A RETROSPECTIVE COHORT STUDY ON THE EFFECTIVENESS OF AUTOMATED PERITONEAL DIALYSIS IN THE MANAGEMENT OF ACUTE RENAL FAILURE IN KENYA

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT FOR THE DEGREE OF MASTER OF SCIENCE IN NURSING OF UNIVERSITY OF NAIROBI

BY

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DECLARATION

I hereby declare that this research is my original work and has not been submitted in any other university, or for any other award.

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ABSTRACT

Background: Automated peritoneal dialysis (APD) is peritoneal dialysis (PD) using cycler machines which can deliver predetermined volumes of dialysate into the peritoneal cavity and then drain it after a programmed dwell time. Anochie and eke (2006) reported that one of the advantages of APD is adequacy of dialysis.

Problem statement: Acute renal failure (ARF) is a common threat accounting to mortality rate of 42% to 88%. It is among the leading causes of mortality worldwide, Kenya included. There are few dialysis centres in Kenya with few options of renal replacement therapy (RRT) modalities, the main one being haemodialysis (HD). PD has scarcely been used in Kenya. Patients have had to travel for long distances to queue for HD machines leading to a delay in treatment and congestion in the two Government HD centres available.

Justification: The results of the study will help guide the policy makers to consider other affordable and accessible RRT options, help encourage the practice of (APD) in various hospitals and become a baseline data for further researches since no other research has been done on APD in Kenya. Mendelssohn et al (2002) reported that there was a big gap between PD and HD which made them recommend further research in this field.

Main objective: The study was aimed at determining the effectiveness of APD in the management of acute renal failure (ARF) in Kenya.

Methodology

The study design was a retrospective cohort study. The study population was children and adults with ARF who were put on APD from may 2006 –may 2010. The sample size was calculated using the Fisher's formula where a sample of 35 subjects was arrived at. Convenience sampling method was used. Use of quantitative techniques of data collection was carried out using a structured questionnaire. Quantitative data was entered, cleaned and analyzed using a computer software package, SPSS. Paired t-test to determine biochemistry parameter changes between

before APD commencement to the time of termination of APD / death parameters was carried out. The statistical significance was set up at $p<0.05$.

Results: The mean Serum Creatinine, Blood Urea Nitrogen (BUN), Serum Potassium prior to APD was comparatively higher than the mean on APD discontinuation, discharge or death. The mean 24-hour urine output prior to APD was 100.8 and after APD discontinuation was 482.5 which were quite significant. The mortality rate was 37% (n=13) while survival rate was 63% (n=22) where patients were treated and discharged. Mater hospital was the leading in the use of APD with 16 patients representing 45.75%.

Discussion: The results were statistically significant in that in all variables, patients who had abnormal values significantly improved at the point of APD discontinuation. This is in consistent with the finding of Kapoor (2007) who reported that APD enables continuous correction of acid-base status and electrolyte imbalance as well as the gradual removal of nitrogenous waste products. Dwinell & Anderson (1999) reported that dialysis outcome is shown by a reduction in BUN, serum potassium, serum creatinine.

Conclusion: There was clear evidence that APD is an effective mode of RRT in the management of ARF.

Recommendations: This treatment modality would be very vital for advocating for APD use especially in district Hospitals and even in the home settings.

LIST OF ACRONYMS

ARF	:	Acute renal failure
AKI	:	Acute kidney injury
AoCRF	:	acute-on-chronic renal failure
APD	:	*Automated peritoneal dialysis*
ATN	:	Acute tubular necrosis
AV	:	Arterial venous
BUN	:	Blood urea nitrogen
CAPD	:	Continuous ambulatory peritoneal dialysis
CKD	:	Chronic kidney disease
ESRD	:	End stage renal disease
GFR	:	Glomerular filtration rate
HD	:	Haemodialysis
CCU	:	Critical care unit
KNH	:	Kenyatta national hospital
PD	:	Peritoneal dialysis
RRT	:	Renal replacement therapy

OPERATIONAL DEFINITIONS

Acute kidney injury: This is the same as acute renal failure which is defined as sudden onset of poor kidney function which is characterized by olyguria where the urine output in 24 hours falls below 400mls or anuria, hyperkalaemia, elevation of toxins like blood urea nitrogen and serum creatinine with metabolic acidosis.

Automated peritoneal dialysis (APD): This is peritoneal dialysis using machines called cyclers which can now deliver predetermined volumes of solution into the peritoneal cavity and then drain it after a programmed dwell time. *(Ploumis & Dimitrios 2007).*

Azotemia: High levels of urea, when the abnormality can be measured chemically but not yet so severe as to produce symptoms (Daugirdas et al 2001).

Dialysate: Special fluid used as a concentration gradient for diffusion and osmosis in dialysis

Dialysis: Removal of solutes from the blood, through a semi permeable membrane – eliminating them from the body (Daugirdas et al 2001).

Effectiveness: Dialysis outcome which is shown by the reduction in blood urea nitrogen, serum potassium, serum creatinine and an improvement in the urine output.

Osmosis: Movement of water through a semi permeable membrane from an area of low solute concentration to area of high solute concentration (Daugirdas et al 2001).

Uremia: is the illness accompanying kidney failure in particular the nitrogenous waste products.

Ultrafiltration:. Fluid removal during the dialysis procedure (Daugirdas et al 2001).

Renal replacement therapy (RRT): Artificial replacement of non-endocrine lost kidney function for renal failure patients and the techniques used include intermittent haemodialysis, continuous hemofiltration and haemodiafiltration, and peritoneal dialysis. All modalities exchange solute and remove fluid from the blood, using dialysis and filtration across semi-permeable membranes.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND

When healthy, the kidneys maintain the body's internal equilibrium of water and minerals. Acidic metabolic end products are also excreted via the kidneys. The kidneys function as part of the endocrine system producing erythropoietin and125-dihydroxycalciferol (calcitriol). Porth (2002) describes renal failure as a condition in which the kidneys fail to remove metabolic end products from the blood and regulate the fluid, electrolyte, and PH balance of the extracellular fluids. If the kidney function fails, the waste products accumulate in the blood and the body which is termed as azotemia. Renal failure is divided into two categories: Acute renal failure (ARF) also called acute kidney injury (AKI) or chronic kidney disease (CKD) also termed as chronic renal failure (CRF).

Renal failure is one of the life threatening diseases globally and affects all stages of life.ARF has become increasingly prevalent in both developed and developing countries, and is associated with severe morbidity and mortality, especially in children. Porth (2002), reports that there was 2% per year incidence of renal failure in children worldwide. Adults above 65 years are most affected because of normal ageing associated with a decline in glomerular filtration rate (GFR), which makes the older person more susceptible to the detrimental effects of nephrotoxic drugs and other conditions that compromise renal function. Dwinell & Anderson (1999) reported that RRT is an artificial replacement for lost kidney function. Dialysis outcome is shown by a reduction in BUN, serum potassium, serum creatinine and an improvement in the urine output. The normal values are as follows in adults:

- Serum Creatinine; 60 -124 micromillimoles per litre
- Serum Potassium: 3.5 l-4.9mmols/L
- Blood urea nitrogen:2.5-6.7mmols/L
- The normal urine output is 1500 -2000mls

The normal values in pediatrics are as follows:

- Serum Creatinine: 27 to 62 micromillimoles per litre
- Serum urea; 1.8-6.4 mmols/L
- The potassium is the same as for adults
- The normal urine output is 1ml/kg/hour and above

There are 5 types of dialysis;

- Intermittent Haemodialysis
- Peritoneal dialysis
- Haemofiltration
- *Haemodiafiltration*
- Continuous renal replacement therapy (CRRT)

Daugirdas et al (2001) have discussed that peritoneal dialysis (PD), involves the transport of solutes and water across the blood in the peritoneal capillaries which in renal failure contains an excess of urea, creatinine, potassium as well as other waste products and the dialysis solution in the peritoneal cavity which contains sodium, chloride, lactate and glucose. The peritoneal membrane acts as a dialyzer and is semi permeable. Porth (2002) has defined the peritoneal membrane or peritoneum as a layer of tissue containing blood vessels that lines and surrounds the peritoneal or abdominal cavity and the intestinal abdominal organs (stomach, liver spleen and intestines).

APD is PD using cycler machines which can deliver predetermined volumes of solution into the peritoneal cavity and then drain it after a programmed dwell time. Dialysis solutions of varying glucose concentrations can be simultaneously attached to a multipronged cycler manifold (up to 5 – 8 containers of 3 – 5 litres each), and the cycler can calculate the ultrafiltration volume (Ploumis & Dimitrios 2007). PD has been established as a modality of RRT for patients with end stage renal disease (ESRD) world-wide with great advantages for quality of life as well as outcome (Souqiyyeh et al 2006).

Arogundade (2005) reported that PD was introduced in 1970s. Improvements in technology and the ability to deliver adequate dialysis resulted in improved outcomes and the acceptance of PD

as a mode of RRT. Cerdá et al (2008) quoted Chitalia et al (2002) by reporting that PD is used by over 100,000 ESRD patients worldwide, accounting for approximately 15% of the dialysis population.

According to Asha & Elamin (2005), Africa is the world's second-largest and second most populous continent. It is also the poorest and most underdeveloped continent, struggling to provide the essential health interventions for its occupants. The majority of African countries cannot regard RRT a health priority. Africa and particularly Kenya has experienced an increasing mortality mainly due to increasing cost of RRT, and lack of facilities. It is required that the patients have to live on treatment throughout their lives. This includes RRT and constant use of hormones for example erythropoetin that would have otherwise been produced by a normal healthy kidney (Were & McLigeyo 1995). As a result PD has been used scarcely in most of the African countries. Dialysis centres are very few and the institutions cannot cope with the number of patients requiring dialysis.

HD was started in Kenya at the Kenyatta National hospital (KNH) in 1984, later than PD which was started in 1978. So far only two dialysis centres – KNH and Moi Teaching and Referral Hospitals offer HD as Government institutions. The rest 20 centres are in the private sector and basically in Nairobi.

The premise of this research stemmed from the fact that the use of cyclers in PD has great advantages including better dialysis adequacy, reduction in the incidence of peritonitis, it can be used anywhere as no water treatment plant is needed and can save much nursing time, yet it is not widely used. There is, therefore, need to assess the effectiveness of APD, the extent of its utilization and factors that may be influence its choice for management of ARF. It is important to document the effectiveness so that the modality is of interest to the government. The research will help in coming up with solutions of how the treatment can be brought closer to the patient without travelling for long distances

1.2 PROBLEM STATEMENT

APD was started in Kenya in the year 2006. So far, no research work has been carried out in this area. APD has not been given much emphasis especially as far as insurance cover is concerned or government funding. This led the researcher to wonder whether the importance of APD had been appreciated in our health institutions since no study had been carried out on its effectiveness in Kenya

Porth (2002) reported that ARF is a common threat accounting to a mortality rate of 42% to 88%. Africa and particularly Kenya has experienced an increasing mortality mainly due to increasing cost of RRT, and lack of facilities. It is required that the patients have to live on treatment throughout their lives. This includes RRT and constant use of hormones for example erythropoetin that would have otherwise been produced by a normal healthy kidney (Were & McLigeyo 1995). Renal conditions are among the highest causes of mortality in Kenya. Many of the people affected are in the reproductive age and also children. No data so far is available on the effectiveness of APD in the Kenyan situation.

In Kenya, PD has become a big challenge especially because of the challenges of peritonitis rates. HD centres are very few and the institutions cannot cope with the number of patients requiring dialysis. Financial problems are the most important hurdle to PD programs as most developing countries such as Kenya have no health insurance system that provides a cover for dialysis. The majority of patients are financing their own treatment. Ploaumis & Dimitrios (2007) reported that the development of APD as a widespread PD treatment modality in developing nations has been jeopardized mainly by educational and financial constraints.

According to the available data in the various hospitals and experience, PD has scarcely been used in Kenya. Slow growth may be caused by a lack of success in demonstrating the significant benefits provided by the modality to those in charge of distributing and assigning financial resources for treatment. Patients have had to travel for long distances to queue for HD machines. Moi teaching and referral hospital has only two HD machines which have to serve all patients in Nyanza, Western and rift valley provinces. KNH has only 12 HD machines out of which 3 are

isolated machines. These are supposed to serve the rest of Kenya. The cost of a HD machine is KSH 1.6 million while an APD machine costs KSH 700, 000. This is a big health burden for the 38 million Kenyans. Some patients had to be sacked from work because they are ever travelling for dialysis. Relatives also have had to leave work to accompany their patients to the far off dialysis centers. PD takes place in some African countries. However, there are problems in starting a PD program due to: Considerable lack of awareness and information about the benefit of PD both amongst the lay public and the medical community. Even many nephrologists consider PD to be inferior to HD and do not accept the potential advantages of PD (Arogundade et al 2005).

Lee et al (2008) reported that patient numbers had resulted in pressure on dialysis centres which resulted to a need to reorganise dialysis treatment. Biesen et al (2008) reported that nurses and doctors have overtime developed biased visions towards HD than PD. Abraham et al (2009) found out that PD is an underutilized RRT in the developing world. They also discussed that several surveys by nephrologists revealed that centre HD had been overused. Cerda et al (2008) found out that uncertainty regarding the true incidence of ARF limits awareness of the problem, thereby reducing political visibility. This hampers the politicians from influencing policies on treatment modalities.

A lot of emphasis has been put on HD unlike PD. Mendelssohn et al (2002) found out that there was quite a big gap between PD and HD which made them recommend further research in this field. According to Rotter (2001) APD has experienced significant growth in highly developed nations in the last few years, while in developing countries with important social, educational, and financial constraints, this treatment modality is, emerging.

This study therefore sought to find out whether APD is an effective treatment modality in RRT in order to yield important information that will help in coming up with a policy that can help the patients in Kenya. No data so far is available on the effectiveness of APD in the Kenyan situation. It is important to document the effectiveness so that the modality is of interest to the government.

1.3 STUDY JUSTIFICATION

APD was started in Kenya in the year 2006. No published literature is available in Kenya and east Africa in general on the effectiveness of APD. APD has not been given much emphasis especially as far as insurance cover is concerned or government funding. There was, therefore, need for research findings that can be used by authorities to make new implementations. This study therefore sought to find out whether APD is an effective treatment modality in order to yield important information that will help in coming up with a policy that can help the patients in Kenya.

It is important to document the effectiveness so that the modality is of interest to the government. The study will help guide the policy makers to consider other options of ensuring bringing RRT close enough to the patients without incurring accommodation fee and other travelling expenses. Water treatment plants are not required in the use of APD machines and it can thus, be used in any hospital or home set up. The study will help in providing the community and the patients at large with information on the importance of APD as a successful option of RRT. In order to broaden an APD program there is need for more education of patients and their relatives. There is also a need to provide technical support for the treatment. This can only be advanced through research.It will help encourage the practice (APD) in various hospitals, help nurses/doctors and patients to know that APD is an important health component of RRT and enable nurses to assist patients in choosing treatment modalities with no biasness.

A lot of emphasis has been put on HD unlike PD. Mendelssohn et al (2002) reported that there was a big gap between PD and HD which made them recommend further research in this field. Grassmann et al (2005) found out that with the current paucity of credible and adequately representative registries, it is justified to resort to innovative means of obtaining information. Grassmann et al (2005) also suggested that in this attempt, world-renowned etiology, and management of ESRD in their respective countries on the basis of integrating available data from different sources is important. Through this effort, it will be possible to identify a number of important trends. These include the APD in Kenya. The study will come out as baseline data for further research.

1.4 STUDY OBJECTIVES

1.4.1 Broad Objective

To determine the effectiveness of automated Peritoneal Dialysis in the management of acute renal failure.

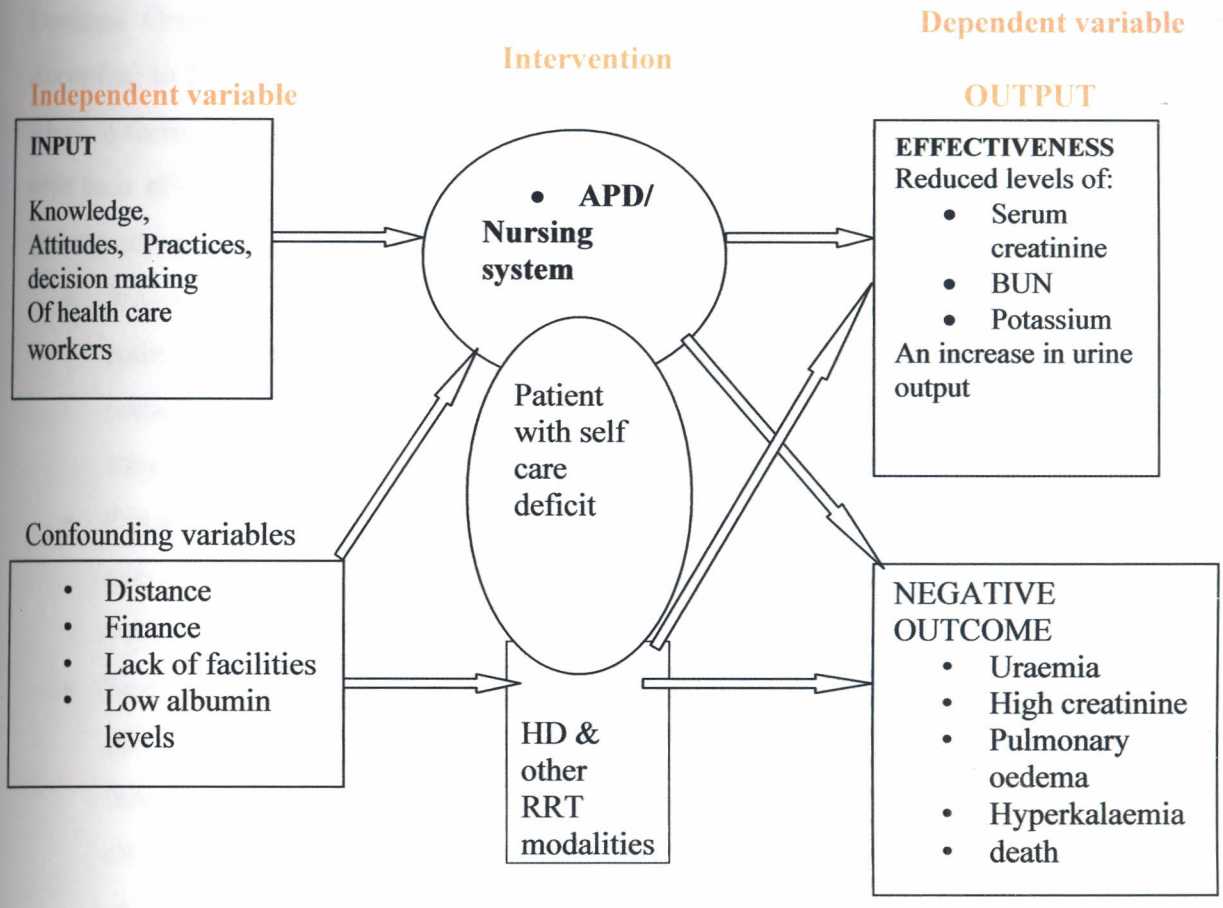
1.4.2 Specific Objectives

1. To establish the socio-demographic data of patients treated with APD
2. To compare Blood biochemistry before and after APD discontinuation
3. To establish the 24 hour urine output before and after discontinuation of APD.
4. To examine the relationship between social demographic data and key measures of outcome after APD

1.5 RESEARCH HYPOTHESIS

1. Automated Peritoneal Dialysis is effective in reducing the blood urea Nitrogen (BUN), serum creatinine and serum potassium.
2. There is a significant improvement of 24 hour urine output after renal replacement therapy using APD

1.6 CONCEPTUAL FRAMEWORK



(Source- From the author)

The conceptual frame work shows that the attitudes, knowledge, practices and decision making of health care workers can determine the selection of treatment modality and have either a positive or a negative patient outcome. The intervention is HD or APD as well as other RRT modalities in combination with one of the 3 nursing systems as per Dorothea Orem's theory.

