patient with chronic kidney disease

HIGHLIGHTS

- Patients with CKD require comprehensive assessment.
- Assessment and management is guided by the stage of CKD.

Assessment and management

There should be a smooth continuum in the management of patients with CKD throughout its stages and during dialysis. Patient assessment and management can be guided by the stage of CKD (Protocol 1.3.1).

PROTOCOL 1.3.1

How to assess and manage patients according to the stage of CKD

Stage of CKD	Based on GFR[(a)]	Direct assessment and management[(b)]
1	≥90	primary disease, cardiovascular risk
2	60–89	early hyperparathyroidism, progression of CKD
3	30–59	anaemia, dyslipidaemia, ECFV
4	15–29	electrolyte abnormalities, preparation for dialysis and transplantation
5	<15	complications of advanced CKD and dialysis

(*a*) May apply for any stage beyond that in which first mentioned.
(*b*) In mL/min/1.73 m^2.

Initial assessment

Initial assessment of the patient with CKD must include a complete history and examination, basic blood and urine tests, renal structural imaging and other tests as dictated by the cause and stage of CKD, and the results of the initial assessment (see Protocol 1.3.2).

PROTOCOL 1.3.2

How to initially assess the patient with CKD

- Full personal and family medical history
- Serum biochemistry and full blood count
- Urinalysis (for protein, glucose, blood, leucocytes, nitrite), urinary sediment, urine protein:creatinine or albumin: creatinine ratio
- Renal ultrasound
- Other tests based on cause and stage of CKD (see Protocol 1.3.1)

Comprehensive assessment

The main principles of a comprehensive assessment of the patient with CKD are summarised in Protocol 1.3.3.

PROTOCOL 1.3.3

How to comprehensively assess the patient with CKD

- Establish the cause of CKD
- Differentiate from acute kidney disease
- Quantify GFR
- Calculate the rate of progression of CKD
- Assess cardiovascular risk
- Look for reversible renal dysfunction
- Assess lifestyle risks
- Look for specific complications of the primary disease
- Assess suitability for dialysis
- Assess suitability for transplantation
- Assess medications

Establish the cause

Establish the cause of CKD as many diagnoses carry additional implications, including a familial nature and recognised complications (see below).

Differentiate from acute kidney disease

Differentiate CKD from acute kidney disease by means of renal ultrasound, haemoglobin level and serial assessment of renal function. The presence of a small renal size, a loss of corticomedullary differentiation and an increased renal echogenicity on ultrasound, normochromic normocytic anaemia and hyperphosphataemia, and a reduction in GFR for more than 3 months are indicative of chronic disease.

Examine urinary sediment

Examine the urinary sediment in a fresh centrifuged sample, which has been transported in boric acid to preserve casts. The presence of red or white cell casts indicates an inflammatory process, usually acute, while broad casts are suggestive of advanced renal disease.

Quantify GFR

Quantify the GFR to assign the stage of CKD. This is usually done by using the Cockcroft–Gault formula to first determine the creatinine clearance:

$$\text{Creatinine clearance (males) (mL/min)} = \frac{(140 - \text{age}) \times \text{body weight (kg)}}{0.814 \times \text{plasma creatinine (mmol/L)}}$$

For females, this equation is multiplied by 0.85.

The creatinine clearance is then divided by 1.73 m^2 to give the GFR in mL/min/1.73 m^2.

The adequacy of the collection can be estimated from the creatinine index (i.e. the expected creatinine excretion), which should be 0.18–0.23 mmol/kg/d for males and 0.12–0.19 mmol/kg/d for females. Measurement of the GFR