Centry 2 Haemodialysis Machine

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Haemodialysis was introduced in Hong Kong in the late 1960s. Haemodialysis requires a dialyser, which replicates the kidney functions of removing excess waste and water from the blood, and a haemodialysis machine. The haemodialysis machine has several key functions. The main function is to prepare dialysate by diluting one part dialysate concentrate with 34 parts of treated water. Dialysate concentrate is used because during dialysis, dialysate is used at 500 mL per minute; a 5-hour dialysis session would consume 150 L. Storage and transportation of such a large volume of dialysate would be problematic and expensive. The haemodialysis machine also delivers the dialysate to the dialyser and drains the waste dialysate. Finally, the haemodialysis machine monitors dialysate pressure in the arterial and venous chambers, conductivity of the dialysate, presence of air in the bloodstream, and blood leakage. Thus, from an engineering perspective, a dialysis machine is more appropriately called a 'dialysate delivery and monitoring system.'

In the early days, there were two types of haemodialysis machines: a batch tank machine and a proportioning pump machine. Batch tank systems are very simple; the batch tank has a capacity of about 120 L, which the user manually fills with one part of dialysate concentrate and 34 parts of treated water to make the dialysate. Although simple, because of the large space requirements, it is unsuitable for dialysis centres where there are often multiple machines. It is more commonly used in home haemodialysis, where simplicity and low cost are important. Proportioning pump machines have two pumps; one pump draws one part of dialysate concentrate and another pump draws 34 parts of water. In this way, the dialysate is made continuously online. This saves a lot of space in a dialysis centre, and the preparation time needed is markedly reduced because there is no need to wait for filling up the batch tanks.[1]

Early haemodialysis machines only prepared the dialysate. In addition to the haemodialysis machine, separate pumps were needed for blood, to deliver the blood from the patient to the dialyser, and heparin, for continuous heparinisation. Moreover, the operator had to calculate the fluid removal rate using the 'transmembrane pressure' and the 'ultrafiltration coefficient' of the dialyser; however, this could only give an estimate. One example of this early type of machine was the Centry One (COBE Laboratories, Inc., Lakewood [CO], United States), which was used in Princess Margaret Hospital, Hong Kong, when it opened in 1977.

In the 1980s, the early machines were replaced with newer models like the Centry 2 machines (COBE Laboratories, Inc.) [Fig a] and the AK10 models (Gambro Company). The Centry 2 machines were more widely used. These offered several upgrades over the older models. They were compact and robust with the blood pump and heparin pump built in. They also included an indicator to show the rate of fluid removal from the dialyser ('ultrafiltration meter') in real time, obviating the need for the operator to calculate this and increasing the accuracy (Fig b).

The Centry 2 machine had been widely used in dialysis centres in Hong Kong as nearly all the public and private dialysis centres all used it. However, it was gradually replaced with newer machines in late 1980s. The main drawback of the machine was that the dialysate contained acetate as the buffer base. During dialysis, the acetate diffused from the dialysate across the dialyser membrane into the blood compartment. The acetate was then converted to bicarbonate in the liver to replenish the bicarbonate buffer in the patients' blood, which was acidic. In elderly patients or those with multi-system disease, the patient's liver might be unable to convert acetate to bicarbonate at a sufficient rate. As a result, some acetate accumulated in the blood. Acetate caused vasodilation with hypotension, headache, and vomiting.

Acetate was used in the dialysate because of its high solubility. If bicarbonate were used, the bicarbonate would combine with calcium in the dialysate and this would cause precipitation and could blockage of the dialysate path. This problem was eventually solved by keeping the dialysate (acid) concentrate solutions and bicarbonate solution separate. Thus, modern dialysis machines have three proportioning pumps, one for the bicarbonate solution, one for the acid concentrate solution, and a third for the water. The three ingredients are mixed online and go to the dialyser immediately, avoiding precipitation.