1.7 THEORETICAL FRAMEWORK

Dorethea Orem,s theory of self care deficit is applicable in this conceptual frame work. According to Polit and Hungler (1995), Orem has defined nursing as the provision of self care which is therapeutic in sustaining life and health in recovering from disease and injury or coping with their effects. In this case the self care requisite is health deviation. All the three nursing systems are applicable. These are:

- Wholly compensatory which encompasses the total nursing care. In cases of AFR, the patient's state sometimes requires them to even be in a critical care unit set up where total nursing care is required. The patient may also be in the ward set up but is in a catabolic state.
- Partially compensatory: This involves both the nurse and the client sharing in the self-care requirements. This entails helping the patient do what they cannot do for themselves but allow them to do as much as they can to be independent.
- Supportive educative: The nurse offers the health education and becomes a resource person. In this case the patient is taught on the causes of ARF and how to assess for renal deterioration and report to the health care workers. The nursing care involves meticulous observation of non touch technique and teaching of the patients. Follow up series is critical in ensuring that treatment is being adhered to. This requires home visits and family involvement in the management of the patients. The patient is taught how to carry out the APD procedure. Some may require dialysis for some time before they resume their normal renal function.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

This chapter focuses on acute renal failure, chronic renal failure, and renal replacement therapy modalities which include peritoneal dialysis, intermittent haemodialysis, haemodiafiltration and continuous renal replacement therapy. PD as an established RRT modality and APD, which is a type of PD, will be discussed including its advantages. RRT resources availability in Africa will also be highlighted.

Porth (2002) describes renal failure as a condition in which the kidneys fail to remove metabolic end products from the blood and regulate the fluid, electrolyte, and PH balance of the extracellular fluids. Renal failure is divided into two categories: ARF and CRF.

2.1.1 Acute Renal Failure

ARF is defined as a sudden onset of poor kidney function where the urine output in 24 hours falls below 400mls in Adults (Isselbacher et al 1981). It is characterized by olyguria or anuria, hyperkalaemia, elevation of toxins like BUN and serum creatinine and metabolic acidosis. According to Devarajan and Wiliams (2008), Oliguria is defined as a urine output that is less than 1 mL/kg/h in infants, less than 0.5 mL/kg/h in children, and less than 400 mL/d in adults. Oliguria is one of the clinical hallmarks of renal failure and has been used as a criterion for diagnosing and staging ARF. It is often the earliest sign of impaired renal function and poses a diagnostic and management challenge to the clinician. Isselbacher et al 1981 reported that previous studies demonstrate a direct relationship between the magnitude of serum creatinine increase and mortality from ARF. Thus, the clinician must carefully evaluate all cases of rising serum creatinine. Clinically, the patients are lethargic and may have acidotic breathing. There may be pulmonary edema, pericardial rub and electrocardiographic tracings may show peaked T waves.

Porth (2002) reports that, ARF is manifested by a sharp decrease in urine output and disproportionate elevation of BUN in relation to serum creatinine levels. The kidney normally responds to a decrease in the GFR with a decrease in urine output. ARF is a common threat accounting to mortality rate of 42% to 88%. Schrier et al (2004) reported that ARF, characterized by sudden loss of the ability of the kidneys to excrete wastes, concentrate urine, conserve electrolytes, and maintain fluid balance, is a frequent clinical problem, particularly in the intensive care unit, where it is associated with a mortality of between 50% and 80%. Sselbacher et al 1981 found out that ARF is the leading cause of mortality, between 50% and 80% and the highest cause being sepsis. . In a study of 226 children with ARF, Bunchman et al (2001) reported that ICU mortality was 3 times higher in ARF than in other patients. In another study, Foley, Parfrey, Harnett, *et al* (2000) found out that ARF causes were: congenital heart disease, acute tubular necrosis sepsis, and bone marrow transplantation. Sepsis and bone marrow transplantation were the most common cases.

Porth (2002) suggests that ARF can result from a variety of causes, classified as prerenal, intrinsic, and postrenal causes. Unlike in CKD, the kidneys can often recover from acute failure, allowing the patient to resume a normal life. People suffering from ARF require supportive treatment until their kidneys recover function, and they often remain at an increased risk of developing future kidney failure.

2.1.2 Chronic Kidney Disease

Unlike ARF, CKD represents progressive and irreversible destruction of kidney structures (Porth 2002). According to Grinsted (2005), CKD can develop slowly and show few initial symptoms, be the long term result of irreversible acute disease, or be part of a disease progression.

2.1.3 Acute-on-chronic Renal Failure

According to Grinsted (2005), AKI can be present on top of CKD. This is called acute-on-chronic renal failure (AoCRF). The acute part of AoCRF may be reversible and the aim of treatment, as with AKI, is to return the patient to their baseline renal function.

2.1.4 Renal Replacement Therapy

There are two types of RRT; Dialysis and kidney transplant. Dialysis is an imperfect treatment to replace kidney function because it does not correct the endocrine function of the kidney. The treatment modality that is most appropriate for ESRD is kidney transplantation which may not favour all patients because of lack of matching donors and even lack of donors themselves. Some may not afford the cost of transplantation.

According to Fan et al (2008), both urea and/or creatinine clearances can be used to monitor dialysis adequacy. There are 5 types of dialysis;

- Intermittent Haemodialysis
- Peritoneal dialysis
- Haemofiltration
- Haemodiafiltration
- CRRT

2.2 INDICATIONS OF DIALYSIS IN THE PATIENT WITH ARF

- Metabolic acidosis in situations where correction with sodium bicarbonate is impractical or may result in fluid overload.
- Electrolyte abnormality such as severe hyperkalemia.
- Intoxication such as acute poisoning with a dialysable drug such as lithium or aspirin.
- Fluid overload not expected to respond to diuretics.
- Complications of uremia such as pericarditis or encephalopathy.

2.3 INDICATIONS OF DIALYSIS IN CRF

- Symptomatic Renal Failure
- Low GFR rate: it is always recommended that dialysis should commence at a GFR of 10 to 15 millilitres per minute per 1.73m^2. In diabetics dialysis is started early.
- Difficulty in medically controlling fluid overload, serum potassium and serum phosphorous when the GFR is low.

Catheter

The catheter is a foreign body in the vein. This results in scarring and narrowing of the vein often to the point of occlusion. Venous stenosis is a serious problem with catheter access.

AV fistula

AV fistulas are recognized as the preferred access method. An artery and vein are joined together through anastomosis. Since this bypasses the capillaries, blood flows rapidly through the fistula. The advantages are lower infection rates, because no foreign material is involved. There is a higher blood flow rate which translates to more effective dialysis and lower incidence of thrombosis. However, if a fistula has very high blood flow rate and the vasculature that supplies the rest of the limb is poor, a still syndrome can occur, where blood entering the limb is drained into the fistula and returned into the general circulation without entering the limb's capillaries. Development of an aneurysm can also occur as a long term complication. This is a bulging in the wall of the vein where it is weakened by continuous insertions of needles over time.

AV graft

Grafts are much like fistulas in most respects, except that an artificial vessel is used to join the artery and the vein. AV grafts are at higher risks of developing narrowness especially in the vein just downstream from where the graft has been sewn to the vein. Narrowing often leads to clotting or thrombosis. As foreign material, they are at higher risk for becoming infected.

Water system

Extensive water purification is critical for HD. Since dialysis patients are exposed to vast quantities of water, which is mixed with dialysate concentrate to form dialysate, even trace contaminants or bacteria endotoxins can filter into the patient's blood. The damaged kidneys cannot perform their intended functions of removing impurities; ions introduced into the blood stream via water can build up to hazardous levels, causing numerous symptoms or death.

deposits of this amyloid in joints as well as other tissues. Beta 2 amyloidosis can cause very serious complications including spodylarythropathy and is often associated with shoulder joint problems.

2.4.2 Haemofiltration

Andystein (2007) explained that haemofiltration is similar treatment to HD but it makes use of a different principle. The blood is pumped through a dialyser or a haemofilter as in HD but no dialysate is used. A pressure gradient is applied, as a result water moves across the semi-permeable membrane rapidly, drugging along with it many dissolved substances importantly ones with large molecular weights which are not cleared well with HD. Salts and water lost from the blood during this process are replaced with a substitution fluid which is infused into the extra corporal circuit during treatment.

Haemodiafiltration is a method used to describe several methods of combining HD and haemofiltration in one process.

2.4.3 Continuous Renal Replacement Therapies (CRRT)

These are continuous HD circuits that utilize the same principles. The dialysis treatments are provided as a continuous 24 hour per day therapy. Blood is removed from the patient, pumped through a dialysis filter and returned to the patient following removal of surplus water and wastes. The major difference between intermittent and continuous therapies is the speed at which water and wastes are removed. Intermittent HD removes large amounts of water and wastes in a short period of time (usually over 2-4 hours), whereas, CRRT remove water and wastes at a slow and steady rate (Sarkar 2009).

According to Paton (2007), the techniques most commonly used are: continuous arteriovenous haemofiltration and haemodiafiltration (CAVH and CAVHDF) and continuous venovenous haemofiltration and haemodiafiltration (CVVH and CVVHDF). The difference is that in CAVH and CAVHDF, there is no pump used while in (CVVH and CVVHDF), a pump is used. The need for continuous anticoagulation has been considered an important disadvantage of CRRT.

square. PD can be performed manually or by a machine. PD is similar to the dialysis performed by kidneys, and operates 24 hours per day, 7 days per week. The nursing care involves meticulous observation of non touch technique and teaching of the patients. Follow up series is critical in ensuring that treatment is being adhered to. This requires home visits and family involvement in the management of the patients.

Daugirdas et al (2001) have discussed the following phases of PD:

a) **Fill phase** – Fluid is introduced into the abdominal cavity.
b) **Dwell phase** – The fluid is left in the cavity for a certain period of time. During the course of PD dwell, 3 transport processes occur:
    i. Diffusion: Uremic solutes and potassium diffuse from the peritoneal capillary blood down the concentration gradient into the peritoneal dialysis solution (dialysate) whereas glucose, lactate and to a lesser extent calcium diffuse in the opposite direction.
    ii. Ultrafiltration: Simultaneously, the relative hyper-osmolarity of the dialysate leads to ultrafiltration of water across the membrane from the capillary blood into the peritoneal cavity. Kallenbach (2005) reported that Ultrafiltration occurs via osmosis where the dialysate used contains a high concentration of glucose, and the resulting osmotic pressure causes fluid to move from the blood into the dialysate. As a result, more fluid is drained than was instilled.
    iii. Absorption: Simultaneously, there is constant absorption of water and solute from the peritoneal cavity both directly and indirectly into the lymphatic system.
c) **Drain phase** –A drain process is the process after the dwell time, the dialysate full of waste products and extra fluid is drained out of the patient's blood

According to Daugirdas et al (2001) PD is divided into continuous ambulatory peritoneal dialysis (CAPD) and APD.

2.4.4.1 CAPD

Daugirdas et al 2001 describe that CAPD involves 2.0 to 2.5 litre dwells in adults daily with each lasting for 4-8 hours. Anochie & Eke (2006) reported that in children, a fluid volume of 20 – 50

mL/kg is typical, starting with the lower volume. The exchange time (combined time for inflow, dwell, and drain) for children most commonly used is 1 hour (Inflow 10 minutes, dwell 30 minutes, outflow 20 minutes).

2.4.4.2 APD

This is PD using machines called cyclers which can now deliver predetermined volumes of solution into the peritoneal cavity and then drain it after a programmed dwell time. Dialysate of varying glucose concentration can be simultaneously attached to a multipronged cycler manifold (up to 5 – 8 containers of 3 – 5 Liters each). The cycler can calculate the ultrafiltration volume (Ploumis & Dimitrios 2007). According to Gabriel, (2007), PD in ARF should be carried out in a continuous and automated method with high volume of dialysate.

According to Daugirdas et al (2001) in APD, 3-10 dwells is delivered nightly using an automated cycler machine. In the day time, the patient usually carries a dwell which is drained out each night before cycling recommences. This is called continuous cyclic PD. Alternatively, the patient is left dry during the day and this is termed as nocturnal intermittent PD.

2.4.4.1 Techniques of PD

Acute PD

It is performed by nurses, and it requires constant supervision to ensure proper inflow, and accurate dwell and drain times are maintained. Acute intermittent PD can either be performed manually or can be delivered by an automated cycling device. The prescription usually involves short dwell times with 2.0 to 3.0 litre dialysate volumes and dialysate flow rates of 2 to 6 litres per hour.

Classical intermittent peritoneal dialysis (IPD)

In this case, a cycling device programmed to deliver a predetermined volume of dialysate and to drain the peritoneal cavity at fixed intervals is used. Short exchanges using volumes of 1 – 2 litres and hourly dialysate flows of 2 – 6 litres, in sessions of 16 – 20 hours twice or three times

mL/kg is typical, starting with the lower volume. The exchange time (combined time for inflow, dwell, and drain) for children most commonly used is 1 hour (Inflow 10 minutes, dwell 30 minutes, outflow 20 minutes).

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weekly, deliver doses of about 40–60 L per session (80 –180 L/week). This type of PD has been widely used in ARF. The use of the automated device or cycler reduces the need for constant nursing supervision.

Tidal Peritoneal Dialysis

Tidal PD (TPD) is a form of PD prescription that leaves a constant 'tidal' volume of 1.0 to 1.5 litres in the peritoneal cavity after the peritoneum is filled with a large (3.0 litre) dialysate volume. TPD is designed to optimize solute clearances by leaving a constant "tidal volume" in the peritoneal cavity throughout the dialysis session. The peritoneal cavity is drained completely only at the end of the session.

Continuous Equilibration PD

Continuous equilibration PD (CEPD), which is similar to, but often more intensive than CAPD, provides PD in an inpatient setting. The CEPD technique differs from IPD in that it uses relatively long dwell times, with multiple daily exchanges, in which dialysate is instilled and drained continuously every 2 – 6 hours by a cycler or manually, in a low-flow continuous system that maintains stable blood levels of nitrogenous products. Fluid is removed by using solutions of varying dextrose concentration.

With regard to glucose concentration, Ploumis & Dimitrios (2007) reported that 2-Litre hourly exchanges of a solution with 1.5% glucose usually gives an ultrafiltration rate of 50 – 150 mL/h, which equals 1200 – 3600 mLs/24 h; higher glucose concentrations (2.5% – 4.25%) can result in the removal of larger volumes of fluid (200 – 400 mLs/h). Occasionally, in patients with pulmonary edema, 2 or 3 consecutive 2-Litre exchanges (without dwell time) of 4.25% glucose solution may remove approximately 1 Liter over a 1-hour period. Furthermore, by reducing the dwell time to 15 minutes from 30 minutes, the dialysate flow rate can be increased to about 4 L/h (66 millilitres/min) and thus achieve more efficient dialysis that might be used for short periods in hypercatabolic and hyperkalemic patients. A patient with ARF requires continuous removal of fluids and solutes, especially when oliguric, hypercatabolic, and in need of ongoing nutritional and therapeutic support.

2.4.5 Advantages of PD

Abraham et al (2009) discussed that in early studies, patients treated with PD had a lower mortality rate and a higher incidence of renal recovery than did similar patients treated with HD. PD offers advantages of simplicity, reduced training, lack of dependence on infrastructure and location. However, the small-molecule clearances achieved with PD are commonly lower than those achieved with daily 4-hour HD treatments, because the small-molecule concentrations in peritoneal dialysate reach approximately 30% – 50% of the equivalent. Conversely, the clearance of higher molecular weight substances is greater with continuous PD than with HD.

According to Kapoor (2007), the peritoneal membrane is more permeable than the cellulose semi permeable membrane of a dialyzer because the pores are larger. It can therefore clear solutes of middle molecular weights (500-5000 Daltons) more readily. This would explain the general well being and improvement patients on P.D experience after sometime. Because of the gradual removal of fluid and solutes, PD results in better hemodynamic stability. Manual PD or APD has been successfully used in many ARF patients, especially those at risk of bleeding or with hemodynamic instability, and in infants and children with ARF or circulatory failure. The patient thus achieves:

- Better volume control
- Reduction in blood pressure
- Decreased prevalence of left ventricular heart failure
- Normalized potassium blood levels
- Reduction in arrhythmias

Slow correction of metabolic imbalances:

- Acute PD enables continuous correction of acid-base status and electrolyte imbalance and the gradual removal of nitrogenous waste products.
- The slow removal of uremic toxins is not associated with the development of the disequilibrium syndrome.

