HAEMODIALYSIS

EXPERIENCES IN 90 PATIENTS*

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Haemodialysis forms part of the treatment of patients with acute renal failure. It has been used in the management of selected patients with chronic renal failure; for the treatment of cases of poisoning with dialysable drugs such as aspirin, bromides and barbiturates and also in an attempt to correct the clinical and biochemical abnormalities in patients with hepatic failure. The historical as well as the clinical aspects of dialysis have been reviewed recently by Merrill.[5] The purpose of this paper is to present our experiences with this form of treatment in the Renal Unit of the Johannesburg General Hospital.

MATERIAL AND RESULTS

One hundred and fifty-five haemodialyses have been done in 90 patients. The series include patients previously reported.[2,4] Their ages ranged from 6 months to 81 years. Thirteen patients had chronic renal failure and all died. They were dialysed either because the diagnosis was not established at the time of their admission with uraemia or in the hope that they had been precipitated into more severe renal insufficiency by an acute incident which might have been reversible. Death occurred in all within 6 weeks of their last dialysis. Three patients with poisoning (2 from barbiturates and 1 from glutethemide) were dialysed. One died and 2 recovered.

The remaining 74 patients all had acute renal failure of varying aetiology. In Table I the causes, numbers of patients and dialyses and results are classified. The over-all mortality was 54%. Four patients were dialysed when already moribund and 2 patients were shown at autopsy to have cortical necrosis. The largest group were those in whom the renal

TABLE I. CAUSES, NUMBERS OF PATIENTS AND DIALYSES AND RESULTS

	Number of patients		*Number of dialyses*	
	Alive	*Dead*	*Alive*	*Dead*
Pregnancy	7‡	5†‡	12	13
Surgery				
General	4	3	8	9
Open-heart ..	1	4	4	8
Trauma	5	6†	16	14
Pyelonephritis ..	2	1	2	1
Obstructive uropathy	3	3‡	3	3
Acute on chronic ..	4‡	6‡	5	9
Acute nephritis ..	5	5	7	6
Carbon tetrachloride	2	2	2	3
Miscellaneous ..	1	5	1	8
Total	34	40	60	74

*Based on a paper presented by one of us (B.G.) at the South African Medical Congress, Johannesburg, July 1963.

†Cortical necrosis in 2 patients.
‡Associated surgery in 6 patients before dialysis.

failure followed trauma or surgery. These patients required the most dialyses and the mortality was also highest in these, particularly in those who had open-heart surgery. Similarly, most patients dying in the obstetric and/or obstructive uropathy group had had previous surgery and/or severe infection. In the miscellaneous group 3 patients had congestive cardiac failure with oliguria and uraemia and all died. Thus, the greatest mortality was observed in patients who had severe associated disease in the form of severe cardiac insufficiency, associated trauma or infection.

Of the remaining patients, those classified as suffering from acute nephritis include 3 with the acute haemolytic uraemic syndrome of infancy, of whom 2 died and 1 recovered, with some persistence of impairment of renal function. The patients with acute on chronic renal failure all had a clear-cut factor, such as infection, precipitating the acute incident. This group was difficult to separate from those with obstructive uropathy and pyelonephritis but an arbitrary division of the 3 categories has been made.

In Table II are shown some differences between the patients who died and those who recovered. A higher mortality was

TABLE II. DIFFERENCES OBSERVED BETWEEN PATIENTS WITH ACUTE RENAL FAILURE WHO RECOVERED AND WHO DIED

	Alive	*Dead*
Mean duration of oliguria (days) ..	12·8	15·9
Mean duration of oliguria before dialysis (days)	6·8	5·9
Mean maximum blood urea (mg./100 ml.)	353	370
Mean increase in blood urea (mg./100 ml./24 hrs.)	42	56
Mean maximum serum potassium (mEq./l.)	6·3	6·5
Mean minimum serum CO_2 (mEq./l.) ..	16·2	12·7
Mean urine output during oliguric phase (ml./24 hrs.)	132	87

seen in those who presented with a more rapidly rising level of blood urea and lower plasma CO_2 combining power. The other differences shown are modified to some extent by the time between the onset of the renal failure and referral to the Unit and by the intervening treatment, e.g. some patients with rapidly rising blood urea levels were referred and dialysed early before the blood urea had increased to very high levels and others were referred and dialysed late with high levels of blood urea but with a slower rate of rise. In general the rate of rise of the blood urea correlated well with the clinical state of the patient and was more rapid in those with trauma, associated infection and those who had undergone surgery.

