

# Design of Mobile Hemodialysis Apparatus for Acute Renal Failure Patient's Self-Help and Treatment Adherence

Sakthivel Sankaran<sup>1\*</sup>, M Pallikonda Rajasekaran<sup>2</sup>, Vishnuvarthanan Govindaraj<sup>3</sup>, Preethika Immaculate Britto<sup>4</sup>, MohamedMydeen Mohamed mansoor<sup>5</sup>, Abinaya srinivasan<sup>6</sup>, Javithrasha Askar<sup>7</sup>

**Abstract:** The major intend of the nephrologists is to reduce the hardships faced by the patients affected with renal ailments. Kidney failure or renal failure is a condition where the function of kidney gets disabled/affected at large. This condition may neither be temporary or lifelong but in order to sustain in life, dialysis was adopted. The dialysis is a technical replacement of function of kidney and its process has two sectors; peritoneal dialysis and hemodialysis. In considering the long term blood filtering process, the hemodialysis will be an efficient device in replacing the renal functioning, but it was currently performed in the stable mode. In undergoing the deep survey, our team has analyzed that the major problem in the dialysis is the duration, cost, difficulties faced by the patients. In order to overcome these barriers, the prototype of the portable technology has been built for highly supporting the patients. In order to fulfill the life supporting requirement, the "Miniaturized portable hemodialysis" device has been introduced which will be portable than the conventional ones.

**Keywords:** Kidney failure, Hemodialysis, Miniaturization

## I. INTRODUCTION

In the total population of the world, 63.7% of people are affected by kidney failure. The kidney failure is the condition where the functioning of the kidney is disabled due to the many internal and external effects. The Kidney is the pair of

### Revised Manuscript Received on July 05, 2019.

**Sakthivel Sankaran**, Assistant Professor, Department of Biomedical Engineering, Kalasalingam Academy of Research and Education, 626126,

**M Pallikonda Rajasekaran**, Professor, Department of Electronics and Communication Engineering, Kalsalingam Academy of Research and Education, Virudhunagar, Tamilnadu,

**Vishnuvarthanan Govindaraj**, Associate Professor and Head, Department of Biomedical Engineering, Kalasalingam Academy of Research and Education, 626126, India.

**Preethika Immaculate Britto**, Assistant Professor, Department of Biomedical Engineering, College of Engineering (Woman), King Faisal University, Kingdom of Saudi Arabia.

**Mohamed Mydeen Mohamed Mansoor**, Final Year Biomedical Engineering, Department of Biomedical Engineering, Kalasalingam Academy of Research and Education, 626126, India,

**Abinaya Srinivasan**, Final Year Biomedical Engineering, Department of Biomedical Engineering, Kalasalingam Academy of Research and Education, 626126, India,

**Javithrasha Askar**, Final Year Biomedical Engineering, Department of Biomedical Engineering, Kalasalingam Academy of Research and Education, 626126, India.

bean shaped organs located in the retroperitoneal space. The nephron is the major structural unit of the kidney.

The main function of the kidney is to filter the blood and remove the waste products in it, and the electrolytic components and maintain the level of electrolytes in the body, and it also removes the excess water and the toxins from the blood. It controls the fluid balance of the body by the proper excreting process. The collected waste products are converted into urine and it is excreted through urine.

In case the kidney function ceases due to the failure, but to sustain alive, we choose the option dialysis. The dialysis is which that effectively replaces the function of the kidney and maintains the patient body. Dialyzer removes the excess water solutes and other toxic products from the blood treatment. The lifesaving dialysis is of two type peritoneal dialysis and hemodialysis. Both work in different mechanism but perform same functions in the body.

The peritoneal dialysis has the methodology of using the peritoneum in the abdomen. The abdomen acts as the porous membrane through which the fluid and the dissolved substance are removed from the blood fluid. The hemodialysis is the process which efficiently performs the function of the purification of blood and filtering the waste products of the blood than other method dialysis.

## II. SURVEY REPORT

The survey is which to analyze the people count up to which range the renal failure condition gets accomplished in this world. The people who are affected by this disease in worldwide are almost in the percentage of 63.7. The despair is which only the 58 percentage of are getting good medication, and the remaining are dead due to the lack of medication. This due to the cost of the treatment and the availability of the dialysis centers. This survey says about both India and international survey of number of people affected by renal failure, availability of dialysis center and cost per dialysis.

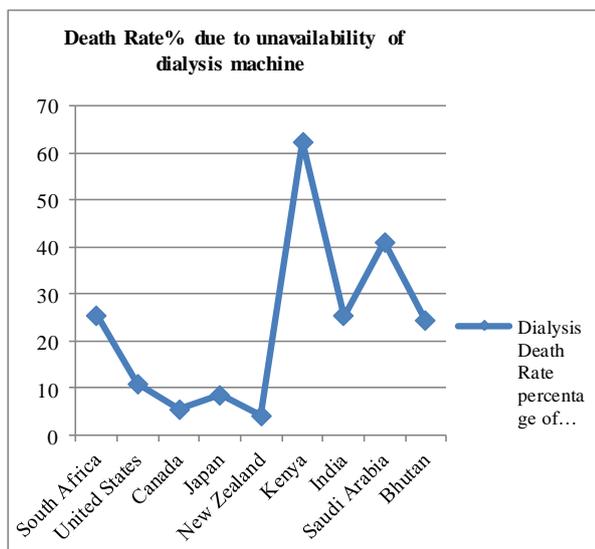


Fig. 1 Death Rate due to unavailability of dialysis machine all over the world.

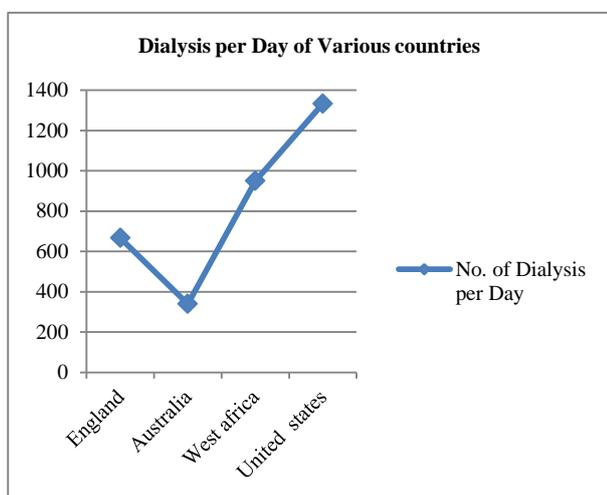


Fig. 2 Dialysis per day of various countries

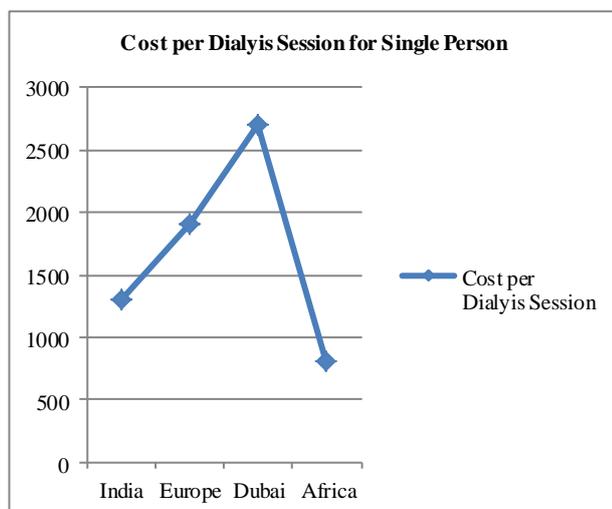


Fig.3 Cost per dialysis session for one person.

### 2.1 Survey of Dialysis patients in India

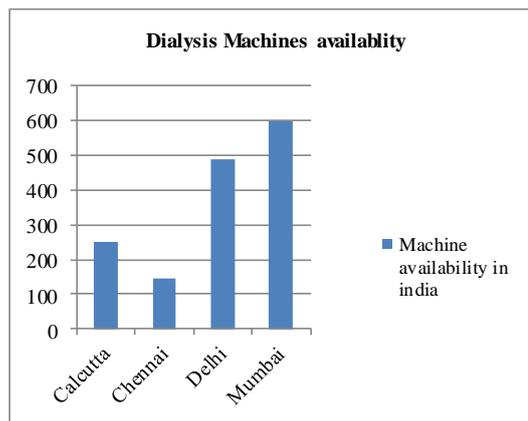


Fig.5 Dialysis Machine Availability in India.