Systemic anticoagulation not required:

Since the PD procedure does not require systemic anticoagulation, excellent candidates for this modality include the following patients:

- Those with a bleeding diathesis

- Patients in the immediate postoperative period
- Trauma patients
- Patients with intra-cerebral hemorrhage

Hyperalimentation:

- The use of hypertonic glucose in PD solutions provides additional calories which is a benefit in malnourished patients.

Tolerated in children:

Tong et al (2004) suggested that PD is well tolerated in children and has the following advantages:

- Acute PD has been frequently utilized and is the preferred form of therapy for dialysis of children with ARF.
- The technique is convenient, relatively simple, and safe to perform in children.
- Acute PD circumvents the need for arterial or venous puncture, both of which are difficult in children. In the paediatric ICUs at most centres, acute PD has been the RRT of choice for decades in part because of its simplicity and safety as well as the relative ease with which the procedure can be performed in very small patients.
- Per unit weight, an infant's peritoneal surface area is about twice that of an adult, leading to more-efficient clearance of urea and creatinine. But the rate of glucose absorption is also increased in infants, and to remove large fluid volumes, either higher dextrose concentrations or shorter dwell times must be used. Thus, continuous PD usually achieves adequate urea clearances in small children.
- In infants weighing less than 2500 g, PD remains the RRT of choice, and acute PD has been successful even in premature infants weighing less than 1000 grams.
- Despite the increasing use of new CRRT in paediatric ICUs to treat children with ARF, PD remains an efficient, useful, and simple method , especially in small children with difficult vascular access
- The technique has no serious hemodynamic consequences, blood priming of a HD circuit is unnecessary, and no vascular access is needed (which is often the limiting factor in the dialysis of small children and infants).

According to Munib (2006), PD has several advantages such as:

- It is carried by the patient in their own home set up.
- Dialysis can be scheduled according to the patient's life style and there are no dietary restrictions
- Transport to the hospital is only needed for clinic or emergency visit.
- PD fluid can be delivered at home with prior arrangements.
- Access is easy to establish and there is freedom from mechanical equipment.
- There is better preservation of the renal residue function than HD
- There is decreased incidence of thrust, anemia and better control of hypertension
- There is no chance of needle pricks and chances of hepatitis B and C infections are limited.
- Exit site infections are rarely serious
- It is safer for patients with poor cardiac function and severe ischemic cardiac disease

According to U.S. Renal Data System (1998), survival rate was found to be high in patients on PD than HD. Liem et al (2007), reported a study in the Danish survival registry 2001 which concluded that PD patients have an initial survival advantage relative to HD. The report shows that the relative risk of death on PD is less than that on HD, except for elderly female diabetic patients. In addition, the Canadian data shows that survival is superior to HD in the first 2 years of therapy. In terms of Logistics we realize that 40 Nurses are required per 100 HD-patients. On the other hand, 4 Nurses are required in the Out-patient Clinic per 100 PD-patients.

2.4.6 Advantages of APD

- Ploumis & Dimitrios (2007) stated that although acute PD was traditionally delivered using manual exchanges, cyclers now deliver predetermined volumes of solution into the peritoneal cavity and then drain it after a programmed dwell time. This has been known to have advantages such as a reduction in the incidence of peritonitis, increased adequacy, save much nursing time, improve the recordkeeping related to fluid balance and more freedom as well as comfort for patients. Fewer connect-disconnect procedures leads to a reduction in the rates of peritonitis. Studies examining the effects of APD

suggest that peritonitis rates are lower in APD patients than in patients treated with CAPD. Two of three recent studies indicated that the risk for transfer to maintenance HD may be lower in APD patients, particularly in the early period after starting chronic PD (Mehrotra 2009).

- Gabriel (2007), suggested that APD offers advantages such as increased adequacy, enhanced patient well-being and positive changes in lifestyle,
- According to Anochie and eke (2006),one of the advantages of APD is few connections thus reduction of peritonitis rates, adequacy of dialysis is much better since the machine is delivering the fluid automatically in time, the nurse does not have to spend time doing the manual exchanges. APD is effective in reducing mortality of children with ARF.
- A practical way to provide additional dialysis is the use of APD. Automation of the fluid exchange process offers a technological advantage directed toward making PD treatment more convenient and less daytime consuming for the patient in order to improve quality of life (Rodriguez et al 1996).
- Poor survival of some patients on PD may be associated with inadequate dialysis dose. Some patients, mainly those who have lost their renal residual function or who have a very large body surface area, may require more than four peritoneal fluid exchanges per day in order to attain acceptable clearances. A practical way to provide additional dialysis is the use of APD.
- The APD machine also warms the dialysate automatically thus reducing complications of pain that usually comes with cold dialysate.
- The machine is lightest and portable. It can thus can be used in any setting because a water treatment plant is not required
- The quality of life is far better because the patient is not restricted on diet and fluids
- Smart dwells ensure overnight therapy is completed as programmed, better small solute removal, better ultrafiltration. It can be used in anuric and larger patients.

2.4.7 Complications of PD

According to Kapoor (2007), PD may be associated with infectious, mechanical, or medical complications of varying severity.

1. Infectious complications

- Peritonitis complicates acute PD in up to 12% of cases, frequently developing within the first 48 hours. Because the major source of infection and of subsequent peritonitis is contamination during connection or disconnection of each new exchange, infection is more common with open-drainage systems. It is thus less common with APD. The acute PD catheter needs careful attention, because catheter-related infections continue to be the most common complication of acute PD in children and infants and the most frequent cause of catheter removal.

- Munib (2006) discusses peritonitis to be one of the complications of PD and that there is the infectious and non infectious peritonitis. However, he reports that with improved technology, peritonitis rates have come down to one episode in 12-24 months which is acceptable according US registry dialysis data. Clinical signs and symptoms of peritonitis are: pain, discomfort, tenderness, rebound tenderness, fever, nausea/vomiting and diarrhoea or constipation. There is also cloudy effluent of (wbc $\geq$ 100 cells /mm3), poor drain, loss of ultrafiltration or bloody effluent, positive culture or gram stain.

- Munib (2006) also reported that exit site infections which present with pus and redness can occur. Tunnel infection can occur which also presents with redness, pain and swelling at the tunnel site

2. Mechanical complications

There are complications related to insertion techniques such as perforation, haemorrhage, hernia mostly in children, haemorrhoids due to increased intra-abdominal pressure by dialysis solution Reducing the volume in a nightly dialysis may be helpful. There are also cardiac complications seen in CAPD such as left ventricular dysfunction and cardiac arrhythmias. Haemoperitonium which is common in young girls during menses can also occur. This can also occur in cases of cell carcinoma, polycystic kidneys, anticoagulant therapy, thrombocytopenia, acute cholecystitis schlerosing peritonitis, IgA nephropathy and post colonoscopy (Munib 2006).

Ploumis & Dimitrios (2007) reported that marked pain on inflow of dialysis solution may be a result of the solution's low pH, its low temperature, the "jet flow" from a straight catheter tip, or

distension of the tissue around the catheter. This pain may be relieved by alkalinization of the solution with sodium bicarbonate (5 – 25 mEq/L), by warming the solution, and by choosing a lower infusion rate. According to Munib (2006), localized outflow pain associated with drainage may indicate that the omentum or other tissues have trapped the catheter. Visceral perforations of bowel, bladder, or aorta are major complications infrequently associated with nonsurgical insertion of a rigid catheter. Bloody dialysate, which is frequently seen after catheter insertion, is usually a result of the lysis of peritoneal adhesions from a previous abdominal operation or of peritoneal irritation. The presence of a bleeding tendency predisposes to this complication.

Early dialysate leakage may be seen in the presence of predisposing factors such as age over 60 years, obesity, diabetes mellitus, chronic use of steroids, multiparity, and a previous abdominal operation. Such leakage may be avoided by using lower fill volumes. Abdominal distension and even respiratory compromise may follow incomplete drainage and progressive accumulation of dialysate in the peritoneal cavity. This complication may be prevented by careful observation to ensure complete emptying during the allowed drainage period. Abdominal wall and genital edema have been attributed to peritoneal defects at the site of catheter insertion. Abdominal-wall edema should be suspected in cases of a sudden reduction in effluent volume and increased abdominal girth and body weight in the absence of edema elsewhere (Daugirdas et al 2001)

According to Kapoor (2007), hydrothorax is a rare complication, and its clinical presentation varies from asymptomatic pleural effusion discovered on routine chest X-ray to life threatening respiratory failure. This complication has been attributed to the presence of a diaphragmatic defect with pleura-peritoneal communication.

3. Medical complications

Anochie and eke (2006) reported that hypervolemia because of poor ultrafiltration is a possibility, as is hypovolemia and hypotension of excess water removal. Hypotension is often seen with rapid hypertonic exchanges; when severe, this complication may require temporary discontinuation of dialysis and infusion of intravenous saline. The patient may also require intravenous administration of 5% dextrose in water to correct the hypernatremia that occurs because of excess water removal (sodium sieving) with hypertonic dialysis.

Kapoor (2007) reported that patients on acute PD may develop an acid–base imbalance in presence of simultaneous intravenous administration of bicarbonate solution to secure a ra correction of metabolic acidosis. Paradoxically, this problem leads to acidosis of cerebrospinal fluid, hyperventilation, and finally alkalosis. Because standard PD soluti contain lactate buffer, patients with hepatic failure or severe lactic acidosis and slow lac metabolism may present with elevated plasma lactate levels; if so, they will need dialy solutions containing bicarbonate buffer. The frequent exchanges used in acute PD may prod hypoalbuminemia; protein losses via the dialysate can be as high as 10 – 20 g in 24 hours and to twice that amount during episodes of peritonitis. To compensate for dialysate protein loss oral or intravenous protein supplementation may be required.

According to Munib (2006), there are other complications such as outflow problems whi present with reduced returns of infused fluid causing retention of fluid. This comes as a result constipation, kinked catheter or fibrins. ultrafiltration failure during acute PD is common associated with high solute transport and early dissipation of the osmotic gradient. Ultrafiltrati failure is observed more frequently during episodes of peritonitis because of increased peritone membrane permeability. Membrane failure can be classified as follows:

- Type I failure: The most common form. It occurs in high transporters
- Type II failure: occurs due to schlerosing peritonitis and inflammation causing decreased membrane permeability and surface area, leading to decreased ultrafiltration and solute transport. It is diagnosed by peritoneal equilibrium test.
- Type III failure; excessive lymphatic absorption leading to loss of net ultrafiltration.

2.5 HISTORY OF PERITONEAL DIALYSIS

Starting in the 1970s, PD was widely used in patients with ARF especially in those with hemodynamic instability or bleeding risk from severe coagulation abnormalities, in infants and children with circulatory failure; and in patients with serious heart failure as well as a low cardiac index who could not tolerate HD. This widespread use largely resulted from the nephrologists' or surgeon's ability to institute PD quickly, easily, and safely by insertion of a

semi-rigid catheter or a single-cuff Tenckhoff catheter at the bedside (Ploumis & Dimitrios 2007).

According to Carter & Callegari (2008), PD was started in 1981 and by the year 2001, approximately 100,000 patients worldwide had used it. In Vietnam, CAPD with a straight line and one bag was first used in 1998. Because the complication rates, mainly as a result of catheter obstruction and peritonitis, was very high (50%), treatment was stopped after the first 10 cases. Use of the modality resumed only in 2001. However, because of skepticism and concern on both the part of physicians and patients about the effectiveness of PD and about the infection risk, PD developed very slowly. Until late 2004, patient numbers were very limited. Since then, CAPD using Y-set and two-bag system-plus routine omentectomy during catheter insertion and better patient selection and training in bag exchange-has resulted in much better outcomes with fewer complications, and the technique has been developing far faster (Iseki et al 2008).

PD was started in Kenya at KNH in 1978 where the first CAPD took place, while HD was started later in 1984. So far only 2 dialysis centres – KNH and Moi Teaching and Referral Hospitals offer HD as Government institutions. The rest 20 centres are in the private sector and basically in Nairobi. APD was started in the year 2006 where the first case was done at the Nairobi hospital.

2.5.1 Peritoneal Dialysis as an Established Renal Replacement Therapy Modality

PD has been established as a modality of RRT for patients with renal failure world- wide with great advantages for quality of life as well as outcome (Souqiyyeh et al 2006). APD has experienced significant growth in highly developed nations in the last few years (Mehrotra 2009). In Canada, there was a very rapid increase in APD from 3% to 21% in only 3 years, mostly to accommodate PD prescription changes and to a lesser extent to fit changes in lifestyle (Perry & Potter 2008). In other developed nations of the European Community, such as Spain, APD has grown even more, constituting close to 80% of all their PD patients. According to Rotter (2001) APD has experienced significant growth in highly developed nations in the last few years. Rotter (2001) reports that Patients on PD account for 6% of ESRD patients in Japan, 13% in the US, 37% in Canada, 42% in the UK, 81% in Hong Kong and 91% in Mexico . APD

in Argentina is used in close to 25% of their PD patients. In Brazil, the situation is similar, with close to 20% of their PD patients on APD. However, Mendelssohn et al (2002) reported that in the USA, 87.3% of the patients with ESRD requiring dialysis are treated with HD and 12.7% with PD. The writers felt that there was underuse of PD and because modality distribution is an important determinant of cost and probably outcome, there was need for further research in this field

2.5.2 The Sluggish Growth of PD in Developing Countries

Rotter (2001) reported that APD was a scarcely used treatment modality in the RRT programs of most developing nations, including those of Latin America. The low use of APD is influenced by non medical factors, including the availability of the modality, physician experience and bias as well as government reimbursement policies. Slow growth may also be caused by a lack of success in demonstrating the significant benefits provided by the modality to those in charge of distributing and assigning financial resources for the treatment. The apparent cost of the therapy is an important factor that may preclude development of treatments for patients that could benefit from them. When the number of patients to be treated is large and growing in a nation that has financial constraints in its health care budget, ''more expensive'' treatment modalities may not be considered a priority. In order to take better care of more patients, less expensive treatment modalities may be indicated in many cases, yet these same modalities may also prove to be more expensive in some instances, when complications and other related costs are considered. Rotter (2001) reported that in developing countries with important social, educational, and financial constraints, APD modality is just emerging.

Sougiyyeh et al (2006) reported that APD use is low for several reasons, including a lack of sufficient financial support from official programs for the treatment of renal diseases as well as logistic and educational problems. In order to broaden an APD program there is need for more education of patients and their relatives. There is also a need to provide technical support for the treatment itself and for maintenance of the necessary equipment.

A survey done by Jassal et al (2002) revealed that a decrease in the overall use of PD had been noted and suggested that a higher proportion of patients should be on APD to optimize dialysis,

cost effectiveness and patient outcome.Some developing nations of Asia and Latin America have experienced significant growth in their PD populations as PD may require less technology than HD and may be less expensive. This statement may not be true for some nations where peritoneal fluids are imported and there is little interest in the development of PD by the medical community. Selection of a dialytic treatment modality is influenced by multiple medical and nonmedical factors, yet the latter are more powerful contributors to this decision. Some of the most important factors that play a role in this decision process are availability of the treatment modality, physicians' experience and bias toward a specific form of treatment, patient preferences based on understanding of the therapies, geographic issues, education, and lifestyle. Nevertheless, the strongest drivers for dialysis modality selection are economic in nature. According to Souqiyyeh (2008), the expansion of use of PD in the kingdom of Saudi Arabia has rather been sluggish over the last 20 years. This is the same thing that has been happening in Kenya. The numbers of HD patients supersede the PD patients.

In Colombia, APD accounts for less than 10% of PD therapy, while in Mexico, less than 3% of PD patients are on APD, in spite of significant efforts to increase this percentage. Why this disparity in distribution? It is possible that in developing countries with high rates of PD utilization, such as Mexico, APD use is low for several reasons, including a lack of sufficient financial support from official programs for the treatment of ESRD as well as logistic and educational problems (Locatelli et al 1999).

Recently, technological developments in HD techniques (bicarbonate dialysis, hemofiltration, hemodiafiltration) and CRRTs, have limited the indications for PD in critically ill patients with ARF but PD remains an effective RRT modality (Ploumis & Dimitrios 2007). According to Mehrotra (2009), the decision to use APD is being dictated by patient and physician preference rather than being based on medical considerations. The implementation of different modalities of RRT is inhibited by the lack of funding (Abraham, Pratap & Gupta 2009).

There are several problems in starting a PD program in the developing world. There is still considerable lack of awareness and information about the benefits of PD both among the lay public and the medical community and even many nephrologists consider PD to be inferior to

HD and do not accept the potential advantages of PD (Abraham, Pratap & Gupta 2009). As can be seen from this report APD has been poorly utilized despite its various advantages.

2.6 THE ROLE OF APD IN THE REDUCTION OF PERITONITIS RATES

One Turkish study done retrospectively from 1996-2007 revealed that 45.2% of the patients put on CAPD developed peritonitis (Cakir et al 2008). Another study done in 2004 on 885 patients on APD revealed that only 25% of the patients developed peritonitis (Tong et al 2004). This shows that APD has led to the advancement of PD therapy by the reduction of peritonitis rates.

According to Gokal et al (2000), Peritonitis is a common problem that occurs in patients with ESRD treated with PD. Although the incidence varies from center to center, since 1980s, it has progressively declined and during the previous decade, approximately 1 episode every 24 patient-treatment month was observed. They also said that the introduction of APD had contributed to the achievement of a reduction in peritonitis rates attributed to fewer connect-disconnect procedures. In many parts of the world, a progressively larger proportion of chronic PD patients are being treated with APD.

2.7 RENAL REPLACEMENT THERAPY RESOURCES AVAILABILITY IN AFRICA

Africa and particularly Kenya has experienced an increasing mortality mainly due to increasing cost of RRT and lack of facilities. It is required that the patients have to live on treatment throughout their lives. This includes RRT and constant use of hormones for example erythropoetin that would have otherwise been produced by a normal healthy kidney (Were &,McLigeyo 1995). As a result PD has been used scarcely in most of the African countries.

In 22 countries in Africa, there are No nephrologists available, no nephrology and no Dialysis. PD takes place in some African countries. However, there are problems in starting a PD program due to considerable lack of awareness and information about the benefit of PD both amongst the lay public and the medical community. Even many nephrologists consider PD to be inferior to HD and do not accept the potential advantages of PD (Arogundade et al 2005). Financial problems are the most important hurdle to PD programs as most developing countries have no health insurance system. The majority of patients are financing their own treatment.

