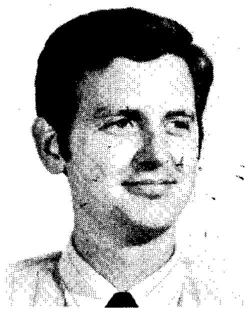
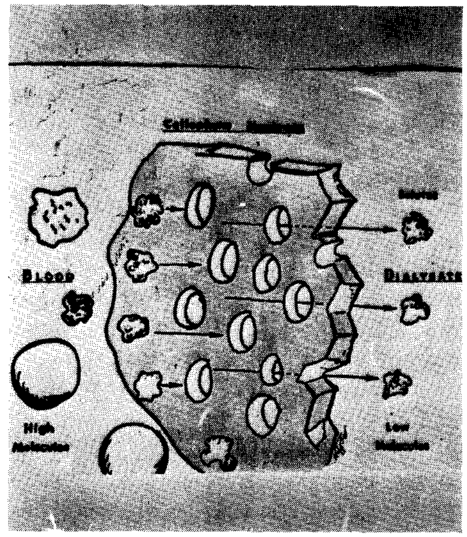
The Artificial Kidney—

A Chance to Live





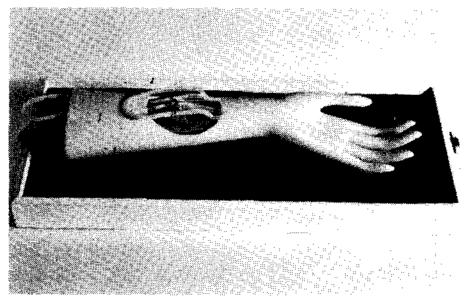
By ROGER L. KIRKHAM

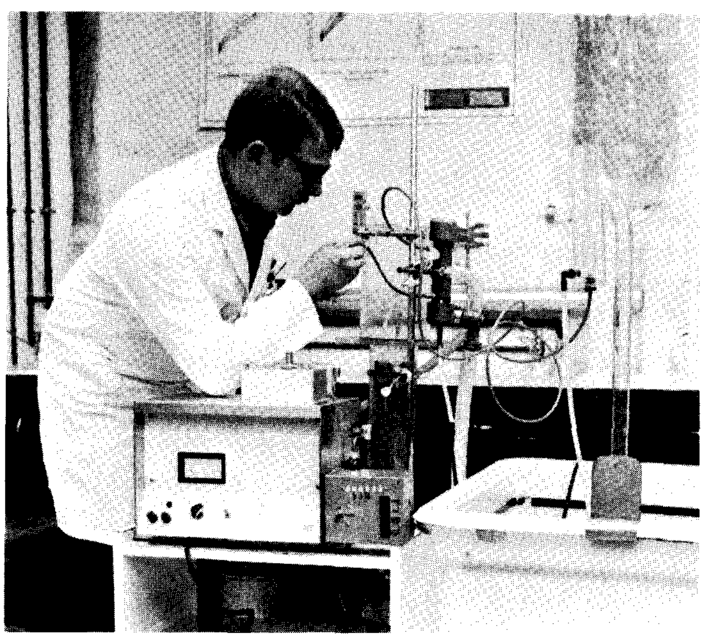
University of Utah Medical Center

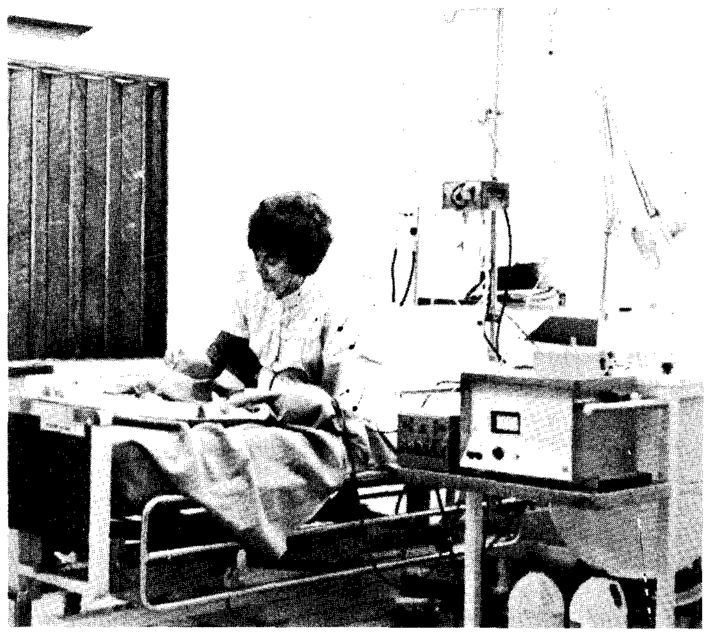
According to reports by two government committees, 40,000 people die each year of kidney disease in the United States. These reports further state that these people could be helped with either kidney transplants or an artificial kidney, if such artificial kidneys are available. However, only 1 1/2 per cent of the people who need artificial kidneys are being treated. As a consequence, the National Institute of Health has given a number of contracts to industry and to scientific laboratories in the hope that better and less expensive artificial kidneys can be developed and built. The Division of Artificial Organs at the University of Utah has received such a contract.