Indications for Dialysis

The indications for dialysis and numbers of patients with one or more of these indications are shown in Table III. The most important guide to the need for dialysis was the general clinical condition of the patient with respect to any uraemic symptoms, particularly with regard to alterations in their mental state. Biochemical criteria, which have been generally recognized as indications for dialysis, are listed and were frequently associated or primary indications but did not necessarily have to be present before dialysis was carried out.

TABLE III. THE INDICATIONS FOR DIALYSIS AND THE NUMBER OF OCCASIONS EACH INDICATION WAS PRESENT BEFORE DIALYSIS

Indication for dialysis	*Number of times indications present*
Mental or neurological	72
Blood urea > 400 mg. % 100 ml.	42
Serum potassium > 7·0 mEq./l.	23
Serum CO_2 < 12·0 mEq./l.	31
Overhydration	22
Prophylactic	8
Pre-operative	4

In most instances the serum potassium level and acidosis could be controlled by the use of exchange resins or alkalis and were seldom single factors in determining the need for dialysis. Overhydration was present in 22 patients and in 3 of these dialysis was carried out to relieve pulmonary oedema. It was possible in some patients to predict their clinical and biochemical course and in these repeated dialyses were done prophylactically before specific indications became apparent. In this way the clinical deterioration, which would have occurred by delaying further dialyses for 24 - 48 hours, was prevented.

Techniques Used in Dialysis

The Kolff Travenol twin-coil artificial kidney was used for all dialyses. In the majority, dialyses were done from artery to vein but in a few a vein-to-vein technique was used. Good flows were obtained with the first method and when it seemed likely that more than 1 dialysis would be necessary an artificial arteriovenous fistula was created and repeated dialyses were done using the same cannulae and vessels. On 3 occasions percutaneous femoral arterial catheterization was done but the flows were generally unsatisfactory. Most patients had regional heparinization, with heparin being infused on the arterial side and protamine on the venous side, to neutralize the heparinized blood returning from the coil to the patient. The rate of infusion of each substance was varied according to the clotting times of the blood taken from the patient and the coil.

In patients with acute renal failure most dialyses were of 6 hours' duration—in some for shorter and a few for longer periods, if the flow rates were poor and it was judged that further improvement could be obtained by prolonging the dialysis. In patients with chronic renal failure the periods of dialysis were generally of 4 hours' duration to prevent too rapid or too great fluid volume, electrolyte or other biochemical alterations.

Effects of Dialysis

Clinically there was usually a fairly rapid improvement in the patient's condition. Drowsy, confused or stuporose patients became alert and cooperative often within 24 hours. There was an increased feeling of well-being, improvement in appetite, disappearance of nausea and vomiting and alleviation of twitching, when these were present before dialysis. The biochemical changes observed for the levels of blood urea, serum potassium, CO_2 combining power and haemoglobin before and after dialysis have been plotted in Fig. 1. Anaemia was corrected by transfusions, when necessary, *during* dialysis. In Fig. 2 is shown the amounts of fluid removed per hour by filtration in 10 patients as calculated from fluid balance and weight changes during dialysis.

Complications in Dialysis

The complications observed and the numbers of patients affected are listed in Table IV. Hypo- or hypertension was usually mild but in 5 patients who developed hypertension and 11 who developed hypotension, antihypertensive drugs or vasopressor agents were required to control the blood pressure. Sudden acute changes were most often due to alterations in the distribution of the blood between coil and patient and could usually be easily and rapidly

adjusted by transfusion of blood to the patient or by reducing the patient's blood volume and increasing the volume in the coil. Bleeding was seen in 8 patients and in 3 of these was the result of inadequate haemostasis at cut-down sites. In the remainder the bleeding observed could be accounted for by the underlying disease. In 5 patients, 4 with chronic renal failure, convulsions occurred. These were probably due to rapid intracranial shifts of fluid in patients who had become adjusted to their previous abnormalities.[3,6]

In 5 patients infection developed at cut-down sites. In 2 of these this was complicated by septicaemia. Both patients recovered with appropriate antibiotic treatment.