Carter et al (2008) found out that Sustainable Kidney Care Foundation (SKCF), working with industry, institutions, universities and funding organizations was in the process of establishing a pilot program for the treatment of ARF using PD as the modality of choice with a special focus on treating children and women of childbearing age in the United Republic of Tanzania.

Anochie and eke (2006), suggested that the development of research strategies directed toward *reducing costs* related to this form of treatment is crucial. An example is the reuse of disposables, which has been highly controversial. Other industry-market strategies for cost reduction could also be developed.

2.8 SUMMARY OF THE LITERATURE REVIEW

As can be seen from the literature review, no studies on APD have been done in Africa and particularly Kenya. A lot of studies in resource rich countries have been done. A major gap has been noted in resource poor countries between PD and HD. PD has not been well supported in most parts of the world despite researches that have shown its success.

CHAPTER THREE

3.0 METHODOLOGY

3.1 STUDY DESIGN

This was a retrospective cohort study on the effectiveness of APD and extent of utilization for the management of ARF patients in Kenya. The patients were their own cohort and the outcome was remission of disease. Since there were very few patients on APD as it was a rare event, this study design was most appropriate. According to Polit. & Hungler (1995), the retrospective design is a very time-efficient and elegant way of answering new questions with existing data. It is inexpensive, uses existing records, and allows study of rare occurrences, easier to assess conditions where there is a long latency between exposure and disease. It can generate hypothesis that is then tested prospectively (quality improvement initiatives). The researcher considered all these advantages when selecting the study design.

3:2 STUDY SITE

In Kenya, only a total of 9 hospitals out of the 22 dialysis units perform APD. 6 of the Hospitals are based in Nairobi while 3 are in Mombasa. Only one is a government institution. The retrospective cohort study was conducted in five Hospitals that practice APD in Nairobi. The selection of the Hospitals was purposeful. Nairobi was chosen because of convenience and experience. The files for study were obtained from KNH, Gertrude children's Hospital, Aga khan hospital Nairobi, Mater hospital and Nairobi west Hospital.

3.3 STUDY POPULATION

The study population were Paediatric and adults with ARF who were on APD from May 2006 – May 2010. As mentioned above, very few hospitals perform APD. The study focussed on the 35 patients with ARF that were treated with APD from May 2006 –May 2010 in five hospitals in Nairobi. These years were chosen because APD was started in the year 2006 in the country and it is a rare event.

3:4 SAMPLING/SAMPLING METHOD

3:4:1 Sampling

Convenient sampling method targeting the entire population was employed. However, since there were very few patients on APD, adjusted sample size formula was used based on the sample frame of all cases of APD with ARF from the year 2006 to 2010 in the five hospitals as shown in the table below.

Selected hospitals	Gertrudes children's Hospital	Aga Khan Hospital	KNH	Nairobi West Hospital	Mater Hospital	Total cases
Number of APD cases	15	6	1	1	15	38

The sample size was determined through the width of the confidence interval to estimate the effectiveness of APD. Thus based on the table above, the adjusted sample size was calculated using the Fisher's formula below:

$$n' = \frac{NZ^2P(1-P)}{d^2(N-1)+Z^2P(1-P)}$$

Where:

n'=the desired sample size after finite population correction

N=the estimated of the population size (In this case 38)

Z=is the standard normal deviation at 95% confidence level (1.96)

P=is the estimated proportion

d=error of margin (degree of precision) (±5%)

Therefore:

$$n' = \frac{38x1.96^2x0.55x0.45}{0.05^2(38-1)+1.96^2x0.55x0.45}$$

$$= \frac{36.130248}{0.0925+0.950796}$$

Nairobi west Hospital CCU. The researcher picked up files available as well as computer stored information and evaluated the data retrospectively. There is a register in all hospitals which indicates the cases and the type of dialysis done. Dialysis is done mostly in the CCU and the renal unit set ups where files were easily retrieved.

The registration numbers were obtained from where the dialysis was carried out, and then files were retrieved with the help of the records officers on the ground and research assistants. Research assistants were trained on how to obtain the information. Hospital protocols were adhered to and guidance sort on how to acquire the files. The files were then perused through and information from source documents (printed documents from the laboratory, nursing and Doctor's records) was obtained and then recorded in the structured questionnaire attached (Appendix I).

The study variables (urine output, serum creatinine, BUN, potassium) prior to or after discontinuation of APD were obtained. Relevant material on each patient was obtained and recorded according to age, sex, diagnosis date of admission and outcome. From experience in previous scientific papers presented in conferences for example the sixth scientific conference in 1997 on CAPD in Kenya, the retrieval rate from 1984 to 1997 was a 100 %. The retrieval rate of the files in this study in the five Hospitals was 100 %. This is because renal patients are special in a way that data is kept intact since they are needed for follow up. On the other hand, all private Hospitals have introduced Care 2000 Computer Data Information System which entails all information regarding the patients' investigations and treatment details. Moreover, these are credible hospitals that could not miss this data since it is mandatory to have it to make the diagnoses and decide when to start or discontinue APD.

3.7 VARIABLES

Key renal parameters that were chosen in the study were creatinine, BUN, urine output and potassium. Serum albumin was noted since it was a confounding variable. This was controlled by finding out whether it was replaced or not. Measures of Outcomes included an improvement in

creatinine, BUN, potassium and urine output. The normal values (reference ranges) as per the practice of the five mentioned hospitals where the research was done are as follows for adults:

- Serum Creatinine; 60 -124 micromillimores
- Serum Potassium: 3.5 -4.9 mmols
- Blood urea nitrogen:2.5-6.7 mmols
- The normal urine output is 1500 -2000mls

The normal values in paediatrics are as follows:

- Serum Creatinine: 27 to 62 micromillimores per litre
- Serum urea; 1.8-6.4 mmol
- The potassium is the same as for adults
- The normal urine output is 1ml/kg/hour

These were the dependent (outcome) variables. The independent (predictor) variable was APD which is a treatment modality. The primary variables of interest were: age, gender and religion. The confounding variables were: serum albumin, financial constraints and distance as well as availability of facilities for APD.

3.8 PRE-TESTING/PILOTING

The pretesting/piloting of the research proposal was done at the Nairobi hospital. The pilot study was done in Nairobi hospital because it has similar characteristics as do the other hospitals where the study was done. The necessary adjustments were made on the questionnaire.

3.9 DATA ANALYSIS

A retrospective cohort analysis of the records of 35 patients from five (5) hospitals with acute renal failure on APD from May 2006 to May 2010 was carried out. Quantitative data was cleaned and entered into a computer software package, SPSS. 24 hour Urine output, Serum Creatinine, Serum Potassium, and BUN prior to and after dialysis was obtained and compared using paired t-test and p-values obtained to determine statistical significance of results. The statistical significance was set up at $p<0.05$.This is because the number of cases done so far in the country is very small. Comparison of the change by socio- demographic parameters of the

patients was carried out. Those patients who died while the PD was still functioning were analyzed as cases of technical survival. Presentation of the data was quantitative.

3.9.1 DATA CLEANING

After information was collected, data was captured in the computer using a computer statistical package called SPSS for cleaning and analysis.

3.9.2 STUDY LIMITATIONS

A few constraints were encountered. Some of the hospitals had erased the details of the old files from the computers and put the files in the achives. It was easy to lose clients' retrospective data if it has not been well stored or entered. There was a likelihood of the researcher skipping some important information. These limitations were avoided by proper training of the research assistants, consulting with the records officers to ensure that the right information was obtained and all the files were available. The information technology department was used to retrieve the details of the files from the main server after which the records department was used to obtain the files from the achives. All gaps were marked with a star. The files were retrieved again and the data was recaptured. All data that was required was entered and keyed in the computer. In all these processes, an experienced statistician was consulted

3.10 ETHICAL CONSIDERATIONS

A request to conduct the study was submitted together with a copy of the study proposal to the ethical committee who approved the study. A written consent was obtained from KNH research and Ethical committee, ministry of research science and technology, the administrators of KNH, Aga khan Hospital Nairobi, Mater Hospital, Gertrude children's Hospital, Nairobi west Hospital, Nairobi hospital. The research was carried out following the approval of all Hospital administrators. There was no consent that was taken from the patients because they had either been discharged or died. Ethical issues in this case needed to be waived and the reason for that is that patient's records are kept for research and other purposes. However, ethical issues were adhered to by maintaining confidentiality where details were collected for no other purpose than for this study. No names of the patients were revealed from the records. Only code numbers were

used. The information obtained was treated with confidentiality as permitted by law. Utmost confidentiality was observed.

3.11 DISSEMINATION OF FINDINGS: THE INFORMATION WILL BE DISSEMINATED TO:

1. Instructors and the administration at the University of Nairobi
2. The Hospital administrators at the 5 hospitals
3. Ministry of health for use in government policy
4. National Nurses Association of Kenya
5. A seminar will be organized for clinical practitioners to be informed on the study findings for the benefit of patient care.
6. A dissertation will be published in the University and peer reviewed Journal
7. Publication to the people will be done

8. CHAPTER FOUR

4.0 RESULTS

Patient distribution per hospital

A total number of 35 patient's files were sampled conveniently and studied. Out of the 35 patients, 45.7% (n=16) were from Mater Hospital, 34.3% (n=12) were from Gertrude Children's Hospital, Aga Khan had 14.3% (n=5) and 2.9 % (n=1) each from Nairobi West Hospital and KNH. From this data collected, Mater hospital had the highest number of APD cases. The graph below illustrates the distribution among hospitals.

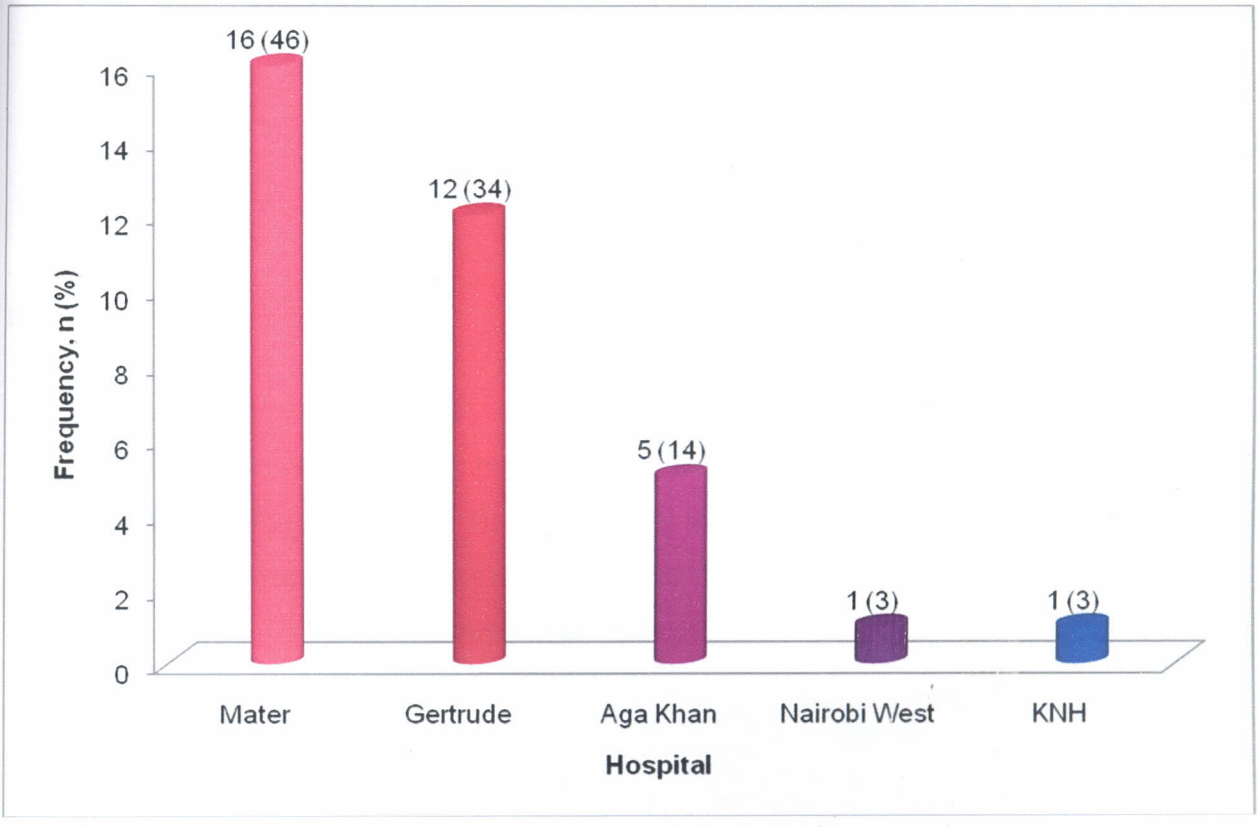

Figure 4.1: ***Patient distributions among the Hospitals***

Gender Distribution in ARF

In this study, male patients (77.1%; n=27) were more than female patients (22.9%; n=8) .This is shown in figure 4.2 below.

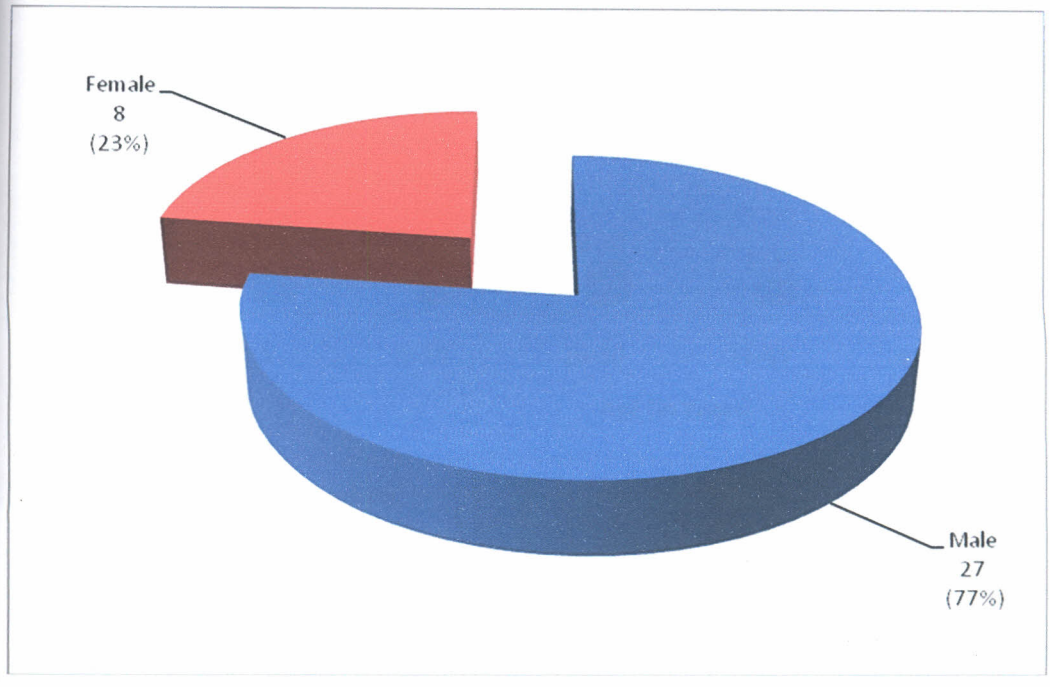

Figure 4.2: Gender distribution

Age Category distribution in ARF

The age category between 0-5 years presented with the highest percentage of 71.4 % (n=25), ages between 46-60 years 8.6% (n=3), the following age categories presented with 5.7% (n=2); 6-15yeears, 16-30 years and 60 years and above. The age category of 31-45 years presented with 2.9% (n=1). Figure 4.3 below illustrates these findings.

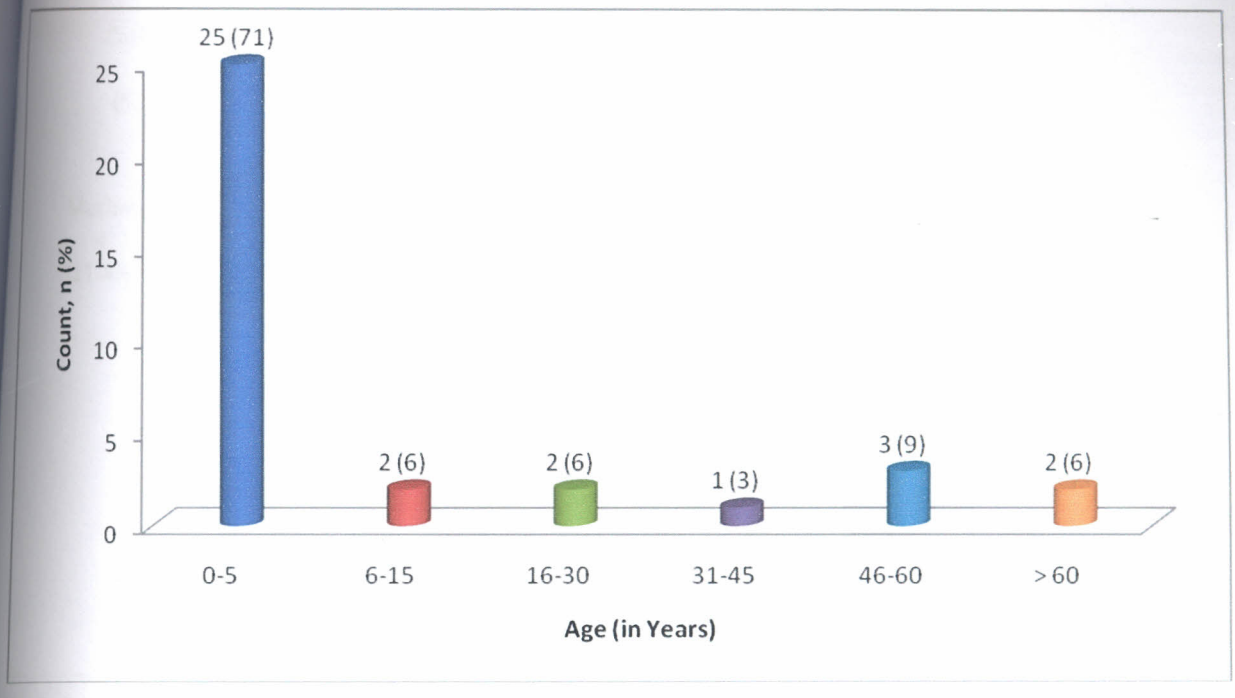

Figure 2.3: Age distribution

Religion distribution

The patients studied were from different religions. Protestants represented 82.9% (n=29), Muslims 11.4% (n=4) and Catholics 5.7% (n=2). The most affected religious group was the Protestants who were 29 (82.9%) affected as shown in figure 4.4.

