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Changes in Serum Osmolality and the Clinical Manifestations of the Dialysis Disequilibrium Syndrome

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CHANGES IN SERUM OSMOLALITY AND THE CLINICAL MANIFESTATIONS OF THE DIALYSIS DISEQUILIBRIUM SYNDROME

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CURRICULUM VITAE

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CHAPTER I

INTRODUCTION

Today hemodialysis is a widely accepted mode of treatment for the chronic renal failure patient. However, prior to 1960 the patient with end-stage kidney disease was managed on a protein and salt restricted diet and drug therapy to control hypertension and the neurologic symptoms of uremia. Despite medical management, the disease was a fatal one.[1]

The development of dialysis equipment and the ability to maintain long-term circulatory access led to the successful clinical application of hemodialysis in chronic renal failure. In 1913 Abel, Rowntree, and Turner first described "vividiffusion", a process of dialyzing blood of a living animal outside of the body and returning the blood to the natural circulation. The authors referred to the apparatus used as an artificial kidney.[2]

In 1943 Kolff introduced the first extracorporeal dialyzer for use in clinical medicine. Although successful,

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[1]Eli A. Friedman, ed., Strategy in Renal Failure (New York: John Wiley and Sons, Inc., 1978), p. 1.

[2]John J. Abel, L. G. Rowntree, and B. B. Turner, "On the Removal of Diffusable Substances From the Circulating Blood by Means of Dialysis," Journal of Pharmacology 5 (1913):275.

the technique was complex and could only be used as long as blood vessels for puncture sites were available.[3]

Merrill and associates presented a modification of Kolff's rotating drum dialyzer in 1949 which minimized clotting and decreased hemolysis.[4] Alwell[5] and Skeggs and Leonard[6] devised a dialyzer which required a hydrostatic gradient to force a thin film of blood between two layers of cellophane, introducing the concept of ultrafiltration.

Despite the advances in dialysis equipment, hemodialysis was primarily indicated in acute renal failure, acute exacerbations of chronic renal failure, and cases of ingestion of toxic substances. It was not until 1960 that Scribner proposed intermittent hemodialysis as a treatment for chronic renal failure patients.[7] The development of the silastic arteriovenous cannula by Quinton and Scribner

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[3]W. J. Kolff et al., "The Artificial Kidney: A Dialyzer with a Great Area," Acta Medica Scandinavica 117 (1944):133.

[4]John P. Merrill, "Clinical Application of an Artificial Kidney," Bulletin of New England Medical Center 11 (1949):111.

[5]N. Alwell, "On the Artificial Kidney, I. Apparatus for Dialysis of Blood in vivo," Acta Medica Scandinavica 128 (1947):317.

[6]L. T. Skeggs, J. R. Leonards, and C. R. Heisler, "Artificial Kidney: II. Construction and Operation of Improved Continuous Dialyzer," Proceedings of the Society for Experimental Biology and Medicine 72 (1949):539.

[7]B. H. Scribner et al., "The Treatment of Chronic Uremia by Means of Intermittent Hemodialysis: A Preliminary Report," Transactions of the American Society for Internal Artificial Organs 6 (1960):114.

in 1960 made long-term circulatory access possible and made intermittent hemodialysis a practical reality.[8]

Since 1960 efforts in this area have produced a variety of more efficient dialyzers. In 1965 Brescia, Cimino, Appel, and Hurwich created an internal arteriovenous fistula.[9] Descriptions of various types of internal fistulas continue to appear in the literature.[10]

The passage of the Social Security Act in 1972 provided financial support for the care of patients with end-stage kidney disease. With advances in the clinical application of hemodialysis and federal legislation providing financial support, hemodialysis has become widely used as a treatment for patients with end-stage kidney disease. In March 1975, 408 patients were being maintained on routine hemodialysis in the state of Virginia.[11]

Hemodialysis can extend the lives of patients with end-stage kidney disease. However, this procedure is not without its complications. Technical problems such as

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[8]W. Quinton, D. Dillard, and B. H. Scribner, "Cannulation of Blood Vessels for Prolonged Hemodialysis," Transactions of the American Society for Artificial Internal Organs 6 (1960):104.

[9]M. J. Brescia et al., "Chronic Hemodialysis Using Venipuncture and Surgically Created Arteriovenous Fistula," New England Journal of Medicine 275 (1966):1089.

[10]Allen L. Sellers and Shaul G. Massry, eds., Clinical Aspects of Uremia and Dialysis (Springfield: Charles C. Thomas, 1976), p. 505.

[11]James C. Pierce, ed., The Renal Program of Virginia (Virginia Regional Medical Program, 1975), p. 48.

blood leaks, tubing separations, and dialysate errors have been reported.[12] Hypotension, hypertension, acute bleeding, cardiac arrythmias, fever, chest pain, and depression may occur during the dialysis procedure.

A frequent and dangerous complication of dialysis is the dialysis disequilibrium syndrome.[13] This syndrome is characterized by acute changes which occur during dialysis. Symptoms of the syndrome include headache, fatigue, muscle cramps, nausea, vomiting, confusion, convulsions, and coma.

The etiology of the dialysis disequilibrium syndrome remains unclear. Various concepts have been introduced in the literature to hypothesize the etiology of the clinical symptoms of the syndrome.[14] The mechanism common to each of these concepts is the shift of water into the cell, due to a change in the osmolar concentration gradient between the intracellular and extracellular environments. This shift causes the cell to swell and is believed to be the cause of the clinical symptoms of the syndrome.[15,16,17]

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[12]Joan D. Harrington and Etta Rae Brener, Patient Care in Renal Failure (Philadelphia: W.B. Saunders, 1973), p. 139.

[13]Sellers and Massry, Uremia and Dialysis, p. 34.

[14]Khalil G. Wakim, "The Pathophysiology of the Dialysis Disequilibrium Syndrome," Mayo Clinic Proceedings 44 (June 1960):425.

[15]A. C. Kennedy et al., "Urea Levels in Cerebrospinal Fluid After Hemodialysis," Lancet (February 24, 1962):410.

[16]V. Sitprija and J. H. Holmes, "Preliminary Observations on the Changes in Intracranial Pressure and Intraocular Pressure During Hemodialysis," Transactions of the American Society of Artificial Internal Organs 8 (1962):300.

[17]Allen I. Arieff et al., "Central Nervous System pH in Uremia and the Effects of Hemodialysis," The Journal of Clinical Investigation 58 (August 1976):306.

Research by Martino[18], Sitprija and Holmes,[19] Peterson and Swanson,[20] and Hagstam[21] examined the etiology of the dialysis disequilibrium syndrome. Their results indicated that variations in serum osmolality occur during dialysis. Port[22] and Rodrigo[23] observed that there is a significant increase in the number of clinical symptoms associated with the syndrome when there is a decrease in the serum osmolality.

Each of these studies have shown that changes in serum osmolality occur during the dialysis procedure. However, no published study has examined the specific relationship between the change in serum osmolality and the number of clinical symptoms of the dialysis disequilibrium syndrome.

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[18]Francisco P. Martino and William A. Kelemen, "Postdialytic Changes in Serum Osmolality and in Blood Urea of 23 Patients," Cleveland Clinic Quarterly 26 (July 1959):113.

[19]Sitprija and Holmes, "Intracranial Pressure and Intraocular Pressure," p. 300.

[20]Hart C. Peterson and August G. Swanson, "Acute Encephalopathy Occurring During Hemodialysis," Archives of Internal Medicine 113 (June 1964):879.

[21]K. E. Hagstam et al., "Mannitol Infusion in Regular Hemodialysis Treatment for Chronic Renal Insufficiency," Scandinavian Journal of Urology and Nephrology 3 (1969): 257.

[22]Friedrich K. Port et al., "Prevention of Dialysis Disequilibrium Syndrome by Use of High Sodium Concentration in the Dialysate," Kidney International 3 (1973):327.

[23]Francisco Rodrigo et al., "Osmolality Changes During Hemodialysis," Annals of Internal Medicine 86 (May 1977): 554.

Knowledge of this relationship may influence the nursing interventions made to increase the comfort of the patient during the hemodialysis procedure. The nurse in the dialysis unit is responsible for the safety and comfort of the patients. This requires coordination of a high quality of physical and emotional nursing care.[24] Functions of the nurse include patient assessment, initiation and discontinuance of the dialysis procedure, patient monitoring during dialysis, patient teaching, and emotional support and counseling.[25,26]

These interventions are based on the nurse's understanding of the principles of hemodialysis and the complications of the treatment. The nurse observes for the mechanical, metabolic, and psychologic problems that may occur during the dialysis procedure. A major complication of dialysis is the dialysis disequilibrium syndrome. Understanding of the specific relationship of clinical symptoms observed and the physiologic changes caused by hemodialysis would further enable the nurse to assess the patient and prevent, modify, or correct symptoms of the dialysis disequilibrium syndrome.

