CHAPTER 1

# INTRODUCTION

**The users of a dialysis clinic**

One of the starting points of the design of a building is the understanding of the needs of the people who will use it and the activities performed within it.

In the case of dialysis centres, the users are mainly the dialysis patients and the medical staff who take care of them.

**The patients**

Dialysis patients are chronic, usually elderly[1], patients with impairments and/or additional health complications who have to receive treatment regularly for the rest of their lives. The following chapters describe some basic concepts related to treatment at a dialysis clinic without the need for prior medical knowledge. Topics such as renal failure, renal chronic disease or the various treatments that perform the function of a lost kidney are described.

**The staff**

The staff of a dialysis clinic is varied, generally consisting of physicians (nephrologists and other medical specialisations), nurses, technicians and cleaning staff. These individuals may also be supplemented with healthcare assistants, porters, administrative assistants, managers, nutritionists, security guards and even social workers.

## 1.1 The dialysis centre

**Variety of settings**

Dialysis treatment may be performed in a variety of settings, including hospitals and freestanding dialysis clinics or centres and the

[1] Elderly are considered here people over 65 years old who can represent more than 50% of the dialysis patient population in some European countries.

patient's home. The size and configuration of the facility depends on many aspects.

**Dialysis clinic as ambulatory healthcare facility**

A dialysis clinic or centre is an ambulatory healthcare facility aimed primarily at treating outpatients with chronic renal disease. A dialysis clinic may also offer treatment for acute kidney failure and peritoneal dialysis training for patients and staff together with medical services not directly related with the main disease being treated.

The distinguishing characteristics of a dialysis clinic with respect to other ambulatory healthcare facilities are the dialysis room and the water treatment room. The capacity is determined by the number treatment sessions per day and the number of dialysis places or positions, called from here on "dialysis stations".

**Dialysis rooms**

The dialysis room or ward is where patients are treated for 4 to 5 hours each session. During this time, under the supervision of staff, they must essentially remain immobile: lying or sitting on a dialysis chair or bed, connected to a dialysis machine whilst reading, watching TV, talking to neighbouring patients or sleeping.

**Water treatment room**

The water treatment room houses equipment which purifies tap-quality water into dialysis water (permeate[2]), i.e. water suitable for haemodialysis treatment. Concentrate preparation and distribution systems as well as other technical features, such as water storage, may also be housed here (see Fig. 1.1).

There are many other rooms at a dialysis clinic essential to the operation of the clinic in addition to the dialysis ward and the water treatment room.

**Water consumption**

Water consumption at a dialysis clinic is another important distinguishing feature, with the average total usage amounting to around 400 litres per treatment[3]. A similar quantity of waste water containing disinfectants, chlorides and organic waste (such as urea) is discarded into the drain.

**Consumables**

Dialysis treatment requires a significant amount of consumable materials which necessitates large storage space. Alternatively, lack of space can be compensated by more frequent delivery.

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[2] Dialysis specific terminology and other terms that the authors consider worthy of explanation are described in the glossary.

[3] This figure includes the water consumption directly related to the dialysis treatment and additional everyday usage for the toilets, kitchenette and even garden in some cases.

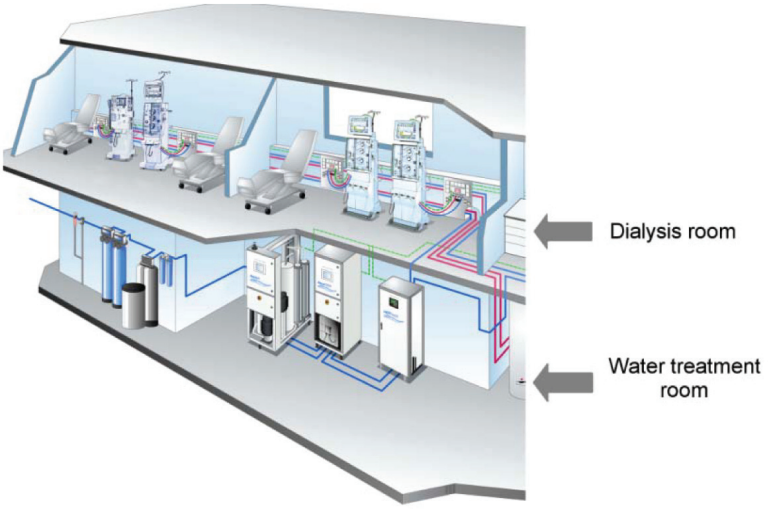


***Fig. 1.1: Cross section of a dialysis centre. In this example the dialysis room is on the upper floor while the water treatment room is located below.***

**Medical waste**

A dialysis clinic also generates a high amount of domestic and medical waste which can be dangerous or potentially infectious.