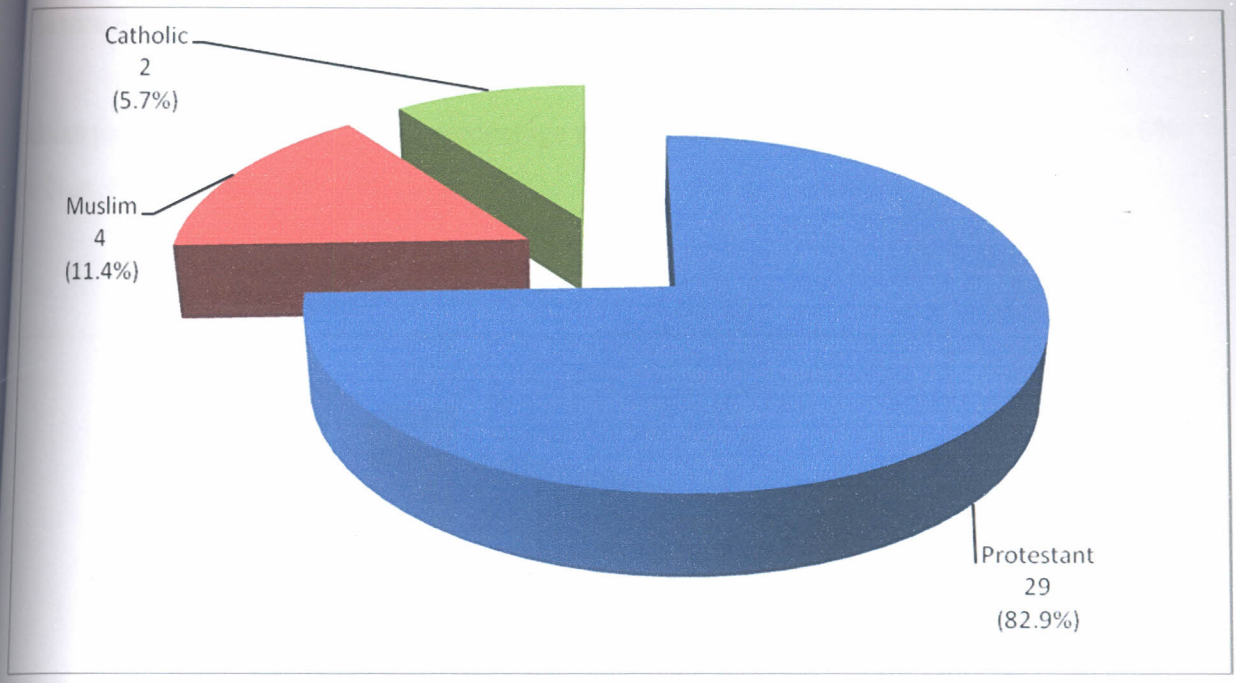

Figure 4.4: Religion distribution

Marital Status of Patients

The group that was most affected were children who accounted for 77.1% (n=27), followed by the married people accounting for 17.1% (n=6) while single people accounted for 5.75(n=2) as shown in figure 4.5

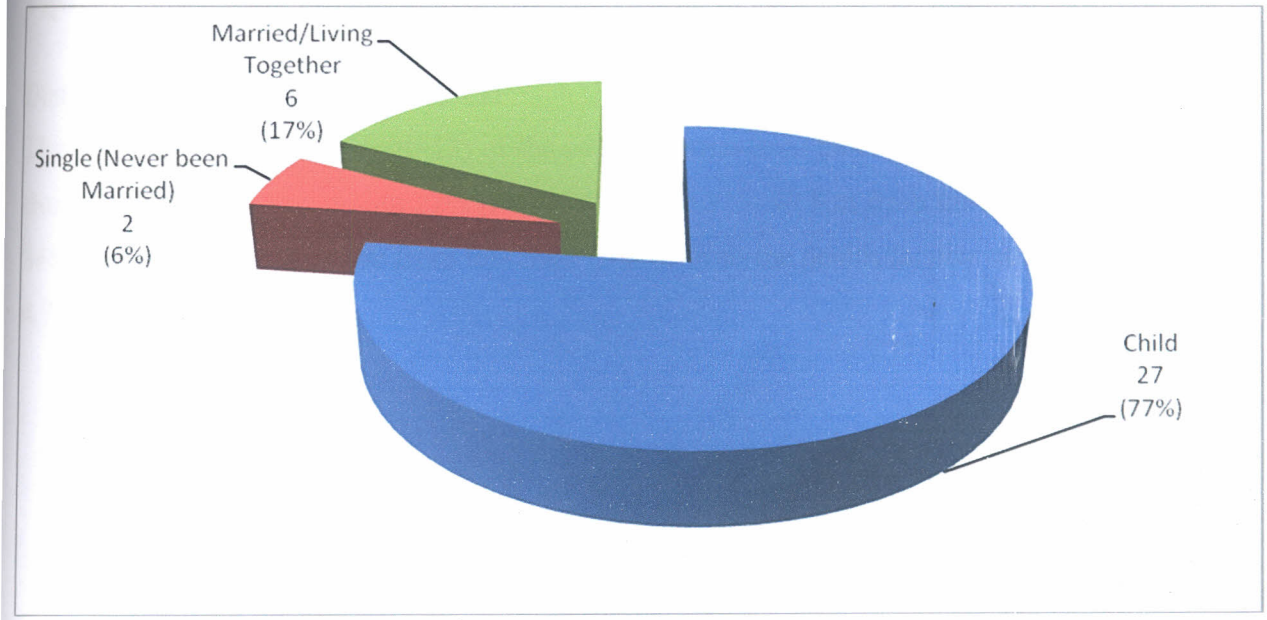

Figure 4.5: Marital Status distributions

The race distribution

African patients were more with a percentage representation of 94% (N=33). Asians were 6% (n=2) as shown in figure 4.6 below.

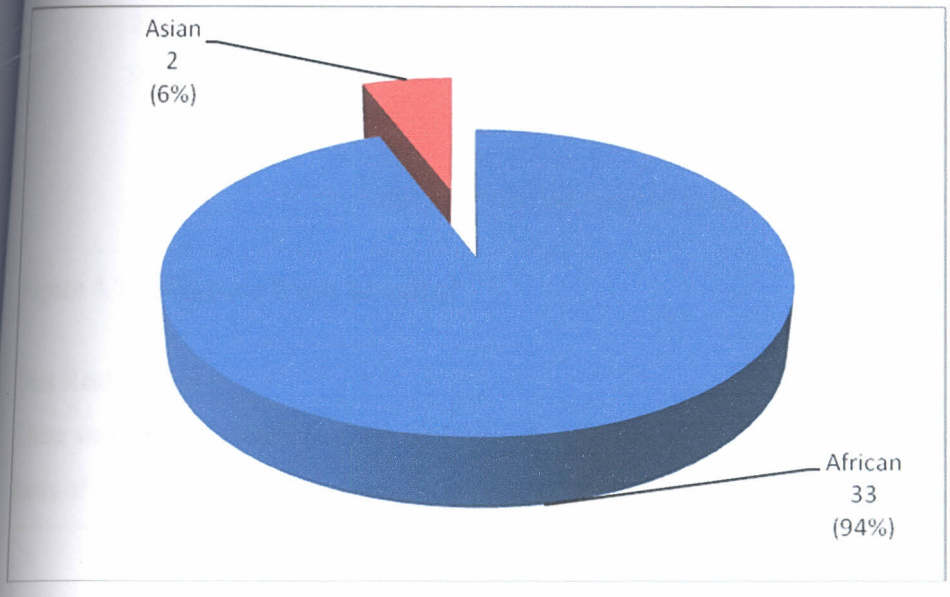

Figure 4.6: Showing patient distribution according to race

Distance from residence to Hospital

This study showed that 37% (n=13) of the patients came from more than 40 kilometres away from the health facility. About 27% (n=6) came from 11 – 40 Km from the health facility while 34% (n=12) of patients came from less than 10 KM from the health facility as shown in figure 4.7.

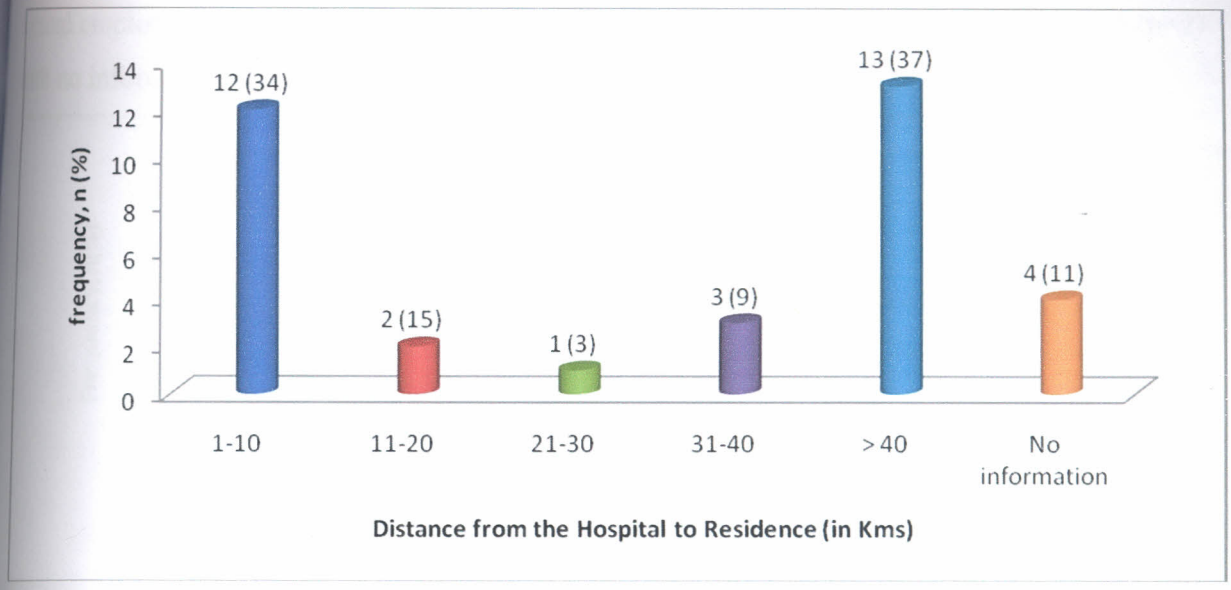

Figure 4.7: Distance from hospital

Diet Restriction

There was no diet restriction on patients on APD except for one patient who was restricted on the basis of other medical conditions (Hypertension and Diabetes) as shown in figure 4.8.

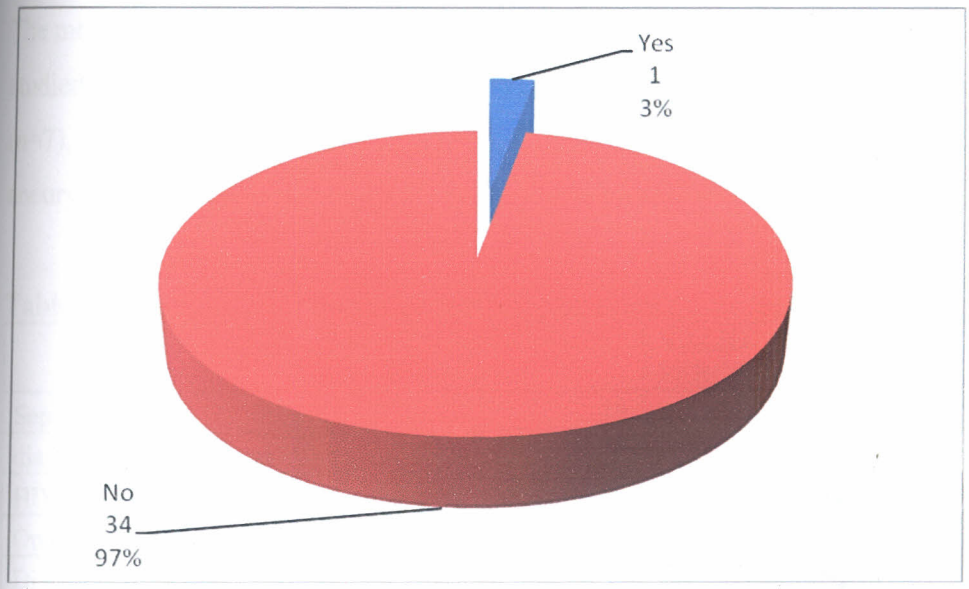

Figure 4.8: Diet restrictions

Occupation distribution This study showed that patients who were put on APD were children who represented 65% (n=23) thus not working. Only 11.4% (n=4) of the patients studied had

formal employment while 5.7% (n=2) were un-employed, 3%) (n=1) was in business, 6% (n=2) with no information provided and others were 9% (n=3) as per figure 4.9.

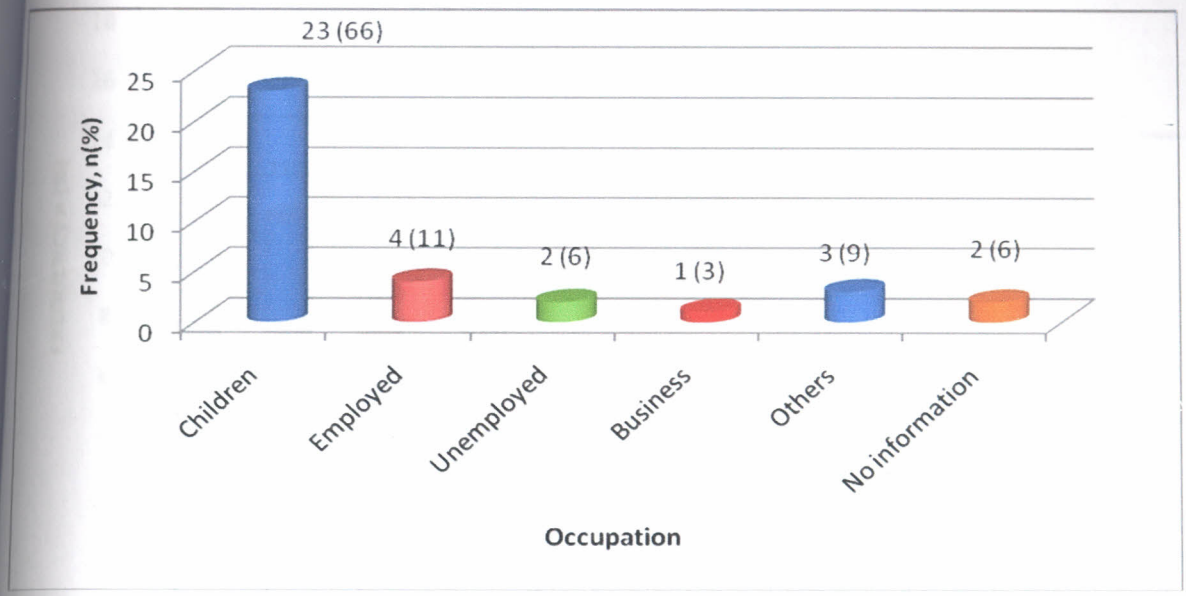

Figure 4.9: Distributions of patients according to occupation

The causes of renal failure that were found in the study

The most common cause of ARF was sepsis accounting for 39 %(n=18) of the population studied. Dehydration/ diarrhea 24% (n=11), HIV nephropathy followed accounting for 15% (n=7), open heart surgery at 13% (n=6), Diabetes mellitus, neurogenic bladder, thoracic aortic aneurysm and trauma at 2 % (n=1) each as shown in Table 4.1 and figure 4.10.

Table 4.1: Percentage and frequency of presenting Causes of acute Renal Failure

	FREQUENCY	VALID PERCENTAGE	
Sepsis	18	39%	
diarrhoea/Dehydration	11	24%	
HIV Nephropathy	7	15%	
Open heart surgery	6	13%	
Diabettes mellitus	1	2%	
Neirogenic bladder	1	2%	
Thoracic aortic aneurysm	1	2%	
Trauma	1	2%	
Total	46	100%	

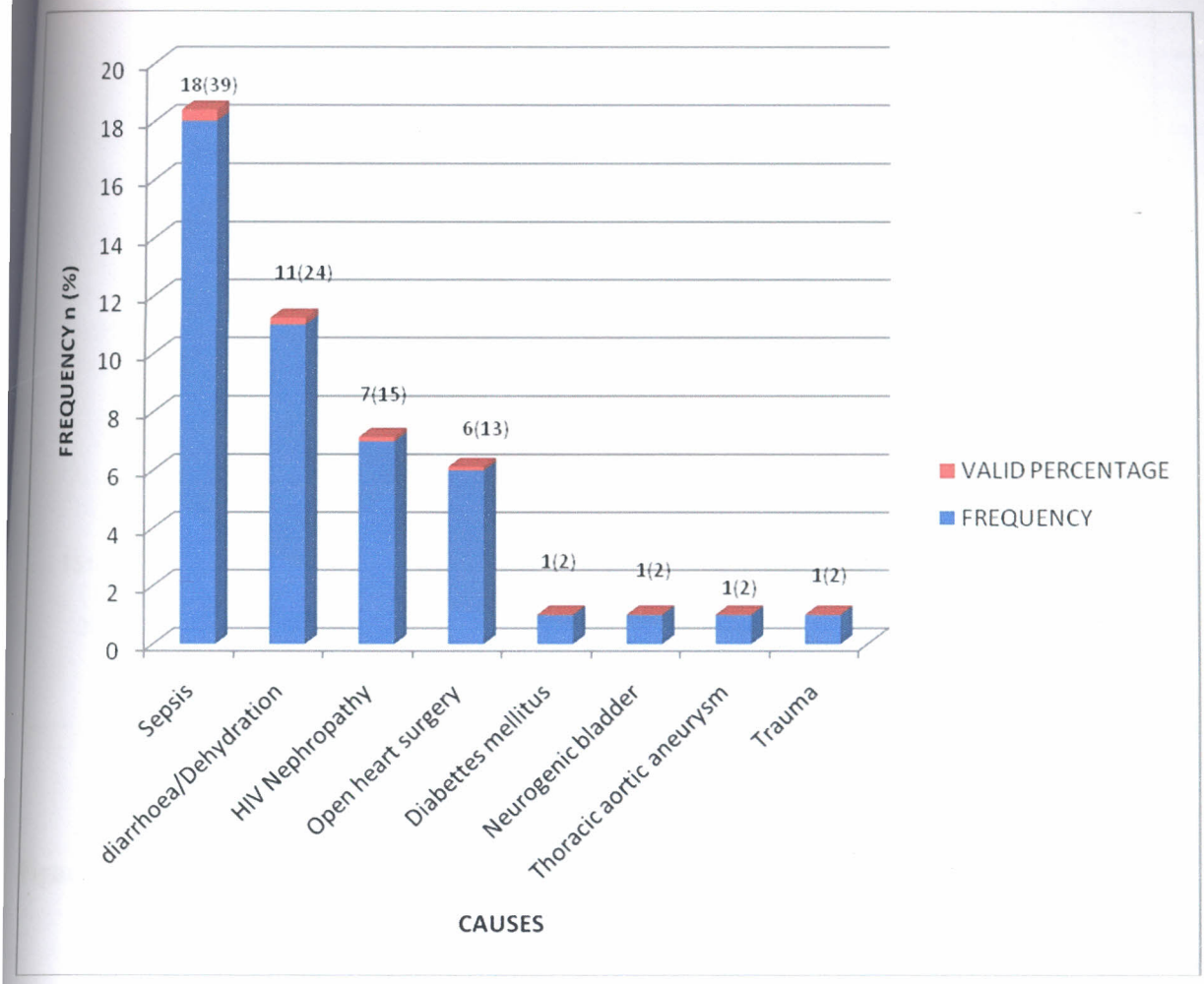

Figure 4.10: Percentage of presenting Causes of acute Renal Failure

The length of Hospital stay

The longest duration of Hospital stay was 8-14 days 37 %(n=13) which was followed by less than 7 days 20 %(n=7) and 15-21 20% (n=7), then 22-28 days at 6 %(n=2) as shown on the pie chart below.

