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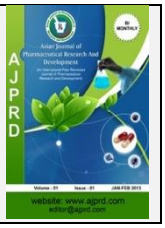

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Review Article

# Review article on hemodialysis and its complications

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## A B S T R A C T

The ability to evaluate outcomes among patients with ESRD increased dramatically after 1988, when the United States Renal Data System (USRDS) was established to record and issue reports that would track mortality and morbidity and determine factors affecting clinical outcomes. Hemodialysis is now substantially safer than it was initially, and deaths directly related to the dialysis procedure are rare. Improved dialysate delivery systems, more reliable monitoring devices, and automated safety mechanisms have reduced the risk of complications. Other technical improvements include the standard use of the more physiologic bicarbonate-based dialysate, better water-quality standards, volumetric ultrafiltration controls, and computer-controlled sodium and potassium modeling. Several in-line devices now allow dynamic monitoring of the rate of blood flow through the vascular access, changes in the hematocrit, and changes in the electrical conductivity of the dialysate, but the complication related to dialysis has not decreased as a result complication related to dialysis is persistent.

**KEYWORDS:** Hemodialysis, End stage renal disease, Complications, Hypotension, Anaemia

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## INTRODUCTION

Fifty years ago, Belding Scribner and his colleagues at the University of Washington developed a blood-access device using Teflon-coated plastic tubes, which facilitated the use of repeated hemodialysis as a life-sustaining treatment for patients with uremia[1]. The introduction of the Scribner shunt, as it became known, soon led to the development of a variety of surgical techniques for the creation of arteriovenous fistulas and grafts. Consequently, hemodialysis has made survival possible for more than a million people throughout the world who have end-stage renal disease (ESRD) with limited or no kidney function. The expansion of dialysis into a form of long-term renal-replacement therapy transformed the field of nephrology and also created a new area of medical science, which has been called the physiology of the artificial kidney[2]. The development of hemodialysis in US since 1960 is summarized in table 1.

## CHRONIC KIDNEY DISEASE - HEMODIALYSIS

Chronic kidney disease (CKD) is defined as an irreversible, substantial and usually gradual loss of renal function leading to a clinical and laboratory syndrome of uremia or GFR of less than 60 ml/min/ 1.73 m2 for 3 months or longer with or without kidney damage[3]. End stage renal disease (ESRD) GFR < 15 ml/min/1.73 m2 would result in death without renal replacement therapy. The important underlying causes are diabetes mellitus, hypertension, chronic glomerulonephritis, chronic pyelonephritis, analgesic nephropathy and polycystic disease [4]. Hemodialysis is indicated for treatment of end stage renal disease. Hemodialysis is a therapeutic procedure that uses the extracorporeal circulation of a patient's blood to ameliorate

the azotemia, fluid, electrolyte, and acid-base abnormalities characteristic of the uremic syn-drome, Autosomal dominant polycystic kidney disease is one of the most common inheritable conditions [5]. Hemodialysis is principally used for the management of acute and chronic renal failure that is refractory to conventional medical therapy. Additional applications include acute intoxications [e.g., ethylene glycol poisoning] and preoperative conditioning of renal transplant recipients [6].Before each dialysis session, the patient's physiological conditions should be checked so that the dialysis prescription can be aligned with the goals for the session. This is accomplished by integrating the separate but related components of the dialysis prescription to achieve the desired rates and total amount of solute and fluid removal. Dialysis is intended to eliminate the symptom complex known as the uremic syndrome[7].Hemodialysis is now substantially safer than it was initially, and deaths directly related to the dialysis procedure are rare. Improved dialysate delivery systems, more reliable monitoring devices, and automated safety mechanisms have reduced the risk of complications. Other technical improvements include the standard use of the more physiologic bicarbonate-based dialysate, better water-quality standards, volumetric ultrafiltration controls, and computer-controlled sodium and potassium modeling[8]. Rather increase in safety of hemodialysis complications related to it remain persistent such complications includes hypotension, nausea and vomiting, hypertension, muscle cramps, dialysis disequilibrium syndrome and many more[9].