All new haemodialysis machine models have bicarbonate dialysis capability. In addition, instead of only monitoring the ultrafiltration rate, new machines have the ability to control the rate of ultrafiltration by directly measuring the volume of the fluid removed. The operator only has to input

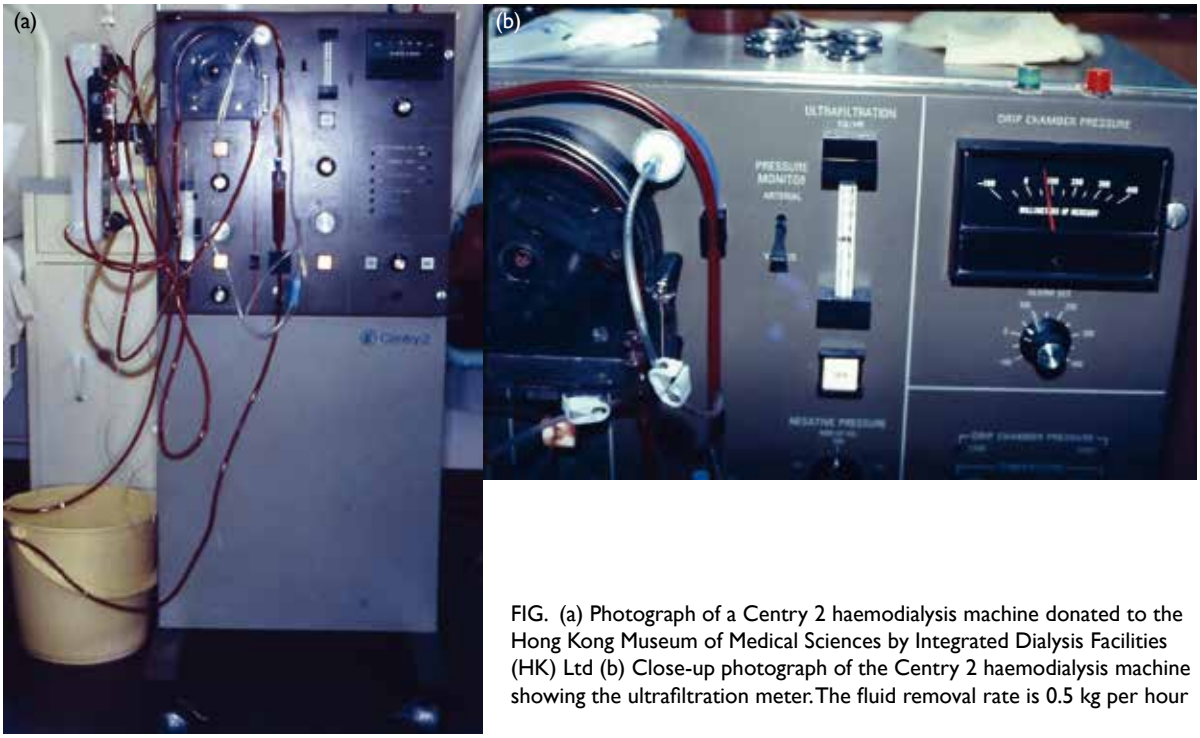

FIG. (a) Photograph of a Centry 2 haemodialysis machine donated to the Hong Kong Museum of Medical Sciences by Integrated Dialysis Facilities (HK) Ltd (b) Close-up photograph of the Centry 2 haemodialysis machine showing the ultrafiltration meter. The fluid removal rate is 0.5 kg per hour

the desired ultrafiltration volume, and the machine automatically monitors the fluid removal and calculates the negative pressure required, resulting in accurate fluid removal.

Despite the shortcomings of the Centry 2 machine, it was loved by dialysis staff because it was compact and reliable. In the early days, relatively young patients were chosen for haemodialysis who could tolerate the bicarbonate dialysis and some volume inaccuracies. The Centry 2 because a workhorse among haemodialysis units. Nevertheless, with society becoming more affluent and technology advancing, new machines were introduced for their 'bicarbonate dialysis' and 'ultrafiltration monitor', older patients could be admitted for haemodialysis with good clinical results.

Reference

1. Ho CP, Au YF, Wong KK. A review of home haemodialysis in Hong Kong. Available from: http://www.dialysis.com.hk/wp-content/uploads/a-review-of-home-haemodialysis-in-HK.pdf. Accessed 20 Jun 2022.