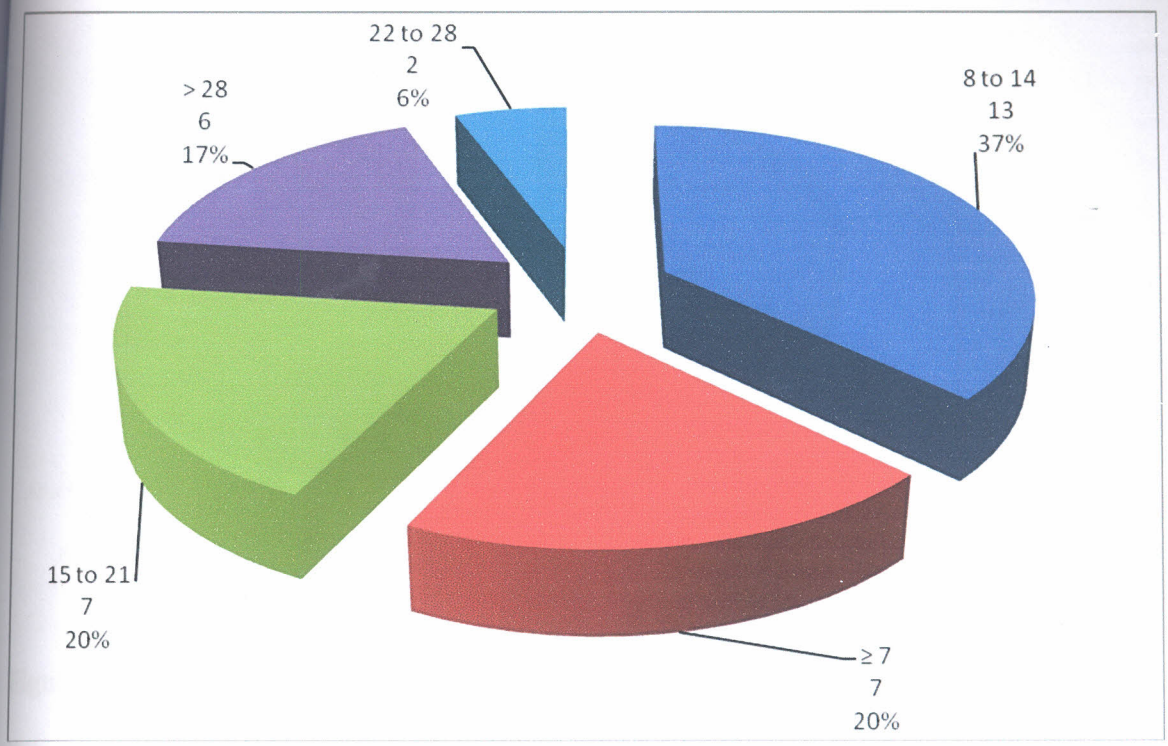

Figure 4.11: Length of hospital stay

Mortality

The mortality rate was 37% (n=13) while survival rate was 63% (n=22) where patients were treated and discharged successfully as shown in the pie chart below.

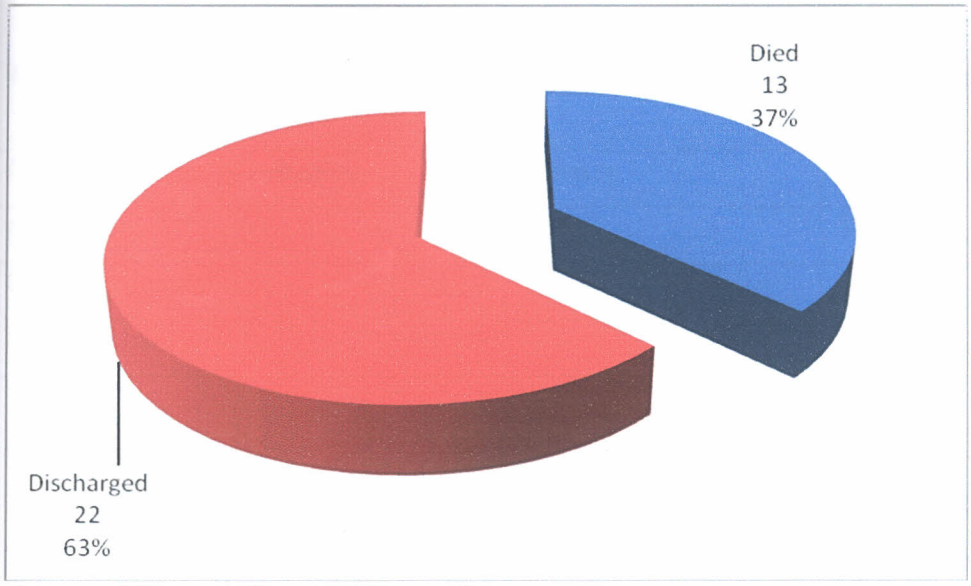

Figure 4.12: Outcomes

Treatment modalities

According to literature review there are several forms of renal replacement modalities (Daugirdas et al 2001). In the hospitals where this study was carried out, there were other forms of RRT modalities available. These were as follows:

1. Aga Khan Hospital: Haemodialysis, Kidney Transplant, and CAPD,
2. Gertrudes Children's Hospital: Only CAPD is carried out.
3. Mater Hospital: Haemodialysis, Kidney Transplant, CAPD and CRRT.
4. Nairobi West Hospital: Haemodialysis and CAPD
5. KNH: Haemodialysis, kidney transplant, CAPD

Choices of treatment moderlities given to Patients

Patients or gurdians were not given a chance to choose from any of these treatment modalities thus accounting to n=35 (100)% of those not given a chance to select the treatment modality.

Conversion from APD to other modalities of treatment

Among the patients studied, 3% (n=1) was changed from this mode of treatment modality to haemodialysis following peritonitis and 3% (n=) was changed in the process following altrafiltration failure as can be seen from table 4.2 below. However 94%(n=33) did not not have treatment changed.

Table 4.2: **Conversion from Automated Peritoneal Dialysis to other treatment modalities.**

Change reason/No change	Frequency	Valid Percent
peritonitis	1	3%
Utrafiltration failure	1	3%
Did not change	33	94%

Nephrology specialists

The researcher established that there were visiting consultants in all the five hospitals studied. They were distributed as follows; Aga Khan 5, Gertrude Children's Hospital 2, Mater Hospital 5, Nairobi West Hospital 2 and KNH 6.

The Renal Data

Paired t-test

Using paired t-test, the mean Serum Creatinine, BUN, Serum Potassium prior to APD was comparatively higher ($p<0.05$) than the mean on APD discontinuation, discharge or death. Table 4.3 below shows paired t-test SPSS outputs for the four variables: Serum Creatinine, Serum Potassium, BUN and Urine output respectively. The values of these variables are also presented in form of line graphs as shown in figure 4.13 to 4.16.

Table 4.3: Correlations & Paired T-Tests for Serum Creatinine, *Serum Potassium, BUN,* and 24 hour urine Output before and after APD discontinuation

	Time	Mean (se)	STD	95% CI	P-value
Serum Creatinine	Before	497.1 (58.0)	343	212.2 to 427.4	<0.001
	After	177.3 (29.8)	176		
Serum Potassium	Before	5.7 (0.3)	1.5	0.9 to 2.0	<0.001
	After	4.2 (0.1)	0.7		
Blood Urea Nitrogen	Before	31.7 (3.2)	18.9	14.3 to 28.4	<0.001
	After	10.3 (1.6)	9.2		
24 hour urine Output	Before	100.8 (28.3)	167.4	195.1 to 568.4	<0.001
	After	482.5 (97.9)	579.5		

- Using Paired T-test, the Mean for Serum Creatinine prior to APD/the time of diagnosis was **497.1** which was greater than the mean on APD discontinuation/time of death **(177.3).** The results are statistically significant with a p-value of 0.001 which is less than 0.05.
- Paired T-test indicates that Mean Serum Potassium output prior to APD is greater than the output at the time of death or on APD discontinuation. That is (**5.7>4.2**). The results are statistically significant (P=0.001<0.05)
- Mean BUN output prior to APD/time of diagnosis is greater than BUN output at the time of death /APD discontinuation (**31.7 > 10.3**). The P-value is also 0.001 which is less than 0.05. This shows that the results are statistically significant.
- From the T-test above the Mean 24 hour Urine output prior to dialysis is less than the urine output on discharge **(100.8 <482.5).** The P-value is also 0.001 which is less than 0.05. This implies that these results were statistically significant.

Variable 1: Serum creatinine

There was a considerable drop of serum creatinine after APD which is shown in figure 4.13

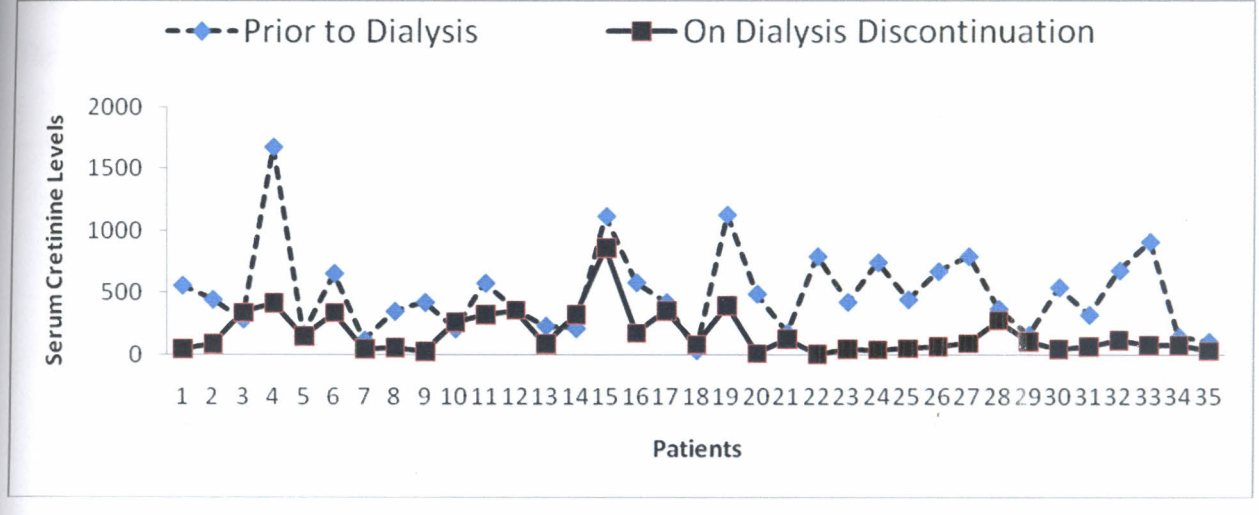

Figure 4.13: Associations between Serum Creatinine Prior to dialysis and on dialysis discontinuation

Variable 2: Serum potassium

The potassium at the time of APD discontinuation was much lower than before APD as shown in figure 4.14.

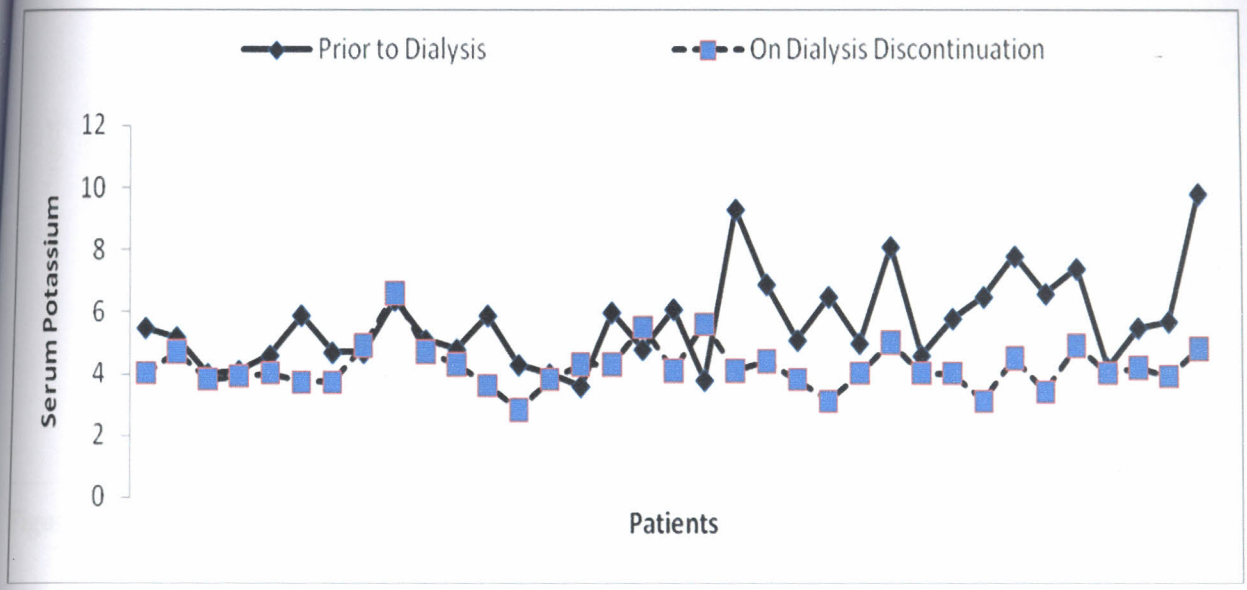

Figure 4.14: Association between Serum Potassium Prior to dialysis and on dialysis discontinuation

Variable 3: BUN

The BUN dropped after APD use as shown in figure 4.15

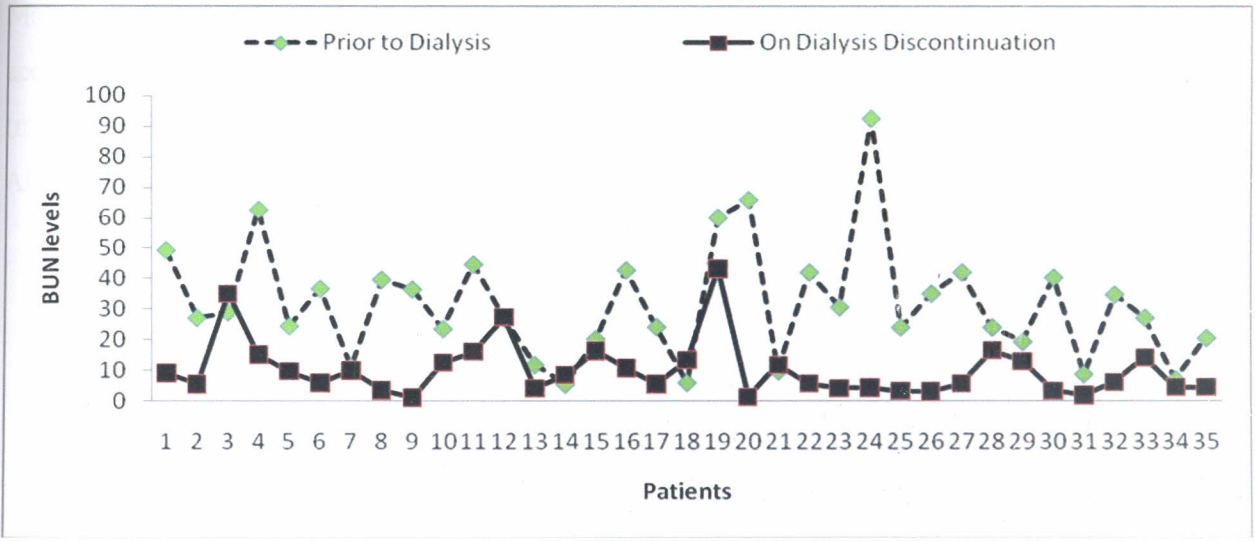

Figure 4.15: Association between BUN Prior to dialysis and on dialysis discontinuation

Variable 4: Urine output

The urine output was lower prior to dialysis than on dialysis discontinuation/discharge.