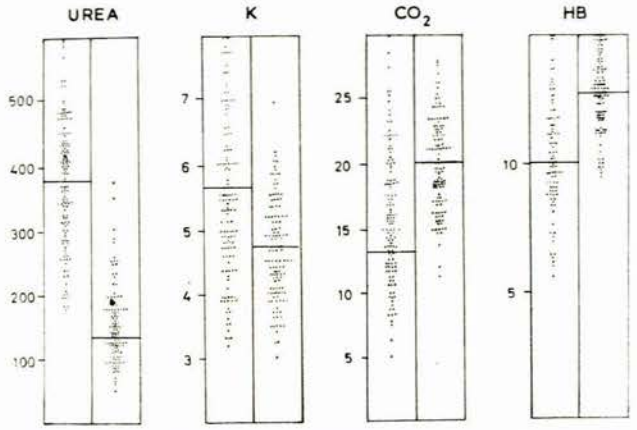

Fig. 1. The changes in blood urea (mg./100 ml.), serum potassium, CO_2 combining power (mEq./l.) and haemoglobin (G/100 ml.) levels in the patients dialysed. Left-hand columns before and right-hand columns after dialysis. Horizontal line across each column is the mean of all measurements.

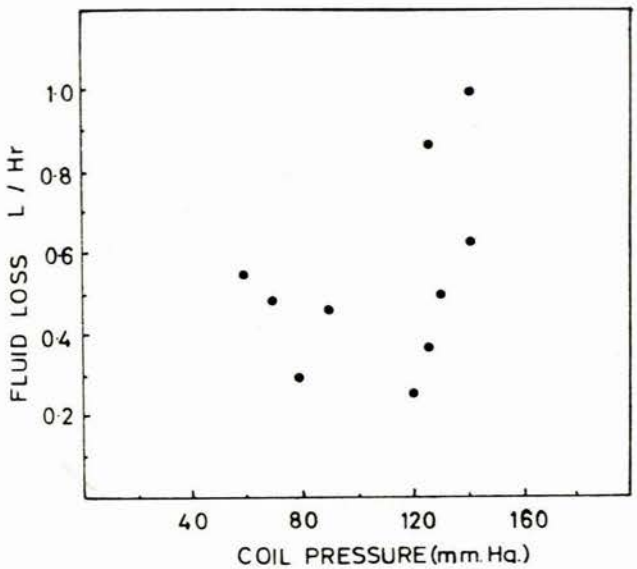

Fig. 2. The amounts of fluid removed per hour during dialysis in 10 patients in relation to the hydrostatic pressure in the coils of the artificial kidney.

TABLE IV. THE OBSERVED COMPLICATIONS OF DIALYSIS AND THE NUMBER OF OCCASIONS THESE OCCURRED

Complications of dialysis	*Number of times complications present*
Hypertension	15
Hypotension	16
Haemorrhage	8
Convulsions	5
Infection	5
Digitalis intoxication	1

