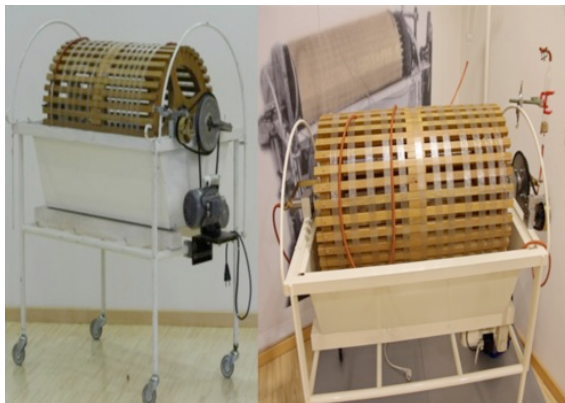


# Hemodialysis Minimal is the Future

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Father of Hemodialysis, Willelm Kolff a Dutch physician, during the terrible times of Nazi occupation risked his life to experiment and invent the first hemodialysis machine. One can imagine, that the power to do something good for your fellow human beings does not wait for the perfect times and facilities. It was a large machine that utilized the large drum of a washing machine, orange juice cans and sausage skin as semipermeable membrane. First Successful Dialysis was thus performed in 1945 using such machine.



**Figure 1:** Kolff First Dialyzer made up of large drum, sausage skin as membrane and motor pump to rotate the drum for contact of blood to the membrane.

**Images from:**

<http://www.kidneydialysis.org.uk/images/KolffDrumKidney-m.jpg>,

[http://upload.wikimedia.org/wikipedia/commons/4/4b/Kolff Trommelniere.jpg](http://upload.wikimedia.org/wikipedia/commons/4/4b/Kolff_Trommelniere.jpg)

The hemodialysis apparatus has witnessed a huge change in improving the hemodialysis process over the years since first hemodialysis was undertaken.

It was an opportunity for me at the American Society of Nephrology, (New Orleans, Louisiana, USA) December 2017, exhibition to see where the next generation of dialysis machines are heading. Major market holders of hemodialysis machines were present including Fresenius, B Braun, Nipro and Baxter-Gambro. Certain innovative machines and technologies were also displayed creating a lot of interest among the nephrologists.

The old players in the market Fresenius displayed its 2008T model. It includes the critline monitoring device that measures the hemoglobin levels online. It thus relays the information about hemo-concentration [meaning fluid removal] and ultrafiltration creating a bio-feedback interplay to decrease or stop ultrafiltration thus avoiding intradialytic hypotension.



**Figure 2:** Fresenius T2008 machine with its LCD display and built in Critline monitor for biofeedback.

Thus in a patient reaching a particular hematocrit may indicate a drop in blood pressure due to extra fluid removal and the machine automatically decreases or stops the ultrafiltration. Once due to refilling of the intravascular volume the hematocrit again drops leading to a feedback for initiation of ultrafiltration. Gambro and Nipro machines are almost same in terms of features and Kt/V measured by Na conductance.

B Braun has a new feature of displaying online Kt/V and URR by actually directly measuring the urea online. It is therefore a more direct measure of urea kinetics during dialysis rather than Na conductance used by other machines to measure Kt/V.



**Gambro**



**B Braun**



**Nipro**

**Figure 3:** Hemodialysis machines displayed from Baxter-Gambro, B Braun and Nipro.

### Next Generation Hemodialysis Machines:

The real flavor of the future is the NxStage, Tablo and Dharma portable hemodialysis devices. These machines are small and smart looking just like the smart phones available now. The mobility that it can provide for the hemodialysis session to be brought to the door step or the freedom to move around the geographical boundaries just like a continuous ambulatory peritoneal dialysis patient. The technicalities to bring a hemodialysis machine of a medium size refrigerator to a small carry-on bag is a huge challenge and it seems the biomedical engineers are heading some way and in near future will be seeing patients taking their hemodialysis machines to work or leisure areas.

**NxStage** was the first in market providing a small bedside table size machine that generates water from the tap water and no separate reverse osmosis plant is need for water supply. The dialysate chemicals are provided as liquid or powder form to add to the water. The large amount of dialysate is made online.



**Figure 4: NxStage** One can use pre made dialysate bags 5 L each or using the 5 L Tap water to make your own Dialysate. That is made online. It is compact and a carry along bag easily fits it for mobility.

It has been so successful and popular due to its ease of use and minimum requirements that it has become one of the favorites for home hemodialysis where machine is moved along with the technician for therapy at home. It has captured a significant market in the USA and will be taken over by Fresenius Inc for almost 2 Billion US Dollars deal over the next 8-10 months.

**Tablo** is another similar product that has its own RO plant within the machine. It takes the tap water [has to be high quality] and makes its Dialysate and needs the acid and bicarb

baths. It is around 200 lbs roughly 100 kg but very easy to move around on the ground. It is already FDA approved and in use for chronic HD and ICU settings. It can perform 12 hour continuous dialysis and needs 2 hours of internal disinfection after 12 hours. A cassette with all the tubing is attached and any dialyzer can be used.

As mentioned on their website: "Tablo is an all-in-one dialysis solution: it makes clean water, produces dialysate, takes blood pressure and delivers medication... all in a compact table-height package. No additional equipment to connect. No heavy bags of fluid to hang. There's not even a hospital pole. Goodbye accessories, hello simplicity."



**Figure 5:** Tablo Hemodialysis machine. Cassette with tubing is shown.

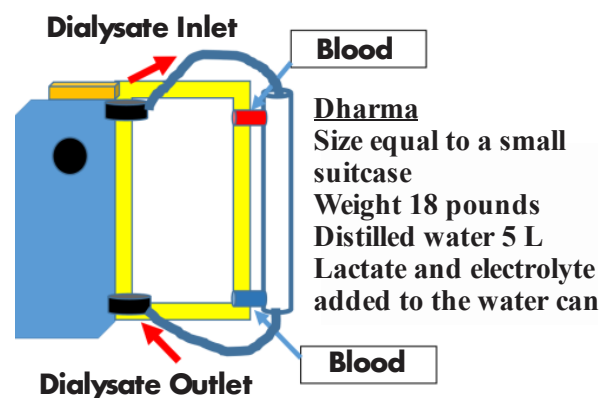
Dharma is the latest kid on the block from USA. It is compact and of the size of a small suitcase, in fact it comes as a trolley bag as shown in figure 6. It is not yet FDA approved and undergoing final clinical trials. Beauty lies in its weight, which is only 18 lbs and is being advertised for mobile dialysis machine for home hemodialysis or places where no hemodialysis facility exists.

**The** concept is simple. A 5 liter can for water is provided inside the machine. You just need to add water and currently lactate based fluid or powder for generation of dialysate. It



**Figure 6: Dharma** hemodialysis machine. Its size is equal to a small suitcase weighing 18 lbs only. One can easily imagine its actual size in the picture.

continuously prepares and reuses the spent dialysate to regenerate the dialysate online, thus no need of continuous water supply as in Tablo hemodialysis machine but similar to NxStage hemodialysis machine. Figure 7 reveals the inner assembly and have made a diagrammatic illustration for understanding.



**Figure 7:** Inner diagram of Dharma hemodialysis machine.

**In summary** emphasis is being made on newer smaller versions of hemodialysis machines. Interest is obvious and we will see more affordable dialysis at the door step and far of areas without carrying huge water treatment plants and machines, even a mobile unit in a van will suffice.