#### ❖ Dialysis Amount per day for a city

Calcutta => 20000 X 1100 = 22 million  
 Chennai => 10220 X 1200 = 12.26 million  
 Delhi => 28500 X 1600 = 45.6 million  
 Mumbai => 40000 X 750 = 30 million

#### ❖ Dialysis Amount per center of a city

Calcutta => 22000000/36 = 0.61 million  
 Chennai => 12264000/44 = 0.28 million  
 Delhi => 45600000/79 = 0.58 million  
 Mumbai => 30000000/112 = 0.26 million

#### ❖ Dialysis carried out per year

Calcutta => 20000 X 12 = 240000  
 Chennai => 10220 X 12 = 122640  
 Delhi => 28500 X 12 = 342000  
 Mumbai => 40000 X 12 = 480000

### III. SOLUTION STATEMENT

Dialysis is a life saving device which helps the renal failure patient to sustain in well living condition. Despite, the device serves the people, yet the flaw in the device is not rectified. The main and major drawback of the device is immobility, which the patient should adopt the 5 hours of time for thrice a week in hospital to keep them alive. In this condition, half the part of the patient life is spent for medication. This condition were to overcome in the year of 2007, with the portable dialysis system for both peritoneal and hemodialysis process. The product as launched in the market does not reach the patient effectively because of its errors and flaws in the technologies incorporated.

The flaws in the new technologies will rewind their medication process to older methods again and cause inconvenience to the patient. The portable dialysis is the device which patient itself should operate and perform



dialysis by his/her own without the help of the physician. The device should be designed in such a way and it should also be easy to mobilize. The major successful concept of the dialysis is the hemodialysis system which has overcome the lot of drawbacks and functioning efficiently than other processes. In order to overcome the problems enlisted above, the regenerating sorbent technology can be used with the increase in the positive pressure of the flow motor. This will reduce the excess use of the dialysate and it increases the efficiency of the device and also reduces the time duration for the dialysis.

#### IV. PAPER SURVEY

Sara alijassmi and Soliman A. Mahmoud have briefed that the patients can perform their dialysis through the control of the mobile phone access [1]. The mobile application will provide the feedback about the duration of the dialysis, the fluid level maintained in the dialysis and heart rate. The device is constructed similar to the model of a life-jacket. The major drawback will access the device function with the mobile charge backup it may dropout at any time.

Antonio tricoli and Giovanni neri have contributed to the current innovations and achievements in technological improvement of sensors in the healthcare sector for monitoring patients with chronic kidney disease and to measure the rate of ammonia, creatinine and urea. [2] They used Stat sensor to detect creatinine electrochemically. The sensors are highly useful in detecting the parameters but accuracy fails during diagnosis. Selection of sensors and the resistible materials should be used to build sensors.

MeghaSalani et. al., have reviewed the innovative technologies used in the wearable artificial kidney [3]. They have briefed about the tidal flow dialysis artificial kidney in both peritoneal dialysis and hemodialysis by the dialysate regenerating process which filters the solution by carbon cleaning process with the feeding pump for the separate circulation. The dialysate regenerating process has the efficiency less filtering mechanism.

Mario bonomini et. al., have reviewed about the examining the advancement in the hemodialysis which have overcome certain drawbacks [4]. The extra corporeal blood purification therapy in the artificial membrane effectively works for the clearance process. In capillary electrophoresis method, the proteins are derived through dialysate liquid by high flux membranes. This process will result in the protein deposition.

Ibrahim mousa et. al., have analyzed the efficiency of the dialysis through the EuroQol dimensional property [5]. In this property, the self-efficiency scale is calculated on the basis of the mean and meridian of the usage of the dialyzer. The membrane which supports the filtration process has the ethical ratio of Six-item scale (SEMCD) and the related quality of life. The usage of the dialyzer also varied with the patient body condition.

Ravindra L. Metha has explained the concept of continuous renal replacement for the patients in the critical condition. [6] The goal is achieved by adding solutes, regeneration process and diffusion. It is highly conventional in removing the molecular weight. The fluid balance requirement of the patient determines the ultra-filtration goal.

The imbalance in the electrolyte value affects the patient health. It goes on with the long term exchange process.

Huiping Zhao et. al., worked on the concept of intraperitoneal method and the prolonged oral antibodies technique to treat the patients with peritonitis [7]. Brucollis is caused by the brucella. For the severe local manifestations patients, the reverse removal process has to be followed for catheter removal, and unresponsive or recurrent disease despite optimal treatment with IP antibiotics combination.

Raymond Vanholder et. al., have discussed about chronic kidney disease and its clinical expression called uremic syndrome [8]. They offered the summary of cardio vascular and its treatment options and chronic kidney disease. They also reviewed about the morbidity and mortality risks in chronic kidney disease. They have concluded as they have discussed completely regarding morbidity and mortality due to cardio vascular disorder of kidney failure.

Giorgina Barbara Piccoli et. al have explained about which hemodialysis process should have higher efficiency in younger and older patients [9]. The authors have shown priority in nutrition level. Hemodiafiltration play a major role in weight loss control. Hemodiafiltration also inhibits the back filtration. Prescription can be increased in hemodiafiltration. The major flaw is medication cost is higher when compared to normal therapy.

Sabrina Haroon and Andrew Davenport have discussed about various aspects of different types of home hemodialysis machines currently present in the market, and which may possibly present in the upcoming along with their cost and how the environmental impact of those machines will be are discussed [10]. In this paper, they authors also discussed about home haemodialysis machines that are going to impact much on dialysis patients.

Wolfgangbieser and Markus welsch have discussed about the comparison of a double-pump SN HD system available in the market with dialysis parameters of new single pump SN HD system (Fresenius Medical Care [FMC] 5008)[11]. In this crossover study of two armed, patients were randomized into two groups (B. Braun - FMC/FMC - B. Braun). The main characteristics of the prescribed treatment are reported and maintained for the full study.

Gunjeet Kaur et. al., have explained about the medication cost of hemodialysis is expensive. To troubleshoot the expense, Government of India has proposed a new idea called national dialysis service program [12]. This proposal has brought a great impact to poor people to undergo hemodialysis therapy. The dialysis patients are increasing, and day-by-day the need of machines and physicians will never drop out.

Marion morena et. al., have described about the impact of hemodialysis in elderly patients [13]. The older people have the high discomfort in the frequent dialysis and they have to tolerate and continue their medication. The high flux in elder patient has the maximum risk of cardiovascular disorder. Accordingly, the deep clinical study discusses the

optimal dialysis condition should be done regularly with complete bed rest mode.

Mohamed alishafiee et. al have reviewed about the impact of the hemodialysis that the cardiovascular disease is the most prominent causes of chronic kidney patients undergoing standard hemodialysis therapy [14]. Since there will be a gradual myocardial stress decrease through lower inter-dialysis weight gain, there will be a lower BP fluctuations and it is highly good for health, but the efficiency of the dialysis process is slightly lower when compared to normal methodologies.

Xu Deng, Yifan Xie and Aihua Zhang have discussed on autophagy and its advancement in chronic kidney diseases in current scenario [15]. They also discussed on topics that include macro autophagy, micro autophagy, chaperone mediated autophagy, and such different types of autophagias are involved in chronic diseases, endoplasmic reticulum autophagy and chronic kidney disease. They also focused more on autophagy present in different types of cells present in the kidney.

Rajeev A. Annigeri et. al., have discussed about the data for advancement in medications of the acute kidney injury [16]. The acute renal medication does not require fistula process. The peritoneal dialysis is strongly recommended for acute renal injury. It can maintain electrolyte balance efficiently. The continuous renal replacement therapy is recommended for the patients who have rapid shifts in their electrolyte balance. The price of the medication is expensive.