**Table 1:** Development of hemodialysis in U.S.

| Year | Development | Description |
|---|---|---|
| **1960** | Scribner shunt invented | Allows for repeated long-term dialysis. |
| **1967** | Gottschalk Committee report | Sets the stage for eventual congressional action on funding ESRD care; projects a low rate of dialysis treatment, with a high rehabilitation rate |
| **1968** | Incorporation of National Medical Care, the first for-profit dialysis provider. | |
| **1972** | Public law 92-603, section 2991 | Authorizes Medicare payment for ESRD treatment, including dialysis and kidney transplantation. |
| **1978** | Congress authorizes ESRD networks | Facilitates quality assurance and continuous quality improvement. |
| **1978** | Public law 95-292 | Paves the way for a bundled composite rate of payment for dialysis services . |
| **1988** | Establishment of U.S. Renal Data System | Creates a government- mandated comprehensive data set on dialysis outcomes. |
| **1989** | Medicare coverage of erythropoietin | Results in coverage of injectable medications in dialysis treatment |
| **1991** | Institute of Medicine's report: *Kidney Failure and the Federal Government* | Facilitates development of quality monitoring in dialysis |
| **1999** | Establishment of ESRD Clinical Performance Measures Project | Initiates public reporting of quality measures and out- comes |
| **2003** | Launch of Fistula First Breakthrough Initiative by CMS | Initiates successful focused quality improvement program |
| **2005–06** | Consolidation of dialysis industry through mergers and acquisitions | Creates an oligopoly whereby two companies control more than 60% of the market |
| **2008** | Passage of Medicare Improvements for Patients and Providers Act | Increases bundling of payments for dialysis in 2011; establishes reimbursement for preventive care and institutes payments for quality |

## COMPLICATIONS OF HEMODIALYSIS:

Although HD is generally a safe procedure, acute intradialytic complications are frequently encountered. The most commonly associated complications include hypotension, muscle cramps, nausea and vomiting, headache, pruritus, fever and chills. Many of the complications are associated with hypotension. Rarely, life threatening complications such as arrhythmias and other cardiovascular complications occur[9]. In a descriptive cross-sectional study was done in 29 patients and Out of the total 573 Hemodialysis sessions analyzed, 176 (30.7%) involved one or more intradialytic complication. Hypotension was the most commonly encountered intradialytic complication occurring in nearly 10% of the sessions followed by nausea and vomiting (5.24%), hypertension (5.06%), muscle cramps (4.71%), and headache (4.54%)(Fig. 1). Other complications such as back pain, chest pain, fever, chills and itching occurred in less than 3% of the sessions. Half of the intradialytic complications occurred in patients with diabetes[10].