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[24]Ginny L. Hansen, ed., Caring for Patients with Chronic Renal Disease (Philadelphia: J.B. Lippincott, 1972), p. 107.

[25]Harrington and Brener, Renal Failure, p. 149.

[26]C. F. Gutch and Martha H. Stoner, Review of Hemodialysis for Nurses and Dialysis Personnel (St. Louis: The C.V. Mosby Company, 1975), p. 2.

Problem Statement

Is there a correlation between the change in serum osmolality and the clinical symptoms of the dialysis disequilibrium syndrome experienced by the chronic renal failure patient during hemodialysis?

Hypothesis

The number of clinical symptoms of the dialysis disequilibrium syndrome experienced by the chronic renal failure patient on hemodialysis will increase as the serum osmolality decreases.

Definition of Terms

Clinical Symptoms - Any subjective change in the body or its function.

Dialysis Disequilibrium Syndrome - A clinical syndrome occurring during a dialysis procedure. The syndrome is characterized by the presence of any or all of the following: headache, dizziness, nausea, vomiting, fatigue, muscle cramps, confusion, seizures, or coma.

Chronic Renal Failure - A progressive, irreversible kidney disease characterized by a decrease in glomerular filtration, tubular reabsorption and/or tubular secretion.

Serum Osmolality - The concentration of dissolved ionic particles per unit volume of aqueous solution. The measurement of serum osmolality is the relationship between the number of molecules present in serum and the effect of these molecules on the colligative properties of the serum.

Hemodialysis - A process of removing substances from the blood and replacing essential constituents. The operating principle of dialysis is the diffusion of solutes across a semipermeable membrane.

Assumptions

1. Clinical symptoms which did not exist immediately prior to the initiation of dialysis and were manifested during the dialysis procedure were considered symptoms of the dialysis disequilibrium syndrome.

2. The dialysis personnel who participated in the study did have the opportunity to make observations and document the patient's clinical symptoms during the dialysis procedure.

Limitations of the Study

1. The tools used in this study were constructed based upon the information sought by the Hagstam study.[27] Symptoms Experienced by the Patient While Receiving Hemodialysis (Appendix C) and Patient Symptoms Observed by the Nurse During Hemodialysis (Appendix D) were not tested for reliability and validity. Inter-rater reliability was measured.

2. The frequency of the nurse/patient interaction during the study may have influenced the patient response and the nurse response on the instruments used to document patient symptoms during hemodialysis.

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[27]Hagstam et al., "Mannitol Infusion," p. 258.

CHAPTER II

LITERATURE REVIEW

The purpose of this study was to examine the relationship between the change in serum osmolality of the chronic renal failure patient during hemodialysis and the number of symptoms of the dialysis disequilibrium syndrome during the procedure.

The symptoms which characterize the dialysis disequilibrium syndrome are similar to the clinical manifestations of chronic renal failure. The investigator felt the need to review the literature regarding the effects of chronic renal failure and hemodialysis upon the body systems in order to differentiate these effects from the clinical symptoms of the dialysis disequilibrium syndrome.

A review of the literature regarding the dialysis disequilibrium syndrome and the clinical significance of serum osmolality is also included.

Effects of Chronic Renal Failure and Hemodialysis Upon the Body Systems

Chronic renal failure is a progressive, irreversible disease characterized by a decrease in the glomerular filtration rate, tubular reabsorption and/or tubular secretion. As the number of functioning renal tubules is reduced,

kidney function decreases. There is an accumulation of toxic materials which are normally excreted. Toxic substances which are retained include urea, creatinine, phosphorus, and drug metabolites.[1] Disturbances in regulatory functions cause abnormalities in fluid, electrolyte, and acid-base balance. Endocrine and metabolic functions of the kidney are altered.

Clinical signs of renal failure occur in all body systems. Chronic renal failure patients who are treated with maintenance hemodialysis may or may not exhibit reversal of the manifestations of the disease. A summary of the signs of chronic renal failure and the effects of hemodialysis is presented by body systems.

Nervous System

Reviews of neurologic disorders in renal failure and neurologic complications of dialysis have been published by Tyler.[2,3] In the early stages of renal failure, central nervous system involvement is manifested by fatigue, apathy, changes in recent and remote memory, impaired cognition, and narrowed span of attention. As the renal failure progresses the patient may show signs of increasing irritability,

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[1]Hansen, Chronic Renal Disease, p. 12.

[2]H. Richard Tyler, "Neurological Complications of Dialysis, Transplantation and Other Forms of Treatment in Chronic Illness," Neurology 15 (1965):1081.

[3]H. Richard Tyler, "Neurologic Disorders in Renal Failure," American Journal of Medicine 44 (May 1968):734.

become disoriented, and muscle twitching or asterixis may be present. Lethargy becomes more severe. Convulsions may occur followed by stupor and coma. Electroencephalographic disturbances indicate diffuse involvement of central nervous system function.[4]

There has been an increasing interest in the polyneuropathy associated with chronic renal failure. The neuropathy is manifested by a reduction in the velocity of nerve conduction.[5] This reduction in nerve conduction may be present prior to the development of clinical symptoms.[6] Clinical signs occur symmetrically, progressing from distal to proximal extremities.[7] Symptoms include the "restless leg syndrome,"[8] paresthesias, loss of vibratory perception, weakness in limbs, and reduction of deep tendon reflexes. Tenckhoff has shown improvement in ten patients who developed sensory or motor neuropathy prior to dialysis or during the first year of dialysis when treated with maintenance hemodialysis. The neuropathy did not progress or develop

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[4]Ibid., p. 735.

[5]Constantine L. Hampers et al., Long-Term Hemodialysis (New York: Grune and Stratton, 1973), p. 162.

[6]Ibid., p. 162.

[7]Neil A. Kurtzman and Manuel Martinez-Maldonado, eds., Pathophysiology of the Kidney (Springfield: Charles C. Thomas, 1977), p. 853.

[8]The "restless leg syndrome" is characterized by pricking and itching sensations in the lower limbs. Symptoms are usually removed by movement of the extremities.

in twenty consecutive patients on maintenance hemodialysis.[9]

Neurologic disturbances may occur while patients undergo hemodialysis treatment. Common complications include irritability, headache, nausea, vomiting, and muscle twitching. Drowsiness during dialysis is common. Convulsions and coma may occur. Abnormalities in the electroencephalographic pattern during the occurrence of these symptoms have been documented.[10] **The neurologic signs** which occur during dialysis usually subside following termination of the procedure.[11]

Maintenance hemodialysis can reverse or prevent the neurologic disorders of chronic renal failure. However, neurologic complications of dialysis are not uncommon and are considered symptoms of the dialysis disequilibrium syndrome.[12]

Cardiovascular System

Hypertension is the most frequent cardiovascular complication of chronic renal failure.[13] Many of these

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[9]H. Tenckhoff, R. H. Jebsen, and J. C. Honet, "The Effect of Long-Term Dialysis Treatment on the Course of Uremic Neuropathy," Transactions of the American Society for Artificial Organs 13 (1967):58.

[10]A. Mayrier et al., "Unusual Aspects of the Dialysis Disequilibrium Syndrome," Clinical Nephrology 6 (July 1976): 313.

[11]Tyler, "Neurologic Complications," p. 1082.

[12]Ibid., p. 1083.

[13]Kurtzman and Martinez-Maldonado, Pathophysiology of the Kidney, p. 858.

patients remain asymptomatic. Hampers notes that 70 - 75% of his patients have become normotensive when treated with hemodialysis and volume reduction.[14]

Impairment of sodium and water metabolism in the patient with chronic renal failure often leads to peripheral edema. The condition is worsened by hypoproteinemia and excess fluid intake in the presence of oliguria.[15] In the presence of heart failure, pulmonary edema may develop. Hemodialysis can remove excess fluid volume and produce clinical improvement.[16]

Pericarditis is a complication of chronic renal failure. It occurs in 30 - 50% of patients with terminal renal failure.[17,18] Most patients are asymptomatic although in some instances chest pain is present. Treatment by dialysis generally resolves the pericardial friction rub. However, it may take longer periods of time to resolve the pericardial disease.[19]

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[14]Hampers et al., Long-Term Hemodialysis, p. 98.

[15]Maxwell M. Wintrobe et al., Harrison's Principles of Internal Medicine (New York: McGraw-Hill Book Company, 1974), p. 1378.

[16]William B. Schwartz and Jerome P. Kassirer, "Medical Management of Chronic Renal Failure," American Journal of Medicine 44 (May 1968):789.

[17]Wintrobe et al., Principles of Internal Medicine, p. 1378.

[18]Hampers et al., Long-Term Hemodialysis, p. 92.

[19]Sellers and Massry, Uremia and Dialysis, p. 87.