An artificial kidney, however, cannot completely replace the natural kidneys. The normal healthy person has two kidneys which perform several functions vital to life:

1. *They remove wastes from the blood.*
2. *They regulate the internal chemistry of the body.*
3. *They regulate the amount of water in the body.*
4. *They help regulate blood pressure.*
5. *They help control red blood production.*







Article available at https://ject.edpsciences.org or https://doi.org/10.1051/ject/1970022005

Artificial kidneys perform jobs 1-3 by dialysis.

Basic to the design of an artificial kidney is the use of a semi-permeable membrane, usually cellophane or cuprophane. The blood flows extracorporeal (outside the body) through membrane tubing or between membrane sheets. On the opposite side of the membrane is a dialysate solution or cleansing fluid. Impurities in the blood, such as urea, pass through the membrane into the dialysate as seen in figure 1.

The use of a cannula makes it possible for the patient to be dialysed several times a week. The cannula consists of tiny plastic tubes placed in the arm or leg. One is in the artery and the other in a vein. Cannulas are connected by a shunt which allows blood flow from one cannula to the other between treatments, see figure 2. Patients are usually treated two to three times a week for approximately six hours each treatment.

W. J. Kolff, head of the Division of Artificial Organs, and Berk developed the first clinically successful artificial kidney in 1943 in Holland.[1] Since that time variations in the design and development of an artificial kidney have been proposed by Skeggs and Leonards in 1948,[2] by Kloff in 1956,[3] by Kiil in 1960,[4] and so on. Today there are many designs of artificial kidneys available ranging from flat plates, coils, to a small cartridge consisting of many hollow fibers or capillaries. The major design considerations common to all these kidneys are:

1. **Efficiency of mass transfer**
2. **Ease of use by the patient**
3. **Safety**
4. **Cost**

Efficiency of Mass Transfer

At the University of Utah collaboration between the Division of Artificial Organs and the Chemical Engineering Dept. is providing answers to the problem of optimal and selective mass transfer. Under the direction of Dr. Boyd and Dr. DeNevers, undergraduate students have been investigating various substances for selective absorption. Students directed by Dr. Christiansen have been investigating the effect of membrane spacing and pulsed flow on mass transfer in blood. Dr. Don Lyman, well-known polymer chemist, who recently joined the Division of Artificial Organs is interested in the selective permeability of new synthetic membranes for the dialysis of blood. Dr. V. K. Kulshrestha has developed new membranes for dialysis with the cupriethylenediamine process.

Ease of Use by the Patient and Safety

When the Division of Artificial Organs was established over two years ago, a contract was applied for and received for the establishment of a Home Dialysis Training Center. In the Center, chronic kidney failure patients are taught to treat themselves (see figure 3) so that eventually the treatment may take place at home. So far sixteen patients have been trained at the center and have artificial kidneys in their homes.

Of vital concern for the patient whose life is dependent on the artificial kidney is its ease of use and safety. To improve present designs of the artificial kidney, a systems approach has been undertaken by the Division for the development of a less expensive and more efficient artificial kidney. The basic design consists of a "wide coil" (named for the 49 cm. wide cellophane tubing which is being used) and a control system developed by student Hung Kok Wong under the direction of Dr. D. K. Gehmlich.

Cost

The high costs of chronic hemodialysis is the major factor which limits the number of patients who may be treated with the artificial kidney. It has been estimated that a cost of $8,400 to $21,000 per year per patient is incurred if treatment is performed at a hospital dialysis center.

For home dialysis, costs per patient per year are estimated to be $3,750 to $9,800.[5] The Division of Artificial Organs at the University of Utah has introduced an inexpensive, "do-it-yourself" artificial kidney (see figure 4).[6]

A unique cooperation and collaboration is taking place at the University of Utah between the College of Medicine and the College of Engineering. Medical doctors, engineers, physicists, technicians, nurses and students are all involved in finding a better answer for thousands of patients suffering from kidney disease.

"To a boy dependent for his existence upon an artificial kidney, the replacement of his own diseased organ by a healthy one through transplantation offers the best hope for resuming a completely normal life. Another possibility lies in the research now under way, supported in part by the Public Health Service, designed to further perfect the artificial kidney, to make dialysis an easier, less complex procedure and even to develop, perhaps, an artificial kidney small enough to be wearable.

In the meantime, acceptance of the present difficult problem, together with a determination to wait and hope, help the person on chronic dialysis to endure. For artificial kidney therapy, whatever its difficulties, frustrations, inconveniences and tensions, is far superior to the grim alternative and gives that person the chance to live."[7]

REFERENCES

1. Kolff, W. J. and H. T. Berk, "The Artificial Kidney, A Dialyzer With Great Area", **Acta. Med. Scand., 117,** 121 (1944).
2. Skeggs, L. T. and J. R. Leonards, "Studies On An Artificial Kidney: Preliminary Results With A New Type Of Continuous Dialyzer", **Science, 108,** 212 (1948).
3. Kolff, W. J. and B. Watschinger, "Further Development Of A Coil Disposable Artificial Kidney", **J. Lab. And Clin. Med., 47,** 969 (1956).
4. Kiil, F., "Development Of A Parallel Flow Artificial Kidney In Plastics", **Acta. Chir. Scand., Supp. 253,** 143, (1960).
5. Gottschalk, C. W., Report of the Committee on Chronic Kidney Disease, September 1967.
6. Kwan-Gett, C. S., et. al., "Inexpensive Hypobaric Recirculating Artificial Kidney", **Transactions A. S. A. I.O.,** Vol. XV, (1969).
7. U. S. Dept. of Health, Education and Welfare, "A Chance to Live", Public Health Ser. Pub. No. 1801.