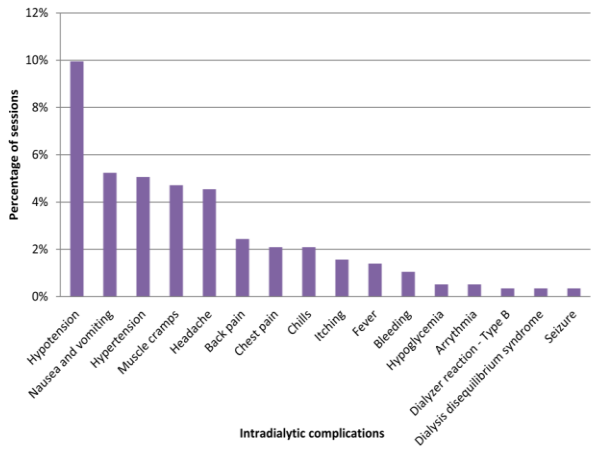


**Figure 1:** Frequency of complication in Hemodialysiscardiovascular instability

Hypotension is the most common intradialytic problem encountered in routine clinical practice. Its incidence has been reported from 05% to 40% of all treatments. In part, the variation is because of the definition, varying from symptomatic hypotension requiring active treatment, to an asymptomatic percentage fall in systolic blood pressure. It has been reported to be more common in female patients, the elderly with isolated systolic hypertension because of arteriosclerosis, diabetics, and those with documented autonomic neuropathy. During dialysis, the fluid is removed from the intravascular compartment because of ultrafiltration, and the rate of removal may exceed that of refilling from the extra and intracellular spaces, resulting in a reduction in circulating blood volume. This is compounded by a reduction in venous capacitance reactivity, in part related to the cardiopulmonary redistribution of blood flow that occurs when patients dialyze using an arteriovenous fistula (AVF) or arteriovenous graft (AVG). This results in reduction in cardiac filling pressures[11].Treatment of Hypotension - Pay attention to how the patient feels, NS bolus, Place patient in Trendelenburg position, Use Sodium, evaluate target and pre-weight for accuracy, evaluate that fluid goal was correct, Review medication list for BP medication[12]. Cardiac arrhythmias, in particular multiform ventricular ectopic, and couplets are very commonly reported during hemodialysis, with estimates of up to 50%. Fortunately, these are usually asymptomatic and settle spontaneously post-treatment. Atrial fibrillation is the most common sustained arrhythmia during dialysis, occurring in up to 20% of treatments. This is more common in patients with left ventricular diastolic dysfunction, particularly in association with a reduction in effective blood volume that occurs during hemodialysis and with sepsis. In many cases, atrial fibrillation settles spontaneously within a few hours of dialysis[13].

## ELECTROLYTE IMBALANCE

Severe hyperkalemia is defined as serum potassium >6 or >5.5 mEq/l with clinical signs such as arrhythmia or other electrocardiogram (ECG) abnormalities (e.g., T-wave elevation, loss of P-wave or sinus-wave QRS pattern), muscle weakness, and/or ascending paralysis[14].Observational evidence from a large cohort of incident and prevalent chronic hemodialysis (HD) patients (n = 81.013) suggests a U-shaped relationship between predialysis serum potassium levels and both, all-cause and cardiovascular mortality. After correction for multiple confounders, these associations remained significant for hyperkalemia[15]. Hyponatremia is a common water balance disorder defined as serum sodium concentration ≤135 mEq/l. Clinical symptoms include nausea, headache, confusion, cognitive deficits, gait disturbances, fatigue, muscle weakness, and cramps but might also be completely absent in mild to moderate hyponatremia (i.e., serum sodium 125–135 mEq/l). Severe hyponatremia (i.e., serum sodium <120 mEq/1) is a potentially life-threatening disorder with severe neurological complications that can result from cerebral edema or osmotic demyelination in the context of inadequate or excessive treatment, respectively[16].There is a large body of evidence demonstrating that chronic hyponatremia is more common (6%–29%), related to malnutrition and loss of residual kidney function, and independently associated with mortality in prevalent and incident HD patients[17].

## NEUROLOGIC

Dialysis disequilibrium syndrome (DDS) is a rare syndrome occurring in patients with severe azotemia undergoing their initial HD session. It is characterized by nausea, vomiting, headache, encephalopathy, and seizures. DDS is attributed to the faster decline of urea concentration in the blood than in the brain during the dialysis session. This lag reverse urea effect creates an osmotic gradient that promotes net water shift from the blood into the brain, leading to cerebral edema and its associated manifestations [18]. Causes – Slower transfer of urea from the brain tissue to the blood. Fluid shift into the brain due to removal of wastes from the blood stream causing cerebral edema. Rapid changes in serum electrolytes, especially in new patients.Treatment - Monitor new patients carefully for hypertension, ACEi and ARBs are effective therapeutic agents which will rarely cause mild to severe hyperkalemia[19], be alert for restlessness, speech/mental changes, assess new patient's electrolyte levels, Use a smaller dialyzer, lower blood filtration rate and shorter dialysis time for first few treatments [5].Muscle Cramps, Painful muscle spasms (usually in extremities) Causes – Associated with removal of large amounts of fluid, Hypotension, Changes in electrolytes (blood chemistry), Rapid sodium removal, Low potassium levels, Inaccurate fluid removal goal. Treatment - Normal saline bolus, reduce ultrafiltration rate, Massage, assess dry weight, Sodium modeling, Assess for accurate target weight [20].