Gastrointestinal System

Anorexia, nausea, and vomiting are common symptoms in the patient with chronic renal failure. Mouth ulcers, gastritis, and duodenitis may develop. Presence of peptic ulcer disease is common in these patients, although the incidence may not be appreciably different from the general population.[20] The etiology of the gastrointestinal symptoms is still unknown. Most symptoms will clear when the patient is treated with maintenance hemodialysis.[21]

The literature published regarding the incidence of viral hepatitis is extensive. The incidence of viral hepatitis, type B ranges from 0 - 100% varying from one center to another.[22] However, Schiff reports that over 80% of dialysis centers in the United States have reported cases of viral hepatitis.[23] Descriptive reports indicate that the incidence of viral hepatitis, type B is much higher in hemodialysis patients, institutionalized mentally retarded patients, and hematology-oncology patients. Transmission of the virus in these environments is related

> to inadvertant percutaneous inoculation from contaminated instruments or objects, entry of contaminated blood through sounds or unprotected breaks in the skin, accidental

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[20]Ibid., p. 200.

[21]Hampers et al., Long-Term Hemodialysis, p. 137.

[22]Sellers and Massry, Uremia and Dialysis, p. 186.

[23]Eugene R. Schiff, "Epidemiology of Virus B Hepatitis," Medical Clinics of North America 59 (July 1974):835.

> splattering or splashing of positive material onto mucous membranes, or inapparent ingestion of contaminated materials.[24]

Hematopoietic System

The development of anemia is inevitable. Red cells are normocytic and normochromic.[25] Clinical signs of anemia include shortness of breath, weakness, and anorexia. Hemodialysis may provide some benefit to the uremic individual, but treatment by dialysis rarely causes elevation of hematocrit levels to normal levels.[26]

A bleeding tendency is not uncommon in the uremic patient. The coagulation defect is believed to be an abnormality in platelet function.[27] Bleeding from mucous membranes is predominant. Correction of the platelet abnormality can be achieved by routine hemodialysis.[28]

Metabolic and Endocrine Systems

Feldman and Singer have extensively reviewed the endocrinology and metabolism in uremia and dialysis. Chronic renal failure patients demonstrate derangement of protein metabolism, glucose intolerance, and lipid

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[24]David R. Snydman, John A. Bryan, and Richard E. Dixon, "Prevention of Nosocomial Viral Hepatitis, Type B," Annals of Internal Medicine 83 (1975):838.

[25]Wintrobe et al., Principles of Internal Medicine, p. 1379.

[26]Hampers et al., Long-Term Hemodialysis, p. 120.

[27]Sellers and Massry, Uremia and Dialysis, p. 179.

[28]Ibid., p. 183.

abnormalities. Alterations in aldosterone, ADH, erythropcietin, gastrin, growth hormone, glucagon, insulin, and parathyroid hormone occur. Gonadal function is altered. Females may experience amenorrhea, infertility, and decreased libido. Males may present with infertility, gynecomastia, and decreased libido.[29] Hemodialysis may not reverse these disturbances.[30,31,32]

Psychological Aspects

The psychological stresses of chronic illness and the patients' adaptation to chronic hemodialysis have been examined by physicians and nurses. In 1959 Schreiner identified the mental and personality changes which manifest in the uremic patient. Neuropsychiatric symptoms identified include fatigue, apathy, inability to concentrate for long periods, cyclic variations in the overall feeling of well-being, decrease in sexual desires and performance, irritability, paranoia, compulsive behavior, and sensory hallucinations. Schreiner described case studies of patients who experienced a reversal of these symptoms following treatment by hemodialysis.[33]

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[29]Harvey A. Feldman and Irwin Singer, "Endocrinology and Metabolism in Uremia and Dialysis: A Clinical Review," Medicine 54 (September 1975):345.

[30]Kurtzman and Martinez-Maldonado, Pathophysiology of the Kidney, p. 865.

[31]Hampers et al., Long-Term Hemodialysis, p. 189.

[32]Sellers and Massry, Uremia and Dialysis, p. 273.

[33]George E. Schreiner, "Mental and Personality Changes in the Uremic Syndrome," Medical Annals of the District of Columbia 28 (June 1959):316.

Wright categorized the psychological stresses experienced by the patient with chronic renal failure on maintenance hemodialysis. The three categories were: (1) actual or threatened losses, including body function, membership in social and work groups, changes in life style, and loss of job and financial status; (2) injury or threat of injury; and (3) frustration in drives, such as dietary restrictions and changes in sexual potency and desires.[34]

Dr. Abram is a psychiatrist who has extensively studied the effects of maintenance hemodialysis upon patients, families, and dialysis staffs. Using psychological testing and interviews, Abram identified four phases of adaptation experienced by the patient on rcutine hemodialysis.

He describes patients who have been treated by hemodialysis for at least three months in Phase IV: The Struggle for Normalcy - "The Problem of Living Rather than Dying." At this stage the patient has begun to acknowledge the realities of his situation and continues to resolve the conflicts he is experiencing. Abram states that patients in this phase who sleep through the dialysis procedure may be exhibiting a decrease in their concern for injury or complication during dialysis.[35]

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[34]Robert G. Wright, Patricia Sand, and Goodhue Livingston, "Psychological Stress During Hemodialysis for Chronic Renal Failure," Annals of Internal Medicine 64 (March 1966):611.

[35]Harry S. Abram, "The Psychiatrist, the Treatment of Chronic Renal Failure and the Prolongation of Life: II," American Journal of Psychiatry 126 (August 1969):157.

Levy found that the patient displayed marked fluctuations in his sense of physical and emotional well-being during the period of long-term adaptation.[36] A chronic renal failure patient describes his treatment:

> Though my contact with the machine is for only thirty hours a week, it is seldom, if ever, completely out of my mind. It maintains a powerful, almost frightening hold on my life. Were it not for the kidney I wouldn't be here to write this and yet I find it impossible to make friends with the monster.[37]

Decreased kidney function affects all body systems. Disturbances in body function may be prevented or reversed by treatment on hemodialysis. However, despite the improvement of body chemistries during dialysis, the patient may experience a temporary and sudden decline in clinical status during the dialysis procedure.

Although an improvement in the patient's clinical status is expected during dialysis, the patient may experience symptoms which are similar to the manifestations of chronic renal failure such as lethargy, nausea, vomiting, confusion, muscle twitching, convulsions, and coma. These clinical signs improve following termination of the procedure. The sudden onset of temporary symptoms occurring

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[36]Norman B. Levy, "The Psychology and Care of the Maintenance Hemodialysis Patient," Heart and Lung 2 (May/June 1973):400.

[37]Harry S. Abram, "The Psychiatrist, the Treatment of Chronic Renal Failure and the Prolongation of Life: I," American Journal of Psychiatry 124 (April 1968):1354.

during dialysis was first described by Kennedy. He referred to the syndrome as the dialysis disequilibrium syndrome.[38]

Dialysis Disequilibrium Syndrome

The dialysis disequilibrium syndrome was first described by Kennedy in 1962. He observed a variety of transient symptoms which occurred during hemodialysis. The symptoms included headache, muscle twitching and confusion. Each patient who experienced these symptoms was a chronic renal failure patient with a plasma urea level greater than 400 mg% prior to hemodialysis. Dialysis occurred over 3½ - 5½ hours, reducing the urea levels to 170 - 220 mg%.[39]

Subsequent reports substantiated Kennedy's findings.[40] Manifestations observed included headache, nausea, vomiting, tremors, disorientation, convulsive seizures, and coma. The disorder characterized by these symptoms was named the dialysis disequilibrium syndrome.

Although the symptoms of the syndrome were observed routinely in dialysis centers, the etiology of the syndrome remained controversial. In 1969 Wakim reviewed the current concepts regarding the pathophysiological mechanisms involved in the production of the clinical symptoms. The concepts reported were: (1) cerebral edema due to the

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[38]Kennedy et al., "Urea Levels," p. 410.

[39]Ibid., p. 410.

[40]Wakim, "Dialysis Disequilibrium Syndrome," p. 425.

"reverse urea effect,"[41] (2) hypoglycemia, (3) alterations in pCO_2 tension, (4) increase in potassium/calcium ratio and shift in electrolytes, (5) overhydration, and (6) significant hyponatremia. The common mechanism of each concept is the rapid biochemical changes which occur during dialysis.[42] Tyler noted that neurologic symptoms which occurred during hemodialysis were caused by rapid changes in pH or shifts in electrolytes, regardless of whether the shift was in the direction of improvement.[43] In 1976 Klinkman documented certain biochemical changes which occurred in uremia and during dialysis. He found that hemodialysis interfered with the pathophysiologic equilibrium which takes place in the uremic individual.[44]

More recently, Graefe and his associates (1978) compared the effects of hemodialysis using dialysate containing acetate ion or bicarbonate ion. The study showed an increase in clinical symptoms of the dialysis disequilibrium syndrome in the group of patients dialyzed against the

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[41]Kennedy and associates (1962) first proposed the concept of the "reverse urea effect." They attributed the clinical symptoms of the dialysis disequilibrium syndrome to cerebral edema induced by the osmotic gradient that results when urea is removed from the cerebrospinal fluid and the brain more slowly than the blood.