Rachael C Walk et. al., have discussed with the concepts of review based on the home used hemodialysis [17]. The authors have undergone the deep survey which economical evolution plays the major role for the development of the home hemodialysis sector. The patient's barriers have reduced a lot by this method. The frequent purchase of the complements of the dialysis process should be proper to avoid the skipping of medications.

Manish Saha and Michael Allon have reviewed and highlighted the major emergency which occurs during hemodialysis treatments [18]. They broadly explained about their pathogenesis, which gives them a measure to minimize them. They also discussed about how to prevent catastrophic consequences which happens in rare scenarios in arise of emergencies. Finally, they concluded by describing the analysis for root cause.

Sabithavadakedath and Venkataramanakandi have discussed about Chronic Renal Failure [19]. Their data says that Chronic Renal Failure is considered to be the highest prevalent public health issue worldwide for the most elderly population. They get stressed that most common reason for Chronic Renal Failure is damaged kidney. They also covered about five different stages of Chronic Renal Failure based on Glomerular filter rate.

Qingyunzhu et. al, have discussed about the acute severe biliary pancreatitis clinical treatments and the clinical ability to renal replacement therapy in continuous way along with the combination of percutaneous transhepatic gallbladder drainage which was guided by ultrasound [20]. They have concluded as continuous renal replacement therapy along

with percutaneous transhepatic gallbladder drainage guided by ultrasound is more effective for treatment purposes.

Soren Christiansen and Steffen Christiansen have explained about renal replacement therapy to overcome the problems faced by the acute kidney disabled patients to reduce the mortality rate [21]. The authors have observed the creatinine and blood sample before doing the renal replacement therapy. The authors have improved the renal replacement therapy up to 3 stages for acute kidney injury patients. The major flaw is the duration of sample testing which takes nearly 24 hours.

Jihane J. Hajj and Krzyszoflauda have discussed about the varied modalities of hemodialysis performed in home [22]. The patients highly focused on the cost efficient medication process which they can spend their treatment duration in home. The outcomes of home hemodialysis were deeply monitored and analyzed. Thus the quality of life of was increased through the higher utility of the same and proper medication.

Graham Woodrow and Stanley L. Fan have explained about peritoneal dialysis, which is widely used as an option in renal replacement medication for infants and children [23]. The major problem in peritoneal dialysis process is the ultra-filtration membrane should be visualized regularly. The catheter which is inserted during dialysis therapy should be in sterilized condition. In case of long term of medication, the patients will get affected under peritoneal sclerosis

Bazae V et. al., have presented the results of a wearable artificial kidney- WAK through in-vitro trials [24]. The in-vitro trial of their experimental prototype of wearable artificial kidney was carried out on the test bench. They also discussed about expendable materials which are used to replace infrequently as once every one and a half day that lowers the risk of peritonitis up to 6 times, which was discussed by the research people.

Gura V et al., have discussed that the technology described in this paper is the Wearable artificial kidney (WAK), which is the miniaturized, wearable hemodialysis machine based on dialysate regenerating sorbent [25]. The patient should wear this device like a belt and its weight is up to 10 pounds. The patient should bear this weight in his/her hip till the dialysis gets completed.

Sean M. bagshaw et. al., reviewed about the complexity of the continuous renal replacement therapy that is dominant form of healing support for the critically affected patients [26]. This equipment is mainly used in the intensive unit care. The major flaw factor is the slow process which will continue for long duration. The additional benefit is that the other medications can also be taken while the renal medication was on-going.

Bhanu Prasad et. al., have reviewed the therapy for continuous renal replacement, which is mainly used for the injury in kidney and the patient with deviation in their pressure are treated under this condition [27]. The patient with condition cannot be treated with the process of peritoneal

dialysis and hemodialysis. The flow conditions which the device is dealing with are the cost of the treatment and the duration of the medication.

Rajnishmehrotra et. al., have briefed about the efficiency and the status of the peritoneal dialysis [28]. The anatomical peritoneal cavity of human gradually gets weaker by continuous usage and leads to peritonitis. The utilization of the peritoneal dialysis is deeply monitored and analyzed the peritoneal physiology. It shows the cardiovascular risk in patients. The metabolic risk will be higher for the long term peritoneal treatment.

Michael j. Ficher et al., have briefed about the fresher people who are attending dialysis specifically for older patients [29]. The authors have undergone the depth survey and compared the outcome of both hemodialysis and peritoneal dialysis. Adopting the type dialysis among elder patients varies with each patient. The pressure fluctuated patient are highly preferred on peritoneal dialysis. According to survey, low flux dialysis is a safe adoption for elder patients.

Thiagogomesromano et. al., have described about the variation in quantity of serum sodium in the patient body during the continuous renal replacement process [30]. The interdialytic weight is directly proportional to the serum sodium content. The concentration of serum is also monitored continuously to avoid brain edema. The sodium mass gets fixed in the mixing chamber. The anticoagulant is responsible for serum concentration.

Sergio mina gaias et al., has undergone the depth study about the recovery of patients after acute kidney injury medication [31]. The critically ill patients are treated with continuous renal replacement treatment in intensive unit care, and after this treatment, the patients will be affected with cardiac block, pressure deviation and lowered creatinine. In order to make the metabolism regular, the relief medications are performed with glomerular diet.

Etienne macedo et. al., have viewed functionalities continuous renal replacement therapy. It stimulates the solute transport of the body. Continuous venous hemo-filtration uses the convection of mode of electrolyte filtration and plays main role in the removal of poison and myoglobin [32]. It is highly helpful for the patients with heart failure to sustain with dialysis. The long term continuous renal replacement gets affected with hypothermic and electrolyte imbalance.

Daniel marcelli et. al., have worked on the concept of high flux hemodialysis and performance of hemodiafiltration [33]. The patients who are undergoing the high flux dialysis should have the stable blood pressure. The renal replacement treatment is specifically for the varied pressure level patients. The weekly medication with low flux dialysis keeps the patient healthily. The long term high flux dialysis will lead to cardiac arrest.

Michele P. Lambert has discussed regarding the list of common manifestation of renal disease and liver disease during platelet dysfunction[34]. They compared the cause of in renal disease and liver diseases in thrombocytopenia. In this paper they have also discussed about understanding the role in pathobiology of platelets in renal disease and liver

disease. This paper covers the emerging information on platelets in renal and liver disease.

Raaymond R.Townsend has discussed about artificial stiffness in chronic kidney disease which was taught by them as chronic renal insufficient cohort study [35]. They summarize that implication from this studies are pulse wave velocity is a robust and substantial predisposition to cardiovascular disease. Their recent finding from chronic renal insufficient cohort study is covered in ten lessons and they enrolled 2800 participants for this cause.

Yi-Chun Du et.al, have detailed about wearable sensor to detect the blood leakage level during hemodialysis process [36]. The authors have used microcontroller unit for flow control and alarm unit is for the indications. The signal differs depend upon patients body weight. The generated signal is insulated to reduce the transmission interference. The major problem is the internet protocol is used for communication process.

Rajnish Mehrotra et. al, have explained about the methodology and the revolution of peritoneal dialysis [37]. The recent technology increased the treatment for long term for end stage renal disability patient. The major target in peritoneal dialysis is to reduce uremic solutes. The major flaw is when aged patients undergoing peritoneal dialysis will be facing cardiovascular disease and it is also leads to peritoneal sclerosis.

Joni H. Hansson and Suzanne Watnick have explained about the recent technology in dialysis catheter [38]. The catheter can be medicated up to the abdomen. The authors have briefed that injecting the catheter and extending the catheter is a challenging operation and it is also a difficult task, and by using icodextrin the rate of ultra-filtration is increased when compared to glucose filtration. Peritoneal dialysis performs efficient in acute kidney injuries than hemodialysis.

Kousoulagerasimoula et. al., have discussed with the concept of the quality of lifestyle of the patients who are undertaking hemodialysis [39]. The authors have undergone depth survey and analyzed that multiple linear integration like session duration, cost and social attachment makes the quality of life down. The worst physical functionality leads the patient stressful. The varied atmosphere might develop their inner confident and increase their quality of living.