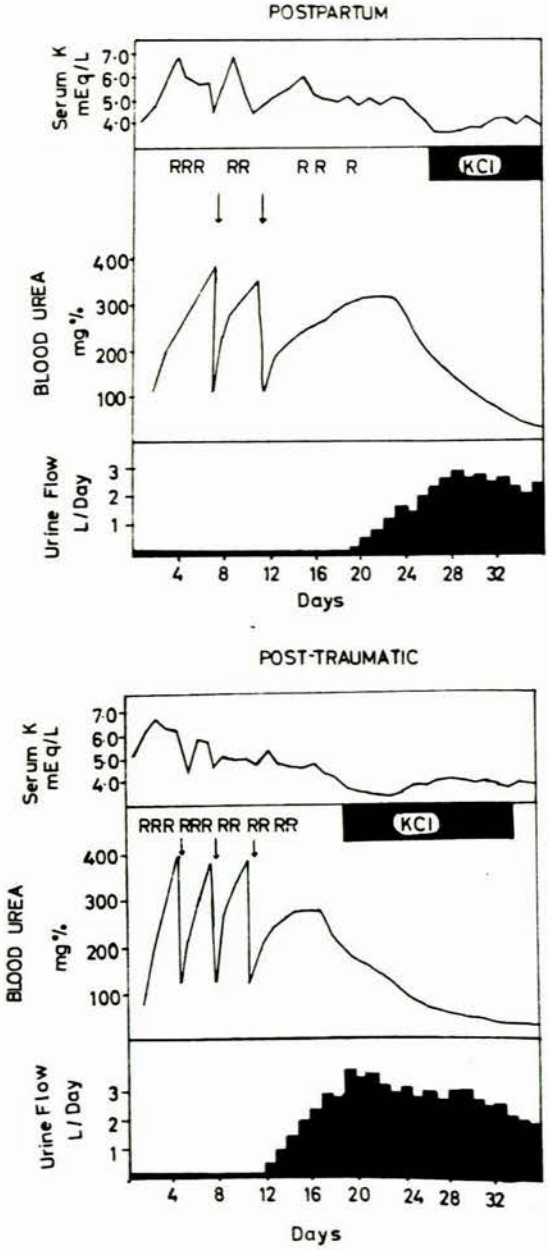

Fig. 3. The course of patients with acute oliguric renal failure requiring dialysis following pregnancy (top) and trauma or surgery (bottom). R = Resins. ↓ = Dialysis. The changes shown are the means observed in this series of patients. The longer oliguric phase in the postpartum group is due to bias introduced by 1 patient with renal cortical necrosis, who was dialysed repeatedly over 105 days.

One patient developed a bizarre arrhythmia probably resulting from digitalis intoxication which became manifest as the serum potassium level was reduced.

General Considerations

The course of a patient who develops oliguric renal failure after pregnancy or trauma and/or surgery and requires dialysis is shown in Fig. 3. The changes plotted have been derived from the mean alterations observed in our groups of patients.

On the whole the post-traumatic/surgical group deteriorates earlier with a more rapid rise in the level of blood urea. Whereas 3 dialyses were required on an average in this group, 2 were necessary in the postpartum patients at longer intervals. Nearly 6 out of every 10 patients, whose renal failure was associated with trauma, died, while about 4 of 10 in the postpartum group died.

In the post-traumatic group the diuretic phase seemed more prolonged and potassium depletion, which is commonly seen in this period, was more severe, requiring larger potassium supplements. This may be related to the need for more intense use of resins and dialyses to prevent and correct hyperpotassaemia during the period of oliguria and consequently more severe depletion of body stores of potassium. The course of the most severe case of oliguric renal failure in the post-traumatic group, who recovered, is depicted in Fig. 4.