[42]Wakim, "Dialysis Disequilibrium Syndrome," p. 425.

[43]Tyler, "Neurologic Complications," p. 739.

[44]Horst Klinkman, "The Dysequilibrium Syndrome in Experimental Hemodialysis," Transactions of the American Society for Artificial Organs 16 (1970):532.

acetate-containing dialysis. This group also showed a decrease in pCO_2 levels and bicarbonate levels during dialysis. Bicarbonate levels rose sharply after termination of the dialysis procedure. The investigators maintained plasma osmolality during dialysis by adding urea to the dialysate.

Graefe proposes that the adverse effects of the acetate dialysis may be attributed to the change in acid-base balance or the direct toxic effects of the acetate ion.[45]

Regardless of the etiology of the syndrome, a phenomenon which has been observed frequently is the osmotic gradient between the brain and the plasma at the end of dialysis. In 1962 Sitprija and Holmes noted an increase in intracranial fluid pressure in mongrel dogs during hemodialysis. This increase in intracranial pressure was correlated with a reduction in serum osmolality and an increase in the sodium bicarbonate in the bath dialysate.[46] Kennedy attributed the symptoms of the dialysis disequilibrium syndrome to an osmotic gradient created by the delayed clearance of urea from the brain and cerebrospinal fluid.[47]

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[45]U. Graefe et al., "Less Dialysis-Induced Morbidity and Vascular Instability with Bicarbonate in Dialysis," Annals of Internal Medicine 88 (May 1978):332.

[46]Sitprija and Holmes, "Intracranial Pressure and Intraocular Pressure," p. 302.

[47]Kennedy et al., "Urea Levels," p. 410.

Peterson and Swanson supported Kennedy's findings. They proposed that the removal of urea causes the dilution of the extracellular fluid. In an effort to maintain equilibrium, water moves into the cell. When this occurs in the brain, cerebral edema results. It is believed that the cerebral edema is responsible for the manifestations of the symptoms.[48]

In 1975 DiMattio studied the effects of changes in serum osmolality on the bulk flow of fluid into the cerebral ventricles. During episodes of induced hypo-osmolality, bulk flow rate increased and brain water content increased respectively. He supports that it is the osmotic gradient between blood and the brain and cerebrospinal fluid which is responsible for the increase in bulk flow and the brain water content.[49]

Studies since 1969 have primarily been directed towards the prevention of the clinical symptoms of the dialysis disequilibrium syndrome. Duration and rate of dialysis have been examined in an effort to prevent the rapid removal of solute during the procedure. Arieff has examined the effects of rapid[50] and slow[51] hemodialysis. In

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[48]Peterson and Swanson, "Acute Encephalopathy," p. 879.

[49]Joseph DiMattio, "Effects of Changes in Serum Osmolarity on Bulk Flow of Fluid into Cerebral Ventricles and on Brain Water Content," Pflugers Archives 359 (1975): 253.

[50]The duration of rapid hemodialysis was 100 minutes at a blood flow rate of 12 ml/kg/minute.

[51]The duration of slow hemodialysis was 200 minutes at a blood flow rate of 5 ml/kg/minute.

dogs treated with rapid hemodialysis, seizures occurred. In these dogs the brain osmolality was significantly higher than that of the plasma osmolality at the end of the dialysis. During slow dialysis the seizure activity did not occur, and there was not a significant difference between the brain osmolality and the plasma osmolality.[52] In clinical practice Mayrier noted a decrease in the occurrence of clinical complications during hemodialysis when the duration of dialysis and the blood flow rate were reduced.[53]

The infusion of hypertonic solutions and the addition of hypertonic solutions to the dialysate during dialysis has been attempted in order to prevent a rapid fall in plasma osmolality. Urea, fructose, glucose, sodium chloride, and glycerol have been used as osmotically active substances to prevent the rapid fall in plasma osmolality during dialysis.

Hagstam documented the presence of complaints during dialysis while administering mannitol infusions and placebo infusions. He observed a decrease in the manifestations of the dialysis disequilibrium syndrome in the experimental group. There was a significant difference in the decrease in plasma osmolality during dialysis between the groups. In the mannitol series the plasma osmolality fell 17 mOsm/kg. The osmolality fell 26 mOsm/kg in the placebo group

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[52]Allen Arieff et al., "Brain Water and Electrolyte Metabolism in Uremia: Effects of Slow and Rapid Hemodialysis," Kidney International 4 (1973):177.

[53]Mayrier et al., "Dialysis Disequilibrium Syndrome," p. 313.

($p < 0.01$).[54] Port was successful in preventing the symptoms of the syndrome in nine patients who were dialyzed with a high sodium dialysate. The patients in the control group experienced a marked decrease in plasma osmolality.[55]

Rodrigo found a decrease in the clinical symptoms of the dialysis disequilibrium syndrome by the use of a high glucose concentration dialysate and/or mannitol infusions. The plasma osmolality in the control group fell 10 mOsm/kg. In the experimental group the osmolality fell 5.2 mOsm/kg.[56]

The etiology of the dialysis disequilibrium syndrome remains inconclusive. The mechanisms which may be responsible for the manifestations of the syndrome are the rapid biochemical changes which occur during hemodialysis and the osmotic gradient which exists between the brain and blood at the end of the dialysis procedure.

Studies performed to find a satisfactory means for preventing the symptoms of the dialysis disequilibrium syndrome have supported the concept that a change occurs in serum osmolality during the dialysis procedure. Researchers have found that if a marked decrease in serum osmolality is prevented, there is a decrease in the clinical symptoms of the dialysis disequilibrium syndrome. However, no study published at this time looked at the specific relationship

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[54]Hagstam et al., "Mannitol Infusion," p. 257.

[55]Port et al., "High Sodium Concentration in the Dialysate," p. 327.

[56]Rodrigo et al., "Osmolality Changes," p. 554.

between the change in serum osmolality and the clinical manifestations of the syndrome.

Clinical Significance of Serum Osmolality

Serum osmolality is the concentration of dissolved ionized particles per unit volume of aqueous solution. The osmolality of the fluid in each body compartment--intravascular, interstitial, and intracellular--is approximately 300 mOsm/l of H_2O. Osmotic equilibrium between fluid compartments is maintained by the process of osmosis.[57]

When there is a difference in osmolality between two fluid compartments, water moves rapidly from the area of less osmolality to the area of greater osmolality. This rapid movement of water is responsible for the state of osmotic equilibrium between the fluid compartments.

In abnormal fluid states, the cell and its environment maintain osmotic equilibrium by the process of osmosis. When the cell is within a hypotonic environment, water moves into the cell in an attempt to achieve a state of equilibrium. Grantham has reviewed the literature concerning the pathophysiology of hyposmolar conditions.[58]

Symptoms associated with acute induction of hyposmolality include weakness, lethargy, confusion, delirium,

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[57]Arthur C. Guyton, Textbook of Medical Physiology (Philadelphia: W.B. Saunders Co., 1971), p. 387.

[58]Jared J. Grantham, "Pathophysiology of Hyposmolar Conditions: A Cellular Perspective," in Disturbances in Body Fluid Osmolality, ed. Thomas E. Andreoli, Jared J. Grantham, and Floyd C. Rector, Jr. (Bethseda: American Physiological Society, 1977), p. 217.

muscle twitching, impaired mentation and convulsions. Arieff proposes that the neurological symptoms of the hypo-osmolar state result from a balance between the gain in brain water and the loss of brain electrolytes, specifically potassium and chloride ions.[59]

The brain also undergoes adaptation to hyperosmolar states. Oakley describes a case study in which the patient presents with hyperosmolar nonketotic coma and a serum osmolality of 366 mOsm/l. Symptoms observed included altered mental status, lethargy, anorexia, nausea, and vomiting. The hyperosmolar state results in cellular dehydration, the primary cause of death.[60]

Arieff reviewed the literature regarding the pathophysiology of hyperosmolar states.[61] The hyperosmolar state which exists in the chronic renal failure patient is usually associated with an increase in the plasma concentration of urea. In 1969 Hagstam found that the serum osmolality in his chronic renal failure patients prior to hemodialysis was

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[59]Allen I. Arieff, Francisco Llach, and Shaul G. Massry, "Neurological Manifestations and Morbidity of Hyponatremia: Correlation with Brain Water and Electrolytes," Medicine 55 (March 1976):121.

[60]David E. Oakley and Philip P. Ellis, "Glycerol and Hyperosmolar Nonketotic Coma," American Journal of Opthalmology 81 (April 1976):470.

[61]Allen I. Arieff, Raul Guisado, and Virginia C. Lazarowitz, "Pathophysiology of Hyperosmolar States," in Disturbances in Body Fluid Osmolality, eds. Thomas E. Andreoli, Jared J. Grantham, and Floyd C. Rector, Jr. (Bethseda: American Physiological Society, 1977), p. 227.