Sunny eloot et. al., have explained the protein exchange operation during dialysis process [40]. The protein removal ratio is the condition of the middle molecule components removal which is adjusted only for the pregnancy patients. The porous membrane constrains are also adjusted for the variation protein flow. The total solute removal gives information about the electrolyte exchange during dialysis.

Jonathan wong et. al., have discussed with the outcome quality of the dialysis for hemodialysis patients [41]. The residual kidney function improves the biomarkers of the kidney. According to the cohorts study the urine traces of the patients are investigated to analyze the electrolyte status,

adequacy and blood pressure of the body. The predictors of the beta trace protein to analyze the interdialytic weight gain which shows the dialytic outcome.

Elizabethoei and Stanley have summarized about both the peritoneal dialysis and the hemodialysis is highly sensitive in the case of elder patients [42]. The author describing that the elder patient's blood pressure condition can't bear which the threshold of the hemodialysis so the elder patients will be facing high risks. The dialysis regimens resulting in the routine utilization of hypertonic in glucose exchange.

Bernaldcaud et. al., have explained about the hemofiltration which is developed to eliminate small and large uremic toxins through diffusion and convective transport of solute [43]. The authors have fixed minimum threshold dose is given by optimal convection method to increase the survival rate. The authors have briefed that the convection volume differs for every patient. The non-standard dosage limitation will affect the patient periodically.

Michael V. Rocco et. al., have discussed with the data of effect of frequent nocturnal hemodialysis [44]. The authors have trailed the patients who are dealing with the frequent hemodialysis network and evaluate the safety. The posterior probabilities of harm between 0.8 and a substantial benefit with relative hard greater than the 0.8 and conservative prior is less than the 0.85. The nocturnal hemodialysis is not as efficient as normal hemodialysis methodology.

Narayanan Prasad et. al., reviewed that the west Asian countries has the less awareness on the dialysis and losing lots of life due to the poor health care system the burden of the disease is keep on increasing on the humans [45]. The demography of the ESRD should implement various features to eradicate this condition in those countries. The government policies for care of patients should also highly support for both the kidney transplant and dialysis process.

Angela D. Coulliette and Matthew J have briefed about the concepts of water mechanisms used in the dialysis [46]. The pre-treatment method is which that removes the waste components during dialysis and water treatment method which removes chemical and microbial waste of water. The chemical standards of dialysate water should be maintained to avoid the contaminants. The authors have evaluates the microbial standards of water to avoid the infections.

Argyropoulos C et. al., have discussed with the basic of the dialysis reusing methods and the expanding use of the high flux of the hemodialysis. The main drawback of the technology is the filtration flux of the dialyzer pores are getting weak for every usage [47]. The secondary analysis and the long process of synthesis supported a lot in the spread usage of clinical hemodialysis.

Matthew B. Rivara et. al., have discussed about the home dialysis changing landscape in the United States along with the clinical outcomes of current research on patients who are all under going home hemodialysis and peritoneal dialysis [48]. Their recent findings support that patient treated by peritoneal dialysis and hemodialysis are as good and better when compared to patients treated at conventional in-center hemodialysis.

Rhonda Shaw Victoria have discussed on the literature survey and regarding dialysis patients self-care literature review by examining the relevance of the concept of cyborg embodiment for the lived experience of people with end-stage renal failure [49]. They concluded as upcoming research on being in dialysis for diverse population samples around perceptions of dialysis use in these settings would enhance understanding of New Zealanders' experiences.

Takashi keikishimoto et. al., have reviewed about the heparin is a medication, which is used as an anticoagulant [50]. It is used to prevent and treat pulmonary embolism, deep vein thrombosis and the arterial thrombo embolism which is mainly used for the process of the dialysis for maintain the blood in anticoagulant state. In addition, the ability of over sulfated chondroitin sulfate to recapitulate key clinical manifestations in vivo was tested in swine.

Yutian lei and Yifanxiong have explained about the usage of peritoneal dialysis process in diabetes patients [51]. The authors have undergone a trail with diabetes patients from initial stage of therapy to 3 months during medication process. The diabetes patients may have a chance of getting cardiovascular diseases in peritoneal dialysis therapy. The major flaw is the diabetes patients are recommended to undergo hemodialysis to reduce mortality rate.

Andrew Davenport et. al., have reviewed about with the theory of Vicenza wearable artificial kidney (ViWAK) that is connected with body through dual lumen catheter which will fill the dialysate in the peritoneal cavity for dialysis process [52]. The interface of blood with the flow air leads to blood clot in the dialysate circuit and it can be solved by exposure of heparin but the continuous exposure of unfractionated heparin leads to osteoporosis.

Bradley A et. al., have explained about the efficiency of peritoneal dialysis on comparison to hemodialysis for infants [53]. The medication process depends on the body surface and the volume should be dependant to anatomical surface. Malnutrition is more complicated in doing peritoneal dialysis for the infants. The medication process done in home parental support is required to do peritoneal dialysis.

Ai-Ching Boon et. al., have discussed about bilirubin which bound with albumin which defense against kidney and renal diseases. [54] The methodology they followed are potential protective effects of bilirubin, antihypertensive effects and causes, antioxidant effect, protection from ischemia reperfusion injury and graft rejection, bilirubin and endothelial function, bilirubin and vascular clarification, systematic review of clinical studies is done.

Karlienfrancois and joanne M bargman have explained about the betterment of peritoneal dialysis [55]. This medication needs dialysis fluid and it can be cleaned in clear water with the help of hands. This process has to be done about 4 to12 weeks. Peritoneal dialysis process needs assistance for doing this therapy at home. The major drawback is the efficiency of the methodology. It will be unfair for the long term medication process.

Veena D and Joshi K.G have discussed and reviewed that quality of life which is associated with other factors [56]. In this paper they discussed much on the instruments used for quality of life, and the factors need to determine for the improvement of quality of life, and the different types of examining methodologies. They concluded with limitations present in validity for quality of life and its predictive power.

Naderaghakhni et. al., have referred about the patients who are handling the physical, emotional and economical barriers in their day to day life [57]. The frequency in dialysis destroys their ethical respect of the patient among their personal society and it also leads to increase in fear of dependency. The advancement in the dialysis should overcome all the threats of the patient and lead their life peacefully with regular medication.

Kristen L. Jablonski and Michel Chonchol have explained about the problem faced by the patients undergoing hemodialysis therapy [58]. The patients affected by cardio vascular diseases and diabetes should not take hemodialysis therapy. The death rate is getting increase in cardio vascular disease patients due to medication. The deviation in blood pressure leads to patient death during hemodialysis process.

Hsiao-Chien Chen and Hsiu-Chen Lin have discussed about the breakthroughs of Plasmon-induced dialysate efficient and safe HD by using comprising it with Au Nano particles (NPs)-treated with (AuNT) water from conventional de-ionised (DI) water that is distinguishable [59]. They also discussed about HD efficacies which are unprecedented and found using AuNT water along high diffusion coefficients activities with weak hydrogen bonds are reported for the first time.

William H. Fissell et. al., have contributed to the technology wearable hemodialysis technology which is based on the roller pump to generate the concurrent blood flow and the dialysate flow [60]. The device is primed with the small volume of the sterile and dialysate sorbent for the regeneration. The main flaw statement of the paper is the interface of the blood and air in the extracorporeal circuit leading to the blood clot which will bring the excess requirement of heparin.

Charles chazot have explained about the medication of hemodialysis process which takes 3 times per week. [61] The authors have viewed some abnormalities during ultra-filtration process. High rate of ultra-filtration may lead to death. The nocturnal dialysis will have the varied pressure rate and that will affect the patients. The authors justified in the comparison chart that the conventional dialysis is more efficient than other medication process.

Steven Kim and Shuvo Roy have explained about MEMs technology to design a device. They have used silicone as a semiconductor material to develop an innovative biomedical device in MEMs technology [62]. They have used micro fluidics in order to reduce the membrane filtration. The tap connections were used as a water source in dialysis process. The challenge in MEMs technology is to improve the efficiency in blood flow sector.

Gautham A and muhammed javad have explained about modified cellulosic membrane to increase the efficiency of high flux segment [63]. The increase in pore size of the

membrane will improve efficiency. Increased wall Synthetic membrane made of polymers is more efficient than modified cellulosic membrane. The major flaw is biocompatibility membranes which has less blood interaction.

