Renal replacement therapy in Poland and worldwide

(Leczenia nerkozastępczego w Polsce i na świecie)

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Abstract – Introduction. The first hemodialysis in Poland was performed on 6 November 1958 in Poznań. An attempt to save the life of a 38-year-old man with acute kidney failure was a success. At that time, only patients with life-threatening conditions caused by conduction, hypercalemia, severe respiratory acidosis or severe uremic toxemia were qualified for haemodialysis treatment.

Aim of the study. The aim of the study was to present a brief historical outline of renal replacement therapy in Poland and worldwide, to characterise haemodialysis as a method of renal replacement therapy and to discuss indications for renal replacement therapy.

Selection of material. The search was conducted in the Scopus database for the period 2002-2019, using *the concepts of history of renal replacement therapy*, *hemodialysis, indications for renal replacement therapy*. From the literature found in the Google Scholar database, studies were selected which, in the opinion of the authors, would be most useful in the preparation of this study.

Conclusions. Kidneys are an extremely important organ. They have the ability to regulate the amount of diuresis, relative concentration and density and the chemical composition of urine. This allows them to maintain the water-electrolyte and acid-base balance. They also play an important role in hormonal regulation of arterial pressure and red blood cell production. When the kidneys stop functioning, the concentration of substances normally excreted in urine, such as urea and creatinine, which are produced as waste in biochemical processes, increases rapidly in the blood, then renal replacement methods are necessary.

Key words **-** history of renal replacement therapy, hemodialysis, indications for renal replacement therapy.

Streszczenie – Wstęp. Pierwszą w Polsce hemodializę wykonano 6 listopada 1958r. w Poznaniu. Sukcesem zakończyła się próba uratowania życia 38- letniego mężczyzny z ostrą niewydolnością nerek. Do leczenia hemodializami kwalifikowano wówczas wyłącznie chorych w stanie zagrożenia życia, spowodowanego przewodnieniem, hiperkaliemią, ciężką kwasicą oddechową lub nasiloną toksemią mocznicową.

Cel pracy. Celem pracy było przedstawienie krótkiego rysu historycznego leczenia nerkozastępczego w Polsce i na świecie, scharakteryzowania hemodializy jako metoda leczenia nerkozastępczego oraz omówienia wskazań do leczenia nerkozastępczego.

Dobór materiału. Poszukiwania przeprowadzono w bazie Scopus za okres 2002-2019, używając pojęć *historia leczenia nerkozastępczego, hemodializa, wskazania do leczenia nerkozastępczego*. Ze znalezionego w bazie Google Scholar piśmiennictwa wyselekcjonowano opracowania, które zdaniem autorów byłyby najbardziej użyteczne w przygotowaniu niniejszego opracowania.

Wnioski. Nerki są niezwykle ważnym narządem. Mają zdolność regulowania wielkości diurezy, stężenia i gęstości względnej oraz składu chemicznego moczu. Dzięki temu służą do zachowania równowagi wodno-elektrolitowej i kwasowozasadowej. Odgrywają również dużą rolę w regulacji hormonalnej ciśnienia tętniczego oraz produkcji krwinek czerwonych. Gdy nerki przestają funkcjonować, we krwi szybko rośnie stężenie substancji normalnie wydalanych z moczem jak na przykład mocznik i kreatynina, które w przemianach biochemicznych powstają jako odpady, wówczas konieczne jest zastosowanie metod nerkozastępczych.

Słowa kluczowe **-** historia leczenia nerkozastępczego, hemodializa, wskazania do leczenia nerkozastępczego.

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I. SHORT HYSTERICAL FEATURES

The pioneer of dialysis was Georg Hass of Giessen, who was the first to carry out dialysis in humans using heparin to treat poisoning in 1928. The first blood purification procedure in the course of acute renal failure was carried out by Prof. Willem Kolf from Kampen (the Netherlands), who in 1945, using repeated haemodialysis, managed to keep a 68-year-old woman alive until her kidney function returned [1].