320 mOsm/l.[62] The patients in the Rodrigo study (1977) had serum osmolalities ranging from 307 - 318 mOsm/l prior to dialysis.[63]

In 1959 Martino reported that changes in serum osmolality occur during hemodialysis. He found that the serum osmolality may increase or decrease during the dialysis procedure.[64] Hagstam reported a fall in serum osmolality of 17 ± 2 mOsm/l in patients receiving mannitol infusions during dialysis. In patients dialyzed against a low sodium and 0.9% glucose dialysate, the serum osmolality decreased 26 ± 3 mOsm/l.[65]

In 1973 Port observed a decrease in the serum osmolality of 25 ± 12.9 mOsm/l in a control group. In patients dialyzed with a high concentration sodium dialysate the fall in serum osmolality was 5.8 ± 2.7 mOsm/l.[66] In 1977 Rodrigo reported a decrease of 10 mOsm/l in his control group and a fall of 5.2 mOsm/l in patients dialyzed against a high glucose dialysate.[67]

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[62]Hagstam et al., "Mannitol Infusion," p. 260.

[63]Rodrigo et al., "Osmolality Changes," p. 555.

[64]Martino and Kelemen, "Changes in Serum Osmolality and in Blood Urea," p. 114.

[65]Hagstam et al., "Mannitol Infusion," p. 260.

[66]Port et al., "High Sodium Concentration in the Dialysate," p. 329.

[67]Rodrigo et al., "Osmolality Changes," p. 554.

The following major points have been presented in the literature review:

1. A frequent and dangerous complication of hemodialysis is the dialysis disequilibrium syndrome.

2. Symptoms of the dialysis disequilibrium syndrome are similar to the clinical signs of chronic renal failure. Symptoms of the syndrome occur during the dialysis procedure and usually subside following termination of the procedure.

3. Changes in serum osmolality occur during the dialysis procedure.

4. Experimental studies directed towards the prevention of the clinical symptoms of the syndrome have suggested correlation between the number of clinical symptoms experienced by the patient during hemodialysis and the change in serum osmolality.

5. When preventing a marked decrease in serum osmolality during hemodialysis, researchers observed a decrease in the occurrence of clinical symptoms of the dialysis disequilibrium syndrome.

6. No published study at this time has examined the specific relationship between the change in serum osmolality and the occurrence of clinical symptoms of the dialysis disequilibrium syndrome during hemodialysis.

CHAPTER III

METHODOLOGY

Hemodialysis has proved to be a successful treatment for the patient with end-stage renal failure. However, the procedure is not without its complications. The most frequent and dangerous complication of hemodialysis is the dialysis disequilibrium syndrome.

The etiology of the syndrome remains unclear. However, research has shown that there is a change in the serum osmolality during the dialysis procedure. Rodrigo observed that the clinical signs of the dialysis disequilibrium syndrome declined in parallel to a decrease in serum osmolality.[1]

It was the purpose of this study to determine if a relationship existed between the change in serum osmolality and the number of clinical symptoms of the dialysis disequilibrium syndrome.

Setting

The sample for this study was selected from the chronic renal failure patients receiving maintenance hemodialysis in the Renal Dialysis Unit of an urban medical

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[1]Rodrigo et al., "Osmolality Changes," p. 554.

center located in a southeastern city. Subject data for this study were collected from May 25, 1978 to June 30, 1978.

The Renal Dialysis Unit is an eight-bed unit. The unit meets the needs of a variety of individuals requiring hemodialysis treatment. One group routinely receives maintenance hemodialysis treatment at this unit. A second group of patients receive hemodialysis treatment for acute episodes of renal failure as in-patients at the medical center. A third group of chronic renal failure patients are in-patients of the medical center who routinely receive their dialysis treatment at other dialysis units. While patients at the medical center, these patients receive hemodialysis treatments at the Renal Dialysis Unit within the medical center. The individuals return to their former dialysis center following discharge from the medical center.

The subjects for this study were selected from the group of chronic renal failure patients who routinely receive maintenance hemodialysis at the Renal Dialysis Unit in the medical center.

Data Source

Serum osmolality measurements and clinical symptom frequencies were taken during 28 separate dialysis procedures conducted on 11 patients who consented to participate in this study.

Each subject in this study had been receiving hemodialysis treatment for at least three months. Patients with

a positive Australian Antigen were not included in this study in order to avoid cross-contamination of patients through collection of the blood samples by the investigator.

The age range of the sample was 23 to 60 years with a mean age of 42 years. Eight females and three males participated in the study. The medical director of this unit stated that the population of the unit is representative of chronic renal failure patients receiving hemodialysis within the United States.

Nursing Personnel

All classifications of nursing personnel employed in the Renal Dialysis Unit, including RN, LPN, and dialysis technicians, were responsible for monitoring the patients during the dialysis procedure. All nursing personnel consented to participate in this study. Participation in the study included observation and documentation of patient's clinical symptoms during the dialysis procedure.

Instrument

The tools used in this study were constructed by the investigator. The list of symptoms included in each tool, Symptoms Experienced by the Patient While Receiving Hemodialysis (Appendix C) and Patient Symptoms Observed by the Nurse During Hemodialysis (Appendix D), was obtained from the observations made by the dialysis nurses in the Hagstam study.[2]

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[2]Hagstam et al., "Mannitol Infusion," p. 258.

The tools have not been tested for reliability and validity. Inter-rater reliability was measured as described by Kazdin.[3]

Procedure

Written permission was obtained to conduct this study from the Director of Nursing Services at the Medical center and the Medical Director of the Renal Dialysis Unit. Each subject and all nursing personnel participating in this study read and signed the consent form.

Prior to initiation of the dialysis procedure, the investigator asked each subject to check each symptom which was being experienced at that time on the tool Symptoms Experienced by the Patient While Receiving Hemodialysis. Only those symptoms which occurred during the dialysis procedure and did not exist prior to the dialysis procedure were considered symptoms of the dialysis disequilibrium syndrome.

The patient checklist was placed convenient to the patient's reach, but not in view of the dialysis nurse. The patient checked each symptom which occurred during dialysis. At half-hour intervals the investigator assisted the patient to mark the checklist. Blurred vision, fatigue, lethargy, nausea and vomiting, or episodes of hypotension requiring a Trendelenburg position prevented the patient from marking the checklist without assistance.

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[3]Alan E. Kazdin, Behavioral Modification (Homewood, Ill.: The Dorsey Press, 1975), p. 78.

At the end of the dialysis procedure, each subject examined the checklist to verify its accuracy.

The tool Patient Symptoms Observed by the Nurse During Hemodialysis was placed in the patient's dialysis chart. This was easily accessible to the nurse and not visible to the patient. Each nurse observed the patient during dialysis and documented clinical symptoms as they occurred.

Each dialysis procedure was performed according to the procedures and policies of the Renal Dialysis Unit.

All dialyzers were connected to a central unit which delivers the dialysate. The ionic composition of the dialysate is sodium - 130 mEq/l, potassium - 2.0 mEq/l, chloride - 101 mEq/l, calcium - 3.0 mEq/l, magnesium - 1.0 mEq/l, and acetate - 35 mEq/l. The osmolality of the dialysate ranged from 269 to 273 during the study period and remained constant during the dialysis procedure.

The dialysis nurse inserted the dialysis needles or prepared the external arteriovenous shunts for connection to the dialyzer. The investigator obtained a one cc blood sample from the dialysis needle or the external shunt for a baseline osmolality prior to connection to the dialyzer. Subsequent one cc blood samples were obtained from the arterial dialysis lines at half-hour intervals during the dialysis procedure. The final sample was obtained immediately prior to termination of the procedure. The duration of dialysis was not constant. The number of samples drawn

during dialysis was dependent upon the duration of the procedure.

Analysis

Pearson's correlation was used to determine the relationship between the change in serum osmolality and the total number of clinical symptoms experienced during the dialysis procedure.

The change in serum osmolality was the difference between the highest and lowest osmolality value obtained during dialysis.

Each symptom experienced during dialysis that was not present at the initiation of the dialysis procedure was given a score of one. The sum total of the clinical symptoms occurring during dialysis was calculated.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

The purpose of this study was to examine the relationship between changes in serum osmolality and the number of clinical signs and symptoms of the dialysis disequilibrium syndrome in the patient with end-stage renal disease during hemodialysis.

Analysis of Data

Twenty-eight dialysis procedures were conducted on 11 subjects. The duration of each dialysis ranged from 3½ to five hours. Serum osmolality measurements were obtained prior to initiation of dialysis, at half-hour intervals during the procedure, and prior to termination of dialysis.