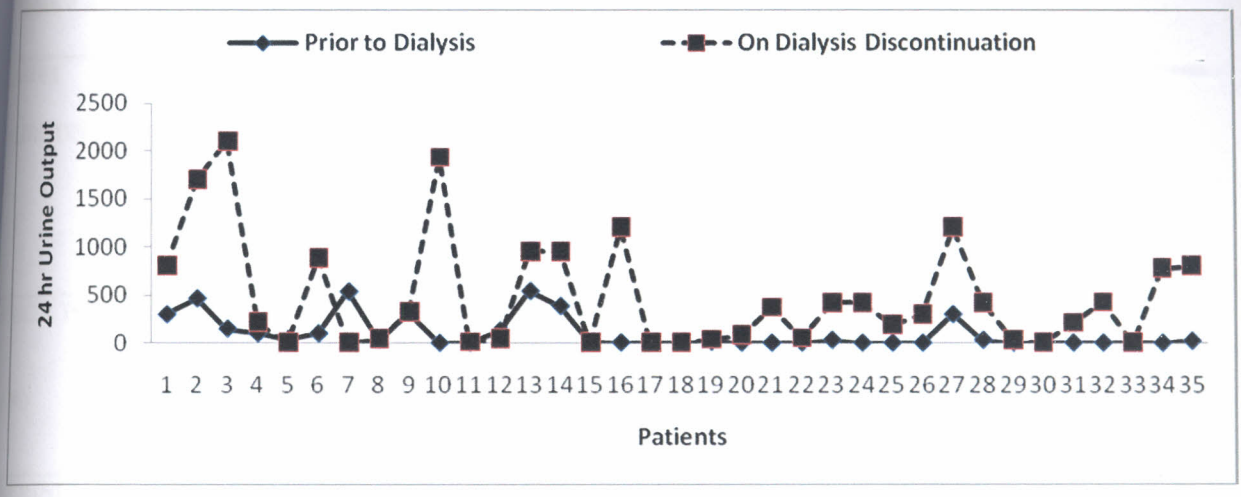

Figure 4.16: Association between Urine Output Prior and on dialysis discontinuation

Albumin supplementation:

Prior to APD 25.7% (n=9) had normal albumin values, 28.6% (n=10) had abnormal values, and 45.7% (n=16) were not tested. During APD 68.6% (n=24) had normal albumin values while 8.6% (n=3) had abnormal values, 40% (n=14) were not tested. After APD 14.3% (n=5) had normal albumin values, 25.7% (n=9) had abnormal values, (60%) (n=21) cases were not tested. Majority of the patients did not have albumin supplementation before, during and after APD accounting for 68.6% (n=24), 60% (n=21) and (77.1%) (n=27) respectively. 31.4% (n=11), 40% (n=14), 57.7% (n=8) had albumin supplementation before, during and after APD respectively. All these are illustrated in table 4.4 below.

Table 4.4: **Serum albumin before, during and after APD**

SERUM ALBUMIN	Frequency% of normal values	Frequency/ % of abnormal values	Frequency/ % of cases not done	Frequency/ % of cases that had albumin supplementation	Frequency% of cases that had no albumin supplementation	Total no. of patients
PRIOR TO APD	9(25.7%)	10(28.6%)	16(45.7%)	11(31.4%)	24(68.6%)	35
DURING APD	24(68.6%)	3(8.6%)	8(22.9%)	14(40%)	21(60%)	35
AFTER APD	5(14.3%)	9(25.7%)	21(60%)	8(57.7%)	27(77.1%)	35

CHAPTER FIVE

5.0 DISCUSSION OF RESULTS

5.1 Introduction

The study was carried out in five hospitals in Nairobi. The patient distribution in the hospitals was: Aga khan hospital 5 (14.3%), Gertrudes hospital 12 (34.3%), Mater hospital 16 (45.75%), Nairobi West hospital 1 (2.9%) and KNH 1 (2.9%). Mater hospital was the leading Hospital in the use of APD in the study. The study revealed that Mater hospital had all the other RRT modalities except haemodiafiltration and haemofiltration yet they still utilized the APD modality. Aga khan hospital had other modalities of RRT except CRRRT and haemodiafiltration as well as haemofiltration. Gertrudes hospital had no other form of RRT apart from APD. KNH offers all options of RRT except CRRT, haemofiltration and haemodiafiltration. The group studied included 27 males and 8 females accounting for 77.1% and 22.9 % of the sample population respectively. Males were more affected than the females. From the literature review, there were no indications as to whether there was any correlation between gender and ARF. This leads the researcher to recommend further research into this aspect.

5.2 Demographic Data and Key measures of outcome

The age distribution of the population studied was 0 to over 60 years. The commonest age group was 0-5 years (71.4%) followed by 46-60years (8.6%), 6-15 years (5.7%), 16-30 years (5.7%), over 60 years (5.7%) and lastly 31-45 years (2.9%). It appears that ARF occurs more frequently in the under fives. This was in consistent with the suggestions of other researchers such as Porth (2002) that ARF has become increasingly prevalent in both developed and developing countries, and was associated with severe morbidity and mortality, especially in children. More data have detailed the underlying causes of paediatric ARF in large cohorts of children. In a study of 226 children with ARF, Bunchman et al (2001) reported that ICU mortality was 3 times higher in ARF than in other patients. There was clear evidence that children in both developed and developing countries were commonly affected by ARF

The most frequent causes of ARF were: sepsis 39 %(n=18) followed by HIV nephropathy 15% (n=7), open heart surgery with dehydration at 13% (n=6) each, neurogenic bladder, thoracic aortic distension and trauma at 2 % (1) each. This shows that the commonest cause of ARF was sepsis. Other studies have shown that ARF is the leading cause of death, leading to a mortality rate of between 50% and 80% and the highest cause of ARF being sepsis (Isselbacher et al 1981). In another study, Foley, Parfrey, Harnett, et al (2000) found out that ARF causes were: congenital heart diseases, acute tubular necrosis sepsis, and bone marrow transplantation. Sepsis and bone marrow transplantation were the most common causes of ARF. According to Foley, Parfrey, Harnett, et al (2000), the most common causes of death are sepsis, cardiovascular and pulmonary dysfunction, and withdrawal of life support. This corresponds with this study. However, there was a positive outcome in that mortality was 37% while on the other hand 63% of the patients were discharged and went home following treatment with APD. Abraham et al (2000) revealed that in early studies, patients treated with PD had a lower mortality rate and a higher incidence of renal recovery than did similar patients treated with HD.

The group that was most affected were the unmarried who were children 77.1% (=27) followed by the married living together who were 17.1% (n=6) and single who had never been married were 5.75(n=2). This shows that most of these patients are not economically empowered and have to rely on their parents for support. Arogundade (2005) reported that financial problems were the most important hurdle to PD programs as most developing countries have no health insurance system. The majority of patients are financing their own treatment.

This study showed that 37% (n=13) of the patients came from more than 40 kilometres away from the health facility. About 27% (n=6) came from 11 – 40 Km from the health facility while 34% (n=12) of patients came from less than 10 Km from the health facility. These involved travelling far distances for treatment. According to Abraham et al (2009) PD offers advantages of simplicity, reduced training, lack of dependence on infrastructure and location. It is possible to reduce travelling for long distances by bringing PD services close to people as much as possible since PD can be done even at home. However ,the study revealed that nephrology nurses are limited .One hospital had less than 5 nephrology nurses, 2 had 5-10 nephrology nurses while the other 2 hospitals had more than 10 nephrology nurses in their units. This leads the researcher to

recommend more training of nephrology nurses to allow more expertise care close to the community.

There was no diet restriction on patients on APD except on one patient who was restricted on the basis of other medical conditions (Hypertension and Diabetes). One of the advantages of PD is that that there are no dietary restrictions. According to Munib (2006), PD has several advantages such as: It is carried by the patient in their own home set up, dialysis can be scheduled according to the patient's life style and there are no dietary restrictions. African patients were more with a percentage representation of 94.3% (n=33). Asians were 5.7% (n=2). This shows that Africans were more affected but it is probably because they are the majority in Kenya.

This study showed that patients who were put on APD were children who represented 65% (n=23) thus not working. Only 11.4% (n=4) of the patients studied had formal employment while 5.7% (n=2) were un-employed, 3%) (n=1) was in business, 6% (n=2) with no information provided and others were 9% (n=3). Children have to rely on their parents for provision of finances for health care and in that matter RRT. Most of the patients in the study had no formal employment. Children diagnosed with ARF depend on their parents for complex, continuous and intensive support. According to Rotter (2001), financial problems are the most important hurdle to PD programs as most developing countries have no health insurance system. The majority of patients are financing their own treatment.

The longest duration of Hospital stay 8-14 days which was 37% (n=13), followed by less than 7 days 20 %(n=7) and 15-21 with 20 %(n=7), then 22-28 days at 6 %(n=2). The average hospital stay was 14 days. However, within this duration, 63% (n=22) were treated successfully and were discharged home while 37% (n=13) died.

According to literature review there are several forms of treatement modalities (Daugirdas et al 2001). In the the hospitals where this study was carried out, there were other forms of RRT modalities available such as haemodialysis which was present in 4 of the hospitals, Kidney transplant was done in 3 hospitals, CAPD was done in all of the hospitals, CRRT was done in only in mater hospital at the time of the study.Patients or gurdians in this study were not given a

chance to choose from any of these treatment modalities as shown probably because it was the only option in the hospital or it was the only suitable mode of treatment modality.All the patients studied were put on APD, however 3% (n=1) and 3% (n=1) of the patients were changed from this mode of treatment modality to HD in the process following failure of ultrafiltration and peritonitis respectively. These are known to be some of the complications of PD but as we can see from this study, the complications were quite negligeble accounting to only 3% each following the use of APD.

The researcher established that there were visiting consultants in all the five hospitals studied. These were distributed as follows; Aga Khan 5, Gertrude Children's Hospital 2, Mater 5, Nairobi West Hospital 2 and KNH 6. Most of these nephrologists were the same consultants rotating in different hospitals. There is clear evidence that nephrologists are quite scarce. This is in consistence with Arogundade (2005) who reported that in 22 countries in Africa, there are No nephrologists available, no nephrology and no Dialysis.

5.3 Blood biochemistry

Using Paired T-test, the Mean for Serum Creatinine prior to dialysis/the time of diagnosis was **497.1** which was greater than the mean on dialysis discontinuation/time of death (**177.3).** The results were statistically significant with a p-value of 0.001 which was less than 0.05. Paired T-test indicated that Mean Serum Potassium prior to dialysis was greater than the potassium at the time of death or on dialysis discontinuation. That is (**5.7>4.2**). The results were statistically significant (P=0.001<0.05).

Prior to dialysis, the patients studied showed that they had high serum potassium an indication that the patients were referred late to the nephrologists. The normal potassium values (reference ranges) as per the practice of the five mentioned hospitals where the research was done was 3.5 - 4.9 mmols. Most of the patients were referred when the potassium was above 7 mmol. Mean BUN prior to dialysis/time of diagnosis was greater than BUN at the time of death /dialysis discontinuation (**31.7 > 10.3**). The P-value was also 0.001 which is less than 0.05. This implies that these results were statistically significant. Kapoor (2007) reported that APD enables continuous correction of acid-base status and electrolyte imbalance as well as the gradual

removal of nitrogenous waste products. The slow removal of uremic toxins is not associated with the development of the disequilibrium syndrome.

5.4 Urine output Analysis

The urine output was lower prior to dialysis than on dialysis discontinuation/discharge. The mean 24 hour urine output prior to dialysis was 100.8 and after dialysis discontinuation was 482.5 which is quite significant. Dwinell & Anderson (1999) reported that there is an improvement in the urine output after dialysis. The normal urine output is 1500 mls-2000mls in an adult. In paediatrics, the normal urine output is 1ml/kg/hour and above. In this study, there was a clear indication of improved urine output following the use of APD.

Kapoor (2007) stated that, because of the gradual removal of fluid and solutes, PD results in better hemodynamic stability. Manually or cycler-assisted ("automated") PD has been successfully used in many ARF patients, especially those at risk of bleeding or with hemodynamic instability, and in infants and children with ARF or circulatory failure. The patient thus achieves:

- Better volume control
- Reduction in blood pressure
- Decreased prevalence of left ventricular heart failure
- Normalized potassium blood levels
- Reduction in arrhythmias

Dwinell & Anderson (1999) reported that RRT is an artificial replacement for lost kidney function. Dialysis outcome is shown by a reduction in BUN, serum potassium, serum creatinine and an improvement in urine output. In this study there was a significant reduction in serum creatinine, serum potassium and BUN. There was an improvement in urine output following APD use.

5.5 Serum Albumin Analysis

Anochie and eke (2006) reported that the frequent exchanges used in acute PD may produce hypoalbuminemia. Protein losses via the dialysate can be as high as 10 – 20 g in 24 hours and up

to twice that amount during episodes of peritonitis. To compensate for dialysate protein losses, oral or intravenous protein supplementation may be required. Hypoalbuminemia, is highly prevalent in kidney failure and is associated with an increased mortality risk in this population. According to Daugirdas et al (2001), PD is associated with significant loss of protein across the peritoneum and the major component of protein loss is albumin thus necessary dietary supplementation is recommended. Hypoalbuminemia was noted as a confounding variable in several patients who received albumin supplementation.

5.6 CONCLUSION

In conclusion this research presents an overview in which the concept of APD as an effective RRT has been used in several hospitals successfully and can be adopted all over the country for the management of ARF and even end stage renal disease. The results showed that in all variables, patients who had abnormal values significantly improved at the point of APD discontinuation. There was no enough evidence to reject the nul-hypothesis since in all variables; the P- value was less than 0.05. There is clear evidence that APD is an effective mode of RRT in the management of ARF and can be used in all set ups since it does not require a water treatment plant.

ARF is a serious disease with a high mortality in children. The commonest cause of ARF was found to be acute tubular necrosis secondary to sepsis. Factors determining outcome of ARF included the time of referral to the nephrologists. For instance some of the patients had very high potassium levels meaning that they were probably referred when it was too late.

There was data to suggest that APD is underused in Kenya. This is based on the medical outcome data outlined above. PD has been a successful mode of RRT with positive response from patients. However, there has been a progressive decline in patient recruitment for this self-care modality. There are some subtle and some real nonmedical reasons for PD underutilization, some of which are financially based

5.7 RECOMMENDATIONS

Debating which therapy is better but rather accepting the fact that patients' treatment should be individualized would be very vital. If the patient is interested in doing home therapy, it is probably reasonable that they should be allowed to try. The renal replacement community have the responsibility to guide patients and adjust the patient's therapy as indicated. Anticipated changes in reimbursement such as bundling of payments for ESRD therapies should stimulate a trend toward increased PD use. However, if the increased utilization is not associated with increased support and further education of the renal replacement community in the practice of PD, the patients may not do as well as they could. Therefore, we should consider consolidation of small PD units into larger specialized PD centres. This will allow for a more robust infrastructure in our PD units, which is important for training, retraining, problem solving, and ease of use for patients and doctors, development and implementation of peritonitis treatment protocols, as well as allowance for more time for education.

The treatment can be brought closer to the patient so that they do not have to travel for long distances. However, if sufficient encouragement were given by the health authorities, this would probably help patients to have access to adequate information, prescription and freedom of choice.

Researchers should get more involved in PD as well as academia so as to be able to keep up efforts to educate nephrologists with the ultimate goal that PD education happens at each academic medical centre, not only on a national level. The government may need to reconsider what is needed for approval of alternative PD fluids in order to make the program as affordable as possible. There is need to work with tax payers and other government bodies so that reimbursement issues do not unintentionally prevent freedom of modality choice by patients and physicians. This research finding would be very vital for advocating for APD use especially in district Hospitals and even in the home set ups. More training of nephrology nurses to allow more expertise care closer to the community should be encouraged. Dialysis is a very expensive venture. Subsidized treatment would go a long way in ensuring that the treatment is being adhered to.

5.7.1 Areas of future research

1. Establish why mortality in the under fives is high in ARF in Kenya
2. Determine the cause of low use of PD in Kenya despite the advantages
3. Determine awareness of APD among patients on dialysis
4. Determine the attitudes, knowledge and practice among nephrology nurses and nephrologists towards PD
5. Determine why ARF is more common in males than females in Kenya
6. Determine the reasons why many nephrologists do not monitor serum albumin before, during and after dialysis including supplementation.

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APPENDICES

APPENDIX I: DATA COLLECTION TOOL

FACILITY IDENTIFICATION		
Questionnaire Number:		
Facility code	01=AGA KHAN HOSPITAL 02=GERTRUDES CHILDRENS' HOSPITAL 03=MATER HOSPITAL 04=NAIROBI WEST HOSPITAL 05=KNH	[__|__]

SECTION ONE: SOCIAL DEMOGRAPHIC DATA

NO.	QUESTION	RESPONSE OPTIONS			CODES	SKIP
Q1	Date of birth	Day	month	year		
Q2	Age	0-5 years			1	
		6-15 years			2	
		16-30 years			3	
		31-45 years			4	
		46-60 years			5	
		Over 60 years			6	
Q3	Gender	Male			1	
		Female			2	
Q 4	Race	African			1	
		Asian			2	
		Whites			3	
Q5	Distance from hospitals	<1km			1	
		1-10 km			2	
		11-20km			3	
		21-30km			4	
		31-40km			5	
		>40km			6	
Q6	Place of Residence					

Q7	Religion	Catholic	1	
		Protestant	2	
		Muslim	3	
		No religion	4	
		Other (specify)	5	
Q8	Marital Status	Married/living together	1	
		Divorced/separated/	2	
		Widowed	3	
		Single(never been married	4	
		Child	5	
Q9	Diet restrictions	Yes	1	
		No	2	
Q10	If yes, what are the reasons?	Diabetes mellitus	1	SKIP TO Q. 11
		Hypertension	2	
		Form of Dialysis	3	
		Others(Specify)	4	
Q11	Occupation	Unemployed	1	
		Not applicable (Child)	2	
		Farming (Large scale)	3	
		Farming(small scale)	4	
		Business (small enterprise)	5	
		Business(large enterprise)	6	
		Employed at senior management level)	7	
		Employed at middle level	8	
		Others (Specify)	9	
Q12	Number of nephrologists in the hospital	0	1	
		1	2	
		2	3	
		3	4	
		4	5	
		5	6	
		6	7	

Q13	Number of nephrology nurses in the hospital	<5	1	
		5-10	2	
		>10	3	

SECTION TWO MEDICAL HISTORY

Q14	Date of admission	
Q15	Date of discharge	
Q16	Date of death	

SECTION THREE: RENAL DATA

Q17	Cause of the acute renal failure	Diarrhoea	1	
		Drugs	2	
		Malaria	3	
		glomerulonephritis	4	
		Sepsis	5	
		HIV nephropathy	6	
		Diabettes mellitus	7	
		Others (specify)	8	

Q18	Length of Hospital stay	<7 days	1	
		8-14 days	2	
		15-21days	3	
		22-28 days	4	
		>28 days	5	
Q19	Serum albumin	Before dialysis	1	
		During dialysis	2	
		After dialysis	3	
Q20	Was the patient given any form of albumin during the Hospital stay?	Yes	1	
		No	2	
Q21	Serum creatinine	Prior to dialysis /the time of diagnosis	1	
		On dialysis discontinuation /time of death	2	

Q22	Blood urea nitrogen(BUN)	Prior to dialysis /the time of diagnosis		1	
		At the time of death/ dialysis discontinuation		2	
Q23	Serum potassium	Prior to dialysis /the time of diagnosis		1	
		At the time of death/ On dialysis discontinuation		2	
Q24	24 hour urine output	Prior to dialysis /the time of diagnosis		1	
		On dialysis discontinuation or time of death		2	

Q25	Was the patient\guardian given a chance to choose the treatment modality?	Yes	1	
		No	2	
		N/A	3	
Q26	Did the patient change to another treatment modality?	Yes	1	Skip to Q27
		No	2	
Q27	If so, Which modality?	Haemodialysis	1	
		Kidney transplant	2	
		Haemodiafiltration	3	
Q28	Did the patient change to another form of peritoneal dialysis?	Yes	1	
		No	2	

Q29	If so give reasons for the change	Peritonitis	1	Skip to Q29
		Leakage	2	
		Utrafiltration failure	3	
		Financial constraints	4	
		Lack of facilities	5	

		Others(specify)	6	
30	Are there other renal replacement therapy modalities in the hospital?	Yes	1	
		No	2	
31	If so, which ones?	Haemodialysis	1	SKIP TO END
		Haemodiafiltration	2	
		Kidney transplant	3	
		CAPD	4	
		Continuous renal replacement therapy	5	

OMMENTS

APPENDIX II: LETTER OF APPROVAL FROM KNH ETHICAL AND RESEARCH COMMITTEE

Grace W. Ngaruiya,
P.O. Box 157,
Ruai.
Nairobi

The Chairman,
KNH Ethical and Research Committee,
P.O Box 20723-00202
Nairobi- Kenya.