In 1950 the first dialysis department was opened in Sweden by Prof. Alwall. It was him who created the devices, which at the end of the 1950s came to Poland. Prof. Jan Roguski from the Clinic of Internal Medicine of the Medical University of Poznań and Prof. Andrzej Biernacki from the 1st Clinic of Internal Medicine of the Medical University of Warsaw tried to buy them [2].

The first hemodialysis in Poland was performed on 6 November 1958 in Poznań. An attempt to save the life of a 38-year-old man with acute kidney failure was a success. At that time, only patients with life-threatening conditions caused by conduction, hypercalemia, severe respiratory acidosis or severe uremic toxemia were qualified for haemodialysis treatment. The treatment lasted from 10 to 12 hours, and the preparation of the device over 24 hours with the necessity to cook it at the end, because it was the only way to sterilise the device. As many as four nurses were involved in the preparation of the device. It was a hard physical work because the drums on which the cellophane dialysis membrane was wound were very important. For haemodialysis, tap water was used without treatment, which posed a pyrogenic threat, so the patient was constantly observed for the appearance of dialysis reactions [3]. Despite difficulties, until January 2, 1959, when the first haemodialysis was performed in Warsaw, 14 procedures were performed in Poznań. In the same year, 81 haemodialysis procedures were carried out in Poznań and 56 in Warsaw. The situation improved in 1961, when haemodialysis started in the Department of Internal Medicine of the Military Medical Academy in Łódź. A year later, the Second Clinic of Internal Diseases of the Medical University of Krakow joined the haemodialysis centres. In 1964, in the Second Clinic of Internal Medicine in Gdansk, hemodialysis therapy with a new type of apparatus - ganglionic kidney constructed by Wilhelm Kolff and Bruno Watschinger was started. The advantage of this model was reduced to 800 ml volume of blood necessary to fill the apparatus before activation, compared to 1.5-2 litres of blood used in Alwall apparatus [4].

In Poland, domestic manufacturers have made attempts to produce dialysis equipment, but due to the great unreliability of the materials, they could not compete with a prototype competing with foreign products. The closest to success was Famed in Lodz, whose HD100 apparatus was produced until 1993. The number of new haemodialysis centres was gradually increasing [2]. At the end of 1970s there were already 39 nephrological centres in Poland. Newer devices of the Bellco 714 and Gambro AK5 company appeared. Thanks to the use of factory-folded ganglionic dialyzers, the duration of hemodialysis was reduced to 5-6 hours. Hemodialysis procedures were very expensive, therefore, for economic reasons, all dialysis stations used dialyzers again [3]. One of the key problems in haemodialysis was the lack of permanent vascular access. In 1959, a milestone was the development of a dual-lumen silastic catheter, which was introduced to the femoral vein using the Seldinger method for repeated dialysis. In 1960 surgeons from Seattle developed a system of cannulation of arterial and venous vessels introducing Teflon endings connected with silastic drains, brought to the skin and connected to each other. They were used on vessels in the ankle or wrist area [4]. At the beginning of hemodialysis, the silastic arch was disconnected and after the treatment it was connected again. The fistula was named Scribner - Quinton after its originator and producer. Despite frequent complications in the form of clots and infections, for the first time it gave the possibility of permanent dialysis.

The breakthrough stage in the history of vascular access was the first ever subcutaneous arterio-venous fistula performed by a team of surgeons from New York City, Ciminio and Brescia in 1965, which type of access is still dominant today [5].

The 1980s saw a breakthrough in Poland in the creation of new centres and the modernisation of dialysis equipment. This was connected with the establishment in 1984. In 1984, the National Specialist Team for Dialysis and Kidney Transplantation was established, which two years later was transformed into the National Specialist Team for Nephrology. Water treatment equipment was installed in all centres. Capillary dialyzers with a large dialysis area were introduced, which reduced the duration of hemodialysis to 4-5 hours 3 times a week. Automatic reutilization

was started, which limited the harmful effects of sterilizers and facilitated the work of nursing personnel [3]. Significant technical progress resulted in a significant increase in effectiveness of the therapy offered to patients [6].