## RESPIRATORY

Respiratory complications encountered in hemodialysis patients include pulmonary edema, pleural effusion, and intradialytic dyspnea. Intradialytic dyspnea may be a consequence of hypoxemia, hypoventilation, pulmonary thromboembolism, or uremic pneumonitis. Dialysis associated hypoxemia is a biocompatibility reaction whereby the alternate complement pathway is activated following contact with the hemodialyzer membrane. Activated complement induces sequestration of neutrophils in the pulmonary capillaries interfering with oxygen diffusion. The hypoxemia is generally mild; however, it may be deleterious in patients with concurrent anemia,

pulmonary or cardiovascular disease. Hypoxemia develops within 30 to 60 minutes of the start of dialysis and resolves within 120 minutes after discontinuing the treatment. Administering supplemental oxygen during the hemodialysis session and ensuring adequate oxygen carrying capacity will minimize hypoxemia[21].

## HEMATOLOGIC

Hematologic complications include leukopenia, thrombocytopenia, and anemia. Leukopenia and thrombocytopenia are common, transient, intra-dialysis clinically insignificant consequences of biocompatibility reactions with the hemodialyzer membrane. [22]. Anemia: Not having enough red blood cells in your blood (anemia) is a common complication of kidney failure and hemodialysis. Failing kidneys reduce production of a hormone called erythropoietin, which stimulates formation of red blood cells. Altough recombinant human erythropoietin is widely used in chronic dialysis patients. Trials of erythropoietin-stimulating agents in persons with kidney disease have also suggested an increased incidence of adverse clinical events [23]. Diet restrictions, poor absorption of iron, frequent blood tests, or removal of iron and vitamins by hemodialysis also can contribute to anemia. Treatment - Packed red blood cell transfusions, Erythropoietic agents (Erythropoietin, Darbepoetin), Oral iron salts, Intravenous iron, iron dextran, Iron sucrose, Iron gluconate [24].

## TECHNICAL

In today's high-technology society, we tend to assume that machines are accurate and infallible. However, errors do still occur. These may be because of failure of the technology or human error, often because of failure to follow standard practices. For example, the blood pump head has to be adjusted according to the diameter of the arterial line pump head segment. This may become misaligned, or inappropriately set following repair, or switching from adult to pediatric lines. Whereas minor hemolysis can occur with arterial pressures in excess of 160 mmHg, because of high flow rates and access problems a misaligned blood pump head generates very high pressures, resulting in severe mechanical hemolysis. Severe hemolysis can cause headache, nausea, malaise, abdominal pain, and severe hyperkalemia [25]. clinical complications include malfunctions in the dialysate circuit (incorrect composition, temperature, impure water) or the blood circuit [blood pump hemolysis, undetected ultrafiltration, air embolism, blood leakage into the dialysate, or blood losses from leaks or clotting in the extracorporeal path]. These complications are eliminated by using modern dialysis equipment containing intrinsic safeguards and internal sensors. Temptations to initiate a hemodialysis program with obsolete, discarded, or surplus equipment based on outdated technology should be abandoned solely on the basis of the inherent technical risks it might predispose [26]. Pyrogenic Reaction, Fever reaction due to presence of dead bacteria endotoxins. Low molecular weight endotoxin fragments may be able to cross any membrane, irrespective of membrane pore size distribution. Caused by contamination of – Bicarbonate containers/system, Water system, Machine, Dialyzer or bloodlines.Treatment – Remove from dialysis immediately, Gather samples of dialysate/blood per company policy, Prevention by Proper disinfection/sterilization, Proper disinfection/sterilization, Use of aseptic technique [27].