Ahmad Taher Azar has discussed about the treatment modality and performance characteristics of dialyzer [64]. They determine the nature and quantity of toxin uremic which is removed from the blood of patients. The author also stressed that dialyzer membranes are the major contributors to the success or failure of hemodialysis therapies. In this paper, the author concluded that the toughest goal is matching a dialyzer based on patient requirement.

Jeremy j song et. al., have explained about the regeneration of kidney tissue using umbilical venous for humans [65]. The kidney cell is cultured and tested in-vitro fertilization to filter the perfusate, and also to clear the metabolism rate along with absorbing electrolyte, glucose and increase in the urine concentration. The demand of donor and kidney transplantation is reduced through orthotopic transplantation of bioengineered kidney.

Praveen tengse et. al., have discussed on both the peritoneal dialysis and the Hemodialysis. The patient's blood got purified and the impurities of the blood are separated and collected in the separate chamber [66]. For driving the machine with various higher volume fluids, peristaltic pumps are used. The main flaw statement of this model is the temperature. The portable models have enhanced a lot to this efficient technology.

Srinivasa R. Pullela et. al., have constructed with the basement membrane which was highly used in the artificial organ development. In that the authors have reviewed about the various technologies like porosity, layer by layer for the better developing structure. [67] The permeability should be maintained in the normal level for the implant safety measures. The drawback is the properties of collagen layer which purity level may affect the patient body condition.

Eduardo lecon et. al., have discussed about the survival rate of the kidney failure patients through a deep survey that half the life time of the patient have been spent for medication. [68] The interdialytic weight gain which will be reduced after the treatment. The hour duration will also be reduced with the same efficient function. The statistical analysis described the reduction of the medication duration will be highly beneficiary of the patients.

Anna Winterbottom et. al., have explained about different types of dialysis process for the treatment of chronic kidney diseases. The patients may have different period of time in doing medication. [69] The authors have undergone an interview among patients regarding their medication procedures. The main objective of this paper is the patients are selecting their medication process based upon the cost, medication time and stage of chronic kidney disease.

Aditi Nayak et. al., have discussed about the brief history of peritoneal dialysis which is used as a treatment for patient with end stage renal disease. [70] They designed a new

strategy as remote monitoring system for peritoneal dialysis, by which patient can share their real time condition with their doctors and they conclude as the real time report sharing will avoid mortality rate increasing.

Michael E. Schachter have summarized about emerging data of balance and quality of life in Intensive hemodialysis. [71] Their proof suggests that the meaningful advantages are offered by long duration dialysis or frequent modalities when compared with old traditional CHD schedules. The necessary changes to deliver optimal renal replacement to the majority of patients with ESRD have to be delivered through new innovations in the healthcare sector.

John B. stokes et. al., have published the paper entitled Nocturnal hemodialysis: Analysis following the frequent hemodialysis network trails in the year 2011. [72] In this project the authors have reviewed that the nocturnal hemodialysis trails which reduce the serum phosphorous concentration. The trail executed very successfully on the both low and high flux membrane. The conventional methodology must attain 42pts in 3 times a week. It highly affects the efficiency due to the various randomized dialysis. The effect of the frequent dialysis will lead to loss of efficiency in electrolyte filtration.

Steven Rosansky, RichardJ. Glasscock and William F. Clark have discussed about patients who are all started dialysis in "early" (at Modification of Diet in Renal Disease estimated GFR [eGFR]> 10 ml/min per 1.73m<sup>2</sup>) when new dialysis starts account for over 50 percent. [73] They also set the trend to an early start is completely on conventional wisdoms based one and regarding those dialytic clearance and its benefits, in that nutritional markers are used to mention Albumin levels.

Eduardo Lacson and Steven M. Brunelli have published the paper entitled [74] Hemodialysis Treatment Time: A Fresh Perspective in the year 2011. In this paper they discussed about how the innovations in technological development has changed long term nearly 6hours long dialysis to complete within few hours as a short term. They have concluded as the new upcoming innovations in dialysis paradigm should convert dialysis timings into 4hours which should be adequate and treatment has to cover majority of the patients.

Jorge cerda et. al., have reviewed about the homeostasis which cannot be implemented for the critical ill patients. [75] The ph value should not exceed the ratio of 7.2. The variant flux of bicarbonate in the dialysate solution will lead to excess formation of co<sub>2</sub> this will cause nausea, headache. The cause of lactic acidosis will create various discomforts for the intensive care unit patients.

Ronco C et. al., have explained about the wearable base hemodialysis mechanism which composed of extracorporeal circuits. [76] They have introduced the dual lumen catheter as an efficient solution for the high flow. The device has been implemented with advanced fluid removal technology and also the safety features for the conventional usage. The carry out water quantity was large so wearable technology is little lacking.

Farah Tasnim. et. al., have discussed about the development and enhancement of the therapies based on bio

artificial kidney for the patients treatments who are all suffering from end-stage renal disease, research approaches and related problems. [77] Also along with this they also discussed about the mobile, wearable, portable and implantable devices developments. They explained in detail about growth substrates and renal cell types which are used in bio artificial kidneys.

Antonio Santoro and Gualtiero have focused mainly on the transport phenomenon which occurs within a dialyser. [78] They have taken this attempt to make a clarification on phenomena of transport which are depend on the membrane characteristics and related to the performance of a dialysis session. They have finally stated that this editorial mainly seems to focus on the improving dialysis therapy in membrane's own merits.

John T. Daugirdas, James E. Tattersall have explained about hemodialysis by using ultraviolet rays to check the electrolyte concentration. [79] The huge electrolyte concentration is calculated through inflow and outflow while doing dialysis process. This method has reduced the dialysis therapy cost. The major challenge is ultraviolet rays will absorb only uric acid but the urea will not be absorbed by ultraviolet rays.

Robert H. Mak et. al., have briefed about the master stage dialysis. [80] In case of acute the children are mostly recommended to undergo hemodialysis. In the long term peritoneal dialysis it will lead to the peritoneal sclerosis. In this serious complication the morality rate exceeds the 30%. The master stage patients are highly encouraged to take renal replacement therapy and it also affects the electrolyte balance in the body.

Victor Gura, Alexandra S. Macy has described about the breakthroughs which made WAK V1.0 as an innovative creation to be possible and V 1.1 and 1.2 are its advanced versions. It consists of powered battery Wearable artificial kidney pump which contains pulsatile counter phase flow with double channel in it. [81] In this paper they concluded as the wearable artificial kidney will be an sufficient and efficient way for providing ESRD treatment and daily dialysis.

Joseph A. Cafazzo et. al., have explained about the impacts of home used nocturnal dialysis. It was undergone over night for 6 to 8 hours in the period of 3 times per week through fistula. [82] The qualitative analysis shows that the chemical compositions for nocturnal analysis should be clearly specified to avoid the errors. The lack of self-efficiency the effort of patient plays the major role.

Poyyapakkam R.srivaths, Craig wong have explained about the nocturnal home hemodialysis for renal failure patients to undergo their medication during night time for the duration of 4 to 6 hours through jugular catheter. [83] In polysulphone dialyzer the blood flow rate and chemical flow are denoted in the ratio of 400:500. The authors have undergone deep survey to test its responds and result it as 85%. It requires duration of 3yrs to adopt an average result.



Vimalachadha have discussed about the peritoneal dialysis and the reason behind peritonitis remains the reason for peritoneal dialysis technique failure [84]. They have concluded that as the vast peritoneal dialysis patients are treated everyday successfully and the least number of patients are noted with peritonitis. In some cases, secondarily due to gram negative bacteria or fungal infections, peritoneal dialysis technique might be a great failure.

Masataka Honda and Bradley A. Warady have briefed about the clinical features of the long term peritoneal dialysis for the children [85]. The patients who are undergoing dialysis for more than five years fall ill with a serious condition called sclerosis. The continuous peritoneal dialysis in for the children will result in the poor ultra-filtration by the pathological mechanism. The creatinine removing rate will be slightly reduced due to long term peritoneal dialysis process.