The year 1992 was of great importance in the development of hemodialysis in Poland, when the "Programme for Improvement and Development of Dialysis" developed by the National Team of Medical Consultants in Nephrology [7] was implemented. Today's hemodialyses undoubtedly do not resemble those of several years ago. The knowledge of medical personnel about the process of dialysis allows to carry out treatments that are increasingly safe, with fewer complications than in the past [8].

II. HEMODIALYSIS AS A RENAL REPLACEMENT THERAPY

Renal replacement therapy is understood to mean methods of therapy that replace the functions of the damaged kidneys. These include dialysis therapy, i.e. hemodialysis and peritoneal dialysis [9].

Kidneys are an extremely important organ. They have the ability to regulate the amount of diuresis, relative concentration and density and the chemical composition of urine. This allows them to maintain the water-electrolyte and acid-base balance. They also play an important role in hormonal regulation of arterial pressure and red blood cell production [10]. When the kidneys stop functioning, the concentration of substances normally excreted in urine, such as urea and creatinine, which are produced as waste in biochemical transformations, increases rapidly in blood. Then the task of the inactive kidney is usually taken over by the "artificial kidney". The procedure involving it is hemodialysis, i.e. blood washing [11].

Haemodialysis is an extracorporeal dialysis. During the procedure blood is collected from the patient by means of vascular access and then flows through sterile plastic drains and a filter, i.e. a dialyzer, which is connected to the apparatus and cleansed returns to the patient. The dialyzer contains up to 10000 thin capillaries made of semi-permeable membrane. There is blood flowing inside the capillaries and outside the dialysis fluid [12]. The process of exchange between the patient's blood and the dialysis fluid of water and substances soluble in it takes place. The composition of the dialysis fluid is selected so that toxic products of metabolism get into it from plasma, and substances from the dialysis fluid which are lacking in the patient's body are delivered to plasma. These include bicarbonates and calcium. The exchange of substances is possible due to diffusion and convection processes, i.e. ultrafiltration [13].

Diffusion is the movement of plasma soluble molecules through pores of sufficient size in the semipermeable membrane to the dialysis fluid and vice versa 9 according to a concentration gradient. With the completion of hemodialysis, the exchange rate decreases, which is associated with the decrease in concentration difference on both sides of the membrane [14]. It is very important that during the procedure, as much blood as possible is in contact with the dialysis membrane. This is influenced by the dialyser surface and appropriate blood flow. The volume of blood expelled during the procedure should be at least equal to the dry mass of the patient, then the dialysis is adequate [15].

Convection is the process of transporting a solvent and substances dissolved in it through a semi-permeable membrane under the influence of differential pressure. Thanks to their small size, water molecules permeate through all types of semi-permeable membranes, therefore, through ultrafiltration the excess of fluids accumulated by the patient in the period between dialysis is removed [16].

Dialysis patients are examined on a monthly basis. The results determine whether the treatments are sufficient and whether additional drugs are not required. Depending on the results, the duration of the procedure is increased, as well as blood flow. Most often haemodialysis takes place 3 times a week for about 4 hours and the blood flow rate is 250- 450ml/min [17]. According to the data of the Polish Nephrological Society in 2016, a total of 20144 people were dialysed, including 19192 by haemodialysis and 952 by peritoneal dialysis. Men dominated among patients, representing 58%. [18]. Haemodialysis is the most frequently used method of renal replacement therapy. It dominates in end-stage therapy and acute renal failure in adults, and in children it is used in less than 1% of cases, peritoneal dialysis is more frequent [19].

III. INDICATIONS FOR CONTINUOUS RENAL REPLACEMENT THERAPY

Kidneys are considered healthy as long as they are properly filtered and there are no signs of protein or blood in the urine. The degree of filtration, i.e. glomerular filtration (GFR), depends on many factors that affect kidney function. The basis for checking the size of glomerular filtration is a laboratory test [20].