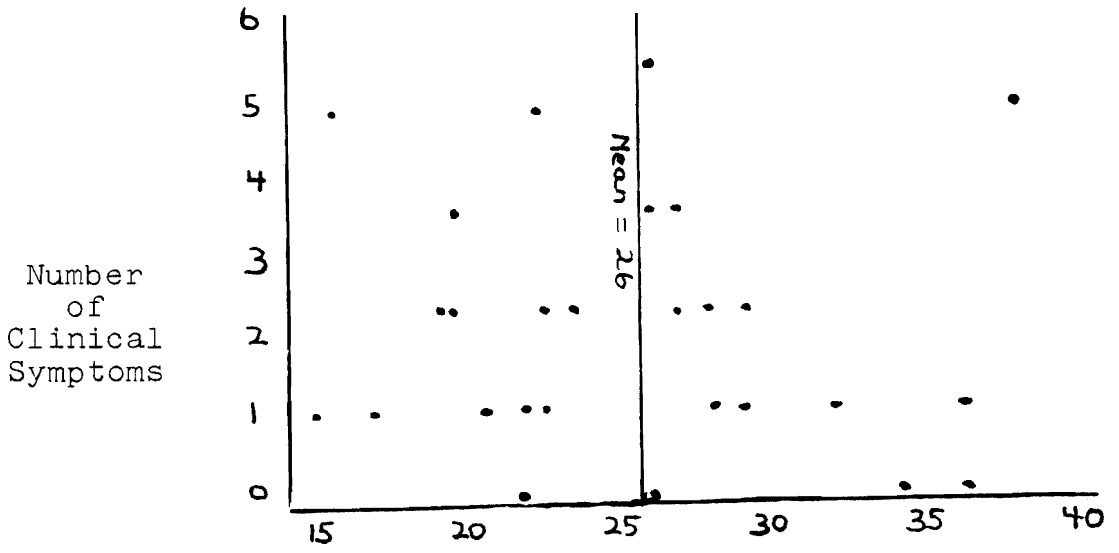
Signs and symptoms which occurred during dialysis were recorded by the patients and the nursing personnel.

Figure 1 displays the change in serum osmolality and the number of clinical symptoms experienced during each hemodialysis procedure. The regression coefficient is -0.27 for this data.

Serum osmolality measurements decreased during each of the 28 dialysis procedures. The decrease in serum osmolality ranged from 15 - 38 mOsm/liter (mOsm/l) with a mean of 25.8 ± 6.2 mOsm/l. Thirteen procedures had

Figure 1

NUMBER OF PATIENT REPORTED SYMPTOMS AND
THE CHANGE IN SERUM OSMOLALITY



osmolality changes that were below the mean, and 15 procedures had changes in serum osmolality that were above the mean.

The total number of clinical symptoms experienced by the patient during hemodialysis ranged from zero to five. The total number of clinical symptoms observed during dialysis by the nurse ranged from zero to six. The correlation between the patient response and the nurses observations ($r = 0.65$, $p < 0.01$) shows agreement between patient and nurse in the recognition and recording of symptoms.

The hypothesis of this study was: The number of clinical symptoms of the dialysis disequilibrium syndrome experienced by the chronic renal failure patient on hemodialysis will increase as the serum osmolality decreases.

There was no correlation between the change in serum osmolality and the total number of clinical symptoms experienced by the patient during hemodialysis. Therefore, the null hypothesis could not be rejected. The hypothesis that there will be an increase in clinical symptoms as the serum osmolality decreases was not supported by the study results.

The hypothesis was not supported by the data collected and analyzed for 28 hemodialysis procedures. Patient data was examined to determine if similarities existed for individual patients in response to different dialysis procedures. The change in serum osmolality and the number of clinical symptoms which occurred during dialysis varied between dialysis procedures conducted on the same patient.

Figure 2 displays the occurrence of each clinical sign and symptom documented by the patient during 28 dialysis procedures. Sleep or fatigue was experienced during 11 dialysis procedures.

Figure 3 displays the occurrence of clinical signs and symptoms observed by the nurse during 28 hemodialysis procedures. Headache and hypotension occurred during seven dialysis procedures. Sleep or fatigue was observed during six dialyses. Muscle cramps were documented during five procedures.

Figure 2

FREQUENCY OF PATIENT REPORTED SYMPTOMS
DURING TWENTY-EIGHT HEMODIALYSIS PROCEDURES

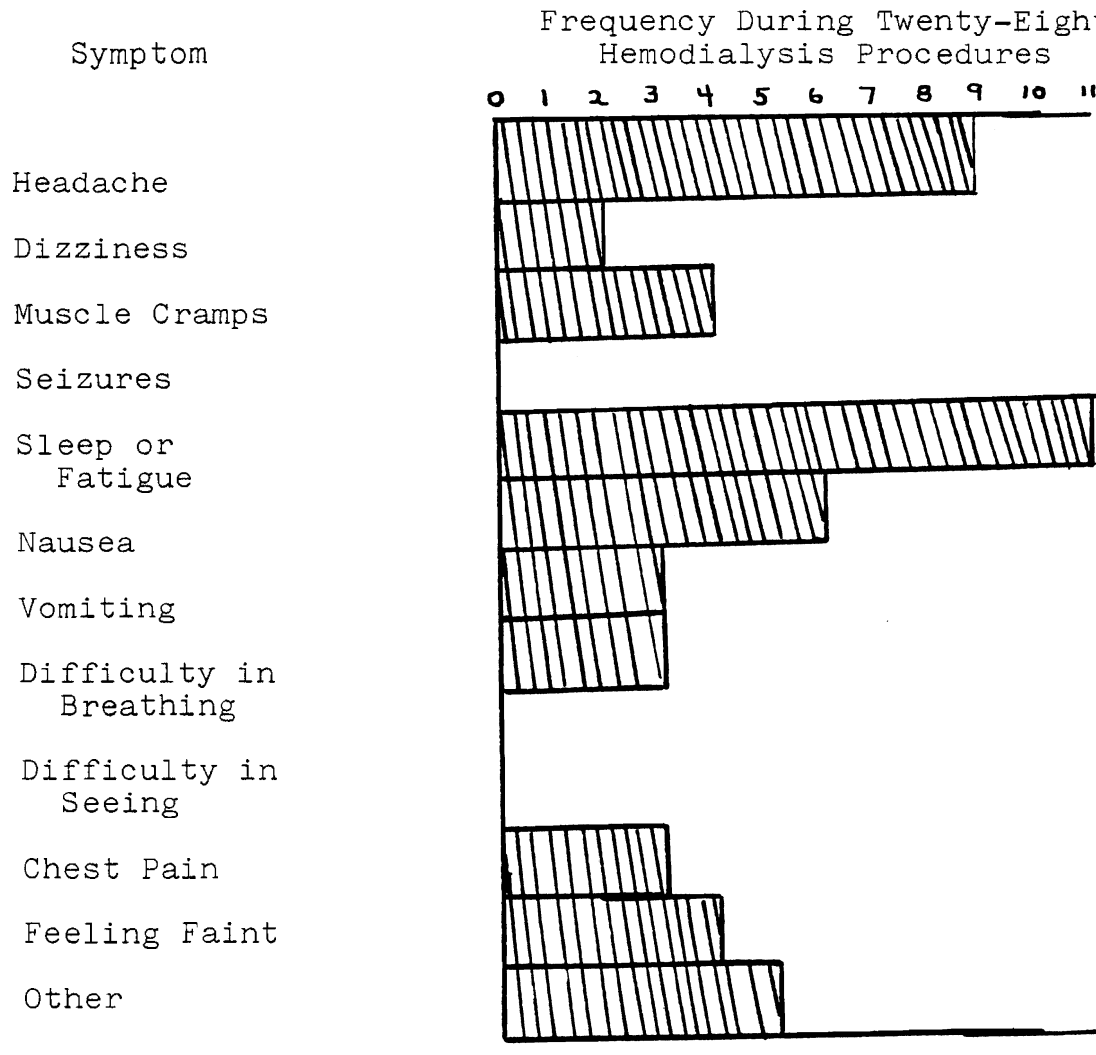
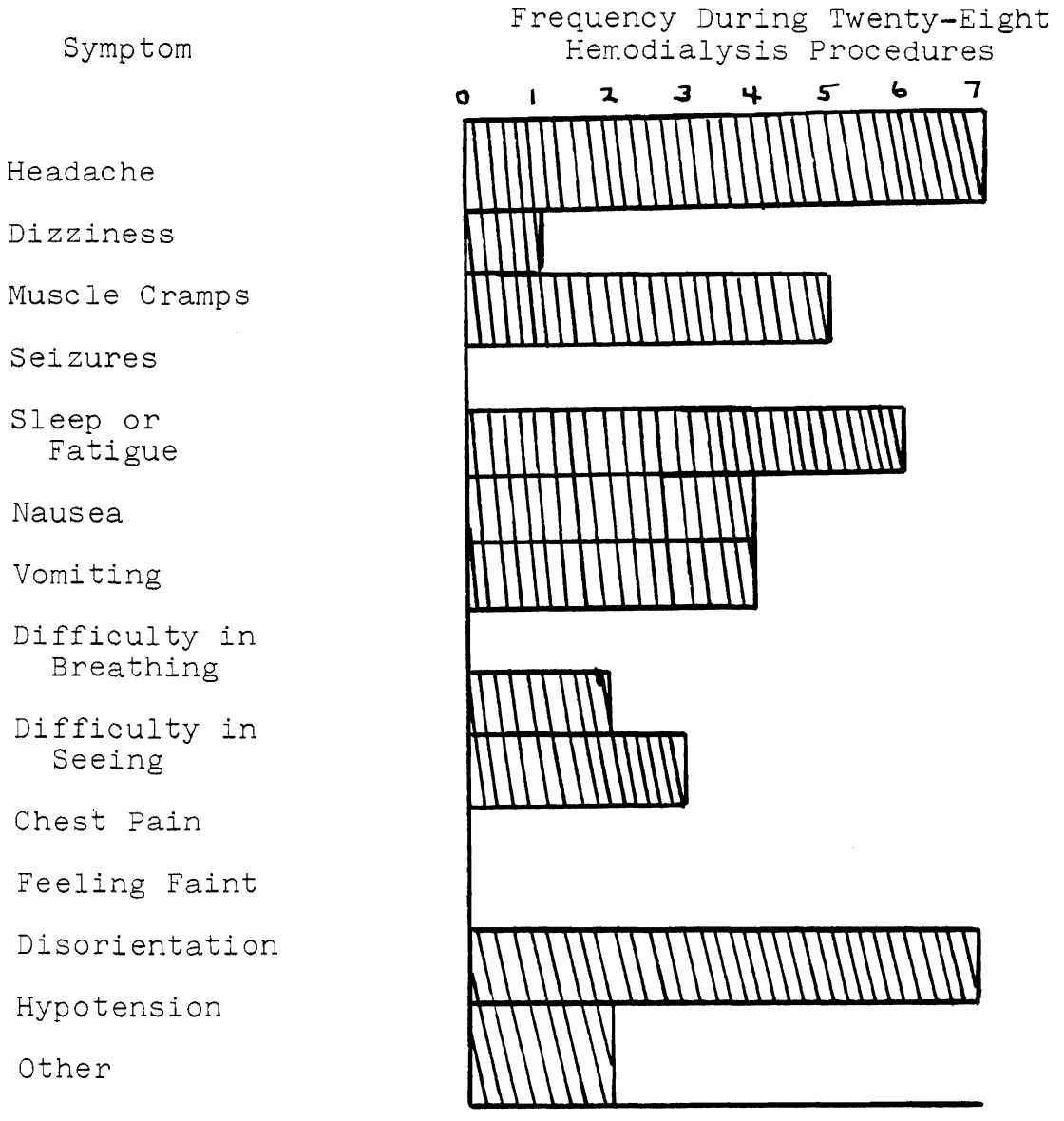