## VASCULAR ACCESS

Thromboembolism, Chronic kidney disease (CKD) has been linked to a hypercoagulable state. Multiple studies have found that CKD defined by proteinuria or reduced estimated glomerular filtration rate (eGFR) increases the risk for venous thromboembolism (VTE).Kidney disease defined by nephrotic syndrome is a well-established risk factor for VTE. Recent data suggest that even low levels of proteinuria increase the risk for VTE. For CKD not requiring dialysis (CKD Stages 2–4), studies suggest that VTE risk increases in a graded fashion with declining eGFR, the high risk of VTE appears to remain among patients with kidney failure requiring dialysis. Treatment – anticoagulants [28], Stenosis of Vascular Access, the development of vascular access stenosis is the single most important complication that develops in an arteriovenous access.16 This complication directly reduces blood flow in a dialysis access. In this way, it can directly lower the quality of dialysis therapy. Consequently, the treatment of stenosis is of paramount importance to provide vital dialysis therapy to an end-stage renal disease patient. Abnormalities in platelet function profiles which characterize this patient population can contribute to these observations [29].Treatment- Physical examination has emerged as an important tool in the evaluation of the dialysis access. Physical examination should be performed at 4 to 6 weeks of fistula creation to ascertain its maturation [30]. Fibroepithelial Sheath, A reduction in blood flow due to catheter dysfunction ultimately results in a reduction of dialysis dose delivered to a hemodialysis patient. The development of catheter-related fibroepithelial sheath leads to catheter malfunction and catheter occlusion. Radiocontrast studies have demonstrated that this complication is found in more than half of the patients with catheter dysfunction. Treatment- Catheter exchange alone does not help the condition. The treatment of fibroepithelial sheath is required to fix catheter dysfunction. Percutaneous balloon angioplasty has emerged as a major tool in successfully treating the fibroepithelial sheath [31].

## MALNUTRITION

Undernutrition is very common among maintenance hemodialysis patients. Indeed, 30% to 40% of them show clinical manifestations of caloric and protein restriction and 15% of them, severely impaired, need enteral or parenteral supplementation. The deleterious effects of malnutrition are severe in the mid and long term. Numerous statistical studies have shown that a higher mortality rate is present in these malnourished patients. Moreover, malnutrition is an important cause of poor or even absence of rehabilitation. The pharmacological interventions in the form of phosphate binders, vit-D analogues and calcium supplements also helped in maintaining the GFR [32]. Physical exercise is difficult, ability to work is impossible, and social and family life are impaired Persisting complications, such as hypertension, left ventricular hypertrophy, and the mandatory need for antihypertensive drugs not always well tolerated, may lead to asthenia and anorexia, the common pathway of malnutrition. Treatment-As soon as the first

week, anorexia tends to disappear, along with more generous dietetic prescriptions. Modify nutrient intake and lifestyle as appropriate for the prevention and treatment of obesity, and nephropathy [33]. Among other changes, investigators have reported a better tolerance of dialysis sessions, a limitation of interdialytic weight gain, the correction of blood pressure, and reduction in left ventricular hypertrophy [34].

## CONCLUSION:

Hemodialysis (HD) a fluid replacement therapy for end stage renal disease (ESRD) patients. Despite being a lifesaving treatment, the rate of mortality in patients under HD is elevated, mainly due to the complication that occur during dialysis which is characterized by hypertension, anemia, inflammation, peritoneal fibrosis, thrombosis and neo-angiogenesis and over the past half century, the widespread use of dialysis to prolong life for people without kidney function has been a remarkable achievement. Despite such successes, the use of dialysis in the treatment of ESRD is problematic in some respects. Aggregate dialysis-associated costs have increased accordingly, and morbidity and mortality among treated patients remain high despite considerable technical and scientific improvements. Our knowledge of which uremic toxins confer injury and of how they can be optimally removed during dialysis therapy remains incomplete. The limited number of clinical trials that have attempted to improve outcomes have had disappointing results, so more well-designed and adequately powered clinical trials are needed. Ongoing studies are assessing whether longer or more frequent dialysis treatments, or both, can improve outcomes and whether these changes would be acceptable to most patients.

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