Dialysis should be started when GFR is less than 10ml/min/1.73m2 of body surface. Urea level above 250 mg/dl is also an indication. In addition to assessing the size

of urea toxins, it is extremely important to determine the level of potassium, which should not be higher than 6.5 mmol/l, and to determine the degree of metabolic acidosis, as stated by the level of total bicarbonates, which should not be lower than 13 mmol/l. In the case of persons with the diagnosis of diabetic nephropathy, renal replacement therapy is initiated much earlier, when the GFR is below 20 ml/min/1.73m2 of body surface area [21]. It is also important to assess the patient's clinical condition in terms of weight loss combined with significant appetite reduction, nausea and vomiting [22].

Dialysis treatment can be divided into periodic treatment, which includes patients with acute renal failure and continuous treatment in patients with chronic end-stage renal failure [23].

Acute kidney failure (AKF) is a disease syndrome that is often reversible, caused by a sudden deterioration in kidney function, which leads to insufficient excretion of metabolic products from the body and large electrolyte and water metabolism disorders. The deterioration of renal blood supply, damage to the renal parenchyma or abnormal urinary excretion may contribute to AKF [24]. Kidney failure can also occur as a result of antibiotic treatment against infectious endocarditis [25]. Acute renal failure is diagnosed when serum creatinine concentration increases above 26.3μmol/l in 48 hours, or creatinine concentration increases 1.5 times the upper limit of the norm, which occurs within a week, or when diuresis is less than 0.5 ml/kg/h for another 6 hours [26]. Acute renal failure manifests itself in stomach or urinelessness, and later in polyuria, as well as blood clotting disorders, anaemia, arrhythmia and difficulty in breathing. Loss of appetite, drowsiness, weakness, irritability and disorientation may also occur [27].

Chronic kidney failure is a disease syndrome that occurs gradually with permanent impairment of kidney function. The disease cannot be cured, but its progress can be slowed down [28]. There are five stages of the disease. In the first four stages, treatment focuses on maintaining kidney function. Unfortunately, the disease is often detected in the last stage when it is necessary to start dialysis therapy [29]. Initially, the symptoms are not noticeable. Only in the third stage, when kidney function is reduced by 30 - 60% from normal values, it is necessary to take medicines and follow a diet to delay the next stages. In the fourth stage, the kidneys lose up to 90% of their filtering capacity and this is stage 11 of preparations for haemodialysis or, if there are no contraindications, for transplantation [30]. As the disease progresses, there are more and more worrying symptoms. The smell of ammonia from the mouth or dryness and metallic taste are characteristic. The skin becomes dry yellowish and itchy. Oral and gum inflammation, skin and mucous membrane cyanosis and gastrointestinal bleeding may occur [31]. As a result of reduced urine volume, arterial pressure increases and swelling occurs. Heart failure and arrhythmias appear. Pulmonary oedema, pulmonary fibrosis and pneumonia or pleuritis may occur [32]. In patients with chronic renal failure, decreased immunity and increased glucose and lipid concentrations are observed. Moreover, hormonal disorders, hyperparathyroidism and disorders of the skeletal and nervous systems, as well as disorders of blood morphology and ionic-acid balance may also occur [33].

In older people, diabetic nephropathy, hypertensive nephropathy and ischemic atherosclerotic nephropathy are the main causes of end-stage renal failure [34]. The causes also include glomerulonephritis, which accounts for 20% of cases, and interstitial nephritis, chronic pyelonephritis and cystic kidneys [35].

In chronic kidney disease, complex mineral-bone disorders occur, which increases the risk of bone fractures [36]. The disease is a factor accelerating the process of deceleration at any age, and its early diagnosis reduces the degree of physical and cognitive disability [37].

End stage renal failure contributes to the risk of death and cardiovascular complications [38]. In the world, about 10-15% of people suffer from chronic kidney disease. In Poland, it is estimated that there are about 4 million patients, many of whom may not yet be aware of it, as the disease develops slowly and asymptomatic [39]. Contraindications for renal replacement therapy are primarily lack of consent for treatment with dialysis, as well as severe systemic diseases such as permanent brain damage and dementia and disseminated cancer combined with lack of awareness and immobilisation in bed. In such situations, the initiation of dialysis treatment would contribute to a deterioration in the quality of life, not an improvement in the patient's condition [40].

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