Figure 3

FREQUENCY OF PATIENT SYMPTOMS OBSERVED BY THE NURSE DURING TWENTY-EIGHT HEMODIALYSIS PROCEDURES



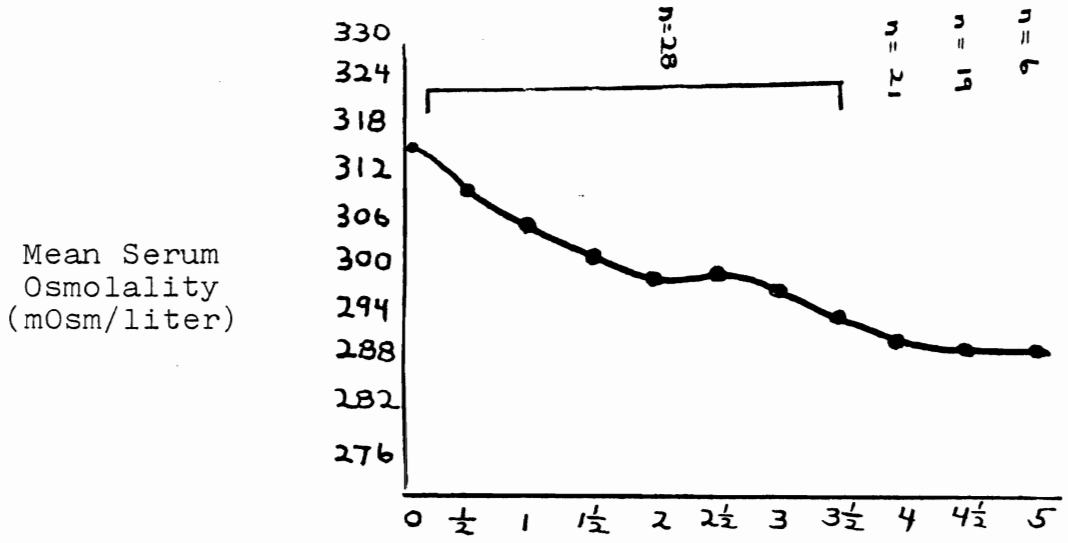
Although agreement existed between the patient responses and the nurses' observations, differences existed in the responses according to specific symptoms. While patients documented the occurrence of sleep or fatigue in 11 dialysis procedures, nurses observed this symptom in only six procedures. Nurses' comments during the study period led the investigator to believe that the nurse did not consider sleep or fatigue an adverse effect of dialysis and, therefore, the nurse tended not to document this symptom.

Nurses reported the occurrence of hypotension in seven dialysis procedures. The patient responses indicate the occurrence of "feeling faint" in only four dialyses. This difference between responses shows that "feeling faint" does not accurately indicate the presence of hypotension. The condition of hypotension is not always accompanied by the experience of feeling faint.

The average change in serum osmolality per interval of time during dialysis was 2.5 mOsm/l/30 minutes. Figure 4 shows the mean serum osmolality for the dialysis procedures at half-hour intervals. The regression coefficient for this line is -2.5. Due to the differences in the duration of procedures between patients, there were 21 dialyses at four hours, 19 dialyses at 4½ hours, and six dialyses at five hours. The slope of the line shows a steady, gradual decrease in the serum osmolality during the dialysis procedure.

Figure 4

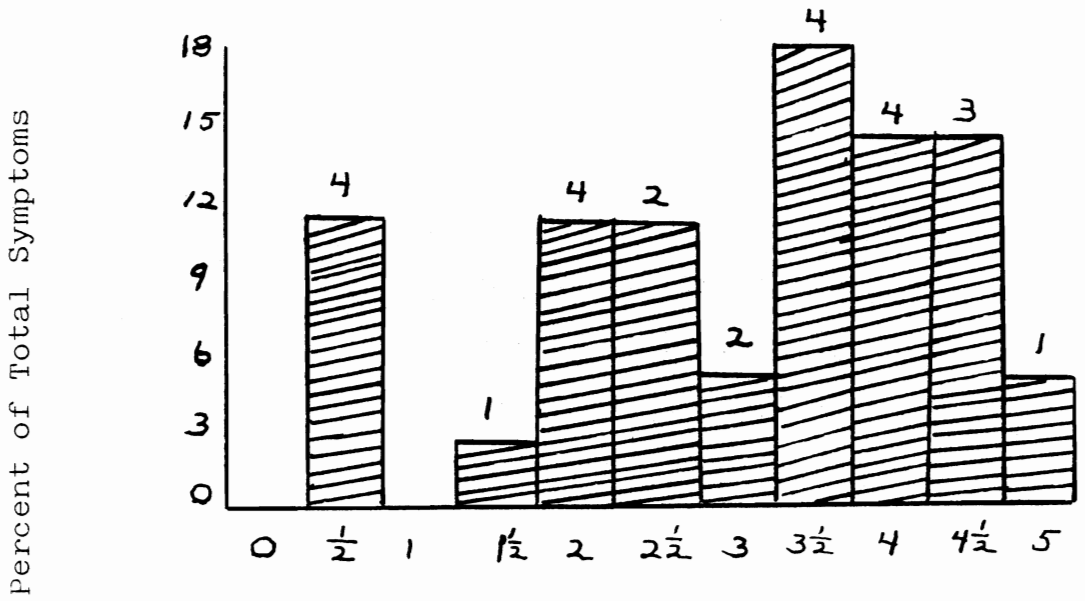
MEAN SERUM OSMOLALITY AT HALF-HOUR INTERVALS



Time in Half-Hour Intervals

Figure 5

PERCENT OF TOTAL SYMPTOMS EXPERIENCED BY THE PATIENT AND NUMBER OF PATIENTS REPORTING SYMPTOMS AT HALF-HOUR INTERVALS DURING TWENTY-EIGHT PROCEDURES



Time in Half-Hour Intervals

Figure 5 displays the percent of clinical symptoms and the number of patients reporting symptoms at half-hour intervals during 28 dialysis procedures. Symptoms may occur throughout the dialysis procedure, although the greatest frequency of symptom manifestation occurs after the first 1½ hours of dialysis. Twenty-eight symptoms or 85 percent occurred after the first 1½ hours of dialysis. Eighteen symptoms or 54 percent occurred after the third hour of dialysis. Four patients reported symptoms during dialysis at one-half hour, two hours, 3½ hours, and four hours after initiation of dialysis.