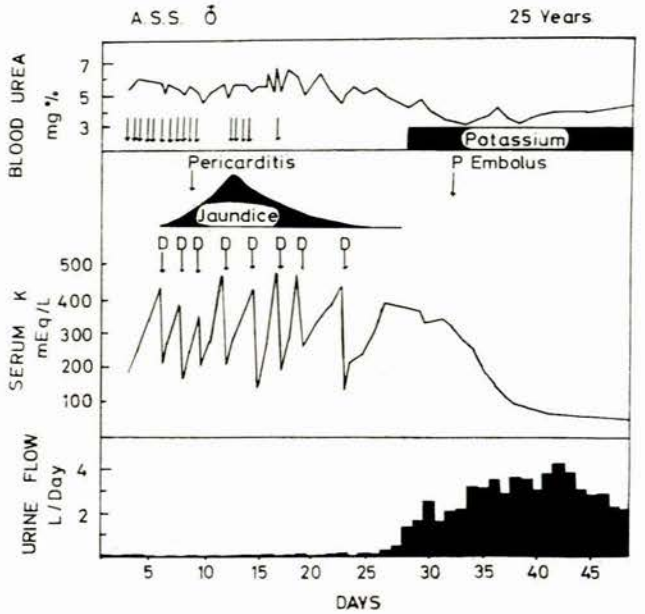

Fig. 4. A 25-year-old miner was injured in an accident and required 17 units of blood for resuscitation. He sustained a fractured pelvis and lumbar spine and formed a massive haematoma. Serum-potassium levels were controlled by administration of resins (↓). He was dialysed on 8 occasions over 16 days and during this time was mentally alert and cooperative. Jaundice due to hepatocellular disease and pericarditis developed; during the diuretic phase a pulmonary embolus occurred. After 3 weeks of oliguria renal biopsy showed recovering tubular necrosis. Large amounts of potassium were necessary during the diuretic phase to prevent hypopotassaemia.

CONCLUSIONS

In the course of renal failure, in spite of conservative care, changes both clinical and biochemical occur which, unless treated, result in death. Correction of these abnormalities may be possible only by the use of some method of dialysis which restores electrolyte abnormalities towards normal, removes known and unknown noxious metabolites and improves the clinical condition of the patient. In situations where renal disease is potentially reversible, or can improve sufficiently to restore health, the use of dialysis will then result in a lowering of the mortality rate.

It is not possible to compare the mortality rate of patients with acute oliguric renal failure among those who are dialysed and those who are not, since the former group will contain the more severely affected with the greater incidence of associated diseases or complicating factors. The over-all mortality reported here does not therefore reflect the mortality of all patients with renal failure but only those requiring dialysis. Some differences are apparent between the patients who died and those who recovered. Mortality was greatest in those with severe trauma in whom catabolism was likely to be greatest and in those with associated disease (in this series patients with severe heart disease). Where these factors were absent the chances of recovery were better.

When haemodialysis was first used in this Unit for the treatment of renal failure there was reluctance to institute dialysis until clear-cut indications were present. Retrospectively, reviewing individual case records, it seems that some patients who died may have survived if earlier or more frequent dialysis had been done in them. Conversely, it is likely that as more experience was gained, dialysis was done in patients who may have recovered without this treatment.

The better results obtained by early 'prophylactic' dialysis seems to us to justify what may at times turn out to be an unnecessary procedure.

More recently, peritoneal dialysis has been re-introduced as an effective, safe and efficient means of treating patients with renal failure. Our experience with this method of treatment is reported in another paper.[1] In most instances the simplicity of the technique and absence of need of specialized equipment make this a highly suitable method for dialysing the average case of acute renal failure. However, in selected cases, the efficiency of peritoneal dialysis is too low, technical considerations may prevent a successful result and long-term complications may make haemodialysis the method of choice for the treatment of an individual case. This is likely to be so in patients who have severe trauma and deteriorate rapidly and those with recent abdominal operations and drains which hinder technically a successful peritoneal dialysis. In patients with chronic renal failure, and in those in whom dialysis is prolonged for many days or repeated frequently, large losses of protein may occur from the peritoneum and this may be deleterious. Under these circumstances haemodialysis is to be preferred.

While there is little doubt that patients who would otherwise have died can now be restored to full health by the selective use of haemodialysis, there is also little doubt

that the incidence of acute renal failure could be lessened by careful pre- and postoperative management of patients undergoing surgery and the prompt treatment of shock and dehydration when they occur. Moreover, when renal failure is established, proper conservative management lessens the frequency of complications and the need for more highly specialized techniques of treatment.

REFERENCES

1. Fleishman, S. J., Goldberg, B., Leonsins, A. J., Rubenstein, A. H., Stables, D. and Van As, A. (1965): S. Afr. Med. J., **39**, 435.
2. Goldberg, B. (1960): Leech (Johannesburg), **30**, 93.
3. Kennedy, A. C., Linton, A. L., Luke, R. A. and Renfrew, S. (1963): Lancet, **1**, 408.
4. Leonsins, A. J. (1963): South African Journal of Surgery, **1**, 163.
5. Merrill, J. P. *in* Strauss, M. B. and Welt, L. A., eds. (1963): In *Diseases of the Kidney*. Boston: Little, Brown & Co.
6. Peterson, H. de C. and Swanson, A. G. (1964): Arch. Intern. Med., **113**, 877.