Zbylut J Twardowski et. al., have fully developed with evolution of hemodialyzer designs in these years [86]. The authors have explained that the dialysis was originated and later it was developed into various advancements likes spiral dialyzers, parallel flow dialyzer, coil dialyzer and various methods was introduced in recent years for the better medications to the patients. All the new launched technologies have some drawbacks and updating should overcome those flaws.

AshishUpadhyay et. al., have constructed with the concept of dialysis therapy which produce huge amount of waste during filtration process [87]. The authors have explained that the contaminated hot water is spilled out in environment. The one time usage of dialysis produces a high amount of solid waste. The main aim in dialysis therapy is reducing cost for the medication. The major flaw is waste production and is higher than the medication process.

Brendan B. McCormick and Joanne M. Bargman have discussed about the peritoneal dialysis and complications present in peritoneal dialysis [88]. They stated that using mechanical catheter is the main reason for peritoneal dialysis failure. In this paper, author concentrated more on non-infectious complications in peritoneal dialysis. The main cause for non-infectious complication is due to the insertion of catheter and keeping it outside the peritoneal cavity.

Deray G have briefly displayed about the patients with renal insufficiency [89].The contrast media was efficiently removed in peritoneal dialysis. In the case of chronic stage failure using hemodialysis, they are using nephrotoxin which efficiently remove the contrast media. It will be a never suitable medication process for the patients in intensive unit care. The varied pressure medium highly affects the patient health during the process.

W. SulowiczA. Radziszewski have discussed about the serious clinical problem dialysis induced hypotension [90]. It is considered to be most frequent complications found in renal replacement therapy which increases dialyzed population rate of mortality. They also discussed about efficient treatments involved in congestive heart failure, which is a common reason for hypotension in uremic patients.

Saudan et. al., have constructed with the dosage properties of the acute renal failure patients [91]. The method of using continuous venovenous dial filtration method will be

highly helpful for curing the temporary disorder. The convection used in this process is to remove the molecular weight. The major drawback is the time consumed for the dialysate flow was very long, and it will be highly inconvenient for the patients to take such a long medication process.

Muriel P. C. Grooteman and MareilleGritters have discussed about chronic hemodialysis patients who have a frequent complication in cardiovascular disease [92]. The methodology used in this paper is as follows: four dialyzers such as low-flux cup ammonium (CU) were compared in chronic HD patients with the number of 15 in a cross-over fashion as randomized. They have concluded as in chronic HD patients than it controls the baseline levels which were considerably higher.

Edmund G.Lowrie, Zhensheng Li Norma has evaluated the death risk of relationship in measured Kt[93].They also worked and evaluated on the relationship associated with the death risk of simple body size measures to risk and also the combination of one such measure Body Surface Area (BSA)] with Kt. They concluded that dialysis dose used for direct measurement at each and every time during each treatment is practical and the clinically updated are relevant.

Luanapillon et. al., have undergone a deep survey on hemodialysis for the adult age group patients in United States [94]. In the survey, they have analyzed that the placing of electrodes in the various locations of the fistula domains will increase the efficiency of the bioelectrical impedance in the patient body. The higher mortality rate in the lower volume of the clearance will variably reduce the frequency range.

Mervyn Dean, MB, ChB, CCFP have explained about Opioids and metabolism variation in renal failure patient. According to the view of authors, the tubular secretion rate is proportional to glomerular filtration rate [95]. The glomerular filtration measurement is calculated by drug pharmacokinetics. The major flaw is the Opioids calculation for glomerular filtration rate is less. The excretion and parent drug will get decreased and it will lead to clinical side-effect.

Stephan troyanov et. al., have summarized that the ultra-filtration rate plays the major role survival[96] in the continuous renal replacement therapy which the solutes like urea, creatinine and other solutes are removed in such a ratio which the plasma effluent ratio should remain stable during continuous venovenous hemofiltration. In case of the pre-dilution process, there will be a loss in the clearance of ultra-filtration rate.

Zbylut J. Twardowski PHD<sup>®</sup> has discussed about Quotidian (daily) hemodialysis. They also analyzed about the quotidian hemodialysis clinical results in past three decades and the reason for the model failure [97]. A brief history and complete mechanism of Quotidian (daily) hemodialysis were published. Their successful model composed of control module, dialyzer module, module for water treatment, module for dialysis solution, and user interface for graphic card.

Barry Kirschbaum has explained about treating the hemodialysis patients with bicarbonate to rectify the metabolism acidosis [98]. They have taken 3 milliliter of



blood sample from arterialline with heparin in beginning and at the end of the dialysis process. During acid-base result, both potassium and chlorine ions can be decreased, whereas, sodium concentration cannot be controlled.

Alfred K. Cheung et al., have explained about the high flux in dialysis for chronic patients that were not effective in decreasing the mortality rate. In the high flux dialysis, ultra-filtration of urea rate is increased[99]. The average medication period in around 4 years and more than 60% of patients were treated under high flux dialysis method. The major flaw is the medication period under high flux dialysis is long.

Malvinder S Parmar have explained about renal dysfunction occurs due to the creatinine level is abnormal [100]. The patients who are having diabetes and hyper tension are facing end stage renal disorders and have high mortality risks. The authors have advised the patients to consult with nephrologists before undergoing medication. This paper concludes the factors for occurring chronic kidney disease.

### V. RESULT AND DISCUSSION

As the conclusion, the portable dialysis mechanism will surely make the patient life better. This project device will be highly helping the renal failure patients in handling their medication at their convenience zone, which will apparently give much more relief to the patients and can improve their health conditions.

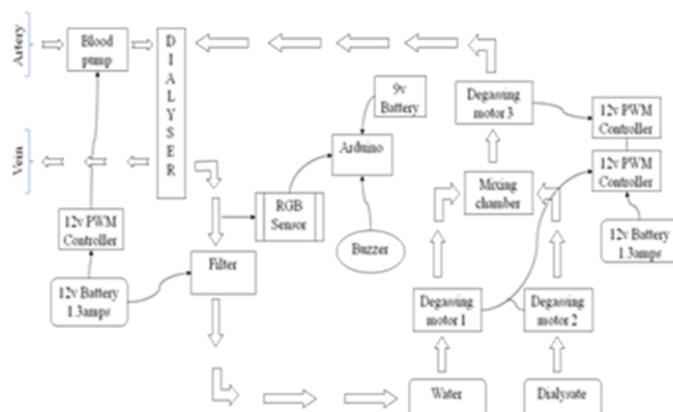


Fig.5 Proposed block diagram of Dialysis Machine.

The complete functioning prototype performs the actual function of hemodialysis in the portable structure. The front side of prototype consists of the source chamber, from which the water and bicarbonate solution gets suctioned, and the mixing chamber is also localized. The back side of the prototype setup consists of dialyzer membrane, sensor segment and the filter chamber. The total setup weighs up to 4.5 kilogram.

In considering the comparative analysis, the past devices in the dialysis sector have come up to making the dialysis medication possible in portable mode but with some flav factors which our team has overcome their drawbacks lik sensor indications for blood leakage alerts and using filter to recycle the water and reduce the carry on water quantity which is used for dialysis. The miniaturized degassing motors where used to reduce the weight of the construction.



Fig. 6 Front side of Dialysis Machine Prototype

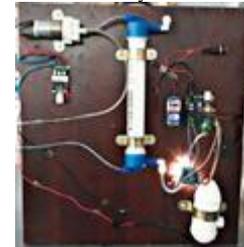


Fig.7 Back side of Dialysis Machine Prototype.

### VI. FUTURE WORK

In the progress of surveying the methods of hemodialysis, we have proposed a coordinate review of papers. In analyzing the various advancements of hemodialysis, the methods which actually satisfy the patient with their convenience are few, in that, the portable dialysis system covers major ratio in fulfilling both the patient need and the actual terminologies of dialysis.

