

Implantable Bio Artificial Kidney Fused With Activated Carbon and HEMO-Filter

Khaleel Naina Mohammed M M S¹, Arun mitharan G¹, Bhuvanesh Kumar R¹, Kirubasankar.K²

Final year B.E, Department of Electronics and Communication Engineering, Chennai Institute of Technology,
Kundrathur, Chennai, India ¹

Associate Professor, Department of Electronics and Communication Engineering, Chennai Institute of Technology,
Kundrathur, Chennai, India ²

ABSTRACT: The main aim of our project is to reduce the death that is caused by kidney failure and to make every people to get a treatment at low cost towards kidney failure and to hit upon the criterion pro this genus of quandary, so as a upshot we have accomplished with this proposal, so far Hemodialysis was only the remedy for kidney failure but it is only a transitory alleviate which is an cyclic progression which is said to be done for 2 to 3 times in a week as per the patientss stipulation and the time in use for this progression is about $4\frac{1}{2}$ hours. Here we have made the idea to create an implantable “ARTIFICIAL KIDNEY” which is meant to be fused with Activated Carbon and Hemo Filter, here the blood is driven through the module and the blood is been purified within a specified time limit and its efficiency is 50% of the Natural Kidney.

KEYWORDS: Kidney failure, cell regeneration, Activated Carbon, Hemo Filter, Patients, artificial kidney.

I. INTRODUCTION

The kidney is a main organ for the human body, which helps in removing the salt content and other toxic materials from blood it is connected to the urinary bladder, in India 5 lakh people are suffering from kidney failure and every year 1 lakh people are added to this list. The kidney is located on both side of the spinal cord above the hip and behind the stomach each kidney will be in the size of fist; kidney is 10-12 cm long, 5-6 cm wide and 3-4 cm thick and weighs approximately 150 gm^[1]. Our kidneys purify around 1500 liter of blood and convert it into approximately 1.5-litre urine per day. 1200ml of blood flows through both the kidneys per minute and out of it 1 ml of urine is formed per minute. They convert vitamin-D from 25-Dihydroxy cholecalciferol to 1:25 Dihydroxy cholecalciferol, which absorbs calcium from intestine and makes bone strong. Kidneys also help in formation of the red blood cells (which are formed in bone marrow) by releasing erythropoietin hormone^[1].

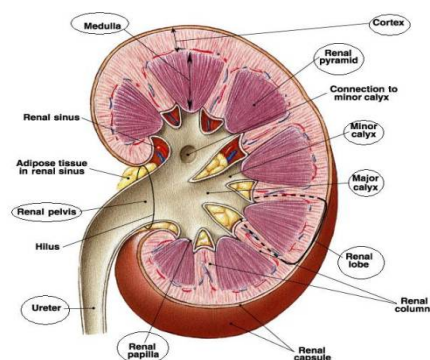


Fig 1 Actual kidney and its description^[1]

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

As per the doctor the kidney failure occurs to people who are suffering from high blood pressure, diabetes and johndiece, these factors gives rise to the increase in urea, creatinine, phosphate, Sulphate etc., and eating of junk foods can cause this problem, kidney failure mainly occur to the people of all age, the only method to rectify this process is only by doing dialysis^[2].

The machine consists of two needles connected to the vein and a glucose bottle and an operation is done to increase vein diameter for the quick absorption of blood by the filter to remove the toxic content from the blood, this process can be of twice or thrice a week and for four hour duration or else kidney transplantation can be done but it would cost around Rs.8 Lakh so we have planned to modify the process by creating an artificial kidney which could cost around 2 lakh and it can do the same process as the kidney does and it is purely operated by electronic systems and this is an feasible because there is an huge demand for kidney transplantation. So we can make a huge profit out of it.

The design and structure is a greatest challenge because already this type of artificial kidney is found but it is externally fixed like a Hemo-dialyser which is portable^[3]. So our plan is to reduce the size and increase the efficiency and to reduce the cost.

II. FUNCTION OF KIDNEY AND ITS MALFUNCTION

Our kidney constitutes lacs of filters and 140-mile long tubules in approximation. The main functional unit of kidney is nephrons. Each kidney comprises approximately 10 lac Nephron^[4]. Filters filter the blood and the filtered blood is sent to the tubules.

The tubules reabsorb useful substances such as sodium, potassium, calcium etc from the liquid and approximately 1.5 liter urine comes out from the body as per a normal victim. There are many reasons for kidney failure but the prominent ones are the following:

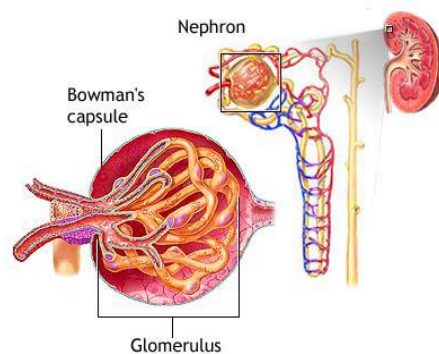


Fig 2 Filtration unit of the Kidney Nephron^[4]

1. Diabetes Mellitus.
2. High Blood Pressure.
3. Some medicines such as taken for relieving pain (pain killers) and other unnecessary medicines.
4. Dehydration that is less amount of blood and water in the body due to vomiting, cholera and diarrhea etc.
5. Inflammation of filters of the kidney due to which proteins are lost in urine and this process is called Glomerulonephritis. Healthy kidney does not allow proteins go in urine .Formation of stones in kidney and urinary system
7. Obstruction in the flow of urine.

Types of Kidney Failure that occur instantly
There are three main types of kidney failure

1. Acute Renal Failure –

This can be treated and cured as the kidney is in diseased state for a short time, which results in reversible damage. Its causes include reduction in level of water in body (dehydration) due to cholera, excessive diarrhea and vomiting, low blood pressure, side effects of medicine and infection etc.

2. Chronic renal failure –

This can be treated but cannot be cured as the kidney is in diseased state for a long period, which results in irreversible damage. Its causes are diseases like long duration of uncontrolled diabetes, high blood pressure, swelling of membrane

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

etc. It requires life-long dialysis or kidney transplantation.

3. Nephrotic Syndrome –

Proteins are lost from the kidney in urine, which leads to swelling up of body and eventually results in kidney failure^[5].

Symptoms of Kidney Failure

Even if one kidney is removed from a person, the person can still lead his life with the other healthy kidney. Symptoms of kidney failure develop when both the kidneys are damaged^[6].

The following can be some of the symptoms:

1. swelling of the body.
2. Decrease in appetite.
3. Recurring vomiting or nausea.
4. Reduction in blood hemoglobin level
5. Weakening of bones (osteoporosis).
6. Fatigue/ weakness.
7. High blood pressure.
8. Reduction in urine formation.
9. Breathlessness.



Fig 3 Symptoms of Kidney Failure

As per all the analysis made there are many causalities are reported to transplant kidney daily by means of illegal form of work and due to the economic condition of a family or an person so by means of this.

Existing System:

The existing method as a cure for kidney failure is hemo dialysis, here the blood of an patients is meant to be dissolved with salts and other by products, so as a result the patients's Kidney malfunctions and at the end it fails to work. This can be rectified by doing dialysis, in which a machine is meant to do the work of the kidney and here the patients's blood is driven via an hemo filter and dialysate is also passed^[6].The contaminated blood is meant to be purified, the toxin and major salt content are being removed and it is an periodic process and which a patients is meant to in rest position for 5hrs and by this process we are only capable to replace about 13% of actual kidney process and still lack behind by 83% and this highest ratio can cause adheres effect towards patients by means of swelling of legs, lack of immunity etc.,

Hemo filter is the main component that is being used in a dialysis machine.

Hemofilter contributes to the stabilization of hemodynamics in patients with systemic inflammatory response syndrome (SIRS) due to a mechanism other than the removal of cytokines^[7].Seven critically ill patients who met criteria for SIRS with unstable hemodynamics requiring vasopressors after emergency surgery.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

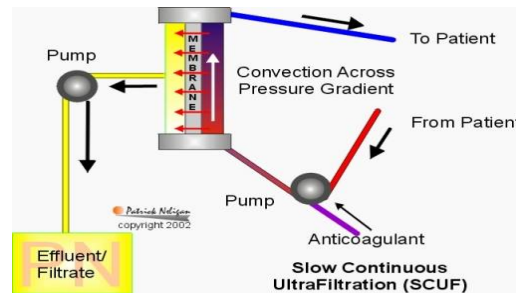
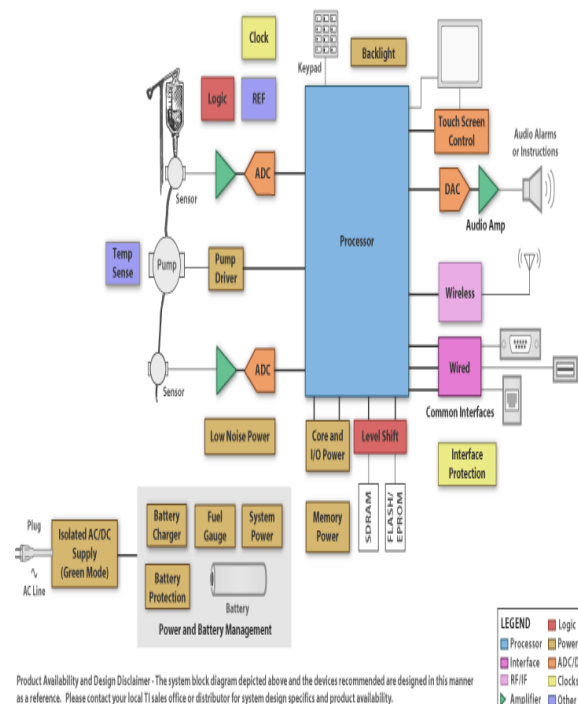


Fig 4 Flow Of Blood through an Hemo Filter During Hemo Dialysis



Vital signs were monitored continuously and hemo-dynamics were evaluated intermittently. The blood level of endotoxin and the plasma levels of cytokines were measured at 0 and 6 h. Changes in plasma levels of cytokines passing through the hemo-filter were evaluated at 3 h. A significant decrease of body temperature ($P < 0.05$ at 3 and 6 h vs 0 h), a significant elevation of mean arterial pressure ($P < 0.05$ at 0.5 h, $P < 0.01$ at 3 and 6 h vs 0 h), and a significant increase of urinary flow rate ($P < 0.05$ at 0 to 3 h vs -3 to 0 h) were observed with ECC. Neither the blood level of endotoxin nor the plasma levels of cytokines decreased. A significant increase of plasma IL-6 as it passed through the hemo-filter was noted^[9]. Here the hemo filter efficiency and its durability are meant to be tested so as they can vulnerable to damage.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

Fig 5 Block diagram of Hemo-Dialysis Machine used to purify the salt content of blood.

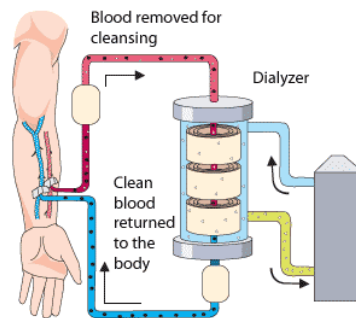


Fig 6 Process of dialysis that takes place in the hemo filter of a dialysis machine

The above fig (3) & (4) shows how the exact process of dialysis happens here the blood is taken from the arteries and purified blood is again sent into the body by means of the veins for this sort if removal of blood from body an surgery is done near the wrist and it is called as fistula for the process of dialysis fistula is mandatory^[8].

Proposed System

The proposed system is that an idea of implanting the artificially made kidney into an patients so that it is meant to be effective about 100% of the natural kidney process the below given is the block diagram of the module

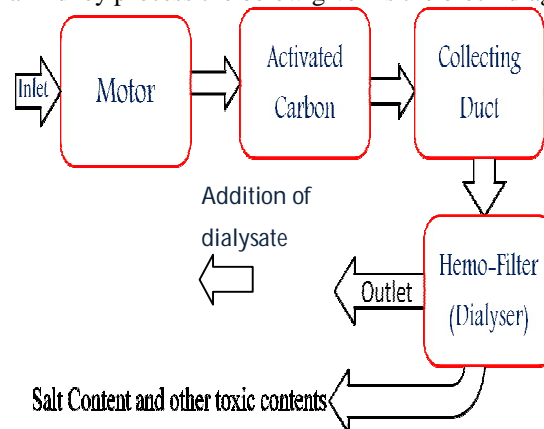


Fig 7 Block diagram of the proposed system

Here it is proven that by this method of replacing the affected kidney we can get absolute and accurate result in this method over dialysis.

Construction of the module

The module consists of majorly two parts they are Activated Carbon and Hemo Filter and for the model purpose the motor is being used as we can be able to show model similar to the actual blood flow along the veins of the kidney and we can be able to describe it by means of the actual system the implantable model will be of this format given below.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

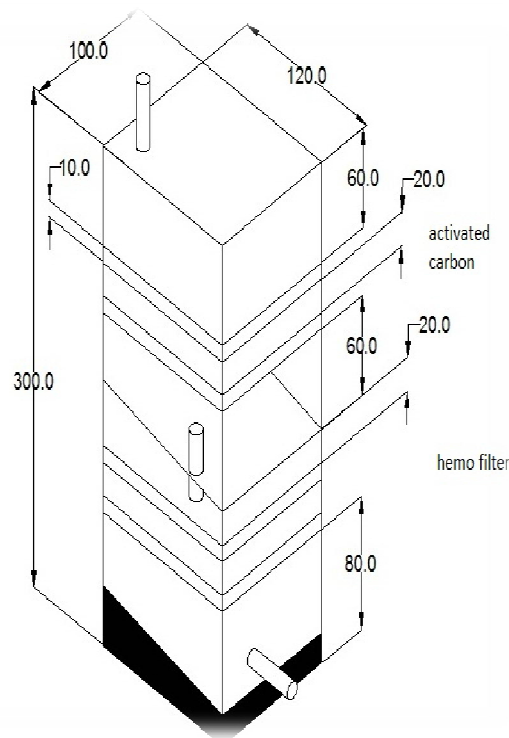


Fig 8 Proposed model that can be implanted and the size is to be reduced by 15 times so that it can be implanted into the patients

The module is meant to contain two layers of activated carbon and two layers of hemo filter each layer is separated by an distance so that there can be an constant flow of blood along the device and there will not be any variation with the level of blood pressure and its viscosity and the equation for blood viscosity is given below

III. WORKING PROCESS OF THE SYSTEM

Here first the blood enters AC-1 Chamber there the dust particles are removed and 6% of the toxin and salt by products are being removed so as an result we have achieved almost 50% working of an dialysis machine so as per then, it passes to the AC-2 Chamber there the remaining salt contents are being

removed. Now almost 28% of the purification process is been done, so as then the blood flow is intended to mix with the dialysate so that it does not clots internally and it traces are found in the inner stratum of the device, Now it passes through the tiny absorbent membranes of the hemo-filter there hemo filter filters the undue salt and other residual salt contents. Mainly Creatine, Potassium, Phosphate, Sulphate are being removed so as they are meant to have a flow of prudent manner then the salt content are collected in a separate duct and the excessive toxins are also collected and the pure blood alone is meant to flow along the blood stream. The sample that is tested by means of the device is given below

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

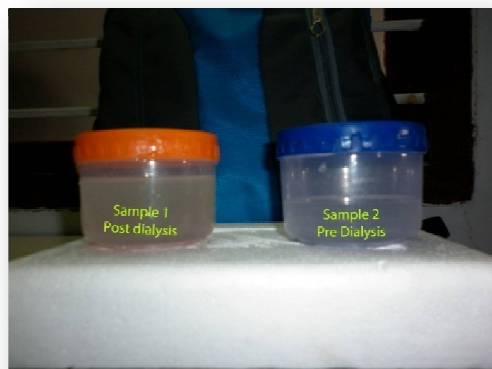


Fig 9 Sample that is being tested during the process

We can see the color change in the Solution as sample 1 is obtained from a patients and it is being tested through the equipment and sample 2 clear solutions is obtained at the end of the process.

V. CONCLUSION

We have proposed this method for human welfare and as the existing treatment for kidney failure is costlier, which is not affordable by many and they are left to die so we made this idea and by introducing this project we can help all 5lac people of India and the rest of the world suffering from kidney failure. The main aim is only to reduce the death rate that is being caused by Chronic Kidney Failure (CKT). The regional and the premature results show great change in the rate of pH reduction, Clearance level of Creatine, Urea, Phosphate, Potassium and Sulphate. So this is feasible to the society and this has a greatest advantage that every person can use it there is no condition of perfect blood equality which is required by actual kidney transplantation with a donor.

Table 1 the preliminary results of the system

| Result | S 1 | | S 2 | | S 3 | | Unit |
|------------------------------|-------|------|-------|-------|------|------|----------|
| Effective Urea Clearance | 39.8 | 24.1 | 40.6 | 28.3 | 37.2 | 18.3 | [mL/min] |
| Effective Creatine Clearance | 40.9 | 25.1 | 43.1 | 28.3 | 28.9 | 22.5 | [mL/min] |
| Total Urea Removal | 15.3 | 12.4 | 19.7 | 14 | 11.1 | 10.2 | [g] |
| Total Phosphate Removal | 1.7 | 0.8 | 1.7 | 0.9 | 1.5 | 0.72 | [g] |
| Total Potassium Removal | 150.5 | 80 | 167.5 | 100 | 162 | 76.3 | [g] |
| Total Creatine Removal | 1.7 | 0.9 | 2.5 | 1.3 | 2.1 | 0.76 | [mmol] |
| Extrapolated Kt/V | 7.7 | 6.9 | 8.2 | 8.8 | 7.2 | 5.7 | - |
| pH Value | 12.4 | 11.9 | 13.3 | 12.26 | 13.1 | 9.68 | On Scale |

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

This table is done for the various samples collected from a patients named **Mohideen peer Kasaali S** and the test results of the sample is meant to effective throughout the process of the system here the primary results of the systems are compromisable for further development of the system and this can be implemented for the human use once it is being approved by the Indian medical council(IMC),we are near to the final stage of output.

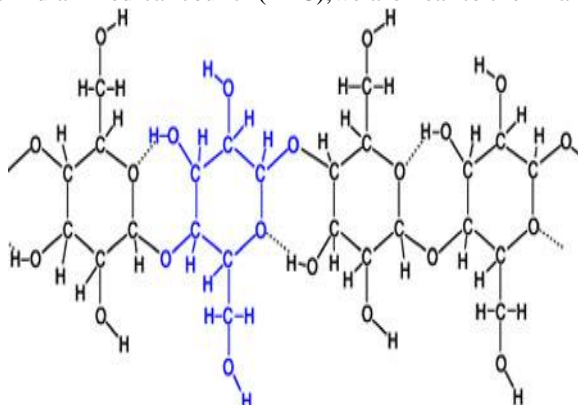


Fig 10 activated Structure of the activated carbon that is being used

Here the structure of the activated carbon is similar to the exact structure that is available but here the chain linkage is broken so the each link exhibits differential method of activation and its regulation are greater.



Fig 11 Activated carbon of IV value 1000 that is being used and mbs value about 350

REFERENCES

1. William H. Fissell, Shuvo Roy and Andrew Davenport. Achieving more frequent and longer dialysis for the majority: wearable dialysis and implantable artificial kidney devices (2013) 84, 256–264; doi:10.1038/ki.2012.466; published online 13 February 2013
2. Sung Joon Shin, Current status of bioartificial kidney, J. Biomedical Science and Engineering, 2014, 7, 108-111 <http://dx.doi.org/10.4236/jbise.2014.73014>
3. Davenport A, Gura V, Ronco C et al. A wearable hemodialysis device for patients with end-stage renal failure: a pilot study. Lancet 2007; 370: 2005–2010.
4. Bomar JB, Decherd JF, Hlavinka DJ et al. The elucidation of maximum efficiency-minimum cost peritoneal dialysis protocols. Trans Am Soc Artif Intern Organs 1974; 20A: 120–129.
5. Moncrief JW, Popovich RP, Nolph KD. The history and current status of continuous ambulatory peritoneal dialysis. Am J Kidney Dis 1990; 16: 579–584.
6. Ronco C, Fecondini L. The Vicenza wearable artificial kidney for peritoneal dialysis (ViWAK PD). Blood Purif 2007; 25: 383–388.
7. Davenport A. Role of dialysis technology in the removal of uraemic toxins. Hemodial Int 2011; 15(Suppl 1): S49–S53.
8. Lee DBN, Roberts M. A peritoneal based automated wearable artificial kidney. Clin Exper Nephrol 2008; 12: 171–180.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

- Maroni BJ, Steinman TI, Mitch WE. A method for estimating nitrogen intake of patients with chronic renal failure. *Kidney Int* 1985; 27: 58–65.
9. Gura V, Ronco C, Nalesso F et al. A wearable haemofilter: first human study of slow continuous ambulatory ultrafiltration. *Kidney Int* 2008; 74: 497–502.
10. Sergeyeva O, Gorodetskaya I, Ramos R et al. Frequent Hemodialysis Network Trials Group. Challenges to enrollment and randomization of the Frequent Hemodialysis Network (FHN) Daily Trial. *J Nephrol* 2012; 25: 302–309.
11. Humes HD, Weitzel WF, Bartlett RH et al. Initial clinical results of the bioartificial kidney containing human cells in ICU patients with acute renal failure. *Kidney Int* 2004; 66: 1578–1588.
12. Fissell WH, Manley S, Westover A et al. Differentiated growth of human renal tubule cells on thin-film and nanostructured materials. *ASAIO J* 2006; 52: 221–227.
13. mllearning.zju.edu.cn/.../20111216134747_555627784412.pdf
14. www.mhprofessional.com/.../jameson_nephrology_ch10_p097-112.pdf
15. <http://www.nlm.nih.gov/medlineplus/kidneyfailure.html>