**Shifts**

Dialysis patients are usually treated three times a week and each dialysis session lasts between 4 to 5 hours.

A dialysis clinic can run one to three or even four shifts a day, although the average is 2 shifts per day. As a patient is treated three times a week, typically either Monday-Wednesday-Friday or Tuesday-Thursday-Saturday, a dialysis clinic is operational six days a week:

| Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|
| Shift 1 | Shift 3 | Shift 1 | Shift 3 | Shift 1 | Shift 3 | |
| Shift 2 | Shift 4 | Shift 2 | Shift 4 | Shift 2 | Shift 4 | |

***Fig. 1.2: Example of a weekly shift organisation with following assumptions:***
- ***clinic operates 2 shifts per day***
- ***patients are treated 3 times per week***
- ***on Sunday the clinic is closed***

Physicians, nurses and healthcare assistants' working shifts can be organised in different ways, and not necessarily according to the patients' shifts.

## 1.2 Renal failure

**Chronic renal failure**

Chronic renal failure is the progressive and irreversible loss of kidney function over months or years. This chronic disease may have different causes ranging from congenital diseases to diabetes, high blood pressure (hypertension) or infectious disease. An excessive intake of certain medication or drug abuse can also lead to chronic kidney damage.

**Acute renal failure**

Acute renal failure occurs abruptly, e.g. as a result of a severe trauma or post-surgery complications, and it is often reversible.

Acute and chronic kidney failure may lead to death within a short time period if untreated.

**Symptoms**

Kidneys which do not function adequately affect the efficiency of the entire body. The accumulation of toxins may damage other organs and even lead to heart rhythm disturbances, infections, disorders in the digestive tract or abnormal changes in the nervous system. Most patients show a significant increase in blood pressure. In the advanced stage of the disease, decalcification of the bones begins and a lack of erythropoietic hormones (dysfunction of blood cell production) leads to anaemia and physical impairment to the patient. The body retains too much water due to the insufficient removal of urine.

**Replacement options**

In advanced cases of chronic disease in which the kidneys have completely ceased to function, kidney replacement therapy such as kidney transplantation, haemodialysis or peritoneal dialysis is necessary. The choice of treatment is dependent on the health, lifestyle and individual preferences of the patient.

**Dialysis treatment**

Dialysis treatment replaces the lost kidney function in patients suffering from either acute or chronic renal failure. There are two main types of dialysis: haemodialysis (HD) and peritoneal dialysis (PD).

## 1.3 What is dialysis

Dialysis is the removal of toxic waste products and excess water directly from the blood through a semipermeable membrane. Two treatment modalities can be performed: haemodialysis and peritoneal dialysis.

**Extracorporeal and intracorporeal treatments**

Haemodialysis (HD) is an extracorporeal treatment employing a synthetic membrane as a filter. Peritoneal dialysis (PD) is an intracorporeal treatment employing a natural membrane: the peritoneum.

**Peritoneal dialysis**

The peritoneum lines the walls of the abdomen and covers the internal organs. It has similar attributes to the artificial filter used in haemodialysis: its pores allow the passage of certain substances while retaining others. Peritoneal dialysis employs this naturally filtering membrane several times a day.

A cleansing liquid (dialysis fluid) is introduced through a catheter placed in the abdominal wall, ending in the pelvis behind the bladder. The metabolic toxins are brought to the abdominal wall in hair-thin blood vessels and pass through the pores into the cleansing liquid. Dextrose in the dialysis solution also pulls water from the body with the help of osmotic mechanisms. The used cleansing liquid is removed from the body through the catheter, together with the toxins and excess water. Peritoneal dialysis patients usually learn self-treatment in a training centre and mainly perform the treatment at home.

***Fig. 1.3: Patient undergoing peritoneal dialysis treatment at home.***

**Haemodialysis**

In haemodialysis, blood is preferably taken from a forearm vein. To ensure that enough blood is available for the treatment, a small surgical operation is performed to prepare the forearm vein. A bypass (known as a shunt) is established between the vein and an artery to allow higher pressure and faster blood flow. If no appropriate blood vessel can be found for the shunt procedure, a catheter can be placed in one of the larger blood vessels of the body (e.g. jugular veins).

During haemodialysis, the patient's blood is passed through a filter outside the body and then reintroduced to the patient. Tiny pores in

the membrane wall filter out toxins while vital components, such as the majority of proteins, are left within the blood. Excess water is also removed through these tiny pores. This process is called ultrafiltration and is controlled by a dialysis machine equipped with a blood pump and monitoring systems to ensure safety. Drugs can also be administered via special ports in the extracorporeal circuit.