### VII. REFERENCE

- [1] Sara alijassmi and Soliman A. Mahmoud www.researchgate publications Doi: 10.13140/RG.2.2.13421.69604.
- [2] Antonio tricoli and Giovanni neri Miniaturized bio and chemical sensor for point of care monitoring of chronic kidney disease. Sensors 2018, 942; Doi: 10.3390/s18040942.
- [3] MeghaSalaniet. al., Innovations in Wearable and Implantable artificial Kidneys Doi: 10.1053/j.ajkd.2018.06.005.
- [4] Mario bonomini et. al., Examining hemodialyzer membrane performance using proteomic technologies Doi: 10.2147/TCRM.S150824.
- [5] Ibrahim mousa et. al., Dialysis related factors affecting self-efficiency and quality of life in patients on hemodialysis: across sectional study from Palestine Doi: 10.1186/s41100-018-0162-y.
- [6] Ravindra L. Metha Continuous renal replacement therapy in critically ill patient Doi: 10.1016/j.chest.2018.09.004.
- [7] Huiping Zhao et. al., Brucella peritonitis in a patient on peritoneal dialysis: Case report and Literature review Doi: 10.3747/pdi.2018.00115.
- [8] Raymond Vanholder et. al., Deleting Death and Dialysis: Conservative Care of Cardio-Vascular Risk and Kidney Function Loss in Chronic Kidney Disease (CKD) Doi: 10.3390/tonins10060237.
- [9] Giordina Barbara sPiccoliet. al., Prescribing Hemodialysis or Hemodiafiltration: When One Size Does Not Fit All the Proposal of a Personalized Approach Based on Comorbidity and Nutritional Status Doi:10.3390/jcm7100331.
- [10] Sabrina Haroon & Andrew Davenport Pages Hemodialysis at home: review of current dialysis machines Doi: 10.1080/17434440.2018.1465817.
- [11] Wolfgang bieser and Markus welsch Effectiveness of a New Single-Needle Single-Pump Dialysis System with Simultaneous Monitoring of Dialysis Dose Doi: 10.1111/aor.13149.
- [12] Gunjeet Kaur et. al., Cost of hemodialysis in a public sector tertiary hospital of India Doi: 10.1093/ckj/sfx152.
- [13] Marion Morena et. al., Treatment tolerance and patient



- reported outcomes favour online hemodiafiltration compared to high flux hemodialysis in elderly Doi: 10.1016/j.kint.2017.01.013.
- [14] Mohamed alishafieet. al., The impact of hemodialysis frequency and duration on blood pressure management and quality of life in end-stage renal disease patient Doi: 10.390/Healthcare5030052.
- [15] XuDeng,YifanXie &AihuaZhangAdvance of autophagy in chronic kidney diseases Doi: 10.1080/0886022X.2016.1274662.
- [16] Rajeev A. Annigeriet. al., Renal support for acute kidney engineering in the developing world Doi: 10.1016/j.ekir.2017.04.006.
- [17] Rachael C Walk et. al., Home hemodialysis: a comprehensive review of patient-centered and economic considerations Doi: 10.2215/CJN.05501008.
- [18] Manish Saha and Michael Allon Diagnosis, Treatment, and Prevention of Hemodialysis Emergencies DOI: 10.2215/CJN.05260516.
- [19] Sabitha vadakedath and Venkataramanakandi cereus Dialysis: A Review of the Mechanisms Underlying Complications in the Management of Chronic Renal Failure Doi: 10.7759/cureus.1603.
- [20] Qingyunzhuet. al, Clinical evolution of continuous renal replacement therapy in combination with ultrasound guided percutaneous transhepatic gallbladder drainage for acute severe pancreatitis: a retrospective study Doi: 10.1159/000485437.
- [21] Soren Christiansen, Steffen Christiansen Timing of renal replacement therapy and long-term risk of chronic kidney disease and death in intensive care patients with acute kidney injury doi: 10.1186/s13054-017-1903-y.
- [22] Jihane J. Hajj and Krzystofluda Home hemodialysis treatment as an effective yet utilized treatment modality in the United States Doi: 10.3390/healthcare5040090.
- [23] Graham Woodrow, Stanley L. Fan, Renal Association Clinical Practice Guideline on peritoneal dialysis in adults and children Doi: 10.1186/s12882-017-0687-2.
- [24] Bazae V et. alIn vitro trials of a wearable artificial kidney (WAK)Doi: 10.5301/ijao.5000651.
- [25] Gura V et al., A wearable artificial kidney for patients with end-stage renal disease PMID: pmc4936831.
- [26] Sean M.bagshawet. al., Precision continuous renal replacement therapy and solute control Doi: 10.1159/00448507.
- [27] Bhanu Prasad et. al., Early mortality on continuous renal replacement therapy (CRRT): the prairie CRRT study Doi: 10.1186/s40697-016-0124-7.
- [28] Rajnishmehrotaet. al., The current state of peritoneal dialysis Doi: 10.1681/ASN.2016010112.
- [29] Michael j. Ficheret. al., Predialysis nephrology care and dialysis related health outcomes among older adult initiating dialysis Doi: 10.1186/s12882-016-0324-5.
- [30] Thiagogomesromano et. al., barufi Insights about serum sodium behaviour after 24 hours of continuous renal replacements therapy Doi: 10.5935/0103-507x.20160026.
- [31] Sergio mina gaiaet. al., Prognostic factors for mortality and renal recovery in critically ill patients with acute kidney injury and renal replacement the therapy Doi: 10.5935/0103-507x.20160015.
- [32] Etienne macedoet. al., Continuous dialysis therapies: Core curriculum 2016 Doi: 10.1053/j.ajkd.206.03.427.
- [33] Daniel marcelliet. al., Dynamics of the erythropoiesis stimulating agent resistance index incident hemodiafiltration and high flux hemodialysis patients Doi: 10.1016/j.kint.2016.03.009.
- [34] Michele P. Lambert Platelets in liver and renal diseaseDoi:10.1182/asheducation-2016.1.251.
- [35] Raaymond R.Townsend Arterial stiffness and chronic kidney disease: lessons from the chronic renal insufficiency cohort study Doi: 10.1097/MNH.000000000000086.
- [36] Yi-Chun Du et.al., Novel Wearable Device for Blood Leakage Detection during Hemodialysis Using an Array Sensing Patch Doi: 10.3390/s16060849.
- [37] Rajnish Mehrotra et. al., The Current State of Peritoneal Dialysis Doi: 10.1681/ASN.2016010112.
- [38] Joni H. Hansson and Suzanne Watnick Update on Peritoneal Dialysis: Core Curriculum Doi: doi.org/10.1053/j.ajkd.2015.06.031.
- [39] Kousoulagerasimoulaet. al., Quality of life in hemodialysis patient Doi: 10.5455/msm.2015.27.305-309.
- [40] Sunny elootet. al., Protein-bound solute removal during extended multipass versus standard hemodialysis Doi:10.1186/s12882-015-0056-y .
- [41] Jonathan wong et. al., Predicting residual kidney function in hemodialysis patients using serum Beta trace protein and Beta2-microglobulin Doi: 10.1016/j.kint.2015.12.042.
- [42] Elizabeth oei and Stanley fan Peritoneal dialysis international Doi: 10.3747/pdi.2014.00336.
- [43] Bernald canaudet. al., Optimal convection for improving patient outcomes in an international dialysis cohort treated with online hemodialysis Doi: 10.1038/ki.2015.139.
- [44] Michael V. Rocco et. al., Long term effect of frequent nocturnal hemodialysis on mortality the frequent hemodialysis network nocturnal trail Doi: 10.1053/j.ajkd.2015.02.331.
- [45]Narayanan Prasad et. al., Hemodialysis in Asia Doi: 10.1159/000441816.
- [46] Angela D. Coulliette and Matthew J Hemodialysis and water quality Doi: 10.1111/sdi.12113.
- [47] Argyropoulos C et. al., Dialyzer Reuse and Outcomes of High Flux Dialysis Doi: 10.1371/journal.pone.0129575.
- [48] Matthew B. Rivaraet. al., The changing landscape of home dialysis in the united states Doi: 10.1097/MNH.0000000000066.
- [49] Rhonda Shaw Victoria University of Wellington Being-in-dialysis: The experience of the machine– body for home dialysis users. DOI: 10.1177/1363459314539775 hea.sagepub.com.
- [50] Takashi keikishimotoet. al., Contaminated heparin associated with adverse clinical events and activation of contact system Doi: 10.1056/NEJMoa0803200.
- [51] Yutian lei, Yifanxiong Comparison of long-term outcomes between peritoneal dialysis patients with diabetes as a primary renal disease as a comorbid condition doi: 10.137/jornal.pone.0126549.
- [52] Andrew Davenport et. al., Portable and wearable dialysis devices for the treatment of patients with end -stage kidney failure: Wishful thinking or just over the horizon DOI: 10.1007/s00467-014-2968-3
- [53] Bradley A et. al., Optimal Care of the Infant, Child, and Adolescent on Dialysis:2014 Update Doi.org/10.1053/j.ajkd.2014.01.430.
- [54] Ai-Ching Boon et. al., Circulating bilirubin and defense against kidney disease and cardiovascular mortality: mechanisms contributing to protection\* in clinical investigations DOI: 10.1152/ajprenal.0039.
- [55] Karlienfrancois and joanne M bargman Evaluating the benefits of home-based peritoneal dialysis Doi.org/10.2147/IJNRD.S50527.
- [56] Veena D Joshi. K.G Quality of life in end stage renal disease patients Doi: 10.5527/wjn.v3.i4.308
- [57] Nader aghakhniet. al., Content analysis and qualitative study of hemodialysis patients, family experiences and perceived social support Doi: 10.5812/ircmj.13748.
- [58] Kristen L. Jablonski and Michel Chonchol Recent advances in the management of hemodialysis patients: a focus on cardiovascular disease Doi:10.12703/P6-72.
- [59] Hsiao-Chien Chen, Hsiu-Chen Lin Innovative strategy with potential to increase hemodialysis efficiency and safety Doi: 10.1038/srep04425.
- [60] William H. Fissellet. al., Achieving more frequent and longer dialysis for the majority: Wearable and Implantable artificial kidney device Doi: 10.1038/ki.2012.466;.
- [61] Charles chazot Thrice weekly nocturnal hemodialysis: the overlooked alternative to improve patient outcomes Doi: 10.1093/ndt/gft078.
- [62] Steven Kim and Shuvo Roy Microelectromechanical Systems and Nephrology: The Next Frontier in Renal Replacement Technology Doi: 10.1053/j.ackd.2013.08.006.
- [63] Gautham A, muhammed javad M Hemodialysis membranes: past, present and future trends Doi:10.7897/2230-8407.04505.
- [64]Ahmad Taher Azar, Dialyzer Performance Parameters, DOI: https://doi.org/10.1007/978.

