Wearable Artificial Kidney
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Abstract—A new and promising method for end-stage kidney disease (ESKD) patients has been developed that may keep them from being bedridden for an extensive period of time during the process of dialysis. The wearable artificial kidney (WAK) gives patients continuous blood purification and mobility while they wait for a kidney donor.

I. INTRODUCTION
According to the USRDS (United States Renal Data System) and ANZDATA (Australia New Zealand Dialysis and Transplant Registry) chronic kidney disease (CKD) and end-stage kidney disease (ESKD) has had an 3.3% and 3.7% increase respectively (data collected in 2012 and 2013) [1]. ESKD is the critical stage of CKD where renal failure is irreversible and may require a kidney transplant from a donor. However, ESKD patients will still require continuous blood purification and restoration of electrolytes to the body as a ‘holding measure’ while they wait for a kidney transplant; this ‘holding measure’ is called hemodialysis. The process of hemodialysis would consist of circulating blood into an external filter called a dialyzer, which would contain a semipermeable membrane. This pump is designed to keep blood flowing in one direction. A sorbent unit containing an electrolyte solution, dialysate, would be pumped into the dialyzer flowing in the opposite direction of the blood. The counter flow helps with the maximization of the concentration gradient of solutions between blood and dialysate, or in other words, it helps to remove more waste and toxins from the blood [2]. The figure below (taken from article [2]) shows the general illustration of this process. The problem with hemodialysis is that treatment is typically done three times per week for four hours and may require up to 120L of dialysate per treatment; the patients is also tethered to a very bulky machine [2].

II. DEVELOPMENT OF WAK
A team led by Dr. Victor Gura has made a very significant breakthrough in dialysis technology where he and his team developed an ingenious design that miniaturize a conventional dialysis machine. The design went through many phases of experiments which included the effectiveness of pumps, the clearance of solutes, the effect of dialysate flow and its pH level and the removal of beta-2 microglobulin from human blood in vitro. The WAK design uses a 3-watt Faulhaber DC Motor which allows a mechanism to use two metal arms that can alternately compress two elastic chambers. These two chambers have two valves at the entry and exit where it allows alternating pulsatile flow of both blood and dialysate into the dialyzer. The motor is powered by a battery that had a battery life of approximately three days [3]. A schematic of the device is shown below (taken from article [3]).

III. RESULTS
Dr. Victor Gura’s WAK device has shown very promising results where the pumps used delivered the same effectiveness as the heavier conventional pumps. During extensive experiments, they found that an increase in pH with the dialysate to 7.4 increased adsorption of ammonia during high pulsatile flow compared to steady flow. Dr. Gura and his team also tested the WAK effectiveness by testing the creatinine clearance from uremic pigs with 18.5mL/min on the first version of the WAK and 27.0mL/min on a more advanced version, WAK v1.1 [3].

IV. DISCUSSION
As of now, the WAK developed by Dr. Victor Gura is in the middle of clinical safety trials by the FDA. There is currently no available data that has been published on how the safety trials are going but experimental data has shown very promising results. Currently the WAK design weighs about 10 pounds and designed to be worn like a workman’s tool belt where each miniaturized component of a dialysis machine are attached to the belt and double lumen catheters are attached to the patient. Though Dr. Gura and colleague’s design of a wearable kidney has been regarded as an ‘ideal conceptualization of a WAK’, the device still has some improvements required in compartmentalizing all components into a lighter design, where it would give ESKD patients freedom from tethered machines and also receiving an effective and efficient dialysis treatment [4].
References