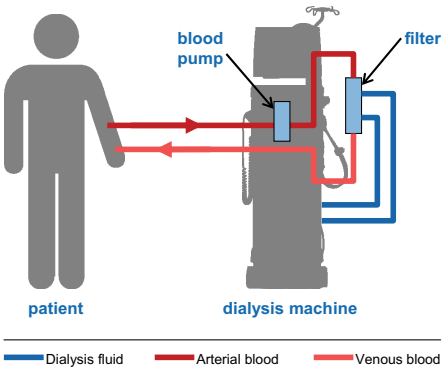


*Fig. 1.4: Schematic diagram of dialysis treatment.*

Dialysis in a clinic is usually performed three times a week on an outpatient basis and lasts four to five hours. Experienced physicians and trained personnel care for the patients throughout the entire treatment. Patients may be weak and feel faint after undergoing the dialysis treatment.

Patients lead a virtually normal everyday life during periods between dialysis treatments, restricted only by some dietary constraints.

Depending on their condition, patients may be able to perform haemodialysis at home by themselves. The patient, and usually a partner, must first learn self-treatment in a dedicated area at a dialysis centre.

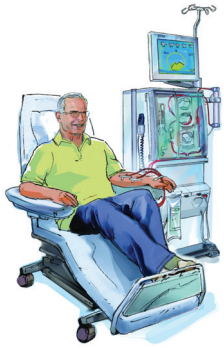

*Fig. 1.5: Patient undertaking haemodialysis treatment.*

## 1.4 Historical overview of the treatment

**Evolution of the treatment**

Acute and chronic kidney failure is an illness that is as old as humanity itself. In the Roman period, treatments of uremia included the use of hot baths, sweating therapies, bloodletting and enemas.

**19th century**

The Scottish chemist Thomas Graham, known as the "Father of Dialysis", formed the scientific basis for the treatment of kidney failure in the mid 19th century. Graham described for the first time transport mechanisms, such as osmosis, which were becoming widespread in chemical laboratories allowing the separation of dissolved substances or the removal of waste from solutions through semipermeable membranes.

**1914**

While significant research into artificial membranes was conducted between 1880 and 1913, it was not until 1914 in the USA that Abel, Rowntree and Turner "dialysed" anaesthetised animals by directing their blood outside the body through tubes with semipermeable membranes.

**1923, dialysis as an experimental therapy**

The German doctor Georg Haas performed the first dialysis treatment involving humans in Giessen (Germany) in 1923. However, none of the patients survived, probably because of their critical condition and the ineffectiveness of the dialysis treatment.

***Fig. 1.6: Georg Haas performing dialysis on a patient at the University Hospital of Giessen.***

**1945, first HD patient survives**

The first successful dialysis treatment for acute renal failure was performed by Willem Kolff in Kampen, in the Netherlands in 1945. Kolff used a rotating drum kidney to treat a 67-year-old female patient. After a week-long treatment, the patient left the hospital with normal kidney function. She died at the age of 73 from an illness unrelated to kidney failure.

**1945-1962**

Examples of the Kolff rotating drum kidney crossed the Atlantic after 1945 ending up at the Peter Brent Brigham Hospital in Boston, where they underwent significant technical improvement. The modified machines became known as the Kolff-Brigham Kidney, and between 1945 and 1962 they were shipped from Boston to hospitals worldwide.

**1960s: first chronic HD program**

Further developments in the fields of membrane materials and vascular access allowed the long-term treatment of patients with chronic kidney failure. In Seattle in 1960, a patient started a treatment that allowed him to live for an additional eleven years before dying of cardiac disease in 1971.

**1970s: HD established as standard in clinical routine**

Haemodialysis established itself as the treatment of choice worldwide for chronic and acute kidney failure after the early successes in Seattle. Membranes, dialysers and dialysis machines were continually improved and produced industrially in ever-increasing numbers. Together with the progress made in the treatment, the technology was also developing rapidly and this, in turn, had an influence on the architectural requirements. For example, the space required for the water treatment technology has been greatly reduced in recent decades, a fact that affects the size of the water treatment rooms.

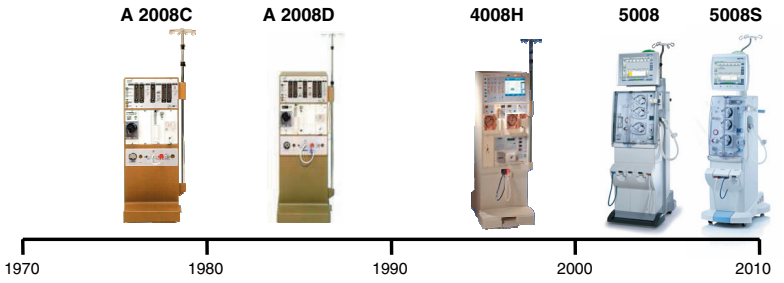


***Fig. 1.7: Evolution of the Fresenius Medical Care dialysis machines from the 70s to today.***