- [65] Jeremy j song et. al., Regeneration and experimental orthotopic transplantation of a bioengineered kidney Doi: 10.1038/nm.3154.
- [66] Praveen tengseet. al., portable kidney machine.
- [67] Srinivasa R. Pullelaet. al., Permselectivity replication of artificial of glomerular basement membrane in Nano porous collagen multilayer Doi: 10.1021/jz200880c.
- [68] Eduardo Iecsonet. al., Survival with three times weekly in-center nocturnal versus conventional hemodialysis Doi: 10.1681/ASN>2011070674.
- [69] Anna Winterbottom et.al., Choosing dialysis modality: decision making in a chronic illness context Doi: 10.1111/j.1369-7625.2012.00798.
- [70] Aditi Nayak et. Al., Use of a peritoneal Dialysis Remote Monitoring System in India Doi: 10.3747/pdi.2011.00124.
- [71] Micheal E. Schachter Christopher T. Chan Current state of intensive hemodialysis: a comparative review of benefits and barriers <http://doi.org/10.1093/ndt/gfs506>.
- [72] John b. stokes et. al., nocturnal hemodialysis: analysis following the frequent hemodialysis network trails doi: 10.1111/j.1525-139x.2011.01.1001x..
- [73] Steven Rosansky, Richard J. Glasscock and William F. Clark Early Start of Dialysis: A Critical Review DOI: 10.2215/CJN.09301010.
- [74] Eduardo Lacson and Steven M. Brunelli Hemodialysis Treatment Time: A Fresh Perspective DOI: 10.2215/CJN.00970211.
- [75] Jorge cerdaet. al., Critical care nephrology: management of acidic-base disorders with CRRT Doi: 10.1038/ki.2011.243.
- [76] Ronco C et. al., The future of the artificial kidney: moving towards wearable and miniaturized devices Doi: 10.3265/nefrologia.pre2010.Nov.10758.
- [77] Farah Tasnim. et. Al Achievements and challenges in bio artificial kidney development Doi: 10.1186/1755-1536-3-14.
- [78] Antonio Santoro and Gualtiero Dialysis membrane: from convection to adsorption Doi: 10.1093/ndtplus/sfq035.
- [79] John T. Daugirdas, James E. Tattersall Automated monitoring of hemodialysis adequacy by dialysis machines: potential benefits to patients and cost savings Doi: 10.1038/ki.2010.218.
- [80] Robert H. Maket. al., Recent advances in chronic dialysis and renal transplantation in children Doi: 10.1007/s00467-008-1102-9.
- [81] Victor Gura, Alexandra S. Macy, Technical Breakthroughs in the Wearable Artificial Kidney (WAK) Doi: 10.2215/CJN.02790409.
- [82] Joseph A. Cafazzoet. al., Patient-Perceived Barriers to the Adoption of Nocturnal Home Hemodialysis Doi: 10.2215/CJN.05501008.
- [83] Poyyapakkam Srivatsa, Craig Wong Nutrition aspects in children receiving maintenance hemodialysis: impact outcome Doi: 10.1007/s00467-007-0728-3.
- [84] Vimala Chadha Dialysis associated peritonitis in children Doi: 10.1007/s00467-008-1113-6.
- [85] Masataka Honda and Bradley A. Warady Long-term peritoneal dialysis and encapsulating peritoneal sclerosis in children DOI: 10.1007/s00467-008-0982-z.
- [86] Zbylut J Twardowskiet. al., History of hemodialyzer's design Doi: 10.1111/j.1542-4758.2008.00253x.
- [87] Ashish Upadhyay et. al., Single-Use versus Reusable Dialyzers: The Known Unknowns Doi: 10.2215/CJN.01040207.
- [88] Brendan B. McCormick and Joanne M. Bargman Noninfectious Complications of Peritoneal Dialysis: Implications for Patient and Technique Survival Doi: 10.1681/ASN.2007070796.
- [89] Deray G Dialysis and iodinated contrast media DOI: 10.108/sj.kj.5000371.
- [90] W. SulowiczA. Radziszewski Pathogenesis and treatment of dialysis hypotension Doi: 10.1038/sj.ki.5001975.
- [91] Saudanet. al., Adding a dialysis dose to continuous hemofiltration increases survival in patients with acute renal failure Doi: 10.1038/sj.ki.50001705.
- [92] Muriel P. C. Grooteman and Mareille Gritters Patient characteristics rather than the type of dialyser predict the variability of endothelial derived surface molecules in chronic haemodialysis patients Doi: 10.1093/ndt/gfi126.
- [93] Edmund G. Lowrie, Zhensheng Li Norma PMID: 15496182.
- [94] Luanapillonet. al., Vector length as a proxy for the adequacy of ultrafiltration in hemodialysis Doi: 10.1111/j.1523-1755.2004.00881.x.
- [95] Mervyn Dean, MB, ChB, CCFP Opioids in Renal Failure and Dialysis Patients doi:10.1016/j.jpainsymman.2004.02.021.
- [96] Stephan troyanovet. al., Solute clearance during continuous venovenous hemofiltration at various ultrafiltration flow rate using multiflow-100 and HF-1000 filters Doi: 10.1093/ndt/gfg055.
- [97] Zbylut J. TwardowskiPHD®: the technological solution for daily hemodialysis, Doi: 10.1093/ndt/18.1.19.
- [98] Barry Kirschbaum The effect of hemodialysis on electrolytes and acid-base parameters Doi: 10.1016/S0009-8981(03)00333-4.
- [99] Alfred K. Cheung et al., Effects of High-Flux Hemodialysis on Clinical Outcomes: Results of the HEMO Study Doi:10.1097/01.ASN.0000096373.
- [100] Malvinder S Parmar, Chronic renal disease PMID: 12114240.