Dear Sir/ Madam,

Ref: Authority to carry out research at KNH renal unit, Aga khan Hospital Nairobi, Gertrudes children's hospital, Mater Hospital and Nairobi west Hospital

I am writing to request your permission to carry out research on, the effectiveness of automated peritoneal dialysis in the management of acute renal failure in Kenya. The study results will be used for patients who will require dialysis in future and can also help improve the management of renal failure.

Your kind consideration will be highly appreciated.

Yours faithfully,

Grace Wanjiku Ngaruiya,
MScN student,
School of Nursing Sciences,
University of Nairobi

APPENDIX III: LETTER OF ACCEPTANCE FROM THE ETHICAL COMMITTEE KNH

KENYATTA NATIONAL HOSPITAL
Hospital Rd. along, Ngong Rd.
P.O. Box 20723, Nairobi.
Tel: 726300-9
Fax: 725272
Telegrams: MEDSUP", Nairobi.
Email: KNHplan@Ken.Healthnet.org

Ref: KNH-ERC/ A/451

15th April 2010

Grace Wanjiku Ngaruiya
School of Nursing Sciences
College of Health Sciences
University of Nairobi

Dear Grace

RESEARCH PROPOSAL: "A RETROSPECTIVE COHORT STUDY ON THE EFFECTIVENESS OF AUTOMATED PERITONEAL DIALYSIS IN THE MANAGEMENT OF ACUTE RENAL FAILURE IN KENYA" (P55/3/2010)

This is to inform you that the KNH/UON-Ethics & Research Committee has reviewed and **approved** your above revised research proposal for the period 15th April 2010 to 14th April 2011.

You will be required to request for a renewal of the approval if you intend to continue with the study beyond the deadline given. Clearance for export of biological specimens must also be obtained from KNH/UON-Ethics & Research Committee for each batch.

On behalf of the Committee, I wish you a fruitful research and look forward to receiving a summary of the research findings upon completion of the study.

This information will form part of the data base that will be consulted in future when processing related research study so as to minimize chances of study duplication.

Yours sincerely

PROF A N GUANTAI
SECRETARY, KNH/UON-ERC

c.c. Prof. K. M. Bhatt, Chairperson, KNH/UON-ERC
The Deputy Director CS, KNH
The Director, School of Nursing Sciences, UON
The HOD, Records, KNH
Supervisors: Theresa M. A. Odero, School of Nursing, UON
Mr. Antony Ayieko, School of Nursing Sciences, UON
Prof. Mohammed Abdullah, Consultant Nephrologist

APPENDIX IV: LETTER OF APPROVAL FROM THE KNH CHIEF EXECUTIVE OFFICER

GRACE WANJIKU NGARUIYA,
P.O BOX 157-00520,
RUAI.
NAIROBI.
TELEPHONE -0725982497.
20TH, APRIL, 2010.

THE C.E.O
THE KENYATTA NATIONAL HOSPITAL.
NAIROBI.

22/4/2010
Study Approved to be carried out

ATTENTION.
THE DEPUTY DIRECTOR.

Dear Sir/ Madam,

Ref: Authority to carry out a retrospective cohort study on the effectiveness of automated peritoneal dialysis in the management of acute renal failure at the Kenyatta National hospital –Renal Unit

I take this precious opportunity to introduce myself as a masters' student taking critical care nursing at the Nairobi University. I am writing to request your permission to carry out research on, the effectiveness of automated peritoneal dialysis in the management of acute renal failure in your Hospital. The aim of this study is to analyze the patients' data base of the automated dialysis program adopted in five Hospitals where automated peritoneal dialysis is carried out in Nairobi Kenya. This is in order to determine its effectiveness in the management, compliance and outcome of the acute renal patients' management.

The study results will be purely academic and can be used for patients who will require dialysis in future. Confidentiality will be maintained and the names of the patients will not be revealed.

Your kind consideration will be highly appreciated.

Yours faithfully,

Grace Wanjiku Ngaruiya,
MScN student,
School of Nursing Sciences,
University of Nairobi

APPENDIX V: LETTER OF AUTHORITY TO CONDUCT RESEARCH FROM GETRUDE'S CHILDREN'S HOSPITAL

Gertrude's
CHILDREN'S HOSPITAL
Quality Healthcare for Children

May 11, 2010

Ms Grace Wanjiku Ngaruiya
P O Box 157 – 00520
RUAI
NAIROBI

Dear Ms Ngaruiya

RE: Authority to carry out a retrospective cohort study in effectiveness of automated peritoneal dialysis in the management of acute renal failure at Gertrude's Children's Hospital – Critical Care Unit

We refer to your letter dated 20th April 2010 and confirm that your research has been approved by the Standards and Ethics Committee of Gertrude's Children's Hospital.

We will appreciate receiving a copy of your final report on the study.

Yours sincerely

Gordon O Odundo
Chief Executive Officer/Administrator

CC: Dr Thomas Ngwiri – Head Clinician

P.O. Box 42325-00100, Nairobi, Kenya | Tel: (+254 20) 3763474/5/6/7 | Fax: (+254 20) 3763281
E-mail: info@gerties.org | www.gerties.org

APPENDIX VI: LETTER OF AUTHORITY TO CONDUCT RESEARCH FROM THE MATER HOSPITAL

The Mater Hospital
we care more

P.O. Box 30325 - 00100
Dunga Road, Nairobi, Kenya
Telephone: (254) (020) 531199, 556010, 558179, 554780, 557552
Mobile Lines: 0722 - 828629, 0733 - 641870
Fax: (254) (020) 534289
Emergency Hotline: 351269
E-mail: inform@materkenya.com
Website: www.materkenya.com

11th May 2010

Grace Ngaruiya
P. O. Box 157 – 00520
Ruai
NAIROBI.
Tel – 0725982497

Dear Mrs. Ngaruiya,

RE: PERMISSION TO CONDUCT A RESEARCH STUDY AT THE MATER HOSPITAL

We acknowledge receipt of your request for permission to conduct a research study at The Mater Hospital on 'The effectiveness of automated peritoneal dialysis in the management of acute renal failure in Kenya.'

The Standards & Ethics Sub-Committee of The Mater Hospital, has reviewed your request as entitled above, and found it acceptable.

You are hereby allowed to proceed with your research but must submit a copy of your findings for inclusion in our inventory.

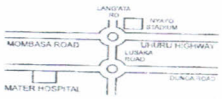
I wish you well.

Thank you,

Yours faithfully,
FOR: THE MATER HOSPITAL

Dr D. K. Karanja,
CHAIR, STANDARDS AND ETHICS SUB COMMITTEE

CC	*Dr. Owen W.O*	*MAC Chairman*
	Dr. John Muriithi	*Chief Executive Officer*
	Dr. Marian Dolan	*Medical Director*
	Mrs. Ruth N. Were	*Director Nursing Services*



APPENDIX VII: LETTER OF AUTHORITY TO CONDUCT RESEARCH FROM THE AGA KHAN HOSPITAL

THE AGA KHAN UNIVERSITY

11th May 2010

Grace Wanjiku Ngaruiya
School of Nursing Sciences
University of Nairobi
P.O. Box 20804-00202
Nairobi, Kenya

Dear Grace,

Re: A Retrospective Cohort Study on the Effectiveness of Automated Peritoneal Dialysis in the Management of Acute Renal Failure in Kenya

It is my pleasure to inform you that your submitted research proposal has been approved by the Aga Khan University Research Ethics Committee.

Please note that as the Principal Investigator, you have the full administrative, scientific and ethical responsibility for the management of the research project in accordance with the University policies and guidelines.

You will be required to present the final report of your study to the Aga Khan University Research Office.

Best wishes,

AGA KHAN UNIVERSITY
ACADEMIC NURSING STUDIES PROGRAMME
TEL 3747483 3745808 FAX 3747004

Mr. John Arudo
Chair, AKU (EA) - Research Ethics Committee

3rd Parkland Avenue, Off Limuru Road P.O. Box 39340, Parklands - 00623, Nairobi, Kenya.
Telephone: 254 20 3747483, 3745808 Fax: 254 20 3747004 E-mail: aku-ea@aku.ac.ke
Website: www.aku.edu

APPENDIX VIII: LETTER OF AUTHORITY TO CONDUCT RESEARCH FROM THE NAIROBI HOSPITAL

KENYA HOSPITAL ASSOCIATION • LUX IN TENEBRIS •

THE NAIROBI HOSPITAL

Our Ref: TNH/ADMIN/CEO/13/05/10

13 May 2010

Ms. Grace Wanjiku Ngaruiya
School of Nursing Sciences
College of Health Sciences
University of Nairobi
P. O. Box 20723
NAIROBI

Dear Ms. Ngaruiya,

RE: RESEARCH PROPOSAL : "A RETROSPECTIVE COHORT STUDY ON THE EFFECTIVENESS OF AUTOMATED PERITONEAL DIALYSIS IN THE MANAGEMENT OF ACUTE RENAL FAILURE AT THE NAIROBI HOSPITAL – CRITICAL CARE UNIT

Reference is made to your letter dated 20 April 2010 on the above subject matter.

This is to inform you that approval of the study has now been granted. You are further advised to maintain confidentiality at all time and ensure that any printed images **do not** bear names or identity of a patient. Kindly liaise with our Ms. Christina Were, Our Human Resources Manager on logistics.

We also request you to forward your findings to our Education & Research committee for record purposes.

Yours sincerely,
FOR: THE NAIROBI HOSPITAL

Dr. Cleopa Mailu, EBS
CHIEF EXECUTIVE OFFICER

cc:
- A & E Coordinator, The Nairobi Hospital
- Human Resources Manager, The Nairobi Hospital
- Chairman, Education & Research Committee, The Nairobi Hospital

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E-mail: hosp@nbihosp.org • website: www.nairobihospital.org

APPENDIX IX: CONSENT FORM BY THE RESEARCHER TO MAINTAIN CONFIDENTIALITY OF THE PATIENTS IN NAIROBI HOSPITAL

THE NAIROBI HOSPITAL

Ref: HRD/research/ cmw.dwk

14th May 2010

Ms. Grace Wanjiku Ngaruiya
School of Nursing Sciences
College of Health Sciences
University of Nairobi
P.O. Box 20723
NAIROBI

Dear Ms. Ngaruiya,

Re: Research - "A retrospective cohort study on the effectiveness of automated peritoneal dialysis in the management of acute renal failure at the Nairobi Hospital- Critical Care Unit."

Reference is made to our letter dated 13th May 2010 informing you that approval to carry out research has been granted. Please sign the acceptance certificate below signifying acceptance of the following terms and conditions of our Research Projects Policy:

- Information/data collected and potential findings shall not to be in conflict with the Hospital's confidentiality clause which states that: "You will not without the consent of the Association, disclose any of its secrets or other confidential matters to anyone who is not authorised to receive them".
- Information/data collected and potential findings shall not to be in conflict with any interests of the Hospital.
- A bound copy of the final research findings report shall be submitted to the Hospital.

Yours sincerely,
For: The Nairobi Hospital

Christina M. Were
For: Chief Executive Officer

CC. Chief Executive Officer

ACCEPTANCE CERTIFICATE.

I have read and understood the above terms and conditions.

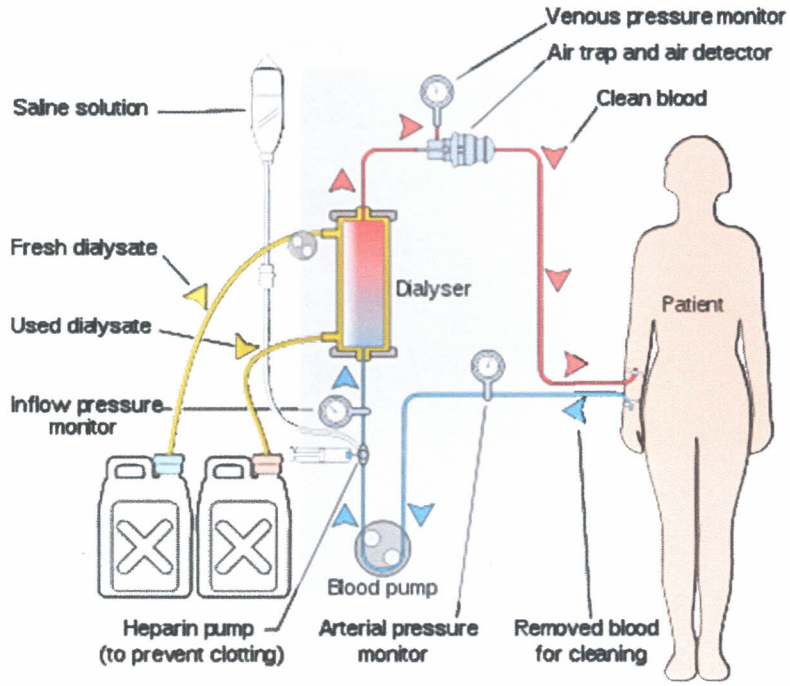
Name: GRACE WANJIKU NGARUIYA

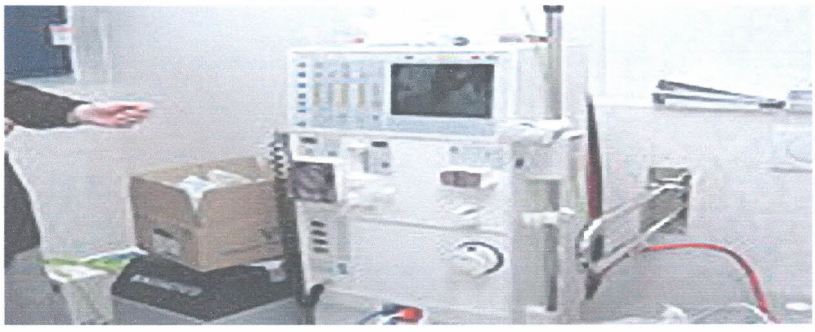
Signature: .....

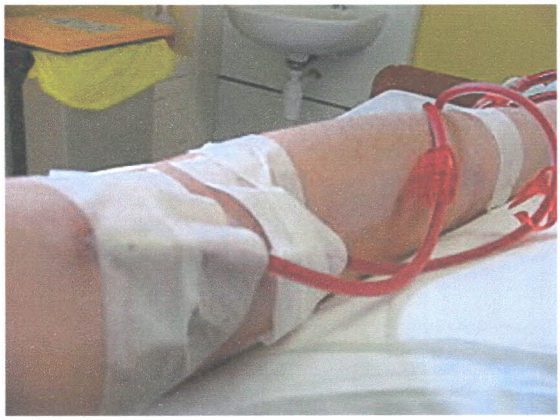
Date: 18TH MAY 2010

APPENDIX X: PICTURES SHOWING DIALYSIS OPTIONS

HAEMODIALYSIS

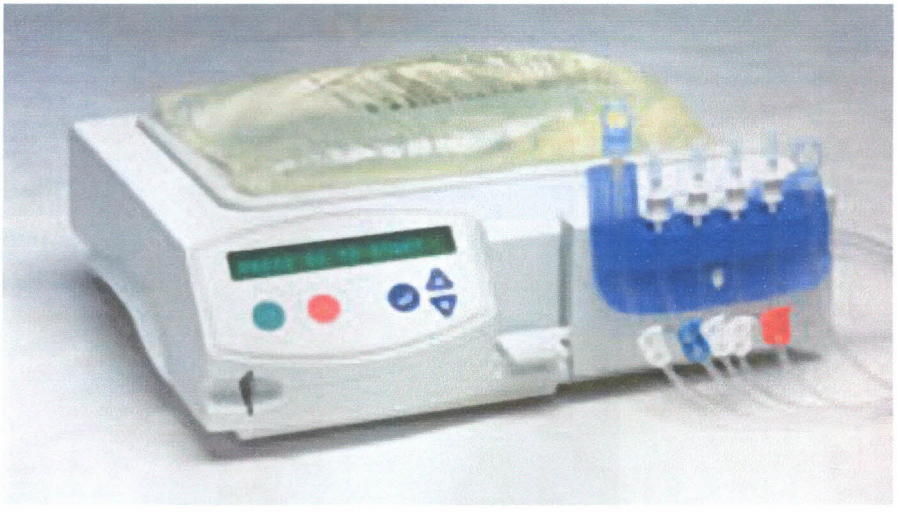






AV FISTULA

BAXTER APD MACHINE



CAPD WITH Y-SET

FRESENIUS APD MACHINE