Interpretation of Data

Each of the patients participating in this study has been treated by hemodialysis for more than three months. During the 28 dialysis procedures, the patients reported the occurrence of sleep or fatigue in 11 dialysis procedures. Abram states that patients who have been treated by hemodialysis for more than three months may sleep during the procedure due to a decrease in concern for injury during dialysis.[1] The patient with end-stage renal disease also experiences fatigue due to anemia, depression, and boredom during dialysis. Therefore, the occurrence of sleep or fatigue during dialysis may not indicate the presence of the dialysis disequilibrium syndrome and can be omitted from the data collection tools used in this study.

[1]Abram, "Prolongation of Life," p. 157.

The finding of this study that there is no correlation between the change in serum osmolality and the manifestation of clinical signs and symptoms of the dialysis disequilibrium syndrome differs from recently published research in this area. Hagstam,[2] Port,[3] and Rodrigo[4] have observed a decrease in the clinical symptoms of the dialysis disequilibrium syndrome when a marked decrease in serum osmolality was prevented. Each investigator prevented changes in serum osmolality by using hypertonic dialysate or infusions. The assumption of each study was that there was a relationship between the occurrence of clinical symptoms during dialysis and the change in serum osmolality.

The maintenance of serum osmolality in the Hagstam and Rodrigo study was associated with a decrease in the number of clinical symptoms observed during dialysis. The infusion of hypertonic solutions maintains extracellular fluid volume, increases blood pressure, increases cardiac output, and maintains serum osmolality. Since the results of this study show that there is no relationship between the changes in serum osmolality and the clinical symptoms during dialysis, the other properties of hypertonic solutions may

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[2]Hagstam et al., "Mannitol Infusion," p. 257.

[3]Port et al., "Use of High Sodium Concentrate in the Dialysate," p. 327.

[4]Rodrigo et al., "Osmolality Changes," p. 554.

be responsible for the decrease in clinical symptoms observed by these researchers.[5,6]

This study examined the relationship between the change in serum osmolality and the number of clinical symptoms which occurred during dialysis. However, this study did not account for other variables which did change during the dialysis procedure. Variables such as blood flow rate, ultrafiltration, the size of the dialyzer, changes in electrolytes, and changes in blood pressure were not examined. Additional research performed to examine the influence of these factors may identify variables which do correlate to the occurrence of clinical symptoms during hemodialysis.

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[5]Hagstam et al., "Mannitol Infusion," p. 257.

[6]Rodrigo et al., "Osmolality Changes," p. 554.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary and Conclusions

The purpose of this study was to determine if a relationship existed between the change in serum osmolality in the chronic renal failure patient on hemodialysis and the number of clinical symptoms of the dialysis disequilibrium syndrome experienced during hemodialysis.

The study was conducted at the Renal Dialysis Unit of an urban medical center located in a southeastern city. Data were collected from May 25, 1978 to June 30, 1978. Data were obtained during 28 hemodialysis procedures performed on 11 subjects.

Serum osmolality measurements were collected prior to initiation of the dialysis procedure, at half-hour intervals during dialysis, and prior to termination of dialysis.

Clinical symptoms which occurred during dialysis were recorded by the patients and nursing personnel.

The hypothesis was that the number of clinical symptoms of the dialysis disequilibrium syndrome experienced by the chronic renal failure patient during hemodialysis will increase as the serum osmolality decreases.

There was no correlation between the change in serum osmolality and the number of clinical symptoms of the dialysis disequilibrium syndrome experienced by the patient during hemodialysis. The hypothesis of this study was not supported.

There does exist a correlation at $r = 0.65$ between the clinical symptoms documented by the patient and the observations documented by the nurse during dialysis. The correlation shows that agreement exists between the recognition and recording of symptoms by the patient and the nurse.

Implications for Nursing Practice

The results of this study suggest the following implications for nursing practice:

1. Research has shown that the infusion of hypertonic solutions may prevent the occurrence of the clinical symptoms of the dialysis disequilibrium syndrome. However, this study has shown that there is no relationship between the change in serum osmolality and the occurrence of clinical symptoms during dialysis. The maintenance of serum osmolality during dialysis by the infusion of hypertonic solutions may not prevent or ameliorate the symptoms of the dialysis disequilibrium syndrome.

2. Documentation of clinical symptoms by the nursing personnel during hemodialysis is a reliable indicator of the symptoms experienced by the patient.

3. Clinical symptoms of the dialysis disequilibrium syndrome may occur throughout the procedure. However, the nurse must be especially observant for clinical symptoms following the first 1½ hours of dialysis.

Recommendations for Further Study

Based on the results of this study, the investigator makes the following recommendations for further study:

1. Since the findings of this study differ from the results of currently published research, the study should be replicated using a larger sample size.

2. When the patient checklist designed for this study is used in other research projects, the symptom sleep or fatigue should be omitted.

3. Studies should be conducted to examine the relationship between the occurrence of clinical symptoms during dialysis and additional variables such as ultrafiltration, blood flow rate, size of the dialyzer, change in electrolytes, and change in blood pressure.

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APPENDIX A

Patient Consent Form

I am conducting a study of chronic hemodialysis patients to find out how they feel while on dialysis. If you give permission to participate in this study, you will be asked to complete a checklist during your dialysis procedure. The checklist will list symptoms which you may experience during dialysis such as headache, muscle cramps, or fatigue. You will check each symptom which you experience during the procedure. The dialysis nurse will also fill out a checklist. She will check each symptom you experience during the dialysis.

During the dialysis the nurse will draw blood samples from the dialysis lines. This blood will be analyzed to tell me if there are any changes in your blood chemistries.

You may ask for further explanations of this study before making a decision. Your wish not to participate will not affect your treatment in any way. If you wish to participate, your name will not be used and all information you give will be kept confidential. You may ask to see the results of your participation at the completion of the study. You may withdraw from the study at any time.

Donna L. Young
Graduate Student

I have read the above explanation for this study and understand the explanation. I consent to participate in the study.

_____

Witness: _____

APPENDIX B

Nurse Consent Form

I am a graduate student who is conducting a research project as a requirement for graduation. My project is to examine the symptoms experienced by the chronic hemodialysis patient during the dialysis procedure.

During this project each patient will fill out a checklist and identify all the symptoms he experiences during the dialysis. The dialysis nurse will also complete a checklist. All symptoms observed or symptoms described by the patient will be recorded. I will draw blood samples from the patient's arterial line every half hour. The blood samples will be analyzed to examine changes in blood chemistry which occur during the dialysis.

You may ask for further explanations of this study before making a decision to participate. If you wish to participate, your name will not be used and all information you give will be kept confidential. You may ask to see the results of your participation at the completion of the study. You may withdraw from the study at any time.

Donna L. Young
Graduate Student

I have read the above explanation for this study and understand the explanation. I consent to participate in the study.

_____

Witness: _____

APPENDIX C

SYMPTOMS EXPERIENCED BY THE PATIENT WHILE RECEIVING HEMODIALYSIS

Instructions to the patient: I am interested to know how you are feeling during your dialysis. Keep this checklist with you during your dialysis. Please check each of the symptoms listed below which you experience and record the time and symptom occurred. Return this to the nurse before leaving the unit today.

SYMPTOMS	OCCURRENCE OF SYMPTOMS		
	Yes	No	Time
1. Headache	____	____	____
2. Dizziness	____	____	____
3. Muscle cramps	____	____	____
4. Seizures	____	____	____
5. Sleep or fatigue	____	____	____
6. Nausea, sick to your stomach	____	____	____
7. Vomiting	____	____	____
8. Difficulty in breathing	____	____	____
9. Difficulty in seeing	____	____	____
10. Chest pain	____	____	____
11. Feeling faint	____	____	____
12. Other_____	____	____	____

APPENDIX D

PATIENT SYMPTOMS OBSERVED BY THE NURSE DURING HEMODIALYSIS

Instructions to the nurse: Please observe the patient during the dialysis procedure. Check each symptom which is experienced by the patient. Record the time the symptom occurred. A patient's verbal complaint is a reliable indication that he is experiencing the symptom.

SYMPTOMS	OCCURRENCE OF SYMPTOMS		
	Yes	No	Time
1. Headache	____	____	____
2. Dizziness	____	____	____
3. Muscle cramps	____	____	____
4. Seizures	____	____	____
5. Sleep or fatigue	____	____	____
6. Nausea	____	____	____
7. Vomiting	____	____	____
8. Difficulty in breathing	____	____	____
9. Difficulty in seeing	____	____	____
10. Chest pain	____	____	____
11. Feeling faint	____	____	____
12. Disorientation	____	____	____
If yes, please describe:			
13. Hypotension	____	____	____
14. Other_____	____	____	____

Please list all treatments and infusions which were administered during dialysis and the time each treatment was given: