HOME DIALYSIS

HOW COULD THE DIALYSIS TREATMENT BE OPTIMIZED IN ORDER TO MINIMIZE THE AFFECT TO THE PATIENTS LIVES?
INTRODUCTION

My mother was born with only one functional kidney. This was known to her at the age of 19 and with this she also were told that her kidney wouldn’t be strong enough to function fully her entire life. 7 years ago her kidney didn’t have the power to do all the job by itself and she had no other choice than to begin her dialysis.

My mother chose to do peritoneal dialysis which took her about 12 hours a week for about a year before her phone rang and a kidney with her blood type was waiting in the hospital to be transplanted to her. The reason why she only had to wait a year before the transplant was that she have an unusual blood type. Others usually have to wait much longer than that.

The problematics I found when my mother was on dialysis still affects one and that is one of the reasons why I’ve chosen to do my degree work on this subject.

Another reason why I chose this subject is to raise the question of how home care is supposed to be designed in the future. The gains of home care can be great both for patient and society. If the home care market increases a new type of medical appliances must be produced to this new need. Due to shifting context and user to medical products there must be adaptation to this which today seems far away. I want to give an example of how this better could be done to integrate the medical appliances to the users and their home.
The kidneys are organs that serve several essential regulatory roles in most animals, including the regulation of water, electrolytes, and acid–base balance. They serve as the body’s waste filter, removing toxins and excess electrolytes from the blood. The kidneys are located on either side of the spine, retroperitoneally. In humans, they are situated in the retroperitoneal space, which is a region between the posterior abdominal wall and the anterior abdominal wall. Each kidney is about the size of a fist and weighs between 125 and 170 grams in males and between 115 and 155 grams in females.

The kidneys are responsible for filtering blood to remove waste products and excess electrolytes. They also regulate the body’s fluid balance and blood pressure. The kidneys produce hormones that help maintain blood pressure, such as renin, which plays a role in sodium and water balance, and erythropoietin, which刺激ulates the production of red blood cells.

The kidneys receive blood from the renal arteries and drain into the renal veins. Each kidney excretes urine into a ureter, which empties into the urinary bladder. The ureters are responsible for transporting urine from the kidneys to the bladder, and the bladder stores urine until it is excreted.

In summary, the kidneys are vital organs that play a crucial role in maintaining homeostasis in the body. They filter blood, regulate fluid balance, and produce hormones that influence electrolyte balance and blood pressure. Proper kidney function is essential for overall health and well-being.
RENAL FAILURE

CAUSES

SYMPTOMS

CLASSIFICATIONS

AKI can result from a variety of causes, generally identified as prerenal, intrinsic, and postrenal. The underlying cause must be identified and treated as soon as possible, and dialysis may be necessary to avoid a toxic state required for treating functional kidney failure.

Acute renal failure (ARF) can be present on top of acute renal disease, a condition in which a sudden rise in blood pressure causes a temporary drop in renal perfusion, and the glomerular filtration rate (GFR) is less than 10% of normal. In ARF, the patient is hemodynamically shock. ARF can be acute or chronic renal failure (AoCRF). The acute part of AoCRF may be present on top of chronic kidney disease, a condition in which the kidneys have been damaged for an extended period of time. The chronic component may be fully reversible, but may be due to poor diet or medication or nephrotoxicity.

Renal failure can occur for a number of reasons in which the kidneys fail to filter the blood. The two main types are acute renal failure and chronic kidney disease. The underlying cause must be identified and treated as soon as possible, and dialysis may be necessary to avoid a toxic state required for treating functional kidney failure.

Acute kidney injury (AKI), previously called acute renal failure (ARF), is a rapidly progressive reduction in renal function. A large number of factors can cause AKI, including sepsis, surgery, trauma, or a medical condition such as diabetes. Some common factors are reviewed in the following sections.

Acute kidney injury (AKI) is a medical condition in which the kidneys suddenly fail to filter the blood. Causes of AKI include sepsis, trauma, or a medical condition such as diabetes. Some common factors are reviewed in the following sections.

Acute-on-chronic renal failure (AoCRF) is a condition in which the kidneys fail to filter the blood. Causes of AoCRF include sepsis, trauma, or a medical condition such as diabetes. Some common factors are reviewed in the following sections.

Acute kidney injury (AKI) is a medical condition in which the kidneys suddenly fail to filter the blood. Causes of AKI include sepsis, trauma, or a medical condition such as diabetes. Some common factors are reviewed in the following sections.
Dr. Willem Kolff, a Dutch physician, constructed the first working dialyzer in 1943 during the Nazi occupation of the Netherlands. Due to the scarcity of available resources, Kolff had to improvise and build the initial machine using sausage casings, beverage cans, a washing machine, and various other items that were available at the time. Over the following two years, Kolff used his machine to treat 16 patients suffering from acute kidney failure, with the first patient surviving for only 11 hours. Following this, a 67-year-old comatose woman regained consciousness and lived for another seven years before dying from an unrelated condition. She was the first-ever patient successfully treated with dialysis.

http://en.wikipedia.org/wiki/Dialysis#History
Chronic kidney failure is measured in five stages, which are based on a patient’s glomerular filtration rate (GFR). Stage 1 CKD is mildly diminished renal function, with few overt symptoms. Stages 2 and 3 need increasing levels of supportive care from medical providers to slow and treat renal dysfunction. Patients in stages 4 and 5 usually require preparation of the patient towards active treatment in order to survive. Stage 5 CKD is considered a severe illness and usually requires some form of renal replacement therapy (dialysis) or kidney transplant in order to live.

Hemo dialysis means “cleaning the blood” and that’s exactly what this treatment does. Blood is withdrawn from the body by a machine and passed through an artificial kidney called a dialyzer.

There are several different kinds of dialysis machines, but they work in almost the same way. A dialyzer (artificial kidney) is attached to the machine. The dialyzer has two spaces: a space for blood and a space for dialysis fluid. Dialysis fluid is a special liquid which helps remove waste products from the blood. The two spaces in the dialyzer are separated from each other by a very thin artificial membrane. Blood passes on one side of the membrane and the dialysis fluid passes on the other side.

Hemo dialysis treatment normally takes four to five hours. Some people call a treatment a “run”. Usually, you need three treatments (or “runs”) a week. However, certain people may need more frequent treatments or longer treatments. Sometimes shorter treatments are sufficient.

Hemo dialysis is done in a hospital dialysis unit where nurses, nephrologists and other medical support staff are available. Once a patient on hemo dialysis is stable, it may be possible to have hemo dialysis treatments in a clinic away from the hospital, in a self-care centre (with some help from the staff), or at home. Special training is needed for self-care or home hemo dialysis.

Strengths
- Relieves symptoms of uremia
- Works quickly and efficiently
- Requires at least three treatments a week, each four to eight hours
- Most people have suitable blood vessels for establishing an access site

Limitations
- You will have to take medications, learn new food choices, and restrict your intake of fluids
- Access to the bloodstream is with needles, which some people find difficult
- You must plan your week around your hemo dialysis schedule (although with home hemo dialysis, you can plan your treatment schedule around your week)
- You may need to travel some distance to the dialysis unit

Some people do not have suitable blood vessels for establishing an access site.

PERITONEAL DIALYSIS
Peritoneal dialysis is another form of dialysis used to remove waste products and excess water. It works on the same principle as hemo dialysis, but your blood is cleaned while still inside your body rather than in a machine.

In peritoneal dialysis, the inside of your abdomen—your peritoneal cavity—is filled with a special dialysis fluid that looks like water. This exposes blood vessels in the peritoneum to the fluid. The peritoneum functions just like the artificial membrane in a dialyzer. Excess water and wastes pass from the blood through the peritoneum into the dialysis fluid. The fluid is then drained from your body and discarded, and the process is repeated four to six times in every 24- hour period.

In peritoneal dialysis you always have dialysis fluid in your peritoneal cavity, so your blood is constantly being cleaned. The fluid is changed at regular intervals throughout the day.

Strengths
- You are using the form of dialysis.
- You will have to learn new food choices
- You will need to be near a dialysis centre

Limitations
- Permanent catheter in your abdomen
- Possibility of peritonitis (infection of your peritoneal cavity)
- Dialysis must be a daily part of your life
- You will have to take medications
- You will need to learn new food choices
- You will need to prevent the catheter from getting wet (no swimming)

Some people do not have suitable blood vessels for establishing an access site.

With advances in kidney transplant methods and improvement in transplant success, a kidney transplant is now widely considered to be the best way of treating chronic kidney disease for many people. A transplant may offer the best chance of restoring a more normal life, but it is not suitable for everyone.

Factors that can affect a person’s suitability for a transplant include:

- General health
- History of heart disease
- History of blood circulation problems
- History of cancer
- Emotional/psychological factors
- Evidence that a person does not or will not follow the medical treatment suggested
- Obesity

There are two types of kidney transplants:

1. Transplant from a live donor
2. Transplant from a person who has died suddenly

Following a series of tests, a person found suitable for a transplant is put on a transplant waiting list until a compatible kidney is found. The length of time a person will have to wait to be treated will depend on how hard the person is to match and how many kidneys become available.

Before any transplant, some of the recipient’s blood and some of the donor’s cells are mixed together to see if the recipient’s blood will damage or kill the donor’s cells. This is called a cross match and is done to make sure that there are no substances in the blood, called cytotoxic antibodies, that may cause the recipient’s body to reject the transplanted kidney. A positive cross match means that the organs are not suitable for that recipient, and the organ is not used to treat a kidney.

Overall, transplant success rates are very good. Transplant from a deceased donor has an 85 to 90% success rate for the first year. That means that after one year, 85 to 90 out of every 100 transplanted kidneys are still functioning. Long-term success is good for people of all ages.


Dialysis is a treatment while waiting for a new kidney to be transplanted, but many patients never get a donor.
MARKET

COMPETITION

PRODUCTS

There are only a few companies worldwide which develop dialysis machines. While Fresenius is one of the biggest at the moment in Europe there is strong competition from Baxter which recently bought Swedish company Gambro. Nx-Stage is a relatively new market competitor who focuses on a stand alone system which can be brought with the patient and therefore more flexible.

The Nx-stage system is the only system right now which focuses on the flexibility of the patient. Unfortunately there are a lot of opinions on how well the treatment works. It’s easy to say the Nx-stage is great compliment to the regular treatment, but this will probably change when other competitors start to develop similar products.
The cost for Hemo treatment depends on which hospital the patient is treated on and it could vary from about 3000 SEK up to 6000 SEK / treatment. This means that one dialysis patient costs about 1.200 000 SEK annually compared to a patient with home HD which costs about 50% or less.

The costs for the patient could be devastating when on dialysis treatment due to the loss of monthly income. Because of the time it takes to do the treatment many have to quit their job or at least go down to part time. If the patient is without partner he or she have to rely on social care.

<table>
<thead>
<tr>
<th>HOME HD</th>
<th>HOSPITAL HD</th>
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<tr>
<td>ANNUAL COSTS</td>
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<tr>
<td>600 000 SEK</td>
<td>1.200 000 SEK</td>
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<tr>
<td>HD MACHINE</td>
<td>HD MACHINE</td>
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<td>28 750 SEK</td>
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<tr>
<td>(based on 230 000 / machine with 8 years of duration)</td>
<td>(based on 6000 per patient/treatment)</td>
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There are several examples of wearable artificial kidneys. What they all have in common is that the size still is too big and the technique too advanced for being practical to carry around. It could be a complement to the regular treatment in a few years but it is too far for being a realistic option in this project.

Artificial kidneys could be one way to solve the problem of insufficient donors but the technical question is present here as well.

The most interesting trend right now is stem cell research. When the opportunity to rebuild a healthy kidney within the patient.

It's an interesting thought to try to design a biological programmed artificial kidney. If we could rebuild the kidneys, would we do them at the same way as nature once did, or could we modify it for increased functionality?

What all of this trends have in common is that they are all held back by our knowledge of the moment and therefore it is impossible to say how such a product would work.
**INTERVIEW A NURSES**

"...The most frequent problem is patients who start to feel comfortable... then they miss on the routines..."

"...If they don't follow protocol and air gets into the system they usually have to start all over again..."

"...when patients remove the scabs before inserting needles it's very important to be sterile due to infections..."

"...some patients have problems removing scabs..."

"...one patient here is allergic to the tape which we use for needles..."

**CONCLUSION**

Patients are human beings and makes mistakes. How could the mistakes be minimized and patients independence be optimized?
INTERVIEW B

PROBLEMS

"...The delivered dialysis is 44/1 parts water..."

"...I’ve heard that the sound and light from the machine is difficult to sleep with,..."

"...There could be micro air bubbles in the system which the sensors miss sometimes..."

"...If the water filtration and dialysis is from two different producers they need separate operation..."

"...Sometimes it’s difficult to know what the problem with the machine is if the patient don’t remember what the error code was..."

"...It’s a dilemma to bring the machine to the patient and keep still the home as a home..."

"...the maximum distance from water filtration to machine is 10 m with the right circumstances..."

CONCLUSION

There are many small problems and uneffective processes which adds up to an complicated product which easily could be simplified in favor for both patients, nurses and doctors.

If the dialysis could be reduced from from water it would decrease occupied space with about 90 %.

Name: Per Jonsson
Profession: Medical technician
INTERVIEW C
FORMER PD PATIENT

PROBLEMS

"...I had to buy new furniture to use as storage... one coffin to keep equipment, and one closet to keep fluids... But I also used the volume under the bed for some stuff..."

"...In the end of each month my whole storage room was full of dialysis boxes..."

"...I did not want to invite people home because it felt like a hospital..."

"...the bag rack had to be kept in the middle of the room because it did not fit into the closet..."

"...the empty boxes almost took more space than the full cardboards..."

CONCLUSION

A lot of equipment is needed today in order to do a treatment of both PD and HD. If these products could be decreased with only a few it would decrease the space it takes to store it for a longer period of time.

Name: Lena Grusell
Age: 52
Family: Son
Profession: Preschool teacher

Former PD 1 year (transplanted)
21 h / week
INTERVIEW D

PD PATIENT

NAME: Björn Påhlsson
AGE: 40
FAMILY: Wife & 2 children
PROFESSION: Former restaurant staff

DIALYSIS CONNECTED ACTIVITY

24.00
12.00

T W T F S S

5 %

KIDNEY FUNCTION

PD 1 years
60h / week

PROBLEMS

"...The sound from the machine annoying nighttime..."
"...the machine is ugly, me and my wife have been talking about building some kind of box around it..."
"...We had to throw a lot of clothes and stuff to get more room for dialysis equipment..."
"I don’t want the feeling of a hospital when I am home..."
"...I can bring my dialysis with me but usually I do it at home anyway..."

CONCLUSION

If the machine could be designed to the context of the home instead of hospital use it would be easier to see problems such as sounds, aesthetics, cognitive problems etc.
INTERVIEW E
HD PATIENT

PROBLEMS

"...I think the relatives to a patient is affected the most..."
"...Dialysis takes 30h / week for me. 16 of those hours are traveling to the hospital..."
"...I miss the flexibility..."
"...It’s like a full time work..."
"...the tape that hold my needles loosen when it gets warm..."
"...It’s difficult to sleep while connected due to the tubes, I tumble around quite much..."

CONCLUSION

It’s not only the patient which have to live with the dialysis, family and friends get strongly affected due to the great changes of routines and high demands of planning.

Security and anxiousness hinders patients to do dialysis at night. If this could be changed the whole day of the patients could unaffected.

Name: Jan Evertsson
Age: 47
Family: Wife & 2 children
Kidney function: 5-10 %
Profession: Former carpenter

HD 2 years
30h / week

CONCLUSION

It’s not only the patient which have to live with the dialysis, family and friends get strongly affected due to the great changes of routines and high demands of planning.

Security and anxiousness hinders patients to do dialysis at night. If this could be changed the whole day of the patients could unaffected.

Name: Jan Evertsson
Age: 47
Family: Wife & 2 children
Kidney function: 5-10 %
Profession: Former carpenter
INTERVIEW F

HOME HD PATIENT

Name: Olle Jäger
Age: 65
Family: Wife
Kidney function: 10%
Profession: 50% lawyer

PROBLEMS

"...The machine is on the same side as your connected arm, this makes it difficult to operate it..."
"...The alarm sounds every time you move your arm..."
"...It’s hard to read and see when you connect yourself...

"...It would be nice to be able to use the evenings to something else..."
"...you need to plan your schedule in detail to be able to make it work..."
"...some of my friends think it smells like hospital and one don’t like blood so she won’t come in here..."
"...It would be nice to dialyse outside summertime...

"...the logistic system of order and delivery of equipment is ineffective... ...it’s by fax...

CONCLUSION

It’s clear that the machine is made for a second person to operate it while the patient is connected. Changing this mindset would strongly improve the product greatly.

A lot of logistics and planning around the dialysis creates more problems which could be fixed with a better overview.

It’s difficult to move while connected due to the artery pressure alarm sounding.

HHD 2 years
28h / week
INTERVIEW G
HOME HD PATIENT

Name: Kent Sandström
Age: 58
Family: Daughter
Profession: Retired / personal assistant

PROBLEMS

"...I’ve also made a rig to hold the tubes when I disconnect the needles... it’s difficult with only one free arm..."

"...I decide how much equipment I want every order... My delivery comes once a month..."

"...The dialysis is empty after 7 hours so I can’t do dialysis longer than 7 hours..."

"...I’ve made a screen-hider out of cardboard to decrease light at night..."

"...the water filtration is in my closet to decrease the sounds..."

"...You get used to it..."

CONCLUSION

If the machine is used nighttime the screen and sound disrupts before patient gets used to it.

The option of dimming the screen and soundproofing the machine would improve that.
OBSERVATION A
DONATING PLASMA

PROBLEMS
– Inserting big needles (HD needles are larger).
– Being connected to the machine locks you.
– The thought of the machine pumping your blood and then returning it feels wrong, unnatural.

CONCLUSION
The cognitive distress makes it difficult to set your own needles and patients would probably have to go some time on assisted treatment before starting inserting themselves.
PROBLEMS
- Depending on your home, some modifications must be done.
- Unknown people rebuilding your home.
- Connection to water system
- A space of about 3m² is dedicated for dialysis

CONCLUSION
A lot in the patient lives changes with renal failure. If home treatment is possible it’s needed for municipality, carpenters and doctors to visit the patient and start planning the modifications needed. This could be a very stigmatizing procedure.
OBSERVATION C
HOME DIALYSIS

PROBLEMS
- Start and end time
- Complex procedure
- A lot of alarms sound
- Alarms sound alike
- Time consuming
- Everything is not used
- The needle insertion takes time
- Needle insertion is cognitively difficult.

CONCLUSION
A lot of equipments is needed and point of inserting needles is a critical moment which the patient have to go through four days a week.

THIS IS NEEDED FOR ONE TREATMENT
1. Dialysis solution
2. Natrium Chloride
3. Dialysis filter
4. NaCl shots
5. Scab remover
6. Chlorhexidine (cleaning)
7. Cleaning kit
8. Start kit
9. Tape
10. Cannulas (needles)
11. Tube kit
12. Hand disinfection
13. Heparin (blood thinning)
14. Plaster
15. Bicarbonate
OBSERVATION D

HOME DIALYSIS

PROBLEMS
- Large area is dedicated for dialysis.
- Linoleum carpet brings the hospital feeling.
- The machine and all equipment don’t connect well to the rest of the home.
- It’s difficult to insert needles in comfortable chair so a second chair is needed with a table.

CONCLUSION
The machine is big, could the components be optimized in order to decrease space?
OBSERVATION E

HOME DIALYSIS PROBLEMS

- Light shines bright nighttime. Solved with cardboard blocking part of screen.
- Difficult to disconnect from tubes. Solved with workshop clamp acting as "third hand"
- Storage for all material and equipment needed. Delivery once a month. 15+ treatments.

CONCLUSION

Own solutions is needed in order to modify the machine for nocturnal dialysis.
It is clear that there are many critical points in the process of hemodialysis. Up to 20 different tools and equipment are used every treatment, which makes the process complicated and could easily result in a mistake in the process. By making this process easier with fewer steps, products, and a more logical flow, the risk of treatment failure would decrease.

It's also easy to see that the time it takes to prepare and finish the treatment is longer than it should be in order to be effective. If this time could be minimized, the time for dialysis or spare time could be longer.

THE DIALYSIS PROCEDURE

The dialysis procedure is as follows:

1 **MACHINE PREPARATION**
   - Turn machines on
   - Bring all gear to dialysis machine

2 **DRESS MACHINE**
   - Put dialysis fluid on machine
   - Connect to pump
   - Connect bicarbonate
   - Hang filter
   - Hang natrium chloride (primer)
   - Start test program

3 **MOUNT TUBES**
   - Open bag with tubes (red tube)
   - Connect to tube with primer
   - Connect to pump
   - Connect to filter
   - Connect to pressure sensor
   - (blue tube)
   - Hang fluid bag with primer (temp)
   - Connect to are guard #1
   - Connect to are guard #2
   - Connect to pressure sensor
   - Connect to filter

4 **SELF PREPARATION**
   - Take blood pressure
   - Clean start kit
   - Clean hands
   - Open needles
   - Prepare tape
   - Open shot
   - Fill shot with primer

5 **FILL MACHINE**
   - Connect machine to filter
   - Shake filter to fill all way and release air bubbles
   - Turn are guard #2
   - Close shot
   - Froze pressure
   - Open shot
   - Fill shot with primer

6 **ACCESS AV- FISTULA**
   - Disinfect hands and arms
   - Pull scab #1 of with needle
   - Push rounded needle into av- fistula
   - Pull scab #2 of with needle
   - Push rounded needle into av- fistula
   - Clean arm from blood
   - Rotate needles to right angle
   - Tape needles to arm
   - Connect shot with Primer to Needles (avoid coagulation)
   - Connect artery needle (red) to red tube
   - Inject anticoagulation into tube x 2
   - Connect vein needle (blue) to blue tube

7 **PROGRAM MACHINE**
   - Program amount of fluid removed
   - Program time
   - Push Ultra filtration button

8 **NOTE VALUES FOR DOCTOR**

9 **DIALYSIS**

10 **EMPTY TUBES**
   - Connect primer to get blood back

11 **REMOVE NEEDLES**
   - Place needle in needle holder
   - Remove needles

12 **UNLESS MACHINE**
   - Remove tubes
   - Remove primer
   - Remove natrium chloride
   - Remove filter
   - Remove fluid bag

13 **EMPTY WASTE**
   - Empty waste bag in sink
   - Throw in trash bag

14 **NOTE VALUES FOR DOCTOR**

15 **CLEAN MACHINE**
   - Use disinfection to clean machine from possible contamination
The hemo dialysis market is quite narrow and does not change form, expression or even that much size although it actually holds different segments within. On one hand there is the hospital machines which is big and bulky with a lot of different buttons and functions for all persons in contact with it. On the other hand there is the smaller machines which do the same work but with less visual impressions in order to make it easier for patients and nurses to read. But the differences between these two segments are thin. First times you see these machines it is difficult to see the differences.

If a new product could be made with focus on the patients it would probably result in an easier understandable machine for both nurses and technicians as well. By changing target group to those who actually uses it would be easier to develop a new product segment and take the opportunity to broaden the market with the trend of bringing treatment home.
In order to get a broader perspective on patients’ thoughts and wishes in a new machine I made a web-based questionnaire which I spread through forums and my contacts in Jönköping and Umeå.

I got really good responses from the participants and it suddenly became clear that patients in a strong group which have a lot of good ideas and suggestions on how to improve the machines and the dialysis process.

A lot of wishes was regarding the interface and using of the machine like bigger buttons and text but there were also a lot of wishes regarding the visual appearance of the machine which I did not expect. It was also clear that every patient wanted to integrate the machine like a piece of furniture when it was not in use and also wanted to hide the machine in a cabinet when not needed.

WISHES FROM PATIENTS

- Flexibility
- Smaller
- Quieter
- Better looks
- Built like an bookshelf
- Invisible
- Easier to prepare
- Lighter
- Be able to connect to any water source
- No bags
- Portable
- Better instructions
- Voice control
- Step by step instructions
- Built in lighting
- External display
- Color choices
- Covered
- Better buttons
- Better height on display
- Handle for easier movement
- Automatic cord retraction
- Bigger wheels

SURVEY WITH PATIENTS
### TIME
- No life like full time work
- Engaging in hospital takes time
- Dialysis takes time
- Preparation takes time
- Ending takes time
- Traveling to hospital takes time

#### What time should be spent dialyzing?

### SPACE
- Where do you store the HD machine?
- Where do you store the water cleaner?
- Where do you store all dialysis gear?
- Where do you store boxes after usage?

#### A lot of water is transported in dialysis

### COGNITION
- Connect thick needles to your self
- Difficult to understand software interface.
- Difficult to understand hardware interface.
- Sounding alarms (similar sound)
- Bad lights makes difficult reading.
- If arm raised - alarm sounds
- The ordering list sometime is misinterpreted
- The user sequence is illogical
- Water filtration and dialysis machine needs different operations if not same producer.

### SLEEPING
- The machine makes noises when active.
- The display shines bright at night.
- Getting stuck in tubes while turning in sleep.
- Alarm sounds when something is wrong.

### COST
- Energy consumption increases.
- Water consumption increases.
- Cost of hospital stay.
- Cost of patient not being able to work.

### STIGMA
- The HD machine is big and radiates the hospital feeling.
- Smell of hospital at home
- Rebuilding your home

### RELATION
- When sleeping connected to machine it is difficult to cuddle.
- Partner wakes up if machine sounds it alarm.
- Frustrating for relatives

### SAFETY
- Insecure due to 2dl blood is outside of body.
- Scared of not waking up if something is wrong.
- If needles disconnects while sleeping blood will be lost.
- If needles disconnects while sleeping blood will be lost.
- Insecure due to 2dl blood is outside of body.

### FLEXIBILITY
- Planning is needed in detail.
- Difficult to use own blood path.
- Difficult to use own blood path.
- Difficult to use own blood path.

### AESTHETICS
- Ugly machine
- Does not connect to the home
- The machine does not connect to the home aesthetically.

### HYGIENE
- Clean everything patient use
- Keep changing tool for use
- Keeping clean at home around machine

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<thead>
<tr>
<th>PROBLEMS</th>
<th>NIGHT DIALYSIS</th>
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<tbody>
<tr>
<td>TIME</td>
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<td>SPACE</td>
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The efficiency of hemodialysis compared to peritoneal dialysis means that time is saved if hemodialysis could enable larger flexibility.

The users are patients with renal failure which is in need of dialysis in order to clean their blood.

To affect the patients life as little as possible, it is most efficient to do dialysis at night while sleeping.

To relieve the patients from the mandatory hospital visits the most flexible solution is to bring the dialysis to the patients bed at home.

To adapt the HD around the patients life instead of adapting the patients life around the HD.
WHAT? PRODUCT

MAIN FUNCTION:
– Supplement kidneys

SUPPORT FUNCTIONS:
– Hold components
– Enable operation
– Access blood path
– Dose chemicals
– Filter blood (clean)

DESIRABLE FUNCTIONS:
– Minimize preparation time
– Minimize round-up time
– Improve flexibility (in movement)
– Minimize space
– Optimize integration (in home)
– Optimize storage
– Optimize intuitiveness
– Optimize overview
– Maximize control
– Maximize safety
– Decrease unwanted sounds
– Enable hygienic maintenance
– Enable easy service
– Enable spontaneous dialysis
– Simplify user experience
– Enhance relatives experience
– Minimize effect on patient’s life
WHO? PERSONA

In order to have a better overview on my target group I made Anders Larsson 45 years of age, the technique of making a persona simplifies by adding all problems, wishes and requests into one individual which symbolizes the core of the whole target group.

By solving Anders problems I would in return solve other patients problems as well.

NAME: Anders Larsson
AGE: 45
FAMILY: Wife, 2 children
PROFESSION: Carpenter
DIALYSIS: Hospital hemo dialysis

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NAME: Anders Larsson
AGE: 45
FAMILY: Wife, 2 children
PROFESSION: Carpenter
DIALYSIS: Hospital hemo dialysis
If the dialysis could be done nighttime (necrotic hemodialysis) it would in return give the patient freedom to spend their daytime however they want. Anders would be able to work part time or as much as he would like. This would also result in less social support needed and a win for the society as well.

Anders is not fond of the thought of sleeping connected to the machine, therefore it has to be safe and stable enough for him to trust the situation and feel comfortable.

**WHEN?**

**NIGHTTIME**
The fact that nocturnal hemo dialysis is well suited as the scenario for Anders for him to be affected as little as possible makes it logical that the treatment product should be integrated into the bedroom. This would also result in a more flexible product when guests and visitors are invited.

In a relationship there could be problematics if one of the partners needs to be connected to the machine. But if the process is easy and fast to adapt to, the couple might only go without this treatment themselves. The hemo dialysis treatment is also only needed to do every second or for some patients, even every third day.
Most medical products today are made only for solving the problems of sickness, but by
only solving that problem, other problems in new routines and a adaption to the
infection it often results in new problems in new routines. If medical appliance companies instead
tried to design machines around the patient it
would probably result in a better solution.

**WHY?**

**PURPOSE**

**BUILDING DIALYSIS AROUND YOUR LIFE INSTEAD OF BUILDING YOUR LIFE AROUND DIALYSIS**
I had the opportunity to visit the department of medical technicians in Norrlands Universitetssjukhus which also gave me the opportunity to look inside a Fresenius hemodialysis machine in order to better understand what it holds under its cover. There are many components with tubings placed in a specific order to get the most effective flow through the machine. By measuring them I could later have a better idea of what volumes I needed.

The units themselves do not take up all volume but there are hoses and tubes which connect the units which fill the empty spaces today.

### COMPONENTS

**WORKSHOP**

1. Heating chamber
2. Circulation pump
3. Air remover
4. Blending chamber
5. Pumps
6. Computer
7. Transformer
8. Backup battery
By rearranging the components in their size today it is clear that it space enough to make the machine smaller and neater to better fit the home context. By keeping all the components size as they are today it compensates for the fact that there have to be hoses connecting them. There are two computers in the home machine in order to keep it failsafe. They are today in comparison with their performance and size large in comparison with slimmer laptops with more performance. This is also due to requirements of a fail safe product. As components shrink fast I see no problem of downsizing this component.

| COMPONENTS TODAY | COMPONENTS OPPORTUNITY | 300 x 300 x 900 mm |
A clear requirement from different patients is to have a better overview. This could mean it would be possible to make orders, have conversations with doctors, leaving messages and calling for service through the device. It should also be possible for patients to keep their rates and the device should be easy to use and for doctors to have a good overview.

One idea was to keep a double set of blood at home and then change it whenever needed. A blood alternation system cleans the blood at home while the patient is away living his normal life. A problem is the critical point of changing blood where it is impossible to be able to empty the body from blood before refilling.

As the dialysis treatment will be made in the home it would be possible to put the machine away in a cabinet and then lead tubes through the walls and thereby get a central dialysis system which could have different connections in different rooms. By filling the tubes with heated natrium chloride in between treatments it would be possible to empty the blood from blood before refilling.

Another concept removes all water from the delivered substances and thereby minimizing the volume needed. By later adding water in the machine it would be possible to dose substances with local water simultaneously with treatment.

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Another concept removes all water from the delivered substances and thereby minimizing the volume needed. By later adding water in the machine it would be possible to dose substances with local water simultaneously with treatment.
One common thing that all homes include is furniture. It would be possible to integrate the machine into a piece of furniture and design it so that it blends in with the rest of the home. Design a furniture that fits into every home because all patients have different interior preferences. It could be possible to camouflage it into different patterns or colors which patients could choose but it would be very costly for the producer.

Hiding the furniture could be a way of making the machine melt into the home. This could be done in a unused corner, in a closet or under the bed.
A movable concept would improve the flexibility in the home. But since the need of water in the dialysis process, it would need water hoses which runs through the home. It would also result in that the machine would stay standing in the spot where it mostly would be used, causing it to be mounted on wheels.
By making portable concept it would be possible to bring the machine with you all the time and therefore also clean the blood continuously just like real kidney. This is a usual concept which many have explored but when it all comes down to size it becomes too big to be practical to carry with you. Not until it would be possible to carry it without showing will it begin to work as an supplement to the regular treatment.

PORTABLE
A portable machine would be optimal due to the fact that it could operate 24 hours a day and a patient could move around or even work with it. This concept is not realistic in the near future and therefore not interesting as a result of my process.
It is usually the details which make the difference between a good and a bad product. By looking at the details I have found some small adjustments which could improve both today's dialysis and a future concept.

By combining all the one-time-use equipment into one product it would make it easier and faster for the patients to prepare and clear the machine after treatment. Mounting and dressing the machine takes time. This could optimise that process.

By combining products like a tray with a display, it would take less space and time by reducing the critical point of inserting the needles. I found that by using a screen as a tray for inserting needles, it took the patients a few minutes every time they had to insert the needles. This could be optimised by having a scab remover which enables the scabs to come off easier. This would make the setup process smoother and less messy.

ONE KIT
To make the dialysis easier for the patient all the gear used for one treatment could be delivered connected as one kit.
When evaluating the concept against the list of problems I found that the three concepts that matched my problems the best was the furniture concept in combination with a waterfree system and a good overview for the patient. With this combination it would be possible to solve most problems and in comparison with the other concepts it stood strong in those it does not fully solve.

<table>
<thead>
<tr>
<th>TIME</th>
<th>PORTABLE</th>
<th>MOVABLE</th>
<th>FURNITURE</th>
<th>BLOOD ALTERNATION</th>
<th>CENTRAL DIALYSIS</th>
<th>WATER FREE</th>
<th>DIALYSIS OVERVIEW</th>
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<th>TIME</th>
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<th>FURNITURE</th>
<th>BLOOD ALTERNATION</th>
<th>CENTRAL DIALYSIS</th>
<th>WATER FREE</th>
<th>DIALYSIS OVERVIEW</th>
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In order to investigate how people would like to spend 5 hours every day in their home, I simply asked. By starting an open thread, I got great pictures of their favorite spots to stay. This online workshop showed me that over 70% of the people asked would like to stay and rest somewhere.

This meant that even though I designed a concept in the bedroom, most people could use it during the day as well. I placed small desks, tables, and small objects in every photo.
Now that I’m sure that the bedroom is where a home hemo dialysis machine should be placed I started to look for common spaces on the pictures and in the homes of my friends and family.

The first common volume I found in which was in every home was underneath the bed. There are beds which don’t have the space needed to fit in a hemo dialysis machine and when there is one it is usually under the bed. Most of the times these beds have legs which are between 10 cm up to 30 cm. This meant that a volume of 90 x 200 x 30 at least could be used.

I also found that everyone I knew without any deviation had a kind of bedside table to put their mobile phone or book nighttime. Another space I found could be used were the headboard, but that only had a headboard bed it would be possible to fit a great volume standing at the head of the bed.

COMMON SPACES IN THE BEDROOM
- Bed side table
- Headboard
- Windows
- Ceiling
- Floor
- Volume under bed
- Corners
- Wardrobe
- Bed lamp

30 x 90 x 200 cm
By building mock-ups on concepts testing the three placements I found that the headboard would be a difficult location for working. The twisting movement would make it hard to do every second evening and morning.

By putting the mock-up underneath the bed I could hide the whole machine plus have storage room for equipment but the low height would make it difficult to reach for elderly.

By having the dock beside the bed on the bedside table a good angle and good visuals is achieved. But in order to fit everything it would need another space as well.
**SWOT Ideas**

Combining a bedside table with the volume under the bed would give the opportunities of good ergonomic and at the same time use the volume for storage. This would mean that the machine would have to be split into different modules which could be placed wherever the patient would like. By making it into a furniture series it would open up a new segment of products, home medical appliance furniture.

<table>
<thead>
<tr>
<th>Bed Headboard</th>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Always close</td>
<td>Bad angle</td>
<td>Fit many beds</td>
<td>Different bed widths</td>
</tr>
<tr>
<td></td>
<td>Big volume</td>
<td>Bounds (close to pillow)</td>
<td>Variable thickness</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No storage</td>
<td>Material variations</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Under Bed</th>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large volume</td>
<td>Hygiene</td>
<td>Fit</td>
<td>Dust</td>
</tr>
<tr>
<td></td>
<td>Easily hidden</td>
<td>Ergonomic</td>
<td>Color / Material opportunities</td>
<td>Low position</td>
</tr>
<tr>
<td></td>
<td>In every home</td>
<td></td>
<td>Expand volume or storage</td>
<td></td>
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<tr>
<td></td>
<td>Easy to fit</td>
<td></td>
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<tr>
<td></td>
<td>Good storage</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Bed Table</th>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good Accessibility</td>
<td>Personal style</td>
<td>Color / material variations</td>
<td>Color / material variations</td>
</tr>
<tr>
<td></td>
<td>Good Visibility</td>
<td>Small volume</td>
<td>A whole new product segment</td>
<td>Existing bed table</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Recognition</td>
<td></td>
</tr>
</tbody>
</table>
By putting different modules underneath the bed with different purposes it would provide to keep both storage, machine and water cleaner with dialysis substances.

A separate module could hold the dock where the patient could place a filter to start the dialysis.
The concept is consisted of 7 parts.

A. Firstly its the bedside table and machine which calculates and regulates the flow and filtering process when a filter is connected.

B. Secondly there is the concentrate container. This is made out of three sections, water filtering, dialysis concentrate and bicarbonate. This unit is big enough to store the concentrate for a month, and when it’s time to refill it is done at the same time as filters are delivered.

C. Thirdly it is the storage and trash unit room for 18 filters which can be filled in about 3 months to have margin. In the storage unit there is also a waste for filter and needles. This is removable, changeable and washable.

D. The filter is consisted out of the filter with built in air guards instead of keeping them on tubes. The tubes and needles are already mounted on the filter at delivery which decreases risk of infection.

E. On the tubes the clips mounted are colored in red and blue indicating artery and vein all the way.

F. In order to increase the safe feeling a soft elastic wristband with a clip locks the tubes to the patients wrist and decreases risk of pulling out needles in the sleep.

G. The interface is small and kept in the filter drawer when not used. It could be held in bed or put on the bedside table. It is loaded through the built in USB in the drawer.
FEEDBACK

HOSPITAL PERSONNEL

"...Night time dialysis is 110% from the patient’s point of view..."

"...Modules would improve the opportunities to integrate it into different homes..."

"...A remote would be nice so the patients could access the machine more easily..."

"...I would choose nighttime dialysis so the day would not be spent with the machine..."

PATIENTS

"...Automatic delivery and a better overview would improve the planning..."

"...Dialysis at night is an utopia for me, I believe it would be possible to do a half time work in that case..."

"...I want home HD because it gives me the flexibility to plan my day just as I wish..."

CONCLUSION

By doing module system the patients could vary and adapt the machine to their own home for optimal integration.

If the feeling of safety and robustness could be strong enough it could inspire new patients to start nocturnal dialysis and see the opportunities with it.

To connect all products it is needed a clear and sophisticated form which doesn’t stand out too much from homes.
## Solutions

By comparing to the original problem list it is obvious that most problems are solved through this concept which is another evidence that the concept is strong.

<table>
<thead>
<tr>
<th>Time</th>
<th>Optimized procedures in Nocturnal dialysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space</td>
<td>Using unused common space under bed</td>
</tr>
<tr>
<td>Cognition</td>
<td>Minimizing steps and components for patients.</td>
</tr>
<tr>
<td>Sleeping</td>
<td>Enhanced security during sleep</td>
</tr>
<tr>
<td>Cost</td>
<td>Space under bed enables machine today to fit, Patients are free daytime for work.</td>
</tr>
<tr>
<td>Stigma</td>
<td>Making the dialysis machine blend into the bedroom no hospital feeling will occur</td>
</tr>
<tr>
<td>Relation</td>
<td>Nocturnal hemo dialysis could be used every second night and making the patient free daytime thus improving chances for better relations with others.</td>
</tr>
<tr>
<td>Safety</td>
<td>Warning system which signals if pressure or other rates are abnormal.</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Giving the patient flexibility by only being connected to machine every second night.</td>
</tr>
<tr>
<td>Ergonomics</td>
<td>Separating the machine into two parts the part which is mostly used could be closer. A separate display makes it easier for patient to have a better overview.</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>Using a neutral form with natural materials the machine could fit into most bedrooms.</td>
</tr>
<tr>
<td>Hygiene</td>
<td>Minimizing touch point surfaces decreases infection risks.</td>
</tr>
</tbody>
</table>
By building mock-ups on different types of bedside tables, I could see that the most common type with a drawer should work best and enable the user to use the top surface while starting the machine.

The low position of the storage makes it a bit difficult to reach from a standing position but if you sit down on the bed, you will come closer to the drawer and thereby be able to open it if the handle is in the top.

It was easy to attach and remove the filter and access into the drawer and if the filter is far into the drawer, it will be difficult to pull the tubes by mistake.

**MOCK UP**

**BEDSIDE TABLE**

- **LIFTABLE**
  - Bad lifting angle
  - Bed access

- **SLIDABLE**
  - Low handle
  - Good access
  - Movable Display
To investigate the possibilities to integrate furniture into different contexts I had a workshop where I asked the participants in different steps to integrate and contrast three volumes into different contexts given. This was done with different word choices in order to broaden the participants’ mindset.

I got a lot of different ideas on how to integrate the volumes but also got a great number of ideas on how I could make things pop in cluttered contexts. When I compiled these ideas into different categories it ended up with three different parameters which made the big difference if an object melted in, or popped out in its context. It was color, form, material.
COLOR

MOOD BOARD

NEUTRAL – WARM WHITE
In order for a hemodialysis machine to blend into so many different homes, the color can’t be too popping. Most beds often have a lot of white in it to bring the freshness to it when new. So a neutral, a bit of warmth, would be needed almost on the edge to light grey.

PERSONAL – WARM DARK GREY
The colors needed for semantics, red and blue for artery and vein would be difficult to combine with any other accent color so the personality has to come from a contrasting color and structure. By bringing in a warm dark grey into the details.

CLEAN – BLACK
To bring cleanliness the inside of the machine should be a black high glossy surface which reflects its surroundings and at the same time is easy to clean and easy to see if it’s dirty.
A discrete basic form is necessary in order to let the machine be integrated in different bedrooms. By having subtle flowing surfaces and lines in the details the discrete basic form is bound together. A uniqueness could be done by tying the modules together and having joints which surprises the user.
MATERIAL

NATURAL – WHITE ASH
By using white oiled ash wood on details a natural and fresh feeling will embrace the modules.

LIGHT – ORGANIC FOAM
Using a soy based foam between ash and aluminum makes a sandwich construction which is noise absorbing.

ROBUST – ALUMINUM
Using Aluminum inside the machine makes a stable construction for electronics and good heat transport.
In order to operate the modules, there will need to be a user interface which is clear and graphical with easy readable information about the treatment. A lot of the information today at the display is not used until the treatment is done, and the patient have to manually write down their rates to keep history for later checkups. If this could be saved automatically and accessed when needed, the patient would save another 10 minutes every day.
FORM STUDY

By exploring shapes, perspectives, silhouettes and proportions in small variations I could see how small different variations could be. By combining a silhouette and side view on the same shape a better understanding of the form was made. Because of the discrete basic shape I wanted to keep I only could do small variation before the shape was lost.
GUIDE FORM SKETCH

Creating a guiding form makes it easier to keep a consistent design when designing more than one product. I therefore came to the decision to use a shape made out of two parallel lines where the inner had a slight, almost not noticeable curve at the center and played with the proportions 1:2 in both thickness and radius. The basic measurement 300 mm came from the components workshop and fits perfectly in size.
After sketching the same bureau for a while I started to see differences between two identical objects that I had sketched before. This insight led me to decide on one specific sketch as a template.
By integrating the air guard, tubes and needles into one kit makes it much more easier for the patient to prepare and start the treatment. Using the guide form to give the shape to the filter as well connects the product well without being that much similar.

FILTER KIT
SKETCHING
COLOR CODED NEEDLES
TUBE COLLECTOR
BUILT IN AIRGUARD
Building the prototype includes both wooden workshop hours, laser scanner and plastic treatment. The build involved sanding and polishing joints on the handle. This was also the part were I wanted to get a fine feeling for the surfaces. Joints were handled with melting. This was the only way to handle the handles in one piece. But after a first trial I had to change strategy by finger working with solid wood. The result was fine and the finish was great.
By moving the treatment to the patient’s homes, it is important to recognize the patient as the primary user for the machine. By changing the target group and context, a totally different product segment must be developed to meet the new requirements.
Bringing the hemo dialysis treatment home to the patient means big improvements to the patient’s life. The flexibility of choosing and planning your own treatment increases independence and decreases the hospitalization. With the new user and new context the product should be adapted to adjust to the patient’s lives instead of the opposite to make great profits in quality of living.
The Home Treatment Concept makes it possible to combine the shapes best, only possible to fit the needs and space. The three modules make it possible to use the modules as bedside tables or just keep them beside a clothing drawer.

The differences of space and style of homes make it important to be able to alternate between combinations.

**Filters and Machines**
- Filter Machine (300x300x300 mm)

**Concentrates**
- Concentrate Container (300x300x600 mm)

**Storage Drawers**
- Storage Drawer (300x600x300 mm)

Example: Under bed

Example: Bedside table

Example: Separate placement
The concept consists of three modules which are small enough to fit underneath the bed for example. The three modules are the Filter Dock, the Concentrate Container and the Storage Drawer.

It also consists of one time-use filter and no bulky tube with a small difference, everything is pushed together to maximize simplicity for the patients. The tubes are connected with blue and red clips to keep them together for better control and easy readability. Even the needles are marked in red and blue to minimize mistakes.
The Filter Dock consists of the apparatus which the filter is connected to and calculates and monitors the dialysis process.

In the Concentrate Container there is a built-in water cleaner which takes water from the house water supply and cleans it before adding dialysis and bicarbonate and continuing on to the filter. The Concentrate container holds concentrate for 18 treatments.

The Storage Drawer is a movable drawer specially built for containing 18 filters which last more than a month. When a filter is used the patient empties the filter and throws it into the waste bin compartment, and empties it at the same time as delivery comes, once a month.
The handles in maple of wood which connects the modules better to the warmth of the bedroom. The positive to the filter dock has a small space which enables the drawer to be shut whilst doing treatment.

Consistent symbols and markings indicate service areas and offer touch points in the system.
FILTER KIT
HOME TREATMENT CONCEPT

The filter kit has built-in air guards to improve safety and reduce the possibility for air to escape through the tubes. Sensors monitoring the equipment are connected by the dock. Delivering the filter as one kit to the patient optimizes the time it takes to prepare a treatment.

The filter locks into the dock which minimizes the possibility for it to come loose.

COLOR CODED MAGNETIC ANTI-TANGLE CLAMPS
ALL INCLUSIVE FILTER
CONSEQUENT COLOR CODING
Simplifying the home dialysis treatment by reducing steps and products needed decreases the time it takes for the patient to learn how to handle the machine by themselves. At the same time, it makes it possible to decrease preparation and cleaning time, making the patient less affected by the disease.

1. TAKE FILTER FROM STORAGE DRAWER
2. PLACE FILTER IN FILTER MACHINE
3. INSERT NEEDLES & START TREATMENT
4. SLEEP TIGHT
By looking at the components and splitting the product into different modules it enables different patients to vary their placement of the machine according to their personal preferences. Most of the components is placed in the concentrate container which could be stored away, only needing access to it once a month or by technicians at service times.
"BUILDING DIALYSIS AROUND YOUR LIFE
INSTEAD OF BUILDING YOUR LIFE AROUND DIALYSIS"